

**MISSISSIPPI
STANDARD SPECIFICATIONS
FOR
ROAD AND BRIDGE
CONSTRUCTION**



**MISSISSIPPI
DEPARTMENT OF TRANSPORTATION
JACKSON**

2017 EDITION

**Mississippi
Standard Specifications
For
Road And Bridge
Construction**

No. _____



Approved and Adopted

By

**The Mississippi
Transportation Commission
Jackson**

November 8, 2016

STANDARD SPECIFICATIONS

2017 EDITION

The Standard Specifications for road and bridge construction in Mississippi have been prepared, examined and recommended in the manner and form set out in a book entitled "Mississippi Standard Specifications for Road and Bridge Construction"--"Mississippi Department of Transportation, Jackson"--"2017 Edition", and a copy has been filed in the office of the Secretary of the Mississippi Transportation Commission. It is hereby ordered that such specifications are approved and adopted as of this date for all road and bridge construction except as may be designated otherwise in the contract documents for work prepared, advertised, or under construction.

Ordered this the 8th day of November, 2016.

* * * * *

STATE OF MISSISSIPPI

COUNTY OF HINDS

I, Amy Hornback, Secretary, Mississippi Transportation Commission, State of Mississippi, do hereby certify that the above is a true and correct copy of an order duly passed by the said Mississippi Transportation Commission at its meeting held on the 8th day of November, 2016.

Given under my hand and seal of office, this the 8th day of November, 2016.



Amy D. Hornback

Secretary

Mississippi Transportation Commission
State of Mississippi

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DIVISION 900 - CONTRACT DOCUMENTARY FORMS

(Under Separate Cover)

901	Advertisement
902	Contract
903	Contract Bond
904	Notice to Bidders (NTB)
905	Proposal
906	Required Contract Provisions (Form FHWA-1273, Training Program, etc.)
907	Special Provisions (SP) and Interim Specifications (IS)
908	Supplemental Specifications

DIVISION 100 - GENERAL PROVISIONS

It is understood and agreed that all of the provisions and requirements of DIVISION 100 shall be applicable to all Contracts.

It is further understood and agreed that the requirements of Figure 1 at the end of Section 101 shall be applicable to all Contracts on which the typical section(s) of the plans show construction of any element of the pavement structure or shoulder(s).

SECTION 101 - DEFINITIONS AND TERMS

Whenever terms not defined herein are used to identify Elements of Geometric Design of the work, such terms shall be understood to have the meaning as established by the most current version of the American Association of State Highway and Transportation Officials in the book entitled "AASHTO Highway Definitions".

Where the following abbreviations and definitions are used in these specifications or other Contract Documents, they are to be construed the same as the respective expression.

101.01--Abbreviations.

AAN	American Association of Nurserymen
AAR	Association of American Railroads
AASHTO	American Association of State Highway Transportation Officials
ACI	American Concrete Institute
AGC	Associated General Contractors of America
AIA	American Institute of Architects
AIEE	American Institute of Electrical Engineers
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AITC	American Institute of Timber Construction
ANSI	American National Standards Institute
AOAC	Association of Official Analytical Chemists
API	American Petroleum Institute
APWA	American Public Works Association
ARA	American Railway Association
ARBA	American Road Builders Association
AREA	American Railway Engineering Association
ARTBA	American Road and Transportation Builders Association
ASCE	American Society of Civil Engineers
ASLA	American Society of Landscape Architects
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWG	American Wire Gage
AWPA	American Wood Preservers Association
AWS	American Welding Society
AWWA	American Water Works Association
Code(NEC)	National Electrical Code
CFR	Code of Federal Regulations

CRSI	Concrete Reinforcing Steel Institute
CS	Commercial Standards, U. S. Department of Commerce
CSPI	Corrugated Steel Pipe Institute
EIA	Electronic Industries Association
EPA	Environmental Protection Agency
ESFE	Estimated State Furnished Excavation
FCP	Fixed Contract Unit Price
FHWA	Federal Highway Administration
FM	Final Measure
FME	Final Measure - Embankment
FSS	Federal Specifications and Standards (General Services Administration)
HRB	Highway Research Board
ICEA	Insulated Cable Engineers Association
ID	Inside Diameter
IES	Illuminating Engineering Society
IMSA	International Municipal Signal Association
IPS	Interior Pipe Size
IS	Interim Specifications
ITE	Institute of Transportation Engineers
LVM	Loose Vehicular Measure
MAPA	Mississippi Asphalt Pavement Association
MASH	Manual for Assessing Safety Hardware
MDAC	Mississippi Department of Agriculture and Commerce
MDOT	Mississippi Department of Transportation
MDEQ	Mississippi Department of Environmental Quality
MIL	Military Specifications
MSG	Manufacturers Standard Gauge
MUTCD	Manual on Uniform Traffic Control Devices
NACE	National Association of Corrosion Engineers
NAPA	National Asphalt Pavement Association
NBC	National Building Code
NBS	U.S. National Bureau of Standards
NCHRP	National Cooperative Highway Research Program
NEC(Code)	National Electric Code
NEMA	National Electrical Manufacturers Association
NPC	National Plumbing Code
NPDES	National Pollution Discharge Elimination System
NSF	National Sanitation Foundation
NTB	Notice To Bidders
OD	Outside Diameter
OSHA	Occupational Safety and Health Administration
PCI	Prestressed Concrete Institute
RCRA	Resource Conservation and Recovery Act
RAP	Recycled Asphalt Pavement
SAE	Society of Automotive Engineers
SAVE	Society of American Value Engineering
SOP	The Department's Standard Operating Procedures
SP	Special Provisions
SS	Supplemental Specifications
SSPC	Steel Structures Painting Council
SWPPP	Storm Water Pollution Prevention Plan

TRB	Transportation Research Board
UL	Underwriters Laboratories, Inc.
UNC	Upset National Coarse Threaded Bolts
UST	Underground Storage Tank

101.02--Definitions.

A + B bidding - A two-part contract bidding method consisting of the Contract amount (A) and the total number of calendar days proposed by the Bidder to complete the work (B).

A + C bidding - A two-part contract bidding method consisting of the Contract amount (A) and the total number of working days proposed by the Bidder to complete the work (C).

additive - A substance or agent added in small amounts to a basic ingredient of a mixture prior to mixing.

admixture - A substance or agent added in small amounts to the basic ingredients of a mixture during the mixing process.

advertisement - The public announcement, as required by law, inviting bids for work to be performed or materials to be furnished.

alternate designs - Alternate designs of construction or construction and materials designated in the bid schedule of the proposal as alternate designs which must be pre-selected by the Contractor and indicated on the bid. Alternate designs may contain alternate or optional items.

alternate Items - Alternate pay items of work, or materials and work designated in the bid schedule of the proposal as Alternate Items, with separate pay item numbers, and that must be pre-selected by the Contractor and indicated on the Contractor's bid.

award - The acceptance by the Mississippi Transportation Commission of a proposal.

base course - The layer or layers of specified or selected material of designed thickness placed on a subgrade to support a pavement.

basement soils - That portion of the roadway in embankment areas below the design soil and to the bottom of the embankment or undercut, whichever is lower, and that portion of the earthwork in cut areas below the design soil and to the bottom of any undercut or other treatment required, whichever is lower.

Beginning of Contract Time - The date shown on the written Notice to Proceed that allows the Contractor to begin work on the project. It is also the date the Contractor begins maintenance of traffic on the project.

Bidder - An individual, partnership, firm or corporation formally submitting a proposal for the advertised work or materials.

borrow - Suitable material from approved sources outside the roadway right-of-way,

used primarily for embankments.

box bridge - A box culvert having a clear distance between inside face of the end supports exceeding 20 feet measured along the centerline of the roadway.

bridge - A structure, including supports, erected over a depression or an obstruction, as water, highway, or railway, and having a track or passageway for carrying traffic or other moving loads and having a length measured along the center of the roadway of more than 20 feet between undercopings of abutments or extreme ends of openings for multiple boxes.

bridge length - The length of a bridge structure is the overall length measured along the line of survey stationing back to back of backwalls of abutments, if present, otherwise end to end of the bridge floor; but in no case less than the total clear opening of the structure.

bridge roadway width - The clear width measured at right angles to the longitudinal centerline of the bridge between the bottom of curbs or guard timbers or in the case of multiple height of curbs, between the bottoms of the lower risers.

bridge site - Unless otherwise specified in the Contract, the bridge site shall be the entire area between the right-of-way lines and between lines paralleling the bridge ends and passing through the longitudinal extremities of the substructure or superstructure, whichever is greater.

calendar day - Any day shown on the calendar, beginning and ending at midnight.

Commission - The Mississippi Transportation Commission.

conformity - The degree of perfection required for the materials furnished and the work performed, and determined:

- (a) In the case of a required "minimum" or "maximum" value of a measurable characteristic, as set out in Subsection 700.04.
- (b) In the case of a required non-measurable characteristic, as being satisfactory to the Engineer.

Contract - The written agreement between the Mississippi Transportation Commission and the Contractor setting forth the obligations of the parties thereunder, including but not limited to, the performance of the work, the furnishing of labor and materials, and the basis of payment.

The Contract includes the invitation for bids, proposal, Contract form and Contract bonds, Standard Specifications, supplemental specifications, interim specifications, general and detailed plans, special provisions, notices to bidders, notice to proceed, and also any agreements that are required to complete the construction of the work in an acceptable manner, including authorized extensions thereof, all of which constitute one instrument.

contract bond - The approved form of security, executed by the Contractor and the Contractor's Surety(ies), guaranteeing complete performance of the Contract and all

Supplemental Agreements pertaining thereto and the payment of all legal debts pertaining to the construction of the project. This term includes Performance and Payment Bond(s).

contract documents - All original documents or papers, including electronically submitted documents, that make up the Contract including those specifically incorporated or referenced into the Contract.

contract item (pay item) - A specifically described unit of work for which a price is provided in the Contract.

contract time - The period of time, including authorized extensions, specified in the Contract for completion of work under the Contract.

contract unit price - The price provided for in the Contract for a specifically described unit of work.

Contractor - The individual, partnership, firm or corporation contracting with the Commission for performance of prescribed work.

controlling item - The work or construction operations normally expected to be in progress as determined by the Engineer after careful consideration of the approved progress schedule for assessment of contract time.

county - The county in which the work is to be done.

cross slope - The rate of transverse slope in a roadbed element or pavement structure.

culvert - Any structure not classified as a bridge that provides an opening under the roadway.

Department's Standard Operating Procedures (SOP) - The Department's Standard Operating Procedures are the rules, regulations, instructions and policies, promulgated by the Commission acting through the Executive Director or authorized representative and on file in the Central Records Section of the Central Services Division.

Department - The Mississippi Department of Transportation.

dependent pay items - Those pay items such as maintenance of traffic, mobilization, and construction stakes for which the amount of payment allowed on progress estimates may be based on the amount earned on other pay items.

design grade - Design grade is an intermediate control grade at a vertical distance, as established on the typical section of the plans for the various intermediate courses, below profile grade.

design soil - That portion of the roadbed consisting of the top three feet of untreated or treated soils in excavated sections and embankments.

direct pay items - Those pay items for which payment is based on the quantity of the item completed.

elements of geometric design - Those geometric elements of the highway as are defined in the "AASHTO Policy on Geometric Design" in effect at the time bids are received.

Engineer - The Chief Engineer of the Department, acting directly or through a duly authorized representative(s), who is responsible for engineering supervision of the work.

equipment - All machinery and equipment, together with the necessary supplies for upkeep and maintenance, and all tools and apparatus necessary for the proper construction and acceptable completion of the work.

Executive Director - The Executive Director of the Mississippi Department of Transportation acting directly or through authorized representatives.

extra work - An item of work not provided for in the Contract as awarded, or an item of work provided for in the Contract the nature or character of which is changed by the Engineer such as to justify a price adjustment, either of which is found by the Department to be essential to the satisfactory completion of the Contract within its intended scope.

fixed contract unit price - When the bid schedule of the proposal form indicates a fixed contract unit price (FCP), this price shall become the contract price for that item and shall be used in determining the total amount of the proposal.

hazardous waste - Wastes that are regulated or "listed" under RCRA (40 CFR 261), or are ignitable, corrosive, reactive, or toxic.

highway, street, or road - A general term denoting a public way for purposes of vehicular travel, including the entire area within the right-of-way.

holidays, legal - In the State of Mississippi, holidays occur on:

January 1 - New Year's Day

Third Monday in January - Robert E. Lee and Dr. Martin Luther King, Jr.'s Birthday

Third Monday in February - Washington's Birthday

Last Monday in April - Confederate Memorial Day

Last Monday in May - National Memorial Day and Jefferson Davis' Birthday

July 4 - Independence Day

First Monday in September - Labor Day

November 11 - Armistice (Veterans') Day

Thanksgiving Day - As Proclaimed

December 25 - Christmas Day

When a legal holiday falls on a Saturday or Sunday, the succeeding Monday will be observed as a legal holiday.

in-grade - The top course or portion of the work that is in place at the time a subsequent material or course is to be placed thereon.

in-grade preparation - In-grade preparation is the preparation of material in place to receive other materials or processing required in super-imposed construction.

inspector - The Engineer's authorized representative assigned to make detailed

inspections of contract performance.

Interim Specifications - Interim Specifications are Contract provisions other than Standard and Supplemental Specifications approved for general use in all applicable Contracts until changes in technology or other conditions indicate revisions should be made for subsequent Contracts.

intermediate course - A combination of graded aggregate and bituminous material which constitutes the lower layer or layers of a flexible pavement, but not part of the base course.

invitation for bids - The advertisement for proposals for all work or materials on which bids are required. The advertisement will indicate with reasonable accuracy the quantity and location of the work to be done or the character and quantity of the material to be furnished and the time and place of the opening of proposals.

laboratory - The testing laboratory of the Department or any other testing laboratory which may be designated by the Engineer.

legend - The words, letters and arrows, and other symbols or markings shown on the plans and designated as legend, required to be placed on the surface of a pavement in the form of paint and glass beads, thermoplastic and glass beads or other similar specified materials, to serve as pavement markings.

local traffic - Traffic whose origin or destination is adjacent to that part of the highway under construction.

major contract items - A major item of work shall be defined as an item whose total monetary value, determined by multiplying the proposal quantity by the contract unit price, is equal to or greater than ten percent of the original total contract amount. Unless otherwise specifically shown in the Contract, all other items shall be considered minor items.

materials - Any substances specified for use in the construction of the project and its appurtenances.

Manual on Uniform Traffic Control Devices (MUTCD) - A document issued by the Federal Highway Administration to specify the standards by which traffic signs, road surface markings, signals, etc. are designed, installed, and used. Any reference in the Standard Specifications or contract documents to a particular Section of the MUTCD, it shall mean that Section of the latest version of the Manual on Uniform Traffic Control Devices.

minor contract items - All items of work not considered to be major items of work. Minor items shall become major items when increased to the extent that the total monetary value of such item at the original contract unit price is equal to or greater than ten percent of the original total contract amount.

Notices to Contractors - Pre-bidding notices to prospective bidders, including the advertisement and other pertinent pre-bid information labeled as Notice to Contractors.

notice to bidders - All notices, issued to the prospective bidders, pertaining to or establishing requirements governing the submission of proposals, quantities or qualities of materials or work, the performance of the work, or payment therefor.

Notice to Proceed - Written notice to the Contractor to proceed with the contract work which is also the date of beginning of contract time.

omitted section - A section within the designated project limits in which no work, excluding construction signing, approaches and/or temporary connections, is to be performed, and the Contractor does not have any responsibility for maintenance of the roadway or traffic unless specifically provided for in the Contract.

optional items - Items listed in the bid schedule of the proposal that are considered to be comparable for the purpose intended, and the Contractor is required to make a selection prior to or at the time of execution of the Contract.

pavement - The portion of the roadbed constructed upon the base course and specifically constructed as the contact element for vehicular traffic.

pavement structure - The combination of a pavement and a base course placed on a subgrade to support the traffic load and distribute it to the roadbed.

payment bond - The approved form of security, executed by the Contractor and issued by the Contractor's Surety(ies), guaranteeing the payment of all legal debts pertaining to the construction of the project including, but not limited to, the labor and materials of Subcontractors and Suppliers to the Prime Contractor.

performance bond - The approved form of security, executed by the Contractor and issued by the Contractor's Surety(ies), guaranteeing satisfactory completion of the Contract and all Supplemental Agreements pertaining thereto.

plans - The approved plans, profiles, typical cross-sections, working drawings and supplemental drawings, or exact reproduction thereof, that show the location, character, dimensions, and details of the work to be done. When the Contract does not have an official set of plans, reference to the plans shall mean the Contract Documents.

profile grade - The trace on a vertical plane intersecting the top surface of the proposed wearing surface as shown on the plans or established by the Engineer, usually along the longitudinal centerline of the roadbed. Profile grade means either elevation or gradient of such trace according to the context.

progress schedule - A bar graph showing the work phases under the Contract and each bar represents a controlling phase of the work. The bars show the planned sequence of operations and the time at which each of the phases is to begin and end. The schedule will be developed by the Department or by the Contractor with Department approval.

project - A specific section of highway or other prescribed limits of work as described by the Plans and Contract Documents including approaches and/or temporary connections together with all appurtenances and construction to be performed thereon under the Contract.

proposal - The offer of a bidder, on the prescribed form, to perform the work at the prices quoted.

proposal form - The approved form on which the Department requires bids to be prepared and submitted for the work.

proposal guaranty - A certified check, cashier's check or bid bond furnished with the bid to guarantee that the bidder will enter into a Contract for the work and furnish acceptable bond if the Contractor's bid is accepted.

quantity adjustment - A modification of contract quantities covering increases or decreases resulting from plan errors, omissions or changes necessary to carry out the intent of the plans.

Resident or Project Engineer - The Engineer assigned by the Chief Engineer and bonded to the State to have immediate charge of the engineering details and the responsibility and authority for on-the-job administration necessary for the satisfactory completion of the work in accordance with the Contract. The obligation to satisfactorily complete the Work remains with the Contractor, despite any duties performed or amended by the Resident or Project Engineer.

retainage - A general term denoting funds withheld from partial payments.

right-of-way - A general term denoting land, property, or interest therein, usually in a strip, acquired for or devoted to a highway and its appurtenances.

roadbed - The graded portion of a highway within top and side slopes prepared as a foundation for a pavement structure and shoulders.

roadside - A general term denoting the area adjoining the outer edge of a roadway. Extensive areas between the roadways of a divided highway are also considered to be roadside.

roadside development - Those items necessary to the complete highway that provide for a preservation of landscape materials and features; the rehabilitation and protection against erosion of all areas disturbed by construction through seeding, sodding, mulching and the placing of other ground covers; and such suitable planting, other improvements and public facilities as may increase the effectiveness and usefulness and enhance the appearance of the highway.

roadway - All surface portions of the highway between shoulder lines. Divided highways are considered to have two roadways.

roadway structure - All vertical and horizontal elements of the work, exclusive of bridges, designed to provide and support the roadway.

shoulders - The portion of the roadway contiguous with the traveled way for the lateral support of the other elements of the pavement structures, and for emergency use of stopped vehicles.

sidewalk - That portion of the road, highway, or street primarily constructed for use by

pedestrians.

special provisions - Additions and revisions to the Standard and Supplemental Specifications covering conditions peculiar to an individual project, and included in the proposal assemblies.

specifications - A general term applied to all directions, provisions and requirements pertaining to performance of the work.

Specified Completion Date - The date on which the contract work is required to be completed, per the Contract.

Standard Specifications - The most current version of the Mississippi Standard Specifications for Road and Bridge Construction. The Standard Specifications are a part of the contract documents.

State - The State of Mississippi acting through its authorized representative.

structures - Bridges, culverts, catch basins, drop inlets, retaining walls, cribbing, manholes, end walls, buildings, sewers, service pipes, underdrains, foundation drains, and similar features that may be required in the work.

Subcontractor - An individual, partnership, firm, or corporation with whom the Contractor, with the written consent of the Executive Director, contracts to complete a portion of the Work, or supply materials to the Project, on behalf of the Contractor.

subgrade - The top surface of a design soil upon which the pavement structure and shoulders are constructed.

substructure - Those parts of a bridge below the bearings of simple and continuous spans, below the bottom surfaces of concrete box girder spans in which the piers form an integral part of the span-pier unity, below skew-backs of arches, below tops of footings of rigid frames, and below wing walls of abutments.

superintendent - The Contractor's authorized representative in responsible charge of the work.

superstructure - All parts of a bridge above and exclusive of the substructure.

supplemental agreement - A written agreement on a form provided by the Department, between the Contractor and the Commission with the assent of the Contractor's Surety when applicable, and the approval of all agencies involved, covering alterations or unforeseen items necessary for the completion of the work within the intent of the Contract.

Supplemental Specifications - Additions to the Standard Specifications that are adopted subsequent to issuance of this book, and which are printed in volume form and issued under the title of "Supplemental Specifications," and considered as part of the Standard Specifications.

Surety - A corporate body, qualified under the laws of Mississippi, that is bound with and for the successful bidder by "Contract Bond(s)" to guarantee acceptable performance of the Contract and payment of all legal taxes and debts pertaining to the construction of the project, including payment of State Sales Tax as prescribed by law, and any overpayment made to the Contractor.

temporary structures - Structures required to maintain traffic while the Contractor constructs permanent structures. The temporary structure shall include the earth approaches thereto unless otherwise specified.

titles (or headings) - The titles or headings of the sections and subsections herein are intended for convenience of reference and shall not be considered as having any bearing on their interpretation.

township, town, city or district - A subdivision of the county used to designate or identify the location of the proposed work.

travelled way - A portion of the roadway improved, designed or ordinarily used for vehicular travel, exclusive of shoulders or berms.

underground storage tanks - Any tank or combination of tanks, including underground pipes connected thereto, that are used to contain an accumulation of regulated substances and the volume of which, including underground pipe volume, is ten percent or more beneath the surface of the ground.

wetlands - As defined in EPA and Corps of Engineers (Corps) regulations and clarified in the latest Federal Wetlands Delineation Manual.

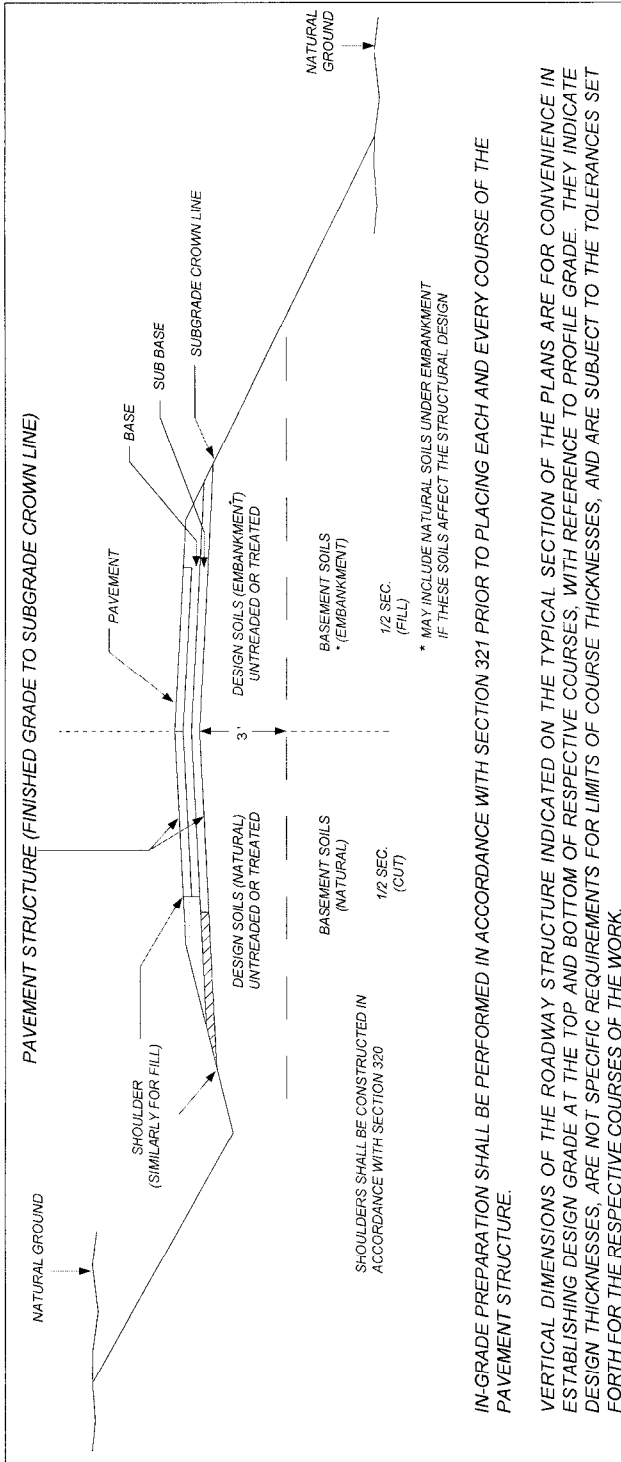
work - The furnishing of all labor, materials, equipment and incidentals necessary or convenient to the successful completion of the project and the carrying out of the duties and obligations imposed by the Contract.

work order - A written order, signed by the Engineer, of contractual status requiring performance by the Contractor without negotiation of any sort.

work phase - A contract item or group of associated items that should be in progress at the time as a controlling phase for the orderly completion of the work within contract time. See progress schedule.

working drawings - Stress sheets, shop drawings, erection plans, falsework plans, framework plans, cofferdam plans, bending diagrams for reinforcing steel, or any other supplementary plans or similar data that the Contractor is required to submit to the Engineer for approval.

101.03--Presumption. To avoid repetition of expressions, it is provided that any directive, action or opinion that is not so denoted shall be understood to be followed by the words "by the Engineer" or "to the Engineer."



IN-GRADE PREPARATION SHALL BE PERFORMED IN ACCORDANCE WITH SECTION 321 PRIOR TO PLACING EACH AND EVERY COURSE OF THE PAVEMENT STRUCTURE.

VERTICAL DIMENSIONS OF THE ROADWAY STRUCTURE INDICATED ON THE TYPICAL SECTION OF THE PLANS ARE FOR CONVENIENCE IN ESTABLISHING DESIGN GRADE AT THE TOP AND BOTTOM OF RESPECTIVE COURSES, WITH REFERENCE TO PROFILE GRADE. THEY INDICATE DESIGN THICKNESSES, ARE NOT SPECIFIC REQUIREMENTS FOR LIMITS OF COURSE THICKNESSES, AND ARE SUBJECT TO THE TOLERANCES SET FORTH FOR THE RESPECTIVE COURSES OF THE WORK.

Figure 1 - Section 101

SECTION 102 - BIDDING REQUIREMENTS AND CONDITIONS

102.001--Advertisement. In conformity with State law, the Commission will publish a Notice to Contractors giving notice of a request for bids, this notice will become one of the contract documents if award is made.

The advertisement will state the time and place for submission of sealed proposals; the location and description of the proposed work; estimates of the quantities and kinds of work to be performed or materials to be furnished and a schedule of pay items for which contract unit prices are asked; specified contract time; and instructions to bidders regarding proposal forms, basis of award, proposal guaranty required, plans, specifications, labor requirements, special provisions and other pertinent information.

102.01--Prequalification of Bidders. Prospective bidders will be required to file with the Department a list of persons authorized to bind the company in all matters. Other information may be required from time to time before issuing proposals.

Bidders must familiarize themselves with all fees and taxes required for the privilege of doing business within the State of Mississippi.

As a condition precedent to the opening of a bid, the total amount of which is equal to or in excess of \$50,000.00 and financed 100% with State funds, the bidder must have a certificate of responsibility issued by the Mississippi State Board of Public Contractors or a similar certificate issued by another state recognizing such certificate issued by the State of Mississippi. The Bidder's Certificate of Responsibility number must be on file with the Department's Contract Administration Division to purchase a bid proposal.

When two or more persons, firms or corporations are submitting a joint venture, each of the persons, firms or corporations shall comply with the above prequalification requirements.

102.02--Contents of Proposal Forms. The proposal forms, designated as Section 905 of the contract documents, will state the location and description of the contemplated construction, will show estimates of the kinds and quantities of work to be performed or materials to be furnished, and will have a schedule of items for which contract unit prices are invited. It will state the time in which the work must be completed. The proposal will also include special provisions and requirements that are not contained in the Standard Specifications or required modifications thereto.

All papers bound with, attached to, submitted electronically with, or designated for addition or substitution in the proposal are considered a part thereof and must not be detached or altered when the proposal is submitted.

The plans, specifications and other documents designated in the proposal shall be considered a part as if attached to and included in the proposal.

The bidder will be required to pay the Department the sum stated in the Notice to Contractors for each copy of the proposal form.

102.03--Issuance of Proposal. Except as hereinafter set forth, the Department will, upon request, furnish the bidder with a proposal. The Department reserves the right to refuse

to issue a proposal to a bidder for the following reasons:

- (a) Lack of competency and adequate machinery, plant, or other equipment, as revealed by the information obtained as provided in Subsection 102.01 or other determinations made by the Department.
- (b) Uncompleted work which, in the judgment of the Department, might hinder or prevent the prompt completion of additional work if awarded.
- (c) Failure to pay, or satisfactorily settle, all bills due for labor and material on former contracts in force at the time of issuance of proposals.
- (d) Unsatisfactory performance on previous contracts.
- (e) Failure to promptly reimburse the Department for any overpayment that might have occurred.
- (f) Debarment of a prospective bidder or any of its corporate officers or principal owners by the Mississippi Transportation Commission.

102.04--Interpretation of Quantities in Bid Schedule. The quantities appearing in the bid schedule are approximate only and have been prepared for the comparison of bids. The Department does not guarantee or assume any responsibility that quantities shown on the plans will not vary during actual construction of the Project, and the Contractor, hereby acknowledging this fact, shall be precluded from claiming in the construction of the Project, and the Contractor shall not claim deception or misunderstanding because of variation in these quantities or variation from the location, character of the work, or any other conditions. Payment to the Contractor will be made only for the actual quantities of work performed and accepted or materials furnished and accepted in accordance with the Contract. The scheduled quantities of work to be done and materials to be furnished may each be increased, decreased, or omitted as hereinafter provided.

102.05--Examination of Plans, Specifications, Special Provisions, Notices to Bidders and Site of Work. The Department intends, to the extent that the facts and circumstances permits, to prepare full, complete, and accurate plans and specifications giving directions that will enable any competent Contractor to carry them out. The bidder is required to examine carefully the site of the proposed work, the proposal, Plans, Standard Specifications, Special Provisions, Notices to Bidders and contract forms before submitting a proposal. The submission of a bid shall be considered prima facie evidence that the bidder has made such an examination and is satisfied as to the conditions to be encountered in performing the work and as to the requirements of the plans, Standard Specifications, Supplemental Specifications, Notices to Bidders, Special Provisions, Contract, and the Federal, State, and local laws that will in any way affect the execution of the work. All Contracts are subject to the provisions of Sections 65-1-89 and 65-1-91, Mississippi Code of 1972, annotated.

Bidders may inspect records of the Department as to investigations made, subject to the conditions set forth herein.

Boring logs and other records of subsurface investigations are available for inspection by bidders. It is understood that such information was obtained and is intended for Department design and estimating purposes only. It is made available to bidders so they may have access to identical subsurface information available to the Department and is not intended as a substitute for personal investigation, interpretations and judgment of the bidders. No representations are made by the Department concerning the results of any subsurface investigation as a result of providing any such information to Bidders and the

Department and the Commission shall not be liable for any errors or omissions in the boring logs or other records of subsurface investigations provided.

The Department makes no guarantees regarding the character or extent of water levels, soil, rock, or other subsurface conditions the bidder may encounter during the work. The Department interpolates test data from completed borings in its reports and representations of subsurface conditions, and does not guarantee the accuracy of these interpolations, nor does the Department guarantee the accuracy of the test data except at the exact points where samples were taken. The Department requires bidders to make their own evaluation of subsurface conditions and to determine how these conditions may affect the methods and cost of construction. Material quality within sources naturally varies.

The bidder shall immediately notify the Department of any apparent error, omission, or ambiguity in any part of the proposal. The Department will review the apparent error, omission, or ambiguity, and will issue a notice to all prospective bidders, as appropriate.

If the Department becomes aware of a change in the information provided at any time during the bidding process, it will provide reasonable notice of the new information to the bidders.

In order to make the most effective use of available engineering personnel, the Department is unable to assign engineering responsibilities at the time of Contract preparation; however, the District Construction Engineer will, by appointment, personally be available or may arrange for representative to be available to lend assistance to prospective bidders for plan-in-hand review of the proposed work features, and, if desirable, field inspection of the site of the proposed work. The Resident or Project Engineer for the Contract will be assigned as soon as the Department can reasonably make an appropriate determination.

102.06--Preparation of Proposal. MDOT will receive bids for construction projects online using the Bid Express Service (BIDX).

The Bidder's complete proposal (Certification of Performance, Certification Regarding Non-Collusion, etc.) will be submitted to the Department electronically via the Bid Express Service no later than the day and at the time bids are to be received. Bidders will be responsible for joining Bid Express and getting all necessary clearances and a digital ID in sufficient time for Bid Express to submit their bid.

Bid Express files shall be downloaded from <http://www.bidx.com>. Bidders are to select Mississippi Department of Transportation under the U.S. AGENCY drop down menu and select the desired project. After completing all necessary data, the Bidders shall submit their bid to Bid Express in sufficient time for the bid to be properly sent to the Department.

Bids submitted via the Bid Express Service will constitute the official bid and shall be digitally signed and delivered to the Department by the Bid Express Service.

It is the responsibility of every bidder to check for any addendum or modification to the contract document(s) for which they intend to submit a response. It shall be the bidder's responsibility to be sure they are in receipt of all addenda, pre-bid conference

information, and/or questions and answers provided at, or subsequent to, the pre-bid conference, if any are issued.

The Commission has no responsibility for defects, irregularities or other problems caused by the use of electronic media. Operation of this electronic media is done at the sole risk of the user.

When the bid schedule contains a fixed contract unit price (FCP) for an item, this price shall be the contract unit price for the item and no alteration shall be made by the bidder.

When an item in the proposal contains a choice to be made by the bidder, the bidder shall indicate the choice in accordance with the INSTRUCTION TO BIDDERS in Section 905 - Proposal; reference is made to Alternate Designs, Alternate Items, and Optional Items as defined in Subsection 101.02.

Where the bid schedule lists alternate designs or alternate items, the one alternate bid shall be designated by bidding only that alternate, and thereafter no further choice will be permitted.

When the bid schedule lists optional items, the Contractor's selection may, but is not required to, be made at the time of bidding. For optional items not pre-selected, the Contractor's selection shall be made prior to or at the time of execution of the Contract.

Each proposal issued will contain a Certification regarding debarment, suspension, and other responsibility matters to be completed by the bidder. The Certification must be sworn to and shall be under penalty of perjury and bidders are cautioned to read and understand its contents in entirety before digitally signing the bid.

The Contractor shall provide immediate written notice to the Contract Administration Engineer at any time, prior to or after award, that an e-certification was erroneous when executed or has become erroneous by reason of changed circumstances.

Failure on the part of the bidder to execute the Certification will result in the proposal being rejected.

The bidder's proposal must be digitally signed by the individual, by one or more members of the partnership, by one or more members or officers of each firm representing a joint venture, or by one or more officers of a corporation, or by an agent of the Contractor legally qualified to bind the Contractor and acceptable to the State. If the proposal is made by an individual, the individual's name and address must be shown; by a partnership, the name and address of each partnership member must be shown; as a joint venture, the name and address of each member or officer of the firms represented by the joint venture must be shown; by a corporation, the name of the corporation and the business address of its corporate officials must be shown.

The address stated on the proposal shall be the bidder's permanent address until changed by written notice to the Executive Director. All notices provided for in the Contract shall be considered as delivered to the Contractor when mailed or delivered to such address.

102.07--Irregular Proposals. Proposals will be considered irregular and may be rejected for any of the following reasons:

- (a) If the proposal is on a form other than that furnished by the Department, or if the form is altered or any part thereof is detached, except as allowed in Subsection 102.06.
- (b) If there are unauthorized additions, conditional or alternate bids, or irregularities of any kind that may tend to make the proposal incomplete, indefinite, or ambiguous as to its meaning.
- (c) If the bidder adds any provisions reserving the right to accept or reject an award, or to enter into a Contract pursuant to an award.
- (d) If the proposal does not contain a contract unit price and extension for each pay item, except in the case of alternate items and when the unit of measurement is lump sum.
- (e) If the proposal, Section 905, does not contain acknowledgement of receipt and addition to the proposal and contract documents of all addenda issued prior to opening of bids.
- (f) Failure to execute required affidavits, certificates, etc., and furnish proposal guaranty.
- (g) The Commission reserves the right, for any reason, to reject any or all proposals, to waive technicalities or irregularities, or to advertise for new proposals, and the decision of the Commission to reject any bid or proposal shall not be cause for any liability or damage against the Commission, the Department, or any of its officers or employees.
- (h) The Department may reject a proposal if any of the unit prices contained therein appear to be mathematically unbalanced, by reason that they are either above or below the Engineer's estimate. A mathematically unbalanced bid generates a reasonable doubt that award to the Bidder submitting a mathematically unbalanced bid will result in the lowest ultimate cost to the Department.

102.08--Proposal Guaranty. No proposal will be considered unless accompanied by certified check, cashier's check or bid bond, made payable to the State of Mississippi, in an amount of not less than five percent (5%) of the total amount of the proposal offered. The proposal guaranty shall be evidence of good faith that, if awarded the Contract, the bidder will execute the Contract and give performance and payment contract bond(s) as stipulated in Subsection 103.05.1, 103.05.2, and as required by law.

If a bid bond is offered as guaranty, the bond must be on a form approved by the Executive Director, made by a Surety acceptable to the Executive Director and signed or countersigned by a Mississippi Agent or Qualified Nonresident Agent and the Bidder. The Mississippi agent or qualified nonresident agent shall be in good standing and licensed, at the time of submission of the bid, by the Insurance Commissioner of the State of Mississippi to represent the Surety company(ies) executing the bonds. Such bid bond shall also conform to the requirements and conditions stipulated in Subsection 103.05.2 as applicable.

102.09--Delivery of Proposals. Unless otherwise specified, each proposal shall be submitted online using Bid Express service. Proposal Forms are non-transferable and no name or names of interested parties may be shown other than those to whom the proposal was issued. All proposals shall be submitted to Bid Express prior to the time and place specified in the Notice to Contractors and on the Bid Express website.

102.10--Withdrawal or Revision of Proposals. A bidder may withdraw or revise a

proposal after it has been submitted to Bid Express any time prior to the time set for opening proposals.

102.11--Combination Bids. Combination bids that combine two or more individual projects may be submitted by stating in writing on each project proposal to be considered in the combination, one of the following:

- (a) That the bidder is bidding on "All or None" of the work for designated proposals. The Department will evaluate all bids on these proposals and make awards based on the bids most advantageous to the State.
- (b) The reduction the bidder will make in the contract unit price of one or more of the items in any or all of the proposals if awarded the combination; however, the bidder will not be permitted to make a reduction in any contract unit price that may be fixed by the Department in the proposal. The Department will select from the proposals submitted the individual or combination bids most advantageous to the State.
- (c) That the bidder is bidding on a number of projects but desires to be awarded work not to exceed a specified total amount or a specified number of Contracts. The Department will select from the bidder's proposal those that are most advantageous to the State within its specified amount or total number of Contracts.

Combination bids that state that a lump sum shall be deducted from the final estimate, or that a reduction in prices shall be made on a percentage basis, or that states that award of a Contract is contingent upon being awarded another Contract will not be accepted and the bids with which such a letter is submitted will be considered irregular and rejected.

102.12--Public Opening of Bids. All bids received in accordance with the terms of the advertisement shall be publicly opened and announced either item by item, or by total amount, at the time and place indicated in the proposal. If any bid received is not read aloud, the name of the Bidder and the reason for not reading the bid aloud shall be publicly announced at the letting. Bidders, their authorized agents, and other interested parties are invited to be present.

102.13--Disqualification of Bidders. Either of the following reasons may be considered as being sufficient for the disqualification of a bidder and the rejection of the bidder's proposal or proposals:

- (a) More than one proposal for the same work from an individual, partnership, firm or corporation under the same or different name(s). However, the Commission may accept proposals on construction contracts from commonly owned but independently managed companies, so long as each bid is not the result of collusion and is accompanied by the required certificate regarding collusion.
- (b) Evidence of collusion among bidders. Participants in such collusion will receive no recognition as bidders for any future work of the Department until reinstated as a qualified bidder.

102.14--Material Guaranty. At the option of the Department, the successful bidder shall be required at any time before or after the award or execution of the Contract to furnish a complete statement of the origin, composition and manufacture of any or all materials to be used in the construction of the work and shall provide the Department

with access to all sources of materials for sampling and testing to determine their quality, uniformity and fitness for the work in accordance with the Contract.

102.15--Questions Regarding Bidding. All questions that arise regarding the contract documents (proposal), plans, or addendum shall be directed to the www.gomdot.com current letting webpage. Click on the call number for the project to open an email form to submit your question. Questions must be submitted by 8:00 a.m. on the day prior to the letting. Answers to questions will be posted by 6:00 p.m. on the day prior to the letting. Answers can be viewed by clicking on Q&A link under the Proposal Addenda column.

It shall be the Bidders responsibility to familiarize themselves with the questions and answers that have been submitted on a particular project. By signing the contract documents for a project, the Bidder agrees that the on-line Questions and Answers submitted on the project shall be added to and made part of the Contract.

SECTION 103 - AWARD AND EXECUTION OF CONTRACT

103.01--Consideration of Proposals. After the proposals are opened and read, they will be compared on the basis of the summation of the products of the quantities shown in the bid schedule and the contract unit prices bid. The results of comparisons will be immediately available to the public. In the event of a discrepancy between any contract unit price and its extension, the contract unit price shall govern.

Resident Contractors actually domiciled in Mississippi are to be granted preference over nonresidents in awarding of Contracts financed 100% with State funds as provided herein.

In consideration of proposals that are equal to or in excess of \$50,000 and financed 100% with State funds, a nonresident bidder domiciled in a state having laws granting preference to local Contractors will be considered for such contracts on the same basis as the nonresident bidder's state awards contracts to Mississippi Contractors bidding under similar circumstances. When a nonresident Contractor submits a bid equal to or in excess of \$50,000 on a contract financed 100% with State funds, a copy of the current laws from the state of domicile and an explanation thereof pertaining to treatment of nonresident Contractors shall be attached. If no preferential treatment is provided for Contractors in the state of domicile and contracts are awarded to the lowest responsible bidder, a statement to this effect shall be attached. Should the attachment not accompany the bid when submitted, the Contractor shall have 10 days following the opening of the bids to furnish the required information to the Contract Administration Engineer for attachment to the bid. As used herein, the term "resident Contractors" includes a nonresident person, firm or corporation that has been qualified to do business in this State and has maintained a permanent full-time office in the State of Mississippi for two years prior to January 1, 1986, and the subsidiaries and affiliates of such a person, firm or corporation.

103.02--Award of Contract. The award of a Contract will be made within 60 calendar days after the opening of proposals to the lowest responsive and responsible bidder, except as provided in Subsection 103.01 for preferential treatment situations, whose proposal complies with all the requirements prescribed. The award of Contracts involving the expenditure of Federal funds is contingent upon concurrence of the Federal

Agency whose funds are being used. The successful bidder will be notified of the award by letter mailed to the address shown on the proposal.

103.03--Cancellation of Award. The Department reserves the right to cancel the award of a Contract for any reason, any time prior to the execution by all parties without liability against the Commission, Department, or any of its officers or employees.

103.04--Return of Proposal Guaranty. The proposal guaranty of each bidder, except those of the two lowest responsive bidders, will be returned within 10 days of Contract award. The retained proposal guaranty of the unsuccessful of the two lowest responsive bidders will be returned within ten days following the execution of a Contract with the successful low responsive bidder. The retained proposal guaranty of the successful bidder will be returned after satisfactory performance and payment bonds have been furnished and the Contract has been executed.

In the event all bids are rejected by the Commission, certified checks or cashier's checks submitted as a proposal guaranty by all bidders will be returned within 10 days of rejection.

In the event no award is made within 30 days after the opening of bids, the Executive Director may permit the successful bidder to replace the certified check or cashier's check with a satisfactory bidder's bond.

Should no award be made within 60 calendar days, all proposals will be deemed rejected and all proposal guaranties returned unless the lowest responsive and responsible bidder, at the request of the Commission, agrees in writing to a longer delay prior to the execution of the 60 days.

103.05--Contract Bonds.

103.05.1--Requirement of Contract Bonds. Prior to the execution of the Contract, the successful bidder shall execute and deliver to the Executive Director a performance and payment bond(s) in the form required by the Commission and in a sum equal to the full amount of the Contract as a guaranty for complete and full performance of the Contract and the protection of the appropriate claimants and the Department for materials and equipment and full payment of wages in accordance with Miss. Code Ann. § 65-1-85(as amended). In the event of the award of a joint venture, each individual, partnership, firm or corporation shall assume jointly the full obligations under the executed Contract, executed Supplemental Agreements, and the contract bond(s).

103.05.2--Form of Bonds. The form of bond(s) shall be that provided by the Contract. These bonds shall be executed by a Mississippi agent or qualified nonresident agent and shall be accompanied by a certification as to authorization of the attorney-in-fact to commit the Surety company. A power of attorney exhibiting the Surety's original seal supporting the Mississippi agent or the qualified nonresident agent's signature shall be furnished with each bond. The Surety company shall be currently authorized and licensed in good standing to conduct business in the State of Mississippi with a minimum rating by A.M. Best of (A-) in the latest printing of "Best's Key Rating Guide" to write individual bonds up to ten percent of the policy holders' surplus or listed on the current list of "Companies Holding Certificates of Authority as Acceptable Sureties on Federal Bonds and as Acceptable Reinsuring Companies" as published by the United States

Department of the Treasury, Financial Management Service, Circular 570 (latest revision as published and supplemented on the Financial Management Service web site and in the Federal Register) within the underwriting limits listed for that Surety. The Mississippi agent or qualified nonresident agent shall be in good standing and currently licensed by the Insurance Commissioner of the State to represent the Surety company(ies) executing the bonds.

Surety bonds shall continue to be acceptable to the Commission throughout the life of the Contract and shall not be canceled by the Surety without the consent of the Department. In the event the Surety fails or becomes financially insolvent, the Contractor shall file a new bond in the amount designated by the Executive Director within thirty (30) days of such failure, insolvency, or bankruptcy. Subsequent to award of Contract, the Commission or the Department may require additional security for any Supplemental Agreements executed under the Contract or replacement security in the event of the surety(ies)'s loss of the ratings required above. Suits concerning bonds shall be filed in the State and adjudicated under its laws without reference to conflict of laws principles.

103.06--Blank.

103.07--Execution and Approval of Contract. The successful bidder to whom the Contract has been awarded shall sign and file with the Executive Director the Contract and all documents required by the Contract within 10 days after the Contract has been mailed or otherwise provided to the bidder. The Contract may require certain documents be submitted at an earlier date, in which case, those documents shall be submitted within the time frame specified. If the Contract is not executed by the Department within 15 days following receipt of the signed Contract and all necessary documents, the bidder shall have the right to withdraw the bid without penalty. No Contract is in effect until it is executed by all parties.

103.08--Failure to Execute Contract. Failure of the bidder to execute the Contract and file acceptable performance and payment bonds and/or other required documents within 10 days shall be just cause for the cancellation of the award and forfeiture of the proposal guaranty, which shall become the property of the Department, not as a penalty but in liquidation of damages sustained. Award may then be made to the next lowest responsive and responsible bidder, or the work may be re-advertised at the discretion of the Department.

SECTION 104 - SCOPE OF WORK

104.01--Intent of Contract. The intent of the Contract is to provide for the execution, construction, and completion in every detail of the work described, and to compensate the Contractor for all acceptable work performed in accordance with the provisions of the Contract. The Contractor shall furnish all labor, materials, equipment, supplies, transportation, supervision, methods and procedures necessary to complete the work in accordance with the plans, specifications and terms of the Contract.

104.01.1--Partnering Process.

104.01.1.1--Covenant of Good Faith and Fair Dealing. The Contract imposes an obligation of good faith and fair dealing in its performance and enforcement.

The Contractor and the Department, with a positive commitment to honesty and integrity, agree to the following mutual duties:

- A. Each will function within the laws and statutes applicable to their duties and responsibilities.
- B. Each will assist in the other's performance.
- C. Each will avoid hindering the other's performance.
- D. Each will proceed to fulfill its obligations diligently.
- E. Each will cooperate in the common endeavor of the Contract.

The Department intends to encourage the foundation of a cohesive partnership with the Contractor and its principal subcontractors and supplier. This partnership will be structured to draw on the strengths of each organization to identify and achieve reciprocal goals. The objectives are effective and efficient contract performance and completion within budget, on schedule, and in accordance with plans and specifications.

104.01.1.2--Formal Partnering. If required by the Contract or requested by the Contractor, this partnership will be bilateral in make-up, and participation will be between both the Department and the Contractor. Any cost associated with effectuating this partnering will be agreed to by both parties and will be shared equally.

To implement this partnering initiative prior to starting of work in accordance with the requirements of Subsection 108.02 Notice to Proceed and prior to the preconstruction conference, the Contractor's management personnel and Department's District Engineer, will initiate a partnering development seminar/team building workshop. The Contractor working with the assistance of the District and the State Construction Engineer will make arrangements to determine attendees for the workshop, agenda of the workshop, duration, and location. Persons required to be in attendance will be the Department's key project personnel, the Contractor's on-site project manager and key project supervision personnel of both the Contractor and principal Subcontractors and suppliers. The project design engineers, FHWA and key local government personnel will also be invited to attend as necessary. The Contractors and the Department will also be required to have Regional/District and Corporate/State level managers on the project team.

Follow-up workshops may be held periodically throughout the duration of the Contract as agreed by the Contractor and the Department.

The establishment of a partnership charter on a project will not change the legal relationship of the parties to the Contract nor relieve either party from any of the terms of the Contract.

104.01.1.3--Informal Partnering. If the Contractor and the Department do not choose to have a Formal Partnering process or the Contract does not require a Mandatory Formal Partnering process, an informal partnering meeting shall be conducted on at least a monthly basis. It will be mandatory that the Project Engineer and Project Superintendent attend the meeting. It is recommended that Department Inspectors, foremen, and other project managers attend the meeting.

The Project Engineer will be responsible for taking minutes of the meeting. As soon as practical after the meeting, the Engineer will send a copy of the minutes of the meeting to

the Contractor, District Construction Engineer, and State Construction Engineer. The Contractor will have 30 days to dispute the contents of the minutes before the minutes become an official record of the project.

104.02--Alterations of Plans or Character of Work. Except as may be necessary to satisfactorily complete the Contract, no alterations of the plans or the nature of the work will involve work beyond the termini of the contemplated construction without modification of the Contract and approval by all parties concerned.

The Department reserves the right to make, in writing, at any time during the work, such changes in quantities and such alterations in the work as are necessary to satisfactorily complete the project. Such changes in quantities and alterations shall neither invalidate the Contract nor release the Surety, and the Contractor agrees to perform the work as altered.

Wherever in the Specifications a Supplemental Agreement is provided for, such Supplemental Agreement may be subject to the approval of the Commission and spread upon its minutes prior to execution by the Executive Director.

104.02.1--Significant Changes in the Character of Work. Before any consideration will be given for an alteration or quantity adjustment, it must be determined that a significant change in the character of the work has occurred. A significant change in quantity of a major item, plus or minus twenty-five percent (25%) variation from original quantity, in and of itself, does not constitute a significant change in the character of the work. The character of the work, as altered, must differ materially in kind or nature from that involved or included in the original proposed construction.

If a proposed alteration or quantity adjustment significantly changes the character of the work under the Contract, whether such alterations or changes are in themselves significant changes to the character of the work or by affecting other work cause such other work to become significantly different in character, an adjustment, excluding anticipated profit, will be made to the Contract. The basis for the adjustment shall be agreed upon prior to the performance of the work. If a basis cannot be agreed upon, then an adjustment will be made either for or against the Contractor in such amount as the Engineer may determine to be fair and equitable.

If the proposed alteration or quantity adjustment does not significantly change the character of the work to be performed under the Contract, the altered work will be paid for as provided elsewhere in the Contract.

The term "significant change" shall be construed to apply only to the following circumstances:

1. When the character of the work as altered differs materially in kind or nature from that involved or included in the original proposed construction, or
2. If a major contract item of work is increased in excess of 125 percent or decreased below 75 percent of the original contract quantity. Any allowance for an increase in quantity shall apply only to that portion in excess of 125 percent of original contract item quantity, or in case of a decrease below 75 percent, to the actual amount of work performed.

Items, quantities, unit prices and amounts, or revisions thereof, established in the Contract by Supplemental Agreement shall be considered as original contract items, quantities, prices, amounts and totals thereof.

When a major contract item is eliminated, the Contractor will be reimbursed for substantiated unrecovered overhead costs but not to exceed five percent of the original contract value of the item. The Contractor shall not be entitled to recover nor shall the Commission, the Department, or any of its officers or employees be subjected to any liability or damages for the elimination of any major contract item.

The Contractor upon request will be paid substantiated actual costs for materials, that are in excess of those used and paid for in the completed work that were mobilized prior to notification of elimination or reduction of a major contract item. Materials that otherwise would have been required prior to such notification that are on order and that cannot be cancelled may be included in the materials to be paid for by the Department. No payment will be allowed for materials in excess of the quantity required under the Contract.

Points of delivery for the reimbursed materials shall be agreeable to the Department. The Contractor shall make delivery at such point and the additional transportation cost, if any, will be reimbursed by the Department.

Mobilization of materials as indicated in this provision shall be understood to be materials that qualify for partial payment under the provisions of Subsection 109.06, and cannot be reasonably used by the Contractor in other work under Contract.

At the option of the Department, living or perishable plant materials, seeds, other materials and warehouse items mobilized for the work may be purchased by the Department.

All mobilized materials for which payment is made shall become the property of the Department, and the Contractor shall furnish the Engineer satisfactory title or other approved evidence of ownership.

104.02.2--Differing Site Conditions. During the progress of the work, if subsurface or latent physical conditions are encountered at the site differing materially from those indicated in the Contract or if unknown physical conditions of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inherent in the work provided for in the Contract, are encountered at the site, the party discovering such conditions shall promptly notify the other party in writing of the specific differing conditions before the site is disturbed and before the affected work is performed.

Upon written notification, the Engineer will investigate the conditions, and if it is determined that the conditions materially differ and cause an increase or decrease in the cost or time required for the performance of any work under the Contract, an adjustment, excluding anticipated profits, will be made and the Contract modified in writing accordingly. The Engineer will notify the Contractor of the determination whether or not an adjustment of the Contract is warranted.

No Contract adjustment which results in a benefit to the Contractor will be allowed

unless the Contractor has provided the required written notice. The written notice shall be submitted upon the forms provided and required by the Department.

Before beginning or continuing work that justifies an adjustment of the contract unit price or contract time under the above provisions, a Supplemental Agreement acceptable to all parties shall be executed. In the event an agreement acceptable to all parties cannot be reached, the Department may order the work to proceed and that part of the work will be paid for in accordance with Subsection 109.04.

If the altered or added work is of a character as to require more than the normal time to complete the work, an adjustment of the contract time may be made.

104.02.3--Minor Alterations to the Contract. When the Department makes alterations in the details of construction or specifications that are minor in nature, the Resident or Project Engineer may elect to make an adjustment to the Contract under the provisions of this subsection. Minor alterations shall be defined as those alterations to the Contract that are not addressed in the Standard Specifications, or Supplements thereto, and are valued at less than \$10,000.00. The District Engineer shall designate, in writing, the Resident or Project Engineer authorized to execute the Class I Supplemental Agreement. The Resident or Project Engineer and Contractor shall agree upon the scope of work and a lump sum amount, within the above stated limit, for the work to be performed. The agreement shall be reflected in a Class I Supplemental Agreement signed by the Resident or Project Engineer and the Contractor's authorized representative, which, when it bears both the signature of the Resident or Project Engineer and Contractor, shall constitute the scope of work and the sole and only basis for payment by the Department or Commission under the item "Minor Alterations to the Contract." Work shall not proceed until both parties sign the agreement.

Any adjustment of contract time due to Minor Alterations will be in accordance with Subsection 108.06 of the Standard Specifications.

Payment will be made under:

104-A S/A: Minor Alterations to the Contract - lump sum

104.02.4--Contract Change Notifications. It is the responsibility of the Contractor to provide reasonable written notice when conditions are believed to require a change to the Contract. The Department will only consider requests for changes to the Contract when the Contractor meets the notification procedures specified in this Subsection.

A. Written Notification by Contractor. The Contractor shall provide immediate written notification to the Engineer upon discovering a condition that may require a change to the Contract. The following detailed information shall be provided to the Engineer, in writing, within 14 calendar days of the Contractor's written notification:

1. A description of the condition, including the time and date first identified, and the location, if appropriate.
2. An explanation of why the condition represents a change to the Contract, with references made to Subsection 104.02 and other pertinent portions of the Contract.

3. A statement of all changes considered necessary to the Contract price(s), delivery schedule(s), phasing, and time. Because of its preliminary nature, the Department recognizes that this information may rely on estimates.

After notifying the Engineer, the Contractor shall continue to perform the work under the Contract including the work subject to the condition. The Contractor shall maintain records of actual labor, equipment and materials used in accordance with Subsection 109.04 for the work subject to the condition.

- B. Written Acknowledgement by Engineer.** The Engineer will provide a written response within seven (7) calendar days of receiving the initial notification.
- C. Written Response by Engineer.** The Engineer will provide a written response within 21 calendar days of receiving the Contractor's detailed notification that includes one of the following:
1. A confirmation that a change is necessary in accordance with Subsection 104.02, and direction on how the Work will proceed.
 2. A denial of the request for a change, which will include references to the Contract as to why the condition does not represent a change.
 3. A request for additional information stating the specific information needed and the date by which it must be received. The Department will respond to the additional information provided within 14 calendar days.

When a change is necessary, the Engineer will make appropriate adjustments to the Contract price and time, if warranted, in accordance with the provisions set forth in the Contract. If the Contractor disagrees with the Engineer's decision or does not agree with the Contract adjustments, the Contractor may pursue the issue as a claim in accordance with Subsection 105.17.

104.03--Extra Work. The Contractor shall perform unforeseen work, for which there is no price included in the Contract, whenever it is deemed necessary or desirable by the Engineer in order to complete fully the work as contemplated. Such work shall be performed in accordance with the applicable specifications and as directed. Payment or adjustment in payment will be made as provided under Subsection 109.04.

104.04--Maintenance of Traffic. Unless otherwise provided, the road under construction and all other roads and entrances to adjacent property within the right-of-way will be kept open to through and local traffic. The Contractor must maintain all traffic control features over the section of road under construction in accordance with the plans, MUTCD, and Section 618 of these specifications.

The Contractor shall keep the portion of the project being used by public traffic in satisfactory condition for traffic to be adequately accommodated. The Contractor shall also provide and maintain in a safe condition temporary approaches or crossings and intersections with trails, roads, streets, businesses, parking lots, residences, garages, and farms. The Contractor shall cooperate with the Department to allow MDOT personnel or MDOT representatives, FHWA, and other governmental agencies to access the construction site to perform inspections at any time deemed appropriate.

In any area where traffic is maintained, mowing shall be performed as necessary and as

determined by the Engineer to provide reasonable appearance and safety to the traveling public. Mowing shall be performed at the direction and satisfaction of the Engineer, and shall include those areas from the edge of the pavement to a minimum of five feet beyond the shoulder line. The cost of mowing shall be absorbed in other contract items when the Contract does not contain a bid item for mowing, and shall not be the basis for any additional payment.

It may become necessary for the Contractor to sweep the roadway surface to completely remove debris from pavement surfaces and other areas designated on the plans or directed by the Engineer. Collected debris shall be disposed of off the right-of-way in accordance with federal, state, and local regulations. Debris is defined as dirt, trash, and other matter not part of the highway facility.

In case it is necessary or desirable to close a portion of the project to traffic, the plans, special provisions, or other contract documents will so indicate, or if provisions are not made on the plans or in other contract documents, the Engineer may permit in writing the temporary closure of small portions of the project as deemed necessary to expedite the work without compromising the convenience and safety of traffic.

The Contractor shall be bound by the provisions of this subsection and other applicable provisions of these specifications and the Contract with regard to the safe and convenient passage of traffic.

In the case of a project for improvements or construction alongside an existing roadway on which traffic is required to be maintained, no equipment, vehicles or materials will be permitted to park or be stored within the clear/safety zone of the roadway unless it is behind a lane or shoulder closure. Unless working under an approved night time operation, the Contractor shall not perform any work within the clear/safety zone of the roadway between sunset and sunrise.

The Contractor shall not obstruct any traffic facility or connection thereto that is officially opened to public or private traffic or required under the Contract to be maintained except as permitted in writing by the Engineer on the basis that other suitable provisions have been made.

Due to accident possibilities for certain days of peak traffic use, the right is hereby reserved for the District Engineer to suspend upon due notice to the Contractor any operation that, if allowed to be carried on, would seriously jeopardize the safety of the traveling public on holidays, the preceding day, and the following day or on days of major public events in the general area. In the event that a holiday or major public event falls during a weekend or on a Monday, no operations will be allowed during that weekend or the Friday immediately preceding that holiday or major public event. The notice will specifically state the date(s) of the suspension. When work is suspended as provided herein, contract time will be adjusted accordingly. Additional compensation will not be paid because of such suspension.

The Contractor will not be directly compensated for constructing, maintaining and removing temporary traffic maintenance facilities unless:

- (a) the proposal contains pay items specifically covering such work, or
- (b) the plans or other contract documents specifically indicate that quantities

involved are to be measured for payment.

The Contractor will be paid for work required to restore and/or maintain traffic that is caused by snow, ice, major flooding, landslide or phenomenon of nature such as an earthquake, hurricane, tornado, etc. when damage from such cause is beyond the control of and without the fault or negligence of the Contractor.

If the Engineer orders special maintenance of traffic over and above the requirements specified in the Contract for the benefit of the traveling public, the ordered work shall be accomplished as provided in Subsection 104.03 -- Extra Work.

Unsatisfactory maintenance of traffic shall be subject to the procedures provided in Subsection 105.15.

104.05--Removal and Disposal of All Materials From the Project. The Contractor shall remove and dispose of all existing structures and obstructions in accordance with the provisions of Section 202. In the event separate pay items are not provided, the cost of removal and disposal shall be included in prices bid for items under Sections 201 and 203.

The Contractor shall not remove or disturb any buildings, public utilities or other improvements that are to be removed and/or replaced by the Department or owners under separate agreement.

It is anticipated that obstructions to be removed by the Department or owners will be removed and disposed of in advance of construction operations, but in the event there are improvements or other properties retained by the property owner, the Contractor shall not interfere with this property until notified in writing by the Engineer that the rights of the property owner have expired.

Delays in the work occasioned by removal or non-removal by the owner will be considered as attributable to the State under the provisions of the Contract for the determination and extension of contract time, but any such delays shall not entitle the Contractor to nor shall such delays justify or be the basis for any monetary damages against the Commission, Department or any of its officers or employees.

Upon notification by the Engineer that the property owner's rights have expired, the Contractor shall proceed to remove and dispose of structures and obstructions in accordance with this subsection and other applicable provisions of the Contract.

All existing structures and obstructions or residual portions of structures and obstructions not designated to remain are to be removed by the Contractor.

Improvements designated for removal are for the Contractor's information only, and the lack of such designation shall not relieve the Contractor of the removal obligation.

When the contract documents indicate the removal of any materials, and disposal of said materials is permitted at locations provided by the Contractor, the Contractor shall furnish the Engineer a copy of a release from each property owner for the servitude of the land. Prior to disposal of any materials, the Contractor shall also furnish the Engineer a certified letter stating that the area of disposal is not in a wetland, Waters of the U.S., or

any other environmentally sensitive area (ESA). The State, the Commission, the Department, and any of its officers and/or employees will have no ownership or liability whatsoever for materials or matter removed.

All removals by the Contractor are to be made in accordance with the provisions of Section 201, Section 202 and Section 203.

104.06--Use of Materials Found in the Work. It is understood that the title to all materials found within the right-of-way or easements remains with the State. However, the Engineer may permit the Contractor to use stone, gravel, sand and other suitable materials found within the grading limits that may be useful in fulfillment of the Contract requirements. The Contractor will be paid both for the excavation of the material at the contract unit price for excavation and for the pay item for which the excavation material is acceptably used. The excavation material, so removed and needed for use in embankments, backfills, approaches, or otherwise in the work, shall be replaced by the Contractor with other material acceptable to the Engineer all at no additional cost to the State. No charge for the material so used will be made against the Contractor. The Contractor shall not excavate or remove any material from within the highway location that is not within the grading limits established by slope stakes without prior written authorization from the Engineer. The Contractor will not be paid for excavation outside the grading limits or below original ground in fill sections.

Unless otherwise provided, material removed from existing structures may be used temporarily by the Contractor. Material designated to be salvaged shall not be cut or otherwise damaged.

104.07--Final Cleaning Up. Before acceptance and final payment will be made, all areas within the right-of-way shall be cleaned of all rubbish, temporary buildings and structures, equipment and excess materials. Salvaged or excess materials expressly reserved by the Engineer for use by the State shall be neatly stockpiled at locations designated. All property occupied or affected by the Contractor and all parts of the work shall be left in a manner acceptable to the Engineer with all waterways unobstructed.

Prior to final inspection for release of maintenance, all areas of the work that have developed an undesirable growth of vegetation shall be given a final mowing, and all undesirable bushes, high grasses and weeds shall be cut and disposed of or sprayed as directed by the Engineer. The cost of mowing shall be absorbed in other contract items when the Contract does not contain a bid item for mowing and shall not be the basis for any additional payment.

104.08--Value Engineering Incentive. Value Engineering Incentive applies to any cost reduction proposal initiated and developed by the Contractor for the purpose of refining the contract documents so as to contribute to design cost effectiveness or significantly improve the quality of the final product. This subsection does not apply unless a proposal is identified by the Contractor at the time of submission as a Value Engineering Incentive Proposal. The Department shall be the sole judge of the acceptability of any such proposal and of the estimated net savings in construction costs from adoption of all or any part of such proposal.

Cost reduction proposals approved by the Department are to be implemented by a Supplemental Agreement to the Contract and must result in savings without impairing

any essential functions and characteristics such as safety, service life, reliability, economy of operations, ease of maintenance, aesthetics and necessary standard design features. Proposed changes in the basic design requirements of a bridge or of a pavement system will not normally be given consideration as a Value Engineering Incentive Proposal. The mere substitution of one contract item for another contract item or substitution of any other item for which the Department has previously established a pay item will not be allowed as value engineering nor will a submittal based on the use of material from the right-of-way.

As a minimum, the following information shall be submitted by the Contractor with each proposal:

- (a) A statement that the proposal is submitted as a Value Engineering Incentive Proposal.
- (b) Description of the proposal.
- (c) Discuss Contract requirements that require modification and present a recommendation for each change.
- (d) An estimate of cost reductions.
- (e) Prediction of any effects on other costs to the Department.
- (f) State when the Supplemental Agreement must be executed to obtain maximum cost reduction during the remainder of the Contract and the reasons thereof.
- (g) A statement as to any effect on the project completion date.

The Commission, the Department and/or any of its officers or employees will not be liable for any delay in acting upon a proposal. The decision of the Engineer as to acceptance of any such proposal will be final and not be subject to Subsection 105.17. The Department may accept the proposal, in whole or in part, by executing a Supplemental Agreement that specifically states that it is executed pursuant to these provisions. Such agreement should incorporate the changes or additions to the plans and specifications that are necessary to permit the proposal or accepted part thereof to be put into effect. If conditional, the agreement should include conditions upon which the Department's approval is based. The agreement should also set forth the estimated net savings attributable to the proposal and provide that the Contractor be paid 50 percent of said savings. The cost to the Department in evaluating the proposal will be considered in determining the estimated net savings. The Contractor's share of the savings shall constitute full compensation for the Value Engineering Incentive Proposal.

Approval of the proposal and performance of the work thereof shall not change the contract completion date unless specifically provided for in the Supplemental Agreement implementing the proposal.

The Contractor may request that the Department not use or disclose the information submitted with a proposal and such request may be honored to the extent allowed by law. Such restriction must be in writing and submitted with the proposal. If the proposal is accepted, this restriction shall be void and the Department may use, duplicate or disclose any data necessary to utilize such proposal. The executed Supplemental Agreement implementing the proposal will become public information in the files of the Department.

This incentive provision applies only to contracts awarded pursuant to competitive bidding.

SECTION 105 - CONTROL OF WORK

105.01--Authority of the Engineer. The Engineer has the authority to make decisions on all questions that may arise as to the quality and acceptability of materials, the work and the progress of the work; all questions that may arise as to the interpretation of the plans and specifications; and all questions as to the fulfillment of the Contract.

The Engineer has the right, but not the obligation, to suspend the work wholly or in part and to withhold payments because of the Contractor's failure to correct conditions unsafe for workmen or the general public, for failure to carry out provisions of the Contract, or for failure to carry out orders. The Engineer may also suspend work for periods deemed necessary due to unsuitable weather conditions, for any conditions considered unsuitable for the prosecution of the work, or for any other condition or reason deemed by the Engineer to be in the public interest. The Department and the Commission shall not be held liable for any conditions that it is not made aware of, and there is no duty on the part of the Department to inspect for said unsafe and/or unsuitable conditions. The duty to ensure that the conditions are safe for workmen and the general public remains at all times with the Contractor, and shall not be altered by any course of conduct and/or action or inaction on the part of the Department.

The Engineer may authorize, in writing, the continued prosecution of items past their specified seasonal limits when it is determined that the quality of the work will not be reduced and the public interest will be best served.

The Engineer will have authority to enforce and make effective all decisions and orders relating to the Contract.

All correspondence concerning a project, other than correspondence related to the execution of the Contract and sub-contracting, shall be sent to the Project Engineer. The Project Engineer will then forward any necessary correspondence to the appropriate Division. This includes general correspondence, submittals, shop drawings, requests for advancement of materials, etc. If electronic submittals are allowed, they may be submitted directly to the appropriate Division with copies to the Project Engineer.

105.02--Plans and Working Drawings. After the Contract is executed by the Executive Director, the Contractor will receive, free of charge, two bound copies of the proposal and contract documents, one executed and one blank, two full scale copies of the plans and five half-scale copies. The Contractor shall have one copy of the proposal and contract documents and one half-scale copy of the plans available at all times during work activity on the project.

Plans will generally show details of the work to be performed and a summary of the items appearing in the proposal.

The plans will be supplemented by working drawings as necessary to adequately control the work. Working drawings shall be furnished by the Contractor as required for the completion of the work. Except where otherwise specified, working drawings shall be approved by the Engineer but such approval will not relieve the Contractor of any responsibility. Working drawings shall not be considered as plan changes and any conflicts on working drawings, whether approved or not, shall not supersede the requirements of the original plans and specifications.

If required, the Contractor shall furnish the original tracings of working plans or drawings to the Engineer.

The contract unit price shall include the cost of furnishing all working drawings. However, when design details of the plans are changed after the Contractor has submitted the required working drawings, the Engineer may order the Contractor to furnish revised or new working drawings as Extra Work.

105.03--Conformity with Plans and Specifications. All work performed and all materials furnished shall be in reasonably close conformity with the lines, grades, cross-sections, dimensions, material requirements and other construction requirements shown on the plans or required by the specifications. Where defined tolerances are specified in the contract, such tolerances shall fix the limits of reasonably close conformity.

Plan dimensions and Contract specification values are target values to be strived for and from which tolerances are allowed. It is the intent of the specifications that the materials and workmanship shall be uniform in character and shall conform as realistically as possible to the prescribed target value or to the middle portion of the tolerance range. The purpose of the tolerance range is to accommodate occasional minor variations from the median zone that are unavoidable for practical reasons. When maximum and/or minimum values are specified, the production and processing of the material and the performance of the work shall be so controlled that the material and work will not be predominately of borderline quality or dimension. Predominantly borderline quality of materials or work on a continuing basis will be just cause for temporary suspension of work.

In the event the Engineer finds that the materials or the finished product in which the materials are used are not within reasonably close conformity with the plans and specifications but that reasonably acceptable work has been produced, the Engineer will make a determination as to whether the work will be accepted and remain in place. The Engineer will then make an appropriate adjustment in the contract price for the work or materials as provided in the Contract. If no provision for adjustment in price is included in the Contract, the Engineer will document the basis of acceptance by Contract modification and also may provide for an adjustment in contract price. The documentation for adjustment in contract price will be based on engineering judgment if a standard criteria for the items involved has not been issued.

When the materials, the finished product or the work are not in reasonably close conformity with the plans and specifications and have resulted in an inferior, unsatisfactory or unacceptable product, the work or materials shall be removed and replaced or otherwise corrected by the Contractor at no additional cost to the State in a manner satisfactory to the Engineer.

When work is of a temporary nature and its use is expected to be of short duration, the Engineer may allow minor deviations, not more than five percent (5%), from specified test values. Any such allowance will not relieve the Contractor from responsibility for maintenance of the work.

105.04--Coordination of Plans, Specifications, Interim Specifications, Special Provisions and Notice to Bidders. These specifications, interim specifications, plans,

special provisions, notices to bidders and all other supplemental documents are essential parts of the Contract, and a requirement occurring in one Contract Document is as binding as though occurring in all. These contract documents are intended to be complementary and provide for a complete work. In case of discrepancy, calculated dimensions will govern over scaled dimensions. Parts of the Contract will prevail in the following order:

- (a) Notices to Bidders
- (b) Supplements to Special Provisions and Supplements to Interim Specifications
- (c) Special Provisions
- (d) Interim Specifications
- (e) Plans
- (f) Standard Specifications and Supplemental Specifications

Any reference in the plans or contract documents to a particular Section or Subsection shall mean that Section or Subsection of the Standard Specifications, or that Section or Subsection as modified by the Contract.

In case of a conflict between plan quantities, advertised quantities, and/or bid sheet quantities, the bid sheet quantities shall prevail.

The Contractor shall not take advantage of any apparent error or omission in the plans or specifications. When the Contractor discovers an error or omission, the Engineer shall be immediately notified. The Engineer will then make corrections and interpretations deemed necessary for fulfilling the intent of the Contract.

105.05--Cooperation by Contractor. The Contractor shall give the work the constant attention necessary to facilitate the progress thereof, and shall cooperate in every possible way with the Engineer, Inspectors and other Contractors on the given project as well as on any adjacent projects, as per Subsection 105.07.

105.05.1--Project Superintendent. The Contractor shall have a competent and experienced full time resident superintendent who is capable of reading and understanding the plans and specifications for the particular work being performed. The superintendent shall be on the project site at any time work is being performed by the Prime Contractor or any Subcontractors. The superintendent shall advise the Project Engineer of an intended absence from the work and designate a person to be in charge of the work during such absence. The superintendent shall receive instructions from the Engineer or authorized representative. On projects that require 24/7 work, the Contractor will be required to list multiple superintendents to cover all time periods when work is being performed. Upon issuance of the Notice to Award, the Contractor or duly appointed agent authorized to bind the Contractor shall file with the Executive Director the name and address of the superintendent(s) who will supervise the work with copies to the Construction Engineer, Contract Administration Engineer, District Engineer and Project Engineer. The Executive Director shall be immediately notified in writing with copies to those stated when a change is made in the Contractor's superintendent or superintendent's address. The superintendent shall have full authority to execute orders or directives of the Engineer without delay and to promptly supply materials, equipment, labor and incidentals as may be required. Such superintendence shall be furnished irrespective of the amount of work sublet.

105.05.2--Certified Erosion Control Person (CECP). On projects that require an erosion control plan, the Contractor shall also designate a responsible person who will monitor and maintain the effectiveness of the erosion control plan, including NPDES permit requirements, and complete storm water reports as required by the Contract. Prior to or at the preconstruction conference, the Contractor shall designate in writing the CECP to the Project Engineer. The designated CECP shall be assigned to only one (1) project. When special conditions exist, such as two (2) adjoining projects or two (2) projects in close proximity, the Contractor may request in writing that the State Construction Engineer approve the use of one (1) CECP for both projects. The Contractor shall request in writing that the Engineer authorize a substitute CECP to act in the absence of the CECP. The designated CECP and substitute or replacement CECP must be certified by an organization approved by the Department. A copy of each CECP's certification must be included in the Contractor's Protection Plan as outlined in Subsection 107.22.1.

105.05.2.1--Responsibilities and Duties of the Certified Erosion Control Person. In addition to the requirements set for in the NPDES Permit, the CECP shall also be responsible for the following:

1. Attending preconstruction conference and each Erosion Control Inspection conducted by the Department.
2. In accordance with the requirements of Subsection 107.22.1, ensuring all required documentation, such as, but not limited to, the SWPPP, ECP are:
 - on the project site at all times,
 - updated on a daily basis, and
 - contain all revisions, additions, and modifications.
3. In accordance with Subsection 107.22.1, ensuring the "19-acre" rule is being adhered to, if applicable.
4. Ensuring the project has a rain gauge and maintain records of rainfall events on the Contractor's Erosion Control Inspection reports.
5. Ensuring the buffer zones around all stream-banks and wetland areas in which no construction activities are to take place are marked/flagged/roped off prior to any land disturbing activity.
6. Ensuring perimeter erosion/sedimentation control devices (BMPs) are in place prior to any land disturbing activity.
7. Reviewing and verifying the proper installation, maintenance, and effectiveness of the BMPs.
8. Notifying the Project Engineer within 24 hours of learning that sediment has been deposited off Department ROW or into a wetland or waters of the U.S.
9. Notifying the MDEQ within 24 hours of learning that sediment has been deposited into a wetland or waters of the U.S., copying the Project Engineer on the correspondence.
10. Performing the Contractor's Erosion Control Inspections of the project on the form provided by the Department for the purpose ensuring compliance with MDEQ's Storm Water Construction General Permit. Contractor Inspections shall be performed:
 - at least weekly, and
 - within 24 hours or on the business day prior to any forecasted rain event of 60% or greater, and

- within 24 hours or on the next business day after a rainfall event of 0.5” or greater.

The Contractor’s Erosion Control inspections shall commence with the installation of the BMPs and continue until the Final Maintenance Release or the partial maintenance release except for plant establishment has been issued. Within 24 hours of completing each Contractor Erosion Control Inspection, the CECP shall provide the Project Engineer with a copy of the report documenting the findings of each Contractor Erosion Control Inspection. The CECP will discuss the findings with the Contractor’s Superintendent, if the CECP and the superintendent aren’t the same person, and the Project Engineer or his representative. Failure to submit the completed and signed inspection forms may result in the withholding of the monthly estimate.

105.05.2.2--Deficient Performance of the Certified Erosion Control Person. In the event that the Contractor’s CECP is not meeting the requirements set forth above, the Project Engineer will notify the Contractor in writing, describing the CECP’s deficient performance. If the deficient performance should continue, the Department may take any or all actions listed below:

1. stop all non-erosion control work,
2. require the Contractor to designate a new CECP with the responsibilities and authority listed in Subsection 105.05.2.1,
3. revise the SWPPP and ECP with the newly designated CECP’s certification information, and

In the event that a CECP is removed from serving as a CECP on a project, this person shall not be accepted as a Contractor’s CECP on MDOT projects for at least one year from the time of removal.

105.06--Cooperation with Utilities. The Department will notify all utility companies, all pipe line owners and other known affected parties and endeavor to have plans and agreements for all necessary adjustments within or adjacent to the limits of construction before bids are received. Such utility plans and agreements will be made available for inspection by the Contractor in the Jackson Office. The Department will also endeavor to have all necessary adjustments made as soon as practicable.

All utility appurtenances are to be relocated or adjusted by others unless provided otherwise in the Contract.

All known utilities within the project are shown on the plans. It is understood and agreed that the Contractor’s bid has considered all of the utility appurtenances in their present or relocated positions and that no additional compensation will be allowed for delays, inconvenience, or damage sustained by the Contractor due to interference from the said utility appurtenances or the operation of moving them. The Engineer's determination that removing, relocating, or adjusting of utility appurtenances or failure of others to do so is causing a delay in major phases of construction that normally should be in progress will be considered a delay by the State in the determination of extension of contract time, but any such delay shall not be the basis for any liability or monetary damage against the Commission, the Department and/or any of its officers or employees. In the event the utility owners fail to comply with their responsibility in relocating or adjusting their facilities, the Engineer may require the Contractor to make adjustments as Extra Work.

105.07--Cooperation Between Contractors. The Department reserves the right to award contracts for work on or near work covered by other contracts. Each Contractor will be expected to cooperate with the other Contractor(s) and the Department in every reasonable manner.

The Department will make a determination as to the practicality of prosecuting an existing contract before an additional award is made for work in the same area. Insofar as is practicable, the Department will give notice of the intent to award subsequent contracts in the same area. Failure to do so, however, shall not prejudice the rights of the Commission to award additional contracts and shall not constitute grounds for claims against the State, the Commission, the Department or any of its officers or employees.

When separate contracts are let for work, any part or all of which is within the same limits, each Contractor's work shall be conducted so as to cause the least interference with work being performed by the other Contractor(s).

When contracts are awarded to separate Contractors for concurrent construction within a common area, the Contractors, in conference with the Engineer, shall establish a written joint schedule of operations. Such schedule will set out approximate dates and sequences for work to be performed with due regard to needs and contract time limitations of each contract. The Engineer may allow modification of the schedule when mutual benefit to the Contractors and the Department will result. Any modification of the joint schedule shall be in writing, mutually agreeable, and signed by the Contractors.

Failure of either Contractor to abide by the terms of the joint schedule or modified schedule will be justification for termination of the Contract under the provision of Subsection 108.08.

Each Contractor's work shall be arranged such that the placement and disposal of the materials and equipment being used shall not interfere with the operations of the other Contractor. Each Contractor shall join their work with that of others in an acceptable manner and perform it in the sequence of the established schedule.

Each Contractor involved shall assume all liability, financial and otherwise, in connection with the Contract and shall protect and save harmless the Commission, the Department or any of its officers or employees from any and all damages or claims of any kind that may arise, including but not limited to, inconvenience, delay or loss experienced because of the presence and operations of the other Contractor(s) working within the same contract limits.

When the plans and/or proposal indicate that there is a railroad crossing the project at grade, the Department may construct or have constructed by others an at-grade railroad crossing. This work may also include adjustment or installation of allied traffic safety features. If the railroad work is to be performed under separate contract let by the Department, all the provisions of this subsection are applicable. When the work is to be performed by the railroad or its Contractor, all the provisions of this subsection are applicable except a schedule of operations will not be required.

105.08--Construction Stakes, Lines and Grades. Except when the Contract contains a pay item for "Roadway Construction Stakes," the Engineer will set construction stakes

establishing lines, slopes, and profile grades in road work and only centerline and bench marks for bridge work. Box bridges shall not be considered as a bridge. The Engineer also will furnish the Contractor with all necessary information relating to lines, slopes, and grades. These stakes and bench marks shall constitute the field control by which the Contractor shall establish and maintain all necessary controls and perform the work.

The Department will assume responsibility for the accuracy of the stakes and bench marks at the time they are set by the Engineer or the Engineer's representative. Any corrective work caused by inaccurate field controls established by the Department will be considered as Extra Work and paid for under appropriate provisions of the Contract.

The Contractor shall be held responsible for the preservation of all stakes and bench marks, and when carelessly or willfully destroyed or disturbed, the cost of replacing them will be charged against the Contractor.

When the Contract contains a pay item for construction stakes, Section 699 shall apply.

105.09--Authority and Duties of the Resident or Project Engineer. As the direct representative of the Chief Engineer, the assigned Resident or Project Engineer has immediate charge of the engineering details of the Contract. The Resident or Project Engineer is responsible for the administration of the Contract, and the authority is delegated commensurate with these responsibilities.

105.10--Duties of the Inspector. Inspectors employed by the Department will be authorized to inspect all work and materials. The inspection may extend to all parts of the work and to the preparation, fabrication or manufacture of the materials. The Inspector will not be authorized to alter or waive the provisions of the Contract, to issue instructions contrary to the plans and specifications or to act as foreman for the Contractor.

105.11--Inspection of Work. All materials and each part or detail of the work are subject to inspection by the Engineer. The Engineer shall be allowed access to all of the work and shall be furnished with such information and assistance by the Contractor as necessary to make a complete and detailed inspection.

Prior to acceptance of the work, the Contractor shall remove or uncover such portions of the work as directed by the Engineer. After examination, the Contractor shall restore said portions of the work. If the work exposed or examined was acceptable, the uncovering or removing and the restoring of the work will be paid as Extra Work. If the work so exposed or examined was unacceptable, the uncovering or removing and the restoring of the work will be at no additional cost to the State or the Commission.

Work performed or materials used by the Contractor without supervision or inspection by an authorized Department representative may be ordered removed and replaced. In the event it is determined by the Executive Director that non-supervision or non-inspection by the Department was due to the failure of the Engineer to have a representative present after having been given reasonable notice in writing that the work was to be performed, the work may be examined, removed or replaced as ordered and will be paid as Extra Work if the work so exposed or examined was acceptable. Otherwise, such unauthorized work shall be removed and replaced at no additional cost to the State or the Commission.

Although the Engineer and/or his authorized representative may inspect the work and has the right to stop any and all work not conforming to the contract documents and these specifications, the ultimate responsibility to ensure that the work is completed according to the contract documents and these specifications rests with the Contractor. Any inspections conducted by or on behalf of the Department do not relieve the Contractor from this obligation, nor does the fact that inspections are conducted or ordered by the Department create a course of conduct that can in any way be construed as a waiver of the Contractor's duties and responsibilities.

When any unit of government, political subdivision, railroad corporation, or other public service is to pay a portion of the cost of the work its respective representative shall have the right to inspect the work. Such inspection shall in no way make said agency or corporation a party to this Contract and shall in no way interfere with the rights of either party of the Contract.

105.12--Removal of Unacceptable and Unauthorized Work. Unless otherwise determined acceptable under the provisions of Subsection 105.03, all work that does not conform to the requirements of the Contract will be considered as unacceptable work.

Unacceptable work, whether the result of poor workmanship, defective materials, damage through carelessness or any other cause, found prior to final acceptance of the work shall be removed and replaced in an acceptable manner, without any additional cost to the Commission.

Work done contrary to the instructions of the Engineer, or beyond the lines shown on the plans or extra work without authority will not be paid for under the provisions of the Contract.

All work shall be warrantied for a period of one (1) year following final acceptance. Any defective or nonconforming work, or latent defects, shall be corrected by the Contractor, at no cost to the Department.

105.13--Load and Speed Restrictions. The Contractor shall determine and comply with all legal load restrictions in the hauling of materials on public roads beyond the limits of the project. The Department shall have no obligation to determine or inform the Contractor of any legal load limitations of any municipality, county or the State of Mississippi. A special permit will not relieve the Contractor of liability for damages that may result from the moving of material or equipment.

All trucks hauling materials to and from this project shall comply with the legal weight limits as established by law. The Department will not compensate the Contractor for any portion of a load delivered to the project in excess of the legal limit for that truck.

Vehicles relying on harvest permits are limited to hauling only those materials set forth in Section 27-19-81(4) of the Mississippi Code, as amended.

Within the project limits, the operation of equipment of such weight or so loaded as to cause damage to the roadway, structures or other work is forbidden. The Contractor shall regulate loads such that damage will not occur to structures or any completed subgrade or pavement structure, but in no case shall loads exceed the legal weight limit. Loads will not be permitted on a concrete pavement, base or structure before the expiration of the

curing period. The Contractor shall be responsible for all damages caused by hauling equipment.

The Contractor shall provide approved platform scales or a sufficient number of approved portable scales together with essentials for calibrating and all labor, tools, and equipment necessary to weigh as many loaded vehicles as will assure the Engineer of the Contractor's compliance with weight restrictions.

The Contractor shall be responsible for the safe speed of vehicles assigned to the project. Speeds less than those provided by law may be ordered in writing by the Engineer when in the opinion of the Engineer such action is essential to public safety or to the quality of work.

105.14--Maintenance During Construction. The Contractor will be responsible for the maintenance of existing roadways within the limits of this project starting on the date of the Notice to Proceed. Anytime work is performed in a travel lane, the Contractor shall install portable lane closure signs meeting the requirement of the Department Standard Drawing or the Latest Edition of the MUTCD.

The Contractor shall maintain the work until released from maintenance. This maintenance shall require continuous and effective work prosecuted day by day with adequate equipment, forces and material to the end that the roadway structures and all other features of the work are kept in satisfactory condition at all times. Traffic shall be continuously, safely and conveniently maintained as required under the Contract.

In the case of a Contract for the placing of a previously constructed course or subgrade, the Contractor shall maintain the previous course or subgrade during all construction operations.

All cost for maintenance of the work shall be included in the contract unit prices bid on the various pay items, and the Contractor will not be paid any additional amount for such work except as otherwise provided in the Contract.

The Contractor must abide by the Department highway right-of-way control of access and any additional construction access points as designed and allowed within the plans or Contract for access within the project limits. The Contractor shall be responsible for obtaining permission from local officials for construction traffic to travel along and access the project limits from local roads. MDOT will not be held liable for any damage to local roads. Local roads that sustain damage due to construction traffic are expected to be restored to conditions equal to or better than the pre-award conditions at the Contractor's expense.

The Contractor shall cooperate with the Department to allow MDOT personnel or MDOT representatives, FHWA, and other governmental agencies to access the construction site to perform inspections at any time deemed appropriate.

105.15--Failure to Maintain Roadway or Structures. If the Contractor, at any time, fails to comply with the provisions of Subsection 105.14, the Engineer will immediately notify the Contractor of such non-compliance. When the deficiency creates a traffic hazard, the Contractor shall immediately use all available means to correct or otherwise remove the hazard. The Contractor's failure to remedy unsatisfactory maintenance within

24 hours after receipt of such notice will be just cause for the Engineer to maintain the project with such forces as the Engineer deems necessary. Any and all cost to the Department will be deducted from monies due or to become due the Contractor.

105.16--Blank.

105.17--Claims for Adjustments and Disputes. No claim shall be considered unless the Contractor has complied with all the requirements of Subsection 104.02.4. If the Engineer has denied the request for a change to the work per Subsection 104.02.4, the Contractor may commence with the filing of a claim as outlined in this Subsection.

A. Notice of Intent to File a Claim. Within 30 calendar days of receiving the Engineer's decision as outlined in Subsection 104.02.4, the Contractor shall provide the Engineer with a written notice of intent to file a claim on the Notice of Intent Form (CSD-145) available from the Project Engineer or on the MDOT Construction Division webpage.

After filing the written notice of intent, the Contractor shall maintain adequate records related to the claim, including records of the labor, equipment and materials, and, if applicable, monthly schedule updates showing critical path delays to the completion date. The Contractor must update and disclose this information to the Department. The Department, any consultant retained by the Department, and/or FHWA may conduct any inspections necessary and/or audit claim records at any time, including the Contractor's books and records. Unless the Engineer suspends in writing the affected work, the Contractor shall continue to perform the disputed work.

If the notice of intent is not submitted within the 30 calendar days as specified above, or if the Engineer is not given sufficient opportunity for keeping strict account of the Contractor's actual costs, then the Contractor waives the right to file a claim for additional compensation or time. Such notice by the Contractor and the Engineer's accounting of the cost shall not in any way prove or substantiate the validity of the claim. Nothing in this subsection shall be construed as establishing a claim contrary to the terms of Subsection 104.02.

B. Submission of a Claim. Within 60 calendar days after submitting the notice of intent to file a claim or within 60 calendar days of completing the disputed work, whichever is later, the Contractor shall submit a complete claim package. If the claim package is not submitted within the 60 calendar days as specified above, then the Contractor waives the right to file a claim for additional compensation or time. The claim package shall include all documents supporting the claim and provide sufficient detail to enable the Department to ascertain the basis and amount of the claim. At a minimum, the following information shall be submitted with each claim:

1. A completed Notice of Claim Form (CSD-155), which form may be obtained from the Project Engineer or on the MDOT Construction Division webpage.
2. A detailed factual statement of the claim for additional compensation, time or both, providing all necessary dates, locations, and items of work affected by the claim.
3. The date on which the facts were discovered that gave rise to the claim.
4. The specific provisions of the Contract that support the claim and a statement of the reasons why such provisions support the claim.

5. If an extension of contract time is sought, a schedule analysis as required by the Engineer.
6. If additional compensation is sought, the amount and specifics of the compensation.

C. Department Decision. Once the Contractor properly files a claim, provides all necessary documentation, and, if requested, allows for reasonable and timely access to the Contractor's books and records, the Department will review the claim and render a written decision to the Contractor to either affirm or deny the claim, in whole or in part. The Department's decision will be provided within 90 calendar days after receipt of all requested information, including any audit of the Contractor's books and records, or at such time agreed upon by the parties.

Once a claim is filed and the Department commences review of the claim, the submission and consideration of additional information or data, other than for clarification and support of previously submitted documentation, will not be permitted. The Department's written decision to the Contractor will describe the information considered by the Department in reaching a decision and the basis for that decision.

If the Department decides to affirm the claim, an adjustment will be made as applicable. If the Department denies the claim, the Contractor may either accept the Department decision as final or may file a claim with the State Highway Arbitration Board or a file a lawsuit, whichever may be appropriate based on the monetary demand made by the Contractor. Strict compliance with the claims process described in this Subsection 105.17 is a condition precedent to the filing of any arbitration claim or lawsuit and failure to follow any of the requirements herein will be grounds for dismissal of the arbitration or lawsuit.

D. Auditing of Claims. All claims filed against the Department may be subject to audit by the Department's internal Audit Division, any consultant retained by the Department to review the Contractor's claim, and/or FHWA at any time following the filing of such claim. The audit may begin upon a 5-day notice to the Contractor, subcontractor or supplier, or at such time agreed to by the parties. The Contractor, subcontractor and/or supplier shall cooperate with the auditor and/or consultant. Failure of the Contractor, subcontractor and/or supplier to maintain and retain sufficient records to allow the Department's auditor and/or consultant to verify the claim shall constitute a waiver of that portion of the claim that cannot be verified and shall bar recovery thereof. The Contractor, subcontractor and/or supplier shall provide the auditor and/or consultant with a minimum of the following documents:

1. Daily time sheets and foreman's daily reports.
2. Union agreements, if any.
3. Insurance, welfare and benefits records.
4. Payroll register.
5. Earnings records.
6. Material invoices, purchase orders and all material and supply acquisition contracts.
7. Equipment records (list of company equipment, rates, etc.).
8. Vendor rental agreements and Subcontractor invoices.
9. Canceled checks (payroll and vendors).
10. Job cost report.

11. Job payroll ledger.
12. General ledger, general journal (if used) and all subsidiary ledgers and journals together with all supporting documentation pertinent to entries made in these ledgers and journals.
13. Cash disbursements journal.
14. Any other documentation that the auditor and/or consultant deems necessary to the review of the claim.

105.18--Automatically Controlled Equipment. Unless otherwise prohibited in other sections of the specifications or other contract documents, automatically controlled equipment that malfunctions may be operated manually or by other approved methods for a period of time approved by the Engineer so as to prevent loss or damage to the work already produced, manufactured, or processed at the time of the breakdown or malfunction. The resulting work must meet the requirements of the Contract.

105.19--Safety Apparel. All workers within the right-of-way shall wear high-visibility safety apparel in accordance with the requirements of Section 6D.03 of the MUTCD. Workers are defined as people on foot whose duties place them within the right-of way of highways, such as highway construction and maintenance forces, survey crews, utility crews, responders to incidents within the highway right-of-way, and law enforcement personnel when directing traffic, investigating crashes, and handling lane closures, obstructed roadways, and disasters within the right-of-way.

105.20--Acceptance.

105.20.1--Partial Acceptance of a Unit. When the Contractor has completed a unit of the work such as an interchange, a structure, a portion of the road or pavement or one project of a multi-project Contract, the Contractor may request the Engineer to make a final inspection of that unit. The Executive Director may also order a final inspection of the unit, at the Executive Director's discretion. If the Engineer finds upon inspection that the unit has been completed in compliance with the Contract and it is a complete facility that can be made available to the public or made available for the prosecution of work under another contract, the Executive Director may conditionally accept the unit and conditionally relieve the Contractor of certain contractual responsibilities as defined in the release.

In the event items of work covered by such release are found to be defective or deficient as evidenced by unsatisfactory test reports of materials incorporated in the work or other engineering determination, the release shall be null and void upon written notification to the Contractor. The Contractor shall make all corrections, restorations, constructions or reconstructions deemed necessary and shall resume all contractual responsibilities until all corrective measures have been made in accordance with the terms of the Contract.

Partial acceptance does not constitute final acceptance of the work, or any part thereof, nor in any way void or alter any of the terms of the Contract.

Relief from "certain contractual responsibilities" as indicated herein may, or may not, include:

- (a) Further maintenance of the defined limits of the partially accepted work.
- (b) Further public liability for the defined limits of the partially accepted work.

- (c) Further liability for liquidated damages as applicable to the value of the partially accepted work when the quantities for the partially accepted work are separate quantities listed on the Summary of Quantities sheet of the plans, and the separate quantities and the total amounts thereof are listed on the Engineer's Estimate. Otherwise, no reduction in liquidated damages will be made because of such partial acceptance.

Unless specifically provided in the Contract, the liability for liquidated damages shall not be reduced to less than that applicable under the Contract for an amount of such work equal to at least fifty percent (50%) of the total amount of work under the Contract.

105.20.2--Partial Maintenance Release of a Project. Upon written notice from the Contractor of presumptive completion of all the work and upon due notice from the Resident or Project Engineer, the Engineer will make an inspection.

If the inspection discloses any work as being unsatisfactory or incomplete, the Engineer will discuss in detail with the Contractor all discrepancies in the work. Upon correction of the work, another inspection will be made that shall constitute the final inspection, provided the work has been satisfactorily completed.

However, if during the final inspection the Engineer determines that all work has been satisfactorily completed except for growth and coverage of plant establishment on all or part of the work, the Engineer may recommend partial release of all work except items related to growth and coverage. Upon such recommendation, the Contractor will be given a partial release of maintenance and shall be released from further contractual liabilities for the completed work other than warranty work or latent defects. The Contractor will retain responsibility for plant establishment and all maintenance and repairs appurtenant thereto until satisfactory growth and coverage is achieved. This responsibility may also include the continuation of the required storm water inspection and reporting.

105.20.3--Final Maintenance Release of a Project. Upon written notice from the Contractor of presumptive completion of all the work and upon due notice from the Resident or Project Engineer, the Engineer will make an inspection. If all work provided by the Contract has been completed to the Engineer's satisfaction, the inspection will constitute the final inspection, and the Engineer will conditionally release the Contractor of maintenance.

As provided in the Contract, in the event items of work are found to be deficient or defective as evidenced by unsatisfactory test reports of material incorporated into the work, the Contractor shall assume full responsibility for corrective measures, and shall reassume maintenance and public liability until such corrective measures are completed to the satisfaction of the Engineer.

105.20.4--Final Acceptance of a Project. Upon evidence that the Contractor has fulfilled all obligations under the Contract, the Executive Director will make final acceptance and notify the Contractor in writing. Final acceptance of the project will not be given until all obligations imposed under the Contract, including but not limited to the final reporting of payrolls, final reporting of DBE payments, acceptable certifications and test reports of materials used, etc., have been fulfilled. However, the Contractor remains

responsible for all warranty work and any latent defects found within one year of final acceptance.

SECTION 106 - CONTROL OF MATERIALS

106.01--Source of Supply and Quality Requirements.

106.01.1--General. The materials used in the work shall meet all quality requirements of the Contract. At the option of the Engineer, materials may be approved at the source of supply provided the Contractor notifies the Engineer of the proposed source of material well in advance of the time of proposed delivery. If previously approved materials do not produce uniform and satisfactory products, the Contractor shall furnish materials from other sources.

106.01.2--Warranties, Guaranties, Instruction Sheets and Parts Lists. For manufactured articles, units, components or materials incorporated in any mechanical or electrical facility required under the Contract, the manufacturer's warranties, guaranties, instruction sheets and parts lists shall be delivered before final acceptance of the work.

106.02--Local Materials Sources.

106.02.1--Designated Sources. Possible sources of local material may be designated on the plans or described in the special provisions. The quality of material in such deposits will be acceptable in general, but the Contractor shall determine for himself the equipment and work required to produce uniform, acceptable material. It shall be understood that it is not feasible to ascertain from samples the specific limits of acceptable material from the entire deposit and variations shall be considered as usual and are to be expected. The Engineer may order procurement of material from any portion of the deposit and may reject other portions of the deposit as unacceptable.

Unless designated sources are identified in the Contract as State Furnished or State Optioned, acquisition and rights of ingress and egress shall be the responsibility of the Contractor.

106.02.2--Contractor Furnished Sources. The Contractor shall provide sources of materials meeting the requirements of the Contract and shall bear all costs involved, including the cost to the Department for sampling and testing for source approval.

The Department's costs will be based on the standard sampling and testing charges published in Department SOP, and the charges will be deducted from monies due the Contractor.

The Department will assume the cost of acceptance sampling and testing during production and use of the materials.

All pits and quarry sites are subject to approval from the Mississippi Department of Environmental Quality, Office of Geology, as set forth in Subsection 107.23.

106.02.3--All Sources. All pit operations including hauling shall comply with the applicable provisions of Subsection 107.22. Unless otherwise permitted, all pits shall be

drained upon completion.

106.03--Samples, Tests, and Cited Specifications. All materials used in the work shall conform to the general requirements of Section 700 and the specific requirements for each item of work. Cited specifications of AASHTO, ASTM or Federal Specifications for materials or test methods shall be understood to mean approved pre-published or published "Standards" of ASTM, AASHTO, Federal Specifications; Interim Specifications of AASHTO denoted by the suffix "I", Tentative Specifications of ASTM denoted by the suffix "T", or amended Federal Specifications denoted by a numbered amendment, current on the date of advertisement for bids. Unless otherwise provided, all materials shall be inspected and tested for acceptance in accordance with Subsection 700.03. The work shall be considered incomplete until acceptance of all materials used in the work. Any work performed prior to approval of materials will be the sole responsibility of the Contractor.

The Department reserves the right to retest all materials even though they have been tested and approved earlier and to reject all retested materials that do not meet the requirements of the Contract.

Prior inspection, test and approval of material used as a component of another item of work shall in no way imply acceptance if the work in which the material is incorporated fails to meet the requirements of the Contract.

Test reports will be furnished to the Contractor upon request.

106.04--Certification of Compliance. Prior to sampling and testing by the Department, the Engineer may permit use of certain materials or assemblies accompanied by acceptable certificates of compliance stating that such materials or assemblies fully comply with the requirements of the Contract. Each lot of such materials or assemblies delivered to the work must be accompanied by an approved certificate of compliance in which the lot is clearly identified.

Certificates of Compliance shall be prepared in accordance with Subsection 700.05.

Materials and assemblies used on the basis of Certificates of Compliance and found not to be in conformity with Contract requirements are subject to rejection whether in place or not.

Unless otherwise required, the original and three copies of all Certificates of Compliance shall be furnished to the Engineer. Unless specifically provided for elsewhere in the Contract, payment for the work will not be made until proper certification has been received.

106.05--Plant Inspection. The Engineer may make the inspection at the source of material produced by a third party.

In the event such plant inspection is undertaken the following conditions shall be met:

- (a) The Engineer shall have the cooperation and assistance of the Contractor and the producer.
- (b) The Engineer shall have full entry of the plant as may concern the manufacture

or production of the materials.

- (c) When specified, the Contractor shall provide an approved laboratory unit conforming to the applicable requirements of Section 621.

106.06--Blank.

106.07--Foreign Materials. Except as specifically prohibited in these specifications or other contract documents, consideration may be given by the Department to the use of certain materials manufactured or produced outside of the United States provided the materials are delivered to approved locations within the State. The Contractor shall, at no additional cost to the State, arrange for any required sampling and testing that the State is not equipped to perform. All testing shall generally be performed within the United States' Mainland and be subject to witnessing by the Engineer. Certain materials or processes may necessitate the testing be performed or witnessed at the foreign source by State personnel. When the Engineer authorizes inspection at a foreign site, the Contractor shall reimburse the State for all expenses incurred outside the United States by the State's representatives.

For materials requiring mill test reports, the State Materials Engineer will determine that in-plant quality controls are adequate to assure delivery of uniform material in accordance with Contract requirements, and the State Materials Engineer's determination of the adequacy of in-plant quality controls with respect to mill test reports and certificates of compliance shall be final.

No structural materials will be accepted that cannot be properly identified with mill test reports and certificates of compliance even though in-plant quality control procedures have been established to the satisfaction of the State Materials Engineer.

106.08--Storage of Materials. Materials shall be stored in a manner to assure the preservation of their quality and fitness for the work. Stored materials may be re-inspected and retested prior to their use in the work. The materials shall be located so as to facilitate their prompt inspection. Approved portions of the right-of-way may be used for plant operation and storage of materials and equipment. Private property shall not be used without written permission of the owner or lessee, and duplicate copies of such written permission shall be furnished the Engineer. All sites shall be restored to their original conditions at no additional cost to the State or the Commission. This shall not apply to stripping and storing of materials salvaged from the work for use by the Department on other work.

106.09--Handling Materials. All materials shall be handled in such manner as to preserve their quality and fitness for the work. Materials shall be transported in tight vehicles so constructed as to prevent loss or segregation of materials after loading and measuring for incorporation in the work.

106.10--Unacceptable Materials. All materials not conforming to the requirements of the specifications at the time they are incorporated in the work shall be rejected and removed immediately unless otherwise instructed by the Engineer. Rejected materials which have been corrected shall not be used until written approval has been given by the Engineer.

106.11--Department Furnished Material. Material furnished by the Department will

be delivered or made available to the Contractor at the points specified in the Contract.

Unless otherwise specified, the cost of handling, placing, and maintaining all materials after they are delivered or made available will be at the Contractor's expense.

The Contractor will be held responsible for all materials delivered or made available and deductions will be made from monies due for shortages or deficiencies, damages that may occur thereafter, and any demurrage charges.

106.12--Substitute Materials. The Contract will typically specify material generally used in highway construction. The Department from time to time will approve substitute materials for specific uses. These materials and their uses will be noted on the Department's APL. Contractors proposing to use substitute materials will be responsible for determining if the material has gained Department approval. When an approved substitute material is to be used, the Contractor will furnish a certification from the manufacturer that the product is the same material as approved by the Department and that no alterations have been made. Material will be sampled and tested by the Department as necessary for acceptance. Approved lists may be obtained from the State Materials Engineer.

106.13--Convict Produced Materials. Materials produced after July 1, 1991, by convict labor may only be incorporated in a Federal-Aid highway construction project if such materials have been:

- (1) Produced by convicts who are on parole, supervised release, or probation from a prison or
- (2) Produced in a qualified prison facility and the cumulative annual production amount of such materials for use in Federal-aid highway construction does not exceed the amount of such materials produced in such facility for use in Federal-Aid highway construction during the 12-month period ending July 1, 1987.

Qualified prison facility means any prison facility in which convicts, during the 12-month period ending July 1, 1987, produced materials for use in Federal-Aid highway construction projects.

SECTION 107 - LEGAL RELATIONS AND RESPONSIBILITY TO PUBLIC

107.01--Laws to Be Observed. The Contractor shall have the authority to and will keep fully informed and comply with all Federal, State and local laws, ordinances, regulations and all orders and decrees of bodies or tribunals having jurisdiction or authority that affect those engaged or employed on the work or affect the conduct of the work. The Contractor shall protect and indemnify the State and its representatives against all claims or liability arising from or based on the violation of such laws, ordinances, regulations, orders or decrees whether by the Contractor, the Contractor's employees, Subcontractors and employees or agents thereof.

107.02--Permits, Licenses, and Taxes. The Contractor or any Subcontractor shall have the duty to determine any and all required permits not previously procured by the Department; determine all required licenses; procure all permits not previously acquired

by the Department; procure all licenses; pay all charges, fees and taxes; and issue all notices necessary and incidental to the due and lawful prosecution of the work. At any time during the life of this Contract, the Department may audit the Contractor's or Subcontractor's compliance with the requirements of this section.

The Contractor and/or any Subcontractor is advised that the requirements and penalties contained in the "Mississippi Special Fuel Tax Law", Section 27-55-501, et seq. and the Mississippi Use Tax Law, Section 27-67-1, et seq., apply to any Contract or subcontract for construction, reconstruction, maintenance or repairs, for Contracts or subcontracts entered into with the State of Mississippi, any political subdivision of the State of Mississippi, or any Department, Agency, Institute of the State of Mississippi or any political subdivision thereof.

Prior to commencing work on any Project, the Contractor shall obtain a Material Purchase Certificate number (MPC#) from the Mississippi Department of Revenue, pursuant to Miss. Code Ann. § 27-65-21, and Miss. Admin. Code 35.IV.10.01. Upon receipt of the MPC#, the Contractor must immediately provide the MPC# to the Contract Administration Division of the Department. Failure to obtain and submit a MPC# prior to commencing work shall result in the withholding of payment to the Contractor until such time that a MPC# is obtained and submitted to the Department.

The Contractor and/or any Subcontractor will be subject to one or more audits by the Department during the life of this Contract to make certain that all applicable fuel taxes, as outlined in Section 27-55-501, et seq., and any sales and/or use taxes, as outlined in Section 27-67-1, et seq. are being paid in compliance with the law. The Department will notify the Mississippi Department of Revenue of the names and addresses of any Contractors or Subcontractors.

107.03--Patented Devices, Materials, and Processes. If the Contractor employs any design, device, material or process covered by letters of patent or copyright, the Contractor shall provide for such use by agreement with the patentee or owner. However, no highways shall be constructed, reconstructed, or maintained out of any patented paving material, regardless of what kind, on which a direct royalty is paid by the Commission or any Contractor; and the Commission shall not have included in the plans or specifications for constructing, reconstructing, or maintenance of any highway the requirements that any material used or specified shall be laid under any process patented requiring the payment of a direct royalty for use of such process or patent. Attention should be given to Miss. Code Ann. Section 65-1-61, regarding use of patented materials for paving. At any time during the prosecution or after completion of the work, the Contractor and Surety shall indemnify and save harmless the State the Commission, and/or any affected third party or political subdivision from and against any and all claims for infringement in connection with any such patent or copyright.

107.04--Restoration of Surfaces Opened by Permit. The right to construct or reconstruct any utility service in the highway or street or to grant permits for same, at any time, is expressly reserved by the Department. The Contractor will not be entitled to any damages from the Commission or the Department for delays or damages due to utility construction or reconstruction by a third party except an adjustment in contract time may be allowed when the Engineer determines a delay prevents the performance of the controlling phase(s) of work.

Any individual, firm or corporation wishing to make an opening in the highway must

secure a permit from the Department. The Contractor shall allow parties bearing approved permits or agreements, and only those parties, to make openings in the highway. When ordered by the Engineer, the Contractor shall make all necessary repairs and will be paid as provided in these specifications or as Extra Work. The repairs will be subject to the same requirements as the original work.

107.05--Federal Aid Participation. When the United States Government pays all or any portion of the cost of a project, the Federal laws and the rules and regulations made pursuant to such laws shall be observed by the Contractor, and the work shall be subject to the inspection of the Federal agency.

Such inspection shall in no way make the Government a party to this Contract nor will it interfere with the rights of either party hereunder.

107.06--Sanitary, Health and Safety Provisions. The Contractor shall provide and maintain adequate sanitation facilities for employee use. The location of such accommodations shall be subject to the prior approval of the Engineer. The Contractor shall also provide adequate dust control on the project, haul roads and at other areas of operation.

Such accommodations shall be designed and operated to conform to local and State health regulations. The Contractor shall not require any worker to work in surroundings or under conditions contrary to local, State, and Federal health and safety regulations. All such requirements and regulations shall be as binding upon the Contractor as if they were actually included in these specifications.

No direct payment will be made for these provisions.

107.07--Public Convenience and Safety. The Contractor shall conduct the work in a manner that assures the least possible obstruction to traffic. The safety and convenience of the general public, residents along the highway and protection of persons and property shall be provided as specified under Subsection 104.04.

All work on grade separation structures, such as overpasses or underpasses of existing highways, roads or streets, shall be completed in a manner that assures the least practicable interference with the public use of the facility. The Contractor shall use reasonable care and precaution to avoid accidents, damage, unnecessary delay or interference with traffic and will provide competent flaggers to ensure maximum public safety.

107.08--Railway-Highway Provisions. The Department will obtain railroad agreements as required by the Contract. The agreements will be available for the bidder's review in the Office of the Bridge Engineer when the railroad is at bridge sites, and the District Office for at-grade railroad crossings.

107.08.1--Authority of Railroad Engineer and Highway Engineer. The authorized representative of the railroad, hereinafter referred to as the Railroad Engineer, shall have final authority in all matters affecting the safe maintenance of railroad traffic including the adequacy of the foundation and structure supporting the railroad tracks.

The authorized representative of the Department, hereinafter referred to as the Engineer,

shall have authority over all other matters.

107.08.2--Notice of Starting Work. The Contractor shall not commence any work on railroad rights-of-way until the following actions have been taken:

- (a) Written notice given the railroad with a copy to the Engineer at least ten days in advance of the proposed date to begin work on railroad rights-of-way;
- (b) Proof obtained from the railroad of liability insurance as required by Subsection 107.14.2.2;
- (c) Written authorization obtained from the railroad to begin work on railroad rights-of-way. Such authorization may include specific conditions; and
- (d) Approval of the Engineer and Railroad Engineer, before the commencement of work on any pier or structure adjacent to any track, of seven prints to be submitted by the Contractor of the proposed sheeting and bracing details and the method of installation for protection of the railroad embankment and tracks. These plans shall bear the seal of a registered structural or professional engineer and shall be accompanied by design computations and soil data pertinent to the site, or other acceptable basis used for the design. During construction, the Contractor shall make provisions satisfactory to the Engineer and Railroad Engineer against disturbing, in any manner, the railroad embankment or track(s).

The railroad's written authorization to proceed with the work should include the name, address and telephone number of the railroad's representative to be notified in advance of the work. Where more than one representative is designated, the area of responsibility of each representative should be specified.

107.08.3--Interference with Railroad Operations. The Contractor shall so arrange and conduct the work in such a manner that there will be no interference with railroad operations, including train, signal, telephone and telegraphic services, or damage to the property of the railroad or to poles, wires and other facilities or tenants on the rights-of-way of the railroad. Whenever work is likely to affect the operations or safety of trains, the method of doing such work shall first be submitted to the Railroad Engineer for approval, but such approval shall not relieve the Contractor from liability. Any work to be performed by the Contractor that requires protective service (flagging or inspection) shall be deferred by the Contractor until the protective service is available at the job site.

When work within railroad rights-of-way is of such a nature that interference to railroad operations is unavoidable, the Contractor shall schedule and conduct the work so that such interference is held to a minimum.

Should conditions arise from the work that require immediate and unusual provisions be made to protect operations and property of the railroad, the Contractor shall provide such provisions. When these provisions are insufficient in the judgment of the Railroad Engineer or the Engineer in the absence of the Railroad Engineer, the Contractor shall provide such provisions as deemed necessary. Any such unusual provisions shall be without cost to the railroad.

107.08.4--Track Clearances. Unless written authorization to the contrary is obtained from the Railroad Engineer, the minimum track clearances shall be as per the most recent edition of the American Railway Engineering and Maintenance-of-Way Association (AREMA) manual or per the governing Railroad's standards or as shown

on the plans, whichever is greater, and shall be maintained by the Contractor at all times during construction operations:

However, before undertaking any work within railroad rights-of-way or before placing any obstruction over any track, the Contractor shall:

- (a) Notify the railroad's representative at least 72 hours in advance of the work.
- (b) Receive assurance from the railroad's representative that arrangements have been made for any required flagging service.
- (c) Receive permission from the railroad's representative to proceed with the work.
- (d) Ascertain that the Engineer has received copies of notice to the railroad and the railroad's response.

107.08.5--Construction Procedures.

107.08.5.1--General. Construction work on railroad property shall be subject to the inspection and approval of the railroad representative and in accordance with the railroad's outline of specific conditions and these specifications.

107.08.5.2--Excavation. The subgrade of an operated track shall be maintained with edge of berm at least 10'0" from centerline of track and not more than 24 inches below top of rail. If existing track section is substandard, the Contractor will be required only to maintain the existing section.

107.08.5.3--Excavation for Structures. When excavating and/or driving piling adjacent to tracks, the Contractor shall take special precaution and care to provide adequate lateral support for the tracks and the loads that they carry, without disturbance of track alignment and grade, and to avoid obstructing track clearances with equipment, tools, or materials. The procedure for doing such work, including the need of and plans for shoring, shall be approved by the Railroad Engineer, but such approval shall not relieve the Contractor from liability.

107.08.5.4--Blasting. The Contractor shall obtain advance approval of the Railroad Engineer and the Engineer for use of explosives on or adjacent to railroad property. If permission is granted, the Contractor will be required to comply with railroad requirements and the following:

- (a) Blasting shall be done with light charges under the direct supervision of a responsible officer or employee of the Contractor.
- (b) Electric detonating fuses shall not be used because of the possibility of premature explosions resulting from operation of two-way radios.
- (c) No blasting shall be done without the presence of an authorized representative of the railroad. At least 72 hours advance notice to the person designated in the railroad's notice of authorization to proceed will be required to arrange for the presence of an authorized railroad representative and such flagging as the railroad may require.
- (d) The Contractor shall have, at the job site, adequate equipment, labor and materials and allow sufficient time to clean up debris resulting from the blasting without delay to trains, and shall correct any track misalignment or other damage to railroad property as directed by the railroad's authorized representative. The cost for any delay of trains caused by the Contractor's

actions shall be borne by the Contractor.

The railroad representative will determine the approximate location of trains and advise the Contractor of the approximate amount of time available for the blasting and clean-up operation. The representative has the authority to order discontinuance of blasting if blasting is too hazardous or is not in accord with these specifications.

107.08.5.5--Maintenance of Railroad Facilities. The Contractor shall maintain all tracks, railroad beds, ditches and drainage structures free of silt or other obstructions, promptly repair eroded areas within railroad rights-of-way, and be responsible to the railroad for repair of any other damage to the property of the railroad or its tenants that is a direct result of the Contractor's operations.

107.08.5.6--Storage of Materials and Equipment. The Contractor shall not store materials and equipment on the rights-of-way of the railroad without obtaining written permission from the Railroad Engineer. Such permission may be with the understanding that the railroad will not be liable for any damages to materials or equipment from any cause and that the Railroad Engineer may move or require the Contractor to move such materials and equipment.

All unattended equipment that is left parked near the track shall be effectively immobilized so that it cannot be moved by unauthorized persons. The Contractor shall protect, defend, indemnify and save the railroad and any associated, controlled or affiliated corporation harmless from and against all loss, costs, expenses, claim or liability for loss of or damage to property or the loss of life or personal injury, due to the Contractor's failure to immobilize said equipment.

107.08.5.7--Cleanup. Upon completion of the work the Contractor shall remove from within the limits of the railroad rights-of-way all machinery, equipment, surplus materials, falsework, rubbish or temporary buildings, and leave said rights-of-way in a neat condition satisfactory to the Chief Engineer of the Railroad or authorized representative.

107.08.6--Damages. The Contractor shall assume liability for damages to the work, the Contractor's employees, servants, equipment and materials caused by railroad traffic unless such damages result from negligent operation of the railroad.

Any cost incurred by the railroad for repairing damages to railroad property or to property of railroad tenants caused by or resulting from the Contractor's operations shall be the responsibility of the Contractor.

107.08.7--Flagging Services.

107.08.7.1--When Required. The Railroad Engineer has sole authority to determine the need for flagging. Generally, the requirement of this service will be when Contractor's personnel or equipment are, or are likely to be, working on the railroad's rights-of-way or when the work is likely to disturb a railroad structure, roadbed or grade and alignment of any track to such extent that the movement of trains must be controlled or when booming over track(s) with a crane.

107.08.7.2--Scheduling and Notification. Not later than the time that approval is initially requested to begin work on railroad rights-of-way, the Contractor shall furnish to the railroad and the Department a schedule for all work required to complete the portion of the project within railroad rights-of-way and arrange for a job site meeting between the Contractor, the Department, and the railroad's authorized representative. Work on railroad rights-of-way shall not begin until the job site meeting has been conducted and the Contractor's work scheduled.

The Contractor must give the railroad representative at least ten days of advance written notice of the Contractor's intent to begin work within railroad rights-of-way in accordance with these specifications. If work is suspended, the Contractor shall give the railroad representative at least three days advance notice before resuming work. Such notices shall include sufficient details of the proposed work to enable the railroad representative to determine if flagging will be required. If such notice is in writing, the Contractor shall furnish the Engineer a copy or if notice is given verbally it shall be confirmed in writing with copy to the Engineer. If flagging is required, no work shall be undertaken until the flagger/flaggers is/are present at the project site.

If, after the flagger is assigned to the project site, emergencies arise that require the flagger's presence elsewhere, the Contractor shall delay work on railroad rights-of-way until such time that a flagger is available.

107.08.7.3--Payment. The Contractor will be required to pay all costs for flagging that are required to accomplish the work required by the Contract.

107.08.8--Haul Across Railroad. Where the plans show or imply that materials must be hauled across a railroad, the Contractor will be required to make all necessary arrangements with the railroad regarding means of transporting such materials unless the plans clearly show that the Department has included arrangements for such haul in its agreement with the railroad. The Department will reimburse the railroad for the costs of flagging, and the Contractor will be required to bear all other costs incidental to such crossings whether services are performed by the Contractor or by railroad personnel.

No crossing may be established for transporting materials or equipment across a railroad unless specific authority for its installation, maintenance, protective services and removal is first obtained from the Railroad Engineer.

107.08.9--Railroad Services for Benefit of the Contractor. Railroad services (including flagging and inspection) needed for any work that is for the benefit of the Contractor or due to work that is the fault of the Contractor shall be at the Contractor's expense. The Contractor shall make specific arrangements for such work including basis of payment with the railroad. Prior to final acceptance, the Contractor shall furnish to the Department satisfactory evidence that the railroad has acknowledged receipt of payment for any such services.

107.08.10--Cooperation and Delays. It shall be the Contractor's responsibility to arrange a schedule with the railroad for accomplishing stage construction involving work by the railroad or tenants of the railroad. In arranging the schedule, the Contractor shall ascertain, from the railroad, the lead time required for assembling crews and materials and make due allowance.

No charge or claims of the Contractor against either the Department or the railroad will be allowed for hindrance or delay on account of railroad traffic, work by the railroad or other delays incident to or necessary for safe maintenance of railroad traffic or any delays due to compliance with these specifications.

107.08.11--Trainman's Walkways. Along the outer side of each exterior track of multiple operated track and on each side of single operated track, an unobstructed continuous space suitable for trainman's use in walking along trains, extending to a line not less than ten feet from centerline of track, shall be maintained. Any temporary impediments to walkways and track drainage encroachments or obstructions allowed during work hours while railroad's protective service is provided shall be removed before the close of each work day. If there is any excavation near the walkway, a handrail with 10-foot minimum clearance from centerline of track shall be installed.

107.08.12--Insurance. The Contractor shall be required to carry insurance in accordance with Subsection 107.14.2.

107.08.13--Failure to Comply. In the event the Contractor violates or fails to comply with any of the requirements of these specifications, the Railroad Engineer may require that the Contractor vacate the railroad property. Any such orders shall remain in effect until the Contractor has remedied the situation to the satisfaction of the Railroad Engineer and the Engineer.

107.09--Construction Over or Adjacent to Navigable Waters and Wetlands. All work on, over or adjacent to navigable waters or wetlands shall be conducted in accordance with permits issued by the controlling authority.

The Department will obtain permits for work over navigable waters and wetlands, and bidders are advised to closely examine the provisions of such permits relative to spoil disposal and water quality considerations and the necessary construction of retention basins, settling ponds, temporary navigation lights, etc. Copies of the permits will be included in the contract documents or available for review at the Jackson and District Offices of the Department.

The Contractor shall conform to all provisions and conditions of the permits.

The permits will only cover work shown on the plans. Should temporary construction be proposed for the Contractor's convenience in the areas set out in the permits, the Contractor shall apply for and furnish a copy of the required permits to the Engineer before proceeding with the temporary construction.

107.10--Barricades, Warning Signs and Flaggers. The Contractor shall provide, erect and maintain all necessary barricades, lights, danger signals, signs and other traffic control devices, shall provide qualified flaggers where necessary to direct the traffic, and shall take all necessary precautions for the protection of the work and the safety of the public. Highways or parts of the work closed to through traffic shall be protected by effective barricades. Suitable warning signs shall be provided to properly control and direct traffic.

The Contractor shall erect warning signs in advance of all places on the project where operations may interfere with traffic and at all intermediate points where the work crosses

or coincides with the existing roadway. Such warning signs shall be constructed and erected in accordance with the provisions of the Contract.

All barricades, warning signs, lights, temporary signals, other protective devices, flaggers and signaling devices shall meet or exceed the minimum requirements contained in the MUTCD that is current at the time bids are received.

All traffic control devices on an existing highway, road or street are understood to be public property under the provisions of Subsection 107.12.

On all sections of a project that coincide with an existing highway, road, or street and are open to traffic, the Contractor shall be fully responsible for the protection, maintenance, and replacement of all existing signs, route markers, traffic control signals, and other traffic service features from the beginning of contract time or beginning of work, whichever occurs earlier, until final completion of the work.

The Contractor shall restore or replace in kind, under the provisions of Subsection 107.12, all devices damaged, destroyed or lost by the Contractor.

On or about the effective date of the Notice to Proceed, the Engineer will make an inventory of all traffic service devices with adequate description of each sign, post, message, signal and other devices as a basis for replacement in kind. A copy of the inventory - dated, identified, and signed - will be forwarded to the District and Contractor.

Near completion of the work, the Engineer will make another inventory of the traffic control devices and distribute as indicated for the earlier inventory. A list and detailed description of the traffic control devices that have been damaged, destroyed or lost and must be replaced in kind by the Contractor will be attached to the inventory. The Engineer will confirm in writing the completion of sign replacement by the Contractor.

Prior to performing work on the project, the Contractor shall make the necessary arrangements to prevent damage or loss of signs and other traffic control devices. Those that cannot be left in their existing positions shall be removed, stored, or reinstalled at locations approved by the Engineer. As soon as work in conflict with the original position of each device has been performed, the device shall be reinstalled at the original position or modified position as approved by the Engineer.

The Contractor shall maintain in position only those signs that are appropriate for existing conditions and those that are not or have served their purpose shall be removed or covered as approved by the Engineer. Sign coverings shall be of such material and so placed that the information contained thereon will not be legible during day or night. If the Contractor has a routine daytime operation and is not working at night, the signs shall be covered or removed during the nighttime when there is no work activity. Likewise, if the Contractor has a routine nighttime operation and is not working during the daytime, the signs shall be covered or removed during the daytime when there is no work activity. The Contractor shall not allow vegetation, construction materials, equipment, etc. to obscure an applicable traffic control device.

No change in posted regulatory speed signs may be made without the written authority of the Department. However, advisory speed plates conforming to the current MUTCD may

be used in conjunction with the other standard warning signs provided each posted advisory speed is appropriate for the individual hazard created by construction. All proposed changes in regulatory speeds shall be submitted through the District Engineer and forwarded with any recommendations to the State Traffic Engineer for further handling and consideration by the proper authority.

Unless otherwise provided in the Contract, no measurement for payment will be made for materials or work under this subsection, it being understood that the cost thereof is included in the price bid for Maintenance of Traffic or other contract items.

The location and spacing of signs, shown in the traffic control plans, are approximate and may be adjusted as necessary to meet field conditions.

All plastic drums used on high speed facilities shall have a crash-tested ballasting collar made from recycled truck tires of other suitable material.

All post lengths for signs shall be verified in the field prior to fabrication.

Unless otherwise provided for in the Contract, roadway signs that are in conflict with construction of the project shall be removed and relocated by the Contractor as directed by the Engineer. The cost of which shall be absorbed in other items bid.

Erection dates shall be legibly written on the back of all signs with a waterproof formula permanent marking stock.

107.11--Use of Explosives. The use of explosives is not permissible under any condition or on any project unless approved in writing by the Engineer. When using explosives, the Contractor shall exercise utmost care not to endanger life and property including the new work. The Contractor shall be responsible for all damage resulting from the use of explosives and shall indemnify and hold harmless the Commission, the Department, and any of its officers or employees.

The Contractor shall comply with all laws and ordinances as well as Title 29 Code of Federal Regulations Part 1926, Safety and Health Regulations for Construction (OSHA), with respect to the use, handling, loading, transportation and storage of explosives and blasting agents.

The Contractor shall notify each property owner and public utility company having structures or facilities in proximity of the explosive work and shall notify all known owners or operators of shortwave radio equipment in the area. Such notice shall be given at least five (5) days in advance to enable those involved to take steps to protect their property.

107.12--Protection and Restoration of Property and Landscape. The Contractor shall be responsible for the preservation of public and private property and shall protect from disturbance or damage all land monuments, historical markers, and property marks and shall not move them until the Engineer has witnessed or otherwise referenced their location.

The Contractor shall be responsible for all damage or injury to public or private property of any character resulting from any act, omission, neglect, misconduct, inefficiency,

method of executing the work or non-execution thereof or due to defective work or materials and shall indemnify and hold harmless the Commission, the Department and any of its officers and/or employees for any such actions or omissions.

The Contractor shall take sufficient precaution to prevent pollution of streams, lakes and reservoirs with any harmful materials including but not limited to fuels, oils, bitumens, calcium chloride, and poisons. The Contractor shall schedule and conduct grading operations, production of materials from material pits or quarry sites exclusive of commercially operated sources, construction of haul roads, hauling operations and other operations so as to prevent or minimize the pollution of adjacent property, ditches, streams, lakes and reservoirs with mineral or organic sediment. Pollution causing injury or damage within the intent of this subsection shall be subject to the restoration requirements and provisions herein set forth.

The Contractor shall restore the property, at no additional costs to the Commission, to a condition equal to that existing before the damage or injury, or shall make good such damage or injury in an acceptable manner.

In case of failure on the part of the Contractor to restore or make good such damage or injury, the Engineer may, upon forty-eight hours written notice, proceed to repair, rebuild or otherwise restore such property and the cost thereof shall be deducted from monies due or that may become due the Contractor. In the event no such monies are available, the amount shall be charged against the Contractor's Surety.

Nothing within this subsection shall be construed to relieve the Contractor from the responsibilities under the requirements of Subsection 107.01.

107.13--Forest Protection. In carrying out work within or adjacent to State or National Forests or other forest areas, the Contractor shall comply with all regulations of the State Fire Marshall, Forestry Commission, Forest Service and any other authority having jurisdiction of the forests and shall observe all sanitary laws and regulations with respect to the performance of work in forest areas. The Contractor shall keep the areas in an orderly condition, dispose of all refuse, and obtain permits for the construction and maintenance of all construction camps, stores, warehouses, residences, latrines, cesspools, septic tanks and other structures in accordance with the requirements of the Forest Supervisor.

The Contractor shall take all reasonable precaution to prevent and suppress forest fires. The Contractor's employees and subcontractors shall be required to take all reasonable steps within their power to prevent and suppress forest fires and to notify at the earliest possible moment a Forest Supervisor or other appropriate official of the location and extent of any fire seen by them.

107.14--Damage Claims and Insurance.

107.14.1--Responsibility for Damage Claims. The Contractor shall indemnify and save harmless the Department and the Commission and their officers and employees from all suits, actions or claims of any character brought for any of the following, non-inclusive reasons: (a) because of any and all injuries or damage received or sustained by person(s) or property resulting in any way from the Contractor's operations; (b) as the result of any neglect in safeguarding the work; (c) because of any claims or amounts recovered from

infringements of patent, trademark, or copyright; and (d) from claims or amounts arising out of or recovered under the "Workmen's Compensation Act" or any other law, ordinance, order or decree. Money due the Contractor may be retained for the use of the State or Commission or in case no money is due, the Contractor's Surety or insurance carrier may be called upon to ensure such suits, actions or claims for injuries or damages have been settled. Suitable evidence of the resolution of any suit, action or claim must be furnished to the Department. Money due the Contractor will not be withheld when satisfactory evidence is produced that the Contractor is adequately protected by general liability and property damage liability insurance.

107.14.2--Liability Insurance.

107.14.2.1--General. The Contractor shall carry commercial general liability, including subcontractors and contractual, with limits not less than: \$500,000 each occurrence; \$1,000,000 aggregate; automobile liability - \$500,000 combined single limit - each accident; Workers' Compensation and Employers' Liability - Statutory & \$100,000 each accident; \$100,000 each employee; \$500,000 policy limit. Each policy shall be signed or countersigned by a Mississippi Agent or Qualified Nonresident Agent of the Insurance Company.

The Contractor shall have certificates furnished to the Department from the insurance companies providing the required coverage. The certificates shall be on the form furnished by the Department and must show the types and limits of coverage.

107.14.2.2--Railroad Protective. The following provisions are applicable to all work performed under a Contract on, over or under the rights-of-way of each railroad shown on the plans.

The Contractor shall assume all liability for any and all damages to work, employees, servants, equipment and materials caused by railroad traffic.

Prior to starting any work on railroad property, the Contractor shall furnish satisfactory evidence to the Department that insurance in the forms and amounts set out herein in paragraphs (a) and (b) has been obtained. Also, the Contractor shall furnish similar evidence to the railroad that insurance has been obtained in accordance with the Standard Provisions for General Liability Policies and the Railroad Protective Liability Form as published in the 23 CFR 646, Subpart A. Evidence to the railroad shall be in the form of a Certificate of Insurance for coverages required in paragraph (b), and the original policy of the Railroad Protective Liability Insurance for coverage required in paragraph (a).

All insurance herein specified shall be carried until the Contract is satisfactorily complete as evidenced by a full release of maintenance from the Department.

The railroad shall be given at least 30-day notice prior to cancellation of the Railroad Protective Liability Insurance policy.

For work within the limits set out in Subsection 107.18 and this subsection, the Contractor shall provide insurance for bodily injury liability, property damage liability and physical damage to property with coverages and limits no less than shown in paragraphs (a) and (b). Bodily injury includes bodily injury, sickness, or disease, including death at any time resulting therefrom. Property damage includes damages

because of physical injury to or destruction of property, including loss of use of any property due to such injury or destruction. Physical damage includes direct and accidental loss of or damage to rolling stock and their contents, mechanical construction equipment or motive power equipment.

(a) Railroad Protective Liability Insurance shall be purchased on behalf of the railroad with limits of \$5,000,000 each occurrence and \$10,000,000 aggregate applying separately to each annual period for lines without passenger trains. If the line carries passenger train(s), railroad protective liability insurance shall be purchased on behalf of the railroad with limits of \$5,000,000 each occurrence and \$10,000,000 aggregate applying separately to each annual period.

Coverage shall be limited to damage suffered by the railroad on account of occurrences arising out of the work of the Contractor on or about the railroad right-of-way, independent of the railroad's general supervision or control, except as noted in paragraph 4 below.

Coverage shall include:

- (1) death of or bodily injury to passengers of the railroad and employees of the railroad not covered by State workmen's compensation laws;
- (2) personal property owned by or in the care, custody or control of the railroads;
- (3) the Contractor, or any of the Contractor's agents or employees who suffer bodily injury or death as a result of acts of the railroad or its agents, regardless of the negligence of the railroads; and
- (4) negligence of only the following classes of railroad employees:
 - (i) any supervisory employee of the railroad at the project site
 - (ii) any employee of the railroad while operating, attached to, or engaged on, work trains or other railroad equipment at the project site that are assigned exclusively to the Contractor, or
 - (iii) any employee of the railroad not within (i) or (ii) above who is specifically loaned or assigned to the work of the Contractor for prevention of accidents or protection of property, the cost of whose services is borne specifically by the Contractor or Governmental authority.

(b) Contractor's Liability - Railroad, including subcontractors, XCU and railroad contractual with limits of \$1,000,000 each occurrence; \$2,000,000 aggregate. Automobile with limits of \$1,000,000 combined single limit any one accident; Workers' Compensation and Employer's Liability - statutory and \$100,000 each accident; \$100,000 each employee; \$500,000 policy limit. Excess/Umbrella Liability - \$5,000,000 each occurrence; \$5,000,000 aggregate. All coverage to be issued in the name of the Contractor shall be written so as to furnish protection to the Contractor in connection with the Contractor's operations in performing work covered by the Contract. Coverage shall include protection from damages arising out of bodily injury or death and damage or destruction of property that may be suffered by persons other than the Contractor's own employees.

In addition, the Contractor shall provide for and on behalf of each subcontractor by means of a separate and individual liability and property damage policy to cover like

liability imposed upon the subcontractor as a result of the subcontractor's operations in the same amounts as contained above; or, in the alternative, each subcontractor shall provide same.

107.15--Third Party Beneficiary Clause. It is not intended by any of the provisions of the Contract to create a third party beneficiary in the public or any member thereof or to authorize any one not a party to the Contract to maintain a suit for personal injury or property damage pursuant to the provisions of the Contract. The duties, obligations and responsibilities of the parties to the Contract with respect to third parties shall remain as imposed by law.

107.16--Opening Sections of Project To Traffic. If the project is not already open to traffic in accordance with the provisions of Subsection 104.04, then at the option of the Executive Director, all or any part may be opened to traffic. The Department will install the traffic control devices necessary for the safety and convenience of traffic. Maintenance of traffic expense will be borne by the Department, or the Contractor will be compensated in accordance with Subsection 109.04 if ordered to provide maintenance of traffic. Opening sections of a project to traffic in accordance with this subsection will be in writing and will not constitute acceptance of the work, or any part thereof, or a waiver of any provision of the Contract.

All damage to the highway, including damage or defacement of traffic control devices furnished and erected by the Department, that is the fault of the Contractor shall be repaired or replaced at the expense of the Contractor.

If the Contractor is dilatory in completing shoulders or other features of work, the Executive Director may order all or a portion of the project open to traffic as set out herein; however, the Contractor shall not be relieved of liability and responsibility during the period the work is so opened prior to release of maintenance. The remainder of the Contractor's construction operations shall be conducted in a manner that will cause the least obstruction to the safe and convenient movement of traffic.

107.17--Contractor's Responsibility for Work. Until release of maintenance in accordance with Subsection 105.20, the Contractor shall have the charge and care of the work and shall take every precaution against injury or damage by action of the elements or from any other cause, whether arising from the execution or the non-execution of the work. The Contractor shall rebuild, repair, restore and make good, in accordance with the requirements of the Contract, all injuries or damages to the work before release of maintenance and shall bear the expense thereof.

If the Engineer determines the work has been properly prosecuted, constructed, protected and maintained and significant damage to the work is determined to be caused by unforeseeable occurrences beyond the control of and without the fault or negligence of the Contractor, including but not limited to acts of nature, of the public enemy or of governmental authorities, the Contractor will be paid for repairing such damage at the contract unit prices for applicable items involved in making repairs.

When contract items are not applicable to repair of work damaged from such cause, a Supplemental Agreement may be entered into or such repairs may be accomplished under the provisions of Subsection 109.04, Extra and Force Account Work.

If the Engineer determines that such repair work has not been properly prosecuted and maintained or determines that the Contractor has not taken all reasonable measures to provide adequate protection for partially completed or completed repair work, payment for repairs will not be made.

Damage to items of construction, caused by the traveling public on a project or section(s) of a project open to traffic, shall be repaired by the Contractor. The Contractor will be paid for repairing such damage to the below acceptably installed items of construction at the contract unit price(s) for the applicable item(s) used in the repair. An acceptably installed item shall be complete-in-place meeting the requirements of the specifications. The acceptably installed items of construction eligible to receive payment for repair of damage caused by the traveling public shall be items used for signing, safety and traffic control. The eligible permanent items shall be limited to traffic signal systems, changeable message signs, roadway signs and sign supports, lighting items, guard rail items, delineators, impact attenuators, median barriers, bridge railing or pavement markings. The eligible temporary items shall be limited to changeable message signs, guard rail items, or median barriers. If damage to the above items necessitate only minor repairs, in lieu of total replacement, the work shall be performed in accordance with Subsection 109.04, or as directed by the Engineer. Damage not meeting the requirements to qualify for repair payment shall be repaired at no additional cost to the Department.

In the case of suspension of work from any cause whatsoever, the Contractor shall be responsible for the work and shall take the precautions necessary to prevent damage to the work, provide for normal drainage, erect necessary temporary structures, signs or other facilities, maintain the work in such a manner as to fully carry out the responsibility for maintaining traffic as required under the Contract, properly and continuously maintain in an acceptable growing condition all living material in newly established plantings, seedings, and soddings furnished under the Contract, and take adequate precautions to protect new tree growth and other vegetative growth against injury. Except when the suspension is ordered by the Engineer for the sole benefit of the Department, all such protection and maintenance shall be performed by the Contractor without additional cost to the State.

107.18--Contractor's Responsibility for Utility Property and Services. Where the Contractor's operations are adjacent to or coincide with properties of railroad, telegraph, telephone, power companies and other utility services and damage to said utility might result in considerable expense, loss or inconvenience, work shall not commence until all arrangements necessary for the protection thereof have been made. At least 48 hours prior to any excavation on the project, the Contractor shall contact MS 811 and advise them to mark all known utilities in the area of the excavation.

All work to be performed within 50 feet either side of the centerline of any railroad track shall be executed in such manner and at such time that interference with the movements of trains or traffic upon the tracks of the railroad is minimal. The Contractor must use all reasonable care and proper precautions to avoid accidents, damage, or unnecessary delays that would interfere with the railroad's trains or other property.

The Contractor shall cooperate with the owners of all underground and overhead utility lines in the removal and rearrangement operations so that these operations may progress in a reasonable manner, duplication of rearrangement work may be reduced to a minimum and services rendered will not be unnecessarily interrupted.

In the event of interruption to utility services as a result of accidental breakage or as a result of being exposed or unsupported, the Contractor shall promptly notify the proper authorities and cooperate in the restoration of service. No work shall be undertaken around fire hydrants without approval of the local fire authority.

The Contractor is advised of Miss. Code Ann., Section 45-15-1, et seq., regarding the performance of work in the proximity of high voltage overhead power lines. It is the Contractor's responsibility to comply with those statutory requirements.

107.19--Furnishing Rights-of-Way. The Department will be responsible for securing all necessary rights-of-way in advance of construction. Any exceptions will be indicated in the Contract.

107.20--Personal Liability of Public Officials. In carrying out the provisions of the Contract or exercising the authority granted by or within the scope of the Contract, there shall be no liability upon the Department, the Commission, the Engineer or authorized representative or any officers or employees of the Department or the Commission, either personally or as officials of the State. It is understood that in all such matters the referenced entities/individuals act solely as agents and representatives of the State.

107.21--No Waiver of Legal Rights. The Department and/or the Commission shall not be precluded or estopped by any measurement, estimate or certificate made either before or after the completion and acceptance of the work and payment therefor from showing the true amount and character of the work performed and materials furnished by the Contractor, nor from showing that any such measurement, estimate or certificate is untrue or is incorrectly made, nor that the work or materials do not in fact conform to the Contract. The Department and/or the Commission shall not be precluded or estopped, notwithstanding any such measurement, estimate or certificate and payment in accordance therewith, from recovering from the Contractor or the Contractor's Sureties, or both, within the provisions of the laws of the State of Mississippi such damage as may be sustained by reason of the failure to comply with any of the terms of the Contract. Neither the acceptance by the Commission or the Department or any representative thereof, nor any payment for or acceptance in whole or in part of the work, nor any extension of Contract time, nor any possession taken by the Department shall operate as a waiver of any portion of the Contract or of any power herein reserved or of any right to damages. A waiver of any breach of the Contract shall not be held to be a waiver of any other subsequent breach.

The Commission reserves the right to correct an error contained in any estimate that has been paid and to adjust the estimate to meet the requirements of the Contract and specifications. Upon conclusive proof of error or collusion or dishonesty between the Contractor or the Contractor's agents and the Engineer or the Engineer's representative that is discovered after final payment has been made, the Commission reserves the right to claim and recover by process of law, any sums that may be sufficient to correct the error or make good the defects in the work resulting from such errors, dishonesty or collusion.

107.22--Environmental Protection. In addition to the applicable provisions of Subsections 107.01 and 107.12, occupancy by the Contractor of any lands, whether on or off the right-of-way, for the performance of any work under the Contract, or preparation

therefore, shall be contingent upon provisions being made and carried out for the prevention or minimization of siltation, pollution from soil erosion, and air pollution. Accordingly, it is the intent of the Contract that erosion be prevented by the establishment of all necessary temporary and permanent erosion control features as the work progresses from beginning to completion. The primary objective shall be to establish and maintain all permanent erosion control features as soon as possible. Until such time, each operation shall include the effective use of temporary measures as necessary to maintain ground surface conditions so as to prevent or minimize siltation or pollution.

107.22.1--Contractor's Erosion Control Plan (ECP). At the preconstruction conference or prior to starting any work on the project, the Contractor shall submit to the Project Engineer for concurrence a comprehensive erosion and siltation control plan (ECP). The ECP shall utilize temporary measures and permanent erosion control features to provide acceptable controls during all stages of construction. If an early Notice to Proceed is desired, the Contractor's ECP should be submitted to the Engineer as soon as possible after award since an approved erosion control plan is required for an early Notice to Proceed.

The time between the Notice of Award and Notice to Proceed/Beginning of Contract Time in the proposal, has been allowed for the submittal and concurrence of the Contractor's ECP, MDOT's review of the plan, and any revisions that may be necessary. The original contract time shall not be adjusted unless delays are caused solely by the Department for the submission, review, and concurrence of the Contractor's ECP.

As a minimum, the ECP shall include the following:

1. ECP sheets or the plan profile sheets, 11" x 17" or larger, of all areas within the rights-of-way from the Beginning of the Project (BOP) to the End of the Project (EOP) showing the location of all temporary erosion control devices. Erosion control devices should be identified by exact type, temporary or permanent, configuration, and placement of each item to prevent erosion and siltation. A narrative of the Contractor's temporary erosion control plan shall be submitted in a format similar to the form below, but must include the heading and sub-heading information. The narrative should include, at a minimum, the following:
 - A detailed description, including locations (station numbers) of the Contractor's proposed sequence of operations including, but not limited to, clearing and grubbing, excavation, drainage, and structures.
 - A detailed description, including locations, and best management practices (BMP) that will be used to prevent siltation and erosion from occurring during the Contractor's proposed sequence of operations.
2. A copy of the certification for the Contractor's Certified Erosion Control Person whose primary duty shall be monitoring and maintaining the effectiveness of the ECP, BMPs, and compliance with the NPDES permit requirements.
3. A plan for the disposal of waste materials on the project right-of-way that includes but should not be limited to the following:
 - containment and disposal of materials resulting from the cleaning (washing out) of concrete trucks that are delivering concrete to the project site.
 - containment and disposal of fuel / petroleum materials at staging areas on the project.

The ECP must be maintained on the project site at all times, updated as work progresses to show changes due to revisions in the sequences of construction operations, replacement of inadequate BMPs, and the maintenance of BMPs. Work shall not start until an ECP has been concurred with by the Department. The Engineer has the authority to suspend all work and/or withhold payments for failure of the Contractor to carry out provisions of MDEQ's Storm Water Construction General Permit, the ECP, updates to the ECP, and /or proper maintenance of the BMPs.

As soon as the ECP has been approved, a copy of the SWPPP (Narrative, ECP with updates) shall be available at the project at all times. The Contractor shall provide and install a weatherproof enclosure, such as a mailbox, at the project at a readily accessible location to the Engineer or others who may want to review the ECP. The cost of installing and maintaining this enclosure shall be included in the prices bid for the various erosion control pay items and no direct payment will be made for this work.

EXAMPLE
MISSISSIPPI DEPARTMENT OF TRANSPORTATION
Storm Water Pollution Prevention Plan (SWPPP)
Narrative

General Permit Coverage No: MSR _____
Project Number: _____
County: _____
Route: _____

SITE INFORMATION

This project consists of grading and installing drainage structures necessary to construct approximately 6 miles of parallel lanes on SR 31 between the Hinds County Line and the Rankin County Line.

SEDIMENT AND EROSION CONTROLS

VEGETATIVE CONTROLS: Clearing and grubbing areas will be minimized to comply with the buffer zones (minimum of 15 feet along the ROW lines and 5 feet along creeks) as per the contract documents. A combination of temporary and permanent grassing will be used to protect slopes as construction progresses. **Should a disturbed area be left undisturbed for 14 days or more, temporary BMPs (seeding & mulching, silt fences, basins, ditch checks, slope drains, etc.) or permanent erosion control measures (seeding & mulching, riprap, paved ditch, flumes, etc.) will be placed within 7 calendar days.**

STRUCTURAL CONTROLS: Gravel construction entrance/exit will be installed near Stations 145+50, 159+50, 164+50 & 172+50. Riprap ditch checks will be constructed at Stations 144+50, 151+75, 162+00 & 166+25. The Concrete washout area will be at Stations 140+25, 152+00 & 168+50.

HOUSEKEEPING PRACTICES: Structural BPM's will be cleaned out when sediment reaches 1/3 to 1/2 of the height of the BMP. Maintenance and repair of equipment will be performed off-site, material wash out will occur either off-site or within designated wash out areas.

POST-CONSTRUCTION CONTROL MEASURES: As construction is completed, permanent vegetative growth will be established on disturbed soils to improve soil stability and provide a buffer zone for loose material. Paved ditches and flumes will be placed as specified in the ECP to reduce erosion in concentrated flow areas and rip rap will be placed as specified to dissipate flow energy and reduce flow velocity.

IMPLEMENTATION SEQUENCE

Perimeter controls will be installed first. Clearing and grubbing will be performed in 19-acre sections beginning at the BOP and temporary grassing will be installed as needed. Temporary erosion control BMP's will be installed at the drainage structures prior/during construction of the drainage structures. Grading activities will commence at the BOP and proceed towards the EOP, fill slopes will be permanently grassed in stages for fill heights that exceed 5 feet. Base materials will be installed on completed grading sections with the paving to follow.

MAINTENANCE PLAN

All erosion and sediment control practices will be checked for stability and operation following every rainfall but in no case less than once every week. Any needed repairs will be made immediately to maintain all practices as designed. Sediment basins will be cleaned out when the level of sediment reaches 2.0 feet below the top of the riser. Sediment will be removed from behind BMP's when it becomes about 1/3 to 1/2 height of BMP.

Prime Contractor's Signature _____
Date

Printed Name _____
Title

107.22.2--Clearing and Grubbing, Haul Roads, Waste Areas, Plant Sites or Other Areas Occupied by the Contractor. Clearing and grubbing on erodible areas, construction and maintenance of haul roads, plant sites or other areas occupied by the Contractor in connection with the work shall include adequate protection for preventing excessive erodible material from entering water or waterways on land not occupied by the Contractor and preventing dust created by hauling equipment.

Temporary measures shall be employed as necessary by the Contractor from the beginning of the work. These measures may consist of the expeditious use of brush, vegetation or other residue from clearing and grubbing, temporary or permanent terraces, berms, dikes, dams, sediment basins or other effective means of containing sediment. All temporary or permanent erosion control features shall be maintained in an effective manner so long as essential to the abatement of siltation.

After temporary features are no longer useful or needed, such features shall be removed and the area restored or prepared for subsequent work. All temporary protection shall be the responsibility of the Contractor, and measurement for direct payment will not be made unless otherwise provided in the Contract.

Unless otherwise determined by the Engineer from a study of overall job conditions, the exposed surface area of erodible material at any one time on this project shall not exceed 19 acres without prior approval by the Engineer.

In addition to the applicable requirements of the MDEQ, Office of Pollution Control, the burning of waste vegetation resulting from site or right-of-way clearing shall meet the following requirements:

- (a) Starter and auxiliary fuels must not cause excessive visible emissions. Rubber tires, etc. are prohibited.
- (b) The burning must be permitted by local ordinance.
- (c) The burning must be conducted at least 500 yards from an occupied dwelling, but may be reduced to 50 yards if forced draft air is provided for combustion.
- (d) The burning must be conducted at least 500 yards from commercial airport property, private airfields or marked aircraft approach corridors except when a lesser distance is authorized by the airport authority.
- (e) The burning must not produce a traffic hazard.
- (f) Burning will not be allowed during a High Fire Danger Alert issued by the Mississippi Forestry Commission or an Emergency Air Pollution Episode Alert issued by MDEQ , Office of Pollution Control.

In response to the MDEQ concern of the air quality (ground-level ozone) in DeSoto, Hancock, Harrison, Hinds, Madison, Rankin, and Jackson Counties, the Department has agreed to place certain restrictions on open burning of land-clearing debris.

The Contractor is advised that no open burning of land-clearing debris will be permitted to begin during ozone action days as designated by MDEQ. An ozone action day is defined as a 24-hour period when the ozone concentration reaches an unacceptable pre-determined level. Usually, an ozone action day has a duration of one (1) day. It is estimated that 3 to 15 ozone action days could occur from April through October.

During open burning operations, the Project Engineer should check the 1, 2, and 3-day ozone forecasts made available each day by MDEQ on its web site, www.deq.state.ms.us, and should e-mail or FAX the forecasts to the Contractor. The Contractor shall provide the Project Engineer sufficient time to monitor the ozone forecasts prior to commencing any open burning operation. The Contractor cannot begin open burning until the forecast for the next three (3) days are non-ozone action days. However, when the Contractor is permitted to begin open burning, that day's burning shall continue regardless of the ozone forecasts when checked on the following day. For example, if the Project Engineer checks the forecast on Monday morning and finds that Monday, Tuesday and Wednesday are non-ozone action days, the Contractor may begin open burning. If the Project Engineer checks the forecasts on Tuesday and finds that Wednesday has been designated as an ozone action day, the open burning that was started on Monday may continue, but the Contractor cannot begin any new burning until the next 3-day forecasts indicate non-ozone action days.

Restrictions on open burning as set forth above will not be a basis for additional time or compensation.

107.22.3--Pit Operations. The Contractor shall schedule, arrange and conduct pit operations in such a manner that prevents siltation or pollution of ditches, streams, lakes, reservoirs and adjacent property with sediment, fuels, oils or other objectionable materials.

107.22.4--Structures, Grading, and Other Construction. The Contractor shall perform all work required under the Contract in such a manner and with such protective features that controls and contain siltation within the limits of the work. Performance in the designated or directed sequence and the providing of all erosion protection for which pay items are not included in the Contract shall be considered as included in prices bid for other items of work.

The Contractor shall prevent or minimize undesirable siltation in connection with excavation, construction and backfill of structures. Such temporary measures as indicated herein for clearing and grubbing or other measures such as covering of excavated materials, lining channels, constructing bulkheads or other effective measures shall be employed.

The Engineer should limit the areas of excavation, borrow, and embankment operations commensurate with the Contractor's capability and progress in keeping the finish grading, seeding, mulching, and other such permanent erosion control measures current. If seasonal limitations make such coordination unrealistic, temporary erosion control measures may be used to the extent feasible and justified. The exposed surface area of erodible material at any one time for each grading operation should not exceed 19 acres without prior approval by the Engineer.

The Engineer may increase or decrease the areas of erodible material to be exposed at any one time by clearing and grubbing, excavation, borrow and fill operations as determined by analysis of project conditions.

It is the intent of these specifications that the work shall proceed in a manner and sequence to ensure the earliest possible establishment of permanent erosion control items.

107.22.5--Special Temporary Erosion Control. The plans may designate special temporary erosion control work such as fast growing grasses or other designated temporary features for problem areas during grading, paving or other construction work. Unless otherwise provided, quantities for such temporary features shown on the plans will be included in items for which bids are to be received. The Contractor shall perform all designated temporary work as indicated on the plans or provided in the Contract or as directed by the Engineer at the time and in the manner deemed to provide the most effective deterrent to siltation.

Any emergency temporary erosion control will be authorized and used only under conditions or causes created solely by the State or unforeseeable causes beyond the control of the Contractor. The Engineer shall be the sole judge as to the use and payment of emergency temporary erosion control work. Unforeseen special emergency erosion control features not contemplated in the plans or contract documents and determined by the Engineer to be essential for the prevention of siltation and pollution for conditions or causes created solely by the State or unforeseeable causes beyond the control of the Contractor shall be performed as Extra Work.

107.22.6--All Operations. It shall be fully understood that nothing in this subsection shall be construed in any manner to relieve the Contractor from any of the responsibilities for the establishment of permanent roadside development items and other permanent work specified for erosion control in the sequence and manner included in other provisions and requirements of the Contract.

107.22.7--Quarantine Information. At the request of the U. S. Department of Agriculture, plant pest control information concerning domestic quarantines is cited as follows:

The entire state of Mississippi has been quarantined for the Imported Fire Ants. Soil and soil-moving equipment operating in the state will be subject to plant quarantine regulations. In general, these regulations provide for cleaning soil from equipment before it is moved from the state. Complete information may be secured from the State of Mississippi Department of Agriculture and Commerce, Bureau of Plant Industry, P. O. Box 5207, Mississippi State, Mississippi 39762-5207, Telephone 662-325-3390 or United States Department of Agriculture, State Plant Health Director, at 662-323-1291.

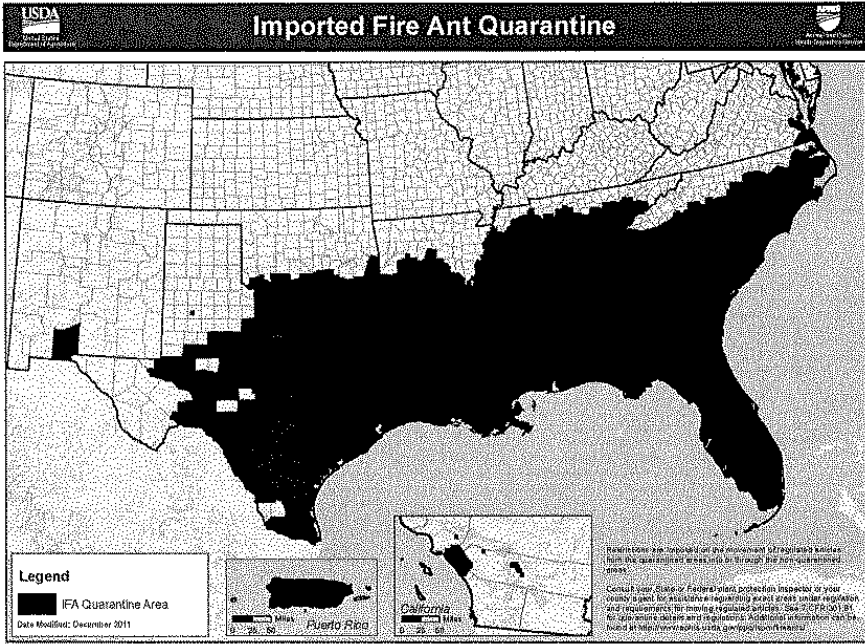
IMPORTED FIRE ANT QUARANTINES

The following regulated articles require a certificate or permit for movement:

1. Soil, separately or with other things, except soil samples shipped to approved laboratories*. Potting soil is exempt, if commercially prepared, packaged and shipped in original containers.
2. Plants with roots with soil attached, except houseplants maintained indoors and not for sale.
3. Grass sod.
4. Baled hay and straw that have been stored in contact with the soil.
5. Used soil-moving equipment.
6. Any other products, articles, or means of conveyance of any character whatsoever not covered by the above, when it is determined by an inspector that they present a hazard of spread of the imported fire ant and

the person in possession thereof has been so notified.

- * Information as to designated laboratories, facilities, gins, oil mills, and processing plants may be obtained from an inspector.



Conditions of Movement.

Counties entirely colored are completely regulated.

■ Regulated Area.

Restrictions are imposed on the movement of regulated articles as follows:
From colored areas into or through other areas.

Contractors should consult their State or Federal plant protection inspector or County Agent for assistance regarding exact areas under regulation and requirements for moving regulated articles. For detailed information, see 7 CFR 301.81 for quarantine and regulations.

107.22.8--Gopher Tortoises. The Contractor will be required to make special considerations regarding gopher tortoises on projects in Clarke, Covington, Forrest, George, Greene, Hancock, Harrison, Jackson, Jasper, Jefferson Davis, Jones, Lamar, Marion, Pearl River, Perry, Smith, Stone, Walthall, and Wayne Counties that require the use of a borrow or disposal land areas. In addition to the normal required documentation associated with borrow pits, the Contractor shall, for each site used to obtain or dispose of materials associated with this project, provide the Engineer with a letter from a qualified biologist certifying that the site was inspected prior to any clearing of vegetation or disposal of project materials and that the site is not inhabited by gopher

tortoises, or appropriate avoidance measures have been installed. No individual lacking the proper State or Federal license shall touch or otherwise harass a gopher tortoise.

107.23--Material Pits. The Contractor is reminded of the Mississippi Surface Mining and Reclamation Act and the Rules and Regulations adopted to implement this act. Questions or problems concerning the Act or the Rules and Regulations should be directed to the MDEQ, Office of Geology, Jackson, Mississippi.

Prior to opening a new pit or enlarging an existing pit, the Contractor will furnish the Engineer either a copy of the "Notification of Exempt Operations" or a copy of the (permanent or temporary) Class II Permit approval from the MDEQ Office of Geology. The Contractor shall also obtain a letter stating that the pit site is satisfactory from an archaeological and historical standpoint from the Mississippi Department of Archives and History, Historic Preservation Division, Jackson, Mississippi. All costs involved in obtaining clearance shall be borne by the Contractor. Delays encountered in obtaining clearance will not be a reason for extension of contract time. This requirement is not applicable to commercial sources.

When the Contract requires the Contractor to dispose of excavated material, the Contractor shall, prior to removal, furnish the Engineer with a copy of a letter from the land owner stating that the Contractor has the right to place material on said property. The Contractor shall also furnish the Engineer with a letter stating that the property is not in a wetland. Delays encountered in obtaining this information will not be a reason for extension of contract time. This requirement is not applicable to commercial sources.

The Contractor is further reminded of and shall comply with the requirements of the Clean Water Act Amendments requiring National Pollutant Discharge Elimination System (NPDES) permits for discharges composed entirely of storm water from active or inactive surface mining operations, excluding work areas covered by a U. S. Army Corps of Engineers Clean Water Act Section 404 Permit. Questions or problems concerning NPDES permits should be directed to the MDEQ, Office of Pollution Control, Industrial Branch, Jackson, Mississippi.

The Contractor shall, before a regulated area is opened or enlarged as a material pit, obtain from MDEQ the necessary Mining Storm Water NPDES Permit(s) authorizing the discharge of storm water subject to the terms and conditions of said permit. The Contractor shall furnish the Engineer a copy of the MDEQ NPDES permit. All costs involved in obtaining the permit(s) shall be borne by the Contractor. Delays encountered in obtaining the permit(s) will not be a reason for extension of contract time.

For regulated commercial sources, the owner(s) shall bear the responsibility for meeting the requirements of the NPDES permitting process.

107.24--Construction Noise Abatement. The Contractor shall comply with all state and local sound control and noise level rules, regulations and ordinances that apply to any work performed pursuant to the Contract.

Each internal combustion engine, used for any purpose on the work or related to the work, shall be equipped with a muffler of a type recommended by the manufacturer. No internal combustion engine shall be operated on the project without such muffler.

107.25--Hazardous and/or Toxic Waste Procedures. No matter how extensive a field investigation, the possibility exists that hazardous and/or toxic wastes on a site will go undetected until excavation is initiated. If underground storage tank (UST), buried containers, hazardous and/or toxic substances are uncovered, or even suspected, during construction, work in this area shall be immediately discontinued and measures taken to protect susceptible nearby wetlands or ground-water sources, and the Engineer shall be immediately notified.

It is essential that the suspected hazardous substances be left in place until they have been identified. The Contractor shall make every effort to prevent the Contractor's personnel, State personnel and the general public from becoming exposed to substances that may be hazardous or toxic. Once contaminated soil or debris has been removed from the ground and leaves the site, it is considered a hazardous waste if the concentration exceeds regulatory levels. In such cases, the Contractor becomes a hazardous waste generator.

Disposition of USTs, containers, hazardous and/or toxic waste shall be in accordance with current rules and regulations of the MDEQ, Office of Pollution Control.

The Contractor shall report to the Engineer and the Office of Pollution Control any evidence or conditions that may cause suspicion that a waste site of hazardous or toxic materials and/or containers or USTs has been located within right-of-way limits of the project. Work shall cease immediately at such suspected site and shall not resume until directed by the Engineer.

When the Contractor is required to perform additional work to dispose of such waste, containers and/or USTs, payment will be made at contract unit prices applicable to the work and/or as provided in Subsection 109.04 when the Contract does not include appropriate pay items.

The Department reserves the right to use other forces for exploratory work to identify and determine the extent of hazardous and/or toxic waste. Should the disposition of such material require special procedures by certified personnel, the Department will make arrangements with qualified persons to dispose of the material.

When the existence of USTs are known in advance of construction activity, the Contractor shall give the Office of Pollution Control written notification 30 days in advance of removal.

When a UST contains or has been used for containment of a regulated substance and the Contractor is required to remove such tank in accordance with the provisions of Subsection 104.05, the Contractor shall not use "flotation" as a method of removal.

SECTION 108 - PROSECUTION AND PROGRESS

108.01--Subletting of Contract.

108.01.1--General. The total value of all work performed by the Contractor's own organization shall be no less than 40 percent of the value of the remaining work after subtracting the Contract value of the specialty items from the value of the original Contract.

The Contractor's "own organization" shall be construed to include workmen employed and paid directly, owned or rented equipment and trucks that are classed as owner-operator.

All items that have been selected as specialty items will be listed as such in contract documents.

The Contractor shall not sublet any portion of the Contract or work provided therein, except the furnishing of necessary materials, without the approval of the Executive Director. Approval to sublet any portion of the Contract or work to a Contractor that the Department refuses to issue a proposal, in accordance with Section 102, will not be granted.

Consideration may be given to requests to sublet a portion of the total value of a contract pay item. When the Contractor proposes to sublet a portion of a pay item, the Contractor's request shall be accompanied by a breakdown of the costs of the various components of each pay item, including haul if applicable, that is proposed to be sublet by part.

Computation of the percentage of the work sublet shall be based on the contract price of each item or in the case of subletting a part of a pay item, the percentage shall be based on the amount acceptably established by the Contractor.

The simple expediency of carrying the workmen of one Contractor on the Contractor's or approved subcontractor's payroll to avoid subcontracting will not be permitted.

If evidence and investigation establish that a violation of the subcontract requirement is being attempted through subterfuge whereby one Contractor's equipment is leased to the Contractor, except as provided in Subsection 108.01.2, or the workmen of one Contractor are placed on the payroll of the Contractor, the Executive Director will take such action as deemed appropriate under the provisions of the Contract and may suspend the bidding qualifications of those found to be in violation for a period of up to one year. This provision does not include the lease or use of equipment from a corporation or company wholly owned by the Contractor.

Subcontracting does not release the Contractor of bond and Contract liability and shall not be construed to imply that a Contract exists between the Department and a third party.

The Contractor must pay subcontractor(s) for satisfactory performance of their contracts no later than 15 calendar days from receipt of payment from the Department. Within 15 calendar days after receiving payment from the Department for work satisfactorily performed, the Contractor shall make prompt payment to all Subcontractors or material suppliers for all monies due. Within 15 calendar days after receiving payment from the Department for work satisfactorily completed, the Contractor shall promptly return all retainage monies due to all Subcontractors or material suppliers. The Engineer may suspend the work wholly or in part and withhold payments because of the Contractor's failure to make prompt payment within 15 calendar days as required above, or failure to submit the required OCR-484 Form, Certification of Payments to Subcontractors, which is also designed to comply with prompt payment requirements.

108.01.2--Work Performed by Equipment Rental Agreement. Work may be performed by equipment operated under Department approved rental agreements independent of the provisions of Subsection 108.01.1.

Trucks that are licensed for operation on the highways of Mississippi are excluded from prior approval of rental agreements under this provision. For other equipment prior approval of a rental agreement shall be obtained in writing before the equipment is used on the work. Consideration for approval will be made by the Resident or Project Engineer, District or Central Office, depending on the nature and scope of the proposed rental agreement and the administrative procedures established by the Department.

At least one of the following qualified conditions is a prerequisite for approval of equipment rental:

- (a) Equipment may be rented from a dealer or firm in the business of selling, renting or leasing equipment when the firm or dealer is not a highway Contractor or Subcontractor. In the event, the dealer or firm is a Contractor or Subcontractor, consideration for approval will be given under one of the subsequent conditions.
- (b) Equipment may be rented from another Contractor provided such Contractor does not have a Contract with the Department or an approved subcontract; or the Contractor or Subcontractor is maintaining satisfactory progress on all work under Contract or subcontract, and the equipment proposed to be rented is not essential to the maintenance of satisfactory progress.
- (c) An occasional piece of equipment may be rented from any party for valid reasons such as breakdown of Contractor owned equipment, temporary need for equipment not normally anticipated for the type of work to be performed or for temporary need for special equipment not normally owned for the type of work involved.

For any work proposed to be performed by rental equipment, the Contractor shall in advance of such use notify the Resident or Project Engineer on the Department's Standard Equipment Rental Request form. The notification shall contain a list and description of equipment, the name of the supplier, the rental rate to be paid, the estimated time use, and the affirmation shown on the form.

In no circumstance shall a Contractor be entitled to any damages for rental or rental rates of equipment where the advanced notification is not given to the Resident or Project Engineer, and the failure to provide the advanced notice shall constitute a waiver of any such claims.

Lease-rental agreements shall provide reimbursement based on time or in the case of trucks: ton, cubic yard, ton-mile, cubic yard-mile, etc. Equipment and operators, if included, shall be under the sole direction of the Contractor in the performance of the work.

If approval has been granted for renting equipment from a Contractor that has work under Contract or subcontract with the Department and the progress on the other work becomes unsatisfactory, the approval shall become null and void. Continued work with the rented equipment shall not be performed except under qualified approval in writing by the Executive Director.

108.02--Notice to Proceed. The Contractor shall not begin construction on any feature of the work before a Notice to Proceed is issued.

The anticipated date of the Notice to Proceed / the Beginning of Contract Time will be specified in the proposal.

If the Department delays the issuance of the Notice to Proceed, the Beginning of Contract Time will be adjusted equal to the number of calendar days of the delay. When the revised date falls on Sunday or a holiday the following day will be the Beginning of Contract Time. The contract time will be extended as provided in Subsection 108.06.

Upon written request from the Contractor and if circumstances permit, the Notice to Proceed may be issued at an earlier date subject to the conditions stated therein. The Contractor shall not be entitled to any monetary damages or extension of contract time for any delay claim or claim of inefficiency occurring between the early issuance Notice To Proceed date and the Notice to Proceed date stated in the Contract.

Failure of the Contractor to commence work by the date specified for the beginning of contract time or within a reasonable time thereafter may be cause for annulment of the Contract.

108.03--Prosecution and Progress.

108.03.1--Progress Schedule. On working day projects, the Department will furnish the Contractor a progress schedule developed for the determination of contract time that may be used as the contract progress schedule, or the Contractor's own proposed progress schedule may be submitted for approval. If the Contractor elects to furnish a progress schedule for approval by the Engineer, it should be furnished promptly after award of the Contract. In the event the Contractor has not submitted an approvable progress schedule by the beginning of contract time, the progress schedule prepared by the Department shall be the acceptable progress schedule and used to assess contract time.

On completion date projects which include A + B projects and on A + C projects, the Contractor shall furnish a progress schedule and be prepared to discuss both its proposed methodologies for fulfilling the scheduling requirements and its sequence of operations.

The Engineer will review Contractor prepared progress schedules and approve schedules as they relate to compliance with the specifications and logic. The progress schedule must be approved by the Engineer prior to commencing work. The progress schedule shall be a computer generated bar-chart type schedule meeting the below minimum requirements. These activities shall be significantly detailed enough to communicate the Contractor's understanding of the construction sequencing and phasing of the project.

An approved progress schedule shall be in effect until the date on which a revised schedule is approved. The approved progress schedule will be the basis for contract time assessment.

When preparing the progress schedule, the Contractor shall include the following:

- A time scale to graphically show the completion of the work within the specified contract time.
- Define and relate activities to the contract pay items.
- All activities in the order the work is to be performed including submittals, submittal reviews, fabrication and delivery.
- All activities that are controlling factors in the completion of the work.
- The time needed to perform each activity and its relationship in time to other activities.

The progress schedule shall provide a bar for each major phase of construction such as, but not limited to, clearing and grubbing, grading, drainage structures, bridges, base, shoulders, paving, etc. with an estimated start working day and completion working day for each bar, all within the specified contract time.

The Contractor will be required to submit monthly progress schedule updates on all projects with a contract time duration of more than eight (8) months.

The Engineer may request the submittal of a revised progress schedule within 10 days of the occurrence of any of the following conditions. If the Contractor fails to submit the requested schedule, the Engineer may withhold the future monthly estimates or portions thereof.

- A major change in the work
- A time extension
- The progress schedule becomes unrealistic

The Engineer's approval of the aforementioned Progress Schedules does not waive any contract requirements.

When a Critical Path Method (CPM) schedule is required in the proposal, this schedule will be used in lieu of the bar graph progress schedule in evaluating work progress. In such case, the same time frame noted in this subsection for the original submittal along with the update requirements will apply.

108.03.2--Preconstruction Conference. Prior to commencement of the work, a preconstruction conference shall be held for the purpose of discussing with the Contractor essential matters pertaining to the prosecution and satisfactory completion of the work. The Contractor in conjunction with the Engineer will schedule the date of the preconstruction conference. The Contractor will advise the Project Engineer in writing as to the date of the conference. When the Contract requires the Contractor to have a certified erosion control person, the Contractor's certified erosion control person must be at the preconstruction conference. The Department will arrange for utility representatives and other affected parties to be present.

If requested by either the Contractor or the Engineer, arrangements will be made for their authorized representatives to inspect the project site with plans in hand and carefully observe pertinent conditions relating to the project, including the status of right-of-way, railroad, utilities and any other special features.

108.03.3--Commencement and Execution of Work. The work shall begin as set out in

the contract documents or approved progress schedule or as directed and shall be prosecuted at the rate necessary to ensure its completion within the contract time. During the progress of the work, the Engineer shall be notified sufficiently in advance of the time the Contractor expects to undertake particular features of construction to permit the required layout and inspection. Should particular phases of the work be discontinued by the Contractor, the Engineer shall be notified at least 24 hours in advance of resuming operations.

All work covered by a Supplemental Agreement shall not commence until the Supplemental Agreement has been properly executed by all parties.

108.04--Limitations of Operations.

108.04.1--General. Work requiring the presence or services of Department personnel will not be permitted on Sunday, New Year's Day, Memorial Day, Independence Day, Labor Day, Thanksgiving Day and Christmas Day, unless otherwise specified in the Contract or the Engineer determines that an emergency or necessity exists. Work on these days, in lieu of supplemental equipment and labor, solely to complete the project within contract time will not be considered a necessity or emergency.

Drainage and minor structures shall be completed ahead of grading to ensure proper setting and curing, thorough compaction of backfill, and improved soil conditions for proper embankment construction.

If the Contractor initiates construction on a greater portion of the work than is necessary for proper prosecution or is carrying on operations to the prejudice of construction already started, the Engineer may require the Contractor to finish the construction in progress before additional portions of construction are started. Work shall be conducted in the manner and sequence necessary to provide for public convenience and safety as set out in Subsection 107.07.

Unless otherwise specified in the contract, lane closures will not be allowed during the following holiday periods.

- Memorial Day -----On the preceding Friday through Memorial Day
- Independence Day -----July 3rd, July 4th, and any adjacent days that fall on a weekend
- Labor Day-----On the preceding Friday through Labor Day
- Thanksgiving-----On the Wednesday before Thanksgiving through the Sunday following Thanksgiving
- Christmas/New Year's ----December 24th through January 1st and any adjacent days that fall on a weekend

108.04.2--Night Work. When early completion of a particular phase of construction is for public benefit or in the case of emergencies, the Engineer may permit construction after daylight hours unless specifically prohibited by the Contract. If night work is permitted, the Contractor shall provide sufficient illumination to satisfy the requirements of Section 680, and the work performed under these conditions shall comply in every respect with the terms and conditions of the Contract.

108.04.3--Temporary Suspension of Work. The Engineer will have the authority to

suspend the work wholly or in part for as long as necessary because of unsuitable weather, unusually heavy traffic, conditions unfavorable for the satisfactory prosecution of the work, failure of the Contractor to carry out instructions or to perform all provisions of the Contract. If it becomes necessary to stop work for an indefinite period, the Contractor shall store all materials so they will not obstruct or impede the traveling public or become damaged in any way. The Contractor shall take every precaution to prevent damage or deterioration of the work, provide suitable drainage of the roadway and erect temporary structures where necessary. An adjustment in contract time, as applicable, will be made for phases of suspended work except during suspension for failure to carry out instructions of the Engineer. Additional compensation will not be paid because of such suspension, except as provided below. The Contractor shall not suspend work without written authority from the Engineer.

If the performance of all or any portion of the work is suspended or delayed by the Engineer in writing for an unreasonable period of time (not originally anticipated, customary, or inherent to the construction industry) and the Contractor believes that additional compensation and/or contract time is due as a result of such suspension or delay, the Contractor shall submit to the Engineer in writing, in accordance with the method set out in Subsection 104.02.4.

108.05--Character of Workers, Methods, and Equipment. The Contractor shall employ competent and efficient laborers, mechanics, or artisans. Whenever an employee is deemed to be careless or incompetent, obstructs the progress of the work, is intemperate, uncooperative or disorderly, the Contractor shall, upon written request of the Engineer, discharge or otherwise remove said employee from the work and shall not reemploy such person without the written consent of the Engineer.

The methods used in performing the construction, and all equipment, tools and machinery, shall be subject to the approval of the Engineer before and during construction. All equipment, tools and machinery used shall be maintained in a satisfactory working condition.

The measure of the capacity and efficiency of machinery and equipment shall be its actual performance on the work. Should it become apparent that the progress of construction is such that the Contractor will be unable to complete the work with the available equipment within contract time, additional equipment meeting the approval of the Engineer may be required.

Permission to use alternative equipment or methods may be granted when it is of a new or improved type, and its use is deemed by the Engineer to be in furtherance of the intent of these specifications. Continued use shall be contingent upon the capability to produce work consistently equal to, or better than, that which can be produced with the equipment or method specified.

Nothing in this subsection shall relieve the Contractor of the responsibility for producing work of the quality specified in the Contract. Should the Contractor continue to employ or re-employ such unsatisfactory person or persons as herein described, fail to furnish suitable and sufficient machinery, equipment or forces for the proper prosecution of the work, all estimates may be withheld until the Engineer's orders are complied with, or the Contract may be terminated as hereinafter provided.

108.06--Determination and Extension of Contract Time.**108.06.1--Based on Working Day Completion.**

108.06.1.1--General. Contract time will be established on the basis of an allowable number of Working Days, as indicated in the Contract. Contract time for A + C projects shall be determined by the Bidder based on the cost to construction the project (A) and the number of working days to complete the project (C). For A + C Contracts, the span of contract time shall be the time between the date of the Beginning of Contract Time and the date representing the number of working days determined by the Contractor to complete the work.

A working day is defined as a day the Contractor worked or could have worked in accordance with the conditions set forth in Subsection 108.06.1.2, Subparagraphs (a) and (b), except during the months of December, January, and February.

During the months of December, January, and February, time will be assessed regardless of whether or not the Contractor actually works. The value for the time on any particular day will be determined by dividing the number of anticipated working day shown in the following table by the number of days in the particular month. This number will be expressed to three decimal places (0.000)

The span of time allowed for the completion of the work included in the Contract will be indicated in the contract documents and will be known as "Contract Time."

108.06.1.2--Contract Time. The following TABLE OF ANTICIPATED WORKING DAYS indicates an average/anticipated number of working days per month.

TABLE OF ANTICIPATED WORKING DAYS

Month	Working Days
January	6
February	7
March	11
April	15
May	19
June	20
July	21
August	21
September	20
October	16
November	11
December	5
Calendar Year	172

NOTE: The above Table is for informational purposes only. The actual working day total as assessed by the Project Engineer on Form CSD-765 shall govern.

On projects other than A + C projects, Available working days will be assessed from the original Notice to Proceed/Beginning of Contract Time date shown in the contract documents, regardless of whether or not the Contractor has been issued an early Notice to Proceed. On A + C projects, available working days will be assessed from the original Notice to Proceed/Beginning of Contract Time date shown in the contract documents, or the earlier Notice to Proceed/Beginning of Contract Time date if an early Notice to Proceed is allowed.

Available working days will be based on soil and weather conditions and other specific conditions cited in the Contract. The Engineer will determine on each applicable day the extent to which work in progress could have been productive, regardless of whether the Contractor actually worked.

An available working day will be assessed as follows:

- (a) any day of the week, Monday through Friday, exclusive of legal holidays recognized by the Department in Subsection 108.04.1, in which the Contractor works or could have worked for more than six (6) consecutive hours on the controlling item(s) of work, as determined by the Engineer from the approved progress schedule. When the Contractor works or could work more than four but less than six consecutive hours, one-half (0.5) of an available work day will be charged for that day. When the Contractor works or could work six or more consecutive hours during the day, one (1.0) available work day will be charged for that day, and
- (b) any Saturday, exclusive of legal holidays recognized by the Department in Subsection 108.04.1, in which the Contractor works for more than six (6) consecutive hours on the controlling item(s) of work, as determined by the Engineer from the approved progress schedule. When the Contractor works less than four consecutive hours during the day, no time will be charged for that day. When the Contractor works more than four but less than six consecutive hours, one-half (0.5) of an available work day will be charged for that day. When the Contractor works six or more consecutive hours during the day, one (1.0) available work day will be charged for that day.

Should the weather or other conditions be such that four (4) consecutive satisfactory hours are not available prior to noon (for daytime operations) or midnight (for nighttime operations), no time will be assessed for that day regardless of the above conditions. However, if the Contractor elects to work, time will be assessed in accordance with the previous paragraph.

Time will not be charged during any required waiting period for placement of permanent pavement markings as set forth in Subsection 618.03 provided all other work is complete except growth and coverage of vegetative items as provided in Subsection 210.01.

Each month the Engineer will complete, and furnish to the Contractor, an "Assessment Report of Working Days" (CSD-765). This report shows the number of working days assessed during the estimate period and the cumulative working days assessed to date. The Contractor should review the Engineer's report as to the accuracy of the assessment and confer with the Resident or Project Engineer to rectify any differences. Each should make a record of the differences, if any, and conclusions reached. In the event mutual

agreement cannot be reached, the Contractor has 15 calendar days following the ending date of the monthly report in question to file a protest Notice of Claim in accordance with the provisions of Subsection 104.02.4. Otherwise, the Engineer's assessment shall be final unless mathematical errors of assessment are subsequently found to exist, and any claim of the Contractor as to such matter shall be waived.

The Contractor's progress will be determined monthly at the time of each progress estimate and will be based on the percentage of money earned by the Contractor compared to the percentage of elapsed time.

The percentage of money earned will be determined by comparing the total money earned to-date by the Contractor, minus any payment for advancement of materials, to the total dollar amount of the Contract. The percentage of time elapsed will be determined by comparing the working days assessed to-date on Form CSD-765 to the total allowable working days for the Contract.

When the "percent complete" lags more than 20 percent behind the "percentage of elapsed time", the Engineer will notify the Contractor that they have seven (7) calendar days to submit a written statement and revised progress schedule indicating any additional equipment, labor, materials, etc. to be assigned to the work to ensure completion within the specified contract time. Failure to submit the revised schedule may result in the withholding of the monthly estimate. When the "percent complete" lags more than 40 percent behind the "percentage of elapsed time", the Contract may be terminated.

108.06.1.3--Extension of Time. The Contractor may, prior to the expiration of the contract time, make a written request to the Engineer for an extension of contract time, in accordance with Subsection 104.02.4, with a valid justification for the request. The Contractor's plea that insufficient time was specified is not a valid reason for extension of contract time.

An extension of contract time may be granted for unforeseen utility delays, abnormal delays caused solely by the State or other governmental authorities, or unforeseeable disastrous phenomena of nature of the magnitude of earthquakes, hurricanes, named tropical storms, tornadoes, or flooded essential work areas that are deemed to unavoidably prevent prosecuting the work.

The span of contract time allowed in the Contract as awarded is based on the quantities used for comparison of bids. If satisfactory fulfillment of the Contract requires performance of work in greater quantities than those set forth in the proposal, the time allowed for completion shall be increased in Working Days in the same ratio that the cost of such added work, exclusive of the cost of work altered by Supplemental Agreement for which a time adjustment is made for such altered work in the Supplemental Agreement, bears to the total value of the original Contract unless it can be established that the extra work was of such character that it required more time than is indicated by the money value.

Any extension of contract time will be on a working day basis.

The Contractor shall provide sufficient materials, equipment and labor to guarantee the completion of the contract work in accordance with the plans and specifications within

the contract time.

If the contract time of the project is extended into a season of the year in which completion of certain items of work would be prohibited or delayed because of seasonal or temperature limitations, the Engineer may waive the limitations provided the completion of the work will not result in a reduction in quality. When determined that the completion of the out-of-season items will cause a reduction in the quality of the work, the completion of the project will be further extended so the items may be completed under favorable weather conditions. In either case, the Engineer will notify the Contractor in writing.

Liquidated damages as set forth in Subsection 108.07 under the heading "Daily Charge Per Calendar Day" in the Table titled "Schedule of Deductions for Each Day of Overrun in Contract Time", shall be applicable to each calendar day after the specified completion date, or authorized extension thereof, and until all work under the Contract is completed.

108.06.1.4--Cessation of Contract Time. When all items of work are complete to the satisfaction of the Engineer and the Engineer has been advised by the Contractor that a final inspection is desired, time will be suspended until the final inspection is conducted and for an additional 14 satisfactory days after the Contractor has been notified in writing of the results of the inspection. If after the end of the 14-day suspension all necessary items of work have not been completed, time charges will resume. If the specified completion date had not been reached at the time the Contractor called for a final inspection, the calendar day difference between the specified completion date and the date the Contractor called for a final inspection will be added after the 14-day period before starting liquidation damages. If a project is on liquidated damages at the time a final inspection is scheduled, liquidated damages will be suspended until the final inspection is conducted and for seven (7) calendar days after the Contractor has been notified in writing of the results of the inspection. If after the end of the 7-day suspension all necessary items of work have not been completed, liquidated damages will resume. When final inspection has been made by the Engineer as prescribed in Subsection 105.20 and all items of work have been completed, the daily time charge will cease.

108.06.2--Based on Specified Completion Date.

108.06.2.1--General. Contract time will be established on the basis of a Specified Completion Date indicated in the Contract, or as determined by the Contractor in accordance with the contract documents. The span of time allowed for the completion of the work included in the Contract will be known as "Contract Time."

For Contracts in which a Specified Completion Date is indicated in the Contract, the span of contract time shall be between the date of the Beginning of Contract Time and the Specified Completion Date indicated in the Contract.

Contract time for A + B projects shall be determined by the Bidder based on the cost to construction the project (A) and the number of calendar days to complete the project (B). For A + B Contracts, the span of contract time shall be the time between the date of the Beginning of Contract Time and the date representing the number of Calendar Days determined by the Contractor to complete the work. The contract time which is determined by the Contractor on A + B projects shall include time for the required waiting periods for placement of permanent pavement markings and all necessary burn-in

periods for electrical items.

The Contractor shall provide sufficient materials, equipment and labor to guarantee the completion of the contract work in accordance with the plans and specifications within the contract time.

At any given date, the ratio of the accumulated monetary value of that part of the work actually accomplished to the total Contract bid amount adjusted to reflect approved increases or decreases shall determine the "percent complete" of the work.

The Contractor's progress will be determined monthly at the time of each progress estimate and will be based on the percentage of money earned by the Contractor compared to the percentage of elapsed time.

The percentage of money earned will be determined by comparing the total money earned to-date by the Contractor, minus any payment for advancement of materials, to the total dollar amount of the Contract. The percentage elapsed time shall be calculated as a direct ratio of the expired Calendar Days to the total Calendar Days provided for in the Contract.

When the "percent complete" lags more than 20 percent behind the "percentage of elapsed time", the Engineer will notify the Contractor that they have seven (7) calendar days to submit a written statement and revised progress schedule indicating any additional equipment, labor, materials, etc. to be assigned to the work to ensure completion within the specified contract time. Failure to submit the revised schedule may result in the withholding of the monthly estimate. When the "percent complete" lags more than 40 percent behind the "percentage of elapsed time", the Contract may be terminated.

108.06.2.2--Extension of Time. The Contractor may, prior to the expiration of the contract time, make a written request to the Engineer for an extension of contract time with a valid justification for the request in accordance with Subsection 104.02.4. The Contractor's plea that insufficient time was specified is not a valid reason for extension of contract time.

On all completion date Contracts, an extension of contract time may be granted for unforeseen utility delays, abnormal delays caused solely by the State or other governmental authorities, or unforeseeable disastrous phenomena of nature of the magnitude of earthquakes, hurricanes, named tropical storms, tornadoes, or flooded essential work areas that are deemed to unavoidably prevent prosecuting the work.

The span of time allowed in the Contract as awarded is based on the quantities used for comparison of bids. If satisfactory fulfillment of the Contract requires performance of work in greater quantities than those set forth in the proposal, the time allowed for completion shall be increased in Calendar Days in the same ratio that the cost of such added work, exclusive of the cost of work altered by Supplemental Agreement for which a time adjustment is made for such altered work in the Supplemental Agreement, bears to the total value of the original Contract unless it can be established that the extra work was of such character that it required more time than is indicated by the money value.

Any extension of contract time will be based on a calendar day basis, excluding

Saturdays, Sundays or legal holidays recognized by the Department in Subsection 108.04.1. Any extension of contract time on A + B Contracts will be based on a calendar day basis, excluding those days in the Contract that restricted the Contractor from working.

If the contract time of the project is extended into a season of the year in which completion of certain items of work would be prohibited or delayed because of seasonal or temperature limitations, the Engineer may waive the limitations provided the completion of the work will not result in a reduction in quality. When determined that the completion of the out-of-season items will cause a reduction in the quality of the work, the completion of the project may be further extended so the items may be completed under favorable weather conditions. In either case, the Engineer will notify the Contractor in writing.

Liquidated damages as set forth in Subsection 108.07 under the heading "Daily Charge Per Calendar Day" in the Table titled "Schedule of Deductions for Each Day of Overrun in Contract Time", shall be applicable to each calendar day after the specified completion date, or authorized extension thereof, and until all work under the Contract is completed.

108.06.2.3--Cessation of Contract Time. When all items of work are complete to the satisfaction of the Engineer and the Engineer has been advised by the Contractor that a final inspection is desired, time will be suspended until the final inspection is conducted and for an additional 14 calendar days after the Contractor has been notified in writing of the results of the inspection. If after the end of the 14-day suspension all necessary items of work have not been completed, time charges will resume. If the specified completion date had not been reached at the time the Contractor called for a final inspection, the calendar day difference between the specified completion date and the date the Contractor called for a final inspection will be added after the 14-day period before starting liquidation damages. If a project is on liquidated damages at the time a final inspection is scheduled, liquidated damages will be suspended until the final inspection is conducted and for seven (7) calendar days after the Contractor has been notified in writing of the results of the inspection. If after the end of the 7-day suspension all necessary items of work have not been completed, liquidated damages will resume. When final inspection has been made by the Engineer as prescribed in Subsection 105.20 and all items of work have been completed, the daily time charge will cease.

108.07--Failure to Complete the Work on Time. When the Contractor fails to complete the work within the time stipulated or as extended under the provisions of the Contract, a deduction calculated from the daily charges listed in the below schedule will be made from money due the Contractor not as a penalty but as liquidated damages. The daily charges set out in the schedule of liquidated damages are based on an approximate average cost to the Department for maintaining Engineers, Inspectors and other employees. The Contractor and the Contractor's Sureties shall be liable for all liquidated damages in excess of money due the Contractor.

Schedule of Deductions for Each Day of Overrun in Contract Time

Original Contract Amount		Daily Charge Per Calendar Day
From More Than	To and Including	
\$ 0	100,000	\$ 150
100,000	500,000	360
500,000	1,000,000	540
1,000,000	5,000,000	830
5,000,000	10,000,000	1,200
10,000,000	20,000,000	1,800
20,000,000	-----	3,500

The applicable daily charge will be made for each calendar day after the expiration of contract time. With the exception of A + B contracts as noted in Subsection 108.06.2.1, daily charges, as shown above, will not be made during any required waiting period for placement of permanent pavement markings as set forth in Subsection 618.03 provided all other work is complete and during specified growth and coverage of the vegetative items as provided in Subsection 210.01.

108.08--Default and Termination of Contract. The Contract may be terminated by the Executive Director for any of the following reasons:

- (a) Failure to proceed with the work when so instructed by the Department or to adhere to the requirements of the Contract.
- (b) Failure to perform the work with sufficient workmen, equipment and materials to assure completion within contract time.
- (c) Performing unacceptable work, or neglecting or refusing to remove materials or to perform anew such work as may be rejected as unacceptable.
- (d) Discontinuing the prosecution of the work.
- (e) Violation of labor provisions and special regulations.
- (f) Becoming insolvent, being declared bankrupt or committing any act of bankruptcy or insolvency.
- (g) Allowing a final judgment to stand unsatisfied.
- (h) Making an assignment for the benefit of creditors.
- (i) Failure for any other cause whatsoever to carry on the work in an acceptable manner.

Before the Contract is terminated, the Contractor and Surety will be notified in writing by either the Project Engineer or the Executive Director of the Department’s intent to declare the Contractor in Default and terminate the Contract. If, for any reason, written notice cannot be delivered to the Contractor, notice of termination may be given by publication in a newspaper in the county in which the project is located. When there is no such newspaper, the notice may be given by publication in a newspaper located in Hinds County. If no satisfactory effort has been made by the Contractor or Surety to correct the conditions enumerated in the notice within 15 calendar days after notice is given, the Executive Director may declare the Contract terminated and notify the Contractor and Surety accordingly.

Upon receipt of notice from the Executive Director that the Contract has been terminated, the Contractor shall immediately discontinue all operations.

After termination, the Executive Director will order the Surety to arrange for the prosecution of the work. If the Surety does not proceed with the satisfactory prosecution of the work within 20 calendar days from the date on which the Contract was terminated, the Executive Director may proceed by either re-advertising and awarding the Contract, or proceed in any other lawful manner that will provide for the completion of the work as planned and set forth in the Contract. The Surety or the Department, at the Surety's expense, will perform or arrange for necessary maintenance between the date of termination and the date that work is resumed. The Surety shall not tender the completion of the Work to the Contractor without the written authorization of the Engineer or the Executive Director.

When the work is finally completed, the total cost to the Department will be computed. If the total cost is greater than the cost that would have resulted at the original contract unit prices, the extra expense will be the responsibility of the original Contractor's Surety. If the total cost is less than the cost that would have resulted at the original contract unit prices, the savings will be paid to the original Contractor's Surety.

108.09--Termination of Contract for Reasons Other Than Default. The Department may, by written notice, with the approval of the FHWA where applicable, terminate any Contract, or any portion thereof for the Department's convenience, when it is determined that a termination is in the best interest of the Department.

Reasons for termination may include, but are not limited to:

- (a) Insufficient funds by the Department due to extenuating circumstances;
- (b) Occurrence of an environmental situation of a significant nature that would require extensive and time-consuming delays in the work for the purposes of identification, evaluation, and possibly mitigation;
- (c) Occurrence of a previously undiscovered error in the bid documents; and
- (d) Any other circumstances the Department determines to be in the best interest of the Department or the public.

In addition to the general reservation of the right to terminate for convenience under this Subsection, the bidding documents may provide for a termination of the Contract for convenience under this subsection upon the occurrence or non-occurrence of a specified event after bid opening.

Under any of the above circumstances for termination, the Engineer will deliver to the Contractor and the Surety a written notice of termination for reasons that will be set forth therein. The notice shall specify the extent to which performance of work is terminated under the Contract and the effective date of termination. Unless otherwise directed by the Engineer, upon receipt of written notice of termination, the Contractor, or its Surety, shall immediately:

- (a) Stop work as directed in the notice;
- (b) Place no further orders or subcontracts for materials, services or facilities except as approved by the Engineer to complete work not terminated;
- (c) Terminate all orders and subcontracts for the terminated work.
- (d) Deliver to the Engineer completed or partially completed plans, drawings, information and other property required to be furnished under the Contract;
- (e) Take actions that the Engineer directs to protect and preserve Contract-related

property that is in the possession of the Contractor in which the Department has or may acquire an interest;

- (f) Provide all other information included in this subsection and as requested by the Engineer; and
- (g) Complete all work not terminated.

If the Department terminates the Contract or any portion thereof before completion of all items of Work in the Contract, the Department will make payment for the actual number of Contract items completed at the contract unit prices and as mutually agreed as provided herein for items or Work partially completed, or will pay on a force account basis, as determined by the Engineer. The Department may, in its discretion, purchase acceptable Materials ordered by the Contractor or delivered to the project site before the date of termination, at actual cost plus delivery cost, including freight, unloading, and hauling unless otherwise provided. The materials will become the property of the Department. The Contractor must submit the proof of actual cost, as shown by receipted bills and actual cost records. If the Engineer does not agree to purchase such materials, the Department may reimburse the Contractor for any reasonable restocking fees and handling costs incurred by the Contractor in returning unused materials to the vendor. If only portions of the work are eliminated, the Department may stop delivery and payment for unnecessary materials. The Department will not pay for loss of overhead or anticipated profits, including anticipated earnings on usage of owned equipment, or impacts, delay, or other direct or indirect costs resulting from the termination.

If the Work is suspended in advance of the termination date, the Department may consider reimbursing the Contractor for such cost items as mobilization, actual idle equipment costs for work stopped in advance of the termination date, and guaranteed payments for land usage as part of the original Contract when not otherwise include in the Contract.

Termination of a Contract or a portion thereof shall not relieve the Contractor of its responsibility for the completed work or work not included in the notice of termination, nor shall it relieve the Surety of its obligation for and concerning any just claims arising out of the Work performed or remaining to be performed. In accordance with Subsection 105.17, the Contractor must submit, within sixty (60) calendar days of the effective termination date, any claim for additional costs as set out above.

108.10--Termination of Contractor's Responsibility. The Contract will be considered complete when all work has been satisfactorily completed, the final inspection made, the work accepted by the Executive Director, and the final estimate paid. When the Executive Director writes the formal letter of acceptance, the Contractor will be released from further obligation except, for any warranty obligations or latent defects within one (1) year of final acceptance, as set forth in the Contract performance and payment bond(s), or as provided by law.

SECTION 109 - MEASUREMENT AND PAYMENT

109.01--Measurement of Quantities. The measurement and determination of quantities for each pay item will be made in general as prescribed hereinafter, and specifically as set out under Method of Measurement and Basis of Payment for each respective pay item. Actual authorized quantities of work, complete and accepted under the Contract, will be

measured by the Engineer according to United States standard measures, and in accordance with well recognized engineering practices. Unauthorized wastage of material will be deducted and only quantities actually incorporated in the completed work or ordered to be wasted will be included in the final estimate.

A station when used as a definition or term of measurement will be 100 linear feet.

Unless otherwise specified, longitudinal measurements for area computations will be made horizontally, and no deductions will be made for individual fixtures having an area of nine square feet or less. Unless otherwise specified, transverse measurements for area computations will be the neat dimensions shown on the plans or ordered by the Engineer.

Where the area unit for measurement and payment is specified for erosion control items, the measurements will be taken on the slope of the ground to compute the actual surface area for payment.

Structures will be measured according to neat lines shown on the plans or as altered to fit field conditions.

All items that are measured by the linear foot, such as pipe culverts, guardrail, underdrains, etc., will be measured as specified under the Method of Measurement for the item unless otherwise shown on the plans.

No payment will be made for unauthorized excavation. Excavation or embankment performed beyond the required neat lines or slope stakes will not be measured for payment unless within tolerances specified or otherwise provided.

In computing volumes of excavation and embankment, the average end area method will be used, unless otherwise specified.

The thickness of plates and galvanized sheets used in the manufacture of corrugated metal pipe, metal plate pipe culverts and arches, and metal cribbing will be specified and measured in decimal fractions of inches as shown in AASHTO M 36 or M 167.

When size number is used in the measurement of wire, it will mean the size number specified in AASHTO M 32.

The term ton will mean the short ton consisting of 2000 pounds avoirdupois. All materials that are specified for measurement by the ton shall be weighed by competent personnel on approved scales set at locations approved by the Engineer or in the case of prepackaged materials, the manufacturer's bag weight may be used. If material is shipped by rail, the car weight may be accepted provided it is the actual weight of material and not minimum car weight used for assessing freight tariff. However, car weights will not be acceptable for material to be used in mixing plants. Trucks used to haul material being paid for by weight shall be weighed empty daily at such time as the Engineer directs, and each truck shall bear a plainly legible identification mark.

Timber, except timber piling, will be measured by the thousand feet board measure (MBM) actually incorporated in the structure. Measurement will be based on nominal widths and thicknesses and the length of each piece.

When a complete structure or structural unit, in effect "lump sum" work, is specified as the unit of measurement, the unit will be construed to include all necessary fittings and accessories.

Volumes of materials computed in cubic yards by the average end area method are designated as "Final Measure" (FM), or "Final Measure - Embankment" (FME). Volumes of materials designated for measurement loose in the vehicle are designated as "Loose Vehicle Measure" (LVM).

Volumetric measurement of excavation, embankment, granular materials or similar materials in cubic yards will be made by the methods designated on the plans or in the proposal. For justifiable reasons, such as impracticability of measurement of volumes (usually small) by the designated method, the Engineer may order measurement by another method as follows:

- (a) Volumes designated for payment by FM may be measured LVM and converted to Contract measurement by multiplying the loose measure by 80 percent.
- (b) Volumes designated for payment by LVM may be measured in its original position by the average end area method and multiply the FM measure by 125 percent.
- (c) Volumes designated for payment by FME may be measured in its original position by the average end area method and multiply the FM measure by 90 percent.
- (d) Small volumes of surplus, excess excavation or other small volumes of excavation that are impractical to measure by the average end area method but are designated to be measured by FME may be measured LVM and multiply the loose measure by 72 percent.

When the Engineer orders the use of a conversion factor for converting a unit of measure, the ordered method of measurement shall be deemed acceptable to all parties and shall be final.

When the average end area method is indicated, other three-dimensional measurements of the prismoid occupied by the material in its natural position before removal or in its final position in the embankment may be used.

When requested by the Contractor, material specified to be measured by the cubic yard or ton may be converted to the other measure as appropriate. Factors for this conversion will be determined by the District Materials Engineer and agreed to by the Contractor. The conversion of the materials along with the conversion factor will be incorporated into the Contract by Supplemental Agreement. The Supplemental Agreement must be executed before such method of measurement is used.

All materials measured by the cubic yard LVM shall be hauled in approved vehicles and verified at the point of delivery. Vehicles may be of any size or type acceptable to the Engineer provided the body is of such shape that the capacity may be readily and accurately determined to the whole cubic yard in accordance with Department SOP. Unless all vehicles on the project are of uniform capacity, each vehicle must be plainly labeled to indicate its measured capacity. Where loose vehicle measurement (LVM) is used, the capacity will be computed to the nearest one-tenth cubic yard and paid to the whole cubic yard. Measurements greater than or equal to nine-tenths of a cubic yard will

be rounded to the next highest number. Measurements less than nine-tenths of a cubic yard will not be rounded to the next highest number. Example: A vehicle measurement of 9.9 cubic yards will be classified as a 10-cubic yard vehicle. A vehicle measurement of 9.8 cubic yards will be classified as a 9-cubic yard vehicle. All vehicles shall be legibly numbered for identification.

The vehicles shall be loaded to ensure a water level load when they arrive at the point of delivery. Loads hauled in unapproved vehicles and loads of a quantity less than the measured quantity for the hauling vehicle will be subject to rejection.

Bituminous materials will be measured by the gallon or ton. Volumes will be measured at 60°F or corrected to the volume at 60°F using tables in Department SOP.

109.02--Scope of Payment. The compensation, as herein provided, constitutes full payment to the Contractor for the complete work and for any and all claims of any type of the Contractor, including, but not limited to, (a) all materials, labor, tools, equipment and incidentals necessary for performing the work contemplated and embraced under the Contract; (b) all loss or damage of any kind arising out of the work; (c) all loss from any action of the elements, except as otherwise provided; (d) any unforeseen difficulties or obstruction of the work that may arise or be encountered during the prosecution of the work until its final acceptance by the Engineer; (e) all risks connected with the prosecution of the work; (f) all expenses incurred by or in consequence of suspension or discontinuance of the work; (g) any infringement of patents, trademarks or copyrights; and (h) completing the work in an acceptable manner according to the plans and specifications.

If the "Basis of Payment" clause for a specific pay item requires that the contract unit price be considered compensation for certain work or material essential to the item, this same work or material will not also be measured or paid for under any other pay item that may appear elsewhere in the specifications.

The payment of any current estimate, prior to final acceptance of the work by the Executive Director, shall in no way constitute an acknowledgment of the acceptance of the work, nor in any way affect the obligation of the Contractor to repair or renew defective parts of the work. The Engineer will be the judge of defects or imperfections, and the Contractor shall be liable to the Department for failure to correct same as provided herein.

109.03--Compensation for Altered Quantities. Whenever the quantity of a pay item is increased or decreased from the original contract quantity, payment will be made on the basis of the actual quantity completed at the contract unit price or as modified by Supplemental Agreement.

109.04--Extra Work. Extra work performed in accordance with the requirements and provisions of Subsection 104.03 will be paid for at the unit prices or lump sum price stipulated in a Supplemental Agreement or a Force Account Agreement authorizing the extra work. All extra work must be authorized prior to proceeding with the extra work, and every effort should be made to foresee the extra work before it becomes an emergency. The Department reserves the right to request a detailed cost breakdown on any request for extra work.

109.04.1--Supplemental Agreement. When the Supplemental Agreement process is initiated, the Contractor will be required to submit to the Engineer a detailed breakdown for Material, Labor, Equipment, Profit and Overhead. The total allowable markup, which includes Contractor and Subcontractor work, if applicable, for Supplemental Agreement work shall not exceed 20%, which also includes tax and bond.

The requirement for detailed cost breakdowns may be waived when a Department's Bid Item History exists for the proposed item(s), and the Contractor's requested price, including mark-up, is within 20% of the Department's Bid History cost for that item(s). In any case, the Department reserves the right to request detailed cost breakdowns from the Contractor on any Supplemental Agreement request.

109.04.2--Force Account Agreement. The Department may direct the Contractor to perform the extra work on a Force Account basis. Work done by Force Account will be handled in the following manner.

The Contractor shall submit a plan of operation for how force account work will be performed including a work schedule, estimated size of the work crew, an equipment list, and anticipated materials. The Department will not allow the Contractor to perform force account work without this plan. The Department will make payments in the manner specified below, and this payment will be full compensation for the prosecution of the work performed on this basis.

- (a) **Labor.** For all authorized labor and foremen employed on the force account work, the Department will pay the actual rate of wage verified by certified payrolls. The wages shall be comparable to the wages paid by the Contractor for work of like nature for each hour that the said labor and foreman are actually engaged in such work, unless otherwise agreed upon in writing before the start of the force account work. Hourly wages for salaried employees will be based on a 40-hour work week.

The Department will allow overtime work only if authorized by the Engineer prior to the start of the force account work.

An amount will be added equal to twenty percent (20%) of the sum thereof

- (b) **Bond, Insurance and Tax.** The Department will pay the actual costs for property damage, liability and workers' compensation insurance premiums, unemployment insurance contributions and social security taxes on the force account work. The Contractor shall furnish satisfactory evidence of the rate or rates paid for such bond, insurance and tax costs.
- (c) **Materials.** For materials accepted by the Engineer and used in the specific force account work, the Department will pay for the actual cost of the materials, including taxes and transportation charges (exclusive of machinery rentals as hereinafter set forth).

If materials used on force account work are taken from Contractor stock, then instead of invoices, the Contractor must furnish an affidavit certifying that the materials were taken from the Contractor's stock, that the quantity claimed was actually used, and that the material and transportation costs claimed represent the

actual costs to the Contractor. The Contractor's authorized representative shall date and sign the statements.

An amount will be added equal to fifteen percent (15%) of the sum thereof.

- (d) **Equipment.** Equipment used for force account work shall be of sufficient size and type necessary to perform the required work in an economic and expeditious manner. The Contractor must provide the manufacturer, make, model, year, type of fuel and other necessary information to determine proper hourly payment rates. Subject to advance approval of the Engineer, actual transportation cost for a distance of not more than 200 miles will be reimbursed for equipment not already on the project.

For equipment authorized by the Engineer for use on the force account work, the Engineer will use the equipment rental rates from the "*Rental Rate Blue Book*" as published on the Equipment Watch website www.equipmentwatch.com for the time period the force account work is authorized to determine payment to the Contractor. The maximum allowable rates are determined as follows:

1. The hourly equipment rate will equal the monthly rate shown divided by 176. The hourly rate is then multiplied by adjustment factors for age and region. Do not use the weekly, daily, or hourly rates shown in the table.
2. The hourly operating cost will be the estimated operating cost shown in the *Rental Rate Blue Book* table. The hourly estimated operating cost shall include all costs associated with routine maintenance and servicing, including but not limited to: fuel, lubrication, filters, blades, belts, pumps, lines, hoses, teeth, tires, tracks and all other incidentals necessary to operate and maintain the equipment. The Department will pay the estimated hourly rates for the actual time that the authorized equipment is in operation. Do not use the weekly, daily, or hourly rates shown in the table.
3. The hourly working rate equals the adjusted hourly equipment rate plus the estimated hourly operating cost which is shown as the total under the FHWA Rate column.
4. The idle or standby rate will equal the FHWA Rate minus the hourly Estimated Operating Costs times fifty percent (50%).
5. These rates include the basic machine plus any necessary attachments.

Idle or standby rates shall apply when equipment is not in operation and is approved by the Engineer to standby for later use to complete the work. In general, idle or standby rates shall apply when equipment is not in use, but will be needed again to complete the work and the cost of moving the equipment will exceed the accumulated standby cost. If the idle standby cost should exceed the equipment moving cost to or from the work site, the Contractor will be entitled to the moving cost only. Idle or standby rates will be used under the following conditions:

1. The equipment is totally dedicated to the force account work and not used intermittently on other work.
2. Idle or standby cost will be considered only after equipment has been operated on force account work.

3. Idle or standby cost will not be paid for more than eight (8) hours in a day or 40 hours in a week.
4. The sum of idle or standby time and operating time shall not exceed eight (8) hours per day.
5. Idle or standby payment will not apply to days not normally considered to be work days such as holidays, weekends, or days of inclement weather when no other work is taking place.

The Department will not pay for idle or standby time when equipment is inoperable, for time spent repairing equipment, or for the time elapsed after the Engineer has advised the Contractor that the equipment is no longer needed. The Department will determine if it will be more cost effective to pay idle time on approved equipment on site or for multiple mobilizations.

If equipment is needed, which is not included in the *Rental Rate Blue Book*, the Department and Contractor will agree upon reasonable rental rates in writing before the equipment is used.

All equipment shall be subject to approval from day to day in accordance with the requirements of Subsection 108.05.

- (e) **Rented or Leased Equipment.** The Department will pay for equipment that is rented or leased from a commercial rental company at actual invoice price, provided the prices are fair and reasonable but not to exceed the *Rental Rate Blue Book's* monthly rates. The Contractor shall obtain competitive rates from multiple rental companies or equipment suppliers to determine the most cost effective rate offering the best value. The Department will determine if it will be more cost effective to leave the equipment on site and pay the invoice price, or pay for multiple mobilizations.

An amount will be added equal to ten percent (10%) of the sum thereof for all costs associated with routine maintenance and servicing, including but not limited to: fuel, lubrication, filters, blades, belts, pumps, lines, hoses, teeth, tires, tracks and all other incidentals necessary to operate and maintain the equipment.

- (f) **Daily Records.** The Contractor and the Engineer, or their representatives, shall compare records at the end of each work day of the work performed and shall indicate agreement by signature on such form(s) provided by the Department
- (g) **Statements.** The Department will not make payment for work performed on a force account basis until the Contractor has furnished the Engineer with duplicate certified and itemized statements of the cost of force account work detailed as follows:
1. Name, classification, date, daily hours, total hours, rate, and extension for each laborer and foreman;
 2. Designation, dates, daily operating and standby hours, total hours, rental rate, and extension for each unit of machinery and equipment;
 3. Quantities of materials, prices, and extensions;
 4. Transportation of equipment and materials; and

5. Cost of property damage, liability and workers' compensation insurance premiums, unemployment insurance contributions and social security tax.

The Contractor shall provide support for all statements with receipted invoices for all materials used, including transportation charges. The Contractor's authorized representative shall date and sign the statements

- (h) **Miscellaneous.** The Department will allow lodging costs only if authorized by the Engineer prior to starting the force account work. Lodging costs must be verified by paid receipts. Costs will not be allowed for meals or travel to and from the jobsite

No allowance will be made for general superintendence, the use of small tools, or any other costs for which no specific allowance is herein provided.

109.05--Eliminated Items. Any item found unnecessary for the proper completion of the work may, upon written order of the Engineer, be eliminated from the Contract. When the Contractor is notified of the elimination of an item, the Contractor will be reimbursed for the actual work and actual costs of materials, which may include delivery and handling costs, prior to the notification as provided in Subsection 104.02.

109.06--Partial Payments.

109.06.1--General. Monthly estimates will be authorized by the Engineer provided the amount due on completed work is no less than \$1,000.00 including advancement on materials. The estimate will be prepared by the Engineer on the day of the month prescribed by the Commission. Partial payment based on estimated quantities and computed at contract unit price will be made on or about the day prescribed by the Commission.

If defective work and/or materials are discovered or reasonable doubt arises as to the integrity of any part of the work for which partial payment has been allowed, a deduction from subsequent estimates in an amount equal to the value of the defective or questioned work will be made until the defects have been remedied or the causes for doubt removed.

Each month the Contractor receives a monthly progress estimate, the Contractor shall review the Engineer's progress estimate as to the accuracy of the quantities. Should the Engineer's estimated quantity for any pay item be greater than a tolerance of plus or minus ten percent ($\pm 10\%$) of the Contractor's estimated quantity, the Contractor shall confer with the Resident or Project Engineer to rectify any differences. Each should make a record of the differences, if any, and conclusions reached. In the event mutual agreement cannot be reached, the Contractor will be allowed a maximum of 30 calendar days following the Contractor's receipt of the monthly estimate in question to submit in writing a Notice of Claim in accordance with the provisions Subsection 104.02.4. Otherwise, the Engineer's estimated quantities shall be considered acceptable pending any changes made during the checking of final quantities.

109.06.2--Advancement on Materials. Advance payment may be received for major, nonperishable or durable materials that will be incorporated permanently into the project, such as base aggregates, reinforcing steel, bridge piling, structural steel, prefabricated bridge components, traffic signal equipment, electrical equipment, fencing materials, and

sign materials with the approval of the Engineer. Advance payment may be requested for structural steel members provided that fabrication has been completed and the members have been declared satisfactory for storage by a Department representative. The Contractor must make a written request to the Project Engineer for advanced payment and furnish written consent of the Surety. To qualify for advance payment, materials must be stored or stockpiled as follows: (a) on or near the project or at other locations approved by the Engineer; (b) in the case of precast concrete members, treated timber, guard posts and other approved preprocessed durable and bulky materials, the materials may be stored at the commercial producer's yard provided it is located in Mississippi; (c) in the case of prestressed concrete members that may require being produced at an out-of-state location, the prestress members shall be produced and may be stored at the commercial manufacturer's yard provided it is a PCI certified plant on the Department's List of Approved Prestress & Precast Plants and located within the continental United States; or (d) in the case of structural steel members that may require fabrication at an out-of-state location, the fabricated members may be stored at the location of the commercial fabricator's yard provided it is located within the continental United States.

Advancements will not be allowed until the Project Engineer has received copies of material invoices and certified test reports or acceptable certificates of conformance, and in the case of materials stored at the commercial producer's/fabricator's yard, the material shall be positively identified for the specific project and a Certificate of Storage issued by the Department or a designated representative of the Department. Requests for advancements on fabricated structural steel members and prestress concrete members stored out-of-state will be denied when the Department does not have available a designated representative to issue a Certificate of Storage.

The Contractor shall make suitable arrangements to the satisfaction of the Engineer for storage and protection at approved sites or, in the case of materials stored at the commercial producer's yard located in Mississippi or, in the case of fabricated structural steel members stored at the commercial fabricator's yard or prestress concrete members stored at a commercial manufacturer's yard located within the continental United States, the Contractor shall make arrangements with the producer/fabricator for suitable storage and protection. If advance payment is allowed and the materials are damaged, lost, destroyed or for any reason become unacceptable, the previous payments will be deducted from subsequent estimates until the materials are replaced or restored to an acceptable condition. In all cases, the Contractor shall indemnify and hold harmless the Commission and Department in the event of loss or damage, regardless of cause.

An invoice or an accumulation of invoices for each eligible material must total \$10,000 or more before consideration will be given for advanced payment. When allowed, advance payment will be based on verified actual material cost plus transportation charges to the point of storage. Sales tax, local haul and handling costs shall not be included as material cost.

Advance payment shall not exceed 100% of the invoice price or 75% of the total contract bid price for the pay item, whichever is less.

Advance payment for a component of a pay item shall not exceed 95% of the invoice price or 75% of the total contract bid price for the pay item of which the material is a part, whichever is less.

No advance payment will be made on minor material items, hardware, etc.

No advance payment will be made for materials when it is anticipated that those materials will be incorporated into the project within 60 calendar days.

Advance payment will be paid for those materials that are not readily available, and that can be easily identified and secured for a specific project and for which lengthy stockpiling periods would not be detrimental.

Where a storage area is used for more than one project, material for each project shall be segregated from material for other projects, identified, and secured. Adequate access for auditing shall be provided. All units shall be stored in a manner so that they are clearly visible for counting and/or inspection of the individual units.

Unless specifically provided for in the Contract, advance payment will not be made on materials stored or stockpiled outside of the State of Mississippi, except for fabricated structural steel members or prestress concrete members.

Materials for which an advanced payment has been allowed must be paid for by the Contractor within 60 days of the estimate on which the advanced payment was first allowed and proof of said payment must be verified by the supplier. If proof of payment is not furnished within the allowable 60 days, the advanced payment will be deducted on subsequent current estimates until such time that proof of payment is furnished.

As the materials are incorporated into the work, proportionate reductions for advance payments shall be made from monthly estimates covering the work performed. Calculation of percentage of completion, or rate of progress, shall be based on completed work and no consideration will be given to stockpiled materials.

109.06.3--Retainage. Regardless of the value of the earned work based on the value of work scheduled for completion by the approved progress schedule, no deduction for retainage will be made from payments and advancement of materials due to the Contractor. Likewise, the Contractor shall not withhold any retainage from any payments due to a Subcontractor or Supplier.

109.06.4--Withholding of Estimates. An estimate may be withheld indefinitely until all directives of the Engineer, given in compliance with and by virtue of the terms of the Contract, have been complied with by the Contractor.

109.07--Changes in Material Costs. Because of the uncertainty in estimating the costs of petroleum products that will be required during the life of a Contract, an adjustment in compensation for certain materials may be allowed if indicated on the bid sheets. If an adjustment is allowed, an adjustment will be provided as follows:

Bituminous Products -- Each month the Department will acquire unit prices from producers or suppliers who supply the State highway construction industry with bituminous products. The average of all quotes for each product will serve as the base price for Contracts let in the subsequent month.

Fuels -- Selected cash price quotations for bulk gasoline and diesel fuel will be obtained by the Department. The appropriate adjustment per gallon for gasoline and diesel fuel

will be added to allow for taxes and markups. The prices thus determined will serve as the base prices for Contracts let in the subsequent month.

Monthly petroleum products base prices will be available on the Department's web site. Current monthly prices will be posted to this web site on or before the 15th of each month. The Contractor should use these petroleum base prices when preparing their bids. The current monthly petroleum products base prices will be acknowledged by the Contractor and become part of the Contract during the execution process.

Monthly Petroleum Products Base Prices can be viewed at:

<http://sp.gomdot.com/Contract%20Administration/BidSystems/Pages/letting%20calendar.aspx>

Each month thereafter the Engineer will be furnished with the current monthly prices. Adjustments for change in cost will be determined from the difference in the Contract base prices and the prices for the period that the work is performed and for the quantities completed. Adjustments may increase or decrease compensation depending on the difference between the base prices and prices for the estimate period.

The adjustments will be determined for the quantities of bituminous products and the average fuel requirements for processing a unit of work as set forth herein.

COST ADJUSTMENT FACTORS FOR FUEL USAGE

<u>Item of Work</u>	<u>Units</u>	<u>Code</u>	<u>Diesel</u>	<u>Gasoline</u>
Excavation & Embankment, Except Structure and Foundation	gallons/cubic yard	(E)	0.29	0.15
Granular Materials, Stabilizer Aggregates or Coarse & Seal Aggregates	gallons/cubic yard	(GY)	0.88	0.57
	or gallons/ton	(GT)	0.62	0.40
Subgrade & Base Mixing Items	gallons/square yard	(M)	0.044	0.028
Asphalt Pavement	gallons/ton	(B)	2.57	0.78
Asphalt Drainage Course	gallons/square yard	(D)	0.49	0.15
Concrete Base & Pavement	gallons/square yard	(C)	0.11	0.15
Bridge Items, Structural Concrete, Pipe Culverts, Including Foundation & Structural Excavation and all other Concrete related items	gallons/\$1000	(S)	11.0	13.0

CONSTRUCTION MATERIALS

The items and quantities subject to compensation adjustment:

ADJUSTMENT CODE

- (A1) Asphalt for HMA mixture -- theoretical gallons based on job mix formula, unit weight of 8.43 pounds per gallon, and new asphalt only for recycled HMA mixture.
- (A2) Asphalt for Surface Treatment -- pay quantity in gallons.
- (A3) Asphalt for Prime -- pay quantity in gallons.
- (A4) Asphalt for Curing Seal -- 0.25 gallons per square yard.
- (A5) Asphalt for Bituminous Treated Roving -- 0.50 gallons per square yard.
- (A6) Asphalt for Asphalt Drainage Course -- theoretical gallons per square yard based on job mix formula and unit weight of 8.43 pounds per gallon.

Any difference between checked final quantity and the sum of quantities shown on the monthly estimates for any item will be adjusted by the following formula:

$$FA = (FCQ - PRQ) \times EA$$

- Where:
- FA = Final Adjustment
 - FCQ = Final Checked Quantity
 - PRQ = Total Quantity Previously Reported on Monthly Estimate
 - EA = Total Adjustment Shown on Monthly Estimate

The final adjustment is to consider any error(s) that may have been made in the computations of monthly adjustments.

The specification for tack coat for Open Graded Friction Courses (OGFC) allows the Contractor several options for OGFC tack coat. Regardless of the tack coat used, the monthly material adjustment will be made using the base and current prices of tack coat Grade PG 76-22.

The specifications allow the use of RC-70, RC-250, RC-800, RS-1, RS-2, MC-30, MC-250, MS-2h, CMS-2h, LD-7, CQS-1h, ETAC-H, NTSS-1HM, and SS-1h, in various other construction operations. If the Contractor uses one of these bituminous materials, the monthly material adjustment will be made using the base and current prices of the materials shown below.

Materials Used	Material Adjustment Made Based on Prices For
RC-70, 250, 800	MC-70
RS-1, 2	CRS-2
MC-30, 250	MC-70
MS-2h, CMS-2h	SS-1
LD-7, CQS-1h, ETAC-H, NTSS-1HM, SS-1h	CSS-1

Adjustments herein provided shall not apply to fuels consumed or materials incorporated into the work during any monthly estimate period falling wholly after the expiration of

contract time as defined in Subsection 101.02 herein, and as determined by checked final quantities.

109.08--Contract Overpayment(s). The Contractor is duly responsible to and will immediately reimburse the Commission, without any demand therefore, for any overpayment(s) of which it has knowledge, or through due diligence, should have knowledge.

If notice is given to the Contractor of any overpayment, and the Contractor fails to make payment within 60 days of the notice, then the Commission may offset and withhold a sum equal to any overpayment(s), plus interest at one percent (1%) per month from the date of notice until paid, against any sums due the Contractor under the terms of this Contract or any other active Contract(s), or any Contract subsequently executed.

109.09--Freight Rates and Labor Rates. No allowance or deduction will be made for increases or decreases in freight rates or demurrage or for any increase or decrease in labor rates unless so stipulated in the Contract.

109.10--Blank.

109.11--Acceptance and Final Payment. When the work has been accepted by the Executive Director, a final estimate showing the value of the work will be prepared by the Engineer as soon as the necessary final measurements and computations can be made. The amount of this estimate, less all previous payments and deductions required under the Contract, will be paid to the Contractor as soon as practicable. Final payment will not be made until written consent of the Contractor and the Surety has been delivered to the Contract Administration Engineer of the Department. It shall be the Contractor's responsibility to have the Surety provide the consent. Delays in final payment because of non-receipt of Surety's consent shall not be cause for the payment of interest under the provisions of Miss. Code Ann. §31-5-27, for the period of time occasioned by such delay.

Acceptance by the Contractor of final payment shall operate as and shall be a release the Commission from all claims or liability under the Contract and any act or neglect of the Commission relating to or connected with the Contract.

However, nothing herein shall release the Contractor from liability for any latent defects subsequently discovered. In addition, the Contractor shall warrant the Work from any defects in Materials or workmanship for a period of one (1) year from final acceptance.

109.12--Right to Audit. The Department reserves the right to audit the Contractor's records at any time during the Contract period, during any claim process, up to three years after the final Contract payment or up to three years after any litigation or arbitration is filed, whichever is later. If the Department commences an audit, the Contractor will be required to provide sufficient original documents and records to satisfy the Department's Audit Division or other appropriate individual, including any outside consultants retained by the Department, that the costs included in the Contractor's claim were incurred and are appropriate for payment under the terms of the Contract and solely in performance of the project and work phase and were not incurred on any other work phase of the project. The Department's audit will be conducted in accordance with United States General Accounting Office's Governmental Auditing Standards, the Institute of Internal Auditor's Professional Practice Standards, and the American Institute

of Certified Public Accountant's Auditing Standards.

SECTION 110 - REQUIRED CONTRACT PROVISIONS

110.01--For Projects Constructed Without Federal Funds.

110.01.1--Statements and Payrolls. The submission by the Contractor of weekly payrolls, or copies thereof, is not required. However, each Contractor and Subcontractor shall preserve weekly payroll records for a period of three years from the date of Contract completion. All Contractor personnel working at the project site will be paid unconditionally and not less often than once a week without subsequent deduction or rebate on any account, except such payroll deductions as are permitted by regulations or law, the full amounts of wages and bona fide fringe benefits due at time of payment.

The payroll records shall contain the name, classification, rate of pay, daily and weekly number of hours worked, itemized deductions and actual wages paid to each employee.

Upon request, the Contractor will make payroll records available at the project site for inspection by the Department Contract Compliance Officer or authorized representative and will permit such officer or representative to interview employees on the job during working hours.

The Contractor and Subcontractors shall submit Form CAD-880, "Weekly Summary of Wage Rates", each week to the Project Engineer. Form CAD-880 is required each week the Contractor or a Subcontractor performs work on the project. The forms may be obtained from the Contract Compliance Officer in the Department's Contract Administration Division. Custom forms, approved by Contract Administration Division, may be used in lieu of CAD forms.

110.02--For Projects Constructed With Federal Funds.

110.02.1--Statements and Payrolls. The Contractor and Subcontractors shall submit weekly copies of all payrolls to the Project Engineer and meet the requirements of U. S. Department of Transportation Form FHWA 1273, on projects constructed in whole or in part with Federal funds.

On Federal-Aid Projects, CAD-880, "Weekly Summary of Wage Rates", CAD-881, "Weekly Statement of Compliance", and certified payroll submissions are required each week the Contractor or a Subcontractor performs work on the project. This is addressed in Section IV of Form FHWA-1273.

When no work is performed on either Federal-Aid or State-Funded Projects, the Contractor should only submit CAD-880 showing no work activities.

The CAD forms may be obtained from the MDOT Contract Administration Division. Custom forms, approved by the Contract Administration Division, may be used in lieu of CAD forms.

The Contractor shall make all efforts necessary to submit this information to the Project Engineer weekly. The Engineer will have the authority to suspend the work wholly or in

part and to withhold payments if the Contractor fails to submit the required information. Submission of forms and payrolls shall be current through the first full week of the month for the estimate period in order for the Project Engineer to process an estimate.

110.02.2--Wage Rates. All persons employed or working upon the site of the work will be paid at wage rates not less than those contained in the wage determination decision of the Secretary of Labor in effect 10 days prior to taking bids.

Regardless of the wage rates listed in the Contract, minimum federal wage rates must be paid.

When a Contract consists of work in two or more counties, workers shall be paid the higher wage rate listed in the Contract regardless of the county in which work is being performed.

110.02.3--Classification. The Department Contract Compliance Officer shall require that any class of laborers or mechanics, including apprentices and trainees, that is not listed in the wage determination and that is to be employed under the Contract, shall be classified or reclassified conformably to the wage determination.

DIVISION 200 - EARTHWORK AND ROADSIDE DEVELOPMENT

SECTION 201 - CLEARING AND GRUBBING

201.01--Description. This work consists of clearing, grubbing, removing and disposing of all items and objects within the limits of the rights-of-way, easement areas or areas shown on the plans or in the contract documents that are not designated to remain or to be removed in accordance with other provisions of the contract. This work shall also include the preservation of all vegetation, objects or materials designated to remain or to be salvaged, and the removal and satisfactory disposal of obstructions and salvageable material when their removal and disposal is not otherwise provided in the contract. The requirements for removal and disposal shall be in accordance with the provisions and requirements of Subsections 104.05 and 107.25, and Section 202.

When the contract proposal does not include an item of clearing and grubbing, the necessary work shall be performed in accordance with this section and will be considered as a subsidiary obligation of the Contractor under other contract items.

201.02--Blank.

201.03--Construction Requirements.

201.03.1--Clearing and Grubbing.

201.03.1.1--General. The Engineer will establish rights-of-way, easements, construction lines and designate all trees, shrubs, plants and items to remain.

It is the intent of these specifications that desirable natural growth within the rights-of-way and easements be preserved where practicable. Undesirable growth and other things that detract from the aesthetic value of the completed work or interfere with construction or future maintenance shall be removed. In areas where desirable natural growth is designated to remain, the Contractor shall thin or trim shrubbery and live trees to the extent consistent with the intent of these specifications. Use of methods or equipment that might mar or destroy vegetation designated to remain will not be permitted.

It shall be the responsibility of the Contractor to consider all rights-of-way agreements with the property owners regarding merchantable timber prior to submitting a bid. Merchantable timber conveyed to the State and required to be removed will become the property of the Contractor unless specifically designated otherwise in the contract documents.

All clearing and grubbing necessary for setting construction stakes shall be completed a satisfactory distance ahead of the grading operations.

201.03.1.2--Clearing and Grubbing. Surface objects, trees, stumps, roots and other protruding or underground obstructions, not designated to remain, shall be cleared and grubbed, including mowing, as required. Undisturbed stumps shall be cut off no more than six inches above the ground line or water level. Undisturbed stumps and non-perishable solid objects that are a minimum of three feet below subgrade or slope of embankment may be left in place when authorized by the Engineer. Stumps and non-perishable solid objects in swampy or wooded areas where mowing is not anticipated

may be authorized to remain, provided they do not extend more than six inches above the ground line or low water level.

The Engineer may also permit sound stumps to remain outside the construction limits where mowing is anticipated provided they are cut off flush with or below the surface of the final ground line.

Except in areas to be excavated, stump holes and other holes from which obstructions are removed shall be backfilled with suitable material and compacted to the satisfaction of the Engineer.

All operations shall be conducted in such a manner as to prevent damage to adjacent property and items that are to remain on the right-of-way.

Burning shall be in accordance with the requirements of Subsection 107.22.2.

If not burned, materials and debris shall be removed from the right-of-way and disposed of outside the limits of view from any public road or facility. Locations for disposal shall be obtained by the Contractor in accordance with Subsection 104.05.

Low hanging tree branches that will interfere with maintenance of the roadside shall be removed, and unsound or unsightly branches on trees or shrubs designated to remain shall be removed as directed. Branches of trees extending over the roadway shall be trimmed to give a clear height of at least 20 feet above the roadway surface. All trimming shall be done by skilled workmen and in accordance with good tree surgery practices. An asphalt base paint or sealer prepared specifically for tree surgery shall be applied to cut or scarred surfaces of trees and shrubs.

201.03.1.3--Clearing and Grubbing of Bridge Sites. When separate and concurrent grading and bridge contracts are to be in progress between the termini of construction, clearing and grubbing of the bridge site shall be the responsibility of the grading Contractor, unless the bridge contract contains a bid item for clearing and grubbing.

When there is not a coincidental grading contract or a bid item for clearing and grubbing in the bridge contract, clearing and grubbing of the bridge sites shall be considered incidental to and included in the price bid for the bridge items.

201.03.2--Random Clearing and Grubbing, and Random Clearing. This work consists of random clearing and grubbing areas designated on the plans or in the contract documents. Random clearing and grubbing will be performed in the designated areas in accordance with the requirements of Subsection 201.03.1.

Random clearing will consist of removing all things such as trees and scrubs within areas shown on the plans or in the contract documents where grubbing is not needed. Examples of such areas may be limits of fencing, site flares, safety zones, etc.

When random clearing is required in areas such as safety/clear zones, cutting shall be approximately flush with the ground. Grubbing will not be permitted in these areas. Stumps are to be cut approximately flush with the ground, but in no case shall stumps extend more than two inches above the ground line. This work also includes the removal and proper disposal of the cut material off of the right-of-way, or it may be chipped or

shredded by mechanical means and mulched on the right-of-way to the satisfaction of the Engineer. Material and debris that is removed from the right-of-way shall be disposed of outside of limits of view from any public road, street, park or other such public facility at locations obtained by the Contractor in accordance with Subsection 104.05 and Section 202.

201.04--Method of Measurement. Any mowing required as a part of the clearing and grubbing, random clearing and grubbing, or random clearing operations will not be measured for payment.

Unless otherwise noted, clearing and grubbing, random clearing and grubbing, or random clearing will be measured as follows.

201.04.1--Lump Sum Basis. The area included under this item will be the entire area within the right-of-way lines shown on the plans. No measurement will be made except when the area of the right-of-way is increased or decreased from that shown on the plans at the time bids are received. In this case, the lump sum contract price will be adjusted in the same ratio that the area of the right-of-way is increased or decreased.

201.04.2--Area Basis. The area included under this item will be measured in acres. Measurement will only be made for the area(s) actually cleared or cleared and grubbed and will not include areas for which payment is made under another item. The clearing of grass, weeds, roots, farm crops, and scattered small bushes will not be measured for payment.

Areas acquired for haul routes, or areas acquired for Contractor use will not be measured for payment, unless noted otherwise in the contract.

201.04.3--Station Basis. The designated areas will be measured per station in accordance with the typical sections shown on the plans. This shall apply to the right or left sides of each separate roadway. Separate measurement shall be made for work required and satisfactorily completed on the right or left sides of each separate roadway.

201.05--Basis of Payment. Clearing and grubbing, random clearing and grubbing, or random clearing, measured as prescribed above, will be paid for at the unit price bid as follows.

201.05.1--Lump Sum Basis. The work under this item will be paid for at the contract lump sum price or adjusted lump sum price in accordance with the above provisions which shall be full compensation for completing the work.

201.05.2--Area Basis. The work under this item, measured as prescribed above, will be paid for at the contract unit price per acre which shall be full compensation for completing the work.

201.05.3--Station Basis. The work under this item, measured as prescribed above, will be paid for at the contract unit price per station which shall be full compensation for completing the work.

The price for clearing and grubbing, or random clearing, shall include the cost of continuous maintenance of traffic and protective services as required by the Traffic

Control Plan included in the contract. This shall include all required individual traffic control.

Payment will be made under:

201-A: Clearing and Grubbing	- lump sum
201-B: Clearing and Grubbing	- per acre
201-C: Random Clearing and Grubbing	- per station or acre
201-D: Random Clearing	- per station or acre

SECTION 202 - REMOVAL OF STRUCTURES AND OBSTRUCTIONS

202.01--Description. This work consists of the removal and satisfactory disposal of all buildings, fences, structures, old pavements, abandoned pipe lines and other obstructions that are not designated to remain or to be removed and disposed of under other provisions of the contract or under separate contracts or agreements as referenced in Subsection 104.05. This work also consists of necessary excavation incidental to the removal of structures and obstructions and backfilling the resulting cavity. Voids created by the removal of, but not limited to, posts, concrete anchors, and footings, shall be backfilled and tamped in accordance with Section 203.

202.02--Blank.

202.03--Construction Requirements.

202.03.1--General. The Contractor shall preserve and protect all structures, fences, public and private utilities and improvements, above or below the ground, that are to remain or be removed by others as set out in Subsection 104.05. Unless specified, removal or adjustment of these items will not be the responsibility of the Contractor. However, the Contractor shall arrange and conduct operations to conform to the requirements set out in Subsections 105.06 and 105.07.

The Contractor shall raze or remove and satisfactorily dispose of all buildings, structures, fences and other obstructions except those items indicated to remain or be otherwise removed and disposed of under other provisions. Basements or cavities left by structure removal shall be filled to the level of the surrounding ground, compacted as directed, or if within the limits of construction, compacted in accordance with Subsection 203.03.

All materials not designated for salvage shall be disposed of by the Contractor in accordance with Subsections 201.03.2 and 104.05.

The use of explosives is not permitted unless approved by the Engineer. Blasting, if permitted, or other operations necessary for the removal of an existing structure or other obstruction that may damage new construction shall be completed prior to constructing the new work. The Contractor shall employ methods of removal that will ensure new work, items to remain or materials to be salvaged will not be damaged. Reference is

made to Subsections 107.11 and 107.12 regarding this work.

202.03.2--Salvage. All material designated for salvage shall be removed, without unnecessary damage, in sections or pieces that may be readily transported. The material shall be stored by the Contractor at designated sites within the project limits or at special locations as designated in the contract.

202.03.3--Removal of Bridges, Culverts and Other Structures. Bridges, culverts and other structures that are in use shall not be removed until the traffic is satisfactorily accommodated.

Unless otherwise directed, existing structures shall be removed to at least one foot below the final ground line or mudline. The removal of a bridge located in a navigable stream shall be subject to the requirements set out in the permit authorizing construction of the new structure.

Unless designated on the plans or in the contract documents to be removed and salvaged, all structural steel, timber and other bridge materials shall become the property of the Contractor. It shall be removed from the site before completion of the work and proper allowance for its value shall be taken into account in the bid price of the item involved. If the structure is to remain the property of the State, steel or timber bridges shall be carefully dismantled without unnecessary damage. Steel members shall be match marked and all salvaged material shall be stored as specified in Subsection 202.03.2.

When required on the plans or in the proposal, concrete that is suitable for riprap shall be salvaged and stockpiled or otherwise disposed of in accordance with Subsection 202.03.5.

All removals shall be in accordance with the provisions of Subsection 104.05.

202.03.4--Removal of Pipe. All pipe lines designated to be salvaged or relaid shall be carefully removed and every reasonable precaution taken to avoid breaking or damaging. Pipes designated to be relaid shall be removed and stored when necessary to prevent loss or damage before relaying. The Contractor shall replace without extra compensation all sections lost from storage or damaged by negligence or improper methods to the extent its reuse is deemed by the Engineer to be unsatisfactory. Pipes not designated to be salvaged or relaid shall be disposed of by the Contractor in accordance with Subsections 201.03 and 104.05.

202.03.5--Removal of Pavement, Sidewalks, Curbs, Etc. When required on the plans or in the proposal, concrete pavement, sidewalks, curbs, gutters, etc. designated for salvage shall be broken into pieces not exceeding 150 pounds and stockpiled at locations designated by the Engineer within the project limits or at special locations as designated in the contract. All non-salvaged materials shall be disposed of by the Contractor in accordance with Subsections 201.03 and 104.05.

202.04--Method of Measurement. Removal of Obstructions will be measured as a unit lump sum quantity and will include all structures and obstructions encountered within the right-of-way and easement areas except items that are to be measured on a unit basis.

Where the proposal stipulates specific items on a unit basis, measurement will be made

by the unit.

The length of pipe removed will be the product of the number of commercial lengths and the nominal laying length.

Traffic stripe removal will be measured by the linear foot from end-to-end of individual stripes. Measurement will be made along the surface of each stripe and will not include nominal skip intervals. Stripes more than six inches in width will be converted to equivalent lengths of six-inch stripe. Legend will be measured for payment by the square foot. When provisions are not included in the contract for legend removal by the square yard, the removal area will be converted to equivalent lengths of six-inch stripe.

202.05--Basis of Payment. Removal of Obstructions will be paid for at the contract lump sum price which shall be full compensation for removing and disposing of the obstructions in accordance with the provisions of the contract.

Specific obstruction items stipulated for removal and disposal under 202-B will be paid for at the contract unit price which shall be full compensation for completing the work.

Payment will be made under:

202-A: Removal of Obstructions - lump sum

202-B: Removal of Item - per each, linear foot, square foot,
square yard, or cubic yard

SECTION 203 - EXCAVATION AND EMBANKMENT

203.01--Description. This work consists of excavation and embankment required for roadways, ditches, channel changes and borrow material, preparation of subgrades and foundations, construction of embankments and other utilization or disposal of materials excavated, and the compaction and dressing of excavated areas and embankments. This work shall also consist of any required site grading in accordance with the details in the plans and/or as directed by the Engineer. The work of excavation for structures is covered separately under Section 206 and not included under this section.

203.01.1--Unclassified Excavation. Unclassified excavation will consist of all excavation materials of whatever character encountered in the work except for those classes of excavation for which separate pay items are provided.

203.01.2--Rock Excavation. When shown as a pay item, rock excavation will consist of material that cannot be excavated without blasting and shall also include large boulders and detached stones having volumes of one-half cubic yard or more. The use of the words "rock," "boulders," "stone," or synonyms of these words appearing elsewhere on the plans, soil profile or these specifications does not imply that these materials may be included under this classification unless so indicated in the contract proposal.

The Contractor shall immediately notify the Engineer when rock excavation is encountered during the progress of the work so the necessary measurements may be made for determining the volume removed.

203.01.3--Muck Excavation. Muck excavation will consist of the excavation, removal and disposal of natural deposits of soils and organic matter in accordance with the provisions of Subsection 203.03.7. Muck excavation shall not be identified by visual means but will be sampled and tested, at a frequency determined by the Engineer, to verify its classification. Muck excavation is defined as a saturated soil having an organic content of at least six percent (6%) as determined by Mississippi Test Method MT-29, or AASHTO T 267.

It is the intent that all areas of muck excavation will be located and defined during the design phase of a project. However, if additional areas of questionable material are found during construction, the material shall be tested to see if it is a saturated soil having an organic content of six percent (6%) or more before it is considered muck. If the material is defined as a muck, based on testing, the method of removal should not be an issue and the material should be paid for as 203-D, Muck Excavation.

Excavated material not meeting the herein established requirements for classification as muck excavation shall be used, measured and paid for under the pay item in which the material is being used.

In extreme cases, in non-organic areas where all efforts to drain the area and/or dry the material have proved unsuccessful, the Project Engineer, in consultation with the District Materials Engineer and District Construction Engineer, shall make the determination as to whether the material will be classified as muck excavation or unclassified excavation.

Removal of muck excavation shall be in accordance with the requirements of Subsection 104.05.

203.01.4--Borrow Excavation. Borrow excavation will consist of approved material required for the construction of embankments or other portions of the work and shall be obtained from approved sources outside the right-of-way except as provided in Subsection 203.03.3. Unless otherwise provided in the contract, the Contractor shall make arrangements for obtaining borrow and pay all costs involved. Contractor-furnished borrow shall meet the requirements of Subsections 106.02.2 and 703.21.

203.01.5--Channel Excavation. When shown as a pay item, channel excavation will consist of excavation and disposal of all material from widening, deepening or straightening of an existing channel, or construction of a new channel. The Contractor shall furnish a disposal area unless otherwise provided in the contract. Material designated as channel excavation and used in the roadbed or other required embankment construction will be measured for payment as channel excavation only.

203.01.6--Excess Excavation. When shown as a pay item, excess excavation will consist of excavation that cannot be satisfactorily used or disposed of within the right-of-way. Exclusive of muck excavation, excess excavation may include any type, kind, or class of excavation that the Engineer determines must be removed from the right-of-way. It will not include any excess caused by the Contractor importing too much excavation from sources outside the roadway structure; in such case, the excess excavation shall be removed from the right-of-way without cost to the State.

Unless otherwise indicated in the contract, the Contractor shall provide a disposal area for

excess excavation.

Removal of excess excavation shall be in accordance with the requirements of Subsection 104.05.

203.01.7--Surplus Excavation. When shown as a pay item, surplus excavation will consist of excavation within the right-of-way that is in excess or unsuitable for embankments but can be satisfactorily used or disposed of within the right-of-way.

203.02--Blank.

203.03--Construction Requirements.

203.03.1--General. Excavation and embankment operations may be started at the location and in the sequence approved by the Engineer when:

- (a) sufficient clearing and grubbing has been completed and accepted;
- (b) the work has been cross sectioned and slope staked;
- (c) installation of required pipes, culverts, and approved backfills are complete;
- (d) the site has been prepared in accordance with these specifications; and
- (e) the Contractor is aware of proper methods of haul and disposal of material.

Excavations and embankments shall be finished to reasonably smooth and uniform surfaces. No material shall be wasted without permission of the Engineer. Excavation operations shall be conducted in a manner that material outside the construction limits will not be unnecessarily disturbed. No excavation or embankment shall be placed while frozen or placed on frozen materials.

Where plating with topsoil is contemplated, either in cut or fill sections, appropriate adjustment shall be made in the graded section during construction so that the finished section after plating will conform to the typical sections shown on the plans.

Unless otherwise specified, rock larger than three inches shall be removed from the roadbed to a minimum depth of eight inches below subgrade and backfilled with material designated on the plans or approved by the Engineer. Care shall be taken that undrained pockets are not left in the surface of rock. Rock removed more than 12 inches below subgrade will not be measured for payment and backfilling in excess of 12 inches will be at the expense of the Contractor. Removal of boulders and subsequent backfilling are excluded from the 12-inch limitation.

Borrow material should not be placed until excavation from the roadway has been utilized as shown on the plans. Excess material determined to have been caused by the Contractor importing too much excavation from sources outside the roadway shall be removed from the right-of-way in accordance with Subsection 104.05 unless permission is given by the Engineer that the material may be disposed of within the right-of-way. In either case, the volume of excess material will be measured by the method deemed most appropriate by the Engineer under the provisions of Subsection 109.01 and deducted from measured quantities. The Contractor shall not excavate beyond the dimensions and elevations established or approved, and no material shall be moved prior to the staking out and cross-sectioning of the site.

If borrow material is to be measured for payment in its original position (FM), the finished borrow areas shall be left in a condition suitable to accurately measure the material used.

Additional requirements shall be those applicable conditions governing the use of local materials as set out in Section 106.

Obliteration of old roadways shall include all operations necessary to incorporate the old roadway into the new roadway or into the surrounding right-of-way in a way that will provide a pleasing appearance from the new roadway. Unless other pay items are provided, roadway obliteration will be paid for as unclassified excavation.

When excavating operations encounter the remains of prehistoric dwelling sites or other artifacts of historical or archeological significance, the operations shall be temporarily discontinued. The Engineer will contact appropriate authorities to determine their significance and appropriate disposition. When directed by the Engineer, the Contractor shall excavate the site in a manner to preserve the artifacts encountered, or aid in the determination of significance and disposition, and when ordered, shall remove them for delivery to the custody of the proper State authorities. Such excavation and removal will be considered and paid for as Extra Work.

If excavation to grade results in a foundation, subgrade, or slope of unsuitable soil, the Engineer may require the Contractor to remove unsuitable materials and backfill to the required grade with approved material. Slides or other soil failures shall be removed by the Contractor unless their removal is waived by the Engineer. The Contractor shall conduct operations in such a way that the Engineer can take the necessary cross sections before backfill is placed.

The Engineer may designate as unsuitable those soils that, at the proper moisture content, cannot be processed to the required density and stability. All unsuitable material shall be disposed of as specified or directed.

When the Engineer orders or the contract requires excavation to be handled more than one time prior to final placement, such as topsoil to be stockpiled and reserved for later use, payment will be made at the contract unit price for the class excavation involved for each handling approved by the Engineer, or it will be paid as another item of work for the final handling when so specified. The topsoil shall be dressed vertically with a dozer or other tracked equipment.

203.03.2--Topsoil. Where the salvaging and stockpiling of topsoil is specified, this operation shall be completed before beginning excavation of the underlying material.

203.03.3--Borrow Excavation from Within the Right-of-Way. When the contract indicates borrow excavation to be paid for as final measure-embankment (FME), the plans may also identify certain estimated excavation volumes by the symbol ESFE (Estimated State Furnished Excavation). Suitable quantities of ESFE may be used by the Contractor without charge in the construction of embankments to be measured FME.

Quantities of ESFE shown on the plans are for the Contractor's information only and may vary or may be varied by the Engineer. The change in quantity shall not be cause for additional compensation.

Excavation designated as ESFE is required to be performed and will not be measured in its original position. ESFE suitable for use in embankment or other features of the work shall be used and will be included in measured quantities of borrow excavation (FME). Any materials indicated as ESFE that are found to be unsuitable shall be removed and disposed of as provided elsewhere in the contract.

203.03.4--Construction of Bridge Approaches. The construction of "spill through" embankments and approaches shall be the responsibility of the grading Contractor. The existence of a separate contract awarded for bridge construction will not alter this responsibility.

The grading Contractor shall construct the bridge approaches to subgrade elevation and extending a minimum of 100 feet from each bridge end as soon as practicable. All bridge end slopes shall be finished to the lines and grades specified except the allowable tolerance for initial construction of bridge end slopes to be paved is plus six inches.

The bridge Contractor shall drive the piling through the fill, complete the end bents, end spans, and slope paving as soon as practicable after the bridge end fills have been placed in order that the grading may be completed by the grading Contractor. The bridge Contractor is responsible for the final shaping of the "spillthrough" embankment for placement of slope paving or riprap.

203.03.5--Excavation Operations. Excavation operations shall be so conducted as to minimize the loosening of materials outside the required slopes or below the indicated grade. No payment will be made for the removal, disposal or replacement of material determined to be loosened or undercut through carelessness or negligence on the part of the Contractor. Neither will payment be made for excavation that is used for purposes other than designated except as provided in Subsection 104.06.

When practicable, excavation and disposal of the material shall be conducted in such a manner that the most suitable material will be placed in the top courses of embankments. Also, adequate drainage that will conform to the finished drainage system shall be maintained.

All earth cut slopes shall be dressed to smooth and uniform surfaces to conform to the specified sections. The allowable horizontal tolerance at subgrade elevation will be five-tenths of a foot. The allowable tolerance from staked cut slopes will be plus or minus five tenths of a foot horizontally for each 10 feet of depth. Allowable vertical tolerances at subgrade elevation shall be in accordance with the tolerances set out in Section 321.

Care shall be taken to avoid overshooting of material when blasting. All rock cut slopes shall be left with a reasonably uniform surface, and all loose, shattered or overhanging rock shall be removed.

203.03.6--Muck Excavation. The depth and width of muck excavation will normally be shown on the plans. The excavation and subsequent basement soil formation shall be completed as soon as practicable in order to obtain maximum consolidation prior to final shaping of the subgrade and subsequent construction of the pavement structure. When directed by the Engineer, other unsatisfactory foundation material beneath or immediately adjacent to the muck shall be removed and disposed of as muck excavation.

Excavation of muck shall proceed ahead of backfilling or embankment operations for the full width and depth shown on the plans or as directed.

Placing of embankment material in the excavated area by backdumping may be permitted when the Engineer determines this method of placement to be satisfactory. In this case, placement shall immediately follow the muck removal, and where deemed desirable, the fill shall be constructed forward in a wedge shape with as much of a surcharge above grade as practicable to afford maximum displacement of the remaining muck. Pressure developed on the advancing toe of the embankment by the displaced muck shall be relieved by excavating and removing the muck. Otherwise, embankment construction shall be performed in accordance with the provisions of Subsection 203.03.8.

The Contractor shall take necessary precautions to ensure that stream channels and drainage ditches will not be filled by movement of muck. Displaced materials adjacent to the roadway shall be leveled or disposed of as specified. In any case, the material shall be left in such a manner that it will not present an unsatisfactory appearance, interfere with essential drainage or prevent proper embankment formation.

203.03.7--Disposal of Unsuitable, Surplus, Channel and Excess Excavation. All material encountered in excavation within the right-of-way that is unsuitable for use in the work shall be removed and disposed of as specified in the contract or as directed. Unsuitable material shall be understood to be any material that, at the proper moisture content, cannot be processed to the required density and stability.

The Contractor will be paid for unsuitable material ordered excavated and disposed of and the required backfill material at the respective contract prices except when the unsuitable material was placed under the contract.

Unless otherwise specified, the Contractor shall provide at no additional costs to the State the location for the disposal of muck and excess excavation and shall furnish the Engineer with two signed copies of the release as provided in Subsection 104.05. Removal of muck and excess excavation shall be in accordance with the requirements of Subsection 104.05.

Surplus excavation as defined in Subsection 203.01.7 shall be used for widening of embankments, flattening slopes or at other locations within the right-of-way for the purpose indicated. If there is more surplus excavation than can be effectively used within the right-of-way, the Engineer may reclassify the excavation as excess excavation as defined in Subsection 203.01.6 when the contract contains a bid item for excess excavation or order its disposal as extra work.

Unless specified for use in embankments, channel excavation may be used to fill old channels when so designated on the plans and to fill washes and gullies or wasted as directed by the Engineer. It shall be spread and leveled or otherwise shaped to blend with the adjacent terrain and shall not obstruct drainage, interfere with the property rights of others or present an unsatisfactory appearance.

203.03.8--Embankment Construction.

203.03.8.1--General. Embankment construction shall consist of constructing roadway

embankments, dikes, placing and compacting of approved material where unsuitable material has been removed, backfilling of structures where not otherwise provided for and placing and compacting embankment material in holes, pits or other depressions. This work shall also consist of preparation of the areas upon which embankments are to be constructed. Only approved materials shall be placed in embankments and backfills. Unsuitable or perishable materials such as rubbish, sod, brush, roots, logs, stumps after removal, heavy vegetation, sawdust, etc., shall not be incorporated in embankments. Rocks, broken concrete, or other solid material shall not be placed in embankment areas where piles are to be driven.

Special materials for inundated areas, filter beds, etc., or special backfill may be specified elsewhere in the contract.

203.03.8.2--Preparation of Embankment Areas. Preparation of embankment areas shall be in accordance with one or a combination of the following procedures:

- (a) All grade points shall be undercut and backfilled with suitable material as directed by the Engineer and compacted to the density for the design soil portion of embankments. The material excavated from the undercut, if suitable, shall be used in other portions of the work. The undercut at each grade point shall be approximately three feet below subgrade. The undercut shall be extended a sufficient distance into the cut to provide an undercut grade at the point of intersection with the subgrade of not less than three feet below natural ground. Approved undercut will be measured for payment as excavation.
- (b) Where an old road surface containing granular materials or surface treatment is less than three feet below subgrade, the old road shall be scarified as directed. The scarified material shall be compacted to the density specified for the design soil portion of the embankment prior to placing additional material.
- (c) Unless otherwise specified or directed by the Engineer, all sod, vegetation and unsuitable soil shall be removed from the surface upon which the embankment is to be constructed when the height of the embankment to subgrade will be three feet or less. The cleared surface shall be thoroughly mixed by plowing, scarifying or disk-harrowing to a depth of at least six inches. The area shall then be compacted to the density specified for the design soil portion of the embankment.

The removed vegetation and unsuitable soil shall be disposed of as directed. No measurement for payment will be made unless the Engineer requires that the material be loaded and hauled for use or disposal in another area. In this case, measurement for payment will be made as provided in Subsection 203.04 and haul will be paid as provided in Section 205. No direct payment will be made for the plowing, scarifying or disk-harrowing.

- (d) In areas where the height of embankment to subgrade is to be greater than three feet, all material determined by the Engineer to be unsuitable as a foundation of the embankment shall be undercut and disposed of as directed. All sod on other areas shall be thoroughly disk-harrowed before construction of the embankment. Approved undercut will be measured for payment as excavation and haul will be paid as provided for in Section 205. No direct payment will be made for the

disk-harrowing.

- (e) Where embankment is to be constructed against existing roadway slopes or on hillsides, the slopes that are steeper than 6:1 shall be continuously benched as the new work is constructed on the slope. Benching shall be of sufficient depth and width to permit operation of the construction equipment. Each horizontal cut shall begin at the intersection of the original ground or slope and the vertical side of the previous cut. Suitable material thus cut out shall be re-compacted along with the new embankment material and will not be measured for payment.

203.03.8.3--Embankment Formation. After the area has been prepared as specified, the embankment shall be constructed in full-width layers parallel to the finished grade.

Except as herein provided, the non-compacted thickness of each layer shall not exceed eight inches and shall be spread, shaped and compacted to the required density and stability. The completed embankment shall conform to the line, grade, and cross-section.

The required stability in embankment construction shall be that which the Engineer determines can be reasonably obtained at the proper moisture content for the material being placed. Sponginess, shoving or other displacement under heavy equipment will be considered prima facie evidence of the lack of stability.

Direct casting or similar methods will not be permitted unless authorized in writing by the Engineer. When direct casting is authorized, all material shall be moved from the point where it is deposited, spread and compacted in uniform layers as specified herein.

203.03.8.4--Basement Soils. Reference is made to Figure 1 at the end of Subsection 101 regarding basement soils. In low, swampy ground that will not support the weight of hauling equipment, the Engineer may permit the bottom portion of the embankment to be built in a uniformly distributed layer of sufficient thickness to support the construction equipment. However, this method will not be permitted in any portion of the embankment within three feet of the subgrade.

Where the embankment material is from an inconsistent soil deposit, construction shall be performed so as to eliminate pockets or strata of varying materials. Each layer shall be disk-harrowed and heavily bladed for its full depth; or moved from its position of deposit by appropriate equipment; or processed by other means to the extent necessary to eliminate pockets or stratification of the embankment materials. The layer shall then be shaped and compacted in accordance with these specifications.

Rock shall be distributed over the embankment area to avoid bridging, nests or pockets, and all voids shall be completely filled with earth or stone fragments and compacted. Where only occasional boulders are encountered, they shall be placed near the outer slopes in lower portions of the embankment.

Where the excavated material consists predominately of rock fragments of sizes that cannot be placed in layers of the thickness specified without crushing, pulverizing or further breaking down of pieces resulting from excavation methods, the material may be placed in layers not exceeding the thickness of the approximate average size of the rocks, but in no case to exceed three feet. The balance of the embankment shall be composed of suitable material placed in layers not exceeding eight inches in loose thickness and

compacted as specified.

203.03.8.5--Design Soils. Reference is made to Figure 1 at the end of Subsection 101 regarding design soils. Each layer of the design soil shall be disk-harrowed and heavily bladed for its full depth, or processed by other approved means to the extent necessary to provide a layer of material reasonably uniform in character. Each layer shall then be shaped and compacted in accordance with these specifications.

203.03.8.6--Backfill and Embankment Formation Adjacent to Structures. Backfilling around structures shall not start until permission has been granted by the Engineer as referenced in Subsection 601.03.6.3. After approval is given to proceed, the work shall be performed under the supervision of the Engineer or the Engineer's designated representative.

Material used shall be suitable material obtained from structure excavation, roadway and drainage excavation or other designated material. The material shall be approved before placement and shall be the best available from the source. It shall preferably be sandy or loamy non-plastic material and free from large lumps, clods, rock or other objectionable matter. Adequate provision shall be made for thorough drainage of all backfilling.

The backfill material shall be deposited in uniform and parallel layers not to exceed eight inches of loose material on each side of box bridges, culverts or other structures. Each layer shall be processed by approved methods for its full depth and to the extent necessary to provide a layer of material reasonably uniform in character and shall be so placed and compacted that drainage of the layer will be away from both the longitudinal and the transverse axes of the structure. In addition, the backfill for abutments, retaining walls, wing walls or other structures or sections thereof shall be built in layers with each layer being constructed for the full length of the unit and special precaution shall be taken to prevent any wedging action against the structure.

The material for each layer shall be uniformly compacted with approved mechanical equipment or self-powered mechanical tampers to not less than the density required in the adjacent embankment. The work shall be conducted so as to form a berm of compacted soil of sufficient width on each side of the structure. The berm at the top of the structure shall be at least six feet in width. The slopes of the backfill shall not be steeper than 2:1 at any point. Unless otherwise specified, backfilling shall continue as applicable to the level of the original ground or to an elevation at least one foot above the top of the structure or to the top of the graded section when less than one foot of cover is provided.

The work shall be conducted in a manner that the Engineer can make the necessary tests for compaction as the work progresses.

The Contractor shall repair, restore with new work or make good without extra compensation all damage to the structure as a result of the backfilling operation.

Payment for this construction shall be included in the contract unit price for the material with which backfill is made.

203.03.8.7--Compaction of Embankments. All embankment material shall be at the moisture content determined to be proper for the particular material being placed so that the resulting work will be both dense and stable.

It shall be the Contractor's responsibility to maintain the proper moisture content during compaction operations and the Engineer may require additional moisture or drying as necessary without additional compensation.

The material shall be compacted until the required density, determined in accordance with Subsections 700.03 and 700.04, has been attained and the embankment is stable.

Acceptance of compaction will be on a lot basis. A lot size will be based on the Contractor's hourly production rate as set out in Department's SOP.

For basement and design soils, the required density shall be 95.0 percent and 98.0 percent, respectively. If a density test is within minus two percent (-2.0%), 93.0 to 95.0% or 96.0 to 98.0%, of the required density, a verification test will be performed and the average of the two tests will be the test value for the lot. The lot shall be rejected if this test value does not meet the required density (95.0 or 98.0%). If the original test value exceeds minus two percent (-2%) of the required density, no verification test will be performed and the lot shall be rejected.

Acceptance of compaction for structural backfill will be considered a separate frame of work. The backfill at each structure up to a depth of five feet will be considered a lot. For long structures, the Engineer may specify that the backfill be divided into smaller lots. Each lot will be divided into four approximately equal sublots with two density tests taken at random on each side of the structure. The single test and the lot average shall conform to the required densities set forth above for basement soils or design soils as applicable.

The Contractor shall make allowance for shrinkage and compaction in the construction of embankment.

203.03.8.8--Tolerances. The tolerances shown below as allowable shall not prevent the work from meeting the requirements of Subsection 105.03.

Allowable vertical tolerances for design soils at subgrade elevation shall be in accordance with the tolerances set out in Section 321.

The allowable horizontal tolerance at subgrade elevation will be five-tenths of a foot. The allowable tolerance from staked slopes on fills will be plus or minus five-tenths of a foot horizontally for each 10 feet of fill height except where surplus excavation is required or permitted by the Engineer for widening embankments or flattening slopes. In these cases tolerances will be modified accordingly.

203.03.9--Site Grading. Site grading shall consist of excavating or shaping foreslopes, backslopes, or areas shown on the plans to the satisfaction of the Engineer. When site grading is performed and the yield of material from shaping the designated area is in excess of the material needed, such material will be removed and disposed of as directed by the Engineer. Payment of removed material will be made at the contract price for the class excavation involved.

Clearing and grubbing, if required, shall be included in the bid item for clearing and grubbing. If no bid item for clearing and grubbing is included in the contract, it shall be

included in the contract unit price for site grading.

The equipment used to site grade shall be capable of grading the site to a uniform and smooth surface as directed by the Engineer.

203.03.10--Maintenance of Earthwork. The Contractor shall satisfactorily maintain all portions of the work until release of maintenance by the Engineer as referenced in Subsections 105.14, 105.15, 105.16 and 107.17. The Contractor shall replace, restore or reconstruct without extra compensation all portions, including materials, determined by the Engineer to have been displaced or damaged due to carelessness or negligence. Carelessness or negligence may include, but not be limited to, improperly maintained; inadequate drainage; failure to remove forms or obstructions; failure to properly prosecute and complete work within the specified time; neglecting to establish erosion control items in accordance with the provisions of Subsection 107.22 and Section 210 or other avoidable causes for displacement or damages.

203.04--Method of Measurement. Items of excavation listed in the proposal will be measured as set forth herein, unless otherwise stipulated.

203.04.1--Unclassified, Rock, Muck, Channel, Excess and Surplus Excavation. These items will be measured by the cubic yard final measure (FM) or loose vehicular measure (LVM) in accordance with Subsection 109.01. The unit of measurement for each item will be shown on the proposal bid sheets. Excavation identified as ESFE will not be measured for payment as excavation except as provided herein.

Excavation identified as ESFE that is unsuitable for placement in the designated roadway prism may be used to construct berms, flatten slopes, wasted on the right-of-way or disposed of by the Contractor off the right-of-way as directed by the Engineer and will be measured for payment under Pay Item No. 203-A, Unclassified Excavation. When the contract does not include a bid price for unclassified excavation, the ESFE will be measured for payment under Pay Item No. 203-EX, Borrow Excavation (ESFE) (FM) (AH), per cubic yard at a unit price equal to 75 percent of the contract unit price for contractor furnished borrow excavation.

203.04.2--Borrow Excavation-State Furnished. Borrow excavation will be measured in accordance with Subsection 109.01 by the cubic yard FM, FME or LVM. The unit of measure will be shown on the proposal bid sheets. When measurement is by FME, it will include excavation identified as ESFE which has been incorporated into the embankment.

203.04.3--Borrow Excavation-Contractor Furnished. Contractor furnished borrow will be measured in accordance with Subsection 109.01 by the cubic yard FME or LVM. The unit of measure will be shown on the proposal bid sheets. When measurement is by FME, it will include excavation identified as ESFE which has been incorporated into the embankment.

Undercut required by the Engineer prior to placement of embankment material that is suitable for placement in other furnished portions of the embankment will be measured for payment as contractor borrow excavation.

Undercut that is unsuitable for placement in the designated roadway prism may be used elsewhere and measured for payment as provided in Subsection 203.04.1 for unsuitable

material identified as ESFE.

203.04.4--Haul. Haul of excavation, when authorized for payment, will be measured in accordance with Subsection 205.04. Unless otherwise provided, haul will not be measured for channel excavation, muck excavation or contractor furnished borrow excavation. Nor will haul be measured for payment of the other excavation items when the pay item description contains the symbol "AH" for absorbed haul.

203.04.5--Site Grading. Site grading, complete and accepted, will be measured by the acre or square yard. Only areas shown on the plans or directed by the Engineer will be considered for measurement of payment.

203.05--Basis of Payment. Excavation items, measured as prescribed above, will be paid for at the contract unit price per cubic yard, square yard or acre, which price shall be full compensation for completing the work.

Payment will be made under:

203-A:	Unclassified Excavation, <u>FM or LVM</u>	- per cubic yard
203-B:	Rock Excavation, <u>FM or LVM</u>	- per cubic yard
203-C:	Blank	
203-D:	Muck Excavation, <u>FM or LVM</u>	- per cubic yard
203-E:	Borrow Excavation, <u>FM, FME or LVM</u> , Class _____	- per cubic yard
203-F:	Channel Excavation, <u>FM or LVM</u>	- per cubic yard
203-G:	Excess Excavation, <u>FM or LVM</u>	- per cubic yard
203-H:	Surplus Excavation, <u>FM or LVM</u>	- per cubic yard

The symbol "AH" may be added to the pay item descriptions as provided in Subsection 203.04.4.

203-I:	Site Grading	- per square yard or acre
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Material Furnished by Contractor:

203-EX:	Borrow Excavation, AH, <u>FME or LVM</u> , Class _____	- per cubic yard
203-EX:	Borrow Excavation, ESFE, FM, AH*	- per cubic yard

* This pay item is not to be included in the plans or contract proposal.

SECTION 204 - GEOGRID REINFORCEMENT OF EMBANKMENT SLOPES AND SUBGRADES

204.01--Description. This work shall consist of furnishing and installing geogrid for reinforcement of embankment slopes and/or subgrades as shown on the plans and in conformance with these specifications.

204.02--Material Requirements. The geogrid shall meet the requirements of Subsection 714.15.

204.03--Construction Requirements.

204.03.1--Preparation of Design Grade of Geogrid.

204.03.1.1--Preparation of Foundation Soil. An embankment site that is to receive geogrid reinforcement upon the foundation soil shall be cleared and graded to establish a relatively smooth surface. Trees and stumps are to be cut off at the ground line and sawdust or sand placed over these areas to provide a cushion for the geogrid.

204.03.1.2--Preparation of Basement Soils. An embankment that is to receive geogrid reinforcement located within the basement soil portion of the embankment shall be brought up to the proper grade as shown on the plans and compacted to the required density. The surface shall be left rough so as to provide for a good bond with the next embankment lift above the geogrid.

204.03.1.3--Preparation of Design Soils or Subgrades. A design soil or subgrade that is to receive geogrid shall be shaped and compacted to the required density thus providing a smooth finish, free of loose material and sharp objects.

204.03.2--Geogrid Installation. Geogrid shall be placed coincidentally with the compacted lift nearest the design elevation shown on the plans. No partial or half-lift thicknesses are required; however, at no time shall the placement elevation deviate by more than one foot from the design grade.

Correct orientation of the geogrid shall be verified by the Engineer.

Geogrid shall be secured in-place to prevent movement while being covered.

204.03.3--Overlaps and Joints.

204.03.3.1--Uniaxial Geogrids. Uniaxial geogrid shall be placed in continuous longitudinal strips in the direction of main reinforcement and adjacent strips do not need to be overlapped. However, if the Contractor is unable to complete a required length with a single continuous length of geogrid, a joint may be made with the Engineer's approval. This joint shall be made for the full width of the strip by interlacing over and under the main reinforcing strands using a solid rod or hollow pipe of similar material and strength. No end joints will be allowed in any two adjacent strips or within 10 feet of the face of the embankment or, in the case of a spill through slope, in front of the abutment. In the event that the length of geogrid reinforcement is greater than the roll length, then end joints will be allowed in adjacent strips, but they cannot be within 75 feet of one another as measured along the length of the strip. Every effort should be made to

keep the number of end joints to a minimum and widely spaced throughout the placement area.

204.03.3.2--Biaxial Geogrids. Biaxial geogrids shall be overlapped three (3) feet between adjacent strips and four (4) feet at the ends except where otherwise noted on the plans and/or in the contract documents.

204.03.4--Placement of Fill over Geogrid. Fill placement shall conform to the requirements of Section 203. Extreme care shall be taken to prevent slippage of the geogrid during fill placement. The fill shall be back dumped and spread on the geogrid in uncompacted lifts of at least six (6) inches before equipment is allowed to continuously operate over it. At no time will tracked equipment be allowed to operate directly upon the geogrid. Rubber tired equipment will be allowed to pass over uncovered geogrid at speeds of less than 5 mph as directed by the Engineer. Any geogrid damage caused by fill placement or equipment movement over the geogrid will be uncovered and repaired as directed by the Engineer at no additional cost to the State.

204.04--Method of Measurement. Geogrid of the type specified will be measured by the square yard of surface area covered. Any overwidth of geogrid installed and additional material required for laps or damage repairs will not be measured. No separate payment shall be made for shipping, handling, storage, protection, fabrication, securing pins or installation, the cost of which shall be included in the contract price for geogrid.

204.05--Basis of Payment. Geogrid, measured as prescribed above, will be paid for at the contract unit price per square yard, which price shall be full compensation for furnishing and placing the geogrid, pins, lapping, joints, repairs, maintaining the geogrid until covered, and satisfactorily completing the work.

Payment will be made under:

204-A: Geogrid, Type _____ - per square yard

SECTION 205 - HAUL

205.01--Description. When the contract contains a pay item for haul, it shall consist of transporting excavated material from its original position to its final location in the work. Haul is designated as Haul of Unclassified Excavation and Haul of Classification Excavation.

205.02--Blank.

205.03--Blank.

205.04--Method of Measurement. Haul of excavation will be measured for payment only when the bid proposal contains a pay item for haul. The pay item will identify the excavation item for which haul is to be measured.

Haul will be measured on a distance-volume or distance-weight basis. The distance being 100-foot stations measured along the stationed control line of the project, and the volume or weight measured in the same manner as the excavation item.

In computing haul, it will be assumed that excavated material, including structure excavation, will be hauled the minimum distance and placed in the nearest embankment unless otherwise specified or directed. Cross-haul, when specified or directed by the Engineer, will be measured for payment.

Haul will be computed by multiplying the units of excavation by the average distance it is hauled.

When excavation is shown on the plans and in the proposal to be measured FM, computation of haul will be based on balanced final excavation and embankment quantities determined from final cross-sectional measurements.

A balanced section will be considered as being between two points across which no excavation is hauled. A shrinkage factor will be determined for each balanced section to convert each embankment quantity to the excavation quantity required to construct the embankment.

The center of volume for the cut will be the point where the accumulated yardage equals one-half the total excavation, and the center of volume for the embankment will be the point where the accumulated yardage equals one-half the total embankment. Within each balanced section, the average haul will be computed along the control line of the project as the distance between the center of volume for the excavation in its original position and the center of volume for the corresponding embankment in its final position.

Embankment and excavation will be considered in sections not exceeding approximately 1,000 feet in length. The center of volume of each section will be determined as set out in the previous paragraph and used in determining the average haul distance.

Structure excavation used in construction of embankments will be included in the excavation quantities of each balanced division, and haul thereof will be determined as set out above.

When the plans and proposal provide for haul of excavation measured as plan haul distance (P.H.D.), the final quantity for Haul of Excavation will be adjusted proportionate to the increase or decrease in the total excavation quantity determined from final cross-sectional measurement of accepted work.

205.05--Basis of Payment. Haul of excavation, measured as prescribed above, will be paid for at the contract unit price per station yard, which shall be full compensation for completing the work.

Payment will be made under:

- 205-A: Haul of Unclassified Excavation, FM or LVM - per station yard
- 205-B: Haul of Classification Excavation, FM, FME or LVM - per station yard
- 205-C: Haul of Classification Excavation, FM, FME or LVM, PHD - per station yard

SECTION 206 - STRUCTURE EXCAVATION FOR CONDUITS AND MINOR STRUCTURES

206.01--Description. This work consists of the removal of material necessary for the construction of foundations for box culverts, box bridges, underdrains, pipe culverts and headwalls, and other minor structures when authorized by the section covering their construction. It shall also include all necessary pumping, bailing, drainage, cribbing or sheeting, other foundation work, and the backfilling and proper disposal of all excavated material as directed. Unless otherwise specified, excavation for pipe used as sidedrain will not be measured as structure excavation.

206.02--Blank.

206.03--Construction Requirements.

206.03.1--Excavation. No excavation shall be made until the Engineer has cross sectioned and staked out the work. The Contractor shall exercise care to ensure that the adjacent natural ground is not unnecessarily disturbed or the foundation loosened below the bottom of the footing unless additional excavation is required.

When the plans indicate or the Engineer directs removal of material classified in the contract as muck excavation or special excavation, the undercut shall be made and the area backfilled approximately one foot above the flow line of the structure and compacted to the required density before structure excavation is performed.

Foundation areas shall be excavated to the footing elevations and dimensions shown on the plans or as established. The right is reserved to make adjustments in the location or flow line to provide adequate drainage and to make dimension changes in the footings to obtain a satisfactory foundation.

In addition to the requirements of this subsection, excavation for pipe culverts will be performed in accordance with Subsection 603.03.

Material encountered that is unsuitable for a stable foundation shall be excavated and backfilled as provided in Subsection 203.03.

206.03.2--Backfill. All backfilling shall be in accordance with the requirements and provisions of Subsection 203.03.

When the plans indicate or the Engineer orders removal of unsuitable material or other undercut below the normal grade line to provide a satisfactory foundation and further orders a specified depth of select material that may not be available from within the right-of-way or easement areas, the Contractor shall furnish a suitable backfill material such as sand, gravel, or other similar granular materials.

206.04--Method of Measurement. Structure excavation acceptably performed will be measured as set forth herein.

For structures other than pipe culverts, the area to be included in the measurement of structure excavation will be that area bounded by vertical planes one foot outside of the neat lines of the footing.

For pipe culverts, the vertical planes will be one foot each side of the nominal inside diameter of the pipe or less for tile and pipe underdrains if indicated on the plans. The length to be allowed will be one foot beyond each end of the pipe, except when the pipe is joined to another structure for which payment for structure excavation will be made. In this case, the length will be limited to the point of intersection of the centerline of the pipe with the boundary of structure excavation of joining structures.

The depth allowed will be that actually removed between the natural ground line or the bottom of the graded section, whichever is lower, and the bottom of the footing or the bottom of the trench in the case of pipe. Measurement will not be made for excavation beyond the neat lines described which are made for the convenience or necessity of the Contractor's operation.

The volume of structure excavation allowed for payment will be the summation of the products of the widths, depths and lengths described.

In case the Engineer orders additional excavation for foundation improvement below the depth indicated herein, this excavation within the designated neat lines will be measured as structure excavation.

Unless otherwise specified, selected backfill material shown on the plans or directed by the Engineer to be produced from an area to be excavated under one of the classes of excavation set out in the contract will be measured and paid for under the applicable item of excavation.

Any special ordered (select) material that is produced from excavation identified on the plans as E.S.F.E. will be measured for payment as contractor furnished select material. Select material ordered or authorized by Engineer to provide a satisfactory foundation for structures and conduit will be measured by the cubic yard (FM). Contractor furnished materials such as sand, gravel, granular materials, timber, etc. for backfilling will be paid at the contract unit price of the material used or as extra work in accordance with Subsection 104.03 when the pay item for select material for undercuts is not set up in the contract.

Haul necessary to supply the selected material, other than Contractor-furnished, will be measured as set out in Section 205.

No measurement will be made for water or other liquids removed.

206.05--Basis of Payment. Structure excavation, measured as prescribed above, will be paid for at the contract unit price per cubic yard which price shall be full compensation for the work.

Special materials and/or methods of strengthening the foundation, ordered by the Engineer, will be paid for at the contract unit price for the material used; or, when no unit price is included in the contract, the work will be paid for as Extra Work in accordance with Subsection 104.03.

Payment will be made under:

206-A: Structure Excavation	- per cubic yard
206-B: Select Material for Undercuts, Contractor Furnished, FM	- per cubic yard

SECTION 207 - SETTLEMENT PLATE

207.01--Description. This work consists of furnishing all labor, materials, equipment, and services necessary to install, protect, maintain, and monitor settlement plate(s) in order to determine and report total embankment settlement. Monitoring shall consist of the surveyed elevation of the top of the vertical interior standpipe at monitoring and reporting increments determined by the rate of embankment construction and/or the time increment specified on the site specific construction plans and guidelines, as compared to the initial baseline survey to determine the total recorded settlement.

207.02--Materials. The required material lengths and quantities are the responsibility of the Contractor based on the embankment total height, plus surcharge height, if required, plus stick-up. The Contractor shall be responsible for verification of ground line at the time of construction and adjustment of quantities, as needed.

207.02.1--1-Inch Diameter Steel Pipe and Couplings. Pipe shall be 1-inch diameter, ASTM A53, Schedule 40, black, threaded end, steel pipe with compatible steel couplings.

207.02.2--2-Inch Diameter Steel Pipe and Couplings. Pipe shall be 2-inch diameter, ASTM A53, Schedule 40, black, threaded end, steel pipe with compatible steel couplings.

207.02.3--Steel Plate. The steel plate shall be a minimum ½-inch thick by 2-foot by 2-foot ASTM A53, steel plate.

207.03--Construction Requirements.

207.03.1--Installation. The settlement plate(s) shall be assembled and placed at the locations shown in the plans or as directed by the Engineer. Each settlement plate shall be placed on a level ground surface at or near the existing ground surface, subsequent to stripping, clearing and grubbing operations in preparation for embankment construction.

Field weld-all-around a 1-inch threaded coupling to center of steel plate using a ¼-inch single bevel weld. Sections of the 1-inch and 2-inch steel pipe shall be added incrementally as the fill height is increased to maintain a 2-foot to 4-foot extension of the steel pipe above the embankment fill level at all times. The 1-inch diameter steel pipe shall be centered within the 2-inch diameter pipe to prevent any interference of movement between the two pipe sections and extend vertically at least 6-inches (or the estimated design settlement depth) above the 2-inch pipe. The 2-inch diameter steel pipe shall begin at an elevation approximately six inches (6") above the elevation of the steel plate.

In the event that damage to the settlement plate(s) occurs as the result of the Contractor's operations and it is deemed by the Engineer to be unusable, the Contractor will be

responsible for replacing or repairing the settlement plate(s) to the satisfaction of the Engineer at no additional cost to the State.

207.03.2--Monitoring. Monitoring of the settlement plate(s) will be done weekly commencing immediately after each settlement plate is set and shall continue until a 180-day waiting period is completed. The 180-day waiting period does not begin until the surcharge construction is complete. The data shall be reported weekly to the Project Engineer for review. The data from the settlement plate(s) shall be forward to the Geotechnical Engineer, with copies to the Project Engineer, every 30 days for evaluation. Monitoring shall be performed from an established survey location outside the limits of anticipated settlement.

207.04--Method of Measurement. Settlement plate, complete and accepted, will be measured per each. No separate payment will be made for maintaining, monitoring or reporting the settlement plate(s) data for the 180-day waiting period. Cost associated with maintaining, monitoring, and reporting settlement plate(s) data shall be included in the cost of the settlement plate.

207.05--Basis of Payment. Settlement plate, measured as prescribed above, will be paid for at the contract unit price per each, which shall be full compensation for furnishing labor, materials, equipment and services necessary to install, maintain, and monitor each settlement plate.

Payment will be made under:

207-A: Settlement Plate - per each

SECTION 209 - GEOTEXTILE STABILIZATION

209.01--Description. This work consists of furnishing and installing geotextile for stabilization of embankments and subgrades as shown in the plans and in conformance with these specifications.

209.02--Materials. The geotextile and incidental materials for this work shall meet the requirements of Subsection 714.13.

209.03--Construction Requirements. A subgrade that is to receive geotextile shall be shaped and compacted to a smooth finish and free of loose material and sharp objects. An embankment site shall be cleared and graded to establish a relatively smooth surface. Trees and stumps are to be cut off at ground line and sawdust or sand placed over these areas to provide a cushion for the geotextile.

The geotextile shall be placed as smooth as possible and free from tension, stress, folds, wrinkles or creases.

Where more than one layer of geotextile is required, all joints of the bottom layer shall be sewn to develop the required geotextile strength perpendicular to the joint. The top layer and single layer installations of geotextile may be overlapped a minimum of two feet at each joint or sewn.

Geotextiles that weigh less than eight ounces per square yard shall be factory or field sewn with a "J" type seam. Heavier weight geotextiles shall be factory sewn with two parallel bag type seams approximately one-fourth inch apart or field sewn with an additional seam zigzagged across the two parallel seams.

Securing pins with washers shall be inserted along a line through the mid-point of any overlap or sewn seam at intervals required by the Engineer to prevent movement of the geotextile until covered.

The subsequent course of material shall be back-dumped in such a manner as to avoid damage to the underlying geotextile. No equipment will be allowed to operate over the geotextile until it is covered with a layer of material of sufficient thickness to protect the geotextile installation. When the underlying soil is very unstable, the two outer one-third portions of an embankment layer shall be placed approximately 25 feet in advance of the center one-third portion to prevent excessive mudwave movements and damage to the geotextile installation.

The Contractor shall provide equipment necessary for placing the geotextile in the position and location as detailed on the plans.

The geotextile shall be protected from contamination and damage during installation and placement of the specified cover material. Contaminated geotextile shall be replaced, and damaged geotextile shall be repaired or replaced as directed at no cost to the Department.

The geotextile shall be covered with a layer of the specified material within 14 calendar days after placement. Geotextile not covered within this time period shall be removed and replaced at the Contractor's expense.

209.04--Method of Measurement. Geotextile stabilization, placed in accordance with these specifications and as directed by the Engineer, will be measured by the square yard of surface area covered. Any over width of material installed and additional material required for laps or sewing will not be measured.

209.05--Basis of Payment. Geotextile stabilization, measured as prescribed above, will be paid for at the contract unit price per square yard, which price shall be full compensation for furnishing and placing the geotextile, pins, lapping, sewing, maintaining the geotextile until covered, and satisfactorily completing the work.

Payment will be made under:

209-A: Geotextile Stabilization, Type _____, AOS * - per square yard

* When not designated, see 714.13.

SECTION 210 - ROADSIDE DEVELOPMENT

210.01--General Provisions. Where the term "plant establishment" is used, it shall be understood to mean the work and time necessary to provide fully established, healthy vegetation.

Where the term "dormant" is used, it shall be understood to mean the temporary inactive stage of a living plant or seed. When the term "dormant season" is used, it shall be understood to mean a period of time during the year when germination and growth is not expected. It shall be further understood that the limits of the dormant season for each kind of plant shall be determined by the State Roadside Development Manager or authorized representative.

Planting and establishment of vegetation shall be performed at the earliest practicable time consistent with other operations to provide that the maximum permanent or temporary vegetation is established as quickly as possible.

The Contractor shall schedule work so finishing of all areas requiring vegetation can begin as soon as practicable. Finishing of such areas and the planting shall progress at the same rate as the work. The Contractor shall perform plant establishment throughout the life of the contract.

The Contractor, upon written notification by the Engineer of noncompliance with the preceding two paragraphs, will have 48 hours, excluding Sunday, to correct the situation and comply with the specifications.

Upon failure of the Contractor to comply with the written notification, the Engineer will suspend any or all operations in progress as deemed necessary to ensure compliance and may deduct from all subsequent estimates an amount equal to 30 percent of the value of all erosion control items completed between the suspension date and subsequent date of compliance. By execution of the contract, the Contractor agrees that such deduction will not be made as a penalty but as agreed reduction in pay for deficient performance by having failed to provide the Department with the maximum possible ground cover as intended under the contract.

The requirements for growth and coverage for each kind of plant in its dormant season may be waived in areas in which planting, plant establishment, and maintenance have been performed in accordance with the requirements of the Contract, provided at least one kind of plantings that is not in its dormant season shows satisfactory growth and coverage.

When contract time has expired and all work under the contract has been completed except for the specified growth and coverage of vegetation, liquidated damages will not be charged provided the Engineer's diary documents that the following conditions have been met:

- (a) The Contractor has complied with all instructions of the Engineer with regard to plant establishment, including but not limited to watering, replanting, mowing, and other work specified for plant establishment; and
- (b) The work is deemed to be in a satisfactory state of maintenance, or every reasonable effort is being made to provide satisfactory maintenance.

When any of the conditions for waiver of liquidated damages have not been met, liquidated damages will be charged until the conditions are met or until release of maintenance, whichever occurs first.

Some contracts may require that planting of trees and shrubs or other plantings be

completed by a specified date because of seasonal requirements for their planting. In the event the Contractor fails to complete these plantings within the specified period and must wait until the next season, liquidated damages will be charged after the specified completion date until completion of all plantings as specified and all other work under the contract is completed, except when the Engineer attests that all other work is completed; all the work is in a satisfactory state of maintenance; and the only remaining work which can be performed under the contract is continued plant establishment, only one-seventh of the specified deductions for liquidated damages will be made.

SECTION 211 - TOPSOILING

211.01--Description. This work consists of, furnishing if specified, excavating, stockpiling if necessary, transporting, spreading, compacting, and finishing topsoil as specified or directed.

211.02--Materials. The sources and provisions for use of topsoil from local pits located outside the right-of-way shall be as set forth in Section 106. Topsoil shall meet the applicable requirements of Subsection 715.01.

When indicated in the contract, topsoil shall be salvaged from within the construction limits. The topsoil shall be removed only from areas and to depths designated by the Engineer.

211.02.1--Materials Obtained from Right-of-Way. Areas from which topsoil is to be obtained shall be mowed and cleared of foreign materials to the satisfaction of the Engineer.

The approved area shall be excavated neither deeper than the limits of good topsoil nor deeper than necessary to produce sufficient volume to cover the designated areas.

If strata or seams of unsuitable material are encountered during the excavation of topsoil, the material shall be removed from the topsoil. If considered necessary, the area shall be abandoned and satisfactory material produced from other sources.

Topsoil shall be transported and stockpiled on well drained areas approved by the Engineer, or transported, deposited, and processed directly on designated areas that have been finished, prepared, and approved to receive the topsoil. The Contractor shall spread or dispose of, as directed, all surplus material left in stockpiles without cost to the Department.

211.02.2--Materials Obtained Outside Right-of-Way. Before mining the material, approved areas shall be mowed and raked and cleared of foreign materials to the satisfaction of the Engineer.

Approval of topsoil pits shall meet the requirements of Subsection 107.23.

It is intended that approved mining operations shall include the mixing or blending of materials that will ensure a homogeneous mixture complying with the requirements of the contract.

For pits proposed by the Contractor, the Contractor shall obtain and submit for testing representative samples taken at places designated by and witnessed by the Engineer or the Engineer's representative. If deemed advisable, the Engineer may have Department forces take the samples, and the Contractor shall furnish the assistance required. Based on test results, the Engineer will approve lateral and depth limits of satisfactory materials.

At the Engineer's discretion, samples of the material may be taken at any point prior to spreading on the road. This sampling and testing will be for the purpose of determining whether or not corrective measures should be taken.

Material produced and approved as provided herein, will be accepted as meeting all requirements at the point of final loading for delivery and incorporation into the work.

Approved topsoil, mined as prescribed, shall be transported, deposited and processed directly into its final position on designated areas that have been finished, prepared, and approved unless temporary stockpiling is required or permitted by the Engineer. In case stockpiling is required or permitted, the Contractor shall spread or dispose of, as directed, surplus material left in the stockpile without cost to the Department.

211.03--Construction Requirements.

211.03.1--Conditioning of Areas to be Plated. The conditioning of areas to be plated will depend on the type of existing soil on cut slopes or fill slopes. Conditioning shall be performed so as to secure a bond between the existing soil and the topsoil. Unless otherwise directed, the area to be plated shall be shaped and dressed to the required line, grade, and typical section; disk-harrowed to a depth of at least two inches; and be reasonably free of large clods and stones exceeding three inches in diameter and other foreign materials before topsoil is deposited. On non-tillable slopes, the areas shall be shaped and dressed to the required section, and the Contractor shall cut trenches or furrows approximately six inches deep and approximately 24 to 36 inches apart, as directed by the Engineer dependent upon the steepness of the slope, and on approximate contours. Surplus material from trenching shall be uniformly spread over the area to be plated or otherwise disposed of in a satisfactory manner. In no case shall topsoil be placed on slopes until conditioning of the areas has been approved.

211.03.2--Application. It is intended that the application of topsoil, the application and incorporation of fertilizer, and other erosion control work will constitute continuous construction, and the Contractor's operation shall be organized accordingly. When the Engineer has determined that the Contractor has made suitable arrangements to carry out these operations as indicated, topsoil shall be deposited on approved areas and spread to the required depth and section. When the required depth of plating material exceeds eight inches, it shall be placed in two or more approximately equal layers of no more than eight inches each.

Objectionable foreign material, large clods that cannot be broken down, and oversize stones shall be removed and the area dressed to present a uniform appearance.

211.03.3--Compaction. After spreading and shaping of the topsoil, compaction shall be performed to the degree that will provide a firm layer having a density of at least what might be expected from one complete coverage of a crawler type tractor track while the material is at a satisfactory moisture content.

211.03.4--Compacted Depth of Topsoil. Topsoil shall be deposited and spread in sufficient quantity so that, when compacted, it will have the depth specified in the contract.

Determination of depth will be made at random and recorded following compaction of each plated area of approximately 20,000 square feet and more often if determined by the Engineer to be necessary to control the specified depth. Each of the plated areas will be considered a lot. The depth of each lot checked will be the average of at least two and not more than four measurements taken within a square yard area. Except as provided in the following two paragraphs, the average depth of each lot shall not vary from the specified depth by more than one inch or 25 percent of the specified depth, whichever is larger. The average depth of the entire area topsoiled, or the average of the depths of individual lots, shall not vary from the specified depth by more than one inch.

Topsoil measured and paid for on a cubic yard basis may exceed the stated plus tolerances, provided the finished surface is uniform, does not obstruct drainage, and otherwise meets the approval of the Engineer; and further provided that in lieu of the Contractor removing the excess materials at no additional cost to the State, a reduction in pay quantity in the amount of the excess will be made. The excess in each lot will be computed by multiplying the depth in excess of the specified depth plus the tolerance by the area of the lot and the computed excess volume in cubic yards converted to loose vehicular measure by multiplying by 1.25.

Topsoil specified to be measured and paid for on a square yard basis may exceed the stated plus tolerance and remain in place provided the finished surface is uniform, does not obstruct drainage, and otherwise meets the approval of the Engineer. No additional payment will be made for the excessive material placed. The removal of excessive topsoil shall be at the election of the Contractor and at no additional cost to the State.

211.03.5--Topsoil for Plant Holes or Pits. When specified or ordered, topsoil shall be used for backfill material for plant holes or pits. Placement shall be in accordance with the applicable provisions of the specifications for the specified plantings.

211.03.6--Maintenance. The Contractor shall, at no additional cost to the State, preserve, protect, replace, and do other work necessary to maintain the topsoil in a satisfactory and acceptable condition from the time of placing until release of maintenance.

211.04--Method of Measurement. Contractor furnished topsoil will be measured by the cubic yard (LVM), at the point of delivery. For topsoil placed in excess of the specified depth, an adjustment in the measured quantity will be made in accordance with Subsection 211.03.4.

Topsoil specified to be obtained from sources within the right-of-way will be measured by the square yard of surface acceptably plated with topsoil.

Topsoil stripped from construction limits will also be included in the measurement of the applicable excavation item as prescribed in Subsection 203.04.

Unless otherwise specified, measurement for haul of topsoil will not be made.

211.05--Basis of Payment. Topsoil for slope treatment and backfilling of plant holes or pits, measured as prescribed above, will be paid for at the contract unit price per cubic yard or per square yard which shall be full compensation for completing the work.

Payment will be made under:

211-A: Topsoil for Slope Treatment, From Right-of-Way	- per square yard
211-B: Topsoil for Slope Treatment, Contractor Furnished	- per cubic yard
211-C: Topsoil for Plant Holes, Contractor Furnished	- per cubic yard
211-D: Topsoil for Plant Pits, Contractor Furnished	- per cubic yard

SECTION 212 - GROUND PREPARATION

212.01--Description. Ground preparation, light or standard as specified, consists of plowing, loosening, and pulverizing the soil to form suitable beds for erosion control items in accordance with these specifications and in reasonably close conformity with the established lines and grades without appreciable humps or depressions. When performing ground preparation on an area that has been previously planted with temporary grassing, the previously planted grasses shall be disked, tilled, plowed, etc. to assure that the existing temporary grasses are thoroughly mixed into the soil.

212.02--Blank.

212.03--Construction Requirements.

212.03.1--General. Equipment used shall be approved units suitable to perform the work and subject to the requirements of Subsection 108.05.

The Contractor shall take full advantage of weather and soil conditions, and no attempt shall be made to prepare soil when it is wet or in a condition that will not allow the soil to be properly tilled.

Light ground preparation will be required on designated areas where seeding is required to improve the coverage of partially vegetated areas.

Standard ground preparation will be required on areas designated to be solid sodded and areas with no vegetation designated to be seeded.

212.03.2--Light Ground Preparation. Light ground preparation shall consist of scratching the surface with a close-tooth harrow, disk-harrow, or similar equipment within 24 hours after application of required fertilizer. The depth of scratching shall be at least three-quarters inch but not deep enough to damage existing vegetation.

212.03.3--Standard Ground Preparation. Standard ground preparation shall consist of plowing or disk-harrowing and thoroughly pulverizing the areas immediately before the application of erosion control (vegetative) items. Unless otherwise specified, the

pulverized and prepared seedbed shall be at least four inches deep and shall be reasonably free of large clods, earth balls, boulders, stumps, roots and other objectionable matter. Incorporation of fertilizer and ground preparation may be performed simultaneously.

Aerating, moistening, or otherwise bringing the soil to a suitable condition for ground preparation shall be considered as incidental to the work and will not be measured for separate payment.

Prepared areas will be inspected by the Engineer, and until approved, subsequent operations shall not be performed.

212.04--Method of Measurement. Ground preparation of the type specified will be measured by the square yard.

212.05--Basis of Payment. Ground preparation will be paid for at the contract unit price per square yard which shall be full compensation for completing the work.

Payment will be made under:

- 212-A: Light Ground Preparation - per square yard
- 212-B: Standard Ground Preparation - per square yard

SECTION 213 - FERTILIZING

213.01--Description. This work consists of furnishing, transporting, spreading, and incorporating fertilizers of the types and in the amounts designated.

213.02--Materials. Fertilizers for purposes of these specifications shall be understood to include standard manufactured products consisting of single or combination ingredients and agricultural limestone.

All fertilizer shall comply with the State Fertilizer Laws and the requirements of these specifications.

Fertilizers shall meet the requirements of Subsection 715.02. All fertilizer shall be handled so as to ensure proper protection at all times. All fertilizers, except agricultural limestone, shall be furnished in standard bags. When approved by the Engineer, bulk fertilizer may be used. The Contractor shall provide means suitable to the Engineer for applying bulk fertilizer. The Engineer shall weigh shipments at random for verification of bulk fertilizer quantities.

213.03--Construction Requirements. The Contractor shall furnish all equipment necessary to properly handle, store, uniformly spread, and incorporate the specified application of fertilizer.

The type and rate of application of each fertilizer to be applied will be indicated on the plans or determined by soil tests. The amounts and types of fertilizers shall be applied uniformly on the areas to be planted or seeded and uniformly incorporated into the soil.

Fertilizers shall be applied on individual areas of not more than three acres. The Engineer will determine the actual amounts of fertilizers to be applied on each area. For agricultural limestone, a tolerance of 15 percent will be permitted without correction. For all other types of fertilizer, a tolerance of 10 percent will be permitted without correction. Areas deficient in application by more than these tolerances shall be corrected by re-application in a manner approved by the Engineer. For areas on which fertilizer has been placed in excess of the tolerance permitted the amounts in excess of the tolerances will be deducted from the measured quantities.

All fertilizer shall be incorporated within 24 hours following spreading unless otherwise directed. Incorporation of fertilizer into soils other than topsoil shall include standard ground preparation in accordance with Subsection 212.03. When topsoil is used, the fertilizer shall be incorporated into the top three inches.

Unless otherwise specified, when fertilizer is to be applied to existing vegetation, incorporation shall be accomplished immediately after the application by mowing the vegetation to a height of approximately four inches.

213.04--Method of Measurement. Fertilizer of the type specified, applied as ordered in accepted work, will be measured by the ton. Fertilizer not applied and incorporated in accordance with these specifications and fertilizer applied in unacceptable work will be deducted from measured quantities.

The measured quantity of fertilizer failing to meet the guaranteed analysis, as set out in Subsection 715.02, will be adjusted in proportion to the guaranteed analysis and the actual analysis.

Mowing required during fertilization of existing vegetation will be measured and paid for under pay item 223-A, Mowing.

213.05--Basis of Payment. Hard rock agricultural limestone will be paid for at the contract unit price per ton. Hard rock agricultural limestone with a relative neutralizing value (RNV), determined in accordance with Subsection 715.02.2.1.3, of between 60.0% and 62.9% will be paid for at half (½) the contract unit price per ton. No payment will be made for hard rock agricultural limestone with an RNV less than 60.0%.

Types of fertilizer, combination and manufactured, specified to be placed prior to planting will be paid for at the contract unit price per ton. All fertilizers for additional applications based on soil tests will be paid for on the basis of the contract unit price per ton for super-phosphate (0-20-0) plus or minus the applicable amount from the following schedule. Prices paid shall be full compensation for furnishing fertilizer and completing the work.

Type of Fertilizer	Superphosphate Contract Unit Price
15-10-10	plus \$25.00 per ton
6-8-8	minus \$10.00 per ton
18-46-0	plus \$130.00 per ton
12-24-12	plus \$60.00 per ton
8-24-24	plus \$60.00 per ton
0-20-20	plus \$20.00 per ton

Type of Fertilizer	Superphosphate Contract Unit Price
13-13-13	plus \$30.00 per ton
Muriate of Potash (60%)	plus \$0.00 per ton
Ammonium Nitrate	plus \$40.00 per ton
Urea	plus \$70.00 per ton
Ureaform (38-0-0)	plus \$225.00 per ton
Ureaform (10-10-10)	plus \$90.00 per ton

Payment will be made under:

- 213-A: Agricultural Limestone - per ton
- 213-B: Combination Fertilizer, Type - per ton
- 213-C: Superphosphate - per ton
- 213-D: Ammonium Nitrate - per ton

SECTION 214 - SEEDING

214.01--Description. This work consists of furnishing the specified seeds and inoculants for legume seed, treating the legume seeds, and planting the seeds in a prepared and approved seedbed; covering the seeds and compacting the seedbed; and providing plant establishment on all areas seeded. All the work shall be in accordance with the plans and these specifications.

214.02--Materials. Seeds shall meet the requirements of Subsection 715.03, subject to the provisions of this subsection. The Contractor shall acquire seed from supplier registered with the MDAC.

Except for the germination test as referenced in Subsection 715.03, bags of seeds properly labeled or tagged according to law and indicating characteristics meeting or exceeding the requirements of these specifications will be acceptable for planting.

The Contractor shall provide adequate dry and otherwise protected and approved storage facilities for seeds, and shall furnish access to the storage for sampling and for the Engineer to inventory stored seed and inspect the suitability of the storage facilities.

Seeds that have been sampled and tested by the MDAC shall be acceptable for planting provided (1) that prior to planting, the Contractor furnishes the Engineer two copies of test reports from the MDAC indicating that the seeds meet the germination requirements, (2) not more than nine months have elapsed, exclusive of the calendar month in which the test was completed, between the germination test data and the time of planting, and (3) the seeds were properly stored and handled.

Seeds that have not been sampled and tested by the MDAC and test reports furnished prior to planting shall be sampled and tested for germination requirements by the Department.

The Contractor may use pre-tested, or post-tested seeds under the conditions stated herein. For seeds to be pre-tested, approximately 35 days from the date of sampling will

be required to obtain the test results.

When pre-tested seeds are planted, a minus tolerance of five percent of the specified germination percentage will be allowed without adjustment. Seeds failing to comply by more than five percent may be planted, provided the rate of seeding is increased by 100 percent of the deficiency with the same or approved seeds, without additional compensation.

The Engineer may permit the Contractor to plant post-tested seeds, provided the seeds are properly tagged and have indicated characteristics meeting the requirements of these specifications without applying tolerances. If the seeds are planted, the Contractor shall assume full responsibility for the specified percent germination of the seeds upon subsequent tests. Acceptance or re-sowing will be based on the results of the subsequent tests. A minus tolerance of five percent of the specified germination percentage will be allowed without adjustment. If the tests indicate a deficiency in excess of five percent; (1) the deficiency shall be corrected by immediately re-sowing an amount of seeds equal to 200 percent of the deficiency with the same or approved seeds without additional compensation, or (2) should it be determined, by inspection, that a sufficient number of seeds have germinated to produce satisfactory growth and coverage, the Engineer will deduct from measured quantities an amount of seeds equal to 100 percent of the deficiency. Otherwise, the area seeded will not be considered in reasonably close conformity with the requirements of these specifications.

214.03--Construction Requirements.

214.03.1--General. Prior to planting the seeds, topsoil when specified, ground preparation, and fertilizing shall have been satisfactorily performed and the area approved by the Engineer.

Seeding may be required for temporary protection or for establishment of permanent ground cover. The plans will indicate temporary seeding.

The rates of application, kinds, and the planting dates of seeds shall be as set out in the vegetation schedule on the plans. The Engineer will determine the actual quantity of seeds to be applied on individual areas of not more than three acres.

Legume seeds shall be treated in accordance with Subsection 715.03.4 immediately before sowing. Seeds shall be uniformly sown over the entire area with approved mechanical seeders. Seeds of different sizes may necessitate separate sowing. Should legume seeds become dry, they shall be re-inoculated.

Seeding shall not be done during windy weather or when the ground is frozen, extremely wet, or in a condition that will not allow the soil to be properly tilled.

All seeds shall be covered lightly with soil by raking, rolling, or other approved methods, and the area compacted with a cultipacker.

When specified, mulching shall be performed in accordance with the requirements of Section 215 as soon as practicable but no later than 24 hours after seeding unless weather conditions are such that mulch cannot be placed.

214.03.2--Plant Establishment. The Contractor shall provide plant establishment on all areas seeded until release of maintenance.

Plant establishment shall be provided for a minimum period of 45 calendar days after completion of seeding. In the event satisfactory growth and coverage has not been attained by the end of the 45-day period, plant establishment shall be continued until the specified growth and coverage is provided for at least one kind of plant as referenced in Section 210. The Contractor shall perform plant establishment on all areas of temporary seeding until the Engineer determines that the temporary seeding has served its purpose.

Plant establishment shall consist of preserving, protecting, watering, reseeding, mowing, and other work necessary to keep the seeded areas in satisfactory condition.

Unless otherwise permitted, areas requiring reseeding shall be prepared and seeded and all other work performed in accordance with the requirements of the contract as if the reseeding was the initial seeding. The types and application rates of fertilizer will be determined by soil tests or otherwise established.

214.03.3--Growth and Coverage. It shall be the Contractor's responsibility to provide satisfactory growth and coverage of grasses, legumes, or combination produced from the specified seeding.

Growth and coverage on seeded areas will be considered to be in reasonably close conformity with the intent of the contract when the type of vegetation specified, exclusive of that from seeds not expected to have germinated and shows growth at that time, has reached a point of maturity where stems or runners overlap adjacent similar growth in each direction over the entire area.

214.04--Method of Measurement. Seeding will be measured by the acre, or by the pound, as indicated in the contract.

Except as provided under Subsection 107.17, no measurement for payment will be made for any materials or work required under Subsections 214.03.2 and 214.03.3.

Watering for seeding will not be measured for separate payment.

214.05--Basis of Payment. Seeding, measured as prescribed above, will be paid for at the contract unit price per acre or per pound, as indicated, which price shall be full compensation for completing the work.

Payment will be made under:

214-A: Seeding, Kind - per acre or pound

214-B: Seeding, Seed Mixture, Designation - per acre

SECTION 215 - MULCHING

215.01--Description. This work consists of furnishing, transporting, placing, and anchoring vegetative mulch on slopes, shoulders, medians, and other designated areas.

Mulching may be accomplished by hydraulically applying the mulch in accordance with these specifications.

215.02--Materials. The vegetative materials for mulch shall meet the requirements of Subsection 715.05.

It is intended that Type I Vegetative Materials shall be used when available. When it is determined by the Engineer that Type I Vegetative Material is not reasonably available, Type II Vegetative Material will be permitted as provided in Subsection 715.05, with the concurrence of the State Roadside Development Manager.

Bituminous material for mulch shall be Emulsified Asphalt, Grade SS-1, meeting the requirement of Subsection 702.07. Subject to satisfactory results being obtained, this material will be accepted on a certification basis in accordance with Subsection 106.04.

215.02.1--Hydraulically Applied Mulch (Hydromulch). Fibers for hydromulch shall be produced from wood, straw, cellulose, natural fibers, or recycled fibers that are free of non-biodegradable substances. The fiber shall disperse into a uniform slurry when mixed with water. Fibers shall be colored green, or other approved contrasting color, and shall not stain concrete or other surfaces. The use of tacifiers or activators will be allowed.

Hydromulch shall be one from the Department's APL.

215.02.1.1--Wood Fiber Mulch. Wood fiber mulch shall be made from wood chip particles manufactured particularly for discharging uniformly on the ground surface when dispersed by a hydraulic water sprayer. It shall remain in uniform suspension in water under agitation and blend with grass seed and fertilizer to form a homogeneous slurry. The fibers shall intertwine physically to form a strong moisture-holding mat on the ground surface and allow rainfall to percolate the underlying soil. The fiber material shall be heat processed so as to contain no germination or growth-inhibiting factors. The mulch shall be dyed an appropriate color to facilitate the application of material using non-toxic dye.

215.02.1.2--Cellulose Fiber Mulch. Cellulose fiber mulch consists of recycled paper stock products which are shredded into small pieces particular for application by hydraulic seeding equipment. It shall mix readily and uniformly under agitation with water and blend with grass seed and fertilizer to form a homogeneous slurry. When applied to the ground surface, the material shall form a strong moisture-holding mat, allow rainfall to percolate the underlying soil, and remain in place until the grass root system is established. The material shall contain no growth inhibiting characteristic or organisms. The mulch shall be dyed an appropriate color to facilitate the application of material using non-toxic dye.

215.02.1.3--Wood/Cellulose Fiber Mulch. Wood/cellulose fiber mix hydroseeding mulch shall consist of a combination of the above wood and cellulose fibers at a ratio recommended by the manufacturer of the products.

215.02.1.4--Straw Mulch. Straw mulch shall consist of a natural straw fiber. This material shall be a minimum 90% straw and essentially free from plastic materials or

other non-bio degradable substances. The material shall be dispersed into a uniform mulch slurry when mixed with water.

215.02.1.5--Tackifier. The tackifier will serve the purpose of an adhesive to form a bond between the soil, fiber, and seed particles. It will also allow the soil to retain moisture. The tackifier shall be of the organic or synthetic variety.

215.03--Construction Requirements.

215.03.1--Equipment. Mulching equipment shall be capable of maintaining a constant air stream that will blow or eject controlled quantities of mulch in a uniform pattern. If asphalt is used, a jet or spray nozzle for applying uniform, controlled amounts of asphalt to the vegetative material as it is ejected shall be located at or near the discharge spout.

Mulch stabilizers shall consist of dull blades or disks without camber and approximately 20 inches in diameter. The disks shall be notched, shall be spaced at approximately 8-inch intervals, and shall be equipped with scrapers. The stabilizer shall weigh approximately 1000 to 1200 pounds, shall have a working width of no more than eight feet, and shall be equipped with a ballast compartment, so that when directed weight can be increased.

215.03.2--Placement of Vegetative Mulch. Mulching shall be placed uniformly on designated areas within 24 hours following seeding unless weather conditions are such that mulching cannot be performed. Placement shall begin on the windward side of areas and from tops of slopes. In its final position the mulch shall be loose enough to allow air to circulate but compact enough to partially shade the ground and reduce erosion.

The baled material shall be loosened and broken thoroughly before it is fed into the machine to avoid placement of unbroken clumps.

215.03.3--Rates of Application and Anchoring Mulch. The Engineer will designate the rate of application of vegetative mulch within the limits of one to two tons per acre. The mulch may be anchored by either the use of a mulch stabilizer or by tacking with bituminous material. If a mulch stabilizer is used, the mulch shall be punched into the soil for a minimum depth of one inch. If bituminous material is used, the rate of application shall be 150 gallons per acre.

Where steep slopes or other conditions are such that anchoring cannot be performed satisfactory with a mulch stabilizer, the Engineer will require the bituminous material be applied at the time or immediately following the mulch placement.

When mulch stabilizers are used, anchoring the mulch shall be performed along the contour of the ground surface.

As the work progresses, the Engineer will determine the actual rate of application of the vegetative mulch and the bituminous material, if used, on each area not to exceed three acres. For vegetative mulch, a tolerance of 15 percent will be permitted without correction. For bituminous material, if used, a tolerance of 10 percent will be permitted without correction. Areas deficient in application by more than these amounts shall be corrected by reapplication in a manner approved by the Engineer. For areas on which vegetative material has been placed in excess of the tolerance permitted, that portion of

the material placed in excess of the tolerance allowed will be deducted from the measured quantities. In the event an excess of vegetative material has been placed in a quantity deemed by the Engineer to be undesirable, the Contractor shall remove and replace all material placed on that area at no additional cost to the State.

215.03.4--Protection and Maintenance. The Contractor shall maintain and protect mulched areas until release of maintenance of the project. The Contractor shall take every precaution to prevent unnecessary foot and vehicular traffic and shall repair and restore immediately any displacement of mulch without extra compensation.

At appropriate times determined by the Engineer, the Contractor shall mow or otherwise remove or destroy all undesirable growth on all areas mulched to prevent competition with the desired plants and to prevent reseeding of undesirable growth. All mowing shall be a part of protection and maintenance.

215.03.5--Hydromulch. Hydromulch shall be applied in accordance with the installation instructions and recommendations of the manufacturer. Hydromulch shall be uniformly applied at the manufacturer's recommended application rate. In no case shall the application rate be less than one (1) ton per acre.

215.03.5.1--Protection and Maintenance. The Contractor should maintain and protect mulched areas until the Release of Maintenance of the project. The Contractor should take every precaution to prevent unnecessary foot and vehicular traffic.

The Contractor should mow, remove or destroy any undesirable growth on all areas mulched as soon as any undesirable growth appears. This will prevent competition with the desired plants and to prevent reseeding of undesirable growth.

215.03.5.2--Hydro Equipment. The equipment for hydraulically applying seed and mulch shall have a built-in agitation system with an operating capacity sufficient to agitate, suspend, and homogeneously mix slurry of the specified amount of fiber, seed, and water. The slurry distribution lines shall be large enough to prevent stoppage. The discharge line shall be equipped with a set of hydraulic spray nozzles, which will provide even distribution of the slurry on the various areas to be seeded.

The mixture shall all be combined into the slurry tank for distribution of all ingredients in one operation as specified herein. The materials shall be combined in a manner recommended by the manufacturer. The slurry mixture shall be so regulated that the amounts and rates of application shall result in a uniform application of all materials at rates not less than the amounts specified. Using the color of the mulch as a guide, the equipment operator shall spray the prepared seedbed with a uniform visible coat. The slurry shall be applied in a sweeping motion, in an arched stream, so as to fall like rain, allowing the mulch to build upon each other until an even coat is achieved.

215.04--Method of Measurement. Accepted quantities of vegetative material for mulch will be measured by the ton.

The weight for measurement will be the product of the number of bales acceptably placed and the average weight per bale as determined on approved scales provided by the Contractor.

Whether by use of a mulch stabilizer or by application of bituminous material, anchoring of vegetative mulch will not be measured for separate payment. The cost of anchoring shall be absorbed in the prices bid for other items of work.

Acceptable quantities of hydromulch will be measured by the ton. The weight for measurement of hydromulch will be the dry weight of the packaged fibers used in the mixture. No separate payment will be made for water, additives, tackifier, or other liquids used in the mixture.

215.05--Basis of Payment. Vegetative material for mulch will be paid for at the contract unit price per ton and shall be full compensation for completing the work.

Hydromulch, measured as prescribed above, will be paid for at the contract unit price per ton, which price shall be full compensation for all materials, equipment, labor, and incidentals necessary to complete the work.

Payment will be made under:

215-A: Vegetative Materials for Mulch - per ton

215-B: Hydromulch - per ton

SECTION 216 - SOLID SODDING

216.01--Description. This work consists of furnishing, transporting, and planting approved grass sod in accordance with the plans and these specifications. This work shall also include plant establishment as specified and required to assure satisfactory growth of the solid sod.

216.02--Materials. Unless otherwise specified, solid sod shall be common bermuda, bahia, or other approved sod species and shall be live, fresh, growing grass, unless in the dormant season, with at least one and one-half inches of soil adhering firmly to the roots when placed. The sod shall be reasonably free from obnoxious weeds or other grasses, and shall not contain any matter deleterious to its growth, or that might affect its subsistence or hardiness when transplanted. The sod shall be in blocks at least eight inches by eight inches and reasonably free from ragged edges. All sod shall be harvested from areas where the topsoil is fertile, and the areas shall have been grazed or mowed sufficiently to form a dense turf. The area from which the solid sod is to be harvested shall be closely mowed, and raked if deemed necessary to remove excessive top growth and debris.

When a kind of solid sod is specified, the material shall be nursery grown, healthy, free from damage, and free from noxious weeds and grasses. The nursery grown sod shall be in blocks at least eight inches by eight inches by one inch and reasonably free of ragged edges.

All solid sod materials shall be approved by the Engineer prior to transplanting.

216.03--Construction Requirements.

216.03.1--Procuring and Handling Sod. Approved sod cutters shall be used for cutting the sod into strips or blocks. Care shall be exercised at all times to retain the native soil on the roots of the sod during the process of excavating, hauling, and planting.

The sod shall be transplanted within 24 hours after arriving on the project, unless it is stacked in a manner satisfactory to the Engineer. All sod in stacks shall be kept moist and protected from exposure to the wind and sun and from freezing.

In no event shall more than three days elapse between the cutting and planting of the sod without approval of the Engineer.

216.03.2--Grading of the Area to Receive Solid Sodding. Prior to ground preparation for solid sodding, all excavating, shaping, and dressing shall have been completed in such a manner that the foundation for the sod has the proper cross section, line, and grade and so that the sod after placement will be flush with or slightly below the adjacent final ground line.

216.03.3--Ground Preparation and Fertilizing. After the area has been graded as required, the specified types and quantities of fertilizers shall be uniformly spread and incorporated in accordance with Section 212 for standard ground preparation. The prepared area shall be at an approved moisture content and shall present a smooth, uniform surface with reasonably close conformity to the specified line, grade, and cross section. After approval by the Engineer of the prepared and fertilized area, sodding shall follow immediately.

216.03.4--Planting Sod. The sod shall be placed on the prepared surface with edges in close contact and starting at the lowest point and working upward. Cracks between blocks of sod shall be filled with small pieces of fresh sod, and all cracks too small for sod shall be filled by a light dressing of approved soil. The entire sodded area shall then be compacted and watered to the satisfaction of the Engineer. Light rollers, hand tamps, or other approved equipment shall be used for compacting.

If the Engineer deems that in a particular area the sodding might slide due to the height and slope of the surface or nature of the soil, the sod shall be "pegged" with wooden pegs driven through the sod blocks into firm earth. Pegs shall be at intervals deemed suitable to hold the sod in place.

216.03.5--Limitations. Solid sodding shall be performed only when weather and soil conditions are deemed by the Engineer to be suitable for proper placement.

216.03.6--Plant Establishment. Plant establishment shall consist of preserving, protecting, replacing, watering, mowing, and other work necessary to keep the sod in a satisfactory condition at all times until final acceptance.

A satisfactory growth of solid sodding shall be understood to mean a healthy, living, and growing grass turf, unless in the dormant season, which has been planted on an approved prepared foundation and has been maintained in accordance with the requirements of these specifications.

216.04--Method of Measurement. Solid sodding will be measured by the square yard.

If solid sodding is required by the contract, or ordered by the Engineer, on a section graded under a previous contract, required excavation, exclusive of trenching out and fine grading, will be measured under the appropriate excavation item of the contract, or as extra work.

Water ordered will be measured and paid for as prescribed in Subsection 219.04.

216.05--Basis of Payment. Solid sodding will be paid for at the contract unit price per square yard, which price shall be full compensation for all labor, equipment, materials, tools, ground preparation, fertilization, and all incidentals necessary to complete the work.

Payment will be made under:

216-A: Solid Sodding - per square yard

216-B: Solid Sodding, Kind - per square yard

SECTION 217 - DITCH LINER

217.01--Description. This work consists of furnishing, placing, and maintaining a ditch liner of jute mesh, excelsior blanket, erosion control blanket or erosion control fabric on seeded, or other designated areas in accordance with the plans and specifications. Asphalt-coated fiber glass roving meeting the requirements of Section 218 may be substituted for ditch liner. Any substituted fiber glass roving will be measured by the square yard and paid at the contract bid price for ditch liner.

217.02--Materials. The type of material used for the ditch liner shall be at the option of the Contractor unless otherwise specified. Jute mesh, excelsior blanket, erosion control blanket and erosion control fabric shall meet the requirements of Subsection 715.09.

217.03--Construction Requirements.

217.03.1--General. The areas to be covered shall be prepared, fertilized, vegetated and left in a smooth uniform condition, free of stones, lumps, roots or other material that will prevent the ditch liner from being in contact with the underlying soil. Immediately following the planting operation, the ditch liner shall be installed by unrolling it in the direction of water flow and draping it loosely, without folds or stretching, so that continuous ground contact is maintained. The mulch material shall be omitted from areas receiving the ditch liner.

When two or more strips are required to cover a ditch area, the longitudinal laps shall be a minimum of four inches with the upgrade width on top. Transverse laps shall be a minimum of 12 inches with the upgrade section on top.

The end of the material at the beginning and ending of each area to be covered shall be folded and placed in a vertical anchor trench at least six inches deep, and stapled in the trench on six-inch centers, backfilled, and tamped. When directed, edges subject to scour shall be buried similarly. On the upgrade end, reinforce with a row of staples on six-inch centers about one foot below the anchor trench. All transverse laps shall be stapled on

12-inch centers and longitudinal laps on 36-inch centers. Each strip of material shall be stapled in three rows at the edges and center with staples spaced not more than three feet longitudinally. The staples shall anchor the fabric netting. Check slots, a row of staples on 12-inch centers perpendicular to the flow line, shall be installed at 50-foot intervals.

On the downstream end of a ditch liner adjoining a structure, the anchor trench shall be omitted and the material folded under six inches and butted tightly against the structure and one row of staples installed on six-inch centers. An edge adjacent to a paved ditch shall be butted tightly against the paved ditch and a row of staples installed on 12-inch centers. All staples shall be driven flush with the soil surfaces.

Ditch liner materials used on areas other than ditches may be placed either horizontally or vertically. Adjacent strips of excelsior blanket material shall be butted tightly together and secured with a common row of staples rather than lapped as set forth for ditch installation. The staples shall be spaced on three-foot centers or less as determined by the Engineer based on field conditions. The excelsior blanket and erosion control blanket shall be placed with the fabric net facing up.

217.03.2--Protection and Maintenance. The Contractor shall maintain and protect the ditch liner until release of maintenance or until the Engineer has determined that the liner has served its useful life, whichever occurs first. Maintenance shall consist of repairs necessitated by erosion, wind, fire, or other cause.

217.04--Method of Measurement. Ditch liner will be measured by the square yard of surface area covered. Any over width of material installed wider than ordered, laps and anchor slots will not be measured for payment.

217.05--Basis of Payment. Ditch liner, measured as prescribed above, will be paid for at the contract unit price per square yard and shall be full compensation for completing the work.

Payment will be made under:

217-A: Ditch Liner - per square yard

SECTION 218 - BITUMINOUS TREATED ROVING

218.01--Description. This work consists of furnishing and installing a layer of bituminous treated roving to stabilize newly planted soil areas in ditches and on slopes in accordance with these specifications and at locations shown on the plans or as directed by the Engineer.

218.02--Materials.

218.02.1--General. The type of roving material, fiberglass or polypropylene, shall be at the option of the Contractor unless otherwise specified and shall meet the applicable requirements of Subsection 715.09.6.

The glass fibers or fibrillated polypropylene yarn shall be wound onto cylindrical packages so that the roving can be continuously fed through an ejector driven by

compressed air and expanded into a mat. The fibers or yarn shall be lightly bound together in a ribbon form, without the use of clay, starch, or other deleterious substances. The material shall not contain petroleum solvents, or other agents known to be toxic to plant or animal life.

The roving material shall not be exposed to moisture prior to placement.

218.02.2--Bituminous Material. The bituminous material used for securing the roving to the existing soil shall be Emulsified Asphalt, Grade SS-1, meeting the requirements of Subsection 702.07.

218.03--Construction Requirements.

218.03.1--Equipment. An air compressor shall be used in conjunction with applying the glass fiber or polypropylene yarn. The compressor shall be capable of supplying 40 cubic feet of air per minute at a pressure of 80 to 100 pounds per square. An air gun specifically designed for spraying glass fibers or polypropylene yarn, sufficient 3/8-inch rubber hose for application, and at least one container shall be furnished for applying the material. Three spools or packages may be run simultaneously from a 125-cubic foot compressor. Equipment that cuts or breaks the roving will not be permitted. Equipment for applying the asphalt shall be capable of applying the material in a uniform spray at the rate specified.

218.03.2--General. The bituminous treated roving shall be applied over designated areas within 24 hours following the planting or seeding operations. The designated areas shall be free of all objects including the vegetative material for mulch that would keep the roving material from being in direct contact with soil throughout the entire area to be treated.

The upgrade and downgrade ends of the bituminous treated roving shall be buried in a six-inch minimum vertical slot and the soil tamped firmly against it.

The bituminous treated roving shall be applied uniformly over the planted areas at one of the following rate with a $\pm 20\%$ tolerance:

- a) Bituminous Treated Fiberglass Roving 0.50 pounds per square yard
- b) Bituminous Treated Polypropylene Roving 0.20 pounds per square yard

The rate of distribution will be determined from the number of spools or packages of roving used on each area and the average weight of the spools or packages. A sample of at least five spools or packages designated at random by the Engineer will be taken and weighed and the average weight to the nearest pound per spool or package will be used for the truckload from which the sample was taken.

Immediately following the spreading of roving, the asphaltic material shall be applied uniformly over the roving at the rate of 0.50 gallons per square yard with a $\pm 20\%$ tolerance.

The Contractor shall be required to apply additional asphaltic material, if needed, to penetrate through the roving in sufficient quantity to secure the roving to the soil.

218.03.3--Protection and Maintenance. The Contractor shall maintain and protect the bituminous treated roving mat until release of maintenance or until the Engineer has determined that the mat has served its useful life, whichever occurs first. Maintenance shall consist of repairs made necessary by erosion, wind, fire, or any other cause.

218.04--Method of Measurement. Bituminous treated roving will be measured by the square yard of surface area covered.

The additional materials required for terminal slots and materials placed outside the limits of the designated area(s) requiring treatment will not be measured for payment.

218.05--Basis of Payment. Bituminous treated roving, measured as prescribed above, will be paid for at the contract unit price per square yard, which shall be full compensation for completing the work.

Payment will be under:

218-A: Bituminous Treated Roving - per square yard

SECTION 219 - WATERING

219.01--Description. This work consists of furnishing, transporting, and applying water as specified during the planting operations and establishment of roadside vegetation excluding seeding. It shall be understood that watering will be measured and paid for only when ordered by the Engineer and used for items specified and when a pay item is included in the contract.

219.02--Materials. Water shall be as specified in Subsection 714.01.5.

219.03--Construction Requirements. Loading operations on the roadway resulting in water-logging or excessively wet basement soils, design soils, or base courses will not be permitted.

Water shall be applied in the manner and quantities, at the times, and for the purposes set forth in the contract or directed.

The quantities of watering shown in the contract are estimated for bidding purposes only and these quantities may be varied dependent upon need or may be omitted entirely with no adjustment in unit contract price.

The equipment furnished and used for this work shall be approved as adequate and suitable for the purpose used.

219.04--Method of Measurement. The quantity of water furnished and applied as directed or permitted will be measured to the nearest one thousand gallons (M gallons) by approved meters, measured tanks, or calibrated tanks.

In accordance with the intent of Subsection 109.01, the capacity of tanks may be made by weight and converted to one thousand gallons (M gallons) by dividing the weight in pounds by 8,330.

Water used by the Contractor in items of work not specifically authorized or directed by the Engineer or water wasted, improperly applied, or otherwise used for unauthorized purposes will not be measured for payment.

219.05--Basis of Payment. Water ordered or authorized, delivered, and applied will be paid for at the fixed contract unit price per one thousand gallons (M gallons) as pre-entered in the proposal and shall be full compensation for satisfactorily completing the work.

No change in payment will be made because of differential cost of watering from the fixed contract unit price. It is fully understood and agreed that any differential cost will be included in the price bid for other roadside development items.

Payment will be made under:

219-A: Watering - per M gallons

SECTION 220 - INSECT PEST CONTROL

220.01--Description. This work consists of furnishing and applying approved insecticides to control armyworms and other destructive insects that damage or destroy planted vegetation.

It shall be the Contractor's responsibility to continually observe the planted areas for insect damage, especially during the late summer and early fall. The Contractor shall, upon observing destructive insects, report it to the Engineer. If the Engineer or the Engineer's representative observes insect damage, the Contractor will be notified.

220.02--Materials. The Contractor shall select and furnish an effective insecticide produced by a reputable manufacturer in accordance with all Federal and State Laws and Regulations, and it shall meet the approval of the Engineer. The material shall be furnished in properly labeled containers. The Contractor shall be responsible for handling, storing and applying the material in accordance with the information shown on the label and complying with all Federal and State Laws and Regulations regarding its application and use. The Department will not be liable for violations in applying the material or damage caused by its use.

220.03--Construction Requirements.

220.03.1--General. The Engineer will determine the areas to be treated, and the Contractor shall immediately treat these areas unless weather conditions are unfavorable for proper treatment. The Contractor shall apply the approved insecticide at the rate and in the manner according to the requirements shown on the label of the container for the destructive pest being controlled. The equipment used in applying the material shall produce uniform coverage.

The Engineer will determine if satisfactory pest control was obtained on the treated areas. The Contractor shall reapply insecticides to areas where control is unsatisfactory at no additional cost to the State.

When the Engineer determines that pest control efforts were timely and correctly applied, the Contractor will be paid for any required re-grassing. If the Engineer determines that pest control efforts were unsatisfactory, the Contractor will re-grass the area at no additional cost to the State.

220.03.2--Safeguards. In addition to the requirements specified in Subsection 220.02, safeguards in applying insecticides are the responsibility of the Contractor, and the Contractor shall be responsible for damage to the wildlife and human welfare.

The following are minimum basic safeguards to be observed:

- (a) All insecticides shall be applied by approved ground equipment or approved aircraft mounted spray equipment. Aerial application shall be approved in writing by the Engineer.
- (b) Personnel must be qualified to engage in this work.
- (c) Personnel handling the insecticide and equipment operators must wear the recommended protective apparel.
- (d) Avoid drift of insecticide on adjacent property.
- (e) Do not contaminate streams, ponds or lakes.
- (f) Some insecticides are highly toxic to bees. When application is to be near bee hives, provide a day advance notice to the beekeeper.
- (g) Normally, insecticide application will be restricted to roadside areas that are under construction and not open to the public. Precautions for the protection of the public must be taken when treatment is ordered for rest areas, parks, etc.; namely, by keeping pedestrians off the area until the insecticide is washed off the turf area or the insecticide deteriorates and is not harmful.

Application methods and rates shall be in accordance with the instructions shown on the label of the insecticide container.

220.03.3--Contract Quantities. The quantity for insect pest control is estimated for bidding purposes only and this quantity may be varied dependent upon actual need or omitted entirely.

220.04--Method of Measurement. Insect pest control of the area properly treated and accepted will be measured by the acre. The area shall be computed from measurements taken parallel to the surface of the treated area.

220.05--Basis of Payment. Insect pest control, measured as provided above, will be paid for at the fixed contract unit price per acre as pre-entered in the proposal and shall be full compensation for completing the work.

No change in payment will be made because of differential costs from the fixed contract unit price. It is fully understood and agreed that any differential cost will be included in the prices bid for other roadside development items.

Payment will be made under:

220-A: Insect Pest Control

- per acre

SECTION 221 - PAVED DITCHES

221.01--Description. This work consists of constructing paved ditches of hydraulic cement concrete or hot bituminous plant mix, as specified in the contract and constructed in accordance with the provisions and requirements of these specifications, and in reasonably close conformity with the lines, grades, typical cross sections, and locations shown on the plans or established.

221.02--Materials.

221.02.1--Concrete Paved Ditches. The materials used in the construction of cement concrete paved ditches shall conform to the applicable provisions and requirements of Section 804.

221.02.2--Bituminous Paved Ditches. The materials used in the construction of bituminous paved ditches shall conform to the applicable requirements for hot bituminous mixtures as set out in Section 401.

221.02.3--Reinforcement. Reinforcement shall meet the requirements of Subsection 711.02.

221.03--Construction Requirements.

221.03.1--General. The foundation for paved ditches shall be formed by excavating to the required depth and dimensions below the prepared finished surface grade of the paved ditch.

The foundation shall be thoroughly compacted by hand tamping or other approved method. Soft, spongy, or other unsuitable material shall be removed as directed and replaced with suitable material thoroughly compacted in six inch layers.

The forms used in this construction may be wood or metal; shall have a depth equal to the prescribed edge thickness of the paved ditch; and shall be of sufficient strength to withstand the weight of the concrete or bituminous mixture and the pressure incidental to vibration or compaction without bulging or displacement. Forms shall be securely staked and braced.

Reinforcement, if specified, shall be placed in a manner that will ensure its proper position in the paved ditch section after all concrete is placed.

221.03.2--Concrete Paved Ditches. Unless otherwise specified on the plans, the concrete paved ditches shall be constructed of Class "C" concrete, mixed and placed in accordance with the applicable requirements of Section 804, and cured in accordance with the requirements of Subsection 501.03.20 or by other approved methods. The limitations of mixing and placing shall conform to the requirements of Subsection 501.03.12.

A template mounted on the side forms shall be used in striking off and finishing the surface of the concrete to the required shape and dimensions. The entire unit shall be constructed monolithic with smooth fillets or curves at all angles or breaks in flow lines. Concrete shall be placed beginning at the bottom of the slope and progressing upward.

The finished exposed surface of concrete paved ditches shall be given a Class 6, Floated Surface Finish in conformity with the requirements of Subsection 804.03.19.

Expansion joints shall be constructed at the locations indicated on the plans or directed, and shall be of the specified materials and dimensions.

221.03.3--Bituminous Paved Ditches. Bituminous paved ditches shall be constructed using an asphalt mixture. The mixture shall meet job-mix requirements for the particular mixture used except the percent of asphalt cement designated in the job-mix formula may be increased by the Engineer by no more than two percent.

The mixture shall be spread, raked, finished, and compacted by hand tools or other satisfactory methods while at the proper temperature to form a smooth, stable, and impermeable lining.

221.03.4--Backfilling and Cleaning Up. After the concrete has set sufficiently or after the asphalt has been compacted to the required shape and dimensions, the forms shall be removed and the spaces around the paved ditch shall be backfilled with approved material and thoroughly compacted without damage to the paved ditch. The adjacent ditch slopes shall be neatly trimmed to the required section, and all surplus material shall be disposed of as directed.

221.04--Method of Measurement. Concrete paved ditch will be measured in cubic yards.

Bituminous paved ditch will be measured by the ton of asphalt material actually placed. No measurement for separate payment will be made for any additional asphalt cement required in the mix.

Excavation required for trenching and fine grading will not be measured for separate payment. Other required excavation will be measured for payment under the applicable excavation items.

221.05--Basis of Payment. Concrete paved ditch will be paid for at the contract unit price per cubic yard and shall be full compensation for completing the work.

Bituminous paved ditches will be paid for at the contract unit price per ton and shall be full compensation for completing the work.

Payment will be made under:

221-A: Concrete Paved Ditch - per cubic yard

221-B: Bituminous Paved Ditch - per ton

SECTION 223 - MOWING

223.01--Description. When the contract includes a pay item for mowing and when the Engineer determines that mowing is necessary, the Contractor shall perform litter removal and mowing of noxious vegetation or excess growth as directed by the Engineer

in accordance with the provisions contained herein. Mowing shall also be required, when necessary, for the safe and convenient passage of traffic, as required in Subsection 104.04, Maintenance of Traffic. The importance of public safety and workplace safety cannot be overemphasized. Special attention is made to Subsections 107.06, 107.07 and 107.10 of the Standard Specifications.

Prior to mowing, the Contractor shall pick up and properly dispose of all trash and debris within the area to be mowed and along any adjacent roadway shoulders. Trash and debris picked up and piled or bagged on the roadside must be removed from the right-of-way by the close of the work day. Piles or bags will not be allowed to remain on the roadside overnight. All trash and debris is defined as all trash, debris, litter, junk, rubbish, paper, cardboard, glass, cans, styrofoam cups, discarded items, garbage, old tires, treads, etc. The Contractor will not be required to pick up such items as cigarette butts, tiny chips of grass or other small items not readily visible to the traveling public.

The Engineer will advise the Contractor when mowing will be needed. The Engineer has the right to eliminate completely or partially any mowing on the project. The Engineer will advise the Contractor of the area to be mowed and the time to begin the mowing operations. The Engineer may delay mowing of lespedezas or crimson clover until after these plants have gone to seed. Mowing may be delayed to retain and promote desirable wildflower growth.

Mowing will be to a height of not more than six (6) inches and will include trimming adjacent to culvert ends, guard rail, sign posts or other appurtenances. Trimming adjacent to objects inaccessible by mower shall be performed by hand mowers, weed-eaters, sling blades, or any acceptable means necessary to complete the work. Care shall be taken not to damage trees, plants, shrubs, delineators or other fixtures that are part of the facility. Any damages by the Contractor's operations to signs, delineators, other traffic control devices or other appurtenances shall be corrected immediately at no additional cost to the State.

The quantity of mowing will be affected by actual conditions that occur during construction and may be eliminated entirely at the direction of the Engineer.

223.02--Blank.

223.03--Construction Requirements.

223.03.1--General. The Contractor shall perform the work throughout the entire project on those areas directed by the Engineer. The Contractor shall take full advantage of weather and soil conditions, and no attempt shall be made to mow while the areas are deemed to be wet enough to cause damage to the soil or vegetation. Care shall be taken to use methods and mowers that will provide even, uniform mowed areas, and not damage adjacent vegetation and structures. Excessive clippings of sufficient magnitude to smother or retard grass growth shall be removed to allow growth of existing or new grass.

The Contractor shall begin mowing operations within two weeks after receipt of the Engineer's letter to begin mowing. If the Contractor fails to begin the work within that time period the Engineer shall notify the Contractor in writing that the work is not being prosecuted properly, and therefore, future progress payments may be withheld in

accordance with Subsection 105.01 of the Standard Specifications.

223.03.2--Equipment. Equipment used for mowing operations shall be of sufficient size, type and condition to perform the work satisfactorily. Mowers may be rotary, flail, sickle or combination thereof as necessary to efficiently accomplish the work. Rotary mowers shall be equipped with safety chains or other devices to prevent flying stones, rocks, cans, etc. from striking persons or property. Change or adjustment of the equipment or operator may be required if at any time during the mowing operation, the Engineer determines that the equipment, or operators of the equipment, are not performing satisfactorily.

When required for the Contractor's mowing operations, appropriate traffic control devices shall be installed in accordance with the MUTCD.

223.04--Method of Measurement. Mowing will be measured by the acre. Litter removal and any required traffic control devices will not be measured for separate payment, but will be included in the fixed contract price for mowing.

223.05--Basis of Payment. When ordered by the Engineer, mowing will be paid for at the fixed contract unit price per acre indicated in the bid schedule, which price shall be full compensation for removing and disposing of litter, all equipment, tools, labor, traffic control devices and incidentals necessary to complete the work.

Payment will be made under:

223-A: Mowing - per acre

SECTION 224 - SOIL REINFORCING MAT

224.01--Description. This work consists of furnishing, placing and maintaining a soil reinforcing mat on seeded or other designated areas in accordance with the requirements of the plans and these specifications.

224.02--Materials.

224.02.1--Preformed Permanent Mat. The soil reinforcing mat must be one from the Department's current APL.

The Contractor will be permitted to furnish and install a multi-width mat with seams securely bonded by welding, stitching or other methods meeting the approval of the Engineer.

224.02.2--Stakes. Unless otherwise specified by the manufacturer of the soil reinforcing mat, stakes used to secure the mat shall be either:

- 1) sound 3/4-inch by 2½-inch by 15-inch minimum, triangular shaped, wood stakes,
- 2) 3/16-inch by 18-inch metal pins with 1½-inch round metal washer, or
- 3) double prong "U" shaped wire staples made from 9-gauge or heavier steel wire with an approximate length of eight inches after bending.

224.02.3--Acceptance Procedure. Prior to use, the Contractor must furnish the Engineer three copies of the manufacturer's certification for each shipment of soil reinforcing mat material stating the number of rolls furnished and that the material in the shipment conforms to the same composition as that originally approved by the Department. When metal pins or wire staples are used, also furnish the Engineer three copies of a certification from the manufacturer or distributor stating the pin and washer size for metal pins or wire size for staples for each shipment.

The certifications by the manufacturer or distributor will be prima facie evidence of the materials meeting the requirements of the specifications.

224.03--Construction Requirements.

224.03.1--General. The area(s) to be covered shall be prepared, fertilized and vegetated as specified in accordance with the requirements of the contract before the mat is installed. The planted area shall be to finish grade, smooth, and free of stones, clods, or trash. The vegetative mulch material shall be omitted from areas receiving the mat. The mat shall be installed immediately following the planting operations. The installation of the mat material shall be performed in accordance with the requirements specified herein and the installation detail sheet in the plans.

Terminal slots, both upstream and downstream, shall be excavated a minimum of twelve inches deep and two feet wide across the full width of each area to be treated before placing the mat.

Transverse check slots shall be excavated a minimum of nine inches deep and six inches wide across the full width of the area to be treated at approximately 25-foot intervals along the entire length of the area.

Outer edge slots shall be excavated four inches deep by six inches wide along the actual perimeter of the mat installation for the full length of the area to be treated.

When possible, the mat installation shall begin at the downstream end and unrolled uphill in continuous contact with the soil. When two or more widths of mat are required to cover an area, they shall overlap a minimum of three inches. In cases where rolls are to be spliced lengthwise, the ends of the rolls shall overlap three feet minimum with the upgrade strip on top.

Temporary staking shall be required to place tension on the mat at crest of check slot for securing mat into slot and for proper alignment during installation.

The mat material shall be secured across the full width of the mat with stakes one-foot apart in all terminal, downstream and upstream, and transverse check slots. The stakes shall be placed three feet apart, with the diagonal edge facing upstream when using wood stakes, on outer edge slots, longitudinal overlaps and bonded seams on multi-widths. For longitudinal overlaps, one stake shall serve the overlapped edges of adjoining strips. The center of each strip including each strip between each bond, if multi-width rolls are used, and the center of ditch bottom shall be staked at six-foot intervals with the stakes placed broadside to the stream flow. When the center of a strip or the longitudinal overlap, including a bonded seam, falls within six inches of the center of ditch, the required ditch bottom stakes may be omitted. Where the rolls of mat are spliced lengthwise, the three-

foot overlap shall be staked with two rows of stakes 30 inches apart with the stakes spaced approximately 18 inches apart in each row.

Wood stakes shall be driven to within approximately two to three inches of the ground surface. When metal pins are used, they shall be firmly embedded in the underlying soil with the attached washers flush with the ground surface. When wire staples are used, they shall be driven flush with the ground surface.

After the mat is placed and staked into all slots, the slots shall be backfilled with soil and compacted to the satisfaction of the Engineer.

Consideration may be given by the Engineer to the use of alternate staking procedures when submitted by the Contractor upon recommendation of the manufacturer of the soil reinforcing mat and at least seven days prior to the proposed installation of the mat.

224.03.2--Protection and Maintenance. The Contractor shall maintain and protect the soil reinforcing mat until release of maintenance. Maintenance shall consist of repairs made necessary by erosion, wind, or any other cause.

224.04--Method of Measurement. Soil reinforcing mat will be measured by the square yard of surface area covered.

The additional mat material required for overlaps, slots and overwidth of strips will not be measured for payment.

224.05--Basis of Payment. Soil reinforcing mat, measured as prescribed above, will be paid for at the contract unit price per square yard, which price shall be full compensation for completing the work.

Payment will be made under:

224-A: Soil Reinforcing Mat - per square yard

SECTION 225 - GRASSING

225.01--Description. This work consists of furnishing, transporting, placing, plant establishment, and all work, including ground preparation, fertilizing, seeding, and mulching, necessary to produce a satisfactory and acceptable growth of grass.

At the Contractor's option, seeds and mulch may be incorporated using a hydraulically applied method under certain limitations. When hydraulically applied, it shall be performed in accordance with the requirements and methods addressed in Section 227. Under no circumstances shall fertilizer be incorporated hydraulically.

225.02--Materials.

225.02.1--Fertilizers. Fertilizers for purposes of this specification shall be understood to include standard manufactured products consisting of single or combination ingredients and agricultural limestone.

All fertilizer shall comply with the State fertilizer laws, Subsection 715.02, and the requirements of this specification.

225.02.2--Seeds. Seeds shall meet the requirements of Subsection 715.03, subject to the provisions of this subsection. The Contractor shall acquire seed from persons registered with the MDAC.

Except for the germination requirements, bags of seeds properly labeled or tagged according to law and indicating characteristics meeting or exceeding the requirements of Subsection 715.03 will be acceptable for planting.

The Contractor should provide adequate dry storage facilities for seeds, and shall furnish access to the storage for sampling stored seed.

225.02.3--Mulch.

225.02.3.1--Vegetative Mulch. The vegetative materials for mulch shall meet the requirements of Subsection 215.02.

225.02.3.2--Hydraulically Applied Mulch (Hydromulch). The vegetative materials for mulch shall meet the requirements of Subsection 215.02.1.

225.03--Construction Requirements.

225.03.1--Ground Preparation. Ground preparation, light or standard, consists of plowing, loosening, and pulverizing the soil to form suitable beds for erosion control items in reasonably close conformity with the established lines and grades without appreciable humps or depressions. When grassing an area that has been previously planted with temporary grassing, a standard ground preparation will be required. The previously planted grasses shall be disked, tilled, plowed, etc. to assure that the existing temporary grasses are thoroughly mixed into the soil.

Any equipment used for ground preparation shall be approved units suitable to perform the work and subject to the requirements of Subsection 108.05.

The Contractor shall take full advantage of weather and soil conditions, and no attempt shall be made to prepare soil when it is wet or in a condition that will not allow the soil to be properly tilled.

Light ground preparation should be used on areas where seeding is required to improve the coverage of partially vegetated areas.

Standard ground preparation should be used on areas designated to be solid sodded and un-vegetated areas designated to be seeded.

Aerating, moistening, or otherwise bringing the soil to a suitable condition for ground preparation shall be considered as incidental to the work and will not be measured for separate payment.

225.03.1.1--Light Ground Preparation. Light ground preparation consists of scratching the surface with a close-tooth harrow, disk-harrow, or similar equipment. The depth of

scratching should be at least three-quarters inch but not deep enough to damage existing grasses of the type being planted.

225.03.1.2--Standard Ground Preparation. Standard ground preparation consists of plowing or disk-harrowing and thoroughly pulverizing the areas immediately before the application of erosion control (vegetative) items. Unless otherwise specified, the pulverized and prepared seedbed should be at least four inches deep and shall be reasonably free of large clods, earth balls, boulders, stumps, roots and other objectionable matter. Incorporation of fertilizer and ground preparation may be performed simultaneously.

225.03.2--Fertilizing. Fertilizing consists of furnishing, transporting, spreading, and incorporating fertilizers. The Contractor shall furnish all equipment necessary to properly handle, store, uniformly spread, and incorporate the specified application of fertilizer.

The Contractor shall incorporate 13-13-13 commercial fertilizer at the rate indicated in the vegetation schedule in the plans. The equivalent rate of other type fertilizers will be allowed if the equivalent percentages of Nitrogen, Phosphorus and Potassium are obtained. The Contractor shall incorporate agricultural limestone at the rate indicated in the vegetation schedule in the plans. Fertilization shall be applied uniformly on the areas to be planted or seeded and uniformly incorporated into the soil.

Fertilizers should be applied on individual areas of not more than three (3) acres.

All fertilizer should be incorporated within 24 hours following spreading.

225.03.3--Seeding. Seeding consists of furnishing and planting seeds in a prepared seedbed, covering the seeds, and providing plant establishment on all areas seeded.

Prior to planting the seeds, ground preparation and fertilizing shall be satisfactorily performed.

The required type of seeds, minimum rates of application, and planting dates of seeds are shown in the vegetation schedule in the plans.

It is the Contractor's responsibility to apply an ample amount of each type of seed to produce a satisfactory growth of grass and of the seed type required. At the completion of the project, a satisfactory growth of grass will be required. The Contractor should reference Section 210 for satisfactory growth and coverage of dormant seed.

Seeding should not be done during windy weather or when the ground is frozen, extremely wet, or in a condition that will not allow the soil to be properly tilled.

225.03.3.1--Conventional Application. Legume seeds should be treated in accordance with Subsection 715.03.4 immediately before sowing. Seeds should be uniformly sown over the entire area with mechanical seeders. Seeds of different sizes may necessitate separate sowing. When legume seeds become dry, they should be re-inoculated.

All seeds should be covered lightly with soil by raking, rolling, or other approved methods, and the area compacted with a cultipacker.

Mulching should be performed as soon as practicable after seeding.

225.03.3.2--Hydroseeding Application. Seeds may be applied using the hydroseeding method except during the months of June, July, August, and September. During these months, the seeding shall be incorporated in accordance with the above Conventional Application method.

The seed(s) shall be combined into a distribution tank with all required ingredients on the project site. The application of the seed(s) and all ingredients shall be performed in one operation.

Mulching should be performed simultaneously with or as soon as practicable after seeding.

225.03.3.3--Plant Establishment. The Contractor should provide plant establishment on all areas seeded until release of maintenance. At the completion of the project, a satisfactory growth of grass will be required. The Contractor should reference Section 210 for satisfactory growth and coverage of dormant seed.

Plant establishment should be provided for a minimum period of 45 calendar days after completion of seeding. In the event satisfactory growth and coverage has not been attained by the end of the 45-day period, plant establishment should be continued until a satisfactory growth and coverage is provided for at least one kind of plant as referenced in Section 210. The Contractor shall perform plant establishment on all areas of temporary seeding until the Engineer determines that the temporary seeding has served its purpose.

Plant establishment shall consist of preserving, protecting, watering, reseeding, mowing, and other work necessary to keep the seeded areas in satisfactory condition.

Areas requiring reseeding should be prepared and seeded and all other work performed as if the reseeding was the initial seeding. The types and application rates of fertilizer will be at the discretion of the Contractor.

225.03.3.4--Growth and Coverage. It shall be the Contractor's responsibility to provide satisfactory growth and coverage of grasses, legumes, or combination produced from the specified seeding.

Growth and coverage on seeded areas will be considered to be in reasonably close conformity with the intent of the contract when the type of vegetation specified, exclusive of that from seeds not expected to have germinated and shows growth at that time, has reached a point of maturity where stems or runners overlap adjacent similar growth in each direction over the entire area.

225.03.4--Mulching. Mulching consists of furnishing, transporting, and placing mulch on slopes, shoulders, medians, and other designated areas. Unless otherwise noted in the contract or directed by the Engineer, the Contractor has the option to place mulch by the conventional method or by the hydraulic method.

225.03.4.1--Vegetative Mulch.

225.03.4.1.1--Equipment. Mulching equipment should be capable of maintaining a constant air stream that will blow or eject controlled quantities of mulch in a uniform pattern.

Mulch stabilizers should consist of dull blades or disks without camber and approximately 20 inches in diameter. The disks should be notched, should be spaced at approximately 8-inch intervals, and should be equipped with scrapers. The stabilizer should weigh approximately 1000 to 1200 pounds, should have a working width of no more than eight feet, and should be equipped with a ballast compartment, so that weight can be increased.

225.03.4.1.2--Placement of Vegetative Mulch. Mulching should be placed uniformly on designated areas within 24 hours following seeding unless weather conditions are such that mulching cannot be performed. Placement should begin on the windward side of areas and from tops of slopes. In its final position, the mulch should be loose enough to allow air to circulate but compact enough to partially shade the ground and reduce erosion.

The baled material should be loosened and broken thoroughly before it is fed into the machine to avoid placement of unbroken clumps.

225.03.4.1.3--Anchoring Mulch. The mulch should be anchored by using a mulch stabilizer when not hydraulically applied. If a mulch stabilizer is used, the mulch should be punched into the soil for a minimum depth of one inch.

When mulch stabilizers are used, anchoring the mulch should be performed along the contour of the ground surface.

225.03.4.2--Hydromulch. Hydromulch shall be applied in accordance Subsection 215.03.5.

225.03.5--Vegetation Schedule. When a vegetation schedule is not shown in the plans or when the contract does not have an official set of plans, the following application rates shall be used, unless otherwise noted or approved by the Engineer.

Agricultural Limestone	1,000 pounds per acre	March 1 to September 1
13-13-13 Commercial Fertilizer	250 pounds per acre	March 1 to September 1
Vegetative Materials	2 tons per acre	
Bermudagrass	80 pounds per acre	March 1 to September 1
	20 pounds per acre	September 1 to March 1 *
Bahiagrass	80 pounds per acre	March 1 to September 1
	25 pounds per acre	September 1 to March 1
Tall Fescue	25 pounds per acre	March 1 to September 1
	100 pounds per acre	October 1 to March 1 **
Sericea Lespedeza	25 pounds per acre	March 1 to September 1
	25 pounds per acre	September 1 to March 1
Crimson Clover	20 pounds per acre	August 1 to April 1

* 80 pounds per acre in District 3 Delta

** 25 pounds per acre in District 3 Delta

225.04--Method of Measurement. Grassing will be measured by the acre. Acceptance will be based on a satisfactory growth and coverage of seeds planted.

Acceptable quantities of agricultural limestone will be measured by the ton.

Acceptable quantities for mulch will be measured by the ton. For vegetative mulch, the weight for measurement will be the product of the number of bales acceptably placed and the average weight per bale as determined on approved scales provided by the Contractor. Anchoring of vegetative mulch will not be measured for separate payment. The cost of anchoring shall be absorbed in the prices bid for other items of work. For hydromulch, the weight for measurement will be the dry weight of the packaged fibers used in the mixture. No payment will be allowed for water, additives, tackifier, or other liquids used in the mixture.

225.05--Basis of Payment. Grassing, measured as prescribed above, will be paid for at the contract unit price per acre, which will be full compensation for all required materials including seeding and fertilizers other than limestone, ground preparation, equipment, labor, testing and all work necessary to establish a satisfactory growth of grass.

Hard rock agricultural limestone will be paid for at the contract unit price per ton. Hard rock agricultural limestone with a relative neutralizing value (RNV), determined in accordance with Subsection 715.02.2.1.3, of between 60.0% and 62.9% will be paid for at half (½) the contract unit price per ton. No payment will be made for hard rock agricultural limestone with an RNV less than 60.0%.

Mulch, measured as prescribed above, will be paid for at the contract unit price per ton, which price shall be full compensation for all materials, equipment, labor, and incidentals necessary to complete the work.

Payment will be made under:

225-A: Grassing	- per acre
225-B: Agricultural Limestone	- per ton
225-C: Mulch, Vegetative Mulch	- per ton
225-D: Mulch, Hydromulch	- per ton

SECTION 226 - TEMPORARY GRASSING

226.01--Description. This work consists of furnishing, transporting, placing, plant establishment and all work necessary to produce rapid-growing grasses, grains or legumes to provide an initial, temporary cover of grass. This work includes ground preparation, fertilizing, seeding and mulching necessary to establish a satisfactory growth of temporary grass. The Contractor may elect to place temporary grassing using the hydroseeding method as set out in Section 227.

The Engineer or the plans will designate areas to be temporarily grassed. Any other areas the Contractor desires to grass will be measured for payment only if agreed upon by the Engineer.

226.02--Materials.

226.02.1--Fertilizers. Fertilizers for purposes of these specifications shall be understood to include standard manufactured products consisting of a combination of ingredients.

All fertilizer shall comply with the State fertilizer laws and Subsection 715.02.

Agricultural limestone will not be required for temporary grassing.

226.02.2--Seeds. Seeds shall meet the requirements of Subsection 715.03, subject to the provisions of this subsection. The Contractor shall acquire seed from persons registered with the MDAC.

Except for the germination requirements, bags of seeds properly labeled or tagged according to law and indicating characteristics meeting or exceeding the requirements of Subsection 715.03 will be acceptable for planting.

The Contractor should provide adequate dry storage facilities for seeds, and shall furnish access to the storage for sampling stored seed.

226.02.3--Mulching. The vegetative materials for mulch shall meet the requirements of Subsection 715.05.

When used, bituminous material for mulch shall be Emulsified Asphalt, Grade SS-1, meeting the requirement of Subsection 702.07.

226.03--Construction Requirements. The rates of application shall not exceed the rates shown on the temporary vegetation schedule, unless otherwise approved by the Engineer. Any unauthorized overage due to increased application rates will not be measured for payment.

226.03.1--Ground Preparation. Any equipment used for ground preparation shall be approved units suitable to perform the work and subject to the requirements of Subsection 108.05.

Light ground preparation should be used on areas where seeding is required.

Light ground preparation consists of scratching the surface with a close-tooth harrow, disk-harrow, or similar equipment. The depth of scratching should be at least three-quarters inch but not deep enough to damage existing grasses of the type being planted.

Aerating, moistening, or otherwise bringing the soil to a suitable condition for ground preparation shall be considered as incidental to the work and will not be measured for separate payment.

226.03.2--Fertilizing. The Contractor shall furnish all equipment necessary to properly handle, store, uniformly spread, and incorporate the specified application of fertilizer.

The Contractor shall incorporate 13-13-13 commercial fertilizer at the rate shown in the vegetation schedule in the plans. The equivalent rate of other type fertilizers will be allowed if the equivalent percentages of Nitrogen, Phosphorus and Potassium are obtained. Fertilization shall be applied uniformly on the areas to be seeded and uniformly incorporated into the soil.

Fertilizer should be applied on individual areas of not more than three acres.

All fertilizer should be incorporated within 24 hours following spreading.

226.03.3--Seeding.

226.03.3.1--General. Prior to planting the seeds, ground preparation and fertilizing should have been satisfactorily performed.

The required type of seeds, recommended rates of application and recommended planting dates of seeds are shown in the vegetation schedule in the plans.

It is the Contractor's responsibility to apply an ample amount of each type of seed to produce a satisfactory growth of grass and of the seed type required.

Legume seeds should be treated in accordance with Subsection 715.03.4 immediately before sowing. Seeds should be uniformly sown over the entire area with mechanical seeders. Seeds of different sizes may necessitate separate sowing. When legume seeds become dry, they should be reinoculated.

Seeding should not be done during windy weather or when the ground is frozen, extremely wet, or in an untillable condition.

All seeds should be covered lightly with soil by raking, rolling, or other approved methods, and the area compacted with a cultipacker.

226.03.3.2--Plant Establishment. Plant establishment shall consist of preserving, protecting, watering, reseeding, and other work necessary to keep the seeded areas in satisfactory condition.

Areas requiring reseeding should be prepared and seeded and all other work performed as if the reseeding was the initial seeding. The types and application rates of fertilizer will be at the discretion of the Contractor. No additional measurement and payment will be made for re-seeding when payment was made for the initial seeding.

226.03.3.3--Growth and Coverage. It shall be the Contractor's responsibility to provide satisfactory growth and coverage of grasses, legumes, or combination produced from the specified seeding.

Growth and coverage on seeded areas will be considered to be in reasonably close conformity with the intent of the contract when the type of vegetation specified, exclusive of that from seeds not expected to have germinated and shows growth at that time, has reached a point of maturity where stems or runners overlap adjacent similar growth in each direction over the entire area.

226.03.4--Mulching.

226.03.4.1--Equipment. Mulching equipment should be capable of maintaining a constant air stream that will blow or eject controlled quantities of mulch in a uniform pattern. If asphalt is used, a jet or spray nozzle for applying uniform, controlled amounts of asphalt to the vegetative material as it is ejected should be located at or near the discharge spout.

Mulch stabilizers should consist of dull blades or disks without camber and approximately 20 inches in diameter. The disks should be notched, should be spaced at approximately 8-inch intervals, and should be equipped with scrapers. The stabilizer should weigh approximately 1000 to 1200 pounds, should have a working width of no more than eight feet, and should be equipped with a ballast compartment, so that weight can be increased.

226.03.4.2--Placement of Vegetative Mulch. If required, mulching should be placed uniformly on designated areas within 24 hours following seeding unless weather conditions are such that mulching cannot be performed. Placement should begin on the windward side of areas and from tops of slopes. In its final position, the mulch should be loose enough to allow air to circulate but compact enough to partially shade the ground and reduce erosion.

The baled material should be loosened and broken thoroughly before it is fed into the machine to avoid placement of unbroken clumps.

226.03.4.3--Rates of Application and Anchoring Mulch. The recommended rate of application of vegetative mulch shall be as shown in the vegetation schedule in the plans. The mulch should be anchored by either the use of a mulch stabilizer or by tacking with bituminous material. If a mulch stabilizer is used, the mulch should be punched into the soil for a minimum depth of one inch. If bituminous material is used, the rate of application should be 150 gallons per acre.

Where steep slopes or other conditions are such that anchoring cannot be performed satisfactory with a mulch stabilizer, the Contractor may elect to use bituminous material applied at the time or immediately following the mulch placement.

When mulch stabilizers are used, anchoring the mulch should be performed along the contour of the ground surface.

226.03.4.4--Protection and Maintenance. The Contractor should take every precaution to prevent unnecessary foot and vehicular traffic.

226.03.5--Vegetation Schedule. When a temporary vegetation schedule is not shown in the plans or when the contract does not have an official set of plans, the following application rates shall be used, unless otherwise noted or approved by the Engineer.

Spring & Summer

Browntop Millet 20 pounds per acre April 1 to August 31

Fall & Winter

Rye Grass..... 25 pounds per acre September 1 to March 31

Oats 90 pounds per acre September 1 to December 15

13-13-13 Commercial Fertilizer 250 pounds per acre

Vegetative Mulch 2 tons per acre

226.04--Method of Measurement. Temporary grassing will be measured by the acre. Acceptance will be based on a satisfactory growth and coverage of seeds planted.

226.05--Basis of Payment. Temporary grassing, measured as prescribed above, will be paid for at the contract unit price per acre, which will be full compensation for all required materials, equipment, labor, testing and all work necessary to establish a satisfactory growth of grass.

Payment will be made under:

226-A: Temporary Grassing - per acre

SECTION 227 - HYDROSEEDING

227.01--Description. This work consists of furnishing, transporting, placing, plant establishment and all work necessary to produce a satisfactory and acceptable growth of grass. The seeds, fertilizers, tackifier, and mulch shall be incorporated using the hydroseeding process. These items shall be combined into a mixture and force-applied to the areas to be grassed.

227.02--Materials. The Contractor shall, prior to application, furnish the Engineer with invoices of all materials used in the grassing operation.

227.02.1--Fertilizers. Fertilizers for purposes of these specifications shall be understood to include standard manufactured products consisting of single or combination ingredients.

All fertilizers shall comply with the State fertilizer laws and Subsection 715.02.

227.02.2--Seeds. Seeds shall meet the requirements of Subsection 715.03, subject to the provisions of this subsection. The Contractor shall acquire seed from persons registered with the MDAC.

Except for the germination requirements, bags of seeds properly labeled or tagged according to law and indicating characteristics meeting or exceeding the requirements of Subsection 715.03 will be acceptable for planting.

The Contractor should provide adequate dry storage facilities for seeds, and shall furnish access to the storage for sampling stored seed.

227.02.3--Mulching. Mulch shall meet the requirements of Subsection 215.02.1.

227.03--Construction Requirements.

227.03.1--Ground Preparation. Light ground preparation consists of plowing, loosening, and pulverizing the soil to form suitable beds for seeding items in reasonably close conformity with the established lines and grades without appreciable humps or depressions. Unless otherwise specified, the pulverized and prepared seedbed should be at least four inches deep and shall be reasonably free of large clods, earth balls, boulders, stumps, roots and other objectionable matter. The Engineer may eliminate or alter the requirements for ground preparation due to site conditions.

227.03.2--Fertilizing. The Contractor shall furnish all equipment necessary to properly handle, store, uniformly spread, and incorporate the specified application of fertilizer.

The Contractor shall incorporate bag fertilizer at a rate of 1000 pounds per acre of 13-13-13 commercial fertilizer. The equivalent rate of other type fertilizers will be allowed if the equivalent percentages of Nitrogen, Phosphorus and Potassium are obtained. Any changes in the type or rate of application of the fertilizers shall be approved by the Engineer prior to being incorporated.

Agricultural limestone will be incorporated into the area and paid for in accordance with Section 213 of the Standard Specifications.

227.03.3--Seeding.

227.03.3.1--General. The Contractor shall use the vegetation schedule in the plan for the correct types of seed and application rates, unless otherwise noted or approved by the Engineer.

When a vegetation schedule for permanent grass is not shown in the plans, the following types of seed and application rates shall be used, unless otherwise approved by the Engineer.

Bermudagrass -----	20 pounds per acre
Bahiagrass -----	25 pounds per acre
Tall Fescue -----	15 pounds per acre
Crimson Clover -----	20 pounds per acre

At the completion of the project, a satisfactory growth of grass will be required. The Contractor should reference Subsection 210 for satisfactory growth and coverage of dormant seed.

227.03.3.2--Plant Establishment. The Contractor should provide plant establishment on all areas seeded until release of maintenance. Plant establishment shall consist of preserving, protecting, watering, reseeding, mowing, and other work necessary to keep the seeded areas in satisfactory condition.

Plant establishment should be provided for a minimum period of 45 calendar days after completion of seeding. In the event satisfactory growth and coverage has not been attained by the end of the 45-day period, plant establishment should be continued until a

satisfactory growth and coverage is provided for at least one kind of plant. The Contractor should reference Section 210 of the Standard Specifications for more information.

227.03.3--Growth and Coverage. It shall be the Contractor's responsibility to provide satisfactory growth and coverage of grasses, legumes, or combination produced from the specified seeding.

Growth and coverage on seeded areas will be considered to be in reasonably close conformity with the intent of the contract when the type of vegetation specified, exclusive of that from seeds not expected to have germinated and shows growth at that time, has reached a point of maturity where stems or runners overlap adjacent similar growth in each direction over the entire area.

Final acceptance of the project will not be made until a satisfactory growth of grass has been acknowledged by the Engineer.

227.03.4--Mulching. At the Contractor's option, mulch may be wood fiber, cellulose fiber, a mixture of wood and cellulose fibers, or straw fiber. The mulch shall be applied at the rate recommended by the manufacturer in a mixture of water, seed and fertilizer. Any changes in the rate of application of the mulch shall be approved by the Engineer prior to its use.

Placement of mulch shall meet the requirements of Subsection 215.03.5.

227.04--Method of Measurement. Hydroseeding, complete and accepted, will be measured by the acre. No separate payment will be made for ground preparation, seeds, fertilizers, or mulch. Acceptance will be based on a satisfactory growth and coverage of seeds planted.

Agricultural limestone shall be measured and paid for under Section 225 of the Standard Specifications.

227.05--Basis of Payment. Hydroseeding, measured as prescribed above, will be paid for at the contract unit price per acre, which will be full compensation for all required materials, equipment, labor, testing and all work necessary to establish a satisfactory growth of grass.

Payment will be made under:

227-A: Hydroseeding - per acre

SECTION 228 - EROSION CONTROL BLANKET

228.01--Description. This work consists of furnishing, placing, and maintaining an Erosion Control Blanket (ECB) of the type specified on seeded or other designated areas in accordance with the plans and specifications.

228.02--Materials. The erosion control blankets shall be a temporary, organic and/or inorganic re-vegetative blanket with non-organic, photodegradable or biodegradable

netting. The netting shall be bonded sufficiently to the parent material to prevent separation of the net from the parent material for the life of the product. For those blankets that have netting attached, the netting and stitching shall be photodegradable and/or biodegradable. The photodegradable stitching shall be of the same material with similar properties as the netting such that the expected degradation periods are the same. The weight of the netting shall not exceed 15% of the total blanket weight.

The Contractor will be permitted to furnish and install a multi-width blanket with seams securely bonded by stapling, staking, stitching, or other methods meeting the approval of the Engineer.

The erosion control blanket must be one from the Department's current APL for the type indicated.

228.02.1--Blanket Types. The following are the types of erosion control blankets.

Type I blankets shall be a processed degradable natural and/or polymer fibers mechanically bound together by a single rapidly degrading, synthetic or natural fiber netting or an open weave textile of processed rapidly degrading natural or polymer yarns or twines woven into a continuous matrix.

Type II blankets shall be a processed degradable natural and/or polymer fibers mechanically bound together between two rapidly degrading, synthetic or natural fiber nettings.

Type III blankets shall be an erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix or an open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.

Type IV blankets shall be an erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix or an open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.

In addition to being on the Department's current APL, the blankets must meet the following general requirements.

TYPES OF BLANKETS

Type	Maximum Gradient	C Factor *, **	Minimum Tensile Strength ***
I	≤3:1 (H:V)	<0.15	50 lbs/ft
II	≤2:1 (H:V)	<0.20	75 lbs/ft
III	≤1.5:1 (H:V)	<0.25	100 lbs/ft
IV	≤1:1 (H:V)	<0.25	125 lbs/ft

* "C" Factor calculated as the ratio of soil loss from the ECB protected slope (tested at specified or greater gradient, h:v) to the ratio of soil loss from unprotected (control) plot in large-scale testing.

** Acceptable large-scale test methods may include ASTM D 6459, or other independent testing deemed acceptable by the Engineer.

*** Minimum Average Roll Values using ASTM D 6818.

228.02.2--Stakes. Unless otherwise specified by the manufacturer of the erosion control blanket, stakes used to secure the blanket shall be one of the following:

- 1) a double prong "U" shaped wire staple made from 11-gauge or heavier steel wire with an approximate length of eight inches (8") after bending,
- 2) a biodegradable anchoring device meeting the requirements of ASTM D 5338, or
- 3) an equal approved by the Engineer.

228.02.3--Acceptance Procedure. Prior to use, the Contractor must furnish the Engineer three copies of the manufacturer's certification for each shipment of erosion control blanket material stating the number of rolls furnished and that the material in the shipment conforms to the same composition as that listed on the Department's current APL.

When wire staples are used, also furnish the Engineer three copies of a certification from the manufacturer or distributor stating the wire size for staples for each shipment.

The certifications by the manufacturer or distributor will be prima facie evidence of the materials meeting the requirements of the specifications.

228.03--Construction Requirements. The Contractor shall furnish and install protective covering blankets for erosion control on prepared areas of slopes at locations shown on the plans or designated by the Engineer.

Erosion control blankets shall be installed according to manufacturer recommendation or install according to the detail plan sheet. The detail plan sheet is to be used as a guide in lieu of the manufacture recommendations.

228.03.1--Site Preparation. The area to receive the erosion control blanket should be fine graded to a smooth profile and relatively free from all weeds, clods, stones, roots, sticks, or other foreign material that may prevent the blanket from bearing completely on the surface. Any voids on the slope shall be filled and properly compacted.

Any seeded areas damaged or destroyed during placement of the erosion blanket shall be reseeded as specified for the original seeding at no additional costs to the State.

228.03.2--Trench Preparation. An anchor trench shall be prepared at the top of the slope by excavating a trench six inches deep by six inches wide. The erosion control blanket shall be anchored into the trench by staking on 1-foot centers. The stakes shall be driven at least flush with the soil surface. The anchor trench shall be backfilled and compacted with soil. A minimum of three feet shall be allowed from the anchor trench to the crest of the slope.

A similar anchor trench shall be installed at the bottom of the slope to terminate the installation. The trench shall be installed similar to the above except the erosion control blanket shall be rolled 24 inches past the toe of the slope. The terminal end of the erosion control blanket shall be staked on 1-foot centers.

On long slopes, an intermediate anchor trench shall be installed at 50-foot intervals.

228.03.3--Placement of Blanket. Starting at the crest of the slope, the erosion control blanket shall be rolled down the slope in a controlled manner. Approximately every 25 feet, the erosion control blanket shall be pulled to take out any excess slack. The goal is to have the erosion control blanket contour and initiate full contact with the soil.

The typical installation will require one stake placed at 3-foot to 5-foot intervals along the vertical length of the erosion control blanket. Stakes shall be staggered 18 to 24 inches horizontally across the erosion control blanket. If the erosion control blanket needs to be spliced in the middle of a slope, the erosion control blanket shall be "shingled" with up-slope erosion control blanket overlapping the down-slope erosion control blanket. There should be a minimum of six inches of overlap in a splice. The joint splice shall be made by placing a row of stakes six inches on center and then placing a second row of stakes six inches on center, staggered from the first row. All overlaps and the edges shall be secured with stakes. All longitudinal and transverse laps shall be a minimum 6-inch joint with the upgrade section on top. All transverse laps shall be staked with two staggered rows of stakes on 6-inch centers. All longitudinal laps shall be staked with two staggered rows on 3-foot to 5-foot centers. The staking shall firmly anchor the fabric netting to the soil surface.

On the downstream end of blankets adjoining a structure, the anchor trench shall be omitted and the material folded six inches and butted tightly against the structure and one row of stakes installed on six-inch centers. An edge adjacent to a paved ditch shall be butted tightly against the paved ditch and a row of stakes installed on 12-inch centers. All stakes shall be driven flush with the soil surfaces.

228.03.4--Protection and Maintenance. The Contractor shall maintain and protect the blankets until release of maintenance or until the Engineer has determined that the blankets have served their useful life, whichever occurs first. Maintenance shall consist of repairs necessitated by erosion, rain, wind, fire, or other cause.

228.04--Method of Measurement. Erosion control blankets of the type specified will be measured by the square yard of surface area covered. Any over width of material installed wider than ordered, laps, and anchor slots will not be measured for payment.

228.05--Basis of Payment. Erosion control blankets, measured as prescribed above, will be paid for at the contract unit price per square yard, which price shall be full compensation for all materials, equipment, labor, maintenance and all work necessary to complete the work.

Payment will be made under:

228-A: Erosion Control Blanket, Type - per square yard

SECTION 229 - EROSION MATS

229.01--Description. This work consists of furnishing and installing erosion mats to protect slopes, ditches, etc. from scour and erosion. The mats shall be installed at

locations shown on the plans in reasonably close conformity with the lines, grades and dimensions shown on the plans or as directed by the Engineer.

229.02--Materials. Erosion mats shall be UV stabilized mat constructed of plastics, composites, polymers, rubber, precast concrete, or cast-in-place concrete. Erosion mats will be used as an erosion preventer for ditches, slopes, and other locations shown on the plans. Erosion mats shall be one from the Department's APL.

The mat shall be visually inspected and approved by the Engineer prior to use. Once approved by the Engineer, the mat may be incorporated into the work.

229.03--Construction Requirements. Erosion mats shall be installed in accordance with the plans and manufacturer's guidelines including any underlayment. The anchor system shall be sufficient to anchor the mat to the ground surface.

The installation area shall be graded to a level, smooth surface to avoid water concentration and to create an appropriate base for the erosion mat. Seed and fertilizer shall be placed on the prepared surface prior to the installation of the erosion mat.

229.04--Measurement. Erosion Mat will be measured by the square yard.

If required, seed and fertilizer will be measured and paid under their appropriate pay items.

229.05--Basis of Payment. Erosion Mat, measured as prescribed above, will be paid for at the contract unit price per square yard, which price shall be full compensation for all labor, materials, tools, equipment, underlayment, anchor system, concrete, and all incidentals necessary to complete the work.

Payment will be made under:

229-A: Erosion Mat - per square yard

SECTION 230 - TREE AND SHRUB PLANTING

230.01--Description. Tree and shrub planting consists of furnishing, delivering, planting and establishing trees and shrubs of the types, species, and sizes indicated in accordance with these specifications and in reasonably close conformity with the locations shown on the plans or as directed.

230.02--Materials.

230.02.1--Quality of Plant Materials. Unless otherwise specified, all trees and shrubs shall be nursery grown stock, strong, healthy, clean, well grown, and free from damage, insects, diseases, or rodents. They shall be root pruned and typical of the species. They shall possess a healthy, normal, and fibrous root system of sufficient size to ensure plant growth. The branch system shall be of normal development and reasonably free from broken terminal growth or other objectionable disfigurements. Trees shall have reasonably straight stems, shall be well branched and symmetrical in accordance with their natural habits of growth, and shall be approved by a representative of the

Department.

230.02.2--Plant Names. All scientific and common plant names shall conform to the "Standardized Plant Names" of the American Committee on Horticulture sponsored by the American Association of Nurserymen (AAN), current at the time of bid. All plant materials used shall be true to names and legibly tagged with name and size of material. There shall be no substitution for the kinds or sizes specified except by prior approval in writing by the Engineer.

230.02.3--Grading Standards. Grading of plants shall conform to the specifications for horticulture standards as adopted by the AAN, and current at the time of bid.

230.02.4--Nursery Inspection and Plant Quarantine. All shipments of plants shall comply with all nursery inspection and plant quarantine regulations of the State of origin and destination, as well as with federal regulations governing the interstate movement of nursery stock. A valid copy of the certificate of inspection shall accompany each package, box, bale, or car load lot delivered.

230.02.5--Balled and Burlapped (B&B) Plants. Plants to be balled and burlapped shall be dug so as to retain as many fibrous roots as possible, and shall come from soil that will form a firm ball. The soil in the ball shall be the original and undisturbed soil in which the plant has been grown. The plant shall be dug, wrapped, transported, and handled so that the soil in the ball will not be loosened sufficiently to cause stripping of the small and fine feeder roots or to cause the soil to drop away from contact with the roots.

230.02.6--Container Grown (CG) Plants. Container grown plants shall be well-rooted and established in the containers in which they are sold. An established container grown plant shall be a plant transplanted into a container and grown in that container sufficiently long for new fibrous roots to have developed so that the root mass will retain its shape and hold together when removed from the container. The container shall be sufficiently rigid to hold the ball shape protecting the root mass during shipping and handling.

230.02.7--Inspection. All plant materials are subject to inspection at any time during the life of the contract by an authorized representative of the Department. Inspections before or during planting operations, however, shall not be construed as final acceptance of the plants involved.

230.02.8--Paint or Tree Wound Dressing. Paint required for cut surfaces shall be an asphalt base paint prepared especially for tree surgery and shall be approved before being used.

230.02.9--Collected Stock. Whenever "collected" stock is specified in connection with a species or variety, the stock shall not be nursery grown, but shall have been grown under natural conditions at the location from which it is acquired. If approved, collected stock may be obtained from areas no longer under cultivation as nursery stock.

230.02.10--Wrapping Material. The wrapping material shall be approved tree trunk wrapping paper.

The tying material to be used in wrapping trees shall be jute twine or other tying materials approved by the Engineer.

230.02.11--Water. The water applied as specified herein shall meet the requirements of Subsection 714.01.5.

230.02.12--Topsoil. Topsoil used for backfilling shall meet the requirements of Subsection 715.01.

230.02.13--Fertilizers. Fertilizers shall meet the requirements of Subsection 715.08.

230.02.14--Mulch. Mulch shall meet the requirements of Subsection 715.07.

230.02.15--Bed Edging. Bed edging shall be steel edging, 3/16-inch by 4-inch in size, green in color with steel stakes. The Contractor shall submit a sample of the bed edging to the Engineer and receive approval prior to delivery to the site.

230.03--Construction Requirements.

230.03.1--Collected Plants. The Contractor shall notify the Engineer at least 24 hours in advance of digging local plants. These plants shall meet the requirements of the contract.

230.03.2--Digging of Plants. All plants, nursery grown or collected, shall be dug with care and skill immediately before shipping. Care shall be taken to avoid all possible injury to the plants or loss or damage to the roots. Particular care shall be given to the fibrous roots. After plants are dug, their roots shall not be permitted to dry out. If necessary to prevent drying out, they shall be puddled immediately upon digging. Dug plants shall not be exposed to artificial heat or to freezing temperatures.

230.03.3--Care and Handling of Plants. Unless otherwise allowed by the Engineer, all plants with bare roots that are not planted within four hours after delivery to the project shall be "heeled-in" in a moist soil.

The roots of "B&B" plants and container grown plants that are not planted within four hours upon delivery shall be adequately protected by a covering of soil, sand, sawdust, etc. and kept moist.

All heeled-in plants shall be properly maintained by the Contractor until planted. When plants are delivered in boxes, wrapped bundles, or other forms of closed packages, the packages shall be opened immediately after delivery and the plants inspected and dampened if necessary. While plants with bare roots are being transported to and from heeling-in beds, or being distributed for planting, the roots shall be protected from drying out by means of wet canvas, burlap, straw or by other approved methods.

230.03.4--Seasonal Limitations. Trees and shrubs shall be planted during the period specified in the plans. When soil and weather conditions are adverse to proper planting, the planting operations shall be suspended.

230.03.5--Excavation of Plant Holes. Plant hole excavation shall be roughly cylindrical in shape with the sides approximately vertical. Plants shall be centered in the holes with the trunk locations as shown on the plans. The soil on the sides and in the bottom shall be loosened by scarifying or other approved methods.

Holes for bare-root plants shall be at least six inches larger than the maximum root spread. Holes for B&B, and CG plants shall be large enough to allow at least six inches of backfill below and around the earth ball. When a tree spade is used, the plant hole and the earth ball shall be approximately equal in size.

230.03.6--Pruning. Before the plant is placed in the plant hole, bruised or broken parts of minor roots shall be cut off in a satisfactory manner.

The tops of all plants shall be properly pruned, either before or immediately after planting. Pruning shall consist of thinning out and/or heading back of stems and top branches as may be necessary according to generally accepted horticultural practices and according to the shape, size, and condition of the individual plant. All cut surfaces one inch or more in diameter shall be painted with an approved asphalt base tree paint.

230.03.7--Planting, Backfilling and Watering. The plant shall be placed in the prepared plant hole at the proper position in regard to depth, alignment, final grade of the surrounding ground, and vertical placement of the trunk, and this position shall be maintained during subsequent backfilling and water operations. Unless otherwise specified or directed, plants shall stand, at the time of completion of planting operations, at the same depth as they stood in the nursery, container or field.

Plant pits are plant bed areas that are bound all around by bed edging and/or paving, or as noted on the drawings. Bed preparation shall be required within plant pits, which shall consist of stripping the proposed bed area of existing grass or plant material, unless designated to remain; removal and disposal of existing soil in order that finished grade of bed, not including surface mulch, is no higher than surrounding grades/pavement edges unless noted otherwise on the drawings; spreading a 4-inch layer of Tree Bark Mulch, Type III throughout the area, and tilling in the Tree Bark Mulch, Type III to a depth of six inches uniformly throughout the area; and excavating plant holes. The entire bed area shall receive Tree Bark Mulch, Type V, as a surface mulch.

Within plant pits, additional Tree Bark Mulch, Type III for each tree, shrub and groundcover plant hole is not necessary beyond the uniform layer of application tilled into the soil as noted on the vegetation schedule. Within each tree and shrub plant hole within a plant pit, backfill with a 50/50 mix of existing soil amended with Type III mulch and topsoil. Groundcover plant holes do not require any other backfill material other than the amended existing soil with Type III mulch incorporated.

Backfill for tree and shrub plant holes outside of plant pits shall be a 50/50 mix of existing soil and topsoil, after applying the 4-inch layer of Tree Bark Mulch, Type III.

230.03.7.1--Plants with Bare Roots. With the plant in its proper position, the plant hole shall be carefully filled to within one-half to two-thirds its capacity with topsoil. The topsoil shall be carefully placed, worked around the roots, and firmed so as to avoid bruising or breaking the roots. When this partial backfilling and firming has been completed, the soil in the plant hole shall be saturated with water.

The remainder of the topsoil backfill shall then be placed, firmed, and brought to an approved moisture content. The top few inches of soil may be allowed to remain loose.

When deemed necessary, water rings shall be constructed of suitable firmed earth six

inches high to encompass the plant hole for the purpose of retaining water.

230.03.7.2--Balled and Burlapped Plants. The plant shall be handled by the ball and placed in the hole in such a manner that the soil will not be loosened from the roots. After the hole has been partially backfilled and the topsoil firmed under and around the ball, the burlap shall be cut away from the stem of the plant. The hole shall then be saturated with water to the elevation of the top of the topsoil. Backfilling and firming shall then be completed in a manner to avoid loosening the soil of the root ball. Water shall then be applied as for bare root plants, and water rings shall be constructed as deemed necessary.

230.03.7.3--Container Grown Plants. Immediately prior to placing the plant in the hole, the container shall be removed so as not to disturb the ball of soil that contains the root system. The planting procedure shall be as specified above for balled and burlapped plants.

230.03.7.4--Tree Spade Plants. When specified or permitted, a tree spade may be used in digging plant holes and planting. This method of planting shall be in accordance with good horticultural practices meeting the approval of the Engineer.

230.03.8--Fertilizer. Fertilizer shall be the types and shall be applied at the rates and in the manner specified. The fertilizer shall be applied during backfilling operations in a manner that will ensure proper placement of the fertilizer and avoid injury to the roots.

230.03.9--Mulching. Mulch shall be the types and shall be applied at the rates specified as a top layer on the backfilled plant hole.

230.03.10--Wrapping. The trunks of smooth-barked trees shall be wrapped with an approved material prepared especially for tree wrapping.

Wrapping shall begin two inches below the ground line and continue upward to the lower-most branches, and shall be firmly placed and securely fastened in a manner that will not injure the trunk of the tree.

230.03.11--Staking and Guying. All trees shall be staked or guyed at the time of planting.

Trees larger than two-inch caliper shall be guyed from at least three points with double strands of 12-gauge wire. Guy wires shall be anchored to 2-inch by 2-inch by 18-inch stakes driven to the extent that the top of the stake is at approximately three inches above the finish ground. Tie wires shall be securely fastened to the tree by means of a collar of rubber hose or other approved material. Guy wires shall be tightened and kept tight by twisting.

Trees, 2-inch and smaller caliper, may be guyed as specified above or staked with two stakes, 2-inch by 2-inch minimum, set 18 inches in the ground. The tree shall be midway between the stakes and held firmly in place by two strands of 12-gauge, soft wire enclosed in rubber hose or other approved covering. The wire shall then be nailed or stapled to the stakes to prevent slippage.

230.03.12--Surplus Excavation. Surplus excavated material from plant holes shall be

disposed of by scattering or as directed. All debris and other objectionable material shall be removed from the site and the area cleaned up and left in neat condition.

230.03.13--Restoration of Plants. At the earliest possible time at the end the growing season, the Contractor shall replace at no additional cost to the Department all dead, damaged, or missing plants.

230.03.14--Plant Establishment.

230.03.14.1--General. The Contractor shall use good horticultural practices to keep all plants installed in a healthy condition until final inspection for release of maintenance.

230.03.14.2--Weed and Grass Control. The area around planted trees and shrubs shall be maintained reasonably free of weeds and grass within a minimum radius of two feet from each plant trunk or the entire plant pit or bed. Where practicable to effectively accomplish this work without removal of the mulch, removal will not be required. If it is necessary to remove the mulch to effectively accomplish this work, removal and replacement shall be performed at no additional cost to the Department. Weed and grass control shall be performed during the time intervals specified on the plans.

230.03.14.3--Watering. Water necessary to thoroughly wet the roots of all trees and shrubs shall be applied in accordance with the provisions shown on the plans.

230.03.14.4--Fertilization. Each tree or shrub shall be fertilized with the types of fertilizer, at the rates, and during the periods shown on the plans.

230.03.14.5--Mulching. Mulch material shall be repositioned, supplemented, or replaced as required during the period shown on the plans.

230.03.14.6--Pruning. All trees and shrubs shall be properly pruned with approved pruning shears. Pruning shall consist of removing all dead or diseased wood and new growth as necessary to maintain natural shape of the plants. Pruning shall be during the periods specified on the plans.

The Contractor shall be fully responsible for protection, preservation, and maintenance of all plantings until final inspection for release of maintenance.

230.03.14.7--Inspection of Plants. Inspection of planted trees and shrubs will be made by the Engineer at the end of the growing season. Determinations will be made by the Engineer of the survival of each size and type of plant. The Engineer will either require replacement of dead, defective, or missing plants, or not require replacement at certain locations.

230.03.14.8--Replacement of Plants. The Contractor may be directed by the Engineer to replace certain dead, defective, or missing plants. Replacement plants shall be made at the earliest practicable time during the planting season and growing season. All replacement plantings shall be in accordance with the requirements applicable to initial planting.

230.03.14.9--Non-Replacement of Plants. Certain plants found to be dead, defective, or missing may be ordered removed and not replaced if non-replacement would not

adversely affect the planting design.

230.03.14.10--Plant Establishment Period. The plant establish period (growing season) shall begin upon the date that the Engineer determines plant material installation has been acceptably completed, including staking/guying and mulching, and continues through the time noted below.

Date of Installation Completion	Growing Season
August 2 nd to November 1 st	240 Calendar Days
November 2 nd to January 1 st	180 Calendar Days
January 2 nd to May 1 st	120 Calendar Days
May 2 nd to August 1 st	90 Calendar Days

Where feasible in the opinion of the Engineer, the Contractor may install plant material well in advance of project completion, in order that the plant establishment period may run concurrent with the contract time. All dead and unsatisfactory plant material shall be replaced after the growing season. No additional growing season will be required after the initial growing season. However, no matter what date the growing season concluded, the Contractor will be required to maintain healthy plants until final inspection of the entire project.

No contract time or liquidated damages will be charged during the plant establishment period if, and only if, all items of work on the project have been completed.

230.04--Method of Measurement. Trees and shrubs, in place, undamaged and healthy at the time of final inspection, will be measured per each for each species, size, and type specified.

Furnishing, installation, staking or guying, weed and grass control, pruning, removal of dead and defective trees and shrubs or missing trees and shrubs will not be measured for separate payment.

Topsoil used for backfilling initial plantings only will be measured and paid for under Section 211.

Fertilizer ordered and acceptably used will be measured and paid for under Section 232.

Mulch ordered and placed in accordance with the requirements of these specifications will be measured and paid for under Section 233.

Water ordered and acceptably used will be measured and paid for under Section 219.

Bed edging, complete in place and accepted, will be measured per linear foot. Excavation, backfilling, and miscellaneous fittings will not be measured for separate payment.

Bed preparation within plant pits, complete in place and accepted, will be measured per square foot. Stripping of existing vegetation, excavation of existing soil, and weeding will not be measured for separate payment.

Tree Bark Mulch will be measured and paid for in accordance with Subsection 233.04.

Construction of water rings, haul and disposal of surplus or unsuitable excavation, and other plant establishment work required in the contract shall be considered incidental to tree or shrub planting and will not be measured for separate payment.

Measurement for payment will be made in the following sequence:

When plants have been planted and are in a healthy condition in accordance with the contract, seventy-five percent (75%) of the bid price for that species of plant material meeting the requirements of the contract will be allowed.

When the inspection of plants at the end of the growing season has been conducted and the replacement of any dead or unsatisfactory plant material has been made, ninety percent (90%) of the bid price for that species of plant material meeting the requirements of the contract will be allowed.

When the final inspection of the project has been conducted and the replacement of any dead or unsatisfactory plant material has been made and upon final release of maintenance, one-hundred percent (100%) of the bid price will be allowed for plant material meeting the requirements of the contract.

230.05--Basis of Payment. Accepted quantities of scrubs and trees of the specified species, size, and type will be paid for at the contract unit price per each, which price shall be full compensation for completing the work.

Accepted quantities for bed edging and bed preparation will be paid for at the contract unit price per linear foot and square foot, respectively. Prices paid shall be full compensation for completing the work.

Payment will be made under:

- 230-A: Shrub Planting, Designation - per each
- 230-B: Tree Planting, Designation - per each
- 230-C: Bed Edging - per linear foot
- 230-D: Bed Preparation - per square foot

SECTION 231 - TREE SEEDLING PLANTING

231.01--Description. Tree seedling consists of furnishing, delivering and planting tree seedlings of the species, type and size indicated, in accordance with these specifications and in reasonably close conformity with the locations shown on the plans or directed.

231.02--Materials.

231.02.1--Quality and Grading Standards. The seedlings shall be nursery grown and

equal to the best quality produced by and graded according to the standards of the Mississippi State Forestry Commission, United States Forest Service, or American Association of Nurserymen (AAN).

231.02.2--Nursery Inspection and Plant Quarantine. All shipments of seedlings shall comply with all nursery inspection and plant quarantine regulations of the State of origin and destination, as well as with federal regulations governing the interstate movement of nursery stock. A valid copy of the certificate of inspection shall accompany each package, box, bale, or car load lot delivered.

231.02.3--Plant Names. All scientific and common plant names shall conform to the "Standardized Plant Names" of the American Committee on Horticulture sponsored by the AAN, current at the time of bid. All plant materials used shall be true to names and legibly tagged with name and size of material. There shall be no substitute for the kinds or sizes specified except by prior approval in writing by the Engineer.

231.02.4--Inspection. All seedlings are subject to inspection at any time during the life of the contract by an authorized representative of the Department. However, inspections before or during planting operations shall not be construed as final acceptance of the seedlings.

231.02.5--Fertilizer. Fertilizer(s) shall meet the applicable requirements of Section 213 or Section 232, as specified.

231.03--Construction Requirements.

231.03.1--Equipment. The furnished tools and equipment for digging plant holes, slits or trenches shall be adequate to perform the excavation to the proper size and depth such that twisted, balled, or "U" roots will not result. All equipment and tools shall meet the approval of the Engineer.

231.03.2--Seasonal Limitations. Seedlings shall be planted during the period specified on the plans. When soil and weather conditions are adverse to proper planting, the planting operations shall be suspended.

231.03.3--Care and Handling. All seedlings shall be planted within fourteen days after pick-up from the nursery. The seedlings shall be stored in a cool, damp, shady place and the roots kept moist at all times until planted. Seedlings allowed to dry out in route to planting site, in storage for daily planting or during handling by individual planters will be unacceptable for planting.

231.03.4--Spacing. The spacing of seedlings shall be as specified on the plans, or as directed by the Engineer.

231.03.5--Area Preparation. All existing vegetation within the area shall be mowed to a height of approximately four inches prior to planting the seedlings.

231.03.6--Planting. The ground shall be cleared of vegetation approximately one square foot at the point of planting when planting seedlings using a dibble bar or mattock. One seedling per trash-free hole shall be planted in the center of the cleared area at the depth grown in the nursery; however, a tolerance of two inches low will be permitted for pine

seedlings. All slits, holes, or trenches shall be closed and the soil packed firmly around the planted seedlings.

Mechanical seedling planters may be used to plant seedlings in relatively flat areas suited to power equipment when approved. The planter shall clean a strip of an approved width and in an approved manner. One seedling shall be planted in the trash-free slit or trench at the depth grown in the nursery; however, a tolerance of two inches low will be permitted for pine seedlings. All plant slits or trenches shall be closed and the soil packed firmly around the planted seedling.

When the plant holes cannot be dug large enough for the seedling's root system using dibble bar, mattock or mechanical planter, other approved methods shall be used. In any case, roots of seedlings shall not be pruned or broken.

231.03.7--Restoration of Seedlings. At the earliest possible time during the planting seasons and at no additional cost to the Department, the Contractor shall replace all dead, damaged, or missing seedlings.

231.03.8--Application of Fertilizer. Fertilizer shall be the types and shall be applied at the rate and in the manner specified.

231.03.9--Inspection of Seedlings. Inspection of planted seedlings will be made by the Engineer before the end of the first full growing season. On or about October 1, determinations will be made by the Engineer of the survival of each species of seedling. The Engineer will divide the portion of the project on which each species of seedling is planted into lots as deemed necessary to represent segments of the work in which survival characteristics are similar. At the discretion of the Engineer, the percentage of survival of seedlings will be determined by sampling from each of the lots selected or the percentage of survival in any lot may be determined from the ratio of the actual count of seedlings within the lot at the time of the inspection to the total number of seedlings required to plant the lot in accordance with the spacing requirements of the contract.

In the determination of the percentage of survival sampling from areas planted, the Engineer will select at random, from within each lot selected, one or more increments, each of which shall be not less than one-tenth acre or ten percent of the area of the lot, whichever is smaller. The area of each increment selected within the lot will be measured and, if more than one increment is selected, their areas will be combined. The number of surviving seedlings within the selected increment(s) of the lot will be counted. The percentage of the survival of the lot will be established by dividing the combined count of surviving seedlings thus obtained by the total number of seedlings required for the combined areas of the increments when planted in accordance with the spacing requirements of the contract.

The survival percentage of each species for the project will be established by multiplying the survival percentage for each lot by the area of each such lot and dividing the sum of these products by the total area planted.

As determined during this inspection, the Engineer will either require replacement of dead, defective, or missing seedlings or not require replacement of such seedlings at certain locations.

231.03.10--Replacement or Non-Replacement of Seedlings.

231.03.10.1--Replacement. The Contractor may be directed by the Engineer to replace certain dead, defective, or missing seedlings. Replacements shall be made at the earliest practicable time during the planting season following the first growing season. All replacement plantings shall be in accordance with the requirements applicable to initial planting.

231.03.10.2--Non-Replacement. Certain seedlings found to be dead, defective, or missing may not be ordered replaced if non-replacement would not adversely affect the planting design.

231.04--Method of Measurement. Seedlings of the type specified, in place, undamaged, and healthy at the time of final inspection, will be measured per thousand seedlings.

At the discretion of the Engineer, the total number of acceptable seedlings in place at the time of final inspection will be determined by sampling from areas planted or by actual count of acceptable surviving seedlings. The Engineer will divide the portion of the project on which each species of seedlings is planted into lots as deemed necessary to represent areas of the work on which survival characteristics are similar. Within each such lot, in the case of determination by sampling, the Engineer will select at random one or more increments, each of which shall be not less than one-tenth acre or ten percent of area of the lot, whichever is smaller. The area of the lot will be determined and the area of each increment selected within the lot will be measured and, if more than one increment is selected within the lot, the areas of such increments will be combined. The number of acceptable surviving seedlings within the increment or increments, as the case may be, will be counted. The number of acceptable surviving seedlings within the increment or increments thus determined shall be multiplied by the ratio between the area of the lot and the area of the increment or increments, as the case may be, to give the total number of surviving seedlings in the lot.

In lieu of such determination by the specified sampling method, the Engineer may elect to determine the total number of acceptable surviving seedlings in place in any lot at the time of final inspection by actual count.

The number of acceptable seedlings of each species in place on the project at the time of final inspection shall be the summation of the number of acceptable surviving seedlings of each species determined for each lot.

Fertilizer(s) ordered and acceptably used will be measured and paid for under Section 213 or Section 232.

Measurement for payment will be made in the following sequence:

When all seedlings have been planted in accordance with the contract, 65 percent of the unit price will be allowed.

When the inspection of seedlings at the end of the first growing season (October 1) as set out in Subsection 231.03.9 determines that the survival rate exceed 65 percent for one or more of the individual species, sizes and types, the same percentage of the unit price will be allowed as the survival rate, but not to exceed 75 percent.

At the end of the second planting season and after all ordered replacement seedlings have been properly planted and the survival rate at the end of the first growing season was determined to exceed 75 percent for one or more of the individual species, sizes and types, the same percentage of the unit price will be allowed as the survival rate, but not to exceed 80 percent.

At the end of the second growing season, 90 percent of the unit price will be allowed for surviving seedlings, trees and shrubs.

Upon release of maintenance, 100 percent of the unit price will be allowed for surviving seedlings, trees and shrubs meeting the requirements of the contract.

231.05--Basis of Payment. Seedlings of the type specified, measured as provided above, will be paid for at the contract unit price per thousand, which price shall be full compensation for completing the work.

Payment will be made under:

231-A: Seedlings, Designation - per thousand

SECTION 232 - FERTILIZER FOR WOODY PLANT MATERIAL

232.01--Description. This work consists of furnishing, transporting, and placing fertilizer under or around the roots of trees, shrubs, liner plants, and other plant materials in accordance with the requirements shown on the plans and in these specifications.

232.02--Materials. The fertilizer for woody plant materials shall meet the requirements of Subsection 715.08.

232.03--Construction Requirements. Unless otherwise specified, the Contractor will have the option of using fertilizer packets or tablets. A one-ounce packet is equivalent to four five-gram tablets; two ten-gram tablets; or one twenty-one-gram tablet. The required number and size of packets or tablets for each type of plant material will be specified on the plans.

When using packets, they shall be placed beneath the roots in the backfill material during the planting operation. Care shall be taken to ensure that packets remain unopened and lie in a horizontal position.

When using tablets, the plant shall be positioned in the plant hole and backfilled no higher than halfway up the root ball. The specified number of tablets, designated on the plans or determined by the Engineer, shall be spaced approximately equal distances around and immediately adjacent to the root ball. The backfilling operation shall then be completed in accordance with the planting specifications.

232.04--Method of Measurement. Fertilizer for woody plant material will be measured by the thousand tablets or packets.

Fertilizer tablets, placed as specified and accepted, will be measured in place by the

thousand tablets.

Fertilizer packets, placed as specified and accepted, will be measured in place by the thousand packets. In the event fertilizer tablets are substituted for fertilizer packets as provided in Subsection 232.03, the quantity of tablets placed and accepted will be converted to packets and included in the measurement for payment for fertilizer packets.

232.05--Basis of Payment. Fertilizer for woody plant material, measured as prescribed above, will be paid for at the contract unit price per thousand tablets or per thousand packets, as specified. Prices thus paid shall be full compensation for completing the work.

Payment will be made under:

232-A: Fertilizer for Woody Plant Material,
Designation, Size - per thousand

SECTION 233 - MULCH FOR WOODY PLANT MATERIAL

233.01--Description. This work consists of furnishing, transporting, placing, and maintaining the kinds of mulch specified in accordance with the requirements of these specifications and in reasonably close conformity with the dimensions and details shown on the plans or established.

233.02--Materials. The mulch for woody plant materials shall meet the applicable requirements of Subsection 715.07.

Tree Bark Mulch, Type III used for plant pits (multiple plants in one bed area) and plant holes outside of plant pit areas shall meet the requirements of Subsection 715.07. Tree Bark Mulch, Type V used for the surface mulching plant holes and plant pits shall meet the requirements of Subsection 715.07.

Straw mulch delivered in bales shall be commercially available baled straw with an approximate length of 32 inches.

233.03--Construction Requirements.

233.03.1--General. All work shall conform to good horticultural practices.

233.03.2--Placement. The specified kinds of mulch shall be placed uniformly on designated areas within 24 hours following planting. The areas to be mulched shall be free of undesirable debris and weeds or grass. The mulch shall be placed to the specified depth by an approved method and in a manner that will present a neat uniform appearance. The mulch shall be kept within the designated areas without undue scattering. The areas to receive mulch and the rates of application will be shown on the plans or designated by the Engineer. The tolerances from the specified rates will be as determined by the Engineer to be reasonable.

233.03.3--Protection and Maintenance. The Contractor shall maintain and protect mulch areas until release of maintenance of the project. The Contractor shall take every

precaution to prevent unnecessary foot and vehicular traffic on the mulched areas and shall repair and restore immediately all displacement of mulch without additional compensation.

233.04--Method of Measurement. Mulch for woody plant materials will be measured by the cubic yard or ton as specified herein.

Tree Bark Mulch, Type III for tree plant holes and for shrub plant holes outside of plant pit areas will be measured per cubic yard.

Tree Bark Mulch, Type V for tree and shrub plant holes outside of plant pit areas requiring bed preparation and in unplanted areas where the mulch is utilized as a surface treatment will be measured per cubic yard;. Tree Bark Mulch, Type V within plant pit areas will not be measured for payment.

Tree bark mulch will be measured by the cubic yard as packaged or baled. Unless the Engineer determines otherwise, the volume shown on the manufacturer's label or tag will be used to determine the volume. Aggregate mulch will be measured by the cubic yard (LVM).

Straw mulch will be measured by the cubic yard, ton, or each bale. When measuring straw mulch by the cubic yard, the volume for measurement will be the product of the number of bales of straw mulch acceptably placed and the average volume per bale. When measuring straw mulch by the ton, the weight for measurement will be the product of the number of bales of straw mulch acceptably placed and the average weight per bale as determined on approved scales provided by the Contractor.

233.05--Basis of Payment. Mulch of the kinds, types, or classes specified will be paid for at the contract unit price per cubic yard for tree bark mulch, per cubic yard (LVM) for aggregate mulch, and per cubic yard, ton or each for straw mulch, which prices thus paid shall be full compensation for completing the work.

Payment will be made under:

233-A: Tree Bark Mulch, <u>Type</u>	- per cubic yard
233-B: Aggregate Mulch	- per cubic yard
233-C: Straw Mulch, <u>Class</u>	- per cubic yard, ton, or each

SECTION 234 - SILT FENCE

234.01--Description. This work consists of furnishing, constructing and maintaining a water permeable filter type fence, inlet siltation guard or turbidity barrier for the purpose of removing suspended soil particles from the water passing through it in accordance with the requirements shown on the plans, as directed by the Engineer and these specifications. Fence, inlet siltation guards and turbidity barriers measured and paid as temporary shall be removed when no longer needed or permanent devices are installed.

It is understood that measurement and payment for silt fence, inlet siltation guards, and turbidity barriers will be made when a pay item is included in the proposal. The quantities are estimated for bidding purposes only, and may be varied dependent upon actual conditions that occur during construction of the project.

234.02--Materials. Geotextile fabric, posts, staples and woven wire backing, when required, shall meet the requirements of Subsection 714.13.

Inlet siltation guards shall be one from the Department's APL.

Turbidity barriers shall be one from the Department's APL.

Chain link fence and hardware for super silt fence shall meet the requirements of Section 607, as applicable. Geotextile for super silt fence shall meet the requirements of Subsection 714.13 for a Type II Woven fabric.

234.03--Construction Requirements.

234.03.1--Placement of Fence.

234.03.1.1--Silt Fence. The silt fences shall be constructed at the locations shown on the plans or as directed by the Engineer.

All posts shall be installed so that no more than three feet of the post shall protrude above the ground. Extra post for bracing shall be installed as directed by the Engineer. The woven wire shall be securely fastened to the wood posts with staples. When metal posts are used, the wire shall be fastened to the post with wire or other approved means. The geotextile shall be attached to the wire fence by wire or other approved means. The bottom edge of the geotextile shall be buried six inches below ground surface to prevent undermining. When splicing of the geotextile is necessary, two posts shall be installed approximately 18 inches apart and each piece of geotextile shall be fastened to both posts.

The geotextile will be rejected if it has defects, rips, holes, flaws, deterioration, or damage incurred during manufacture, transportation, storage or installation.

Type II geotextile may be installed without the woven wire fence backing provided all of the following conditions are met:

- (a) Post spacing is reduced to six feet or less.
- (b) The geotextile has been approved by the Engineer and the manufacturer recommends its use without the woven wire backing.
- (c) Fence posts shall be inclined toward the runoff source at an angle of not more than 20° from vertical.
- (d) Geotextile shall be attached to the posts in such manner that purpose intended is satisfied and maintained.

234.03.1.2--Super Silt Fence. Super silt fence shall be constructed in accordance with the plans and these specifications.

All posts shall be installed/driven so that at least 34 inches of the post will protrude above

the ground. The chain link wire and geotextile shall be stretched taut and securely fastened to the posts as shown on the plans. The bottom edge of the fence and geotextile shall be buried at least eight inches below ground surface to prevent undermining. When splicing of the geotextile is necessary, the fabric shall be overlapped approximately 18 inches.

234.03.2--Placement of Inlet Siltation Guards and Turbidity Barriers. The inlet siltation guards and turbidity barriers shall be constructed at the locations shown on the erosion control plan. Inlet siltation guards and turbidity barriers shall be installed in accordance with the erosion control drawings in the plans. A copy of the manufacturer's instructions for placement of inlet siltation guards and turbidity barriers shall be provided to the Engineer prior to construction.

234.03.3--Maintenance and Removal. The Contractor shall maintain the silt fence and the geotextile shall be removed and replaced when deteriorated to such extent that it reduces the effectiveness of the silt fence. Excessive accumulations against the fence shall be removed and disposed of as directed by the Engineer.

The Contractor shall maintain the inlet siltation guards. The geotextile shall be removed and replaced when deteriorated to such extent that it reduces the effectiveness of the guard. Replacement geotextile shall be the same type and manufacture as the original. Excessive accumulations against the guard shall be removed and disposed of at a location approved by the Engineer.

The Contractor shall maintain the turbidity barriers. Excessive accumulations against the turbidity barrier shall be removed and disposed of at a location approved by the Engineer.

Unless otherwise directed, all temporary silt fences, inlet guards and turbidity barriers shall be removed. Upon removal, the Contractor shall remove and dispose of any excess silt accumulations, shape the area to the line, grade, and cross section shown on the plans and place vegetation on all bare areas in accordance with the contract requirements. The temporary fence, inlet guard materials and turbidity barriers will remain the property of the Contractor and may be used at other locations provided the materials are acceptable to the Engineer.

234.03.4--Resetting Inlet Siltation Guards and Turbidity Barriers. When inlet siltation guards and turbidity barriers are no longer needed at one location, they may be removed and reset at other needed locations. The Engineer may allow the resetting of siltation guards and turbidity barriers upon an inspection and determination that the siltation guards (frame and geotextile) and turbidity barriers are adequate for their intended purpose. When they have to be stored until needed at another location, payment for resetting will not be made until they are reset at their needed location.

234.04--Method of Measurement. Silt fence and super silt fence will be measured by the linear foot.

Inlet siltation guard and resetting siltation guards will be measured per each. Turbidity barrier will be measured per linear foot.

234.05--Basis of Payment. Silt fence and super silt fence, measured as prescribed above, will be paid for at the contract unit price per linear foot which shall be full

compensation for completing the work.

Inlet siltation guard, resetting inlet siltation guards, and turbidity barrier, measured as prescribed above, will be paid for at the contract unit price per each or linear foot, which shall be full compensation for furnishing, constructing, and maintaining the work and for the removal and disposal of all items comprising the devices.

Payment will be made under:

234-A: Temporary Silt Fence	- per linear foot
234-B: Permanent Silt Fence	- per linear foot
234-C: Super Silt Fence	- per linear foot
234-D: Inlet Siltation Guard	- per each
234-E: Reset Inlet Siltation Guard	- per each
234-F: Turbidity Barrier	- per linear foot

SECTION 235 - TEMPORARY EROSION CHECK

235.01--Description. This work consists of furnishing, constructing and maintaining baled hay or straw erosion checks for the retention of soil along the toe of fill slopes, around inlets, swale areas, small ditches, sediment basins and other areas as directed by the Engineer in accordance with the requirements shown on the plans and these specifications. Also, the work includes removing and disposing of the erosion checks and silt accumulations as directed by the Engineer.

Measurement and payment for temporary erosion checks will be made only when ordered and a pay item is included in the bid schedule of the proposal. The quantity is estimated for bidding purposes only and will be dependent upon actual conditions that occur during construction of the project.

235.02--Materials. Approved Type I or II baled hay or straw material shall be rectangular in shape with a minimum length of 32 inches and shall meet the requirements of Subsection 715.05. The wooden stakes used in securing the baled material in place shall be approximately 2 inches by 2 inches x 34 inches meeting the approval of the Engineer.

235.03--Construction Requirements.

235.03.1--General. The erosion checks shall be constructed at the locations and according to the requirements shown on the plans or as directed by the Engineer. Erosion checks required along the toe of fill slopes shall be constructed prior to grading operations at the site. For other locations, the erosion checks shall be constructed when directed by the Engineer.

The soil shall be excavated at least three inches in depth to embed the baled material.

After securing in place, a sufficient quantity of the excavated material shall be placed around the erosion check and compacted to prevent undermining.

235.03.2--Maintenance and Removal. The Contractor shall maintain the erosion checks and remove and dispose of silt accumulations as directed by the Engineer.

When the erosion checks are no longer needed, they shall be removed and the Contractor shall dispose of silt accumulations and treat the disturbed areas in accordance with the contract requirements.

235.04--Method of Measurement. Erosion check will be measured per each by actual count of the total bales used in constructing, replacing and maintaining the erosion checks.

235.05--Basis of Payment. Erosion check, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for completing, maintaining and removal of the erosion checks and the removal and disposal of silt accumulations.

Payment will be made under:

235-A: Temporary Erosion Check - per each

SECTION 236 - TEMPORARY SILT BASINS

236.01--Description. This work shall consist of excavation and satisfactory disposal of all materials excavated in the construction, clean out, and maintenance of silt basins. This work may also consist of maintenance and removal of existing silt basins constructed on previous projects.

The Contractor shall construct earth dikes and overflow spillways, furnish and install outfall pipe, perforated elbows, perforated risers, and trash racks in silt basins where shown on the plans or as directed by the Engineer. The quantity of silt basins to be placed will be affected by the actual conditions that occur during the construction of the project.

It is understood that measurement and payment for silt basins will be made only when shown on the plans or ordered by the Engineer, and a pay item is included in the bid schedule of the proposal. The quantity is estimated for bidding purposes only and will be dependent upon actual needs during construction of the project.

236.02--Blank.

236.03-Construction Requirements.

236.03.1-General. The Contractor shall excavate silt basins to the dimensions and at the locations shown on the plans or as directed by the Engineer. The silt basins, new or existing, shall be cleaned out as frequently as necessary to have at least 50% of the basin capacity available at all times. The silt basins shall be completely cleaned out and the slopes shaped and dressed for seeding and mulching prior to completion of the project

unless otherwise directed by the Engineer. Grassing shall be done in accordance with the provisions contained in the contract for the roadway and will not be measured as a separate item.

236.03.2--Maintenance and Removal. The silt basins shall be maintained so they will function properly until the Contractor is released from maintenance, all as determined by the Engineer.

All excavated materials shall be utilized in the construction of basins or roadway embankments except where otherwise directed by the Engineer. Materials not used shall be disposed of as directed by the Engineer.

Upon removal of a silt basin, the pipe, elbows, risers and trash racks may be used at other locations provided they are in condition acceptable to the Engineer. Pipe, elbows, risers and trash racks will become the property of the Department upon completion of the project.

236.04--Method of Measurement. Silt basin will be measured per each. Once a silt basin has been constructed, it shall be paid for at the unit price per each.

Maintenance and removal of existing silt basin will be measured per each. Once an existing silt basin has been cleaned out, it shall be paid for at the unit price per each. Additional clean outs or maintenance may need to be performed on that silt basin throughout the length of the project.

236.05--Basis of Payment. Silt basin will be paid for at the contract unit price per each, which price shall be full compensation for construction, maintaining, removal unless noted otherwise, grassing and any other work required to make the basin function. Maintenance and removal of existing silt basin will be paid for at the contract unit price per each, which price shall be full compensation for maintaining, removal, grassing and any other work required to complete the work.

Payment will be made under:

236-A: Silt Basin, Type - per each

236-B: Maintenance and Removal of Existing Silt Basin * - per each

* Type may be specified

SECTION 237 - WATTLES

237.01--Description. This work consists of furnishing, constructing and maintaining wattles for the retention of soil around inlets, swale areas, small ditches, sediment basins and other areas as necessary. Also, the work includes removing and disposing of the wattles and silt accumulations.

Measurement and payment for wattles will be made only when a pay item is included in the bid schedule of the proposal. The quantity is estimated for bidding purposes only and will be dependent upon actual conditions that occur during construction of the project.

237.02--Materials. Wattles used around inlets shall have a diameter of twelve inches (12”) and a length adequate to meet field conditions. Wattles used at other locations shall have a diameter of twenty inches (20”) and a length adequate to meet field conditions. The minimum diameter for the above wattle sizes shall be one inch (1”) less than the specified diameter.

The stakes used in securing the wattles in place shall be placed approximately three feet (3’) apart throughout the length of the wattle. Stakes shall be wooden and of adequate size to stabilize the wattles to the satisfaction of the Engineer.

Wattles shall be one from the Department’s APL.

237.03--Construction Requirements.

237.03.1--General. The wattles shall be constructed at the locations and according to the requirements shown on the erosion control plan.

237.03.2--Maintenance and Removal. The Contractor shall maintain the wattles and remove and dispose of silt accumulations.

When the wattles are no longer needed, they shall be removed and the Contractor shall dispose of silt accumulations and treat the disturbed areas in accordance with the contract requirements.

237.04--Method of Measurement. Wattles of the size specified will be measured per linear foot.

237.05--Basis of Payment. Wattles, measured as prescribed above, will be paid for at the contract unit price per linear foot, which price shall be full compensation for installation, maintaining and removal of the wattles, the removal and disposal of silt accumulations and any required restoration of the disturbed areas.

Payment will be made under:

237-A: Wattles, Size - per linear foot

SECTION 239 - TEMPORARY SLOPE DRAINS

239.01--Description. This work consists of furnishing materials for, constructing and maintaining temporary slope drains, to include berms, pipe and riprap, as directed by the Engineer in accordance with the requirements shown on the plans and these specifications to control soil erosion and water pollution. Also, the work includes removing and disposing of the temporary slope drains.

This temporary erosion control provision shall be coordinated with the permanent erosion control features to assure economical, effective and continuous erosion control throughout the construction period.

Measurement and payment for temporary slope drains will be made only when a pay item

is included in the bid schedule of the proposal. The quantity is estimated for bidding purposes only and may vary depending upon actual construction requirements.

239.02--Materials. The temporary shoulder berm may be constructed from embankment material.

The temporary pipe shall be 8-inch minimum diameter and leak proof.

The temporary riprap shall be hard, durable stones or broken concrete, angular in shape and shall be of sufficient size to prevent scour where installed.

239.03--Construction Requirements. Temporary slope drains shall be constructed at the intervals and locations designated or deemed appropriate by the Contractor and approved by the Engineer for channeling runoff waters down embankment slopes and according to the requirements shown on the plans.

Slope drains shall be adequately anchored to the slopes and their outlets constructed or placed to prevent erosion.

Berms may be constructed from embankment material using the heel of a motor grader, bulldozer blade or other approved equipment and compacted using the wheels or tracks of same equipment.

Riprap shall be placed in accordance with the plans where the pipe outlet location is subject to scour. The riprap may be end dumped.

Pipe shall be placed in accordance with the plans and extended as required to coincide with the height of embankment by the end of each work day.

Prior to the suspension of grading operations each day, the Contractor shall shape the earthwork in a manner that will direct storm water runoff to the temporary slope drain installations.

The temporary slope drains shall be operated and maintained by the Contractor in an acceptable functional condition until the slopes are protected with permanent erosion control measures.

When the temporary erosion and pollution control installations are no longer required, the Contractor shall remove and dispose of all materials and restore the areas by establishing growth and coverage of vegetative items as required for the remainder of the project.

239.04--Method of Measurement. Temporary slope drains will be measured by the linear foot of temporary pipe, which includes berms, riprap, and pipe including elbows or special sections. Measurement shall be along the line and grade of the pipe installation from end to end along the centerline of the pipe installed and accepted.

Temporary shoulder berms and temporary riprap will not be measured for separate payment. Their costs shall be included in the per linear foot price bid for temporary slope drains.

239.05--Basis of Payment. Temporary slope drains, measured as prescribed above, will

be paid for at the contract unit price per linear foot, which price shall be full compensation for completing and maintaining the work and for the removal and disposal of, when no longer required, all items comprising the temporary slope drains.

Payment will be made under:

239-A: Temporary Slope Drains - per linear foot

SECTION 245 - SILT DIKE

245.01--Description. This work consists of furnishing, installing, maintaining and removing temporary silt dikes. Silt dikes shall be used for velocity reduction of stormwater run-off. Silt dikes shall be considered to have “minimal” capabilities for sediment filtration of stormwater run-off. With the exception of placement along the ends and edges of a construction bridge across a Water of the U.S., silt dikes shall not be used as a discharge structure or the last sediment control item in a “BMP train” prior to stormwater discharge off Department Right-of-Way or into Waters of the U.S.

245.02--Materials. Silt dikes shall have a dike height of at least nine inches (9”) in the center. The outer cover shall be a woven geotextile fabric placed around the inner plane and allowed to extend beyond at least one side of the device for a minimum of two feet (2’) to form an apron. The device may also have aprons on both sides, each of which shall extend from the device a minimum of two feet (2’). In the event that the silt dike has an apron extending from only one side, geotextile fabric shall be placed under the silt dike as shown on the standard drawing.

Silt dikes shall rebound to their originally installed height when driven over by vehicles or equipment. Silt dikes shall not be damaged when driven over by vehicles or equipment.

The silt dike shall also be one listed on the Department’s APL.

245.03--Construction Requirements. The flexibility of the materials in silt dikes allows them to conform to various channel configurations.

The dikes shall be attached to the ground with wire staples. The staples shall be No. 11 gauge wire and be at least six inches long. As a minimum, the staples shall be placed as recommended by the manufacture.

Prior to placement of the silt dikes, the Contractor shall make sure the surface on which the dike is to be placed is flat. The silt dikes shall be placed in ditch, keeping excess fabric extended up and downstream of the dam. Excess material shall be trenched into the ground on the upstream end and stapled on the downstream end. A minimum 6-inch overlap between end sections shall be required should the width require multiple silt dikes to be installed. The overlapped end sections shall be connected with wire wraps or staples every 12 inches on center. The dike aprons shall be entrenched at the upstream side and anchored to the ground at downstream end using staples. This device can be used on surfaces that do not allow for trenching by securing the aprons with sand or gravel bags or other manner as described by the manufacturer. The device can be easily removed for maintenance and is considered to be reusable. Silt dikes which do not

rebound to their originally install height or become damaged shall be removed, disposed of, and replaced by the Contractor at no additional expense to the Department.

The Contractor shall be required to remove and dispose of all sediment that is accumulated adjacent to the dike.

245.04--Method of Measurement. Silt dike will be measured by the linear foot.

245.05--Basis of Payment. Silt dike, measured as prescribed above, will be paid for by the linear foot, which price shall be full compensation for all cost of equipment, labor, materials, installation, cleaning and removal, and all incidentals necessary to complete the work.

Payment will be made under:

245-A: Silt Dike - per linear foot

SECTION 246 - SANDBAGS AND ROCKBAGS

246.01--Description. This item of work shall consist of the furnishing, installing, and maintaining sandbags and rockbags for the purpose of temporary erosion control by intercepting and slowing the flow of sediment-laden runoff water, or for use as a temporary dam.

246.02--Materials. The filler material for sandbags shall consist of a fine aggregate meeting the requirements of Subsection 703.02. The filler material for rockbags shall consist of a size 57 aggregate meeting the requirements of Subsection 703.03.

The bag material shall be woven polypropylene, polyethylene or polyamide fabric with a minimum unit weight of four (4) ounces per square yard. The bags shall be a minimum of 21 inches in length, 12 inches in width, and four (4) in thickness when filled.

246.03--Construction Requirements. Sandbags and rockbags shall be used to construct a berm/dam that will intercept sediment-laden storm water runoff from disturbed areas, create a retention pond, detain sediment, and release water in sheet flow. Sand or rock shall be placed in the bag so that at least the top six (6) inches of the bag is unfilled to allow for proper tying of the open end. Any subsequent rows of bags shall be offset one-half the length of the preceding row to provide a layered brick-type arrangement.

The sandbag and rockbag berm/dam installation shall be maintained in good condition by the Contractor. All necessary work and materials to maintain the integrity of the installation shall be provided until earthwork construction is complete and permanent erosion-control features are in place. The maintenance of the bags will not be paid for separately and will be included in the cost for sandbags or rockbags.

246.04--Method of Measurement. Sandbags and rockbags will be measured per linear foot or each.

Sandbags and rockbags measured by the linear foot shall be in accordance with the details in the erosion control drawing. The length of the sandbag or rockbag berm/dam

will be measured end-to-end along the cross-section of the ditch in accordance with the erosion control drawing.

246.05--Basis of Payment. Sandbags and rockbags, measured as prescribed above, will be paid for per linear foot or each, which prices shall be full compensation for furnishing bags, fine aggregate, size 57 aggregate, placement of bags, maintenance of the installation, removal and disposal of the sediment deposits and removal after construction has been completed, and for all labor, tools, equipment and incidentals necessary to complete the work.

Payment will be made under:

246-A: Sandbags - per linear foot or each

246-B: Rockbags - per linear foot or each

SECTION 247 - TEMPORARY STREAM DIVERSION

247.01--Description. Temporary stream diversion shall consist of excavating, stockpiling excavated material, and constructing a stream diversion at a new/existing drainage structure. It shall also include preparation of the diversion stream's bottom and slopes in accordance with the erosion control drawings.

247.02--Materials. Geotextiles of the type specified shall meet the requirements of Subsection 714.13. Riprap of the size specified shall meet the requirements of Section 705.

247.03--Construction Requirements. Temporary stream diversion(s) will be constructed in accordance with the erosion control drawings.

During the excavation of the stream diversion, all excavated material shall be stockpiled and used to backfill the stream diversion when no longer needed. The stockpiled material shall be treated so the sediment runoff from the stockpile shall not contaminate surrounding areas or enter the nearby streams. If the Contractor elects not to stockpile and maintain suitable excavated material, other suitable material will be used to backfill the stream diversion at no additional costs to the State. Any excavated material that the Engineer deems to be unsatisfactory, will be removed from the project and replaced with suitable material when the stream diversion is backfilled.

247.04--Method of Measurement. Temporary stream diversion will be measured per each. Stream diversions that are both left and right of a station number will not be measured separately and will be measured as one unit (each).

Payment for the disposal and replacement of the unsuitable excavated material during the construction of the stream diversion will be measured and payment made under the appropriate pay items.

247.05--Basis of Payment. Temporary stream diversion, measured as prescribed above, will be paid per each, which prices shall be full compensation for all excavation, backfill, geotextile fabric, pumps, pipe, sandbags, riprap, silt fence, maintenance of the

installation, backfill after no longer needed, and for all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

247-A: Temporary Stream Diversion

- per each

SECTION 249 - RIPRAP FOR EROSION CONTROL

249.01--Description. Riprap for erosion control consists of furnishing and installing riprap for the purpose of temporary erosion control by intercepting and slowing the flow of sediment-laden runoff water, or for use as a temporary dam. It also includes the maintenance and removal of riprap when no longer needed.

Remove and reset riprap consists of the removal and relocation of riprap to other locations shown on the plans, directed by the Engineer, or indicated on the Contractor's Erosion Control Plan.

Riprap shall be installed in accordance with the specifications in reasonably close conformity with the locations and dimensions shown on the plans or as directed by the Engineer.

249.02--Materials. Stones for riprap shall be Size 100 meeting the requirements of Subsection 705.04.

249.03--Construction Requirements. Riprap shall be used to construct a berm/dam that will intercept sediment-laden storm water runoff from disturbed areas, create a retention pond, detain sediment, and release water in sheet flow.

The riprap installation shall be maintained in good condition by the Contractor. All necessary work and materials to maintain the integrity of the installation shall be provided until earthwork construction is complete and permanent erosion-control features are in place. The maintenance of the riprap will not be paid for separately and will be included in the cost for riprap for erosion control.

When required, existing riprap may need to be removed and reset at other locations. These locations may be for additional temporary erosion control or may be placed in permanent locations designated by the Engineer.

249.04--Method of Measurement. Riprap for erosion control will be measured per ton. Remove and reset riprap shall be measured per cubic yard, FM.

249.05--Basis of Payment. Riprap for erosion control, measured as prescribed above, will be paid for per ton, which prices shall be full compensation for furnishing, installation, maintenance of the installation, and removal/disposal after construction has been completed; and for all labor, tools, equipment and incidentals necessary to complete the work.

Remove and reset of riprap, measured as prescribed above, will be paid for per cubic yard, which prices shall be full compensation for loading, transporting, installing,

maintenance of the new installation, and removal/disposal after construction has been completed; and for all labor, tools, equipment and incidentals necessary to complete the work.

Payment will be made under:

249-A: Riprap for Erosion Control - per ton

249-B: Remove and Reset Riprap - per cubic yard

DIVISION 300 - BASES

The sections in the 300 series include the specification requirements for bases, shoulders, and other work closely related to the construction of the pavement foundation and shoulders.

The term "course" used in this series of sections shall be understood to mean a structural component of specified thickness. A course may consist of one or more layers.

Shoulder courses shown on the plans to be constructed separately from base courses shall be performed in accordance with the provisions and requirements of Section 320.

SECTION 304 - GRANULAR COURSES

304.01--Description. This work consists of furnishing granular materials and the construction of one or more courses of base, shoulders, or other required construction on a prepared foundation in reasonably close conformity with the lines, grades, and typical cross sections shown on the plans or established by the Engineer.

304.02--Materials.

304.02.1--General. Unless otherwise specified, materials used in this work shall conform to the requirements of Subsections 703.04 & 703.07. General conditions governing the use of materials shall be as set out in Section 106.

Crushed concrete meeting the requirements of Subsection 703.04.3 may be used in lieu of granular courses or crushed stone courses specified in the contract. This applies to base courses, shoulders, or other required construction on a prepared foundation.

When crushed stone base is bid as alternate pay items, the Contractor must select one of the alternates at the time of bid. The Contractor must use the selected crushed stone base throughout the entire project.

304.02.2--Sampling, Testing and Acceptance. A minimum of one random sample will be obtained from the roadway for each 1000 cubic yards or 1400 tons for determining acceptance of the material for gradation, liquid limit and plasticity index. When borderline or failing results are obtained the Engineer may increase the sampling frequency.

When a roadway sample fails to meet the requirements of the specifications additional samples will be taken along the roadway for determining the limits of the inferior material. Such inferior material shall be corrected or removed and replaced at no additional costs to the State.

304.03--Construction Requirements.

304.03.1--Equipment. When measurement for payment is to be made by the ton, the Contractor shall furnish approved platform scales capable of weighing the entire loaded vehicle. Scales and their use shall be in accordance with the requirements set out in Subsection 401.03.2.1.11, except they shall be installed at an approved location on or near

the project.

Rollers shall be of sufficient number, type, size, and weight to accomplish the required compaction.

Watering equipment shall have pressurized spray bars with suitable nozzle openings.

304.03.2--Preparation of Grade. The foundation on which granular material is to be placed shall be prepared as set out in Section 321. A section of prepared roadbed of sufficient length to allow time for inspection, test, necessary corrections, and approval shall be maintained at all times ahead of placing material.

304.03.3--Placing of Materials. The Contractor shall be responsible for furnishing a material that meets the requirements of the contract and in such quantity to produce the specified compacted thicknesses. All material placed in excess of the tolerances allowed in Section 321 shall be removed and placed at other approved locations, or removed and hauled off the project without compensation.

A course whose compacted thickness is designated to be more than eight inches shall be constructed in two or more layers of approximately equal thickness. The maximum compacted thickness of any one layer shall not exceed eight inches.

No granular materials shall be placed while frozen or placed on frozen materials.

When the Engineer determines that in-place material, including the top portion of the design soil, is wet to the degree that there is a possibility of rutting, deforming, or displacing the underlying material, the hauling operation shall be suspended.

The Contractor shall produce such material as is necessary to meet the specifications for gradation, liquid limit and plasticity index and shall make such corrections as are necessary or shall remove and replace, at no additional cost to the State, any deficient material placed in the work. In all cases of correcting deficiencies on the roadbed, the Contractor shall be fully responsible for any damage to the underlying course(s) and other work.

Vegetative material shall be removed prior to placement of granular material on the roadbed or along shoulders. The costs of this work will not be measured for separate payment and should be included in the costs of other items bid.

304.03.4--Blending. After the material has been initially shaped, the entire volume of material for the course or layer being placed shall be processed and blended by blading in such a manner and as many times as necessary to produce a course visually uniform in color and texture. Care shall be exercised during the blending process to prevent contamination with underlying material. The Contractor shall be fully responsible for damage to or contamination with underlying or other unlike material and shall make corrections as necessary at no additional cost to the state.

When granular material is required to be placed adjacent to pavement in place, blending shall be performed to the satisfaction of the Engineer prior to placement of the material on shoulders.

304.03.5--Shaping, Compacting, and Finishing. Each course or layer of material shall be shaped to the required section, watered or aerated as necessary to provide the needed moisture content for compaction, and compacted. Throughout the compaction operation, the shape of the course or layer shall be maintained by blading and rolling so that the aggregates are uniformly distributed and firmly keyed.

Shaping and compaction shall be carried out in a manner that will prevent lamination and shall continue until the entire depth and width of the course or layer has reached the required density. Surface compaction and finishing shall be performed so as to produce a smooth, closely knit surface that is free from lamination, cracks, ridges or loose material. The finished surface shall conform, within allowable tolerances, to the required section and established lines and grades. Allowable tolerances are set out in Section 321.

Prior to subsequent construction or release of maintenance, all irregularities, depressions, soft spots, and other deficiencies found by the Engineer shall be corrected to meet the requirements of these specifications without additional compensation.

After compaction and finishing, if the mixture contains plus No. 4 aggregate and the course is to serve as a base for bituminous pavement, at least one complete coverage shall be made with a steel wheel roller. The resulting surface shall be sprinkled as necessary to maintain the required moisture content and shall be thoroughly compacted and sealed with a pneumatic roller.

In addition to the requirements for density and correction of deficiencies, the Contractor shall be responsible for constructing and maintaining a course that will remain firm and stable under construction equipment and other traffic which the course will be subjected to prior to release of maintenance.

Density tests will be performed in accordance with the methods as provided in Subsections 700.03 and 700.04.

Determination of acceptance of compaction of granular courses for required density will be performed on a lot to lot basis. Each lot will be each 2,500 linear feet per layer placed. At the discretion of the Engineer, a residual portion of a lot completed during a day's operation may be considered as a separate lot or may be included in the previous or the subsequent lot, except that any day's operation of less than one full lot will be considered a lot.

The lot will be divided into five approximately equal sublots with one density test taken at random in each subplot. The individual tests and the average of the five tests shall equal or exceed the values as shown in the table below.

Granular Material Class	Lot Average	Individual Test
7, 8, 9 or 10	97.0	93.0
5 or 6	99.0	95.0
3 or 4	100.0	96.0
1 or 2	102.0	98.0
Crushed Courses*	99.0	95.0

* When placed on filter fabric on untreated subgrade, the individual tests and the average of the five (5) tests shall equal or exceed the following values.

<u>Lot Average</u>	<u>Individual Test</u>
96.0	92.0

When pavement is not required, the required density for the top course will be as shown in the table below.

Granular Material <u>Class</u>	Lot <u>Average</u>	Individual <u>Test</u>
10	94.0	90.0
7, 8 or 9	95.0	91.0
5 or 6	96.0	92.0
3 or 4	97.0	93.0
1 or 2	98.0	94.0
Crushed Stone Courses	96.0	92.0

No density tests will be required for granular or crushed stone courses used for temporary work such as maintaining temporary ramps and driveways.

A finished course shall be continually maintained until a subsequent course is placed thereon or the work is released from maintenance.

304.04--Method of Measurement. Granular material and crushed stone courses will be measured by the cubic yard, average end area (AEA) or LVM, or by the ton, as indicated in the bid schedule of the contract.

When the method of measurement is by the ton, measurement will be made on the dry unit weight basis. The moisture determination for computing the dry unit weight will be made in accordance with the methods as provided in Subsections 700.03 and 700.04 at least once a day and as many additional times as the Engineer deems necessary.

When the method of measurement is by the cubic yard average end area method (AEA), all calculations of areas for payment shall be based on computations made to the nearest hundredth of a square foot from the typical sections shown on the plans. The length will be measured along the surface of the course at the centerline of each roadway or ramp. The theoretical volume calculated for payment will be to the neat lines as shown on the plans. The accepted quantity for payment will be the itemized proposal quantity as adjusted for authorized changes. The itemized proposal quantity will be corrected if it is shown to be in error by more than 2.0 percent.

Water necessary for processing granular material will not be measured for separate payment.

304.05--Basis of Payment. Granular material and crushed stone courses will be paid for at the contract unit price per unit specified in the bid schedule of the contract, which shall be full compensation for completing the work.

Payment will be made under:

304-A: Granular Material, LVM, Class____, Group____	- per cubic yard
304-B: Granular Material, Class____, Group____	- per ton
304-C: Granular Material, AEA, Class____, Group____	- per cubic yard
304-D: Granular Material, <u>Size</u>	- per ton
304-E: Granular Material, LVM, <u>Size</u>	- per cubic yard
304-F: <u>Size</u> Crushed Stone Base	- per ton
304-G: <u>Size</u> Crushed Stone Base, AEA	- per cubic yard
304-H: <u>Size</u> Crushed Stone Base, LVM	- per cubic yard

SECTION 305 - IN-GRADE MODIFICATION

305.01--Description. This work consists of modifying in place materials by incorporating other materials and constructing one or more courses in accordance with these specifications and in reasonably close conformity with the lines, grades, and typical cross sections shown on the plans or established by the Engineer.

305.02--Materials.

305.02.1--Materials to be Modified. The materials to be modified shall consist of material in place on the roadbed or material placed under this contract or a combination thereof.

General conditions governing the use of materials shall be as set out in Section 106.

305.02.2--Stabilizer Aggregates. Stabilizer aggregates of the kind and size specified shall meet the requirements of Subsection 703.20.

305.03--Construction Requirements.

305.03.1--Equipment. The methods and equipment used in performing the work shall meet the requirements of Subsection 108.05. Equipment necessary for proper prosecution of the work shall be on the project and approved by the Engineer prior to commencing work.

Watering equipment shall have pressurized spray bars with suitable nozzle openings.

Mixing and scarifying equipment shall have positive depth controls.

Rollers shall be of sufficient number, type, size, and weight to accomplish the required compaction.

When measurement for payment for stabilizer aggregate is to be made by the ton, the Contractor shall furnish approved platform scales capable of weighing the entire loaded vehicle. Scales and their use shall be in accordance with the requirements set out in Subsection 401.03.2.1.11, except they shall be installed at an approved location on or near the project.

305.03.2--Processing.

305.03.2.1--Before Addition of Stabilizer Aggregate. The material to be modified shall be prepared in accordance with the requirements of Section 321. In addition, if the existing surface consists of bituminous surfacing, the surfacing shall be scarified, pulverized, and thoroughly mixed until all the material will pass a three-inch sieve. The material shall then be brought to the designated lines, grades, and cross sections and to the required density.

To ensure proper prosecution of the work, sufficient roadbed shall be prepared in advance of spreading stabilizer aggregate.

305.03.2.2--After Addition of Stabilizer Aggregate. After the roadbed and in-place material have been prepared as specified and approved, the designated quantity of aggregate to be added shall be uniformly spread.

The Contractor shall organize the work so that delay in spreading and incorporation of aggregate will be only for the time necessary to haul the required quantity of stabilizer materials on a section of sufficient length to permit a single effective spreading, mixing, shaping, and compacting operation. Dumping of long lines of stabilizer aggregates on the roadbed and prolonged periods of hauling adjacent thereto will not be permitted. Unless wet soil conditions prevent satisfactory manipulation, aggregates shall be incorporated not later than the following day.

Preliminary scarifying shall be carefully controlled, and the undisturbed foundation beneath the loose material shall have a crown conforming as nearly as practicable to that of the finished course.

Mixing shall immediately follow the proper distribution of the aggregate and shall be performed with rotary or other agitating type mixers, supplemented by other equipment as necessary to pulverize the materials and thoroughly incorporate each into the other so that the resulting course will be uniform throughout. During mixing, sufficient water shall be added to bring the material to the proper moisture content.

Mixing shall be carefully controlled to provide an undisturbed underlying foundation at the designed grade and cross section, and shall be continued until a minimum of 95.0 percent of all materials, exclusive of individual rocks or stone, will pass a two-inch sieve.

The first section of each modified course constructed will serve as a test section. The length of the test section shall be determined by the capabilities of the equipment selected to perform the work but will be at least 1000 feet and not more than 1500 feet for the designated width. The Contractor and Engineer will evaluate the results of the test section in relation to contract requirements. In case the Engineer determines the work does not comply with contract requirements, the Contractor's procedure and augment or equipment shall be revise as necessary to provide work completed in accordance with the

contract and shall correct all deficient work at no additional cost to the State.

The Contractor shall be fully responsible for damage to or contamination of the underlying material or shoulder material and shall make corrections as necessary at no additional cost to the State.

For the purpose of determining reasonable conformity with the designated width of a course, the width of a course shall not vary from the designated edge lines by more than plus or minus three inches.

A course whose compacted thickness is designated to be more than eight inches shall be constructed in two or more layers of approximately equal thickness. The maximum compacted thickness of any one layer shall not exceed eight inches.

No material shall be placed on or mixed with frozen material.

305.03.3--Shaping, Compacting and Finishing. Compaction shall start longitudinally at the outer edges of the course and proceed toward the center. The material shall be sprinkled or aerated as necessary during compaction to maintain the needed moisture content for compaction.

Shaping and compacting shall be carried out in a manner that will prevent lamination and shall continue until the entire depth and width of the course has reached the required density. Throughout the entire compaction operation, the shape of the course shall be maintained by blading and rolling. Surface compaction and finishing shall be performed so as to produce a smooth, closely knit surface, free from lamination, cracks, ridges, or loose material, and conforming to the required section and established lines and grades.

Prior to subsequent construction or release of maintenance, all irregularities, depressions, soft spots, and other deficiencies shall be corrected to meet the requirements of these specifications without additional compensation.

Density tests will be performed in accordance with the methods as provided in Subsection 700.03 and 700.04.

Determination of acceptance of compaction of in-grade modification for required density will be performed on a lot to lot basis. Each lot will be 2,500 linear feet per layer placed. At the discretion of the Engineer, a residual portion of a lot completed during a day's operation may be considered as a separate lot or may be included in the previous or the subsequent lot, except that any day's operation of less than one full lot will be considered a lot.

The lot will be divided into five approximately equal sublots with one density test taken at random in each subplot. The average of the five density tests shall equal or exceed 93.0 percent with no single density test below 89.0 percent.

In addition to the requirements for density and correction of deficiencies, the Contractor shall be fully responsible for constructing and maintaining a course which will remain firm and stable under construction equipment and other traffic the course will be subjected to prior to release of maintenance.

The finished surface of a course shall conform to the requirements shown on the plans within the tolerances allowable under Section 321 and shall be maintained until covered by a subsequent course or the work is released from maintenance.

305.04--Method of Measurement. Processing for in-grade modification will be measured by the square yard, station, or mile, as designated.

Stabilizer aggregates of the type or size specified will be measured by the cubic yard (LVM) or by the ton, as indicated in the bid schedule of the contract. No measurement for payment for water will be made.

When the method of measurement is by the ton, measurement will be made on the dry unit weight basis at the point of weighing. The moisture determination for computing the dry unit weight will be made in accordance with the methods set out in Subsection 700.03 at least once a day, and as many additional times as the Engineer deems necessary.

305.05--Basis of Payment. Processing for in-grade modification will be paid for at the contract unit price per unit specified. Stabilizer aggregate will be paid for at the contract unit price per unit specified, which price shall be full compensation for completing the work.

Payment will be made under:

305-A: Processing for In-Grade Modification	- per square yard, station, or mile
305-B: Size __ Stabilizer Aggregate, Coarse	- per cubic yard or ton
305-C: Stabilizer Aggregate, Shell	- per cubic yard or ton
305-D: Stabilizer Aggregate, Medium	- per cubic yard or ton
305-E: Stabilizer Aggregate, Fine	- per cubic yard or ton

SECTION 307 - LIME TREATED COURSES

307.01--Description. This work consists of constructing one or more courses of a mixture of soil, hydrated lime and water, or a mixture of soil and hydrated lime slurry in accordance with these specifications and in reasonably close conformity with the lines, grades, thicknesses, and typical cross sections shown on the plans or established by the Engineer. When lime slurry is used the Contractor shall mix hydrated lime with water to produce lime slurry or, at the Contractor's option, produce lime slurry at the job site by the use of equipment specifically manufactured for the slaking of quick lime.

The use of quick lime by the dry application method will not be allowed unless the lime meets the requirements of Subsection 714.03.3.2 for Dry Quick Lime.

The work shall include preparation of the roadbed, incorporation of lime or lime slurry, and processing to the proper grade, section and density in accordance with one of the following methods:

Class A lime treatment shall consist of spreading and incorporating the specified percentage of lime in two increments in the following sequence: spreading the first increment, initial mixing, mellowing, spreading the second increment, final mixing, compacting, and finishing.

Class B lime treatment shall consist of spreading the specified percentage of lime, initial mixing, mellowing, final mixing, compacting, and finishing.

Class C lime treatment shall consist of spreading the specified percentage of lime, mixing, compacting, and finishing.

Occasionally, the scheduling of contract lettings results in advertising a project before the final soil profile is available, and it is not possible to determine, prior to advertising, the precise class of lime treatment required. Design considerations, therefore, sometimes necessitate changing the class(es) of lime treatment in order to obtain the contemplated structural qualities without unnecessary cost.

The Department reserves the right to modify by Supplemental Agreement or Quantity Adjustment the class of treatment or to eliminate lime treatment from certain sections or to add other sections for lime treatment depending on the results of soil tests.

307.02--Materials.

307.02.1--Materials to be Treated. The material to be treated shall consist of existing roadbed material or material added as directed. Particles of aggregate retained on a three-inch sieve and deleterious substances such as roots, stumps, grass turfs, and other vegetable matter shall be removed from the soil. Material considered by the Engineer to be unsuitable for stabilization shall be removed and replaced with suitable material.

307.02.2--Water. Water used in this construction shall meet the requirements of Subsection 714.01.3.

307.02.3--Lime. Lime shall be either a commercial dry hydrated lime or a commercial dry, granular or pelletized quick lime meeting the applicable requirements of Subsection 714.03. When bulk lime is used, the Contractor shall provide means suitable to the Engineer for applying. The Engineer shall weigh shipments at random for verification of bulk lime quantities.

307.02.4--Curing Seals. Curing seal shall be Emulsified Asphalt, Grade EA-1, EPR-1, AE-P, CSS-1, SS-1, CMS-2h, or MS-2h meeting the applicable requirements of Section 702.

307.02.5--Soil-Lime Design. Quantities and percentages of lime shown on the plans are preliminary. The actual application rate will be established from tests made prior to beginning treatment. The design of soil-lime courses shall be performed by the Central Laboratory. At least 45 days prior to the proposed use of a lime course, the Contractor shall make available materials proposed for use in the mixture for sampling and testing by the Department as the Engineer may consider necessary for the establishment of a mix design.

Changes in source of lime shall not be made without approval. Approval will be based on verification of a mix design.

307.03--Construction Requirements.

307.03.1--General. Quantities and percentages of lime shown on the plans and in the proposal are based on preliminary soil investigations and dry laboratory sample tests. The actual application rates will be established from tests made just prior to beginning treatment. The Contractor is advised that the estimated quantity of lime is based on application rates of hydrated lime.

It is necessary that lime treated materials be kept moist at all times. It shall be the Contractor's responsibility to provide sufficient equipment and keep all partially constructed or completed lime stabilized layers sufficiently and continually moist until a succeeding layer has been placed thereon or until the project is released from maintenance.

The first section of each mixing operation, both initial and final, will serve as a test section. The length of the test section will be determined by the capabilities of the equipment provided to perform the work, but not less than 350 linear feet nor more than 500 linear feet for the designated width. The Engineer and the Contractor will evaluate the results of the test section in relation to contract requirements. In case the Engineer determines the work is not satisfactory, the Contractor shall revise procedures and augment or replace equipment as necessary to assure work is completed in accordance with the contract and shall correct all deficient work at no additional cost to the State.

Also within the test section and only when the dry-application method of quicklime is used, a sample of the soil-lime-water mixture shall be taken after the completion of the mixing operation. This sample shall be taken, by the Contractor, to an independent testing laboratory to determine, using the X-ray Diffraction Test or the Titration Analysis Test, the percent of hydration. After the completion of the test section, the Contractor shall not continue operations until the results of the test sample have been determined. The Contractor shall provide the Engineer with three copies of a certified test report showing that the non-hydrated content of the sample has not exceeded one percent (1.0%) of the total mix. Should the sample not meet the hydration requirements, the Contractor shall re-mix the section and add sufficient water until satisfactory results are achieved. All testing costs associated with determining the hydration efficiency of the sample(s) will be at no additional cost to the State. The Department reserves the right to make hydration verification checks of the soil-lime-water mixture at any time.

307.03.2--Equipment. The methods and equipment used in performing the work shall conform to the requirements of Subsection 108.05. Equipment necessary for proper prosecution of the work shall be on the project and approved by the Engineer prior to its use.

When bulk lime is used, the Contractor shall provide approved mechanical spreader(s) having adjustable strike-off gate(s), or other approved spreading equipment constructed so as to provide positive control of the spread. Approval of a spreader will be contingent upon its known or demonstrated ability to make distribution of lime within the tolerances allowable.

Mixing and scarifying equipment shall be capable of positive depth control. Mixing shall be performed with approved rotary-type mixers or other approved equipment.

Rollers shall be of sufficient number, type, size, and weight to accomplish the required compaction.

The Contractor may use approved alternate equipment provided it produces work meeting the requirements of these specifications.

307.03.3--Preparation of Grade. Before treatment, the roadbed shall be prepared in accordance with the requirements of Section 321.

Prior to the application of dry hydrated lime, a light windrow shall be bladed along the edges of the area to be treated, or the surface on which the lime is to be applied shall be scarified to retain the spread.

Prior to the application of slurry, the full width of the area shall be scarified or partially pulverized to the depth necessary to retain the lime slurry until it has been incorporated.

The depth of scarification shall be carefully controlled so that the surface of the roadbed below the scarified material will remain undisturbed and conform to the established cross section.

307.03.4--Application of Lime. The rate of application of lime shall be as specified. The first application for Class A treatment shall not be made after October 15, and no lime shall be applied between November 1 and March 1 without written authorization from the Engineer.

Lime shall not be applied unless the temperature in the shade is at least 40°F and is expected to remain at least 40°F during the mixing period. In no case shall lime be applied on a frozen foundation.

Application of lime shall be accomplished by either an approved "dry application" or "slurry application" method.

The following guide lines will govern the acceptability of the method to be used:

Dry Application. Lime applied by this method shall be spread uniformly and shall be sprinkled with sufficient water to prevent loss of lime by wind. Spreading of lime when wind and weather conditions are unfavorable will not be permitted nor will spreading of lime by motor patrol be acceptable.

The Department reserves the right to check, at any time, the dispersion of quick lime dust in the atmosphere. At no time shall the atmosphere dispersion of quick lime dust exceed a rate of 30,000 $\mu\text{g}/\text{m}^3$, measured at a distance of 100 feet.

Slurry Application. Lime applied by this method shall be mixed with water in approved agitation equipment and applied to the roadbed as a thin water suspension or slurry. The distributing equipment shall be equipped to provide continuous agitation of the slurry until applied on the roadbed. The proportion of lime shall be such that the "Dry Solids Content" shall be at least 30 percent by weight.

The distribution of lime at the rate specified shall be attained by one or more passes over a measured section until the specified percentage of lime has been spread. After each successive pass the material shall be incorporated into the soil with the mixing equipment. Additional water, if necessary, shall be added and mixed into the mass to hasten mellowing.

Payment will not be made for lime that has been spread and exposed for a period of six hours or more before mixing. Such areas shall be treated again with the full required rate of application.

Additional lime shall be added at the Contractor's expense to any section on which excessive lime loss has occurred due to washing or blowing, prior to mixing.

The quantity of lime applied on a section shall be spread uniformly and shall not vary more than plus or minus five percent of the quantity ordered. No payment will be made for lime application exceeding the five percent plus tolerance. When the quantity applied is deficient by more than five percent, additional lime shall be applied prior to mixing.

307.03.5--Mixing.

307.03.5.1--Initial Mixing. For Class A and Class B treatments, the lime and water shall be incorporated uniformly into the soil. The mixing and watering operation shall be continued until a homogeneous mixture that will pass a three-inch sieve is obtained. After satisfactory mixing is obtained, the layer shall be reshaped to line, grade, and section and sealed with a light roller no later than the next day following mixing. The sealed mixture shall then mellow for the period specified in the lime mix design furnished by the Central Laboratory. The mellowing period will be measured in degree days. This period will not be less than five (5) nor more than 20 calendar days. The temperature to be used to determine the degree days mellowing period will be the average of the high and low temperatures for each day of the mellowing period. In the event the average is 40°F or less, that day will not be used in computing the degree days mellowing period. The recommended degree days for the mellowing period may be reduced by the Engineer provided pulverization during final mixing is documented by sieve analysis.

During the mellowing period the partially treated course or layer shall be kept moist by sprinkling. All sections on which the surface becomes dry during the mellowing period shall be reprocessed to the satisfaction of the Engineer or reconstructed in accordance with these specifications.

For Class C treatment, the lime and water shall be incorporated uniformly into the soil. The mixing and water application shall be continued until a homogeneous mixture of which 100 percent of the material by dry weight, exclusive of gravel and stone, will pass a 1-inch sieve and 60 percent will pass a No. 4 sieve. At the completion of moist mixing and during the compaction operations, the percentage of moisture shall be that necessary to obtain the required density. No mellowing period will be required or permitted, and compaction shall begin immediately. The mixing, water application, and final compaction shall be completed during the same work day.

307.03.5.2--Final Mixing. After the mellowing period of Classes A and B treatments, the layer shall be scarified and, in the case of Class A treatment, the second application of

lime added. The layer shall then be remixed as prescribed in the initial mixing operations. Mixing shall continue until 100 percent of material by dry weight, exclusive of gravel and stone, will pass a 1-inch sieve and 60 percent will pass a No. 4 sieve. At the end of mixing and during compaction, the moisture in the mixture shall be that necessary to obtain the required density.

307.03.5.3--Thickness and Width Requirements. For the purpose of determining reasonable conformity with the designated thickness of a course, it shall be understood that the depth of a course shall not vary from the designated thickness by more than plus or minus one inch. All sections not in reasonably close conformity because of deficient thickness shall be reprocessed to meet specification requirements. All sections not in reasonably close conformity because of excess thickness shall have additional lime applied and shall be reprocessed to meet specification requirements at no additional cost to the State.

For the purpose of determining reasonable conformity with the designated width of a course, it shall be understood that the width of a course shall not vary from the designated edge lines by more than plus or minus three inches.

307.03.6--Compaction. Compaction of the mixture shall begin immediately after the required mixing operation has been completed.

Compaction shall be completed during same day it was begun and shall provide uniform and continuous compaction from bottom to top of the layer. The mixture shall be aerated or watered as necessary to provide the needed moisture content for obtaining the required density.

Throughout the entire compaction operation, depressions, defective areas, and soft spots that develop shall be corrected immediately by scarifying the area, adding lime when required, or removing the material, and reshaping and compacting in accordance with these specifications at no additional cost to the State.

Density tests will be performed in accordance with the methods as provided in Subsections 700.03 and 700.04.

Determination of acceptance of compaction of Classes A, B, and C lime treated design soil will be performed on a lot to lot basis. Each lot will be 2,500 linear feet per layer placed. At the discretion of the Engineer, a residual portion of a lot completed during a day's operation may be considered as a separate lot or may be included in the previous or subsequent lot, except that any day's operation of less than one full lot will be considered a lot.

The lot will be divided into five approximately equal sublots with one density test taken at random in each subplot. The average of the five density tests shall equal or exceed 95.0 percent with no single density test below 91.0 percent. Sublots with a density below 91.0 percent shall be corrected at no additional cost to the State and retested for acceptance.

307.03.7--Finishing, Curing, Protection, and Maintaining. The surface of the layer shall be smooth and conform to the lines, grades, and typical cross sections shown on the plans or established by the Engineer. Surface requirements shall be as specified in Subsection 321.03.7.

Each complete course shall be covered with a bituminous curing seal as soon as possible but no later than 24 hours after completion. The surface shall be sealed with one of the specified bituminous materials applied by a pressure distributor at the rate of 0.10 to 0.25 gallon per square yard or as directed by the Engineer. The bituminous material shall be heated or otherwise prepared to ensure uniform distribution. Should the Contractor fail to seal the treated course within the time specified, the Engineer will suspend all other work and withhold payment of the current estimate(s) until all damages resulting there from is corrected and the treated course is sealed.

A subsequent course shall not be placed on the sealed course for at least seven (7) calendar days. During this 7-day period, the treated course shall not be subjected to any type of traffic and equipment.

The Contractor shall maintain the treated course and the curing seal in a satisfactory condition until covered by a subsequent course. Protection shall include immediate repairs of any surface irregularities or other defects that may occur or develop. It shall be the Contractor's responsibility to control traffic and equipment loads to avoid damage and to guard against freezing of the treated material.

All damage resulting from the Contractor's failure to protect and cure the treated course as specified herein or from freezing that may occur prior to being covered with the next course shall be corrected at no additional cost to the State.

Lime treated courses shall be corrected by reprocessing with Class C treatment to such depth as necessary to restore the CBR (California Bearing Ratio) of the damaged material to that shown on the mix design, all at no additional cost to the State. The Contractor shall add the necessary quantity of lime, as determined by the Central Laboratory, and in no case shall it be less than two percent by weight.

307.04--Method of Measurement. Soil-lime-water mixing will be measured by the square yard, complete in place, for each course designated on the plans and for which quantities have been included in the contract.

If a change in the class of treatment is made, as provided in Subsection 307.01, each class of treatment constructed will be measured separately.

Lime incorporated in accepted treatment will be measured by the ton. Lime in excess of the tolerance allowable and all lime required to be furnished by the Contractor at no additional cost to the State will be deducted from measured quantities.

The basis of pay for jobsite slaked lime slurry shall be the "calculated method" using the certified lime purity for each truckload as follows:

$$\text{Pure Quick Lime (Ca O)} \times 1.32 = \text{Hydrated Lime (Ca (OH)}_2\text{)}$$

$$\text{Quick Lime delivered} \times \% \text{ purity} \times 1.32 = A$$

$$\text{Quick Lime delivered} \times \% \text{ inert material} \times 1.0 = B$$

$$A + B = \text{Total Hydrated Lime produced (Pay Quantity)}$$

The basis of pay for quick lime by the dry application method shall be the "calculated method" using the certified lime purity for each truckload as follows:

$$\text{Pure Quick Lime (Ca O)} \times 1.32 = \text{Hydrated Lime (Ca (OH)}_2\text{)}$$

$$\text{Quick Lime delivered} \times \% \text{ purity} \times 1.32 = A$$

$$\underline{\text{QUICK LIME DELIVERED} \times \% \text{ INERT MATERIAL} \times 1.0 = B}$$

$$A + B = \text{Total Hydrated Lime produced (Pay Quantity)}$$

Bituminous curing seal will be measured by the gallon as prescribed in Subsection 109.01. Unless otherwise specified, distributor tank measurements will be used. The volume of material over five percent above the allowed range for each shot will be deducted from measured quantities, except that 15 percent will be allowed for irregular areas where hand spraying is necessary. The volume of all bituminous material lost, wasted, damaged, or rejected, or applied outside of designated areas, or in excess of the Engineer's directions and tolerances allowed, or contrary to the specifications, will be deducted from measured quantities.

Water will not be measured for separate payment.

307.05--Basis of Payment. Soil-lime-water mixing and lime, measured as provided above, will be paid for as follows:

Soil-lime-water mixing of the class(es) specified or ordered will be paid for at the contract unit price, or adjusted unit price as provided herein, per square yard.

Quantities of soil-lime-water mixing changed as ordered will be paid for at the contract unit price for soil-lime-water mixing plus or minus, as applicable, the amount indicated in the following schedule:

SCHEDULE FOR 6" DEPTH⁽¹⁾

<u>Class Ordered</u>	<u>Unit Price Per Square Yard</u>
A	Class B Unit Price Bid Plus \$0.05
A	Class C Unit Price Bid Plus \$0.10
B	Class A Unit Price Bid Minus \$0.05
B	Class C Unit Price Bid Plus \$0.05
C	Class A Unit Price Bid Minus \$0.10
C	Class B Unit Price Bid Minus \$0.05

SCHEDULE FOR 8" DEPTH⁽¹⁾

<u>Class Ordered</u>	<u>Unit Price Per Square Yard</u>
A	Class B Unit Price Bid Plus \$0.10
A	Class C Unit Price Bid Plus \$0.15
B	Class A Unit Price Bid Minus \$0.10
B	Class C Unit Price Bid Plus \$0.05
C	Class A Unit Price Bid Minus \$0.15
C	Class B Unit Price Bid Minus \$0.05

SCHEDULE FOR 10" DEPTH⁽¹⁾

<u>Class Ordered</u>	<u>Unit Price Per Square Yard</u>
A	Class 'B' unit price bid plus \$0.15
A	Class 'C' unit price bid plus \$0.20
B	Class 'A' unit price bid minus \$0.15
B	Class 'C' unit price bid plus \$0.05
C	Class 'A' unit price bid minus \$0.20
C	Class 'B' unit price bid minus \$0.05

- (1) When the Schedule and classes bid in the contract result in two unit prices for an ordered class, the smaller of the two is to be used as the established unit price.

Lime will be paid for at the contract unit price per ton.

Payment for removal and disposal of unsuitable material will be made under other provisions of the contract.

The prices thus paid shall be full compensation for completing the work.

Bituminous curing seal, measured as prescribed above, will be paid for at the contract unit price per gallon, which price shall be full compensation for furnishing, applying and reapplying if needed, protecting, maintaining; and all tools, equipment, labor and incidentals necessary to complete the work.

Payment will be made under:

307-A: ___" Soil-Lime-Water Mixing, Class A	- per square yard
307-B: ___" Soil-Lime-Water Mixing, Class B	- per square yard
307-C: ___" Soil-Lime-Water Mixing, Class C	- per square yard
307-D: Lime	- per ton
307-S: Bituminous Curing Seal	- per gallon

SECTION 308 - CEMENT TREATED COURSES

308.01--Description. This work consists of constructing one or more courses of a mixture of cement, soil or soil aggregate, and water in accordance with these specifications and in reasonably close conformity with the lines, grades, and typical cross sections shown on the plans or established by the Engineer.

308.02--Materials.

308.02.1--Materials to be Treated. The materials to be treated shall consist of materials in place or placed under this contract.

308.02.2--Water. Water shall conform to the requirements of Subsection 714.01.3.

308.02.3--Cement. Cement shall conform to the requirements of Section 701.

When bulk cement is used, the Contractor shall provide means suitable to the Engineer for applying. The Engineer shall weigh shipments at random for verification of bulk cement quantities.

When bag cement is furnished, the bag shall bear the manufacturer's certified weight. Bags varying more than five percent from the certified weight will be rejected, and the average weight of bags in any shipment, determined by weighing 50 bags taken at random, shall not be less than the certified weight.

Cement shall be stored and handled in closed, weatherproof containers until distribution to the section of road being processed. If storage bins are used, they shall be completely enclosed.

308.02.4--Curing Seals. Curing seal shall be Emulsified Asphalt, Grade EA-1, EPR-1, AE-P, CSS-1, SS-1, CMS-2h, or MS-2h meeting the applicable requirements of Section 702.

308.02.5--Soil-Cement Design. The design of soil-cement courses shall be performed by the Central Laboratory.

308.03--Construction Requirements.

308.03.1--General. The intent of these specifications is to provide for a cement treated course of designated thickness consisting of a uniform mixture of cement, soil or soil aggregate, and water; constructed at the required moisture content to the required density; free of laminations, construction cracks, ridges, or loose material; and with a smooth, closely knit surface meeting the requirements set out in Section 321.

A course whose compacted thickness is designated to be more than eight inches, shall be constructed in two or more layers of approximately equal thickness. The maximum compacted thickness of any one layer shall not exceed eight inches.

Immediately prior to placement of a course to be cement treated on an in place cement treated course, the in place course shall be thoroughly moistened.

Except as necessary to provide the required curing and maintenance of traffic, all equipment and traffic shall be kept off each completed cement treated course until it is thoroughly cured. Unless otherwise specified, the curing period shall be seven days exclusive of days during which the temperature falls below 35°F.

Prior to joining a previous day's work, or work more than two hours old, a vertical construction joint, normal to the centerline of the roadbed, shall be made in the old work. The joint shall be moistened if dry. Additional processing shall not be started until the construction joint has been approved by the Engineer.

When vertical longitudinal joints are specified or permitted, the joints shall be constructed parallel to the centerline by cutting into the existing edge for a sufficient distance to provide a vertical face for the depth of the course. The material cut away may

be disposed of by spreading in a thin layer on the adjacent lane to be constructed, or otherwise disposed of in a satisfactory manner. If dry, cut joints shall be moistened immediately in advance of placing fresh mixture adjacent to them.

On multi-lane construction, the Contractor may construct temporary crossovers at locations approved by the Engineer between roadway lanes to facilitate construction operations. The crossovers shall be built, removed, the median restored to section, and all erosion control items completed in accordance with the requirements of the specifications without extra cost to the State.

The first section of each cement treated course constructed will serve as a test section. The length of the test section will be determined by the capability of the equipment provided to perform the work, but not less than 350 linear feet nor more than 500 linear feet for the designated width. The Engineer and the Contractor will evaluate results of the test section in relation to contract requirements. In case the Engineer determines the work is not satisfactory, the Contractor shall revise procedures and augment or replace equipment as necessary to assure work completed in accordance with the contract, and shall correct all deficient work at no additional cost to the State.

308.03.2--Equipment.

308.03.2.1--General. Equipment necessary for the proper prosecution of the work shall be on the project and approved by the Engineer prior to its use.

Approval of cement spreaders will be contingent upon their known or demonstrated ability to make distribution of cement within allowable tolerances.

Watering equipment shall be pressurized, have one or more spray bars with suitable nozzle openings, and have positive controls for applying varying quantities of water.

Mixing shall be performed with multiple pass mixers, single pass mixers, traveling mixing plants, or central mixing plants, as specified in the contract.

Mixing and scarifying equipment for the road mix methods shall be capable of positive depth control.

Rollers shall be of sufficient number, type, size, and weight to accomplish the required compaction.

Leakage of water, oil, grease, or other liquids from equipment shall be immediately corrected, or the leaking equipment removed from the work and replaced with satisfactory equipment.

308.03.2.2--Multiple Pass Mixers. Multiple pass mixers shall be the rotary-type with sufficient tines and so constructed and operable as to obtain by multiple passes uniform mixture of the cement, soil-aggregate, and water for the full depth of the course.

308.03.2.3--Single Pass Mixers. Single pass mixers shall be the pugmill type so constructed and operable as to meter the required quantity of water through a pressurized spray and obtain by a single pass a uniform mixture of the cement, soil or soil-aggregate, and water for the full depth of the course.

308.03.2.4--Traveling Plant Mixers. Traveling mixing plants shall be either of the type that will pulverize the material to be treated and mix it and cement with the proper quantity of water without picking the materials up from the roadway, or of the pugmill type that elevates the materials into a pugmill for mixing. The plant shall be equipped with a device that will accurately control and measure the quantity of water used. Worn scarifying and mixing parts shall be replaced, and extra parts shall be available for replacements.

308.03.2.5--Central Plant Mixers. Central mixing plants shall be either the batch type using revolving blade or rotary drum mixers or the continuous mixing type. The cement, soil or soil-aggregate, and water may be proportioned either by weight or by volume. There shall be means by which the Engineer can readily verify the proportions in each batch or the rate of flow for continuous mixing.

The charge and mixing time in a batch mixer, or the rate of feed to a continuous mixer, shall be such as to obtain complete mixing of all the material. Dead areas in the mixer, in which the material does not move or is not sufficiently agitated, shall be corrected. The plant shall deliver a uniform mixture meeting all specified requirements.

308.03.3--Road Mix Method. When the road mix method is used, no hauling of materials for a subsequent course will be permitted directly on a completed cement treated course. Placing of material for a higher course shall be accomplished as outlined in Subsection 321.03. Materials for a higher course shall be kept bladed down as it is placed, and hauled over with truck traffic being distributed over its entire width.

Where reconstruction is required, it shall be for the full depth and width of the deficient section. The adding of a thin layer or strip of cement treated material will not be permitted. All sections to be reconstructed later than the two-hour period allowed for initial compaction shall have additional cement. When reconstruction is to be performed within 48 hours after the initial application of cement, 50 percent of the original quantity of cement shall be added. When reconstruction is to be later than 48 hours after the initial application of cement, an engineering study will be made, and the Engineer will specify the additional quantity of cement to be added, or the Engineer may require the total removal of the deficient work. If removal is required, a course meeting the requirements of the contract shall be constructed with new materials.

In all cases where reconstruction is performed by the addition of cement, the cement, in place materials, and water shall be thoroughly mixed, processed, compacted, and finished in accordance with the requirements of the contract.

Where deficient work is removed, the removal and disposal shall be performed in a manner satisfactory to the Engineer, and all materials shall be replaced and a new course constructed in accordance with the requirements of the contract.

The furnishing of all materials for and all reconstruction shall be performed by the Contractor at no additional cost to the State.

308.03.4--Central Plant Mix Method. When the central plant mix method is used, material for a higher course may be hauled directly on a completed and properly cured cement treated course for the minimum distance necessary as referenced in Subsection

321.03. The Contractor shall be fully responsible for all damages to the course.

Prior to placement of a course processed by the plant mix method, the Contractor shall have made satisfactory provisions for completing the section to specified requirements. To comply with these requirements, the Contractor shall, if necessary, use material(s) specified for contiguous shoulder construction.

The mixture shall be hauled to the roadway in trucks equipped with protective covers. The mixture shall be uniformly placed on a moistened foundation by full-width spreader, or partial-width spreaders working in echelon and spaced close enough together to place the entire course in one operation. The elapsed time between the start of moist mixing and the start of compaction on the roadway shall not exceed 60 minutes. The elapsed time between placement of cement treated material in adjacent lanes shall not exceed 30 minutes, except where longitudinal construction joints are specified, or when joints are permitted by the Engineer in case of emergency. In the latter case longitudinal joints conforming to the requirements of these specifications will be permitted only to allow placement of material in transit at the time of the emergency.

The material shall be placed, shaped, and compacted so that the completed course will be uniform, smooth, and conform to all of the requirements specified.

Dumping of the mixture in piles or windrows and spreading with a motor grader or similar equipment will not be permitted except where the Engineer determines that such spreading is reasonable, as in the case of small areas inaccessible to mechanical spreaders.

In all cases where reconstruction is required, the deficient work shall be removed, disposed of, and replaced with materials meeting the requirements of these specifications. Reconstruction shall be for the full depth and width of the deficient section, except where the Engineer determines that partial reconstruction will be sufficient, the Engineer may authorize in writing that reconstruction may be made on the defined partial section in accordance with the provisions and requirements for reconstruction under Subsection 308.03.3 at no additional cost to the State.

308.03.5--Preparation of Grade. Prior to construction or reconstruction, the foundation shall be prepared in accordance with the requirements of Section 321. The tolerance from design grade immediately prior to spreading cement shall be minus one inch for design soils and plus or minus one-half inch for bases.

308.03.6--Preparation of Materials. Particles of aggregates larger than those passing a three-inch sieve and deleterious substances, such as roots, sticks, grass turfs, or other vegetable matter shall be removed.

308.03.7--Application of Cement.

308.03.7.1--General. The percentages of cement shown on the plans are based on preliminary soil investigation and are approximate. Before construction is started, the Department will make the necessary tests to determine the percentages of cement required.

The quantity of cement spread on a section or added through a central plant shall not vary

more than five percent of the quantity ordered. When the quantity spread is deficient by more than five percent, an additional application of cement shall be uniformly spread over the entire section to correct the deficiency prior to mixing operation. Cement, including that applied to correct deficiency, in excess of the allowable plus tolerance will be deducted from measured quantities.

When the quantity of cement added through a central plant is deficient by more than the allowable tolerance, all mixtures produced with deficient cement will be considered unacceptable.

When the quantity of cement added through a central plant is in excess of the allowable tolerance, the excess will be computed by the Engineer and deducted from measured quantities.

308.03.7.2--Weather Limitations. No cement or cement treated material shall be applied or placed when the temperature is below 40°F nor when the Engineer determines, based on the latest information available from the National Weather Service, that the forecast temperature will fall below 40°F within the next three (3) days in the area in which the project is located. For anticipated mixing operations on a Monday, a Friday forecast that runs through the following Wednesday shall be used to determine if conditions will allow the application of cement on Monday. No cement or cement treated material shall be placed on a frozen foundation or mixed with frozen material.

308.03.7.3--Road Mix Method. After preparation of the grade, the required quantity of cement shall be spread uniformly over the grade. Cement lost or damaged from any cause shall be replaced without additional compensation before mixing is started.

The cement spreader shall be positioned by string lines or other approved methods during spreading to ensure proper application of cement. All cement deposited into the spreader shall be weighed so that the pay quantity and the rate of spread can be determined.

In small areas, bag distribution in an approved manner will be permitted. When bag distribution is made, a spike-toothed harrow or other equipment, that will not drag or blade the cement out of desired position but will strike it off at a uniform height, may be used. A motor grader, or other blade-type equipment, shall not be used to spread the cement.

Except for final finishing, all processing shall be completed within three hours after spreading. Except by written permission of the Engineer, no cement shall be spread on an area that cannot be completely processed, including all final surface finishing, during the same day.

No cement shall be applied when the moisture content of the material to be processed exceeds the optimum for the soil-cement mixture by more than two percentage points. No cement shall be spread when free water is on the surface of the roadbed.

No equipment except that used in spreading or mixing shall be allowed to pass over the freshly spread cement until mixed with the material to be treated.

308.03.7.4--Central Plant Mix Method. The cement shall be uniformly metered into the soil or soil-aggregate in the specified proportions and at the time and in the manner

that the application of water will not cause formation of cement balls.

308.03.8--Mixing.

308.03.8.1--General. Unless otherwise indicated, cement treated materials may be processed by any one or combination of the mixing equipment described in Subsection 308.03.2. Where the bid schedule indicates single pass mixers, traveling plant mixers or central plant mixers will also be permitted. Where the bid schedule indicates traveling plant mixers, central plant mixers will also be permitted.

Preliminary scarifying shall be carefully controlled and the undisturbed foundation shall have a crown conforming as nearly as practicable to that of the finished course. Subject to the moisture limitations prior to spreading cement as referenced in Subsection 308.03.7.3, soil to be processed may be pre-wet prior to spreading cement. All additional water required to bring the section being processed to the required moisture content shall be applied within one hour after the beginning of mixing.

Mixing shall be carefully controlled so that the bottom of the course will conform as closely as possible to the design grade and cross section.

When the plans indicate multiple courses to be constructed, the material for each course shall be mixed separately. Multiple courses shall be constructed so that each course is in direct contact with the underlying course, and an unmixed cushion of material between layers will not be permitted.

Each increment of water added during mixing shall be incorporated into the mixture for the full depth, and no portion of the mixture shall remain undisturbed for more than 30 minutes prior to compaction. Mixing and water application shall be continued as necessary to produce a completed mixture of uniform moisture content. Particular care shall be exercised to ensure satisfactory moisture distribution along the edges of the section, and to avoid the addition of excess water.

The soil-cement mixture for subgrade and base construction shall be pulverized to the extent that 100 percent of the material, exclusive of gravel and stone, by dry weight will pass a 1-inch sieve and a minimum of 75 percent will pass a No. 4 sieve.

The soil-cement mixture for design soils shall be pulverized to the extent that 100 percent of the material, exclusive of gravel and stone, by dry weight will pass a 1-inch sieve and a minimum of 60 percent will pass No. 4 sieve.

When the un-compacted mixture is wetted by rain to the extent the average moisture content at the time for final compaction exceeds optimum by more than two percent, or if any of the operations after the start of mixing are interrupted continuously for more than 30 minutes, the entire area affected shall be reconstructed in accordance with these specifications at no additional cost to the State.

308.03.8.2--Road Mix Methods.

308.03.8.2.1--Multiple Pass Mixing. After the cement has been spread, it shall be mixed with the material to be treated without the addition of water. Immediately after the preliminary mixing of cement and soil or soil-aggregate, water as necessary shall be

applied in the quantity required and incorporated uniformly into the mixture for the full depth.

After the last increment of water has been applied, mixing shall continue as necessary until a uniform mixture of cement, soil or soil-aggregate, and water for the full depth of the course has been obtained.

308.03.8.2.2--Single Pass Mixing. After the cement has been spread, it shall be mixed by a mixer that applies water and mixes in one simultaneous and continuous operation. The mixer shall be operated at a speed that will produce a uniform mixture meeting all specified requirements for the full depth of the course.

308.03.8.2.3--Traveling Plant Mixing. After the cement has been spread, it shall be mixed with a traveling plant mixer that will apply the proper quantity of water and produce in one simultaneous and continuous operation a mixture meeting all the requirements of the contract.

308.03.8.3--Central Plant Method. Mixing in a central plant shall continue until a homogeneous mixture meeting specified requirements is obtained, and no varying appearance is evident. The mixing time may be adjusted by the Engineer as necessary.

308.03.9--Shaping, Compacting, and Finishing.

308.03.9.1--General. The mixed material shall be shaped as required immediately after mixing, or delivery to the roadbed in the case of central plant mixed material. Initial compaction shall begin immediately, and machining and compacting shall continue until the entire depth and width of the course is compacted to the required density within two hours of the time of beginning mixing. Compaction shall be by equipment and methods that do not result in lamination.

Areas inaccessible to rollers shall be compacted to the required density by other approved methods.

The addition of thin layers of cement-treated material in order to conform to cross sectional or grade requirements will not be permitted.

Compaction by vibration shall not be performed after the cement has taken its initial set. Vibratory compaction of a section shall be completed within one hour.

During compaction, a spike-tooth harrow or other suitable equipment shall be used as required to prevent lamination.

After the mixture, except the top mulch, is compacted, water shall be added as required to the mulch, and thoroughly mixed with a spike-tooth harrow or its equivalent to bring the mulch to the needed moisture content.

The surface shall then be reshaped to the required lines, grades, and cross section, and if necessary shall be lightly scarified to remove imprints left by the compacting or shaping equipment. The surface shall then be sprinkled as necessary and thoroughly rolled with a pneumatic roller, and if the mixture contains plus No. 4 aggregate, at least one complete coverage of the section shall be made with a steel-wheel tandem roller.

Surface compaction and finishing for the entire section shall be performed in a manner that will produce a smooth, closely knit surface, free from laminations, construction cracks, ridges, or loose material, and conforming to the crown, grade, and lines stipulated within four hours after the beginning of mixing.

Upon completion of compaction, testing will be performed in accordance with Subsections 700.03 and 700.04.

308.03.9.2--Density. Determination of acceptance of compaction of cement treated courses for required density will be performed on a lot to lot basis. Each lot will be each 2,500 linear feet per layer placed. At the discretion of the Engineer, a residual portion of a lot completed during a day's operation may be considered a separate lot or may be included in the previous or subsequent lot, except that any day's operation of less than one full lot will be considered a lot.

Soil Cement Treatment of Subgrade. The lot will be divided into five approximately equal sublots with one density test taken at random in each subplot. The average of the five (5) density tests shall equal or exceed 96.0 percent with no single density test below 94.0 percent. Sublots with a density below 94.0 percent shall be corrected at no additional cost to the State and retested for acceptance.

Each lot of work found not to meet the density requirement of 96.0% of maximum density, may remain in place with a reduction in payment as set out in the following table:

PAYMENT SCHEDULE FOR COMPACTION

<u>Pay Factor</u>	<u>Lot Density *</u> <u>% of Maximum Density</u>
1.00	96.0 and above
0.90	95.0 - 95.9
0.50	94.0 - 94.9

- * Any lot with a density less than 94.0% of maximum density shall be corrected at no additional cost to the State.

The above Pay Factors shall be applied to the square yards of treated area of each lot found not to meet the density requirement.

Soil Cement Treatment of Base. The lot will be divided into five approximately equal sublots with one density test taken at random in each subplot. The average of the five (5) density tests shall equal or exceed 97.0 percent with no single density test below 95.0 percent. Sublots with a density below 95.0 percent shall be corrected at no additional cost to the State and retested for acceptance.

Each lot of work found not to meet the density requirement of 97.0% of maximum density, may remain in place with a reduction in payment as set out in the following table:

PAYMENT SCHEDULE FOR COMPACTION

<u>Pay Factor</u>	<u>Lot Density **</u> <u>% of Maximum Density</u>
1.02	98.0 and above
1.00	97.0 - 97.9
0.90	96.0 - 96.9
0.50	95.0 - 95.9

** Any lot with a density less than 95.0% of maximum density shall be corrected at no additional cost to the State.

The above Pay Factors shall be applied to the square yards of treated area of each lot found not to meet the density requirement.

Soil Cement Treatment of Irregular Areas. Density of irregular areas shall be rolled to highest stability. Irregular areas shall be defined as pre-leveling, wedging [less than fifty percent (50%) of width greater than minimum lift thickness], ramp pads, irregular shoulder areas, median crossovers, turnouts, and other areas where an established rolling pattern cannot be obtained.

For cement treated materials other than for design soils and bases, the required density will be set out elsewhere in the contract.

308.03.9.3--Width, Thickness, and Surface Requirements. For the purpose of determining reasonable conformity with the designated width of a treated course, it shall be understood that the width of a treated course shall not vary from the designated edge lines by more than plus or minus one inch.

For the purpose of determining reasonable conformance with the designated thickness of a treated course, it shall be understood that the depth of a treated course shall not vary from the designated thickness by more than plus or minus one inch.

The finished surface of a treated course shall conform to the requirements shown on the plans, within the tolerances allowable under Section 321.

308.03.10--Protection and Curing. Each completed course shall be covered with a bituminous curing seal as soon as possible but no later than 24 hours after completion. The surface shall be sealed with one of the specified bituminous materials applied by a pressure distributor at the rate of 0.10 to 0.25 gallon per square yard or as directed by the Engineer. The bituminous material shall be heated or otherwise prepared to ensure uniform distribution. Should the Contractor fail to seal the treated course within the time specified, the Engineer will suspend all other work and withhold payment of the current estimate(s) until all damages resulting there from is corrected and the treated course is sealed.

When the treated course is the subgrade, a subsequent course shall not be placed on the sealed course for at least seven (7) calendar days. During this 7-day period, the treated course shall not be subjected to any type of traffic and equipment.

When the treated course is the base, the Contractor shall use the mix design (7-day or 14-day) as specified on the Mix Design from the Central Laboratory. Depending on the specified mix design, a subsequent course shall not be placed on the sealed course for at least seven (7) or fourteen (14) calendar days. During this period, the treated course shall not be subjected to any type of traffic and equipment.

The Contractor shall maintain the treated course and the curing seal in a satisfactory condition until covered by a subsequent course. Protection shall include immediate repairs of any surface irregularities or other defects that may occur or develop. It shall be the Contractor's responsibility to control traffic and equipment loads to avoid damage and to guard against freezing of the treated material.

All damage resulting from the Contractor's failure to protect and cure the treated course as specified herein or from freezing that may occur prior to being covered with the next course shall be corrected at no additional cost to the State.

The Contractor shall submit, for approval of the Engineer, a method of correction that will restore the strength of the damaged material to that originally specified.

308.03.11--Maintenance. The Contractor shall maintain the cement treated course and the curing seal in a satisfactory condition until covered by a subsequent course. Maintenance shall include immediate repairs of surface irregularities or other defects that may occur. It shall be the Contractor's responsibility to control traffic and equipment loads to avoid damage and to guard against freezing of the course. All maintenance shall be performed at the expense of the Contractor and repeated as necessary to keep the cement treated material and the curing seal intact.

308.04--Method of Measurement. Cement incorporated in the accepted work, subject to the limitations set out in Subsection 308.03.7.1, will be measured by the ton, as designated, in accordance with the provisions of Section 109.

Accepted soil-cement-water mixing will be measured by the square yard or ton.

Contractor furnished materials will be measured and paid for in accordance with the provisions for the governing pay items shown in the contract.

Bituminous curing seal will be measured by the gallon as prescribed in Subsection 109.01. Unless otherwise specified, distributor tank measurements will be used. The volume of material over five percent above the allowed range for each shot will be deducted from measured quantities, except that 15 percent will be allowed for irregular areas where hand spraying is necessary. The volume of all bituminous material lost, wasted, damaged, or rejected, or applied outside of designated areas, or in excess of the Engineer's directions and tolerances allowed, or contrary to the specifications, will be deducted from measured quantities.

Water will not be measured for separate payment.

Unauthorized wastage or usage of any materials, unused materials remaining in stockpiles, and additional materials required for reconstruction of unacceptable work will be deducted from measured quantities. Determination of quantities to be deducted will be made by the method the Engineer considers to be most practicable and equitable, and

the Contractor's decision as to the method used shall be final.

308.05--Basis of Payment. Cement will be paid for at the contract unit price per ton. Soil-cement-water mixing will be paid for at the contract unit price per square yard or ton, as specified. The prices thus paid shall be full compensation for completing the work.

Bituminous curing seal, measured as prescribed above, will be paid for at the contract unit price per gallon, which price shall be full compensation for furnishing, applying and reapplying if needed, protecting, maintaining; and all tools, equipment, labor and incidentals necessary to complete the work.

Payment will be made under:

308-A: Cement	- per ton
308-B: Soil-Cement-Water Mixing, <u>Type*</u> Mixers, <u>Component</u>	- per square yard or ton**
308-S: Bituminous Curing Seal	- per gallon

* Optional, Single Pass, Multiple Pass, Traveling Plant, or Central Plant.

** Central Plant Mixers Only.

SECTION 310 - MECHANICALLY STABILIZED COURSES

310.01--Description. This work consists of constructing one or more courses by the incorporation of stabilizer aggregate in accordance with these specifications and in reasonably close conformity with the lines, grades, and typical cross sections shown on the plans or established by the Engineer.

310.02--Materials.

310.02.1--Materials to be Stabilized. The material to be stabilized shall consist of base material placed under this contract or under a previous contract.

General conditions governing the use of materials shall be as set out in Section 106.

310.02.2--Stabilizer Aggregates. Stabilizer aggregates of the kind and size specified shall meet the requirements of Subsection 703.20.

310.02.3--Composite Mixture. The composite mixture of mechanically stabilized courses shall be in accordance with the requirements and provisions of Subsection 703.08. In order to obtain the desirable composite mixture, the Engineer may vary the quantity of stabilizer aggregate shown on the plans by as much as 25 percent.

Acceptance of the composite mixture for conformance to the specification requirements for gradation, liquid limit and plasticity index shall be based on samples obtained from the roadway. A minimum of one random sample shall be obtained for each 1000 linear

feet of 24 foot lane. In case a sample fails to meet the requirements of the specifications, additional samples shall be obtained to locate the limits of the non-conforming material. Such non-conforming material shall be corrected by the Contractor, at no additional costs to the State, prior to final acceptance.

310.03--Construction Requirements.

310.03.1--General. The first section of each course to be constructed will serve as a test section. The length of the test section will be determined by the capability of the equipment selected to perform the work, but will be at least 1000 linear feet but not more than 1500 linear feet for the designated width. The Engineer and the Contractor will evaluate results of the test section in relation to contract requirements. In case the Engineer determines the work is not satisfactory, the Contractor shall revise procedures and augment or replace equipment as necessary to assure work is completed in accordance with the contract, and shall correct all deficient work at no additional cost to the State.

For the purpose of determining reasonable conformity with the designated width of a course, the width of a course shall not vary from the designated edge lines by more than plus or minus three inches.

Courses designated to be more than eight inches thick shall be constructed in two or more layers of approximately equal thickness. The maximum compacted thickness of any one layer shall not exceed eight inches.

When the plans indicate multiple courses, each course shall be mixed or spread, shaped, and compacted separately. Multiple courses shall be constructed so that each course is in direct contact with the preceding course, and a cushion of un-stabilized material between layers will not be permitted.

When material for shoulders is of a different class or type from that specified for the course being constructed, the partial formation of shoulders shall precede the placement of aggregate or plant mixed material. Temporary drainage as necessary through partially constructed shoulders shall be provided and maintained until construction of the contiguous course.

No material shall be placed on or mixed with frozen material.

310.03.2--Equipment. Watering equipment shall have pressurized spray bars with suitable nozzle openings.

Mixing shall be performed with multiple pass mixers, single pass mixers, traveling mixing plants, or central mixing plants. Unless otherwise specified, the type mixer used will be at the option of the Contractor.

Mixing equipment shall meet the applicable requirements of Subsection 308.03.2.

Rollers shall be of sufficient number, type, size, and weight to accomplish the required compaction.

When measurement for payment is to be made by the ton, the Contractor shall furnish

approved platform scales capable of weighing the entire loaded vehicle. Scales and their use shall be in accordance with the requirements set out in Subsection 401.03.2.1.11, except they shall be installed at an approved location on or near the project.

310.03.3--Preparation of Grade. Prior to placing material, the foundation shall be prepared in accordance with the requirements of Section 321 for a sufficient distance in advance to ensure proper prosecution of the work.

310.03.4--Preparation of Materials. The material to be stabilized shall be reasonably free from clay balls, roots, grass, organic matter, and other deleterious substances.

310.03.5--Application of Stabilizer Aggregate (Road Mix Method). When the roadbed has been prepared and approved, aggregate in the quantity specified shall be uniformly spread.

The Contractor shall provide sufficient equipment and shall organize the work so that the time interval between dumping and spreading of aggregate and subsequent incorporation shall be the minimum necessary to carry on an efficient and continuous operation. Dumping of long lines of aggregate on the roadbed and prolonged periods of hauling adjacent thereto will not be permitted. Unless prevented by unavoidable conditions, aggregate shall be incorporated, mixed, shaped, compacted, and finished not later than the second day following delivery to the roadbed.

310.03.6--Mixing.

310.03.6.1--General. During the mixing operations, clay balls and other undesirable materials present in sufficient quantity to impair the quality of the course shall be removed.

310.03.6.2--Road Mix Method. After the stabilizer aggregate has been uniformly spread, the material shall be scarified, if necessary, and the mixing operation begun immediately.

All preliminary scarifying and mixing shall be carefully controlled to provide an undisturbed foundation course with the designated grade and cross section.

The Contractor shall be responsible for damage to or contamination with the underlying material or shoulder material, and shall make corrections and repairs as necessary at no additional cost to the State.

All material to be stabilized shall be thoroughly mixed and pulverized by incorporating the added materials so that the course will be homogeneous throughout. During the mixing operation, water shall be applied as necessary to provide the needed moisture content for obtaining the required density.

Particular care shall be exercised to ensure satisfactory moisture distribution along the edges of the course, and to avoid the application of excess water on any portion of a section.

310.03.6.3--Central Plant Method. Water shall be added during the mixing operation in the quantity necessary to provide the needed moisture content. Mixing shall continue

until a homogeneous mixture is obtained. After the mixing is complete, the mixture shall be transported while at the proper moisture content for compaction, and shall be placed on the prepared grade by means of an aggregate spreader.

The Contractor shall deliver to the roadbed a sufficient quantity of mixed material to produce the designated course. All material placed in excess of the tolerances allowable in Section 321 shall be removed and hauled from the project without compensation, or removed and placed at other approved locations requiring use of the same material.

310.03.7--Spreading, Compacting, and Finishing. The mixed material shall be spread immediately after mixing, or after delivery in the case of central plant mixed material.

Spreading shall be carried out in a manner that will minimize segregation and will result in a completed course within the tolerances allowable.

Compaction shall start longitudinally at the outer edges of the course and proceed toward the center. The material shall be sprinkled or aerated as necessary during compaction to maintain the needed moisture content.

Shaping and compaction shall be carried out in such a manner as to prevent lamination and shall continue until the entire depth and width of the course has obtained the required density. Throughout the entire compaction operation, the shape of the course shall be maintained by blading and rolling. Surface compaction and finishing shall be performed so as to produce a smooth, closely knit surface, free from lamination, cracks, ridges, or loose material, and conforming to the required section and the established lines and grades within the tolerances allowable.

Prior to subsequent construction, all irregularities, depressions, soft spots, and other deficiencies shall be corrected to meet the requirements of these specifications at no additional cost to the State.

After compaction and finishing, if the mixture contains plus No. 4 aggregate and the course is to serve as a base for bituminous pavement, at least one complete coverage shall be made with a steel wheel roller. The Engineer may waive this requirement for shell stabilized bases.

In addition to the requirements for density and correction of irregularities, depressions, or soft spots, the Contractor shall be fully responsible for constructing and maintaining a course that will remain firm and stable under all construction equipment and other traffic that the course is subjected prior to the acceptance of the work.

Density tests will be performed in accordance with the methods as provided in Subsections 700.03 and 700.04.

Determination of acceptance of compaction of mechanically stabilized courses for required density will be performed on a lot to lot basis. Each lot will be each 2,500 linear feet per layer placed. At the discretion of the Engineer, a residual portion of a lot completed during a day's operation may be considered a separate lot or may be included in the previous or the subsequent lot, except that any day's operation of less than one full lot will be considered a lot.

The lot will be divided into five approximately equal sublots with one density test taken at random in each subplot. The individual tests and the average of the five tests shall equal or exceed the values as shown in the table below. For any course that is to be subsequently chemically treated, the average of the five density tests shall equal or exceed 93.0 percent with no single density test below 89.0 percent.

Composite Mixture		
Type	Lot Average	Individual Test
A	102.0	98.0
B	100.0	96.0
C	99.0	95.0
D	97.0	93.0

The finished surface of all courses shall conform to the required section and the established lines and grades, within the tolerances allowable under Section 321. All finished courses shall be continually maintained until covered by a subsequent course or the work released from maintenance.

310.04--Method of Measurement. Mixing, shaping, and compaction will be measured by the square yard, station, or mile, as designated, for each course included in the contract.

Stabilizer aggregate will be measured by the cubic yard (LVM) or by the ton, as designated in the bid schedule of the contract. Other materials (except water) specified and incorporated into accepted work will be measured and paid for under the provisions of the governing pay items shown in the contract. When the method of measurement is by the ton, measurement will be made on the dry unit weight basis at the point of weighing. The moisture determination for computing the dry unit weight will be made in accordance with the methods set out in Subsection 700.03 at least one time each day, and as many additional times as the Engineer deems necessary. Water will not be measured for payment.

Unauthorized wastage or usage of materials, unused materials remaining in stockpiles, and additional materials required for correction of unacceptable work will be deducted from measured quantities. Determination of quantities to be deducted will be made by the method the Engineer considers to be most practicable and equitable, and the Engineer’s decision as to the method used for such computations shall be final.

310.05--Basis of Payment. Mixing, shaping, and compaction will be paid for at the contract unit price per specified unit. Stabilizer aggregates will be paid for at the contract unit price per specified unit. The prices thus paid shall be full compensation for completing the work.

Payment will be made under:

310-A: Mixing, Shaping, and Compaction,
 Type____, Group____ - per square yard, station,
 or mile

310-B: Size____ Stabilizer Aggregate, Coarse - per cubic yard or ton

310-C: Stabilizer Aggregate, Shell	- per cubic yard or ton
310-D: Stabilizer Aggregate, Medium	- per cubic yard or ton
310-E: Stabilizer Aggregate, Fine	- per cubic yard or ton

SECTION 311 - LIME-FLY ASH TREATED COURSES

311.01--Description. This work consists of constructing one or more courses of a mixture of soil, soil aggregate or aggregate, fly ash, lime, and water in accordance with these specifications and in reasonably close conformity with the lines, grades, thickness and typical cross sections shown on the plans or established by the Engineer.

Unless otherwise provided, the Contractor may use either the travel plant or central plant method.

311.02--Materials. Soil, soil aggregate or aggregate, when Contractor furnished, shall conform to the requirements set forth on the plans or in the contract. Other materials shall conform to the requirements of Division 700 as specified in the following subsections:

Cut-back Asphalt	702.06
Emulsified Asphalt	702.07
Aggregate	703.20
Water	714.01
Lime	714.03
Fly Ash	714.05

311.02.1--Soil-Lime-Fly Ash Design. Quantities and percentages of lime and fly ash shown on the plans are preliminary. The actual application rate will be established from tests made prior to beginning treatment. The design of soil-lime-fly ash courses shall be performed by the Central Laboratory. At least 45 days prior to the proposed use of a lime-fly ash course, the Contractor shall make available materials conforming to the specifications and proposed for use in the mixture for sampling and testing by the Department as the Engineer may consider necessary for the establishment of a mix design.

The approved proportions of material will govern during the progress of the work, and changes in source or character of any material shall not be made without approval. Approval will be based on verification of a mix design.

311.02.2--Curing Seals. Curing seal shall be Emulsified Asphalt, Grade EA-1, EPR-1, AE-P, CSS-1, SS-1, CMS-2h, or MS-2h meeting the applicable requirements of Section 702.

311.03--Construction Requirements.

311.03.1--General. Fly ash shall be spread at the specified rate and lightly disked or mixed into the soil or soil aggregate prior to spreading the lime.

Prior to the application of fly ash, a light windrow shall be bladed along the edges of the area to be treated, or the surface on which the fly ash is to be applied shall be scarified to retain the spread fly ash. The depth of scarification shall be carefully controlled so that the surface of the roadbed below the scarified material will remain undisturbed and conform to the established cross section.

311.03.2--Equipment. Equipment necessary for the proper prosecution of the work shall meet the applicable requirements of Subsection 308.03.2.

311.03.3--Preparation of Grade. Before treatment, the roadbed shall be prepared in accordance with the requirements of Section 321.

311.03.4--Application.

311.03.4.1--Fly Ash. Fly ash shall be applied as set out in Subsection 308.03.7, except that weather limitations shall be in accordance with Subsection 311.03.5.

311.03.4.2--Lime. The rate of application of lime shall be as specified.

Application of lime shall be accomplished by either an approved "dry application" or "slurry application" method.

The following guide lines will govern the acceptability of the method to be used:

Dry Application. Hydrated lime applied by this method shall be spread uniformly and shall be sprinkled with sufficient water to prevent loss of lime by wind. Spreading of hydrated lime when wind and weather conditions are unfavorable will not be permitted nor will spreading of lime by motor patrol be acceptable. The use of quick lime in the "dry application" method will not be permitted.

Slurry Application. Lime applied by this method shall be mixed with water in approved agitation equipment and applied to the roadbed as a thin water suspension or slurry. The distributing equipment shall be equipped to provide continuous agitation of the slurry until applied on the roadbed. The proportion of lime shall be such that the "Dry Solids Content" shall be at least 30 percent by weight.

The distribution of lime at the rate specified shall be attained by one or more passes over a measured section until the specified percentage of lime has been spread. After each successive pass the material shall be incorporated into the soil with the mixing equipment.

311.03.5--Weather Limitations. Lime-fly ash treatment shall not be performed when either the soil or soil aggregates or the surface on which a lime-fly ash treated material is to be laid is wet or frozen or when it is raining or snowing. Processing operations for the lime-fly ash course shall not begin until the surface temperature is at least 40°F and rising. Construction of the soil/soil aggregate-lime-fly ash stabilized course will not be permitted between November 30 and March 1.

311.03.6--Fly Ash-Lime and Water Mixing Phase. The lime and water shall be incorporated uniformly into the soil course of fly ash and aggregate. The mixing and water application shall be continued until a homogeneous mixture of which 100 percent

of the material by dry weight, exclusive of gravel and stone, will pass a two-inch sieve and 60 percent will pass a No. 4 sieve. At the completion of moist mixing and during the compaction operations, the percentage of moisture shall be that necessary to obtain the required density. No mellowing period will be required or permitted, and compaction shall begin immediately. The mixing, water application, and final compaction shall be completed during the same work day.

311.03.7--Shaping, Compacting, and Finishing.

311.03.7.1--General. The mixed material shall be shaped as required immediately after mixing, or delivery to the roadbed in the case of central plant mixed material. Initial compaction shall begin immediately, and machining and compacting shall continue until the entire depth and width of the course is compacted to the required density within two hours of the time of beginning mixing. Compaction shall be by equipment and methods that do not result in lamination.

Areas inaccessible to rollers shall be compacted to the required density by other approved methods.

The addition of thin layers of treated material in order to conform to cross sectional or grade requirements will not be permitted.

Compaction by vibration shall not be performed after the lime fly-ash has taken its initial set. Vibratory compaction of a section shall be completed within one hour.

During compaction, a spike-tooth harrow or other suitable equipment shall be used as required to prevent lamination.

The surface shall then be reshaped to the required lines, grades, and cross section, and if necessary shall be lightly scarified to remove imprints left by the compacting or shaping equipment. The surface shall then be sprinkled as necessary and thoroughly rolled with a pneumatic roller, and if the mixture contains plus No. 4 aggregate, at least one complete coverage of the section shall be made with a steel-wheel tandem roller.

Surface compaction and finishing for the entire section shall be performed in a manner that will produce a smooth, closely knit surface, free from laminations, construction cracks, ridges, or loose material, and conforming to the crown, grade, and lines stipulated within four hours after the beginning of mixing.

Upon completion of compaction, testing will be performed in accordance with Subsections 700.03 and 700.04.

311.03.7.2--Density. Determination of acceptance of compaction of treated courses for required density will be performed on a lot to lot basis. Each lot will be each 2,500 linear feet per layer placed. At the discretion of the Engineer, a residual portion of a lot completed during a day's operation may be considered a separate lot or may be included in the previous or subsequent lot, except that any day's operation of less than one full lot will be considered a lot.

The lot will be divided into five approximately equal sublots with one density test taken at random in each subplot. The average of the five (5) density tests shall equal or exceed

98.0 percent with no single density test below 94.0 percent. Sublots with a density below 94.0 percent shall be corrected at no additional cost to the State and retested for acceptance.

For treated materials other than for design soils and bases, the required density will be set out elsewhere in the contract.

311.03.7.3--Width, Thickness, and Surface Requirements. For the purpose of determining reasonable conformity with the designated width of a treated course, it shall be understood that the width of a treated course shall not vary from the designated edge lines by more than plus or minus one inch.

For the purpose of determining reasonable conformance with the designated thickness of a treated course, it shall be understood that the depth of the treated course shall not vary from designated thickness by more than minus one-half (1/2) inch or plus one (1) inch.

The finished surface of a treated course shall conform to the requirements shown on the plans, within the tolerances allowable under Section 321.

311.03.8--Protection and Curing. Each completed course shall be covered with a bituminous curing seal as soon as possible but no later than 24 hours after completion. The surface shall be sealed with one of the specified bituminous materials applied by a pressure distributor at the rate of 0.10 to 0.25 gallon per square yard or as directed by the Engineer. The bituminous material shall be heated or otherwise prepared to ensure uniform distribution. Should the Contractor fail to seal the lime-fly ash course within the time specified, the Engineer will suspend all other work and withhold payment of the current estimate(s) until all damages resulting therefrom is corrected and the lime-fly ash course is sealed.

A subsequent course shall not be placed on the sealed lime-fly ash course for at least seven (7) calendar days. During this 7-day period, the lime-fly ash course shall not be subjected to any type of traffic and equipment.

The Contractor shall maintain the lime-fly ash course and the curing seal in a satisfactory condition until covered by a subsequent course. Protection shall include immediate repairs of any surface irregularities or other defects that may occur or develop. It shall be the Contractor's responsibility to control traffic and equipment loads to avoid damage and to guard against freezing of the lime-fly ash treated material.

All damage resulting from the Contractor's failure to protect and cure the lime-fly ash course as specified herein or from freezing that may occur prior to being covered with the next course shall be corrected at no additional cost to the State.

The Contractor shall submit, for approval of the Engineer, a method of correction that will restore the strength of the damaged material to that originally specified.

311.04--Method of Measurement. Lime and fly ash will be measured by the ton in accordance with Section 109. If bagged lime is used, the net weight as packaged by the manufacturer will be used for measurement.

The basis of pay for jobsite slaked lime slurry shall be the "calculated method" as

provided for jobsite slaked lime slurry in Subsection 307.04.

Aggregate will be measured by the ton or cubic yard (LVM). When measurement is by weight, the weight of moisture, surface and hygroscopic, will be deducted.

Processing will be measured by the square yard and shall include preparation of the roadbed, scarifying, pulverizing, drying of the material, mixing of the various materials, compaction of the mixture, finishing, protection and curing, and maintenance of the completed course.

Bituminous curing seal will be measured by the gallon as prescribed in Subsection 109.01. Unless otherwise specified, distributor tank measurements will be used. The volume of material over five percent above the allowed range for each shot will be deducted from measured quantities, except that 15 percent will be allowed for irregular areas where hand spraying is necessary. The volume of all bituminous material lost, wasted, damaged, or rejected, or applied outside of designated areas, or in excess of the Engineer's directions and tolerances allowed, or contrary to the specifications, will be deducted from measured quantities.

Water will not be measured for separate payment.

311.05--Basis of Payment. The accepted quantities of lime and fly ash treated material will be paid for at the contract price per ton for lime and fly ash, per ton or cubic yard (LVM) for aggregate, and per square yard for processing lime and fly ash treated material complete in place. The prices thus paid shall be full compensation for completing the work.

Bituminous curing seal, measured as prescribed above, will be paid for at the contract unit price per gallon, which price shall be full compensation for furnishing, applying and reapplying if needed, protecting, maintaining; and all tools, equipment, labor and incidentals necessary to complete the work.

Payment will be made under:

311-A: ___" Processing Lime and Fly Ash Treated Course	- per square yard
311-B: Lime	- per ton
311-C: Fly Ash, Class_____	- per ton
311-D: Aggregate	- per cubic yard or ton
311-S: Bituminous Curing Seal	- per gallon

SECTION 320 - SHOULDERS

320.01--Description. This work consists of constructing the shoulder portion of courses specified to be constructed; the shaping, compacting, finishing, and surfacing, if required, of the shoulder portion of the work in reasonably close conformity with the required lines, grades, and cross sections; and the construction and establishment of erosion

control items specified for the shoulder portion of the work. All work shall conform to the sequence and timing indicated herein and to the other applicable requirements of the contract.

This work shall also include preservation from injury or damage to and repair and reconstruction of, if necessary, underlying courses and other elements of the pavement structure. Except as otherwise specified, construction of shoulders shall also include reshaping, finishing, and mowing of cut ditches, foreslopes, and upper embankment slopes adjacent to shoulders. Areas to receive this work shall include the areas between the finished shoulder line and the same elevation at the back of the ditch in cut sections and the areas on fill slopes between the finished shoulder line and a line 12 feet horizontally outside the finished shoulder line. Similar areas in the median portion of divided highways shall also be reshaped and finished.

320.02--Materials. Materials used in constructing shoulders shall meet the applicable requirements of Division 700.

320.03--Construction Requirements.

320.03.1--Preparation of Grade. Before beginning each course of shoulder construction, the foundation shall be prepared in accordance with Section 321.

320.03.2--Construction Details. Except as otherwise specified, the construction of each course of the shoulders shall be in accordance with controlling requirements for bases constructed of like material.

Shoulder construction shall begin at the earliest practicable time and proceed in the proper sequence with contiguous base or pavement construction. Each designated course for shoulders shall be constructed to the established lines, grades, and cross sections within tolerances allowable under Section 321 and shall be firm and stable; reference is made to Subsection 321.03.

Determination of acceptance of compaction of shoulders for required density will be performed on a lot to lot basis. Each lot will consist of each day's operation per layer placed, with a maximum lot length of 10,000 linear feet.

The lot will be divided into five approximately equal sublots with one density test taken at random in each subplot. The lot average and each single density test shall conform to the required density.

The required density for the shoulder portion of any layer or course shall be the same as for the adjacent (internal) portion of the layer or course when constructed of the same material.

The required density for the shoulder portion of any layer or course where the adjacent (internal) portion is of unlike material shall be as follows:

Granular Material	Lot	Individual
<u>Class</u>	<u>Average</u>	<u>Test</u>
10	94.0	90.0
7,8 or 9	95.0	91.0
5 or 6	96.0	92.0
3 or 4	97.0	93.0
1 or 2	98.0	94.0

except,

- (a) When the finished shoulder is required to be paved, the required density for such shoulder course shall be that required for the same material for bases, and
- (b) Where an existing pavement is to be overlaid, or widened and overlaid, without shoulder widening, and the existing shoulder is to be raised to match the new pavement, satisfactory density of each layer of new shoulder material shall be that which can be obtained from six coverages of a pneumatic roller with an operating weight of approximately six tons while the shoulder material is at the proper moisture content.

In cases of base or pavement in which cement is used as a material of construction, shoulder construction shall follow immediately upon expiration of the curing period, unless it has been otherwise provided that the shoulder course be constructed in advance of the contiguous course.

The rate of progress for each phase of shoulder construction shall be consistent with the rate of progress of the controlling construction. When the Engineer deems that other operations are being carried on to the unnecessary neglect of shoulder construction, the Engineer may suspend the operations in progress and order that shoulder construction be brought up to and then continued, without prejudice to other work, in the proper sequence.

320.04--Blank.

320.05--Basis of Payment. Unless otherwise specified in the contract, no separate payment will be made for shoulder construction. Payment will be made for the materials and their processing when set up in the contract as pay items. All additional work involved in shoulder construction is considered an obligation of the Contractor subsidiary to the placement of the materials required and work performed for which provisions for payment are contained in the contract.

SECTION 321 - IN-GRADE PREPARATION

321.01--Description. The term "in-grade preparation" is defined as the work required to prepare, blade, shape, scarify, disk, mix, compact, etc. the existing material to specification requirements prior to placement of a subsequent course of material.

Figure 1, Section 101, graphically defines the limits of the roadway, the design soil and the components of the pavement structure.

In-grade preparation shall be in reasonable close conformity with the lines, grades, and

typical section(s) shown on the plans. All work will be performed in the sequence and timing specified.

No direct compensation will be allowed for in-grade preparation, except as specifically provided herein.

321.01.1--Applicability. In-grade preparation will be required on all projects that require replacement of any component of a pavement structure or chemical treatment of the design soil.

In-grade preparation will not be required on pavements or chemically treated courses that are to remain in place undisturbed.

Unless otherwise specified, the in-grade preparation course shall be the top six inches of the design soil.

321.02--Blank.

321.03--Construction Requirements.

321.03.1--General. Prior to beginning in-grade preparation, the roadway will be cleaned of all vegetation or debris, bladed, shaped and filled as necessary to obtain the required line, grades and typical section as shown on the plans or as specified. The Contractor will perform unclassified excavation where required for grade changes, removal of temporary ramps at bridge ends, shape foreslopes and cut ditches to the required line, grade and typical section, and other work required to alter work performed on previous contracts. All material obtained in preparation prior to in-grade preparation work will be disposed of or utilized by the Contractor.

321.03.2--First In-Grade Course.

321.03.2.1--Design Soil. When the first in-grade preparation course is the top portion of the design soil, which was constructed under a previous contract, the top six inches, unless a greater depth is specified, shall be broken up, either by scarifying or blading to the specified depth and then thoroughly mixed by a disk-harrow. If the embankment design soil was constructed under this contract in accordance with the requirements of Section 203, then only the cut section will require mixing as stated herein. The disk shall be of sufficient weight and size to cut a minimum depth of eight inches, or ten inches when eight inches design soil mixing is required, in loose material. After mixing with a disk-harrow, the roadway will be shaped and compacted to the proper section and density.

321.03.2.2--Component of Pavement Structure. When the first in-grade preparation course is a component of the pavement structure, other than design soil, the course shall be prepared by blading, shaping to the specified section, and compacting to the specified density for the particular layer being prepared.

321.03.3--Unsuitable Materials. All materials which cannot be stabilized and compacted to the required density, shall be removed and disposed of as directed. The material removed will be replaced by acceptable materials. Unless the unsuitable material was placed under this contract, the removal, disposal, and replacement of the

material will be measured and paid for under the appropriate items of the contract. Materials that meet contract requirements, except for moisture content, will not be classified as unsuitable materials.

321.03.4--Stability. When density and stability cannot be obtained due to the instability of the underlying material, the Contractor will take the necessary action to stabilize and compact the underlying material. Unless the unstable material was placed under this contract, the work required to stabilize and compact the material will be paid for under the appropriate items of the contract. When the Contractor has initiated appropriate action to stabilize and compact the underlying material and density cannot be obtained, then the material will be classified as unsuitable and proceed in accordance with Subsection 321.03.3.

321.03.5--Haul, Protection and Repair. All materials hauled through or over any part of the project shall be hauled in the sequence and manner to cause the least damage to the previously placed course. The Contractor's operations shall provide the maximum protection to each course in place from deformation or contamination from underlying material.

The first course of material to be placed on a chemically treated design soil shall be placed by hauling to the point nearest the source of the material, thus hauling over the material being placed. Subsequent hauling shall be over the maximum practical thickness of material in order to provide the greatest protection to the underlying material.

The Contractor shall satisfactorily maintain the material over which he is hauling, and the materials being hauled shall be spread as hauling progresses to prevent hauling equipment from repetitive passes alongside lines of dumped and unspread material.

The Contractor shall repair, at no additional cost to the State, all damage to prepared in-grade material whether the material was placed under this contract or under previous contract.

321.03.6--Density. The required density for in-grade preparation of courses that do not require a chemical treatment or modification shall be the required density for the particular course. The required density for courses that require chemical treatment or modification shall be 93.0 percent prior to the addition of the chemical, stabilizer or modification.

321.03.7--Tolerances.

321.03.7.1--General. It shall be understood that although certain tolerances in grade, cross section, and density are allowable under the specifications, it shall be the Contractor's responsibility to prepare the surface of all in-grade courses to the degree of true grade and cross section and to the density and stability necessary to ensure the ability to construct subsequent courses to the specified requirements for surface, thickness, and compaction. It is essential in pavement structure construction that the degree of accuracy must be increased for each succeeding course in order that the final surface requirements can be met and the thickness of each course will be within design tolerances. It shall be the Contractor's responsibility to construct each course to the degree of accuracy, maximum allowable tolerances notwithstanding, necessary to ensure meeting final

requirements.

321.03.7.2--Vertical Tolerances. No vertical tolerances will be allowed that will pond water. Otherwise, allowable tolerances will be as follows:

321.03.7.2.1-For Design Soil.

Tolerances from Design Grade:

- a. Where the top portion of the design soil is to be lime treated or lime-fly ash treated and the next course is stone or is to be chemically treated -
 - Before Treatment -1" (1)
 - Treatment In Place ±1" (2)
- b. Where the top portion of the design soil is to be cement treated and the next course is stone or is to be chemically treated -
 - Before Treatment -1"
 - Treatment In Place -1"
- c. Where the design soil is not to be treated and the next course is stone or is to be treated or untreated -
 - Preparation In Place -1"
- d. Where the design soil is not to be treated and a superimposed course is not required under this contract -
 - In Place ±1"

Notes: (1) From the design grade established before spreading lime to allow for bulking.
 (2) From the design grade established for bulked material.

321.03.7.2.2--For Bases.

The surface tolerances from design grade before placing base material shall be the tolerances from design grade in place as set out herein for design soils.

Grade stakes or other reference points shall be set at 25-foot intervals; when tested longitudinally, the maximum deviation when measured at the midpoint (12½ feet) shall be ±1/2 inches.

- a. Where a base course is not to be treated and the next course is to be bituminous pavement -
 - In Place ±1/2"
- b. Where a base course is stone or is to be cement treated and the next course is a drainage layer -
 - In Place ±1/2"

- c. Where a base course is to be lime-fly ash treated and the next course is a drainage layer -
- In Place $\pm 1/2"$ (3)
- d. Where a base course is stone or is to be cement treated and the next course is to be bituminous pavement -
- In Place $\pm 1/2"$
- e. Where a base course is to be lime-fly ash treated and the next course is to be bituminous pavement -
- In Place $\pm 1/2"$ (3)

Note: (3) From the design grade established for bulked material.

Where stone is specified, it shall meet the requirements of Section 304.

321.03.7.2.3-For Drainage Layers.

Tolerances from Design Grade:

Where a drainage layer is required - - In Place $+1/8"$ to $-3/8"$

321.03.7.2.4--For Any Course.

Tolerances from Design Grade:

- a. Where a course is to be stone or is to be treated or untreated and the next course is a drainage layer or bituminous pavement -
- In Place $\pm 1/2"$
- b. Where a course is stone or is to be treated, followed by a drainage layer and concrete pavement -
- Under the Form Line
or Track Line $\pm 1/8"$ (4)
- Elsewhere $-1"$ (5)

Notes: (4) The Contractor may construct the course at the form line to a tentative grade having a tolerance of not more than minus 1/2 inch, in which case the Contractor shall, at no additional cost to the State, bring the surface of the base at the form line to the specified grade and density with materials and methods approved by the Engineer and consistent with the requirements for foundation formation for forms or tracks required under the contract.

- (5) Provided the Contractor places at no additional cost to the State, at the time of placing concrete base course or pavement, the additional concrete necessary to compensate for the deficiency from a true design base grade.

321.03.7.2.5--For Mechanical Stabilization and In-Grade Modification. Where material is to be mechanically stabilized or modified with stabilizer aggregate or other materials on the roadbed, the tolerance from design grade, both before spreading the aggregate and after mechanical stabilization, shall be those as respectively set out

hereinbefore with an appropriate allowance having been made in the grade prior to spreading the aggregate to compensate for anticipated bulking.

321.03.7.2.6--Thickness. Unless otherwise specified and except for chemical treatment, mechanical stabilization, in-grade modification, and in-grade preparation of the top portion of the design soil, no thickness determination as such will be required for bases. The preceding tolerances from design grade shall determine the tolerance limits for thickness.

The thickness tolerance for in-grade preparation of the top portion of design soil shall be plus or minus one inch. For chemical treatment, mechanical stabilization, or in-grade modification, thickness tolerances shall be those set out in the sections applicable to the required courses.

321.03.7.3--Horizontal Tolerances. Allowable horizontal tolerances for in-grade preparation shall be those set out in the respective sections for the required courses. Where no horizontal tolerance is specified, the tolerance for a course shall be that which will not result in an unsightly appearance or detract from the esthetic value of the finished crown line and slope.

Each course of base and shoulder materials, and combined courses of shoulder materials and the top portion of the design soil shall be shaped in such a manner that after compaction the finished course and combined courses shall closely conform to the widths, lines grades, and cross sections shown on the plans or established.

321.04--Method of Measurement. Unless shown as a separate pay item in the proposal, in-grade preparation will not be measured for direct payment, but shall be considered a necessary part of the construction involved, and the cost thereof shall be included in the appropriate contract unit prices.

When shown as a separate pay item, in-grade preparation of the depth specified will be measured by the mile for each separate roadway of the main facility without respect to width or number of lanes or courses involved. No separate measurement for payment will be made for frontage roads, interchanges, intersections, entrances, or other features of the work, nor for intersecting roads unless such roads are set out under the contract as separate projects. It shall be understood that the cost of in-grade preparation for such subsidiary facilities is included in the contract unit price per mile for the main facility.

In the case of in-grade preparation of material in place under previous contract, if it is necessary to excavate, pickup, load, and haul any of the in-grade material for use at other locations or for disposal as directed in order to prepare the section in accordance with the design grade, typical sections and conditions specified, such work shall be performed and will be measured and paid for under the applicable provisions and requirements as follows:

- a. When designated in the contract, under the provisions and requirements designated.
- b. When material loaded and hauled is used in lieu of material required under another item, measurement and payment will be made under the item of use.
- c. Measurement and payment for base or pavement material required in the work performed will be made in accordance with the requirements and provisions for

use of such material.

- d. When an item of excavation is not included in the contract, excavation required by the Engineer to be picked up, loaded, and hauled to other locations will be paid for as Extra Work or at unit prices established by Supplemental Agreement.
- e. Necessary haul of material not specified to be furnished by the Contractor, or not designated as absorbed haul (AH), shall be performed and will be paid for as provided under Section 205, or, in the event the contract does not provide a unit bid price for haul, as Extra Work.

321.05--Basis of Payment. Except as provided above, no payment will be made for in-grade preparation. It shall be fully understood that compensation: for all specified scarifying, disk-harrowing, mixing, or other processing; for furnishing and applying all water; for all aerating necessary to dry wet materials; for all shaping and compacting; for all other work of whatever nature necessary for preparation as set forth under this section; and for furnishing all labor, tools, equipment and incidentals necessary to complete the work shall be included in the unit prices for the materials used and the work performed under contract items.

When shown as a separate pay item in the contract, in-grade preparation will be paid for at the contract unit price per mile, which price shall be full compensation for satisfactorily completing the work.

Payment will be made under:

321-A: ___ " In-Grade Preparation - per mile

DIVISION 400 - BITUMINOUS PAVEMENTS

SECTION 401 - ASPHALT PAVEMENT -- GENERAL

401.01--Description. These specifications include general requirements that are applicable to all types of asphalt whether producing Hot Mix Asphalt (HMA) mixtures or Warm Mix Asphalt (WMA) mixtures. These specifications also include the specific requirements for each particular mixture when deviations from the general requirements are necessary.

This work consists of the construction of one or more lifts of asphalt pavement in accordance with these specifications and the specific requirements for the mixture to be produced and in reasonably close conformity with the lines, grades, thicknesses and typical sections shown on the plans or established by the Engineer.

401.01.1--Definitions.

Maximum Sieve Size - Maximum sieve size is the smallest sieve size at which 100 percent of the aggregate passes.

Nominal Maximum Sieve Size - The nominal maximum sieve size is one sieve size larger than the first sieve to retain more than 10 percent of the aggregate.

Maximum Density Line - The maximum density line is a straight line plot on the FHWA 0.45 power gradation chart that extends from the zero origin point of the chart through the plotted point of the combined aggregate gradation curve on the nominal maximum sieve size.

Mechanically Fractured Face - An angular, rough, or broken surface of an aggregate particle created by crushing as determined by ASTM D 5821.

401.02--Materials.

401.02.1--Component Materials.

401.02.1.1--General. Component materials will be conditionally accepted at the plant subject to later rejection if incorporated in a mixture or in work that fails to meet contract requirements.

401.02.1.2--Aggregates. The source of aggregates shall meet the applicable requirements of Section 703.

401.02.1.2.1--Coarse Aggregate Blend. Mechanically fractured faces by weight of the combined mineral aggregate coarser than the No. 4 sieve:

Mixture	Percent Fractured Faces, minimum
25-mm	70, one-face
19-mm *	80, one-face
12.5-mm	90, two-face
9.5-mm	90, two-face
4.75-mm	90, two-face

- * When used on routes requiring polymer modified asphalt, the top intermediate lift (19-mm mixture), including travel lane and adjacent lane, shall have at least 90 percent two fractured faces minimum. When placed on an existing concrete surface, all intermediate lifts (19-mm mixture) shall have at least 90 percent fractured two faces minimum.

The maximum percentage by weight of flat and elongated particles, for all mixes other than 4.75-mm, maximum to minimum dimension greater than 5, shall not exceed 10% for all mixtures. This shall be determined in accordance with ASTM D 4791, Section 8.4, on the combined mineral aggregate retained on the 3/8” sieve.

401.02.1.2.2--Fine Aggregate Blend. Of all the material passing the No. 8 sieve and retained on the No. 200 sieve, not more than 60 percent shall pass the No. 30 sieve.

Uncrushed natural sand shall pass the 3/8” sieve and may be used, excluding the content in RAP, in the percentages of the total mineral aggregate by weight set out in the following table:

Mixture	Maximum Percentage of Natural Sand by Total Weight of Mineral Aggregate		
	HT	MT	ST
25-mm	10	10	20
19-mm	10	10	20
12.5-mm	10	10	20
9.5-mm	10	10	10
4.75-mm	25	30	35

401.02.1.2.3--Combined Aggregate Blend.

Design Master Range

Mixture:	25-mm	19-mm	12.5-mm	9.5-mm	4.75-mm
Nominal Maximum Sieve Size:	1 inch	3/4 inch	1/2 inch	3/8 inch	1/4 inch
Sieve Size	Percent Passing				
1½ inch	100				
1 inch	90-100	100			
¾ inch	89 max.	90-100	100		
½ inch	-	89 max.	90-100	100	100
3/8 inch	-	-	89 max.	90-100	95-100
No. 4	-	-	-	89 max.	90-100
No. 8	16-50	18-55	20-60	22-70	-
No. 16	-	-	-	-	30-60
No. 200	4.0-9.0	4.0-9.0	4.0-9.0	4.0-9.0	6.0-12.0

For MT and HT mixtures, the combined aggregate gradation of the job mix formula, when plotted on FHWA 0.45 power chart paper, shall fall entirely below the Maximum Density Line on all sieve sizes smaller than the No. 4 sieve. However, MT and HT mixtures having a minimum fine aggregate angularity index of 44.0, per ASTM C1252,

Method A, may be designed above the maximum density line.

The 9.5-mm mixtures shall have a minimum fine aggregate angularity of 44.0 for HT and MT mixtures and 40.0 for ST mixtures when tested on combined aggregate in accordance with ASTM C1252 Method A. The 4.75-mm mixtures shall have a minimum fine aggregate angularity of 45.0 for all design levels when tested on combined aggregate in accordance with ASTM C 1252, Method A.

The minus No. 40 fraction of the combined aggregate shall be non-plastic when tested according to AASHTO T 90. The clay content for the combined aggregate for underlying layers shall not exceed 1.0 percent, and for the top layer shall not exceed 0.5 percent by weight of the total mineral aggregate when tested according to AASHTO T 88.

401.02.1.3--Bituminous Materials. Bituminous materials shall meet the applicable requirements of Section 702 for the grade specified.

401.02.1.4--Blank.

401.02.1.5--Hydrated Lime. Hydrated lime shall meet the requirements of Subsection 714.03.2 for lime used in soil stabilization.

401.02.1.6--Asphalt Admixtures. Additives for liquid asphalt, when required or permitted, shall meet the requirements of Subsection 702.08.

401.02.1.7--Polymers. Polymers for use in polymer modified asphalt pavements shall meet the requirements of Subsection 702.08.3.

401.02.2--WMA Products and Processes. The Department will maintain a list of qualified WMA products and processes. No product or process shall be used unless it appears on this list.

The Contractor may propose other products or processes for approval by the Product Evaluation Committee. Documentation shall be provided to demonstrate laboratory performance, field performance, and construction experience.

401.02.3--Composition of Mixtures.

401.02.3.1--General. Unless otherwise specified or permitted, the asphalt shall consist of a uniform mixture of asphalt, aggregate, hydrated lime and, when required or necessary to obtain desired properties, antistripping agent and/or other materials.

The total amount of crushed limestone aggregate for mixtures, excluding shoulders, when used in the top lift, shall not exceed 50 percent of the total combined aggregate by weight.

Hydrated lime shall be used in all asphalt at the rate of one percent (1%) by weight of the total dry aggregate including aggregate in RAP, if used. The aggregate, prior to the addition of the hydrated lime, shall contain sufficient surface moisture. If necessary, the Contractor shall add moisture to the aggregate according to the procedures set out in Subsection 401.03.2.1.2.

The Contractor shall obtain a shipping ticket for each shipment of hydrated lime. The Contractor shall provide the District Materials Engineer with a copy of each shipping ticket from the supplier, including the date, time and weight of hydrated lime shipped and used in asphalt production. An amount equal to twenty-five percent (25%) of the total value of asphalt items performed during the initial estimate period in which the Contractor fails to submit the hydrated lime shipping tickets to the District Materials Engineer will be withheld from the Contractor's earned work. Non-conformance with this specification for successive estimate period(s) will result in the total value (100%) of asphalt items performed during this period(s) being withheld from the Contractor's earned work. Monies withheld for this non-conformance will be released for payment on the next monthly estimate following the date the submittal of hydrated lime shipping tickets to the District Materials Engineer is brought back into compliance with this specification.

Mixtures will require the addition of an antistripping agent when the Tensile Strength Ratio (MT-63) and/or the Boiling Water Test (MT-59) fail to meet the following criteria.

Tensile Strength Ratio (TSR - MT-63)

- Wet Strength / Dry Strength 85 percent minimum
 - Interior Face Coating 95 percent minimum
- Boiling Water Test (MT-59)
- Particle Coating 95 percent minimum

Reclaimed asphalt pavement (RAP) materials may be used in the production of asphalt in the percentages of the total mix by weight set out in the following table:

Asphalt Mixture	Maximum Percentage of RAP by total weight of mix
4.75-mm	0
9.5-mm	20 *
12.5-mm Surface Lift	20 *
12.5-mm Underlying Lift	30
19-mm	30
25-mm	30

* At a minimum, RAP shall be processed and/or screened such that the RAP material size does not exceed the nominal maximum sieve size for the mixture specified.

During asphalt production, the RAP shall pass through a maximum 2-inch square sieve located in the asphalt plant after the RAP cold feed bin and prior to the RAP weighing system.

Crushed reclaimed concrete pavement may be used as an aggregate component of all asphalt pavements. When crushed reclaimed concrete pavement is used as an aggregate component, controls shall be implemented to prevent segregation. Crushed reclaimed concrete pavement aggregate shall be separated into coarse and fine aggregate stockpiles using the 3/8-inch or 1/2-inch sieve as a break-point unless otherwise approved by the Engineer in writing.

401.02.3.1.1--Mixture Properties.

<u>ALL MIXTURES</u>	<u>Percent of Maximum Specific Gravity (Gmm)</u>
N _{Design}	96.0
N _{Initial}	Less than 90.0
N _{Maximum}	Less than 98.0
<u>VMA CRITERIA</u>	<u>Minimum percent</u>
25-mm mixture	12.0
19-mm mixture	13.0
12.5-mm mixture	14.0
9.5-mm mixture	15.0
4.75-mm mixture	16.0

Mixtures with VMA more than two percent higher than the minimum may be susceptible to flushing and rutting; therefore, unless satisfactory experience with high VMA mixtures is available, mixtures with VMA greater than two percent above the minimum should be avoided.

The specified VFA range for 4.75-mm nominal maximum size mixtures for design traffic levels >3 million ESAL's (HT Mixtures) shall be 75 to 78 percent, for design traffic levels of 1.0 to 3 million ESAL's (MT mixtures) 65 to 78 percent, and for design traffic levels of <1.0 million ESAL's (ST mixtures) 65 to 78 percent.

DUST/BINDER RATIO for 4.75-mm mixtures

Percent Passing No.200 / Effective Binder Percent 0.9 to 2.0

DUST/BINDER RATIO for 9.5-mm, 12.5-mm, 19-mm & 25-mm mixtures

Percent Passing No.200 / Effective Binder Percent 0.8 to 1.6

401.02.3.2--Job Mix Formula. The job mix formula shall be established in accordance with Mississippi Test Method: MT-78, where N represents the number of revolutions of the gyratory compactor.

Compaction Requirements:	N _{Initial}	N _{Design}	N _{Maximum}
High Type (HT) Mixtures			
19-mm, 12.5-mm, 9.5-mm & 4.75-mm	7	85	130
Medium Type (MT) Mixtures			
19-mm, 12.5-mm, 9.5-mm & 4.75-mm	7	65	100
All Standard Type (ST) Mixtures;			
25-mm HT & MT Mixtures	6	50	75

At least 10 working days prior to the proposed use of each mixture, the Contractor shall submit in writing to the Engineer a proposed job-mix formula or request the transfer of a verified job-mix formula as set forth in the latest edition of MDOT's Field Manual for HMA and SOP TMD-11-78-00-000. The proposed job-mix formula shall indicate whether the mixture will be produced as HMA or WMA. The process or product used to produce WMA should also be noted on the proposed documentation for the job-mix formula. The job-mix formula shall be signed by a Certified Mixture Design Technician (CMDT).

The Department will perform the tests necessary for review of a proposed job-mix formula for each required mixture free of charge one time only. A charge will be made for additional job-mix formulas submitted by the Contractor for review.

Review of the proposed job-mix formula will be based on percent maximum specific gravity at N_{Initial} , N_{Design} , and N_{Maximum} , VMA @ N_{Design} , resistance to stripping, and other criteria specified for the mixture.

The mixture shall conform thereto within the range of tolerances specified for the particular mixture. No change in properties or proportion of any component of the job-mix formula shall be made without permission of the Engineer. The job-mix formula for each mixture shall be in effect until revised in writing by the Engineer.

A job-mix formula may be transferred to other contracts in accordance with conditions set forth in the Department's Field Manual for HMA.

The Contractor shall not place any asphalt prior to receiving "tentative" approval and a MDOT design number from the Central Laboratory.

When a change in source of materials, unsatisfactory mixture production results (such as segregation, bleeding, shoving, rutting over $\frac{1}{8}$ ", raveling & cracking) or changed conditions make it necessary, a new job-mix formula will be required. The conditions set out herein for the original job-mix formula are applicable to the new job-mix formula.

In the event the Contractor wishes to change from an approved HMA job-mix formula to WMA or an approved WMA job-mix formula to HMA, the Contractor shall submit the proposed change in writing to the Engineer at least 10 working days prior to the proposed change. If no changes (other than the plant production temperature) are to be made to the job-mix formula, a new MDOT design number will be assigned by the MDOT Central Laboratory.

401.02.4--Substitution of Mixture. The substitution of a one (1) size finer mixture for an underlying lift shall require written permission of the State Construction Engineer, except no substitution of a 4.75-mm mixture will be allowed. The 19-mm mixture may be substituted for the 25-mm mixture in trench widening work. Any substitution of mixtures shall be of the same type. No other substitutions will be allowed. The quantity of substituted mixture shall be measured and paid for at the contract unit price for the mixture designated on the plans. The substitution of any mixture will be contingent on meeting the required total structure thickness and maintaining the minimum and/or maximum laying thickness for the particular substituted mixture as set out in the following table.

Mixture	Single Lift Laying Thickness Inches	
	Minimum	Maximum
25-mm	3	4
19-mm	2¼	3½
12.5-mm	1½	2½
9.5-mm	1	1½
4.75-mm	½	¾

401.02.5--Contractor's Quality Management Program.

401.02.5.1--General. The Contractor shall have full responsibility for quality management and maintain a quality control system that will furnish reasonable assurance that the mixtures and all component materials incorporated in the work conform to contract requirements. The Contractor shall have responsibility for the initial determination and all subsequent adjustments in proportioning materials used to produce the specified mixture. Adjustments to plant operation and spreading and compaction procedures shall be made immediately when results indicate that they are necessary. Mixture produced by the Contractor without the required testing or personnel on the project shall be subject to removal and replacement by the Contractor at no additional cost to the State.

401.02.5.2--Personnel Requirements. The Contractor shall provide at least one Certified Asphalt Technician-I (CAT-I) full-time during asphalt production at each plant site used to furnish material to the project. Sampling shall be conducted by a certified technician or by plant personnel under the direct observation of a certified technician. All testing, data analysis and data posting will be performed by the CAT-I or by an assistant under the direct supervision of the CAT-I. The Contractor shall have a Certified Asphalt Technician-II (CAT-II) available to make any necessary process adjustments. Technician certification shall be in accordance with MDOT SOP TMD-22-10-00-000, MDOT HMA Technician Certification Program. An organizational chart, including names, telephone numbers and current certification, of all those responsible for the quality control program shall be posted in the Contractor's laboratory while the asphaltic paving work is in progress.

401.02.5.3--Testing Requirements. As a minimum, the Contractor's quality management program shall include the following:

- (a) Bituminous Material. Provide Engineer with samples in a sealed one quart metal container at the frequency given in MDOT SOP TMD-20-04-00-000.
- (b) Mechanically Fractured Face. Determine mechanically fractured face content of aggregates retained on the No. 4 sieve, at a minimum of one test per day of production.
- (c) Mixture Gradation. Conduct extraction tests for gradation determination on the mixture. Sample according to the frequency in paragraph (i) and test according to Mississippi Test Method MT-31.
- (d) Total Voids and VMA. Determine total voids and voids in mineral aggregate (VMA), at N_{Design} , from the results of bulk specific gravity tests on laboratory compacted specimens. Sample according to the sampling frequency in paragraph (i) and test according to the latest edition of MDOT's Field Manual for HMA.
- (e) Asphalt Content. Sample asphalt content according to the sampling frequency in paragraph (i). Determine the asphalt content using one of the following procedures.
 - (1) Nuclear gauge per Mississippi Test Method MT-6.
 - (2) Incinerator oven per AASHTO T 308, Method A.
- (f) Stripping Tests. Conduct a minimum of one stripping test at the beginning of each job-mix production and thereafter, at least once per each two weeks of production according to Mississippi Test Method: MT-63 and one stripping test per day of production according to Mississippi Test Method: MT-59. Should

either the TSR (MT-63) or the boiling water (MT-59) stripping tests fail, a new antistripping additive or rate shall be established or other changes made immediately that will result in a mixture that conforms to the specifications; otherwise, production shall be suspended until corrections are made.

- (g) Density Tests. For 25-mm, 19.5-mm, 12.5-mm & 9.5-mm mixtures, conduct density tests as necessary to control and maintain required compaction according to Mississippi Test Method: MT-16, Method C (nuclear gauge), or AASHTO T 166. Note - The nuclear gauge may be correlated, at the Contractor's option, with the average of a minimum of five pavement sample densities. For 4.75-mm mixtures, conduct density tests as necessary to control and maintain required compaction according to AASHTO T 166.
- (h) Quality Control Charts. Plot the individual test data, the average of the last four tests and the control limits for the following items as a minimum:

Mixture Gradation (Percent Passing) Sieves:
 1/2-inch, 3/8-inch, No. 8, No. 16, No. 30 and No. 200.
 Asphalt Content, Percent
 Maximum Specific Gravity, G_{mm}
 Total Voids @ N_{Design} , Percent
 VMA @ N_{Design} , Percent

NOTE: For 4.75-mm mixtures, Quality Control Charts for mixture gradation are not required on the No. 8 and No. 30 sieves. For 4.75-mm mixtures, as a minimum, Quality Control Charts for mixture gradation shall be kept on the 3/8-inch, No. 16 and No. 200 sieves. For all mixtures other than 4.75-mm, Quality Control Charts for mixture gradation are not required on the No. 16 sieve.

Quality Control charts shall be updated daily and be available to both Contractor and MDOT personnel at any time during the production of asphalt mixture. The charts shall note any process changes or adjustments made to the mixture design

- (i) Sampling Frequency. Conduct those tests as required above at the following frequency for each mixture produced based on the estimated plant tonnage at the beginning of the day.

<u>Total Estimated Production, tons</u>	<u>Number of Tests</u>
50-800	1
801-1700	2
1701-2700	3
2701+	4

NOTE: Material placed in a storage silo from a previous day's production shall be randomly sampled and tested when removed for placement on the roadway. Such sample(s) shall be independent of the day's production sampling frequency and shall be used in calculating the four (4) sample running average.

- (j) Sample Requirements. Obtain the asphalt mixture samples from trucks at the plant. Obtain aggregate samples from cold feed bins or aggregate stockpile. Save a split portion of all mixture samples at the laboratory site in a dry and protected location for 14 calendar days. At the completion of the project, the remaining samples may be disposed of with the approval of the Engineer.

The above testing frequencies are for the estimated plant production for the day. If

production is discontinued or interrupted, the tests will be conducted at the previously established sample tonnage points for the materials that are actually produced. If the production exceeds the estimated tonnage, sampling and testing will continue at the testing increments previously established for the day. A testing increment is defined as the estimated daily tonnage divided by the required number of tests from the table in Subsection 401.02.5.3 paragraph (i).

In addition to the above program, the following tests shall be conducted on the first day of production and once for every eight production samples thereafter, with a minimum of one test per production week.

Aggregate Stockpile Gradations per AASHTO Designations: T-11 and T-27.

Reclaimed Asphalt Pavement (RAP) Gradation per Mississippi Test Method MT-31.

Fine Aggregate Angularity for all 4.75-mm and 9.5-mm mixtures and all MT and HT mixtures designed above the maximum density line per ASTM C 1252, Method A.

Testing of the aggregate and RAP stockpiles during production will be waived provided the Contractor provides the Engineer with gradation test results for the materials in the stockpile determined during the building of the stockpiles. The test results provided shall represent a minimum frequency of one per one thousand tons of material in the stockpile. If the Contractor continues to add materials to the stockpile during asphalt production, the requirements for gradation testing during production are not waived.

401.02.5.4--Documentation. The Contractor shall document all observations, records of inspection, adjustments to the mixture, and test results on a daily basis. All tests conducted by the Contractor in accordance with Subsection 401.02.5.3(h) shall be included in the running average calculations. If single tests are performed as a check on individual asphalt properties, between regular samples, without performing all tests required in Subsection 401.02.5.3(h), the results of those individual tests shall not be included in the running average calculations for that particular property. The Contractor shall record the results of observations and records of inspection as they occur in a permanent field record. The Contractor shall record all process adjustments and job mix formula (JMF) changes on the air void charts. The Contractor shall provide copies of all test data sheets and the daily summary reports on the appropriate MDOT forms to the District Materials Engineer on a daily basis. The Contractor shall provide a written description of any process change, including blend proportions, to the Engineer as they occur. Information provided to the District Materials Engineer must be received in the Engineer's office by no later than 9:00 AM the day after the asphalt is produced. Upon completion of the placement of all asphalt for the project, the Contractor shall provide the Engineer with the original test reports and control charts in a neat and orderly manner.

401.02.5.5--Control Limits. The following control limits for the job mix formula (JMF) and warning limits are based on a running average of the last four data points.

Item	JMF Limits	Warning Limits
Sieve - % Passing		
1/2-inch	± 5.5	± 4.0
3/8-inch	± 5.5	± 4.0
No. 8	± 5.0	± 4.0

Item	JMF Limits	Warning Limits
Sieve - % Passing		
No. 16, for 4.75-mm mixtures ONLY	± 4.0	± 3.0
No. 30	± 4.0	± 3.0
No. 200	± 1.5	± 1.0
Asphalt Content, %	-0.3 to +0.5	-0.2 to + 0.4
Total Voids @ N _{Design} , %	± 1.3	± 1.0
VMA @ N _{Design} , %	- 1.5	- 1.0

401.02.5.6--Warning Bands. Warning bands are defined as the area between the JMF limits and the warning limits.

401.02.5.7--Job Mix Formula Adjustments. A request for a JMF adjustment signed by a CAT-II may be made to the Engineer by the Contractor. Sufficient testing data shall be submitted with the request to justify the change. The requested change will be reviewed by the State Materials Engineer for the Department. If current production values meet the mixture design requirements, a revised JMF will be issued. Adjustments to the JMF shall conform to the latest edition of MDOT's Field Manual for HMA. Adjustments to the JMF to conform to actual production shall not exceed the tolerances specified for the JMF limits. Regardless of such tolerances, any adjusted JMF gradation shall be within the design master range for the mixture specified. The JMF asphalt content may only be reduced if the production VMA meets or exceeds the minimum design VMA requirements for the mixture being produced.

401.02.5.8--Actions and Adjustments. Based on the process control test results for any property in question, the following actions shall be taken or adjustments made when appropriate:

- (a) When the running average trends toward the warning limits, the Contractor shall consider taking corrective action. The corrective action, if any, shall be documented. All tests shall be part of the contract files and shall be included in the running average calculations.
- (b) The Contractor shall notify the Engineer whenever the running average exceeds the warning limits.
- (c) If two consecutive running averages exceed the warning limit, the Contractor shall stop production and make adjustments. Production shall only be restarted after notifying the Engineer of the adjustments made.
- (d) If the adjustment made under (c) improves the process such that the running average after four additional tests is within the warning limits, the Contractor may continue production with no reduction in payment.
- (e) If the adjustment made under (c) does not improve the process and the running average after four additional tests stays in the warning band, the mixture will be considered unsatisfactory. Reduced payment for unsatisfactory mixtures will be applied starting from the stop point to the point when the running average is back within the warning limits in accordance with Subsection 401.02.6.3.
- (f) Failure to stop production and make adjustments when required shall subject all mixture produced from the stop point to the point when the running average is back within the warning limits to be considered unsatisfactory. Reduced payment for unsatisfactory mixtures will be applied in accordance with Subsection 401.02.6.3.
- (g) If the running average exceeds the JMF limits, the Contractor shall stop production and make adjustments. Production shall only be restarted after

notifying the Engineer of the adjustments made.

- (h) All materials for which the running average exceeds the JMF limits will be considered unacceptable and shall be removed and replaced by the Contractor at no additional cost to the State. The Engineer will determine the quantity of material to be replaced based on a review of the individual testing data that make up the running average in question and an inspection of the completed pavement. If the Engineer decides to leave the mixture in place because of special circumstances, the quantity of mixture, as defined above, will be paid for in accordance with Subsection 401.02.6.3.
- (i) If only a small quantity of an asphalt type is to be placed on a project, a single test result may be compared to 1.7 times the warning and JMF limits. If the test results verified by QA testing (within allowable differences in Subsection 401.02.6.2) exceed these limits, the pay factor provided in Subsection 401.02.6.3 will apply for the quantity of material represented by the test(s).
- (j) The above corrective action will also apply for a mixture when the Contractor's testing data has been proven incorrect. The Contractor's data will be considered incorrect when; 1) the Contractor's tests and the Engineer's tests do not agree within the allowable differences given in Subsection 401.02.6.2 and the difference can not be resolved, or 2) the Engineer's tests indicates that production is outside the JMF limits and the results have been verified by the Materials Division. The Engineer's data will be used in place of the Contractor's data to determine the appropriate pay factor.

401.02.6--Standards of Acceptance.

401.02.6.1--General. Acceptance for mixture quality (VMA and total voids @ N_{Design} , gradation, and asphalt content) will be based on random samples tested in accordance with the latest edition of MDOT's Field Manual for HMA. Pavement densities and smoothness will be accepted by lots as set out in Subsections 401.02.6.4 and 401.02.6.8.

401.02.6.2--Assurance Program for Mixture Quality. The Engineer will conduct a quality assurance program. The quality assurance program will be accomplished as follows:

- 1) Conducting verification tests.
- 2) Validate Contractor test results.
- 3) Periodically observing Contractor quality control sampling and testing.
- 4) Monitoring required quality control charts and test results.
- 5) Sampling and testing materials at any time and at any point in the production or laydown process.

The rounding of all test results will be in accordance with Subsection 700.04.

The Engineer will conduct verification tests on samples taken by the Contractor under the direct supervision of the Engineer at a time specified by the Engineer. The frequency will be equal to or greater than ten percent (10%) of the tests required for Contractor quality control and the data will be provided to the Contractor within two asphalt mixture production days after the sample has been obtained by the Engineer. At least one sample shall be tested from the first two days of production. All testing and data analysis shall be performed by a Certified Asphalt Technician-I (CAT-I) or by an assistant under the direct supervision of the CAT-I. Certification shall be in accordance with the *MDOT HMA Technician Certification*

Program chapter in the Materials Division Inspection, Testing, and Certification Manual. The Department shall post a chart giving the names and telephone numbers for the personnel responsible for the assurance program.

The Engineer shall be allowed to inspect Contractor testing equipment and equipment calibration records to confirm both calibration and condition. The Contractor shall calibrate and correlate all testing equipment in accordance with the latest versions of the Department's Test Methods and AASHTO R 18.

Random differences between the Engineer's verification tests and the current running average of four quality control tests at the time of obtaining the verification sample will be considered acceptable if within the following limits:

Item	Allowable Differences
Sieve - % Passing	
3/8-inch and above	6.0
No. 4	5.0
No. 8	4.0
No. 16, for 4.75-mm mixtures ONLY	3.5
No. 30	3.5
No. 200	2.0
AC Content	0.4
Specimen Bulk SG, Gmb @ N_{Design}	0.030
Maximum SG, Gmm	0.020

If four quality control tests have not been tested prior to the time of the first verification test, the verification test results will be compared to the average of the preceding quality control tests. If the verification test is the first material tested on the project or if a significant process adjustment was made just prior to the verification test, the verification test results will be compared to the average of four subsequent quality control test results. For all other cases after a significant process adjustment, the verification test results will be compared to the average of the preceding quality control tests (taken after the adjustment) as in the case of a new project start-up when four quality control tests are not available.

In the event that; 1) the comparison of the Contractor's running average quality control data and Engineer's quality assurance verification test results are outside the allowable differences in the above table, or 2) if a bias exists between the results, such that one of the results is predominately higher or lower than the other, and the Engineer's results fail to meet the JMF control limits, the Engineer will investigate the reason immediately. As soon as the need for an investigation becomes known, the Engineer will increase the quality assurance sampling rate to the same frequency required for Contractor testing. The additional samples obtained by the Engineer may be used as part of the investigation process or for routine quality assurance verification tests. The Engineer's investigation may include testing of the remaining quality control split samples, review and observation of the Contractor's testing procedures and equipment, and a comparison of split sample test results by the Contractor quality control laboratory, Department quality assurance laboratory and the Materials Division laboratory. The procedures outlined in the latest edition of Department's Field Manual for HMA may be used as a guide for the investigation. In the event that the

Contractor's results are determined to be incorrect, the Engineer's results will be used for the quality control data and the appropriate payment for the mixture will be based on the procedures specified in Subsection 401.02.5.8(j).

The Engineer will periodically witness the sampling and testing being performed by the Contractor. The Engineer, both verbally and in writing, will promptly notify the Contractor of any observed deficiencies. When differences exist between the Contractor and the Engineer that cannot be resolved, a decision will be made by the State Materials Engineer, acting as the referee. The Contractor will be promptly notified in writing of the decision. If the deficiencies are not corrected, the Engineer will stop production until corrective action is taken.

401.02.6.3--Acceptance Procedure for Mixture Quality. All obviously defective material or mixture will be subject to rejection by the Engineer. Such defective material or mixture shall not be incorporated into the finished work. If the defective material has already been placed in the work, the material shall be removed and replaced at no additional cost to the State.

The Engineer will base final acceptance of the asphalt mixture production on the results of the Contractor's testing for total voids and VMA @ N_{Design} , gradation, and asphalt content as verified by the Engineer in the manner hereinbefore described and the uniformity and condition of the completed pavement. Areas of pavement that exhibit non-uniformity or failures, materials or construction related, such as but not limited to segregation, bleeding, shoving, rutting over $\frac{1}{8}$ ", raveling, slippage, or cracking will not be accepted. Such areas will be removed and replaced at no additional cost to the State.

Bituminous mixture placed prior to correction for deficiencies in VMA and total voids @ N_{Design} , gradation, or asphalt content, as required in Subsection 401.02.5.8 and determined by the Engineer satisfactory to remain in place will be paid for in accordance with the following pay factors times the contract unit price per ton.

Pay Factor for Mixture Quality *

Item	Produced in Warning Bands	Produced Outside JMF Limits, Allowed to Remain in Place
Gradation	0.90	0.75
Asphalt Content	0.85	0.75
Total Voids @ N_{Design}	0.70	0.50
VMA @ N_{Design}	0.90	0.75

* The minimum single payment will apply.

401.02.6.4--Acceptance Procedure for Density. Each completed lift will be accepted with respect to compaction on a lot to lot basis from density tests performed by the Department. For normal production days, divide the production into approximately equal lots as shown in the following table. When cores are being used for the compaction evaluation, randomly obtain one core from each lot. When the nuclear density gauge is being used for compaction evaluation, obtain two random readings from each lot and average the results. See Chapter 7 of the latest edition of MDOT's Field Manual for HMA for more details. Additional tests may be required by the Engineer to determine

acceptance of work appearing deficient. The Contractor shall furnish and maintain traffic control for all compaction evaluations, including coring, required in satisfying specified density requirements.

Lot Determination

<u>Daily Production - Tons</u>	<u>Number of Lots</u>
0 - 300	1
301 - 600	2
601 - 1000	3
1001 - 1500	4
1501 - 2100	5
2101 - 2800	6
2801+	7

401.02.6.4.1--Roadway Density. The density requirement for each completed lift on a lot to lot basis from density tests performed by the Department shall be as follows:

1. For leveling lifts where full lane width is paved and a minimum thickness requirement as specified in the table in Subsection 401.02.4 is met, the required lot density shall be 92.0 percent of maximum density. For all other leveling, no density shall be required but the pavement shall be rolled to refusal densification.
2. For all single lift overlays, with or without a leveling lift and/or milling, the required lot density shall be 92.0 percent of maximum density.
3. For all multiple lift overlays of two (2) or more lifts excluding leveling lifts, the required lot density of the bottom lift shall be 92.0 percent of maximum density. The required lot density for all subsequent lifts shall be 93.0 percent of maximum density.
4. For all pavements on new construction except shoulders that are untreated, the required lot density for all lifts shall be 93.0 percent of maximum density. For all pavements on shoulders that are untreated, the required lot density for all lifts shall be 92.0 percent of maximum density.

When it is determined that the density for a lot is below the required density (93.0 percent or 92.0 percent) but not lower than 91.0 or 90.0 percent of maximum density, respectively, the Contractor will have the right to remove and replace the lot(s) not meeting the specified density requirements in lieu of accepting reduced payment for the lot(s).

When it is determined that the density for a lot is above 96.0 percent, the Engineer shall notify the Contractor who will make plant adjustments to resolve the problem.

When it is determined that the density for a lot is below 91.0 or 90.0 percent, respectively, the lot(s), or portions thereof shall be removed and replaced in accordance with Chapter 7 of the latest edition of MDOT's Field Manual for HMA at no additional cost to the State. A corrected lot will be retested for approval. No resampling will be performed when pavement samples are used for determining density.

At any time the average daily compaction (the total of the percent compaction for the lots produced in one day divided by the total number of lots for the day) does not meet the

required percent compaction or more for two consecutive days, the Contractor shall notify the Engineer of proposed changes to the compactive effort. If the average daily compaction does not meet the required percent compaction or more for a third consecutive day, the Contractor shall stop production until compaction procedures are established to meet the specified density requirements.

Each lot of work found not to meet the density requirement of 92.0% or 93% of maximum density, respectively, may remain in place with a reduction in payment as set out in the following tables:

**PAYMENT SCHEDULE FOR COMPACTION
OF 92.0 PERCENT OF MAXIMUM DENSITY**

<u>Pay Factor</u>	<u>Lot Density ** % of Maximum Density</u>
1.00	92.0 and above
0.90	91.0 - 91.9
0.70	90.0 - 90.9

** Any lot or portion thereof with a density of less than 90.0 percent of maximum density shall be removed and replaced at no additional cost to the State.

**PAYMENT SCHEDULE FOR COMPACTION
OF 93.0 PERCENT OF MAXIMUM DENSITY**

Lot Density ***	
<u>Pay Factor</u>	<u>% of Maximum Density</u>
1.00	93.0 and above
0.90	92.0 - 92.9
0.70	91.0 - 91.9

*** Any lot or portion thereof with a density of less than 91.0 percent of maximum density shall be removed and replaced at no additional cost to the State.

The compaction pay factors and mixture quality pay factor, as described in Subsection 401.02.6.3, will each apply separately. However, the combined pay factor shall not be less than 0.50 for any mixture allowed to remain in place.

401.02.6.4.2--Trench Widening Density. The density for trench widening on a lot to lot basis shall be determined from density tests performed by the Department using pavement samples (cores).

When it is determined that the density for a trench widening lot is below 89.0 percent but not lower than 88.0 percent of maximum density, the Contractor will have the right to remove and replace the lot(s) not meeting the specified density requirements in lieu of accepting reduced payment for the lot(s).

When it is determined that the density for a trench widening lot is above 95.0 percent, the Engineer shall notify the Contractor who will make plant adjustments to resolve the problem.

When it is determined that the density for a trench widening lot is below 88.0 percent, the lot(s), or portions thereof shall be removed and replaced in accordance with Chapter 7 of the latest edition of Department’s Field Manual for HMA at no additional cost to the State. A corrected lot will be retested for approval. No resampling will be performed when pavement samples are used for determining density.

At any time the daily compaction (the total of the percent compaction for the lots produced in one day divided by the total number of lots for the day) does not meet 89.0 percent compaction or more for two consecutive days, the Contractor shall notify the Engineer of proposed changes to the compactive effort. If the average daily compaction does not meet 89.0 percent compaction or more for a third consecutive day, the Contractor shall stop production until compaction procedures are established to meet the specified density requirement.

Each lot of trench widening work found not to meet the density requirement of 89.0 percent of maximum density may remain in place with a reduction in payment as set out in the following table:

**PAYMENT SCHEDULE FOR COMPACTION
TRENCH WIDENING WORK**

<u>Pay Factor</u>	<u>Lot Density *** % of Maximum Density</u>
1.00	89.0 and above
0.50	88.0 - 88.9

*** Any lot or portion thereof with a density of less than 88.0 percent of maximum density shall be removed and replaced at no additional cost to the State.

The compaction pay factors and mixture quality pay factor, as described in Subsection 401.02.6.3, will each apply separately. However, the combined pay factor shall not be less than 0.50 for any mixture allowed to remain in place.

401.02.6.5--Blank.

401.02.6.6--Blank.

401.02.6.7--Surface Correction. Corrective work to sections exceeding short continuous interval thresholds reported by ProVal, as described in Subsection 403.03.2.1, shall consist of diamond grinding in accordance with these specifications or methods approved by the Engineer. All surface areas corrected by grinding shall be sealed with a sealant approved by the Engineer.

401.02.6.7.1--Diamond Grinding. Grinding of asphalt surfaces shall consist of diamond grinding the existing asphalt pavement surface to remove surface distortions to achieve the specified surface smoothness requirements.

401.02.6.7.2--Equipment. The grinding equipment shall be a power driven, self-propelled machine that is specifically designed to smooth and texture pavement surfaces with diamond blades. The effective wheel base of the machine shall not be less than 12.0

feet. It shall have a set of pivoting tandem bogey wheels at the front of the machine and the rear wheels shall be arranged to travel in the track of the fresh cut pavement. The center of the grinding head shall be no further than 3.0 feet forward from the center of the back wheels.

The equipment shall be of a size that will cut or plane at least two feet (2') wide. It shall also be of a shape and dimension that does not encroach on traffic movement outside of the work area. The equipment shall be capable of grinding the surface without causing spalls at joints, or other locations.

401.02.6.7.3--Construction. The construction operation shall be scheduled and proceed in a manner that produces a uniform finish surface. Grinding will be accomplished in a manner to provide positive lateral drainage by maintaining a constant cross-slope between grinding extremities in each lane.

The operation shall result in pavement that conforms to the typical cross-section and the requirements specified in Subsection 401.02.6.7.4. It is the intent of this specification that the surface smoothness characteristics be within the limits specified.

The Contractor shall establish positive means for removal of grinding residue. Solid residue shall be removed from pavement surfaces before it is blown by traffic action or wind. Residue shall not be permitted to flow across lanes used by public traffic or into gutters or drainage facilities, but may be allowed to flow into adjacent ditches.

401.02.6.7.4--Finished Pavement Surface. The grinding process shall produce a pavement surface that is smooth and uniform in appearance with a longitudinal line type texture. The line type texture shall contain parallel longitudinal corrugations that present a narrow ridge corduroy type appearance. The peaks of the ridges shall not be more than 1/16 inch higher than the bottoms of the grooves.

The finished pavement surface will be measured for riding quality. The grinding shall produce a riding surface that does not exceed either the specified profile index or the specified bump and dip limit.

401.02.6.8--Acceptance Procedure for Pavement Smoothness Using Mean Roughness Index (MRI). When compaction is completed, the lift shall have a uniform surface and be in reasonably close conformity with the line, grade and cross section shown on the plans.

The smoothness of the surface lift will be determined by using an Inertial Profiling System (IPS) to measure and record roughness data in each designated location. Roughness data for each longitudinal profile will be reported as a Mean Roughness Index (MRI). MRI is calculated by averaging the International Roughness Index (IRI) values from the two individual wheelpath profiles. The surface shall be tested and corrected to a smoothness index as described herein with the exception of those locations or specific projects that are excluded from smoothness testing with an IPS.

The smoothness of the surface lift will be determined for traffic lanes, auxiliary lanes, climbing lane and two-way turn lanes. Areas excluded from a smoothness test with the IPS are acceleration and deceleration lanes, tapered sections, transition sections for width, shoulders, crossovers, ramps, side street returns, etc. The roadway pavement on bridge

replacement projects having 1,000 feet or less of pavement on each side of the structure will be excluded from a smoothness test. Pavement on horizontal curves having a radius of less than 1,000 feet at the centerline and pavement within the super elevation transition of such curves are excluded from smoothness testing. Smoothness testing shall terminate 264 feet from each transverse joint that separates the pavement from a bridge deck, bridge approach slab or existing pavement not constructed under the contract. This shall apply to any other exceptions including, but not limited to, railroad crossings and manholes. Segments containing a considerable amount of encroachments such as intersections, manholes, curb and gutter sections, etc. may be excluded at the Project Engineer's discretion.

Initial smoothness measurements shall take place no more than 72 hours following placement of surface and must be performed at the posted speed limit or 50 miles per hour (± 5 mile per hour), whichever is lower. This testing window may be waived for single lift (Category C) overlay projects at the Engineer's discretion. This speed requirement will be waived for all lightweight profilers. Measurements will be made in both wheel paths of exterior and interior lanes. The wheel paths shall be designated as being located three feet (3') and nine feet (9') from centerline or longitudinal joint, respectively. Beginning and ending latitude and longitude coordinates shall be required on each smoothness surface test. Testing will also be required on sections that have been surface corrected. No smoothness testing shall be performed when there is moisture of any kind on the pavement surface. Any additional testing shall meet the requirements of Subsection 403.03.2.

The surface lift will be accepted on a continuous interval basis for pavement smoothness. Continuous reporting is based upon all MRI values for a specified running interval. These values are averaged and presented at the midpoint of the specified running interval. The last 15 feet of a day's lift may not be obtainable until the lift is continued and for this reason may be included in the subsequent section.

Areas of localized roughness exceeding the continuous 25-foot interval threshold described in Subsection 403.03.2.1 shall be corrected regardless of the 528-foot interval MRI value of the section. Surface correction by grinding shall be performed in accordance with Subsection 401.02.6.7. The Contractor shall also make other necessary surface corrections to ensure that the final mean roughness index of the section meets the requirements of Subsection 403.03.2.

Continuous sections exceeding the accepted long interval MRI value shall be corrected as specified in Subsection 403.03.4. All such corrections shall be performed at no additional costs to the State. Scheduling and traffic control will be the responsibility of the Contractor with approval of the Engineer. All tests and corrections shall be in accordance with AASHTO R 54-10, Accepting Pavement Ride Quality When Measured Using Inertial Profiling Systems.

401.02.6.9--High Speed Inertial Profiling System.

401.02.6.9.1--General. The IPS, furnished and operated by the Contractor under the supervision of the Engineer or the Engineer's representative, shall be a dual laser high speed or lightweight vehicle meeting the requirements of AASHTO M 328-10, Standard Specification for Inertial Profiler.

401.02.6.9.2--Mechanical Requirements. The IPS should function independent of vehicle suspension and speed with an operational range of 15-70 mph (for high speed profilers only) and must collect data at a sample interval of no more than three inches (3"). All IPSs, operators, and combinations thereof shall be verified in accordance with AASHTO R 56-10, Standard Practice for Certification of Inertial Profiler Systems and AASHTO R 57-10, Operating Inertial Profiler Systems.

401.02.6.9.3--Computer Requirements. The computer measurement program must be menu driven, Windows compatible, and able to produce unfiltered profiler runs in any one of the following file formats: University of Michigan's Transportation Research Institute's (UMTRI) Engineering Research Division (*.erd) file, ProVAL's Pavement Profile (*.ppf) file, or Ames Engineering's (*.adf, *.ard) file format. The computer shall have the ability to display and print data on site for verification and shall have the ability to save and transfer data via Universal Serial Bus (USB) flash drive, which shall be provided by the Contractor.

All profiler runs must be named in the following format for acceptance by the Project Engineer.

- County_Route_Direction_Lane_BeginStation_EndStation

In addition to manufacturers software; the latest version of FHWA's ProVAL software shall be installed on the IPS computer. ProVAL software is available for free download at <http://www.roadprofile.com>.

401.02.7--Nuclear Moisture-Density Gauge. The nuclear gauge unit used to monitor density shall contain a full data processor which holds all calibration constants necessary to compute and directly display wet density, moisture, and dry density in pounds per cubic foot. The data processor shall compute and display the percent moisture and percent density based on dry weight.

401.03--Construction Requirements. The Department has adopted the "Hot-Mix Asphalt Paving Handbook" as the guideline for acceptable asphalt construction practices.

401.03.1--Specific Requirements.

401.03.1.1--Weather Limitations - General. The mixture shall not be placed when weather conditions prevent the proper handling and finishing or the surface on which it is to be placed is wet or frozen.

When paving operations are discontinued because of rain, the mixture in transit shall be protected until the rain ceases. The surface on which the mixture is to be placed shall be swept to remove as much moisture as possible and the mixture may then be placed subject to removal and replacement at no additional cost to the State if contract requirements are not met.

401.03.1.1.1--Weather Limitations For HMA. At the time of placement, the air and pavement surface temperature limitations shall be equal to or exceed that specified in the following table.

TEMPERATURE LIMITATIONS

Compacted Thickness	Temperature
Less than 1½ inches	55°F
1½ inches to 2 inches	50°F
2¼ inches to 3 inches	45°F
Greater than 3 inches	40°F

401.03.1.1.2--Weather Limitations For WMA. The air and pavement temperature at the time of placement shall equal or exceed 40°F, regardless of compacted lift thickness.

401.03.1.2--Tack Coat. Tack coat for asphalt mixtures shall be one from the Department's APL under the category "Non-tracking Tack for Asphalt Mixtures." Tack coat shall be applied to previously placed asphalt and between lifts, unless otherwise directed by the Engineer. Tack coat shall be applied with a distributor spray bar. A hand wand will only be allowed for applying tack coat on ramp pads, irregular shoulder areas, median crossovers, turnouts, or other irregular areas. Application rate for tack coat shall be 0.05 to 0.10 gallons per square yard. Emulsified asphalt used for tack coat shall not be diluted. Construction requirements shall be in accordance with Subsection 407.03 of the Standard Specifications.

401.03.1.3--Blank.

401.03.1.4--Density. The lot density for all dense graded pavement lifts, except as provided below for preleveling, wedging [less than fifty percent (50%) of width greater than minimum lift thickness], ramp pads, irregular shoulder areas, median crossovers, turnouts, or other areas where the established rolling pattern cannot be performed, shall not be less than the specified percent (92.0% or 93.0%) of the maximum density based on AASHTO T 209 for the day's production. If a job-mix formula adjustment is made during the day that affects the maximum specific gravity, calculate a new average maximum density for the lot(s) placed after the change.

Pavement core samples obtained for determining density that has a thickness less than two times the maximum size aggregate permitted by the job-mix formula will not be used as a representative sample.

Preleveling, wedging (less than fifty percent of width greater than minimum lift thickness), ramp pads, irregular shoulder areas, median crossovers, turnouts, and other areas where an established rolling pattern cannot be obtained shall be compacted to refusal densification.

401.03.2--Bituminous Mixing Plants.

401.03.2.1--Plant Requirements.

401.03.2.1.1--Cold Aggregate Storage. The cold storage for hydrated lime shall be a separate bulk storage bin with a vane feeder or other approved feeder system that can readily be calibrated. The system shall provide a means for easy sampling of the hydrated lime additive and verifying the quantity of lime dispensed. The feeder system

shall require a totalizer.

The hydrated lime additive equipment shall be interlocked and synchronized with the cold feed controls to operate concurrently with the cold feed operation that will automatically adjust the hydrated lime feed to variations in the cold aggregate feed. A positive signal system shall be installed that will automatically shut the plant down when malfunctions cause an improper supply of hydrated lime or water.

The plant shall not operate unless the entire hydrated lime system is functioning properly.

401.03.2.1.2--Cold Aggregate Feed. The hydrated lime shall be dispensed dry or as a slurry directly onto the composite aggregate between the cold feed and the dryer. The slurry shall consist of 1 part hydrated lime to 3 parts water.

When hydrated lime is introduced dry, a spray bar or other approved system capable of spraying all aggregate with water shall be installed in order to maintain all aggregate at the moisture condition set out in Subsection 401.02.3.1 prior to addition of the hydrated lime. An alternate system for spraying the coarse aggregate stockpiles may be allowed when approved by the Engineer. The approved equipment and methods shall consistently maintain the aggregate in a uniform, surface wet condition. The moisture content of the aggregate-hydrated lime mixture, following spraying and mixing, shall be introduced into the automatic moisture controls of the plant.

The aggregate-hydrated lime mixture shall be uniformly blended by some mechanical means such as a motorized "on the belt" mixer or pug mill located between the cold feed and the dryer. Other mixing devices may be used subject to approval by the Engineer.

A maximum of forty five (45) percent of the total aggregate blend may be fed through any single cold feed bin. If the JMF calls for more than forty five (45) percent of a specific aggregate, that aggregate must be fed through two (2) or more separate cold feed bins.

401.03.2.1.3--Dryer. The efficiency of drying aggregates shall be such that the moisture content of the top asphalt mixture shall not exceed 0.50 percent by weight of the total mixture, and the moisture content of all the underlying mixtures shall not exceed 0.75 percent by weight of the total mixture being produced.

401.03.2.1.4--Blank.

401.03.2.1.5--Control of Bituminous Material and Antistripping Agent. Specified bituminous materials from different manufacturers or from different refineries of a single manufacturer shall not be mixed in the plant's asphalt cement supply system storage tank and used in the work without prior written approval of the Engineer. Approval is contingent upon the Engineer's receipt of three copies of the manufacturer's certified test report(s) from the Contractor showing that the bituminous material blend conforms to the specifications.

A satisfactory method of weighing or metering shall be provided to ensure the specified quantity of bituminous material. Provisions shall be provided for checking the quantity or rate of flow. Weighing or metering devices shall be accurate within plus or minus one-half percent.

The antistripping agent shall be injected into the bituminous material immediately prior to the mixing operation with an approved in-line injector system capable of being calibrated so as to ensure the prescribed dosage.

An in-line spigot for sampling of asphalt shall be located between the asphalt storage tank and the antistripping agent in-line injector.

401.03.2.1.6--Thermometric Equipment. An armored thermometer of adequate range and calibrated in 5°F increments shall be fixed at a suitable location in the bituminous line near the charging valve of the mixer unit.

The plant shall be equipped with an approved dial-scale, mercury-actuated thermometer, pyrometer or other approved thermometric instrument placed at the discharge chute of the plant to measure the temperature of the material.

When the temperature control is unsatisfactory, the Engineer may require an approved temperature-recording apparatus for better regulation of the temperature.

401.03.2.1.7--Screens. A scalping screen shall be used.

401.03.2.1.8--Dust Collector. The plant shall be equipped with a dust collector constructed to waste or return collected material. When collected material is returned, it shall be returned through a controlling device that will provide a uniform flow of material into the aggregate mixture.

401.03.2.1.9--Safety Requirements. A platform or other suitable device shall be provided so the Engineer will have access to the truck bodies for sampling and mixture temperature data.

401.03.2.1.10--Blank.

401.03.2.1.11--Truck Scales. The specifications, tolerances and regulations for commercial weighing and measuring devices as recommended by the National Bureau of Standards [National Institute of Standards and Technology (NIST) Handbook 44] shall govern truck scales used in the State of Mississippi, except weighing devices with a capacity of ten thousand (10,000) pounds or more used to weigh road construction materials (i.e. sand, gravel, asphalt, fill dirt, topsoil and concrete) shall have a tolerance of one-half of one percent (1/2 of 1%) in lieu of the requirements of Handbook 44 and shall be regulated by the Department.

Scales shall be checked and certified by a scale company certified in heavy truck weights by the MDAC. In the case of scales used for measurement of materials on Department projects, certification shall be performed in the presence of an authorized representative of the Department or a copy of the certification may be furnished for scales that have been checked and certified within the last six months for use on other Department projects and are still in the position where previously tested. Scales that have not been checked and certified under NIST Handbook 44 guidelines, except for the herein modified tolerances allowed, shall be so checked and certified prior to use for measurement of materials on Department projects. Tests shall be continued on six month intervals with the test conducted in the presence of an authorized representative of the

Department.

Truck scales shall be accurate to one-half of one percent of the applied load, shall be sensitive to 20 pounds, and shall have a graduation of not more than 20 pounds.

The Contractor may use an electronic weighing system approved by the Engineer in lieu of truck scales. The system shall be equipped with an automatic print out system that will print a ticket for each load with the following information:

MDOT, Contractor's name, project number, county, ticket number, load number, pay item number, item description of the material delivered, date, time of day, haul vehicle number, gross weight, tare weight, net weight and total daily net weight.

When approved by the Engineer and materials are measured directly from a storage bin equipped with load cells, exceptions may be made to the gross and tare weight requirements.

The ticket shall also have a place for recording the temperature of asphalt mixtures, if applicable, and the signatures of the Department's plant and roadway inspectors. The load numbers for each project shall begin with load number one (1) for the first load of the day and shall be numbered consecutively without a break until the last load of the day. The Contractor shall provide the Department with an original and one copy of each ticket. When the ticket information provided by the Contractor proves to be unsatisfactory, the Department will use imprinter(s) and imprinter tickets to record load information. All recorded weights shall be in pounds and shall be accurate to within one-half of one percent of the true weight, and the system shall be sensitive to 20 pounds. The Engineer may require random loads to be checked on certified platform scales at no cost to the Department. If the electronic scales are found to be inaccurate, a re-certification of the scales shall be performed before the Contractor can continue use of the scales.

When an electronic weighing system utilizes the plant scales of a batch plant, the system may be used only in conjunction with a fully automatic batching and control system.

401.03.2.2--Additional Requirements for Batching Plants.

401.03.2.2.1--Plant Scales. The plant batch scale weight shall not exceed the platform scale weight by more than one percent (1.0%).

401.03.2.3--Additional Requirements for Drum Mixing Plants.

401.03.2.3.1--Plant Controls. The plant shall be operated with all the automatic controls as designed and provided by the plant manufacturer. If the automatic controls malfunction, brief periods of manual operations to complete the day's work or to protect the work already placed may be conducted with the approval of the Engineer. During manual operation, the Contractor must continue to produce a uniform mixture meeting all contract requirements.

401.03.2.3.2--Aggregate Handling and Proportioning. A screening unit shall be placed between the bins and the mixer to remove oversized aggregate, roots, clayballs, etc.

401.03.2.4--Surge or Storage Bins. Surge and/or storage systems may be used at the option of the Contractor provided each system is approved by the Department prior to use. Surge bins shall be emptied at the end of each day's operation. Storage silos may be used to store mixtures as follows:

19-mm & 25-mm mixtures	24 hours
9.5-mm & 12.5-mm mixtures	36 hours

The storage silos must be well sealed, completely heated and very well insulated. The mixture when removed from the storage silo shall be tested to ensure that it meets all the same specifications and requirements as the mixture delivered directly to the paving site. See Subsection 401.02.5.3, subparagraph (i) for sampling and testing requirements.

401.03.3--Hauling Equipment. The inside surfaces of each vehicle bed shall be coated with a light application of water and thin oil, soap solution, lime water solution or other approved material to prevent the mixture from sticking. Diesel fuel or gasoline shall not be used to lubricate vehicle beds. Truck beds shall be raised to drain excessive lubricants before placing mixture in the bed. An excess of lubricant will not be permitted.

401.03.4--Asphalt Mixture Pavers. The screed shall be capable of vibrating and heating the full width of the mixture being placed and shall lay the lift with an automatic control device to the specified slope and grade without tearing, pulling or gouging the mixture surface. Rigid screed and auger extensions should be used when the width of the screed is not adequate to pave a full lane width or full paved width (lane width plus shoulder width). Typically, the end of the auger extension should extend to approximately 18 inches or less from the end plate to ensure uniform mixture placement. Strike-off extensions should be avoided wherever possible but may be used for items such as driveway/mailbox turnouts or intersections in which frequent variations in pavement width are encountered.

401.03.5--Rollers. All rollers shall be self-propelled units capable of maintaining a smooth and uniform forward and reverse speed as required for proper compaction. They shall be equipped with adjustable scrapers, water tanks, mats and a device for wetting the wheels or tires to prevent the mixture from sticking. Adhesion of the mixture to the rollers will not be permitted. The use of diesel fuel or gasoline for cleaning roller wheels or tires or to aid in preventing the mixture from sticking to the wheels or tires is prohibited.

All rollers shall be in good mechanical condition, free from leaking fuels and lubricants, loose link motion, faulty steering mechanism, worn king bolts and bearings. They shall be operational at slow speeds to avoid displacement of the mixture and capable of reversing direction smoothly and without backlash.

401.03.6--Preparation of Grade. The foundation upon which asphalt pavement is to be placed shall be prepared in accordance with the applicable Section of the Standard Specification.

Unless otherwise directed, tack coat shall be applied to the underlying surface on which the mixture is to be placed. Emulsions, if used, must be allowed to "break" prior to placement of the bituminous mixture.

Bituminous mixture shall not be placed against the edge of pavements, curbs, gutters, manholes and other structures until these edges located adjacent to the asphalt layer to be placed are sprayed with a thin uniform tack coating. The tack coat shall be protected until the mixture has been placed.

Existing asphalt pavements that require preliminary leveling or patching in advance of placing the bituminous mixture shall be sprayed with a tack coat material and then brought as nearly as practicable to uniform grade and cross section. The material shall be placed by hand or machine in one or more compacted layers approximately two (2) inches or less in compacted thickness.

401.03.7--Blank.

401.03.8--Preparation of Mixture.

401.03.8.1--Preparation of Mixture For HMA. The temperature of the mixture, when discharged from the mixer, shall not exceed 340°F.

401.03.8.2--Preparation of Mixture For WMA. Warm mix asphalt is defined as a plant produced asphalt mixture that can be produced and constructed at lower temperatures than typical hot mix asphalt. Typical temperature ranges of non-polymer modified, WMA produced by foaming the asphalt binder at the plant are typically 270°F to 295°F at the point of discharge of the plant. Typical temperature ranges of polymer modified, WMA produced by foaming the asphalt binder at the plant are typically 280°F to 305°F at the point of discharge of the plant. WMA produced by addition of a terminal blended additive may allow the producer to reduce the temperatures below 270°F as long as all mixture quality and field density requirements are met. Production temperatures at the plant may need to be increased or decreased due to factors such as material characteristics, environmental conditions, and haul time to achieve mixture temperatures at the time of compaction in which uniform mat density can be achieved.

401.03.9--Material Transfer Equipment. Excluding the areas mentioned below, the material transferred from the hauling unit when placing the top lift, or the top two (2) lifts of a multi-lift asphalt pavement with density requirements, shall be remixed prior to being placed in the paver hopper or insert by using an approved Materials Transfer Device. Information on approved devices can be obtained from the State Construction Engineer. Areas excluded from this requirement include: leveling courses, temporary work of short duration, detours, bridge replacement projects having less than 1,000 feet of pavement on each side of the structure, acceleration and deceleration lanes less than 1,000 feet in length, tapered sections, transition sections for width, shoulders less than 10 feet in width, crossovers, ramps, side street returns and other areas designated by the Engineer.

401.03.10--Spreading and Finishing. Grade control for asphalt pavements shall be established by stringline at least 500 feet ahead of spreading, unless placement is adjacent to curb and gutter, concrete pavement, or other allowed grade control.

The mixture shall be spread to the depth and width that will provide the specified compacted thickness, line, grade and cross section. Placing of the mixture shall be as continuous as possible. On areas where mechanical spreading and finishing is impracticable, the mixture may be spread, raked and luted by hand tools.

Immediately after screeding and prior to compaction, the surface shall be checked by the Contractor and irregularities adjusted. When the edge is feathered as in a wedge lift, it may be sealed by rolling. Irregularities in alignment and grade along the edges shall be corrected before the edges are rolled.

Hauling, spreading and finishing equipment shall be furnished that is capable of and operated in such a manner that the rolling operation will satisfactorily correct any surface blemishes.

The longitudinal joint in the subsequent lift shall offset that in the underlying lift by approximately six (6) inches. However, the joint in the top lift shall be at the centerline or lane line.

401.03.11--Compaction. After the mixture has been spread and surface irregularities corrected, it shall be thoroughly and uniformly compacted to the required line, grade, cross section and density.

401.03.12--Joints. Joints between previously placed pavement and pavement being placed shall be so formed as to ensure thorough and continuous bond.

Transverse construction joints shall be formed by cutting the previously placed mixture to expose the full depth of the lift.

The contact surface of transverse joints and longitudinal joints, except hot joints, shall be sprayed with a thin uniform tack coating before additional mixture is placed against the previously placed material.

Longitudinal joints shall be formed by overlapping the screed on the previously placed material for a width of at least one (1) inch and depositing the quantity of mixture to form a smooth, tight joint.

Joint Sealant. When a pay item for 403-S, Joint Sealant, is included in the contract, the contact surface of transverse joints and longitudinal joints in the surface lift, except hot joints, shall be sealed by spraying the joint prior to placement of additional asphalt against the previously placed material. Joint sealant shall be an approved sealant listed on the Department's APL. Manufacturer's recommendations shall be followed if the material needs to be re-heated, and when placing the thin, uniform coat.

Prior to application of the sealant, the face of the joint shall be thoroughly dry and free from dust or any other material that would prevent proper sealing. All joints shall be swept or blown free of loose material, dirt, vegetation, and other debris by means of compressed air or a power sweeper.

Truck and vehicle traffic shall not drive across a sealed joint until it has dried sufficient to prevent damage from tracking.

The Contractor shall furnish the Engineer three copies of the manufacturer's certification stating that the material used meets the requirement of the specifications.

401.03.13--Pavement Samples. The Contractor shall cut samples from each lift of

asphalt at the time and locations designated by the Engineer. The samples shall be taken for the full depth of each lift and shall be of a size approved by the Engineer but not to exceed 120 square inches. Tools used for cutting or coring of samples shall be of the revolving blade type such as saw or core drill. Cores shall be taken using a 4.0 to 6.0-inch inside diameter coring bit. The sample hole shall be filled, compacted and finished by the Contractor to conform to the surrounding area. No additional compensation will be allowed for furnishing samples and repairing the areas with new pavement.

401.03.14--Shoulder Wedge. The Contractor shall attach a device to the screed of the paver that confines the material at the end gate and extrudes the asphalt material in such a way that results in a compacted wedge shape pavement edge of approximately 30 degrees, but not steeper than 35 degrees. The device shall maintain contact between itself and the road shoulder surface and allow for automatic transition to cross roads, driveways, and obstructions. The device shall be used to constrain the asphalt head reducing the area by 10% to 15% increasing the density of the extruded profile. Conventional single plate strike off shall not be used.

Short sections of handwork will be allowed when necessary for transitions and turnouts, or otherwise authorized by the Engineer.

Information on approved devices can be obtained from the State Construction Engineer. If the Contractor has a similar device they want to get approved, the Contractor shall provide proof that the device has been used on previous projects with acceptable results, or construct a test section prior to the beginning of work and demonstrate wedge compaction to the satisfaction of the State Construction Engineer.

SECTION 402 - OPEN GRADED FRICTION COURSE

402.01--Description. These specifications include general requirements that are applicable to Open Graded Friction Course (OGFC).

This work consists of the construction of one lift of OGFC in accordance with these specifications and the specific requirements for the mixture to be produced and placed in reasonably close conformity with the lines, grades, thicknesses and typical sections shown on the plans or established by the Engineer.

402.01.1--Definitions.

Maximum Sieve Size - Maximum sieve size is the smallest sieve size at which 100 percent of the aggregate passes.

Nominal Maximum Sieve Size - The nominal maximum sieve size is one sieve size larger than the first sieve to retain more than 10 percent of the aggregate.

Mechanically Fractured Face - An angular, rough, or broken surface of an aggregate particle created by crushing as determined by ASTM D 5821.

Break Point Sieve – The sieve size which separates the coarse and fine aggregate fractions of an OGFC mixture.

402.02--Materials.**402.02.1--Component Materials.**

402.02.1.1--General. Component materials will be conditionally accepted at the plant subject to later rejection if incorporated in a mixture or in work that fails to meet contract requirements.

402.02.1.2--Aggregates. The source of aggregates shall meet the applicable requirements of Section 703.

402.02.1.2.1--Coarse Aggregate Blend. Mechanically fractured faces by weight of the combined aggregate blend retained on the break point sieve shall be 90 percent two or more fractured faces, as determined by ASTM D 5821.

The maximum percentage by weight of flat and elongated particles, maximum to minimum dimension greater than three (3), shall not exceed 20% for OGFC mixtures. This shall be determined in accordance with ASTM D 4791, Section 8.4, on the combined mineral aggregate retained on the break point sieve.

The following table indicates the break point sieves for various nominal maximum size OGFC mixes.

Mixture Size	Break Point Sieve
12.5-mm	No. 4
9.5-mm	No. 8

402.02.1.2.2--Combined Aggregate Blend. All gradations will be based on percent passing by weight. The gradation requirements for OGFC mixtures are provided in the following table. Natural sand shall not be used in OGFC mixtures.

Sieve Size	12.5-mm	9.5-mm
12.5-mm	100	100
9.5-mm	80-89	90-100
4.75-mm	15-30	15-30
2.36-mm	10-20	10-20
75- μ m	2-5	2-5

402.02.1.3--Bituminous Materials. Bituminous materials shall meet the applicable requirements of Section 702 for the grade specified. A PG 76-22 asphalt binder shall be used for all OGFC mixtures. The asphalt content (by weight of total mix) shall be based on the bulk specific gravity of the combined aggregate blend (G_{sb}) to ensure a constant asphalt binder volume in the mix for durability purposes. The relationship between G_{sb} and the minimum asphalt binder content by weight of total mix is provided in the following table.

Combined Aggregate Bulk Specific Gravity, G_{sb}	Minimum Asphalt Content (%)
2.40	6.6
2.45	6.5
2.50	6.3
2.55	6.2
2.60	6.1
2.65	6.0
2.70	5.9
2.75	5.8
2.80	5.7
2.85	5.6
2.90	5.5
2.95	5.4
3.00	5.3

Tack coat shall meet the requirements of Subsection 402.03.1.2.

402.02.1.4--Hydrated Lime. Hydrated lime shall meet the requirements of Subsection 714.03.2 for lime used in soil stabilization.

402.02.1.5--Asphalt Admixtures. Additives for liquid asphalt, when required or permitted, shall meet the requirements of Subsection 702.08.

402.02.1.6--Polymers. Polymers for use in OGFC shall meet the requirements of Subsection 702.08.3.

402.02.1.7--Stabilizing Fiber. Stabilizing fiber shall meet the requirements of Subsection 714.07, with the exception that if mineral fibers are used, the minimum dosage rate shall be 0.40 percent.

402.02.2--Blank.

402.02.3--Composition of Mixtures.

402.02.3.1--General. Unless otherwise specified or permitted, the OGFC shall consist of a uniform mixture of asphalt, aggregate, stabilizing fibers, hydrated lime and, when required or necessary to obtain desired properties, antistripping agent and/or other materials.

The total amount of crushed limestone aggregate shall not exceed 50 percent of the total combined aggregate by weight.

Hydrated lime shall be used in all OGFC at the rate of one percent (1%) by weight of the total dry aggregate. The aggregate, prior to the addition of the hydrated lime, shall contain sufficient surface moisture. If necessary, the Contractor shall add moisture to the aggregate according to the procedures set out in Subsection 401.03.2.1.2.

The Contractor shall obtain a shipping ticket for each shipment of hydrated lime. The Contractor shall provide the District Materials Engineer with a copy of each shipping ticket from the supplier, including the date, time and weight of hydrated lime shipped.

Mixtures will require the addition of an antistripping agent when the Tensile Strength Ratio (MT-63*) and/or the Boiling Water Test (MT-59) fail to meet the following criteria.

Tensile Strength Ratio (TSR - MT-63*)

Wet Strength / Dry Strength	85 percent minimum
Interior Face Coating	95 percent minimum

Boiling Water Test (MT-59)

Particle Coating	95 percent minimum
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* MT-63 shall be performed at design air void content of OGFC mixtures rather than seven percent (7%) air voids. Vacuum saturation shall not be required. All other testing parameters shall apply.

Reclaimed asphalt pavement (RAP) or crushed reclaimed concrete may not be used as an aggregate component in the production of OGFC.

402.02.3.1.1--Mixture Properties. All mixes shall be designed according to Mississippi Test Method MT-83. OGFC mixes shall be designed with the Superpave gyratory compactor utilizing an N_{design} of 50 gyrations. The design air voids for all OGFC mixes shall be a minimum of 15.0 percent, as determined by ASTM D 6752 (vacuum sealing method). The ratio of the voids in the coarse aggregate in the compacted mix (VCA_{mix}) to the voids in the coarse aggregate as determined with the dry rodded unit weight test (VCA_{dr}) shall be less than 1.0.

The designed mixture shall have a draindown of less than 0.3 percent when tested in accordance with Mississippi Test Method MT-82. The minimum permeability of the mixture shall be 30 meters per day as determined by Mississippi Test Method MT-84. The aged abrasion loss of compacted specimens at the optimum asphalt content shall not exceed 40%, and the unaged abrasion loss of compacted specimens at the optimum asphalt content shall not exceed 30%, as determined by Mississippi Test Method MT-85.

402.02.3.2--Job Mix Formula. At least 14 working days prior to the proposed use of each mixture, the Contractor shall submit in writing to the Engineer a proposed job-mix formula or request the transfer of a verified job-mix formula as set forth in the latest edition of the Department’s Field Manual for HMA and MT-83. The job-mix formula shall be signed by a Certified Mixture Design Technician (CMDT).

The Department will perform the tests necessary for review of a proposed job-mix formula for each OGFC mixture free of charge one time only. A charge will be made for additional job-mix formulas submitted by the Contractor for review.

Review of the proposed job-mix formula will be based on ratio of Voids in the Coarse Aggregate (VCA_{mix}/VCA_{dr}), draindown, permeability, abrasion loss, resistance to stripping, and other criteria specified for the mixture.

The mixture shall conform thereto within the range of tolerances specified for the particular mixture. No change in properties or proportion of any component of the job-mix formula shall be made without permission of the Engineer. The job-mix formula for each mixture shall be in effect until revised in writing by the Engineer.

A job-mix formula may be transferred to other contracts in accordance with conditions set forth in the Department's Field Manual for HMA.

The Contractor shall not place any OGFC prior to receiving "tentative" approval and a MDOT design number from the Department's Central Laboratory.

When a change in source of materials, unsatisfactory mixture production results (such as segregation, bleeding, shoving, rutting over $\frac{1}{8}$ inch, raveling & cracking) or changed conditions make it necessary, a new job-mix formula will be required. The conditions set out herein for the original job-mix formula are applicable to the new job-mix formula.

402.02.4--Layer Thickness. The minimum and maximum laying thickness for OGFC mixtures are provided in the following table.

Mixture Nominal Maximum Size	Single Lift Laying Thickness, Inches	
	Minimum	Maximum
12.5-mm	1	1 $\frac{1}{4}$
9.5-mm	$\frac{3}{4}$	1

402.02.5--Contractor's Quality Management Program.

402.02.5.1--General. The Contractor shall have full responsibility for quality management and maintain a quality control system that will furnish reasonable assurance that the mixtures and all component materials incorporated in the work conform to contract requirements. The Contractor shall have responsibility for the initial determination and all subsequent adjustments in proportioning materials used to produce the specified mixture. Adjustments to plant operation and spreading and compaction procedures shall be made immediately when results indicate that they are necessary. Mixture produced by the Contractor without the required testing or personnel on the project shall be subject to removal and replacement by the Contractor at no additional cost to the State.

402.02.5.2--Personnel Requirements. The Contractor shall provide at least one Certified Asphalt Technician-I (CAT-I) full-time during OGFC production at each plant site used to furnish material to the project. Sampling shall be conducted by a certified technician or by plant personnel under the direct observation of a certified technician. All testing, data analysis and data posting will be performed by the CAT-I or by an assistant under the direct supervision of the CAT-I. The Contractor shall have a Certified Asphalt Technician-II (CAT-II) available to make any necessary process adjustments. Technician certification shall be in accordance with the Department's *Materials Division Inspection, Testing, and Certification Manual*, Section 1.3.3 - MDOT HMA Technician Certification Program. An organizational chart, including names, telephone numbers and current certification, of all those responsible for the quality control program shall be posted in the contractor's laboratory while the OGFC paving work is in progress.

402.02.5.3--Testing Requirements. As a minimum, the Contractor's quality management program shall include the following:

- (a) Bituminous Material. Provide the Engineer with samples in a sealed one quart metal container at the frequency given in SOP TMD-20-04-00-000.
- (b) Mechanically Fractured Face. Determine mechanically fractured face content of aggregates retained on the break point sieve, at a minimum of one test per day of production.
- (c) Mixture Gradation. Conduct extraction tests for gradation determination on the mixture. Sample according to the frequency in paragraph (h) and test according to Mississippi Test Method MT-31.
- (d) Total Voids. Determine total voids at N_{Design} from the results of bulk specific gravity tests on laboratory compacted specimens. Sample according to the sampling frequency in paragraph (h) and test according to ASTM D 6752.
- (e) Asphalt Content. Sample according to the sampling frequency in paragraph (h), and determine the asphalt content using one of the following procedures.
 - (1) Nuclear gauge. (Mississippi Test Method MT-6)
 - (2) Incinerator oven. (AASHTO T 308, Method A)
 Draindown tests shall also be conducted according to Mississippi Test Method MT-82, at a minimum of one test per day of production.
- (f) Stripping Tests. Conduct a minimum of one stripping test at the beginning of each job-mix production and thereafter, at least once per each two weeks of production according to Mississippi Test Method: MT-63 (as amended) and one stripping test per day of production according to Mississippi Test Method: MT-59. Should either the TSR (MT-63) or the boiling water (MT-59) stripping tests fail, a new antistripping additive or rate shall be established or other changes made immediately that will result in a mixture that conforms to the specifications; otherwise, production shall be suspended until corrections are made.
- (g) Quality Control Charts. Plot the individual test data, the average of the last four tests and the control limits for the following items as a minimum:

- Mixture Gradation (Percent Passing) Sieves:
 - 1/2-in, 3/8-in, No. 4, No. 8, and No. 200
 - Asphalt Content, Percent
 - Maximum Specific Gravity
 - Total Voids @ N_{Design} , Percent

Quality Control charts shall be updated daily and be available to both Contractor and MDOT personnel at any time during the production of asphalt mixture. The charts shall note any process changes or adjustments made to the mixture design.

- (h) Sampling Frequency. Conduct those tests as required above at the following frequency for each mixture produced based on the estimated plant tonnage at the beginning of the day.

<u>Total Estimated Production, tons</u>	<u>Number of Tests</u>
1-400	1
401-800	2
801-1200	3
1201+	4

- (i) **Sample Requirements.** Obtain the OGFC mixture samples from trucks at the plant. Obtain aggregate samples from cold feed bins or aggregate stockpile. Save a split portion of all mixture samples at the laboratory site in a dry and protected location for 14 calendar days. At the completion of the project, the remaining samples may be disposed of with the approval of the Engineer.

The above testing frequencies are for the estimated plant production for the day. If production is discontinued or interrupted, the tests will be conducted at the previously established sample tonnage points for the materials that are actually produced. If the production exceeds the estimated tonnage, sampling and testing will continue at the testing increments previously established for the day. A testing increment is defined as the estimated daily tonnage divided by the required number of tests from the table in Subsection 402.02.5.3 paragraph (h).

In addition to the above program, aggregate stockpile gradation tests (AASHTO Designations: T-11 and T-27) shall be conducted every other production day. Tests to determine VCA_{dr} shall be conducted on the first day of production and once for every eight production samples thereafter, with a minimum of one test per production week.

402.02.5.4--Documentation. The Contractor shall document all observations, records of inspection, adjustments to the mixture, and test results on a daily basis. All tests conducted by the Contractor in accordance with Subsection 402.02.5.3(g) shall be included in the running average calculations. If single tests are performed as a check on individual OGFC properties, between regular samples, without performing all tests required in Subsection 402.02.5.3(g), the results of those individual tests shall not be included in the running average calculations for that particular property. The Contractor shall record the results of observations and records of inspection as they occur in a permanent field record. The Contractor shall record all process adjustments and job mix formula (JMF) changes on the air void charts. The Contractor shall provide copies of all test data sheets and the daily summary reports on the appropriate Department forms to the Engineer on a daily basis. The Contractor shall provide a written description of any process change, including blend proportions, to the Engineer as they occur. Information provided to the District Materials Engineer must be received in the Engineer's office by no later than 9:00 AM the day after the OGFC is produced. Upon completion of the placement of all OGFC on the project, the Contractor shall provide the Engineer with the original test reports and control charts in a neat and orderly manner.

402.02.5.5--Control Limits. The following control limits for the job mix formula (JMF) and warning limits are based on a running average of the last four data points.

<u>Item</u>	<u>JMF Limits</u>	<u>Warning Limits</u>
Sieve - % Passing		
1/2-inch	± 4.0	± 3.0
3/8-inch	± 4.0	± 3.0
No. 4	± 3.0	± 2.0
No. 8	± 3.0	± 2.0
No. 200	± 1.5	± 1.0
Asphalt Content, %	-0.3 to +0.5	-0.2 to +0.4
Total Voids @ N_{Design} , %	-1.3 to +2.5	-1.0 to +2.0

402.02.5.6--Warning Bands. Warning bands are defined as the area between the JMF limits and the warning limits.

402.02.5.7--Job Mix Formula Adjustments. A request for a JMF adjustment signed by a CAT-II may be made to the Engineer by the Contractor. Sufficient testing data shall be submitted with the request to justify the change. The requested change will be reviewed by the State Materials Engineer for the Department. If current production values meet the mixture design requirements, a revised JMF will be issued. Adjustments to the JMF shall conform to the latest edition of the Department's Field Manual for HMA. Adjustments to the JMF to conform to actual production shall not exceed the tolerances specified for the JMF limits. Regardless of such tolerances, any adjusted JMF gradation shall be within the range given in Subsection 402.02.3.2 for the mixture specified. **The JMF asphalt content may only be adjusted after verification for minimum voids, permeability, and abrasion loss.**

402.02.5.8--Actions and Adjustments. Based on the process control test results for any property in question, the following actions shall be taken or adjustments made when appropriate:

- (a) When the running average trends toward the warning limits, the Contractor shall consider taking corrective action. The corrective action, if any, shall be documented. All tests shall be part of the contract files and shall be included in the running average calculations.
- (b) The Contractor shall notify the Engineer whenever the running average exceeds the warning limits.
- (c) If two consecutive running averages exceed the warning limit, the Contractor shall stop production and make adjustments. Production shall only be restarted after notifying the Engineer of the adjustments made.
- (d) If the adjustment made under (c) improves the process such that the running average after four additional tests is within the warning limits, the Contractor may continue production with no reduction in payment.
- (e) If the adjustment made under (c) does not improve the process and the running average after four additional tests stays in the warning band, the mixture will be considered unsatisfactory. Reduced payment for unsatisfactory mixtures will be applied starting from the stop point to the point when the running average is back within the warning limits in accordance with Subsection 402.02.6.3.
- (f) Failure to stop production and make adjustments when required shall subject all mixture produced from the stop point to the point when the running average is back within the warning limits to be considered unsatisfactory. Reduced payment for unsatisfactory mixtures will be applied in accordance with Subsection 402.02.6.3.
- (g) If the running average exceeds the JMF limits, the Contractor shall stop production and make adjustments. Production shall only be restarted after notifying the Engineer of the adjustments made.
- (h) All materials for which the running average exceeds the JMF limits will be considered unacceptable and shall be removed and replaced by the Contractor at no additional cost to the State. The Engineer will determine the quantity of material to be replaced based on a review of the individual testing data that make up the running average in question and an inspection of the completed pavement. If the Engineer decides to leave the mixture in place because of

special circumstances, the quantity of mixture, as defined above, will be paid for in accordance with Subsection 402.02.6.3.

- (i) Single test results shall be compared to 1.7 times the warning and JMF limits. If the QC test results, as verified by the Engineer's tests (within allowable differences in Subsection 402.02.6.2), exceed these limits, the pay factor provided in Subsection 402.02.6.3 will apply for the quantity of material represented by the test(s). Single test limits will be used for the acceptance of projects when insufficient tonnage is produced to require four (4) Contractor's tests.
- (j) The above corrective action will also apply for a mixture when the Contractor's testing data has been proven incorrect. The Contractor's data will be considered incorrect when, 1) the Contractor's QC tests and the Engineer's verification tests do not agree within the allowable differences given in Subsection 402.02.6.2 and the difference cannot be resolved, or 2) the Engineer's verification tests indicates that production is outside the JMF limits and the results have been substantiated by the Materials Division's test results. The Engineer's data will be used in place of the Contractor's data to determine the appropriate pay factor.

402.02.5.9--Trial Section. At the beginning of placement for the lift, the Contractor shall construct a trial section of a maximum of a maximum of 250 tons of mix, for the purpose of establishing and evaluating consistent mixture and compaction properties. The Contractor shall determine the production point at which the mix shall be sampled during trial section construction. This sample does not have to be selected by the formal random selection procedures used during actual production, but should be representative of the mix produced.

The Contractor (QC) and the Department (QA) will conduct tests for mixture quality. A trial section is considered to be successful if the QC test results are within the Warning Limits (the testing indicates a pay factor of 1.0) and the QC tests compare to the QA tests within the allowable differences set forth in Subsection 402.02.6.2. If the criteria for a successful trial section is not achieved, additional trial sections shall be constructed until the criteria is achieved, at which time full production can begin. In the event a successful trial section is not accomplished by the completion of the second trial section, the Contractor will be required to construct additional trial sections at an offsite location. The Engineer reserves the right to have any trial section removed and replaced at no additional cost to the State, if the pay factor for any characteristic for a trial section is less than 0.75.

For actual payment purposes, a pay factor of 1.00 will be used for the first and second trial sections allowed to remain in place. Any required offsite trial sections will be constructed at no additional cost to the State.

402.02.6--Standards of Acceptance.

402.02.6.1--General. Acceptance for mixture quality (Total voids @ N_{Design} , gradation, and asphalt content) will be based on random samples tested in accordance with the latest edition of the Department's Field Manual for HMA.

402.02.6.2--Assurance Program for Mixture Quality. The Engineer will conduct a quality assurance program. The quality assurance program will be accomplished as follows:

- 1) Conducting verification tests.
- 2) Validate Contractor test results.
- 3) Periodically observing Contractor quality control sampling and testing.
- 4) Monitoring required quality control charts and test results.
- 5) Sampling and testing materials at any time and at any point in the production or laydown process.

The rounding of all test results will be in accordance with Subsection 700.04.

The Engineer will conduct verification tests on samples taken by the Contractor under the direct supervision of the Engineer at a time specified by the Engineer. The frequency will be equal to or greater than ten percent (10%) of the tests required for Contractor quality control and the data will be provided to the Contractor within two asphalt mixture production days after the sample has been obtained by the Engineer. At least one sample shall be tested from the first two days of production. All testing and data analysis shall be performed by a Certified Asphalt Technician-I (CAT-I) or by an assistant under the direct supervision of the CAT-I. Certification shall be in accordance with the *MDOT HMA Technician Certification Program* chapter in the Materials Division Inspection, Testing, and Certification Manual. The Department shall post a chart giving the names and telephone numbers for the personnel responsible for the assurance program.

The Engineer shall be allowed to inspect Contractor testing equipment and equipment calibration records to confirm both calibration and condition. The Contractor shall calibrate and correlate all testing equipment in accordance with the latest versions of the Department's Test Methods and AASHTO R 18.

Random differences between the Engineer's verification tests and the current running average of four quality control tests at the time of obtaining the verification sample will be considered acceptable if within the following limits.

Item	Allowable Differences
Sieve - % Passing	
3/8-inch and above	6.0
No. 4	5.0
No. 8	4.0
No. 200	2.0
AC Content	0.4
Specimen Bulk SG, Gmb @ N_{Design}	0.030
Maximum SG, Gmm	0.020

If four quality control tests have not been tested prior to the time of the first verification test, the verification test results will be compared to the average of the preceding quality control tests. If the verification test is the first material tested on the project or if a significant process adjustment was made just prior to the verification test, the verification test results will be compared to the average of four subsequent quality control test results. For all other cases after a significant process adjustment, the verification test results will

be compared to the average of the preceding quality control tests, taken after the adjustment, as in the case of a new project start-up when four quality control tests are not available.

In the event that, 1) the comparison of the Contractor's running average quality control data and Engineer's quality assurance verification test results are outside the allowable differences in the above table, or 2) if a bias exists between the results, such that one of the results is predominately higher or lower than the other, and the Engineer's results fail to meet the JMF control limits, the Engineer will investigate the reason immediately. As soon as the need for an investigation becomes known, the Engineer will increase the quality assurance sampling rate to the same frequency required for Contractor testing. The additional samples obtained by the Engineer may be used as part of the investigation process or for routine quality assurance verification tests. The Engineer's investigation may include testing of the remaining quality control split samples, review and observation of the Contractor's testing procedures and equipment, and a comparison of split sample test results by the Contractor quality control laboratory, Department quality assurance laboratory and the Materials Division laboratory. The procedures outlined in the latest edition of the Department's Field Manual for HMA may be used as a guide for the investigation. In the event that the Contractor's results are determined to be incorrect, the Engineer's results will be used for the quality control data and the appropriate payment for the mixture will be based on the procedures specified in Subsection 402.02.5.8(j).

The Engineer will periodically witness the sampling and testing being performed by the Contractor. The Engineer, both verbally and in writing, will promptly notify the Contractor of any observed deficiencies. When differences exist between the Contractor and the Engineer that cannot be resolved, a decision will be made by the State Materials Engineer, acting as the referee. The Contractor will be promptly notified in writing of the decision. If the deficiencies are not corrected, the Engineer will stop production until corrective action is taken.

402.02.6.3--Acceptance Procedure for Mixture Quality. All obviously defective material or mixture will be subject to rejection by the Engineer. Such defective material or mixture shall not be incorporated into the finished work. If the defective material has already been placed in the work, the material shall be removed and replaced at no additional cost to the State.

The Engineer will base final acceptance of the asphalt mixture production on the results of the Contractor's testing for total voids, gradation, and asphalt content as verified by the Engineer in the manner described and the uniformity and condition of the completed pavement. Areas of pavement that exhibit nonuniformity or failures (materials or construction related) such as but not limited to segregation, bleeding, shoving, rutting over 1/8", raveling, slippage, or cracking will not be accepted. Such areas will be removed and replaced at no additional cost to the State.

Bituminous mixture placed prior to correction for deficiencies in total voids @ N_{Design} , gradation, or asphalt content, as required in Subsection 402.02.5.8 and determined by the Engineer satisfactory to remain in place will be paid for in accordance with the following pay factors times the contract unit price per ton.

Pay Factor for Mixture Quality *

Item	Produced in Warning Bands	Produced Outside JMF Limits (Allowed to Remain in Place)
Gradation	0.90	0.50
Asphalt Content	0.85	0.50
Total Voids @ N _{Design}	0.70	0.50

* The minimum single payment will apply.

402.02.7--Acceptance Procedure for OGFC Pavement Smoothness. The OGFC will not be considered a surface lift in the completed pavement structure. There shall be no smoothness requirement for OGFC pavements. However, all transverse joints in or abutting the OGFC shall meet a tolerance of 1/8" or less when checked using a 10-foot straight edge.

402.03--Construction Requirements. The Department has adopted the "Hot-Mix Asphalt Paving Handbook" as the guideline for acceptable asphalt construction practices.

402.03.1--Specific Requirements.

402.03.1.1--Weather Limitations. The mixture shall not be placed when weather conditions prevent the proper handling and finishing or the surface on which it is to be placed is wet or frozen. At the time of placement, the air and pavement surface temperature limitations shall be equal to or exceed 55°F and rising. OGFC placement should be avoided when the paving window, based on temperature, is limited

When paving operations are discontinued because of rain, the mixture in transit shall be protected until the rain ceases. The surface on which the mixture is to be placed shall be swept to remove as much moisture as possible and the mixture may then be placed subject to removal and replacement at no additional cost to the State if contract requirements are not met.

402.03.1.2--Tack Coat. Tack coat for OGFC shall be one from the Department's APL under the category "Open Graded Friction Course (OGFC) Asphalt Tack Materials." PG 76-22 binder shall meet the requirements of Section 702 of the Standard Specifications.

Tack Coat for OGFC shall be applied with a distributor spray bar at the applied rate of between 0.10 and 0.14 gallons per square yard. The application rate of the tack coat shall result in complete and uniform coverage of the underlying lift in which the OGFC will be placed.

The tack coat for OGFC should be allowed to break, cool and/or cure until a point in time that the tack coat does not pick-up or track due to traffic from trucks or the paving equipment. It should be pointed out that breaking, cooling, and/or curing times of the tack coat may vary based on the environmental conditions at the time of placement.

402.03.2--Bituminous Mixing Plants.**402.03.2.1--Plant Requirements.**

402.03.2.1.1--Cold Aggregate Storage. The cold storage for hydrated lime shall be a separate bulk storage bin with a vane feeder or other approved feeder system that can readily be calibrated. The system shall provide a means for easy sampling of the hydrated lime additive and verifying the quantity of lime dispensed. The feeder system shall require a totalizer.

The hydrated lime additive equipment shall be interlocked and synchronized with the cold feed controls to operate concurrently with the cold feed operation that will automatically adjust the hydrated lime feed to variations in the cold aggregate feed. A positive signal system shall be installed that will automatically shut the plant down when malfunctions cause an improper supply of hydrated lime or water.

The plant shall not operate unless the entire hydrated lime system is functioning properly.

402.03.2.1.2--Cold Aggregate Feed. The hydrated lime shall be dispensed dry or as a slurry (1 part hydrated lime to 3 parts water) directly onto the composite aggregate between the cold feed and the dryer.

When hydrated lime is introduced dry, a spray bar or other approved system capable of spraying all aggregate with water shall be installed in order to maintain all aggregate at the moisture condition set out in Subsection 402.02.3.1 prior to addition of the hydrated lime. An alternate system for spraying the coarse aggregate stockpiles may be allowed when approved by the Engineer. The approved equipment and methods shall consistently maintain the aggregate in a uniform, surface wet condition. The moisture content of the aggregate-hydrated lime mixture, following spraying and mixing, shall be introduced into the automatic moisture controls of the plant.

The aggregate-hydrated lime mixture shall be uniformly blended by some mechanical means such as a motorized "on the belt" mixer or pug mill located between the cold feed and the dryer. Other mixing devices may be used subject to approval by the Engineer.

A maximum of forty five (45) percent of the total aggregate blend may be fed through any single cold feed bin. If the JMF calls for more than forty five (45) percent of a specific aggregate, that aggregate must be fed through two (2) or more separate cold feed bins.

402.03.2.1.3--Dryer. The efficiency of drying aggregates shall be such that the moisture content of an OGFC mixture shall not exceed 0.50 percent by weight of the total mixture, and the moisture content of any underlying lifts shall not exceed 0.75 percent by weight of the total mixture being produced.

402.03.2.1.4--Stabilizing Fiber Addition. For batch plants, fibers shall be added (manually or automatic) to either the pugmill or the weigh hopper. At least one aggregate source shall be added prior to the fiber addition, if fibers are added to the weigh hopper. Otherwise, fibers shall be added to the pugmill immediately after the addition of all the aggregate and prior to the addition of the asphalt binder.

402.03.2.1.4.1--Manual Method. Provided it is demonstrated to the satisfaction of the Engineer that the proper dosage rate of the stabilizing fibers is uniformly distributed into the mix, manual introduction of the fibers is acceptable when a batch plant is used to make the mix. When the fibers are available in prepackaged (weighed) containers,

proper dosage may be pre-determined per batch. A device is required to interrupt mixture production and warn the plant operator if the operator manually feeding the fiber fails to introduce it properly.

Manual introduction of fibers shall not be used in drum plants.

402.03.2.1.4.2--Automatic Method. The automatic method requires specialized equipment that can accurately proportion and meter, by weight, the proper amount per batch for batch plants, or continuously and in a steady uniform manner for drum plants. Fiber, pelletized or loose, shall not be fed through the cold feed bins or through the RAP bins.

These proportioning devices shall be interlocked with the plant system and controlled to ± 10 percent of the weight of the fibers required so as to maintain the correct proportions for all production rates and batch sizes. During trial section construction, an equipment calibration check shall be performed to the satisfaction of the Engineer that shows the fiber is being accurately metered and uniformly distributed into the mix. These metering devices shall provide in-process high flow (>10 percent or more) and low flow (<10 percent or less) plant operator notification and interrupt the mix production where the fiber rate is not properly controlled. The fiber metering system shall also provide a record of feed rate (weight per time) and include a minimum two-foot long section of translucent pipe for visual confirmation of consistent flow rates. Care shall be taken to ensure that the fibers are not entrained in the plant's exhaust system. If there is any evidence of fiber in the bag-house or wet-washer fines, the liquid asphalt binder line and/or the fiber line shall be relocated so that the fiber is captured by liquid asphalt binder spray and incorporated into the mix. If there is any evidence of clumps of fibers or pellets at the discharge chute, the contractor shall increase the mixing time and/or intensity. This may entail extending the liquid asphalt binder and fiber feeding lines further into the drum.

Note: Various stabilizing fiber suppliers have developed methodology and equipment for metering bulk loose and pelletized fiber into asphalt plants. Whenever the fiber supplier's recommendations are more stringent than this specification, the fiber supplier's recommendations shall control.

402.03.2.1.5--Control of Bituminous Material and Antistripping Agent. Specified bituminous materials from different manufacturers or from different refineries of a single manufacturer shall not be mixed in the plant's asphalt cement supply system storage tank and used in the work without prior written approval of the Engineer. Approval is contingent upon the Engineer's receipt of three copies of the manufacturer's certified test report(s) from the Contractor showing that the bituminous material blend conforms to the specifications.

A satisfactory method of weighing or metering shall be provided to ensure the specified quantity of bituminous material. Provisions shall be provided for checking the quantity or rate of flow. Weighing or metering devices shall be accurate within plus or minus one-half percent.

The antistripping agent shall be injected into the bituminous material immediately prior to the mixing operation with an approved in-line injector system capable of being calibrated so as to ensure the prescribed dosage.

An in-line spigot for sampling of asphalt shall be located between the asphalt storage tank and the antistripping agent in-line injector.

402.03.2.1.6--Thermometric Equipment. An armored thermometer of adequate range and calibrated in 5°F increments shall be fixed at a suitable location in the bituminous line near the charging valve of the mixer unit.

The plant shall be equipped with an approved dial-scale, mercury-actuated thermometer, pyrometer or other approved thermometric instrument placed at the discharge chute of the dryer to measure the temperature of the material.

When the temperature control is unsatisfactory, the Engineer may require an approved temperature-recording apparatus for better regulation of the temperature.

402.03.2.1.7--Screens. A 1-inch scalping screen shall be used.

402.03.2.1.8--Dust Collector. The plant shall be equipped with a dust collector constructed to waste or return collected material. When collected material is returned, it shall be returned through a controlling device that will provide a uniform flow of material into the aggregate mixture.

402.03.2.1.9--Safety Requirements. A platform or other suitable device shall be provided so the Engineer will have access to the truck bodies for sampling and mixture temperature data.

402.03.2.1.10--Blank.

402.03.2.1.11--Truck Scales. The specifications, tolerances and regulations for commercial weighing and measuring devices as recommended by the National Bureau of Standards [National Institute of Standards and Technology (NIST) Handbook 44] shall govern truck scales used in the State of Mississippi, except weighing devices with a capacity of ten thousand (10,000) pounds or more used to weigh road construction materials (i.e. sand, gravel, asphalt, fill dirt, topsoil and concrete) shall have a tolerance of one-half of one percent (1/2 of 1%) in lieu of the requirements of Handbook 44 and shall be regulated by the Department.

Scales shall be checked and certified by a scale company certified in heavy truck weights by the MDAC. In the case of scales used for measurement of materials on Department of Transportation projects, certification shall be performed in the presence of an authorized representative of the Department or a copy of the certification may be furnished for scales that have been checked and certified within the last six months for use on other Department projects and are still in the position where previously tested. Scales that have not been checked and certified under NIST Handbook 44 guidelines, except for the herein modified tolerances allowed, shall be so checked and certified prior to use for measurement of materials on Department of Transportation projects. Tests shall be continued on six month intervals with the test conducted in the presence of an authorized representative of the Department.

Truck scales shall be accurate to one-half of one percent of the applied load, shall be sensitive to 20 pounds, and shall have a graduation of not more than 20 pounds.

The Contractor may use an electronic weighing system approved by the Engineer in lieu of truck scales. The system shall be equipped with an automatic print out system that will print a ticket for each load with the following information:

MDOT, Contractor's name, project number, county, ticket number, load number, pay item number, item description of the material delivered, date, time of day, haul vehicle number, gross weight, tare weight, net weight and total daily net weight.

When approved by the Engineer and materials are measured directly from a storage bin equipped with load cells, exceptions may be made to the gross and tare weight requirements.

The ticket shall also have a place for recording the temperature of OGFC mixtures, if applicable, and the signatures of the Department's plant and roadway inspectors. The load numbers for each project shall begin with load number one (1) for the first load of the day and shall be numbered consecutively without a break until the last load of the day. The Contractor shall provide the Department with an original and one copy of each ticket. When the ticket information provided by the Contractor proves to be unsatisfactory, the Department will use imprinter(s) and imprinter tickets to record load information. All recorded weights shall be in pounds and shall be accurate to within one-half of one percent of the true weight, and the system shall be sensitive to 20 pounds. The Engineer may require random loads to be checked on certified platform scales at no cost to the Department. If the electronic scales are found to be inaccurate, a re-certification of the scales shall be performed before the Contractor can continue use of the scales.

When an electronic weighing system utilizes the plant scales of a batch plant, the system may be used only in conjunction with a fully automatic batching and control system.

402.03.2.2--Additional Requirements for Batching Plants.

402.03.2.2.1--Plant Scales. The plant batch scale weight shall not exceed the platform scale weight by more than one percent (1%).

402.03.2.3--Additional Requirements for Drum Mixing Plants.

402.03.2.3.1--Plant Controls. The plant shall be operated with all the automatic controls as designed and provided by the plant manufacturer. If the automatic controls malfunction, brief periods of manual operations to complete the day's work or to protect the work already placed may be conducted with the approval of the Engineer. During manual operation, the Contractor must continue to produce a uniform mixture meeting all contract requirements.

402.03.2.3.2--Aggregate Handling and Proportioning. A screening unit shall be placed between the bins and the mixer to remove oversized aggregate, roots, clayballs, etc.

402.03.2.4--Surge or Storage Bins. Normally the surge bins will be emptied at the end of each day's operation. During breakdowns or adverse weather conditions, the material

may be stored for a period not to exceed three hours in a well-sealed, well-insulated, heated bin.

402.03.3--Hauling Equipment. The inside surfaces of each vehicle bed shall be coated with a light application of water and thin oil, soap solution, lime water solution or other approved material to prevent the mixture from sticking. Diesel fuel or gasoline shall not be used to lubricate vehicle beds. Truck beds shall be raised to drain excessive lubricants before placing mixture in the bed. An excess of lubricant will not be permitted.

402.03.4--Asphalt Mixture Pavers. The screed shall be capable of vibrating and heating the full width of the mixture being placed and shall lay the lift with an automatic control device to the specified slope and grade without tearing, pulling or gouging the mixture surface. Rigid screed and auger extensions should be used when the width of the screed is not adequate to pave a full lane width or full paved width (lane width plus shoulder width). Typically, the end of the auger extension should extend to approximately 18 inches or less from the end plate to ensure uniform mixture placement. Strike-off extensions should not be used for OGFC placement

402.03.5--Rollers. All rollers shall be self-propelled units capable of maintaining a smooth and uniform forward and reverse speed as required for proper compaction. Pneumatic-tired rollers shall not be permitted for compacting OGFC mixes. Rollers shall be equipped with adjustable scrapers, water tanks, mats and a device for wetting the wheels to prevent the mixture from sticking. Adhesion of the mixture to the rollers will not be permitted. The use of diesel fuel or gasoline for cleaning roller wheels, or to aid in preventing the mixture from sticking to the wheels, is prohibited.

All rollers shall be in good mechanical condition, free from leaking fuels and lubricants, loose link motion, faulty steering mechanism, worn king bolts and bearings. They shall be operational at slow speeds to avoid displacement of the mixture and capable of reversing direction smoothly and without backlash.

402.03.6--Preparation of Grade. The foundation upon which OGFC pavement is to be placed shall be prepared in accordance with the applicable Section of the Standard Specifications.

Unless otherwise directed, tack coat shall be applied to the underlying surface on which the mixture is to be placed. Emulsions, if used, must be allowed to "break" prior to placement of the bituminous mixture.

Bituminous mixture shall not be placed against the edge of pavements, curbs, gutters, manholes and other structures until the edges located adjacent to the asphalt layer to be placed are sprayed with a thin uniform tack coating. The tack coat shall be protected until the mixture has been placed.

Existing pavements that require preliminary leveling or patching in advance of placing the OGFC mixture shall be sprayed with a tack coat material and then brought as nearly as practicable to uniform grade and cross section. The material shall be placed by hand or machine in one or more compacted layers approximately two (2) inches or less in compacted thickness.

402.03.7--Blank.

402.03.8--Preparation of Mixture. The temperature of the mixture, when discharged from the mixer, shall not exceed 340°F.

402.03.9--Material Transfer Equipment. Except for the areas mentioned below, the material transferred from the hauling unit shall be remixed prior to being placed in the paver hopper or insert by using an approved Materials Transfer Device. Information on approved devices can be obtained from the State Construction Engineer. Areas excluded from this requirement include: temporary work of short duration, detours, bridge replacement projects having less than 1,000 feet of pavement on each side of the structure, acceleration and deceleration lanes less than 1,000 feet in length, tapered sections, transition sections (for width), shoulders less than 10 feet in width, crossovers, ramps, side street returns and other areas designated by the Engineer.

402.03.10--Spreading and Finishing. The mixture shall be spread to the depth and width that will provide the specified compacted thickness, line, grade and cross section. Placing of the mixture shall be as continuous as possible. On areas where mechanical spreading and finishing is impracticable, the mixture may be spread, raked and luted by hand tools.

Immediately after screeding and prior to compaction, the surface shall be checked by the Contractor and irregularities adjusted. When the edge is feathered as in a wedge lift, it may be sealed by rolling. Irregularities in alignment and grade along the edges shall be corrected before the edges are rolled.

Hauling, spreading and finishing equipment shall be furnished that is capable of and operated in such a manner that the rolling operation will satisfactorily correct any surface blemishes.

The longitudinal joint in the subsequent lift shall offset that in the underlying lift by approximately six (6) inches. However, the joint in the top lift shall be at the centerline or lane line.

402.03.11--Roadway Compaction. Compaction shall be achieved by two to three passes of a 10 to 12-ton steel wheel roller operating in static mode. Finish rolling to remove any roller marks shall be performed after the mat temperature decreases to 250°F.

402.03.12--Joints. Joints between previously placed pavement and pavement being placed shall be so formed as to ensure thorough and continuous bond.

The contact surface of longitudinal joints, except hot joints, shall be sprayed with a thin uniform tack coating before additional mixture is placed against the previously placed material.

402.04--Method of Measurement. Open Graded Friction Course will be measured by the ton. The weight of the composite mixture shall be determined in accordance with the provisions of Subsection 402.03.2.1.11.

Bituminous Tack Coat for Open Graded Friction Course shall be measured by the gallon as in accordance with the provisions of Subsections 109.01 and 410.04.

402.05--Basis of Payment. Subject to the adjustments set forth in Subsection 402.02.6.3, Open Graded Friction Course, measured as prescribed above, will be paid for at the contract unit price per ton and shall be full compensation for completing the work.

Bituminous Tack Coat, measured as prescribed above, will be paid for at the contract unit price per gallon, which price shall be full compensation for completing the work.

Payment will be made under the following items:

402-A: Open Graded Friction Course, $\frac{\text{ * }}{\text{ Mixture}}$ - per ton

402-B: Bituminous Tack Coat - per gallon

* 9.5-mm mixture or 12.5-mm mixture

SECTION 403 - ASPHALT PAVEMENTS

403.01--Description. This work consists of constructing one or more lifts of asphalt pavement meeting the requirements of Section 401 on a prepared surface in accordance with the requirements of this section and in reasonably close conformity with the lines, grades, thicknesses, and typical cross sections shown on the plans or established by the Engineer. This work shall also include applicable in-grade preparation of the underlying course in accordance with Section 321.

The Contractor must select one of the asphalt mixture processes (HMA or WMA) to be used on this project.

403.02--Material Requirements. Materials and their use shall conform to the applicable requirements of Subsection 401.02.

403.03--Construction Requirements.

403.03.1--General. Construction requirements shall be as specified in Subsection 401.03, except as otherwise indicated in this section or applicable special provisions.

403.03.2--Smoothness Tolerances. Except as noted herein, the finished smoothness of each lift shall conform to the designated grade and cross section within the following tolerances from grade stakes or other grade reference points set at 25-foot intervals:

	Lower* & Leveling Lifts	Lower* Intermediate Lift	Top Intermediate Lift	Surface Lift
Maximum deviation from grade and cross section at any point	1/2"	3/8"	1/4"	1/4"
Maximum deviation from A 10 foot straight edge	3/8"	1/4"	1/8"	1/8"

Note: Where more than four (4) lifts of asphalt are required, all lifts, excluding the top three (3) lifts, shall meet the requirements of the lower lift.

- * When tested longitudinally from a stringline located equidistant above points 50 feet apart, the distance from the stringline to the surface at any two points located 12½ feet apart shall not vary one from the other more than the maximum deviation allowed above from a 10-foot straight edge.

Grade stakes or other grade reference points set at 25-foot intervals and maximum deviation from grade and cross section will not be required provided an approved profile averaging device is furnished and properly used for the four conditions set forth herein; however, all other surface requirements are applicable.

- (a) Overlays with one overall lift.
- (b) Overlays with two or more overall lifts -- for each lift above the first overall lift provided each underlying overall lift is within the allowable tolerances.
- (c) Surface lift of new construction provided the underlying lift is within the allowable tolerances.
- (d) Full-depth asphalt construction for lifts above the lower lift provided the lower lift is within the specified tolerances for the lower intermediate lift.

In the placement of full depth asphalt pavement, where the chemically treated base is constructed, graded and/or trimmed, full lane width, to a surface tolerance of $\pm 3/8$ inches from design grade, stringline grade controls may be eliminated for the placement of the asphalt drainage course and all asphalt lifts. In addition, where the base course is crushed stone or crushed concrete and is constructed to a surface tolerance of $\pm 3/8$ inches from design grade using a stringline controlled spreader, stringline grade controls may be eliminated for the placement of the asphalt drainage course and all asphalt lifts.

All other tolerances as specified in Section 321 are applicable, except for bases, when tested longitudinally, the maximum deviation when measured at the 12½-foot midpoint shall be $\pm 3/8$ inches.

Acceptance and payment of asphalt will be determined on a lot to lot basis by cores taken from the completed pavement as outlined in Subsection 403.03.3.

Approved contacting type profile averaging devices are those devices capable of working in conjunction with a taut string or wire set to grade, or ski-type device with extreme contact points with the surface at least 30 feet apart. Approved non-contacting type profile averaging devices are laser type ski devices with at least four referencing mobile stations at a minimum length of 24 feet, or an approved equal.

When approved by the Engineer, a short ski or shoe may be substituted for a long ski on the second paving operation working in tandem.

During the finishing and compacting of pavement lifts, it shall be the responsibility of the Contractor to check the surface and joints for progress toward conformance to surface requirements set forth herein. Variations from surface requirements exceeding the allowable tolerances shall be corrected at the Contractor's expense.

When a portland cement concrete pavement is to be placed on an asphalt lift, the finished top of the asphalt lift shall meet the requirements of Sections 321 and 501.

Sections(s) or portions thereof representing areas excluded from a smoothness test with the High Speed Inertial Profiling System (IPS) shall also be excluded from consideration for a contract price adjustment for rideability.

Any contract price adjustment for rideability will be applied on a continuous basis to the pay tonnage, determined in accordance with Subsections 401.02.6.8 and 403.04, for the section(s) or portions thereof for which an adjustment is warranted.

Contract price adjustments for rideability shall only be applicable to the surface lift and furthermore to only the long continuous section(s) or portions of the long continuous section(s) of the surface lift that require smoothness be determined by using a profiling device.

403.03.2.1--Smoothness Tolerances for Mean Roughness Index (MRI). Smoothness tolerances shall be applied to asphalt pavements based on the following pavement categories.

Category A applies to the following pavement constructions:

- New construction
- Construction with three (3) or more lifts
- Mill and two (2) or more lifts

Category B applies to the following pavement constructions:

- Mill and one (1) lift
- Two (2) lift overlays without milling

Category C applies to the following pavement constructions:

- Single lift overlay without milling
- All 57,650-pound routes regardless of the pavement construction

Additional projects may qualify for Category C construction at the Department's discretion. Spot leveling / preliminary leveling does not count as a lift. Full width / continuous leveling courses that have a minimum thickness of ¾" across the entire lane width will be considered a lift.

Category A projects shall have a long continuous interval (528-foot) surface MRI of not more than 60 inches per mile.

Category B projects shall have a long continuous interval (528-foot) surface MRI of not more than 70 inches per mile.

Category C projects shall have the existing surface profiled at no additional cost to the State. These projects shall be measured by a long fixed interval (528-foot) surface MRI and meet the higher value of the following requirements:

A 50% improvement in MRI from the existing surface
 or
 80 inches per mile

In the case that 50% of the existing surface MRI is greater than 80 inches per mile, the short continuous threshold shall be increased from 160 inches per mile by the difference between 50% of the existing surface MRI and 80 inches per mile.

For all projects, areas of the surface lift with localized roughness greater than 160 inches per mile as determined by the continuous short interval (25') report will be identified for correction by the Project Engineer.

When a project has multiple lifts, the lift underlying the surface lift shall have a MRI of no more than 10 inches/mile more than the surface lift threshold for both long and short continuous intervals. Category B projects containing multiple lifts must meet the Category C percent improvement requirement for the underlying lift. Corrective action must be taken on those segments that do not meet this requirement. No unit price adjustment will be applied on any underlying lift.

For Category A and B projects, a unit price increase will be added when the MRI for the final surface lift, prior to any required localized roughness (short interval) corrective action, is less than or equal to fifty inches per mile (50.0 inches / mile) on the long interval report. These Projects will be considered for incentive pay based on the following guidelines for the long interval surface lift MRI.

Mean Roughness Index inches / mile	Contract Price Adjustment Percent of Asphalt Unit Bid Price
Less than 35.0	108
35.1 to 40.0	106
40.1 to 45.0	104
45.1 to 50.0	102
50.1 to Required Surface MRI	100

In addition to the above pay incentive factors, a project may be subject to a disincentive when the Long Continuous Interval MRI for the surface exceeds the allowable tolerance.

Mean Roughness Index (inches / mile)	Contract Price Adjustment Percent of Asphalt Unit Bid Price
Above 20.0 Over	REMOVE AND REPLACE
15.1 to 20.0 Over	80
10.1 to 15.0 Over	85
5.1 to 10.0 Over	90
0.1 to 5.0 Over	95
Required Surface MRI	100

For Category C projects, segments may be subject to a disincentive when the Fixed Interval MRI for the surface does not meet the minimum requirements.

Percent Improvement MRI (inches/mile)	Contract Price Adjustment Percent of Asphalt Unit Bid Price
Below 30 Percent	80 *
30.1 to 35.0 Percent	80
35.1 to 40.0 Percent	85
40.1 to 45.0 Percent	90
45.1 to 50.0 Percent	95
Above 50%	100

- * Segments that not only show less than 30 percent improvement but also a final surface MRI greater than 100 inches/mile will be subject to removal.

Segment(s) or portions thereof representing areas excluded from a smoothness test shall also be excluded from consideration for a contract price adjustment for rideability. Where a segment less than 528 feet occurs at the end of a section, it will be combined with the preceding 528-foot segment for calculation of MRI. Corrective action must be taken on those sections that exceed the 'Remove and Replace' threshold as directed by the Project Engineer. The minimum remove and replace length will be 528 feet (0.1 mile). Additional smoothness testing shall be required on sections following replacement and will be required to meet *at least* the maximum surface MRI short of 'Remove and Replace' tolerance.

The above pay factors will be applied in conjunction with the Long Continuous Histogram Chart from ProVAL's Smoothness Assurance Module. The price adjustments for rideability will be tabulated in the Department's Pay Incentive spreadsheet on the basis of a theoretical tonnage of 110 lbs/yd² * inch thickness (pounds per square yard * inch thickness) determined in accordance with Subsections 401.02.6.8 and 403.04, for the segment(s) or portions thereof for which an adjustment is warranted.

403.03.3--Thickness Requirements. Asphalt overlay lifts shall be constructed as nearly in accordance with the thickness shown on the plans as the underlying pavement and foundation will permit. Periodic and cumulative yield tests will be made to determine practicable conformity to the thickness of each lift. The Engineer may order modifications in placement thicknesses to prevent unwarranted variations in plan quantities.

When the paver is operating off an established grade line, no thickness determination will be required for the various lifts of pavement. It is understood that the tolerances from design grade will control the thickness requirements.

When grade stakes are eliminated by Notice to Bidders or as outlined in Subsection 403.03.2(d) and where resulting in the placement of two (2) or more lifts, acceptance and payment will be determined on a lot to lot basis by cores taken from the completed pavement. Lots will be coincidental with acceptance lots for the surface lift as provided in Subsection 401.02.6.4, except that only lots resulting from the placement of mainline surface lift will be used for thickness assessment. One core will be obtained at random from each lot. Irregular areas will not be cored.

When the average thickness of all the cores from the lots representing a day's production, excluding any discarded by the Engineer for justifiable reason, is within three-eighths of an inch (3/8") of the total pavement thickness shown on the plans, excluding lift(s) placed using an established grade line, corrective action will not be required and a price adjustment will not be made for non-conformity to specified thickness.

When the average thickness of all the cores from the lots representing a day's production is deficient in thickness by more than three eighths of an inch (3/8") of the total pavement thickness shown on the plans, excluding lift(s) placed using an established grade line, the deficiency shall be corrected by overlaying the entire length of the day's production. The thickness of the overlay shall be equal to the thickness deficiency but no less than the minimum single lift laying thickness for the specified mixture.

When the thickness of all the cores from the lots representing a day's production is more than three eighths of an inch (3/8") thicker than the total thickness shown on the plans, excluding lift(s) placed using an established grade line, a price adjustment will be made in accordance with Subsection 403.05.1.

The cores shall be cut and removed by the Contractor in the presence of the Engineer's representative and turned over to the Engineer's representative for further handling. The Contractor shall fill each core hole with surface lift mixture and compact to the satisfaction of the Engineer within 24 hours after coring.

403.03.4--Lift Corrections. Pavement exceeding the allowable surface tolerances shall be corrected at the Contractor's expense by the following methods:

Lower, Leveling and Lower Intermediate Lifts:

- (a) Removal or addition of mixture by skin patching, feather edging, wedge lift construction or full depth patching where appropriate and can be completed in a satisfactory manner.
- (b) Superimposing an additional layer that shall be an approved grade raise for the full roadway width and length of the area to be corrected.

Top Intermediate Lift:

- (a) Removal and the addition of sufficient mixture to provide the specified thickness. Corrections by this method shall be square or rectangular in shape and shall completely cover the area to be corrected.
- (b) Superimposing an additional layer of minimum lift thickness for mixture being used that shall be an approved grade raise for full roadway width of the area to be corrected. Transverse joints shall be perpendicular to the centerline of the pavement.

Surface Lift:

- (a) Removal and the addition of sufficient mixture to provide new material of at least minimum single lift laying thickness for full lane width of the area to be corrected. Transverse joints shall be perpendicular to the centerline of the lane.
- (b) Superimposing an additional layer (minimum lift thickness for mixture being used) that shall be an approved grade raise for full roadway width of the area to

be corrected. Transverse joints shall be perpendicular to the centerline of the pavement.

All mixtures used in the correction of unacceptable pavement shall be approved by the Engineer prior to use.

403.03.5--Overlays or Widening and Overlays. In addition to the requirements of Subsections 403.03.1 through 403.03.4, the following requirements will be applicable when an existing pavement is to be overlaid or widened and overlaid.

403.03.5.1--Blank.

403.03.5.2--Sequence of Operations. In order to expedite the safe movement of traffic and to protect each phase of the work as it is performed, a firm sequence of operations is essential. Unless otherwise provided in the traffic control plan and/or the contract, the following appropriate items of work shall be begun and continually prosecuted in the order listed:

- (a) In sections designated by the Engineer, trim the shoulders along the pavement edges to provide drainage from the pavement.
- (b) Perform pre-rolling to locate areas of pavement with excessive movement per Section 511.
- (c) Perform selective undercutting and patching as directed per Subsection 403.03.5.4.
- (d) Perform pressure grouting as specified in Section 512.
- (e) Clean and seal joints per Section 413.
- (f) Complete preparation on one side of roadway to be widened and place widening materials.
- (g) Reconstruct shoulders to elevation necessary to assure traffic safety.
- (h) Open the widened section to traffic.
- (i) Complete above work for other side of roadway.
- (j) Perform preliminary leveling as directed.
- (k) Apply interlayer as specified.
- (l) Place the first overall leveling lift.
- (m) After the first overall leveling lift, reconstruct shoulders as necessary to eliminate vertical differentials which may be hazardous to traffic.
- (n) Place first intermediate lift.
- (o) Construct shoulders to the contiguous elevation of the first intermediate lift.
- (p) Place remaining intermediate lift, if required.
- (q) Place surface lift.
- (r) Complete construction of shoulders.
- (s) Apply permanent traffic marking.
- (t) Final cleanup.

The above operations shall be performed in such a manner that traffic will be maintained on a paved surface at all times. Two-lane, two-way highways should not be restricted to a single lane in excess of a 3,000-foot section.

403.03.5.3--Widening of Pavement. The foundation for widening shall be formed by trenching or excavating to the required depth and constructing a smooth, firm and compacted foundation. It shall have sufficient density and stability to withstand the

placement and compaction of subsequent lifts. Soft, yielding and other unsuitable material that the Engineer determines will not compact readily shall be removed and backfilled with granular material or asphalt as directed.

Except as provided herein, excavation for widening, undercutting or other required excavation shall be spread along the edge of the shoulders, foreslopes or other adjacent areas as directed and will be an absorbed item. When the quantity is in excess of what may be used satisfactorily on adjacent areas, the Engineer may direct that the material be loaded, hauled and spread uniformly on other designated areas. In this case, compensation for handling surplus material will be in accordance with the appropriate pay items as provided in the contract or as extra work.

If the plans require widening of the shoulders or embankment with Contractor furnished material, all suitable material obtained from widening excavation may be used and will be measured and paid for as Contractor furnished materials. No measurement for payment of haul will be made.

Removal and disposal of old stakes, forms and other debris encountered in excavating shall be in accordance with Section 201 and shall be considered as incidental to and included in the unit prices bid for other items. No separate measurement will be made therefor. Pavement edges and surfaces shall be cleaned prior to final shaping and compaction of adjacent trenching or undercut areas.

Granular material for widening shall be placed on a previously prepared, smooth, firm and unyielding foundation in accordance with the typical section. Density of the granular material shall be as specified.

Asphalt for widening, including trench widening, shall meet the applicable requirements of Section 401, Section 403, and shall be placed in one or more layers as shown on the plans or directed. The surface of the mixture shall be finished as a continuation of the adjacent pavement slope.

Trench rollers or other compaction equipment shall be used to compact the foundation, granular material and bituminous mixtures for widening when standard width rolling equipment cannot be used.

403.03.5.4--Patching. Existing pavement that has failed or unsatisfactorily stabilized shall be removed as directed. Removal of pavement will be measured and paid for under the appropriate pay items as provided in the contract.

Backfill shall consist of asphalt or a combination of compacted layers of aggregate material and asphalt. Unless otherwise specified, the Engineer will make this determination based on depth and field conditions.

Asphalt used for backfilling will be measured and paid for at the contract unit price for the mixture designated on the plans as the lowest lift. Aggregate will be measured and paid for under the appropriate pay item as provided in the contract or as extra work.

403.03.5.5--Preliminary Leveling. All localized irregularities of the existing pavement, such as ruts, cross-slope deficiencies, etc., shall be corrected by spot leveling, skin patching, feather edging or a wedge lift in advance of placing the first overall lift.

403.03.5.6--Placement of Lifts. The leveling lift shall be placed in a layer, or layers, not exceeding approximately two and one-half inches compacted thickness.

When single lane construction is required, placement of a lift on the adjacent lane may be performed by an approved profile averaging device provided the lane previously placed is within the allowable tolerances for all surface requirements. When any of the tolerances are exceeded, the Contractor shall reestablish the control stringline for laying the adjacent lane should the Contractor elect to perform this work prior to correcting the deficiencies of the lane previously placed. In no case shall a "matching shoe" be used to control the grade of an adjacent lane.

In instances where there are only minor deviations from the allowable tolerances in the first overall lift, the Engineer may permit the Contractor to place the next higher lift by graded stringline in lieu of making the corrections.

Single lane placement of leveling, intermediate and surface lifts shall be limited to the distance covered in one and one-half days in advance of that placed in the adjacent lane.

403.03.5.7--Protection of Pavement. The pavement shall be protected and properly maintained until it has been compacted and cooled sufficiently for use by traffic.

403.04--Method of Measurement. Asphalt pavement, of the type specified, will be measured by the ton. The weight of the composite mixture shall be determined in accordance with the provisions of Subsection 401.03.2.1.11.

The pay quantities for each individual job mix formula (JMF) will be calculated using the approved JMF maximum specific gravity (Gmm) and the following formulas.

When the composite mixture has a maximum specific gravity of 2.540 or less,

$$T_p = T_w$$

When the composite mixture has a maximum specific gravity greater than 2.540,

$$T_p = T_w \left(\frac{100 - ((G_{mm} * A * B) - C) / (G_{mm} * A * B) * 100}{100} \right)$$

Where:

- T_p = Total tonnage for payment
- T_w = Total tonnage weighed, used and accepted
- G_{mm} = Maximum Specific Gravity of the approved composite asphalt mixture
- A = 46.725 lbs/yd²/in
- B = 0.93 = 93% density
- C = 110.374 lbs/yd²/in = Theoretical density at 2.540 Gmm

Unless shown as a separate pay item, the furnishing and application of the tack coat will not be measured for payment. When payment is provided, tack coat will be measured as set out in Section 407.

Joint sealant will be measured by the linear foot for each joint sealed.

The quantity of bituminous mixture required to correct the work, when made at the expense of the Contractor, will not be measured for payment.

Any trenching required for widening will not be measured for payment, such cost thereof shall be included in other items of work.

Undercut required by the Engineer will be measured for payment under the appropriate excavation item as provided in the contract or as extra work. Pavement removal and any required trenching will not be included in the measurement for undercut.

Class "B" structural concrete base substituted for asphalt under portland cement concrete bridge end pavement, as per Subsection 502.03.1, will be paid for as asphalt calculated as follows:

Square yards of portland cement concrete bridge end pavement * concrete base thickness in inches * 0.055 = tons of asphalt.

403.05--Basis of Payment. Subject to the adjustments set out in Subsections 401.02.6.3, 401.02.6.4, 401.02.6.8 & 403.03.2, asphalt pavement, measured as prescribed above, will be paid for at the contract unit price per ton for each lift of pavement specified in the bid schedule and shall be full compensation for completing the work.

Joint sealant will be paid for at the contract unit price per linear foot for each joint which shall be full compensation for furnishing the joint sealant material, cleaning the joint, applying the sealant, and for all equipment, tools, labor, and incidentals necessary to complete the work.

403.05.1--Price Adjustment for Thickness Requirement. When grade stakes are eliminated as provided in Subsection 403.03.3 and the average thickness of all cores from lots representing a day's production is more than three eighths of an inch (3/8") thicker than the total specified thickness of the pavement, excluding lift(s) placed using an established grade line, a lump sum reduction in payment for the surface lift of lots representing a day's production will be made as follows:

$$\text{Individual Day's L.S. Reduction} = \frac{(\text{Monetary Value of the Day's Surface Lift Production})}{\text{Surface Lift Production}} \times \frac{(D - 3/8)}{ST}$$

Where:

D = The day's average deviation from total pavement thickness shown on the plans, excluding lift(s) placed using an established grade line.

ST = Specified thickness for surface lift.

The total L.S. reduction for the project is the summation of the individual day's reductions in payment.

403.05.2--Pay Items.

Payment will be made under:

403-A:	<u>(1)</u> , <u>(4)</u> , Asphalt Pavement	- per ton
403-B:	<u>(2)</u> , <u>(4)</u> , Asphalt Pavement, Leveling	- per ton
403-C:	<u>(3)</u> , <u>(4)</u> , Asphalt Pavement, Trench Widening	- per ton
403-D:	<u>(2)</u> , HT, Asphalt Pavement, Polymer Modified	- per ton
403-E:	<u>(2)</u> , HT, Asphalt Pavement, Polymer Modified, Leveling	- per ton
403-S:	Joint Sealant	- per linear foot or mile
	(1) 4.75-mm mixture, 9.5-mm mixture, 12.5-mm mixture, 19-mm mixture, or 25-mm mixture	
	(2) 4.75-mm mixture, 9.5-mm mixture, 12.5-mm mixture, or 19-mm mixture	
	(3) 19-mm mixture or 25-mm mixture	
	(4) ST, MT or HT	

SECTION 404 - COLD BITUMINOUS PAVEMENT

404.01--Description. This work consists of constructing one or more courses of cold bituminous pavement in accordance with these specifications and in reasonably close conformity with the lines, grades, thicknesses, and typical cross sections shown on the plans or established by the Engineer. This work shall also include applicable in-grade preparation of the underlying course in accordance with Section 321.

The bituminous pavement shall be composed of aggregates and bituminous material, and, if specified, a top dressing of sand, gravel, stone, or slag screenings.

404.02--Materials.

404.02.1--General. Cold bituminous mixtures shall be either a preapproved commercial cold mix as listed on the Department's APL, or conform to the requirements of the Department's standard cold mixture as set out below.

404.02.2--Preapproved Commercial Cold Bituminous Mixture. Commercial cold bituminous mixture must be an approved product as listed on the Department's APL. Such approval will be based on satisfactory performance of the cold bituminous mixture on a field test section, placed in accordance with the manufacturer's recommendations, after from six months to one year's evaluation by the Department. The mixture shall have a minimum shelf life of six months.

404.02.3--Department Standard Cold Bituminous Mixtures - General. Department standard cold bituminous mixtures shall conform to the requirements of Subsection 703.13 and the requirements as set out below. The mixture shall have a minimum shelf life of six months.

404.02.3.1--Mineral Filler. Mineral filler shall meet the requirements of Subsection

703.16. Mineral filler may be used as necessary to obtain desired properties of the mixture; however, excessive use will not be permitted.

404.02.3.2--Bituminous Materials. Bituminous material shall be cutback asphalt of one of the grades set out in AASHTO M 82 or, in lieu thereof, a combination of petroleum asphalt cement Grade PG 58-28, 64-22 or 67-22 conforming to Section 702 and a liquefier.

404.02.3.3--Hydrated Lime. Hydrated lime meeting the requirements of Subsection 714.03.2 may be used as a facilitator in the mixture and will be required when siliceous aggregates are used.

404.03--Construction Requirements.

404.03.1--General. Construction requirements shall be as prescribed in Subsection 401.03, except as modified in the following subsections.

404.03.2--Weather Limitations. Cold bituminous pavement courses shall be placed only when the air temperature is 40°F or above.

404.03.3--Tack Coat. Unless otherwise directed by the Engineer, tack coat shall be applied at a minimum rate of 0.05 gallon per square yard residual asphalt. The tack coat shall be applied as a complete coating, fog coating, or "spider webbing" as directed.

404.03.4--Preparation of Aggregate. When combined with cut-back asphalt, aggregates shall be dry and at a temperature of at least 60°F and not more than 225°F. If not already surface dry, aggregates shall be dried at a temperature between 150°F to 300°F and then cooled before being mixed with bituminous material.

When combined with emulsified asphalt, the aggregates shall be at a temperature of at least 60°F and not more than 175°F.

404.03.5--Mixing. The prepared aggregates shall be combined in the quantities required to meet the job-mix formula, introduced into the mixer, and mixed dry for a period sufficient to distribute the various sizes uniformly throughout the batch. The bituminous material shall then be introduced and mixed until the aggregates are thoroughly coated and the mass is a uniform color.

The mixing time for each phase of the mixing operations will be set by the Engineer, based on the nature of the aggregates, the job-mix formula, and the size of the batch, but in no case shall the mixing time, after introduction of the bituminous material, be less than two minutes.

404.03.6--Spreading and Finishing. The material shall be spread by a motor grader or mechanical paver.

Where the compacted thickness is to be more than two inches, the mixture shall be spread and compacted in layers of no more than two inches in thickness.

When spreading with a motor grader the mixture shall be dumped along the centerline or along the outside quarter point in sufficient volume to produce the weight per square yard

indicated or directed. It shall then be moved for its full depth and formed into a windrow of uniform section. The windrow shall then be spread, at the prescribed rate per square yard.

While the surface is being compacted and finished, the edges shall be shaped to a neat line.

404.03.7--Compaction. Immediately after the mixture has been spread, it shall be thoroughly and uniformly compacted. Rolling shall extend over a period of three days after the initial rolling and shall consist of a minimum of two coverages each day.

404.03.8--Top Dressing. When a top dressing of aggregate is specified, it shall be applied immediately after the rolling of the surface course. The top dressing shall be applied at the rate specified and rolled as directed.

404.03.9--Surface Tolerances. The distance at any point from a 10 foot straight edge to the surface shall not exceed three- sixteenths inch. Lumps or depressions exceeding this tolerance shall be corrected by removing defective work and replacing with new material as directed.

404.04--Method of Measurement. Cold bituminous pavement of the type specified will be measured by the square yard or ton. When measured by the ton, measurement will be as prescribed in Subsection 403.04.

404.05--Basis of Payment. Cold bituminous pavement will be paid for by the square yard or ton. Payment on a tonnage basis will be as set out in Subsection 403.05, except no reduction in payment will be made for compaction.

Payment will be made under:

404-A: ____” Cold Bituminous Pavement, Type _____ - per square yard or ton

404-B: Aggregate Top Dressing - per ton

SECTION 405 – STONE MATRIX ASPHALT

405.01--Description. These specifications include general requirements that are applicable to Stone Matrix Asphalt (SMA).

This work consists of constructing one or more lifts of SMA pavement on a prepared surface in accordance with the requirements of Sections 401 and 403 for Asphalt Pavements, with the exceptions set forth herein. The SMA shall meet the specific requirements for the mixture to be produced and placed in reasonably close conformity with the lines, grades, thicknesses and typical sections shown on the plans or established by the Engineer.

405.02--Materials.

405.02.1--Component Materials.

405.02.1.1--General. Component materials will be conditionally accepted at the plant subject to later rejection if incorporated in a mixture or in work that fails to meet contract requirements.

405.02.1.2--Aggregates. The source of aggregates shall meet the applicable requirements of Section 703.

405.02.1.2.1--Coarse Aggregate Blend. Mechanically fractured faces by weight of the combined mineral aggregate coarser than the No. 4 sieve shall be 95 percent two or more fractured faces for all SMA mixtures.

The maximum percentage by weight of flat and elongated particles, maximum to minimum dimension greater than 3, shall not exceed 20% for SMA mixtures. This shall be determined in accordance with ASTM D 4791, Section 8.4, on the combined mineral aggregate retained on the 3/8" sieve.

405.02.1.2.2--Fine Aggregate Blend. All SMA mixture fine aggregate blends shall have a minimum fine aggregate angularity index of 44.0 (ASTM C1252, Method A). The minus No. 40 fraction of the combined aggregate shall be non-plastic when tested according to AASHTO T 90. The clay content for the combined aggregate used in underlying layers shall not exceed 1.0 percent, and when used in top layers shall not exceed 0.5 percent by weight of the total mineral aggregate when tested according to AASHTO T 88.

405.02.1.2.3--Combined Aggregate Blend. All gradations will be based on percent passing by volume and not mass. Refer to Mississippi Test Method MT-80 Stone Matrix Asphalt (SMA) Volumetric Mix Design, Section 11 for the procedure to calculate gradations based on volumes. The gradation requirements, by volume, for SMA mixtures are provided in the following table.

Sieve Size	Nominal Maximum Aggregate Size					
	19.0-mm		12.5-mm		9.5-mm	
	Lower Control	Upper Control	Lower Control	Upper Control	Lower Control	Upper Control
1-inch	100	100				
3/4-inch	90	100	100	100		
1/2-inch	50	74	90	100	100	100
3/8-inch	25	60	26	78	90	100
No. 4	20	28	20	28	26	60
No. 8	16	24	16	24	20	28
No. 16	13	21	13	21	13	21
No. 30	12	18	12	18	12	18
No. 50	12	15	12	15	12	15
No. 200	8.0	10.0	8.0	10.0	8.0	10.0

405.02.1.3--Bituminous Materials. Bituminous materials shall meet the applicable requirements of Section 702 for the grade specified. A PG 76-22 asphalt binder shall be used for all SMA mixtures. The asphalt content (by weight of total mix) shall be based on the bulk specific gravity of the combined aggregate blend (G_{sb}) to ensure a constant asphalt binder volume in the mix for durability purposes. The relationship between G_{sb} and the minimum asphalt binder content by weight of total mix is provided in the following table.

Based on Minimum Asphalt Content by Volume of 6.0 Percent		
Combined Aggregate Bulk Specific Gravity, G_{sb}	Minimum Asphalt Content (%)	Rounded Minimum Asphalt Content (%)
2.40	6.58	6.6
2.45	6.46	6.5
2.50	6.34	6.3
2.55	6.22	6.2
2.60	6.11	6.1
2.65	6.00	6.0
2.70	5.90	5.9
2.75	5.79	5.8
2.80	5.70	5.7
2.85	5.60	5.6
2.90	5.51	5.5
2.95	5.42	5.4
3.00	5.34	5.3
Minimum AC, % (mass) = $0.724*(G_{sb})^2 - 5.98*G_{sb} + 16.76$		

Tack coat shall meet the requirements of Subsection 401.03.1.2. Emulsified asphalt shall not be diluted without approval of the Engineer.

405.02.1.4--Mineral Filler. Mineral filler shall meet the requirements of Subsection 703.16.

405.02.1.5--Hydrated Lime. Hydrated lime shall meet the requirements of Subsection 714.03.2 for lime used in soil stabilization.

405.02.1.6--Asphalt Admixtures. Additives for liquid asphalt, when required or permitted, shall meet the requirements of Subsection 702.08.

405.02.1.7--Polymers. Polymers for use in polymer modified asphalt pavements shall meet the requirements of Subsection 702.08.3.

405.02.1.8--Stabilizing Fiber. Stabilizing fiber shall meet the requirements of Subsection 714.07.

405.02.2--Blank.

405.02.3--Composition of Mixtures.

405.02.3.1--General. Unless otherwise specified or permitted, the SMA shall consist of a uniform mixture of asphalt, aggregate, mineral filler, stabilizing fibers, hydrated lime and, when required or necessary to obtain desired properties, antistripping agent and/or other materials.

The total amount of crushed limestone aggregate, in the top lift, shall not exceed 50 percent of the total combined aggregate by weight.

Hydrated lime shall be used in all SMA at the rate of one percent (1%) by weight of the total dry aggregate. The aggregate, prior to the addition of the hydrated lime, shall contain sufficient surface moisture. If necessary, the Contractor shall add moisture to the aggregate according to the procedures set out in Subsection 401.03.2.1.2.

The Contractor shall obtain a shipping ticket for each shipment of hydrated lime. The Contractor shall provide the District Materials Engineer with a copy of each shipping ticket from the supplier, including the date, time and weight of hydrated lime shipped.

Mixtures will require the addition of an antistripping agent when the Tensile Strength Ratio (MT-63) and/or the Boiling Water Test (MT-59) fail to meet the following criteria.

Tensile Strength Ratio (TSR - MT-63)

- Wet Strength / Dry Strength 85 percent minimum
- Interior Face Coating 95 percent minimum

Boiling Water Test (MT-59)

- Particle Coating 95 percent minimum

Reclaimed asphalt pavement (RAP) or crushed reclaimed concrete may be used in the production of SMA in the percentages of the total mix by weight set out in the following table.

SMA Mixture	Maximum Percentage of RAP by total weight of mix
9.5-mm	10 *
12.5-mm	10 *

* At a minimum, RAP shall be crushed, processed and/or screened such that the RAP material size does not exceed the nominal maximum sieve size for the mixture specified.

405.02.3.1.1--Mixture Properties. The mortar is defined as the combination of the percent passing the 0.075 mm sieve, liquid asphalt binder, and the stabilizing fiber. Mix design and approval shall include mortar preparation and testing conducted in accordance with Mississippi Test Method MT-81. The mortar shall have a minimum unaged dynamic shear rheometer (DSR) $G^*/\sin\delta$ of 5.00 kPa, a minimum rolling thin film oven (RTFO) DSR $G^*/\sin\delta$ of 11.00 kPa, and a maximum pressure aging vessel (PAV) bending beam rheometer (BBR) stiffness (S) of 1500 MPa.

All mixes shall be designed according to Mississippi Test Method MT-80. SMA mixes shall be designed with the Superpave gyratory compactor utilizing an N_{design} of 75

gyrations. The design air voids and voids in the mineral aggregate for all SMA mixes are 4.0 and a minimum of 17.0 percent, respectively. The ratio of the voids in the coarse aggregate in the compacted mix (VCA_{mix}) to the voids in the coarse aggregate as determined with the dry rodded unit weight test (VCA_{dr}) shall be less than 1.0.

The designed mixture shall have a draindown of less than 0.3 percent when tested in accordance with Mississippi Test Method MT-82, Draindown Determination for Stone Matrix Asphalt Mixtures.

405.02.3.2--Job Mix Formula. The job mix formula shall be established in accordance with Mississippi Test Method MT-80.

At least 10 working days prior to the proposed use of each mixture, the Contractor shall submit in writing to the Engineer a proposed job-mix formula or request the transfer of a verified job-mix formula as set forth in the latest edition of MDOT's Field Manual for HMA and MT-80. The job-mix formula shall be signed by a Certified Mixture Design Technician (CMDT).

The Department will perform the tests necessary for review of a proposed job-mix formula for each required mixture free of charge one time only. A charge will be made for additional job-mix formulas submitted by the Contractor for review.

Review of the proposed job-mix formula will be based on percent maximum specific gravity at N_{Design} , $VMA @ N_{Design}$, ratio of voids in the Coarse Aggregate (VCA_{mix}/VCA_{dr}), draindown, mortar properties, resistance to stripping, and other criteria specified for the mixture.

The mixture shall conform thereto within the range of tolerances specified for the particular mixture. No change in properties or proportion of any component of the job-mix formula shall be made without permission of the Engineer. The job-mix formula for each mixture shall be in effect until revised in writing by the Engineer.

A job-mix formula may be transferred to other contracts in accordance with conditions set forth in the Department's Field Manual for HMA.

The Contractor shall not place any SMA prior to receiving "tentative" approval and a MDOT design number from the Central Laboratory.

When a change in source of materials, unsatisfactory mixture production results (such as segregation, bleeding, shoving, rutting over 1/8", raveling & cracking) or changed conditions make it necessary, a new job-mix formula will be required. The conditions set out herein for the original job-mix formula are applicable to the new job-mix formula.

405.02.4--Substitution of Mixture. Mixture substitution shall meet the requirements of Subsection 401.02.4.

405.02.5--Contractor's Quality Management Program.

405.02.5.1-General. The Contractor's quality management program shall meet the general requirements of Subsection 401.02.5.1.

405.02.5.2--Personnel Requirements. Personnel requirements shall meet the requirements of Subsection 401.02.5.2.

405.02.5.3--Testing Requirements. As a minimum, the Contractor's quality management program shall include the following:

- (a) Bituminous Material. Provide Engineer with samples in a sealed one quart metal container at the frequency given in MDOT SOP TMD-20-04-00-000.
- (b) Mechanically Fractured Face. Determine mechanically fractured face content of aggregates retained on the No. 4 sieve, at a minimum of one test per day of production.
- (c) Mixture Gradation. Conduct extraction tests for gradation determination on the mixture. Sample according to the frequency in paragraph (i) and test according to Mississippi Test Method MT-31.
- (d) Total Voids and VMA. Determine total voids and voids in mineral aggregate (VMA), at N_{Design} , from the results of bulk specific gravity tests on laboratory compacted specimens. Sample according to the sampling frequency in paragraph (i) and test according to the latest edition of MDOT's Field Manual for HMA.
- (e) Asphalt Content. Sample according to the sampling frequency in paragraph (i), and determine the asphalt content using one of the following procedures.
 - (1) Nuclear gauge. (Mississippi Test Method MT-6)
 - (2) Incinerator oven. (AASHTO T 308, Method A)

Draindown tests shall also be conducted according to Mississippi Test Method MT-82, at a minimum of one test per day of production.

- (f) Stripping Tests. Conduct a minimum of one stripping test at the beginning of each job-mix production and thereafter, at least once per each two weeks of production according to Mississippi Test Method: MT-63 and one stripping test per day of production according to Mississippi Test Method: MT-59. Should either the TSR (MT-63) or the boiling water (MT-59) stripping tests fail, a new antistripping additive or rate shall be established or other changes made immediately that will result in a mixture which conforms to the specifications; otherwise, production shall be suspended until corrections are made.
- (g) Density Tests. Conduct density tests as necessary to control and maintain required compaction according to Mississippi Test Method: MT-16, Method C (nuclear gauge), or AASHTO T 166.
- (h) Quality Control Charts. Plot the individual test data, the average of the last four tests and the control limits for the following items as a minimum:

Mixture Gradation (Percent Passing) Sieves:

1/2-in, 3/8-in, No. 4, No. 8, No. 30, and No. 200.

Asphalt Content, Percent

Maximum Specific Gravity

Total Voids @ N_{Design} , Percent

VMA @ N_{Design} , Percent

Keep charts up-to-date and posted in a readily observable location. Charts may be kept on a computer, however, the charts shall be printed out a minimum of

once each production day and displayed in the laboratory. Note any process changes or adjustments on the Air Voids chart.

- (i) **Sampling Frequency.** Conduct those tests as required above at the following frequency for each mixture produced based on the estimated plant tonnage at the beginning of the day.

<u>Total Estimated Production, tons</u>	<u>Number of Tests</u>
1-700	1
701-1400	2
1401-2100	3
2101+	4

- (j) **Sample Requirements.** Obtain the asphalt mixture samples from trucks at the plant. Obtain aggregate samples from cold feed bins or aggregate stockpile. Save a split portion of all mixture samples at the laboratory site in a dry and protected location for 14 calendar days. At the completion of the project, the remaining samples may be disposed of with the approval of the Engineer.

The above testing frequencies are for the estimated plant production for the day. If production is discontinued or interrupted, the tests will be conducted at the previously established sample tonnage points for the materials that are actually produced. If the production exceeds the estimated tonnage, sampling and testing will continue at the testing increments previously established for the day. A testing increment is defined as the estimated daily tonnage divided by the required number of tests from the table in the above subparagraph (i).

In addition to the above program, aggregate stockpile gradation tests (AASHTO T-11 and T-27) shall be conducted every other production day. Fine aggregate angularity tests (ASTM C 1252, Method A) shall be conducted on the first day of production and once for every eight production samples thereafter, with a minimum of one test per production week.

405.02.5.4--Documentation. Documentation shall be as required in Subsection 401.02.5.4.

405.02.5.5--Control Limits. The following control limits for the job mix formula (JMF) and warning limits are based on a running average of the last four data points.

Item	JMF Limits	Warning Limits
Sieve - % Passing		
1/2-in	± 5.5	± 4.0
3/8-in	± 5.5	± 4.0
No. 4	± 4.0	± 3.0
No. 8	± 4.0	± 3.0
No. 30	± 4.0	± 3.0
No. 200	± 2.0	± 1.5
Asphalt Content, %	-0.3 to +0.5	-0.2 to +0.4
Total Voids @ N _{Design} , %	± 1.3	± 1.0
VMA @ N _{Design} , %	- 1.5	- 1.0

405.02.5.6-- Warning Bands. Warning bands are defined as the area between the JMF limits and the warning limits.

405.02.5.7--Job Mix Formula Adjustments. A request for a JMF adjustment signed by a CAT-II may be made to the Engineer by the Contractor. Sufficient testing data shall be submitted with the request to justify the change. The requested change will be reviewed by the State Materials Engineer for the Department. If current production values meet the mixture design requirements, a revised JMF will be issued. Adjustments to the JMF shall conform to the latest edition of MDOT's Field Manual for HMA. Adjustments to the JMF to conform to actual production shall not exceed the tolerances specified for the JMF limits. Regardless of such tolerances, any adjusted JMF gradation shall be within the range given in Subsection 405.02.1.2.3 for the mixture specified. The JMF asphalt content may only be reduced if the production VMA meets or exceeds the minimum design VMA requirements for the mixture being produced.

405.02.5.8--Actions and Adjustments. Actions and adjustments shall be as required in Subsection 401.02.5.8.

405.02.5.9--Trial Section. At the beginning of placement for each lift, the Contractor shall construct a trial section of a maximum of 400 tons of mix, for the purpose of establishing and evaluating consistent mixture properties and the compactibility of the mixture. The Contractor shall determine the production point at which the mix shall be sampled during trial section construction. This sample does not have to be selected by the formal random selection procedures used during actual production, but should be representative of the mix produced.

Density tests shall be performed according to the procedures in Chapter 7 of MDOT's Field Manual for Hot Mix Asphalt (First Day Production). The Contractor (QC) and the Department (QA) will conduct tests for mixture quality. A trial section is considered to be successful if the QC test results are within the Warning Limits (the testing indicates a pay factor of 1.0) and the QC tests compare to the QA tests within the allowable differences set forth in Subsection 401.02.6.2. If the criteria for a successful trial section is not achieved, additional trial sections of at least 200 tons but not more than 400 tons shall be constructed until the criteria is achieved, at which time full production can begin. In the event a successful trial section is not accomplished by the completion of the second trial section, the Contractor will be required to construct additional trial sections at an offsite location. The Engineer reserves the right to have any trial section removed and replaced at no additional cost to the State, if the pay factor for any characteristic for a trial section is less than 0.75.

For actual payment purposes, a pay factor of 1.00 will be used for all first and second trial sections allowed to remain in place. Any required offsite trial sections will be constructed at no additional cost to the State.

405.02.6--Standards of Acceptance.

405.02.6.1--General. The general requirements shall be as required in Subsection 401.2.6.1.

405.02.6.2--Assurance Program for Mixture Quality. The assurance program for mixture quality shall be as required in Subsection 401.2.6.2.

405.02.6.3--Acceptance Procedure for Mixture Quality. The acceptance procedure for mixture quality shall be as required in Subsection 401.2.6.3.

405.02.6.4--Acceptance Procedure for Density. Each completed lift will be accepted with respect to compaction on a lot to lot basis from density tests performed by the Department. Material produced and placed during the trial section(s), if placed on the roadway, will be designated as separate lots. For normal production days, divide the production into approximately equal lots as shown in the following table. When cores are being used for the compaction evaluation, randomly obtain one core from each lot. When the nuclear density gauge is being used for compaction evaluation, obtain two random readings from each lot and average the results (see Chapter 7 of the latest edition of MDOT's Field Manual for HMA). Additional tests may be required by the Engineer to determine acceptance of work appearing deficient. The Contractor shall furnish and maintain traffic control for all compaction evaluations, including coring, required in satisfying specified density requirements.

Lot Determination

<u>Daily Production - Tons</u>	<u>Number of Lots</u>
0-300	1
301-600	2
601-1000	3
1001-1500	4
1501-2100	5
2101-2800	6
2801+	7

405.02.6.4.1--Roadway Density. The density requirement for each completed lift on a lot to lot basis from density tests performed by the Department shall be 93.0 percent of maximum density. When it is determined that the density for a lot is below 93.0 percent but not lower than 91.0 percent of maximum density, the Contractor will have the right to remove and replace the lot(s) not meeting the specified density requirements in lieu of accepting reduced payment for the lot(s).

When it is determined that the density for a lot is above 96.0 percent, the Engineer shall notify the Contractor who will make plant adjustments to resolve the problem.

When it is determined that the density for a lot is below 91.0 percent, the lot(s), or portions thereof, shall be removed and replaced in accordance with Chapter 7 of the latest edition of MDOT's Field Manual for HMA at no additional cost to the State. A corrected lot will be retested for approval. No resampling will be performed when pavement samples are used for determining density.

At any time the average daily compaction (the total of the percent compaction for the lots produced in one day divided by the total number of lots for the day) does not meet 93.0 percent compaction or more for two consecutive days, the Contractor shall notify the Engineer of proposed changes to the compactive effort. If the average daily compaction does not meet 93.0 percent compaction or more for a third consecutive day, the Contractor shall stop production and construct another trial section to establish proper compaction procedures.

Each lot of work found not to meet the density requirement of 93.0 percent of maximum density may remain in place with a reduction in payment as set out in the following table:

PAYMENT SCHEDULE FOR COMPACTION

<u>Pay Factor</u>	<u>Lot Density ** % of Maximum Density</u>
1.00	93.0 and above
0.90	92.0 - 92.9
0.70	91.0 - 91.9

** Any lot or portion thereof with a density of less than 91.0 percent of maximum density shall be removed and replaced at no additional cost to the State.

The compaction pay factors and mixture quality pay factor will each apply separately (See Subsection 401.02.6.3). However, the combined pay factor shall not be less than 0.50 for any mixture allowed to remain in place.

405.03--Construction Requirements. Mississippi DOT has adopted the “Hot-Mix Asphalt Paving Handbook” as the guideline for acceptable SMA construction practices.

405.03.1--Specific Requirements.

405.03.1.1--Weather Limitations. The mixture shall not be placed when weather conditions prevent the proper handling and finishing or the surface on which it is to be placed is wet or frozen. At the time of placement, the air and pavement surface temperature limitations shall be equal to or exceed 55°F.

405.03.1.2--Tack Coat. Tack coat shall be in accordance with Subsection 401.03.1.2.

405.03.1.3--Blank.

405.03.1.4--Density. The lot density for all SMA pavement lifts, except as provided below for preleveling, wedging [less than fifty percent (50%) of width greater than minimum lift thickness], ramp pads, irregular shoulder areas, median crossovers, turnouts, or other areas where the established rolling pattern cannot be performed, shall not be less than 93.0 percent of the maximum density based on AASHTO T 209 for the day’s production. If a job-mix formula adjustment is made during the day which affects the maximum specific gravity, calculate a new average maximum density for the lot(s) placed after the change.

Pavement core samples obtained for determining density which have a thickness less than two times the maximum size aggregate permitted by the job-mix formula will not be used as a representative sample.

Preleveling, wedging [less than fifty percent (50%) of width greater than minimum lift thickness], ramp pads, irregular shoulder areas, median crossovers, turnouts, and other areas where an established rolling pattern cannot be obtained shall be compacted to refusal densification.

405.03.2--Bituminous Mixing Plants.**405.03.2.1--Plant Requirements.**

405.03.2.1.1--Cold Aggregate Storage. The cold aggregate storage requirements shall be in accordance with Subsection 401.03.2.1.1.

405.03.2.1.2--Cold Aggregate Feed. The cold aggregate feed requirements shall be in accordance with Subsection 401.03.2.1.2.

405.03.2.1.3--Dryer. The dryer requirements shall be in accordance with Subsection 401.03.2.1.3.

405.03.2.1.4--Stabilizing Fiber Addition. For batch plants, fibers shall be added (manually or automatic) to either the pugmill or the weigh hopper. At least one aggregate source shall be added prior to the fiber addition, if fibers are added to the weigh hopper. Otherwise, fibers shall be added to the pugmill immediately after the addition of all the aggregate and prior to the addition of the asphalt binder.

405.03.2.1.4.1--Manual Method. Provided it is demonstrated to the satisfaction of the Engineer that the proper dosage rate of the stabilizing fibers is uniformly distributed into the mix, manual introduction of the fibers is acceptable when a batch plant is used to make the mix. When the fibers are available in prepackaged (weighed) containers, proper dosage may be pre-determined per batch. A device is required to interrupt mixture production and warn the plant operator if the operator manually feeding the fiber fails to introduce it properly.

Manual introduction of fibers shall not be used in drum plants.

405.03.2.1.4.2--Automatic Method. The automatic method requires specialized equipment that can accurately proportion and meter, by weight, the proper amount per batch for batch plants, or continuously and in a steady uniform manner for drum plants. Fiber, pelletized or loose, shall not be fed through the cold feed bins or through the RAP bins.

These proportioning devices shall be interlocked with the plant system and controlled to +/-10 percent of the weight of the fibers required so as to maintain the correct proportions for all production rates and batch sizes. During trial section construction, an equipment calibration check shall be performed to the satisfaction of the Engineer that shows the fiber is being accurately metered and uniformly distributed into the mix. These metering devices shall provide in-process high flow (≥ 10 percent or more) and low flow (<10 percent or less) plant operator notification and interrupt the mix production where the fiber rate is not properly controlled. The fiber metering system shall also provide a record of feed rate (weight or mass per time) and include a section a minimum of two feet long of translucent pipe for visual confirmation of consistent flow rates. Care shall be taken to ensure that the fibers are not entrained in the plant's exhaust system. If there is any evidence of fiber in the bag-house or wet-washer fines, the liquid asphalt binder line and/or the fiber line shall be relocated so that the fiber is captured by liquid asphalt binder spray and incorporated into the mix. If there is any evidence of clumps of fibers or pellets at the discharge chute, the contractor shall increase the mixing time and/or

intensity. This may entail extending the liquid asphalt binder and fiber feeding lines further into the drum.

Note: Various stabilizing fiber suppliers have developed methodology and equipment for metering bulk loose and pelletized fiber into asphalt plants. Whenever the fiber supplier's recommendations are more stringent than this specification, the fiber supplier's recommendations shall control.

405.03.2.2--Additional Requirements for Batching Plants. Additional requirements for batching plants shall be in accordance with Subsection 401.03.2.2.

405.03.2.3--Additional Requirements for Drum Mixing Plants. Additional requirements for drum mixing plants shall be in accordance with Subsection 401.03.2.3.

405.03.2.4--Surge or Storage Bins. Normally the surge bins shall be emptied at the end of each day's operation. During breakdowns or adverse weather conditions, the material may be stored for a period not to exceed three (3) hours in a well-sealed, well insulated, heated bin.

405.03.3--Hauling Equipment. Hauling equipment shall be in accordance with Subsection 401.03.3.

405.03.4--Bituminous Pavers. Bituminous pavers shall be in accordance with Subsection 401.03.4.

405.03.5--Rollers. All rollers shall be self-propelled units capable of maintaining a smooth and uniform forward and reverse speed as required for proper compaction. Pneumatic-tired rollers shall not be permitted for compacting SMA mixes. Rollers shall be equipped with adjustable scrapers, water tanks, mats and a device for wetting the wheels to prevent the mixture from sticking. Adhesion of the mixture to the rollers will not be permitted. The use of diesel fuel or gasoline for cleaning roller wheels, or to aid in preventing the mixture from sticking to the wheels, is prohibited.

405.03.6--Preparation of Grade. Grade preparation shall be in accordance with Subsection 401.03.6.

405.03.7--Blank.

405.03.8--Preparation of Mixture. Mixture preparation shall be in accordance with the requirements of Subsection 401.03.8.

405.03.9--Material Transfer Equipment. Except for the areas mentioned below, the material transferred from the hauling unit shall be remixed prior to being placed in the paver hopper or insert by using an approved Materials Transfer Device. Information on approved devices can be obtained from the State Construction Engineer. Areas excluded from this requirement include: temporary work of short duration, detours, bridge replacement projects having less than 1,000 feet of pavement on each side of the structure, acceleration and deceleration lanes less than 1,000 feet in length, tapered sections, transition sections (for width), shoulders less than 10 feet in width, crossovers, ramps, side street returns and other areas designated by the Engineer.

405.03.10--Spreading and Finishing. Spreading and finishing shall be in accordance with Subsection 401.03.10.

405.03.11--Compaction. After the mixture has been spread and surface irregularities corrected, it shall be thoroughly and uniformly compacted to the required line, grade, cross section and density. It is recommended that compaction of SMA mixtures be completed before the mat temperature drops to 250°F.

405.04--Method of Measurement. Stone matrix asphalt will be measured by the ton in accordance with the requirements of Subsection 403.04 for asphalt pavements.

405.05--Basis of Payment. Stone matrix asphalt, measured as prescribed above, will be paid for by the ton in accordance with the requirements of Subsection 403.05 for asphalt pavements.

405.05.1--Price Adjustment for Thickness Requirement. Adjustments in price for thickness shall be in accordance with Subsection 403.05.1.

405.05.2--Pay Items.

Payment will be made under:

405-A: Stone Matrix Asphalt, $\frac{(1)}{\text{Mixture}}$ - per ton

(1) 9.5-mm mixture, 12.5-mm mixture, or 19-mm mixture

SECTION 406 - COLD MILLING

406.01--Description. This work consists of removal of pavement materials on the roadway and shoulders by cold milling to the designated depth and, loading, hauling, and disposal of the milled materials by the Contractor in accordance with the plans and specifications, or as directed by the Engineer. The milled surface shall provide a desirable surface free from gouges, continuous grooves, ridges, oil film, and other imperfections of workmanship and shall have a uniform appearance.

This work also consists of the removal of portions of existing pavement using a cold fine milling process to a nominal depth using grade control as specified on the plans or as directed by the Engineer. It shall also include the loading, hauling, and disposal of the milled materials by the Contractor in accordance with the plans and specifications. The planed surface shall provide a textured surface suitable for repairs, paving, or as a temporary riding surface, whichever is specified.

406.02--Blank.

406.03--Construction Requirements.

406.03.1--Equipment. The equipment to be used for this work shall be a self-propelled milling machine capable of removing a minimum width of four feet. The equipment shall have sufficient power, traction, and stability to remove material and maintain an

accurate grade and cross slope. The equipment shall accurately and automatically establishing profile grades along each edge of the machine by referencing from the existing pavement with means of an approved profile averaging device with extreme contact points with surface at least 30 feet apart, or from an independent grade line and shall have an automatic system for controlling cross slope. The machine shall be equipped with an integral loading and reclaiming means to immediately remove material being cut from the surface and discharge the cuttings into a truck or windrow, all in one operation.

When fine milling is required, the milling machine shall, in addition to the above, be designed specifically for grinding surfaces to close tolerances and shall be operated at a rate recommended by the manufacturer so as to avoid tearing and gouging of the pavement surface. The fine milling machine shall be equipped with a fine milling drum of the size and shape necessary to produce an ultrafine texture to the milled surface and meet the requirements of this specification. The bit or teeth spacing on the drum shall have a maximum spacing of six millimeters (6 mm). The equipment shall have a positive means for limiting any dust resulting from the operation from escaping into the air.

Adequate back-up equipment, such as mechanical sweepers, loaders, water truck, etc., and personnel shall be provided to ensure that all cuttings are removed immediately behind the milling machine.

406.03.2--Construction Methods. When asphalt will be required on the milled area, milling operations shall not begin until the Contractor has an approved job-mix formula and is prepared to begin paving operations.

The pavement and shoulder materials shall be removed to the depth, width, grade, and cross section shown on the plans, or as directed by the Engineer. The number of passes necessary to accomplish the work required herein and on the plans shall be determined by the Contractor.

The surface of the pavement and shoulders, after milling, shall be reasonably smooth and true to the established line, grade and cross section. Areas damaged by the Contractor's operations shall be corrected and/or repaired as directed by the Engineer at no additional costs to the State. The Contractor shall take necessary action to prevent or minimize the ponding of water on the milled roadway and shoulder.

Where traffic is required to be maintained adjacent to the milled area, no more than a 2¼-inch differential in grade between the milled area and the adjacent surface will be allowed, unless a positive separation in accordance with the plans and specifications is established between the traffic and milled area.

A longitudinal pavement edge that traffic is expected to move across should have an elevation difference of not more than 2¼ inches. Uneven pavement signs, as shown in the plans or contract documents, will be required if the pavement edge is more than 1½ inches and less than or equal to 2¼ inches. If the pavement edge is less than or equal to 1½ inches, no uneven pavement signs will be required. Transverse pavement joints shall be sufficiently tapered to allow for the safe movement of traffic.

When traffic is required to be maintained adjacent to milled shoulders, traffic control devices shall be placed in accordance with the requirements of the detail sheet for

shoulder closures, or as directed by the Engineer.

It is understood that the milled shoulder shall be covered with the next required course as soon as possible but in no case later than 30 calendar days after milling.

406.03.3--Fine Milling. Unless otherwise noted or advised by the Engineer, the fine milling operation shall be conducted using an automatic grade control device, as referenced in Subsection 406.03.1, to establish accurate grade control and cross slope. The milled surface shall be textured, substantially free from waves or irregularities.

Prior to beginning a fine milling operation, the Engineer may require the Contractor to construct a 500-foot test section. The texture and consistency of profile and cross slope of this test section will be evaluated by the Engineer to verify the above straight-edge requirement can be met.

If the tolerance is exceeded in the test section, the Contractor shall cease work and take corrective actions to improve the process. Once corrective actions are taken, the Contractor will construct another test section. This designated section shall be fine milled to conform to the same requirements as those required in the initial test section. The Contractor shall not be allowed to start continuous fine milling until an acceptable test section is obtained.

Fine milling shall produce a uniform finished surface and maintain a constant cross slope between extremities in each lane.

The surface tolerance of the fine milling shall be checked to assure a uniform pavement texture that is true to line, grade, and cross section.

Fine milled pavement surfaces are subject to visual and straightedge inspections by the Engineer at any time during the milling operation. The final fine milled surface shall be a uniform finish on the grade and slope shown to be required on the plans. The finished surface shall also not vary more than ¼" from a 10-foot straightedge placed anywhere on the surface of the milled area.

The cross slope shall be checked to assure uniformity and that no depressions or slope misalignments exist when the slope is tested with a straightedge placed perpendicular to the center line.

Dust, residue, and loose milled material shall be removed from the fine milled surface. Traffic shall not be allowed on the milled surface nor any tack coat applied and asphalt lift placed on the milled surface until removal is complete.

406.04--Method of Measurement. Cold milling of pavement and shoulders, all depths, will be measured by the square yard, cubic yard (LVM), or ton as indicated in the contract.

Fine milling of pavement and shoulders will be measured by the square yard, cubic yard (LVM), or ton as indicated in the contract. Fine milling to repair failed areas in Open Graded Friction Courses will not be measured for payment unless authorized by the Engineer.

Loading, hauling, and disposal will not be measured for separate payment.

406.05--Basis of Payment. Cold milling of pavement and shoulders, all depths, measured as prescribed above, will be paid for at the contract unit price per square yard, cubic yard (LVM) or ton, as indicated, which price shall be full compensation for completing the work.

Fine milling of pavement and shoulders, measured as prescribed above, will be paid for at the contract unit price per square yard, cubic yard (LVM) or ton, as indicated, which price shall be full compensation for completing the work.

When not shown as a separate pay item in the contract, the price for each item of milling shall include the cost of continuous maintenance of traffic and protective services as required by the Department's Traffic Control Plan, including all required individual traffic control devices.

Payment will be made under:

406-A: Cold Milling of Bituminous Pavement, All Depths	- per square yard, cubic yard or ton
406-B: Cold Milling of Concrete Pavement, All Depths	- per square yard, cubic yard or ton
406-C: Cold Milling of Shoulders, All Types, All Depths	- per square yard, cubic yard or ton
406-D: Fine Milling of Bituminous Pavement, All Depths	- per square yard, cubic yard or ton
406-E: Fine Milling of Concrete Pavement, All Depths	- per square yard, cubic yard or ton
406-F: Fine Milling of Shoulders, All Depths	- per square yard, cubic yard or ton

SECTION 407 - TACK COAT

407.01--Description. This work consists of preparing and treating an existing bituminous or concrete surface with bituminous material in accordance with these specifications and in reasonably close conformity with the lines shown on the plans or established by the Engineer.

407.02--Materials.

407.02.1--Bituminous Material. The materials shall conform to the applicable requirements of Section 702. When not specified, the materials shall be one from the Department's APL.

When emulsified asphalt is used, it shall not be diluted without approval of the Engineer.

407.03--Construction Requirements.

407.03.1--Equipment. The Contractor shall provide equipment for heating and applying bituminous material. Heating equipment and distributors shall meet the requirements of Subsection 410.03.3. Other equipment for applying tack coat shall be approved by the Engineer prior to use.

407.03.2--Preparation of Surface. The existing surface shall be prepared in accordance with Subsections 401.03.6 and 410.03.4.

407.03.3--Application of Bituminous Material. Tack coat shall be applied with a distributor spray bar. A hand wand will only be allowed for applying tack coat on ramp pads, irregular shoulder areas, median crossovers, turnouts, or other irregular areas. Bituminous materials and application rates for tack coat shall be 0.05 to 0.10 gallons per square yard. Tack coat shall not be applied during wet or cold weather, or to a wet surface. Emulsions shall be allowed to "break" prior to superimposed construction.

407.04--Method of Measurement. Unless shown as a separate pay item in the proposal, tack coat will not be measured for direct payment, but shall be considered a necessary part of the construction involved, and the cost thereof shall be included in the appropriate contract unit prices.

When shown as a separate pay item, bituminous tack coat material will be measured by the gallon as prescribed in Subsections 109.01 and 410.04.

Emulsified asphalt as delivered by the producer will be measured prior to any dilution that may be required by the Engineer.

407.05--Basis of Payment. When shown as a separate pay item in the contract, tack coat will be paid for at the contract unit price per gallon, which price shall be full compensation for completing the work.

Payment will be made under:

407-A: Asphalt for Tack Coat * - per gallon

* Grade may be specified

SECTION 408 - PRIME COAT

408.01--Description. This work consists of preparing and treating an existing surface with bituminous material, and blotter material if required, in accordance with these specifications and in reasonably close conformity with the lines shown on the plans or established by the Engineer.

408.02--Materials.

408.02.1--Bituminous Materials. The bituminous material shall conform to the applicable requirements of Section 702. The type and grade of bituminous material will

be specified in the contract. The grade may be changed one step by the Engineer at no change in unit price.

408.02.2--Blotter Material. Blotter material shall be sand clay or other friable or near friable material approved by the Engineer.

408.03--Construction Requirements.

408.03.1--Seasonal and Weather Limitations. Bituminous material shall be applied only when permitted under the seasonal and weather limitations specified in Subsection 410.03.2.

408.03.2--Equipment. The Contractor shall provide equipment for heating and applying bituminous material. Heating equipment and distributors shall meet the requirements of Subsection 410.03.3.

408.03.3--Preparation of Surface. The surface to be primed shall be prepared in accordance with Section 321 free from ruts, corrugations, segregated material, or other irregularities. It shall be conditioned as set out in Subsection 410.03.4.

408.03.4--Application of Bituminous Material. The bituminous material shall be applied in accordance with applicable requirements of Subsection 410.03.5. The bituminous material shall be applied at a rate of 0.15 to 0.50 gallons per square unless otherwise directed by the Engineer.

408.03.5--Application of Blotter Material. The Contractor shall furnish and spread, at no additional cost to the State, the minimum necessary quantity of approved blotter material over the prime coat where necessary under the requirements of Subsection 104.04.

408.03.6--Maintenance. The Contractor shall maintain the prime coat in a satisfactory condition until covered by subsequent construction. Maintenance shall include immediate repairs of all damage that may occur. All maintenance shall be performed at the expense of the Contractor, and shall be repeated as often as necessary to properly maintain the work.

408.04--Method of Measurement. Asphalt for prime coat will be measured by the gallon as prescribed in Subsections 109.01 and 410.04. Blotter material will not be paid for separately but shall be included in the unit price per gallon for prime coat.

408.05--Basis of Payment. Asphalt for prime coat, measured as prescribed above, will be paid for at the contract unit price per gallon, which prices shall be full compensation for all incidentals necessary to complete the work.

Payment will be made under:

408-A: Asphalt for Prime Coat, Grade - per gallon

SECTION 409 - GEOTEXTILE FABRIC FOR UNDERSEAL

409.01--Description. This work consists of furnishing and placing fabric underseal in accordance with the details shown on the plans and the requirements of these specifications. An underseal shall consist of an application of asphalt cement covered with a layer of fabric.

409.02--Materials.

409.02.1--Geotextile Fabric. The fabric shall meet the specific requirements for geotextile fabric underseal contained in Subsection 714.13.4 and the applicable requirements of Subsection 714.13.

409.02.2--Bituminous Material. Unless otherwise designated, the asphalt sealant shall be asphalt cement Grade PG 67-22 meeting the applicable requirements of Section 702.

409.03--Construction Requirements.

409.03.1--Equipment. The Contractor shall provide equipment for heating and applying bituminous material and for laying the pavement fabric.

Heating equipment and distributors shall meet the requirements of Subsection 410.03.3.

The mechanical fabric laydown equipment shall be capable of handling full rolls of fabric and shall be capable of laying the fabric smoothly without excessive wrinkles and/or folds. When manual laydown is required, a length of standard one inch pipe and suitable roll tension devices shall be used for proper roll handling.

The fabric manufacturer or distributor shall furnish a technician to supervise installation of the fabric and training of Contractor's personnel.

409.03.2--Surface Preparation. The surface to be treated, and at least one additional foot on each side, shall be cleaned by sweeping, blowing, or other methods until all dust, dirt, mud, vegetation, and foreign materials are removed entirely from the pavement before the asphalt sealant is applied. Care shall be exercised to prevent material so removed from becoming mixed with subsequent courses.

409.03.3--Application of the Asphalt Sealant. The application of the asphalt sealant shall conform to the applicable requirements of Section 410. The sealant shall be uniformly sprayed over the area to be covered by fabric at a rate recommended by the fabric manufacturer or distributor's technician and/or ordered by the Engineer. The rate of application is usually between 0.20 and 0.40 gallon per square yard. Varying surface conditions such as the degree of porosity of the existing pavement will cause varying application rates. The quantity applied shall be sufficient to bond and saturate the fabric, and to bond the subsequent overlay course to the fabric. Within intersections or other zones where vehicle braking is frequent, the application rate should be reduced. The sealant shall be applied to an area two to six inches wider than the width of fabric being placed, but restricted to the area of immediate fabric laydown. Application shall be by distributor spray bar with hand hose spraying allowed only where the distributor spray bar cannot be used. Asphalt leakage from the distributor and any spillage shall be cleaned from the road surface to avoid flushing and possible fabric movement at these

asphalt rich areas. The asphalt cement used as a sealant shall have distributor tank temperature between 300°F and 350°F, except when applying a tack coat to the fabric, the temperature shall not exceed 320°F to avoid damaging the fabric.

409.03.4--Fabric Placement. The fabric shall be placed on the asphaltic sealant as soon as practical and before the adhesion properties of the sealant is lost. The fabric shall be placed as smoothly as possible to avoid wrinkles.

Wrinkles severe enough to cause "folds" shall be slit and laid flat. Small wrinkles which flatten under compaction are not detrimental to performance. The fabric shall be broomed or squeegeed to remove air bubbles and make complete contact with the road surface as recommended by the fabric manufacturer or distributor. The fabric shall be laid straight, however moderate curves can be negotiated by stretching the fabric on the outside of the curve.

Longitudinal and transverse joints shall be made by overlapping the fabric at least six inches. Additional sealant shall be applied to the joints as required and may be applied by hand hose spraying or with mop and bucket if extreme care is taken to not over apply. Transverse joints should be "shingled" in the direction of construction traffic and paving to prevent pick-up. In circumstances where this method is impractical, asphalt pavement or sand spread over the joint will aid in prevention of pick-up.

When recommended by the manufacturer or distributor's technician and/or ordered by the Engineer, the fabric shall be rolled with a pneumatic roller to improve bonding and reduce slippage.

409.03.5--Treatment of Fabric Prior to Overlay. Normally it is not necessary to tack coat the fabric unless there are circumstances such as delay in placement of subsequent course, dust accumulation or insufficient initial application of sealant which would make tack coating desirable. If a tack coat is required by the Engineer, emulsified asphalt shall be applied at a rate of 0.02 to 0.05 gallon of residual asphalt per square yard.

Placement of the subsequent course shall closely follow fabric laydown. In the event that the sealant bleeds through the fabric, it may be necessary to blot the sealant with sand to prevent construction equipment from picking up the fabric. Turning of the paver and other vehicles must be gradual to avoid stripping or damage to the fabric.

If traffic must be maintained on the fabric prior to placement of the subsequent course, it is advisable to spread a small quantity of sand over the fabric and roll with a pneumatic roller to prevent tires from picking up the fabric.

If rain should cause a blistered appearance and bond loss, it shall be corrected by rolling with a pneumatic roller.

409.03.6--Asphalt Pavement Overlay. The overlay shall conform to Sections 401 and 403 except that the mixture shall be delivered to the paver at a temperature of 275°F to 300°F. Temperature of the mix shall in no case exceed 325°F.

409.04--Method of Measurement. Geotextile fabric for underseal, placed in accordance with these specifications and as directed by the Engineer, will be measured by the square yard of surface area. Any overwidth of material installed and additional material required

for laps will not be measured.

Asphalt cement for fabric underseal, applied in accordance with these specifications and as directed by the Engineer, will be measured by the gallon in accordance with Subsections 109.01 and 410.04.

Any blotting with sand, rolling to restore bond and application of a tack coat will not be measured for payment and is considered incidental to completion of the work.

409.05--Basis of Payment. Geotextile fabric for underseal will be paid for at the contract unit price per square yard. Asphalt cement for fabric underseal of the kind and grade specified, measured as provided above, will be paid for at the contract unit price per gallon. These prices shall be full compensation for satisfactorily completing the work.

Payment will be made under:

409-A: Geotextile Fabric for Underseal, Type * - per square yard

409-B: Asphalt Cement for Fabric Underseal - per gallon

* When not designated, see Subsection 714.13.

SECTION 410 - BITUMINOUS SURFACE TREATMENT

410.01--Description. This work consists of the construction of a single layer bituminous surface treatment (chip seal) in accordance with these specifications and in reasonably close conformity with the lines shown on the plans or established by the Engineer.

410.02--Materials.

410.02.1--Bituminous Material. The type and grade of bituminous materials will be specified in the contract and shall conform to the applicable requirements of Section 702.

410.02.2--Cover Material. Cover material shall meet the applicable requirements of Subsection 703.14, and the kind and type will be specified in the contract.

Only one type of aggregate or combination of aggregates shall be used on a particular project except with written permission of the Engineer.

Sites for stockpiles of materials shall be grubbed and cleaned prior to storing the aggregates, and the ground shall be firm, smooth, and well drained.

410.03--Construction Requirements.

410.03.1--General. Prime coats, when specified, shall meet the requirements of Section 408. After the application of a prime coat, the primed surface shall be kept in continuous repair. All holes, raveled areas, and areas deficient in prime shall be patched and repaired with approved materials.

Prior to any chip sealing operation, "Loose Rock" signs shall be installed and remain in place until all sealing operations are complete. Prior to any daily sealing operation, portable "Loose Rock" signs shall be installed in accordance with the drawing in the plans or contract documents. Portable signs shall be installed and remain in place on a daily basis in the active sealing area. Payment for signs shall be made under pay item no. 618-A, Maintenance of Traffic.

410.03.2--Seasonal and Weather Limitations. Emulsified asphalt and cut-back asphalt shall be applied only when both the air and pavement temperatures are above 70°F. Asphalt cement shall be applied only when both the air and surface temperatures are above 75°F.

Cut-back asphalt shall not be placed during the period between October 15 and March 1. No prime shall be placed when soil and weather conditions would prevent the proper placement and retention of the materials.

Bituminous materials for surface treatment shall not be placed during the period between November 1 and March 1, nor when weather conditions otherwise prevent the proper placement and retention of the materials.

On projects where completion of seal coats after November 1 or before March 1 is determined to be in the public interest, the Engineer may permit variations from the above under the condition that all the following requirements are met:

- (a) The air and pavement temperature is 70°F or higher.
- (b) Asphalt cement used is cut back with naphtha of the type that will yield from 5-10 percent off at 680°F when tested by method AASHTO T 78 and the naphtha is added at the refinery.
- (c) As an alternate to (b), the Contractor substitutes a rapid setting cationic emulsified asphalt meeting the requirements of AASHTO M 208.
- (d) Aggregate is satisfactorily air dried in covered storage, or mechanically dried.
- (e) The sun is shining.
- (f) Aggregate is applied immediately behind the distributor.
- (g) No shot is made after mid-afternoon, and rolling is increased as directed for shots made after noon.
- (h) The Contractor retains full responsibility for the acceptable quality of the work within the intent of the contract, these conditions notwithstanding.
- (i) The work is performed under these modifications at no additional cost to the State.

Blanket authorization will not be given for use of the above modification, but will be given only when completion of the surface treatment would make the facility available for use by public traffic, or for subsequent construction.

Prior to November 1 and after March 1, when the requirements of these specifications are being met, but conditions are less than good for the adhesion of cover aggregate to the bituminous material, the Engineer may permit or require, at no additional cost to the State that the asphalt cement be cut back with naphtha as previously indicated. Less than good placement conditions shall be understood to include, but not limited to: lower than desirable temperature; higher than desirable humidity; surface dampness; or coolness of the foundation or aggregate.

410.03.3--Equipment. The following or equivalent equipment shall be furnished.

410.03.3.1--Bituminous Heating Equipment. This equipment shall heat and maintain the bituminous material within specification requirements without damaging the material. The heating equipment shall be supplied with at least one accurate asphalt thermometer.

410.03.3.2--Distributor. The distributor shall be mounted on pneumatic tires of sufficient width to prevent breaking the surface bond when the tank is fully loaded. It shall be self-propelled and sufficiently powered to maintain the desired speeds during operation. It shall be equipped to evenly heat and maintain the material at the required temperature; have adequate pressure devices and suitable manifolds to provide constant and even distribution for the entire length of the spray bars; and have positive cutoff to prevent dripping from the nozzles. It shall be so constructed that uniform applications may be made at the specified rate on variable widths up to 26 feet. Charts and devices shall be provided by the Contractor for determining the quantity being applied.

410.03.3.3--Rotary Brooms. Rotary brooms shall be constructed to permit the revolutions of the broom to be adjusted to its progression and to permit adjustment of the broom in relation to the surface. The broom bristles shall be stiff enough to sweep clean without injury to the surface.

410.03.3.4--Power Rollers. Steel-wheel rollers will not be allowed.

Pneumatic rollers shall be self-propelled with wheels mounted on two axles in such a manner that the rear tires will not follow in the tracks of the forward group. The rollers shall be capable of applying a minimum of 50 pounds per square inch contact pressure under each tire, and shall be of a weight that will not damage the base or surface treatment.

410.03.3.5--Trucks. Trucks of sufficient number and size to adequately supply the material shall be furnished.

410.03.3.6--Aggregate Spreaders. Aggregate spreaders shall be constructed so that they can be accurately gauged and set to uniformly distribute the required quantity of aggregate at regulated speed.

410.03.3.7--Other Equipment. Drag brooms shall be furnished and used as conditions dictate.

410.03.4--Preparation of Surface. The entire surface to be treated and at least one foot on each side shall be cleaned by sweeping, blowing, or other methods until all dust, mud, clay lumps, and foreign material is removed. A primed base shall be properly cured and approved prior to application of bituminous material.

410.03.5--Application of Bituminous Material. Bituminous material shall not be applied until the prepared surface has been approved by the Engineer. Where practicable, shots shall be at least 500 feet in length, and longer shots are desirable. No shot shall be in excess of a length which can be covered with aggregate before the bitumen hardens.

The bituminous material shall be uniformly heated and maintained within the specified

temperature range during application. All material damaged by heating shall be rejected, and if a section has been treated with damaged material it shall be removed and replaced by the Contractor without additional compensation.

Emulsified asphalt material shall be applied with a pressure distributor at the specified rate, and at a temperature of 140° to 180°F. All other bituminous material shall be applied with a pressure distributor at the temperature range set out in Subsection 702.11. It shall be uniformly applied full width in one operation unless the Engineer permits it to be applied in narrower widths.

The application rate of the bituminous material shall result in complete and uniform coverage of the pavement receiving the bituminous surface treatment. If the application of the bituminous material does not result in complete coverage, the Contractor shall cease operations and adjust the distributor bar height and/or nozzle(s) such that complete coverage is attained. At a minimum, the application rate of the Bituminous Material should be verified daily by the Department.

The optimum application rate of bituminous material for chip seals is dependent on the chosen seal aggregate gradation as well as the condition of the pavement in which the chip seal is to be applied. The application rate of the bituminous material may be adjusted by the Engineer based on field conditions at the time of construction. The following are target application rates for bituminous material.

Seal Aggregate Gradation	Bituminous Material	Target Application Rate (gal/yd²)	Tolerance
Size No. 7	AC	0.28	±0.03
Size No. 8 or 89	AC	0.23	±0.03
Size No. 7	Emulsified Asphalt	0.38	±0.03
Size No. 8 or 89	Emulsified Asphalt	0.35	±0.03

Note: Emulsified Asphalt shall not be diluted. A sample of emulsified asphalt should be obtained from the Contractor's distributor on the first day of production and thereafter at a frequency not to exceed 1 sample per 50,000 gallons. Because the time between sampling of the emulsified asphalt and the testing of the material can affect the test results, samples should be sent to the MDOT Central Lab for testing as soon as possible.

The application shall be stopped before the distributor is completely empty, and the length of shots shall be computed so that the application is stopped before it begins to run light. At the beginning of the application, including joints with preceding applications, intersections, and junctions with all pavements, etc., the distributor nozzles shall be operating at full force when the application begins. Building paper or other suitable material shall be used to receive the initial application from the nozzles before the asphalt reaches the road surface at the joint. The material shall be removed immediately after use without spilling asphalt on the road surface.

Spray bar nozzles shall be kept clean at all times, and should one become blocked during application of the bituminous material, the distributor shall be stopped immediately and the nozzle cleaned before proceeding. Bare or light areas shall be immediately made uniform by use of a hand hose or pouring pot.

Due to possible spillage, the transfer of material from the delivery truck to the distributor shall be outside the limits of the roadway. Bituminous material shall not be discharged on the right-of-way when cleaning out the distributor. Any spillage shall be removed from the roadway and right-of-way.

During application of bituminous material, the Contractor shall provide adequate protection to prevent marring or discoloration of pavements, structures, curbs, trees, etc., adjacent to the area being treated.

Longitudinal joints, when permitted, shall be reasonably true to line and parallel to the centerline. The overlap in the application of the bituminous material shall be the minimum to assure complete coverage.

At construction joints, the treatment of the edges shall be blended so that there are no gaps, the elevations are the same, and the joints are free from ridges and depressions.

410.03.6--Application of Cover Coat Material. The application of cover material shall immediately follow the application of bituminous material. Adhesion of the cover aggregate to the bitumen is the Contractor's responsibility. The time interval between applications of bituminous material and cover aggregate shall not exceed 20 minutes when the air temperature is below 85°F or 30 minutes when the temperature is 85°F or above.

Aggregate shall be spread directly from approved spreaders. Trucks or spreaders shall not drive on the uncovered bituminous material.

The application rate of cover aggregate shall be within the following range.

Size 7 Slag, Stone, Gravel or Expanded Clay	0.30 ±0.02 ft ³ / yd ²
Size 8 Expanded Clay	0.25 ±0.02 ft ³ / yd ²
Size 89 Slag, Stone, or Gravel	0.25 ±0.02 ft ³ / yd ²

During the first day of production and at least once a week thereafter, the application rate of the seal aggregate shall be verified by the Department to assure that the appropriate application rate of the seal aggregate is applied. The rate can be verified by placing a tarp of at least 1.0 yd² area on the roadway surface. After allowing the seal aggregate spreader to pass over the tarp, the aggregate on the tarp should be collected and weighed to determine the weight of aggregate. The measured weight should then be compared to the target weight calculated using the following formula.

$$W = 0.85(G_{sb})(U_w)(R)(A)(e)$$

Where:

- W = target weight of aggregate in lbs.
- G_{sb} = bulk specific gravity of aggregate
- U_w = Unit weight of water at 70°F = 62.3 lbs./ft³
- R = target application rate in ft³/yd²
- A = area of tarp in yd²
- e = air voids in loose aggregate = 0.4

G _{sb} for gravel	= 2.650
G _{sb} for limestone	= 2.700

Note: Bulk specific gravities of expanded clay and steel slag should be obtained from the seal aggregate supplier.

Upon determining the target weight, it should be compared to the actual measured weight. If the difference in the target weight and the actual measured weight is over 2.5 pounds, the seal aggregate distributor should be adjusted such that the spread rate is within the above tolerance. The above procedure shall be repeated until the spread rate is within the allowable tolerance.

If at any point during production, excessive seal aggregate is noted, the seal aggregate application rate should be verified and the spread rate adjusted. The intent is to minimize the amount of excess seal aggregate. Excess seal aggregate removed from the roadway surface after brooming shall be removed from the job site and should not be reused in the seal aggregate operation.

The dry aggregate shall be spread uniformly to cover the bituminous material with the quantity of aggregate specified by the Engineer. All deficient areas shall be covered by additional material.

If needed, approved drag brooms and hand brooms shall be used to distribute the aggregate uniformly before and while the rolling operations are in progress.

The entire application of aggregate shall be rolled as soon as possible after application. Rolling shall be continued and repeated as often as necessary to key the cover material thoroughly into the bituminous material over the entire surface.

Pneumatic rollers and steel-wheel rollers shall be used in the sequence that will provide the rolling pattern that results in the best adhesion of the aggregate to the bituminous material and the best surface qualities.

Subsequent to the initial application of the aggregate the Contractor shall distribute, as many times as is deemed necessary, loose aggregate over the surface to absorb free bituminous material and to cover areas deficient in aggregate. Immediately following each distribution, the Contractor shall roll the entire surface treatment or seal with a pneumatic-tire roller until the maximum quantity of aggregate is embedded in the bitumen. Rolling in each case shall be at least one complete coverage and as many additional coverages as necessary to properly embed the aggregate. All rolling shall be performed while the temperature is favorable for sealing the aggregate into the bitumen.

In all cases there shall be at least five complete coverages of the entire surface of the treatment with a pneumatic-tire roller.

410.03.7--Control of Traffic. Unless otherwise advised, the Contractor's operations shall be schedule such that all lanes of traffic are open to the traveling public at the end of each day. Considering time needed for curing and preparation prior to opening traffic, the Contractor should not apply bituminous material two (2) hours before dusk, or longer, to allow sufficient time for bonding of the aggregates.

After the surface treatment has been rolled and the bituminous material has cured a minimum of one (1) hour, or longer if necessary to sufficiently hold the aggregate in place, the Contractor shall perform an initial brooming operation consisting of lightly sweeping excess aggregate material from the surface. After the initial brooming has been completed, public traffic will be allowed on the roadway.

Immediately the next morning, a final brooming shall be performed to remove any remaining excess aggregate material from the previous day's seal operation.

410.04--Method of Measurement. Accepted asphalt for surface treatment will be measured by the gallon as prescribed in Subsection 109.01. Unless otherwise specified, distributor tank measurement will be used. The volume of material over five percent above the quantity ordered for each shot will be deducted from measured quantities, except that 15 percent will be allowed for irregular areas where hand spraying is necessary.

Aggregate cover material will be measured by the cubic yard (LVM) at the point of delivery on the road. Measurement will be for the actual volume spread. The volume of material over five percent above the quantity ordered for each "spreading" will be deducted from measured quantities, except that 15 percent will be allowed for irregular areas where hand "spreading" is necessary.

The volume of all cover material and the volume of all bituminous material lost, wasted, damaged, or rejected, or applied outside of designated areas, or in excess of the Engineer's directions and tolerances allowed, or contrary to the specifications, will be deducted from measured quantities.

410.05--Basis of Payment. Asphalt for surface treatment will be paid for at the contract unit price per gallon. Aggregate cover material will be paid for at the contract unit price per cubic yard (LVM). The prices thus paid shall be full compensation for completing the work.

Payment will be made under:

410-A: Asphalt for Surface Treatment, Grade - per gallon

410-B: Seal Aggregate Cover Material, Size ____, Kind - per cubic yard

SECTION 411 - ULTRA-THIN ASPHALT PAVEMENT

411.01--Description. These specifications include general requirements that are applicable to Ultra-Thin Hot Mix Asphalt (UHMA) and Ultra-Thin Warm Mix Asphalt (UWMA).

This work consists of the construction of one lift of ultra-thin asphalt pavement (UTAP) in accordance with these specifications and the specific requirements for the mixture to be produced and placed in reasonable close conformity with the lines, grades, thicknesses and typical sections shown on the plans or established by the Engineer.

The asphalt mixture (UHMA or UWMA) used on this project will not be bid as an alternate pay item. **The Contractor must select one of the asphalt mixtures, UHMA or UWMA, to be used throughout the entire project.**

411.01.1--Definitions.

Maximum Sieve Size - Maximum sieve size is the smallest sieve size at which 100 percent of the aggregate passes.

Nominal Maximum Sieve Size - The nominal maximum sieve size is one sieve size larger than the first sieve to retain more than 10 percent of the aggregate.

Maximum Density Line - The maximum density line is a straight line plot on the FHWA 0.45 power gradation chart which extends from the zero origin point of the chart through the plotted point of the combined aggregate gradation curve on the nominal maximum sieve size.

Mechanically Fractured Face - An angular, rough, or broken surface of an aggregate particle created by crushing as determined by ASTM D 5821.

411.02--Materials.

411.02.1--Component Materials.

411.02.1.1--Aggregates. The source of aggregates shall meet the applicable requirements of Section 703.

The total amount of crushed limestone shall not exceed fifty percent (50%) of the total aggregate by weight.

411.02.1.1.1--Coarse Aggregate Blend. Mechanically fractured faces by weight of the combined mineral aggregate coarser than the No. 4 sieve shall be 90 percent, two faces.

411.02.1.1.2--Fine Aggregate Blend. Uncrushed natural sand shall pass the 3/8" sieve and can be used, excluding the content in RAP, as no greater than 30 percent of the total mineral aggregate by weight.

411.02.1.1.3--Combined Aggregate Blend. The gradation requirements for Ultra-thin asphalt pavements are provided in the following table:

Sieve Size	Percent Passing
1/2 inch	100
3/8 inch	95-100
No. 4	75 min
No. 8	22-70
No.16	--
No. 200	4-12

The ultra-thin mixtures shall have a minimum fine aggregate angularity of 40.0 when tested on combined aggregate in accordance with ASTM C1252 Method A.

The minus No. 40 fraction of the combined aggregate shall be non-plastic when tested according to AASHTO T 90. The clay content shall not exceed 0.5 percent by weight of the total mineral aggregate when tested according to AASHTO T 88.

411.02.1.2--Reclaimed Asphalt Pavement. Reclaimed asphalt pavement may be used in ultra-thin asphalt pavement and shall be no greater than 25 percent of the total mix weight.

Reclaimed asphalt pavement shall be separated into coarse and fine aggregate stockpiles using a 1/2" sieve as the break point.

411.02.1.3--Bituminous Materials. Bituminous materials shall meet the applicable requirements of Section 702 for the grade specified.

411.02.1.4--Hydrated Lime. Hydrated lime shall meet the requirements of Subsection 714.03.2 for lime used in soil stabilization.

411.02.1.5--Mineral Filler. Mineral filler shall meet the requirements of Subsection 703.16.

411.02.2--Composition of Mixtures.

411.02.2.1--General. Unless otherwise specified or permitted, the UTAP shall consist of a uniform mixture of asphalt, aggregate, mineral filler, hydrated lime and, when required or necessary to obtain desired properties, antistripping agent and/or other materials.

Hydrated lime shall be used in all UTAP at the rate of one percent (1%) by weight of the total dry aggregate. The aggregate, prior to the addition of the hydrated lime, shall contain sufficient surface moisture.

The Contractor shall obtain a shipping ticket for each shipment of hydrated lime. The Contractor shall provide the District Materials Engineer with a copy of each shipping ticket from the supplier, including the date, time and weight of hydrated lime shipped.

Mixtures will require the addition of an antistripping agent when the Tensile Strength Ratio (MT-63) and/or the Boiling Water Test (MT-59) fail to meet the following criteria.

Tensile Strength Ratio (TSR - MT-63)

- Wet Strength / Dry Strength 85 percent minimum
- Interior Face Coating 95 percent minimum

Boiling Water Test (MT-59)

- Particle Coating 95 percent minimum

411.02.2.2--Mixture Properties. Ultra-thin asphalt pavement shall be designed at N_{design} of 50 revolutions of the gyratory compactor.

Mixtures shall be designed such that the percent of maximum specific gravity (G_{mm}) shall be between 94.0 and 96.0.

There will not be voids in mineral aggregate (VMA) requirement for ultra-thin asphalt. However, the specified volume of effective binder (the difference between total air voids and VMA) shall be a minimum of 12 percent.

Dust/Binder Ratio (Percent Passing No. 200 / Effective Binder Content) for ultra-thin asphalt pavement shall be between 1.0 and 2.0.

411.02.2.3--Job Mix Formula. At least 10 working days prior to the proposed use of each mixture, the Contractor shall submit in writing to the Engineer a proposed job-mix formula or request the transfer of a verified job-mix formula as set forth in the latest edition of MDOT's Field Manual for HMA. The job-mix formula shall be signed by a Certified Mixture Design Technician (CMDT).

The Department will perform the tests necessary for review of a proposed job-mix formula for each required mixture free of charge one time only. A charge will be made for additional job-mix formulas submitted by the Contractor for review.

The mixture shall conform thereto within the range of tolerances specified for the UTAP mixture. No change in properties or proportion of any component of the job-mix formula shall be made without permission of the Engineer. The job-mix formula for each mixture shall be in effect until revised in writing by the Engineer.

A job-mix formula may be transferred to other contracts in accordance with conditions set forth in the Department's Field Manual for HMA.

The Contractor shall not place any UTAP prior to receiving "tentative" approval and a MDOT design number from the Central Laboratory.

When a change in source of materials, unsatisfactory mixture production results such as segregation, bleeding, shoving, rutting over 1/8 inch, raveling & cracking, or changed conditions make it necessary, a new job-mix formula will be required. The conditions set out herein for the original job-mix formula are applicable to the new job-mix formula.

411.02.2.4--Single Lift Laying Thickness. The minimum lift thickness for ultra-thin asphalt pavement shall be 1/2 inch and the maximum lift thickness shall not exceed one inch (1").

411.02.2.5--UWMA Products and Processes. The Department will maintain a list of qualified UWMA products and processes. No product or process shall be used unless it appears on this list.

The Contractor may propose other products or processes for approval by the Product Evaluation Committee. Documentation shall be provided to demonstrate laboratory performance, field performance, and construction experience.

411.02.3--Contractor's Quality Management Program.

411.02.3.1--General. The Contractor shall have full responsibility for quality management and maintain a quality control system that will furnish reasonable assurance that the mixtures and all component materials incorporated in the work conform to contract requirements. The Contractor shall have responsibility for the initial determination and all subsequent adjustments in proportioning materials used to produce the specified mixture. Adjustments to plant operation and spreading and compaction procedures shall be made immediately when results indicate that they are necessary. Mixture produced by the Contractor without the required testing or personnel on the project shall be subject to removal and replacement by the Contractor at no additional cost to the State.

411.02.3.2--Personnel Requirements. The Contractor shall provide at least one Certified Asphalt Technician-I (CAT-I) full-time during UTAP production at each plant site used to furnish material to the project. Sampling shall be conducted by a certified technician or by plant personnel under the direct observation of a certified technician. All testing, data analysis and data posting will be performed by the CAT-I or by an assistant under the direct supervision of the CAT-I. The Contractor shall have a Certified Asphalt Technician-II (CAT-II) available to make any necessary process adjustments. An organizational chart, including names, telephone numbers and current certification, of all those responsible for the quality control program shall be posted in the contractor's laboratory while the UTAP paving work is in progress

411.02.3.3--Testing Requirements. As a minimum, the Contractor's quality management program shall include the following:

- (a) Bituminous Material. Provide Engineer with samples in a sealed one-quart metal container at the frequency given in MDOT SOP TMD-20-04-00-000.
- (b) Mechanically Fractured Face. Determine mechanically fractured face content of aggregates retained on the No. 4 sieve, at a minimum of one test per day of production.
- (c) Mixture Gradation. Conduct extraction tests for gradation determination on the mixture. Sample according to the frequency in paragraph (i) and test according to Mississippi Test Method MT-31.
- (d) Total Voids and V_{be} . Determine total voids and volume of effective binder (V_{be}), at N_{Design} , from the results of bulk specific gravity tests on laboratory compacted specimens. Sample according to the sampling frequency in paragraph (h) and test according to the latest edition of MDOT's Field Manual for HMA.
- (e) Asphalt Content. Sample according to the sampling frequency in paragraph (i), and determine the asphalt content using one of the following procedures.
 - (1) Nuclear gauge. (Mississippi Test Method MT-6)
 - (2) Incinerator oven. (AASHTO T 308, Method A)
- (f) Stripping Tests. Conduct a minimum of one stripping test at the beginning of each job-mix production and thereafter, at least once per each two weeks of production according to Mississippi Test Method: MT-63 and one stripping test per day of production according to Mississippi Test Method: MT-59. Should either the TSR (MT-63) or the boiling water (MT-59) stripping tests fail, a new antistripping additive or rate shall be established or other changes made

immediately that will result in a mixture which conforms to the specifications; otherwise, production shall be suspended until corrections are made.

- (g) **Quality Control Charts.** Plot the individual test data, the average of the last four tests and the control limits for the following items as a minimum:

Mixture Gradation (Percent Passing) Sieves:
 1/2-in, 3/8-in, No. 4, No. 8, No. 30, and No. 200.
 Asphalt Content, Percent
 Maximum Specific Gravity
 Total Voids @ N_{Design} , Percent
 V_{be} @ N_{Design} , Percent

Keep charts up-to-date and posted in a readily observable location. Charts may be kept on a computer; however, the charts shall be printed out a minimum of once each production day and displayed in the laboratory. Note any process changes or adjustments on the Air Voids chart.

- (h) **Sampling Frequency.** Conduct those tests as required above at the following frequency for each mixture produced based on the estimated plant tonnage at the beginning of the day.

Total Estimated Production, tons	Number of Tests
0-500	1
501-1000	2
1001-1500	3
1501-2000	4
2001+	5

- (i) **Sample Requirements.** Obtain the asphalt mixture samples from trucks at the plant. Obtain aggregate samples from cold feed bins or aggregate stockpile. Save a split portion of all mixture samples at the laboratory site in a dry and protected location for 14 calendar days. At the completion of the project, the remaining samples may be disposed of with the approval of the Engineer.

The above testing frequencies are for the estimated plant production for the day. If production is discontinued or interrupted, the tests will be conducted at the previously established sample tonnage points for the materials that are actually produced. If the production exceeds the estimated tonnage, sampling and testing will continue at the testing increments previously established for the day. A testing increment is defined as the estimated daily tonnage divided by the required number of tests from the table in Subsection 411.02.3.3 paragraph (h).

In addition to the above program, aggregate stockpile gradation tests (AASHTO T-11 and T-27) shall be conducted every other production day. Fine aggregate angularity tests (ASTM C 1252, Method A) shall be conducted on the first day of production and once for every eight production samples thereafter, with a minimum of one test per production week.

411.02.3.4--Documentation. The Contractor shall document all observations, records of inspection, adjustments to the mixture, and test results on a daily basis. All tests conducted by the Contractor in accordance with Subsection 411.02.3.3 (g) shall be included in the running average calculations. If single tests are performed as a check on

individual UTAP properties, between regular samples, without performing all tests required in Subsection 411.02.3.3 (g), the results of those individual tests shall not be included in the running average calculations for that particular property. The Contractor shall record the results of observations and records of inspection as they occur in a permanent field record. The Contractor shall record all process adjustments and job mix formula (JMF) changes on the air void charts. The Contractor shall provide copies of all test data sheets and the daily summary reports on the appropriate Mississippi DOT forms to the Engineer on a daily basis. The Contractor shall provide a written description of any process change, including blend proportions, to the Engineer as they occur. Information provided to the District Materials Engineer must be received in the Engineer's office by no later than 9:00 AM the day after the UTAP is produced. Upon completion of the placement of all UTAP on the project, the Contractor shall provide the Engineer with the original test reports and control charts in a neat and orderly manner.

411.02.3.5--Control Limits. The following control limits for the job mix formula (JMF) and warning limits are based on a running average of the last four data points.

<u>Sieve - % Passing</u>	<u>JMF Limits</u>	<u>Warning Limits</u>
1/2-in	± 5.5	± 4.0
3/8-in	± 5.5	± 4.0
No. 4	± 4.0	± 3.0
No. 8	± 4.0	± 3.0
No. 30	± 4.0	± 3.0
No. 200	± 2.0	± 1.5
Asphalt Content, %	-0.3 to +0.5	-0.2 to +0.4
Design Total Voids @N _{Design} , %	± 1.3	± 1.0
V _{be} @ N _{Design} , %	- 1.5	- 1.0

411.02.3.6--Warning Bands. Warning bands are defined as the area between the JMF limits and the warning limits.

411.02.3.7--Job Mix Formula Adjustments. A request for a JMF adjustment signed by a CAT-II may be made to the Engineer by the Contractor. Submit sufficient testing data with the request to justify the change. The requested change will be reviewed by the State Materials Engineer for the Department. If current production values meet the mixture design requirements, a revised JMF will be issued. Adjustments to the JMF shall conform to the latest edition of MDOT's Field Manual for HMA. Adjustments to the JMF to conform to actual production shall not exceed the tolerances specified for the JMF limits. Regardless of such tolerances, any adjusted JMF gradation shall be within the range given in Subsection 411.02.1.1.3 for the mixture specified. The JMF asphalt content may only be reduced if the production V_{be} meets or exceeds the minimum design V_{be} requirements for the mixture being produced.

411.02.3.8--Actions and Adjustments. Actions and adjustments shall be in accordance with Subsection 401.02.5.8.

411.02.4--Standards of Acceptance.

411.02.4.1--General. Acceptance for mixture quality (V_{be} and total voids @ N_{Design} , gradation, and asphalt content) will be based on random samples tested in accordance with the latest edition of MDOT's Field Manual for HMA. Smoothness will be accepted by lots as set out in Subsection 411.02.4.3.

411.02.4.2--Assurance Program for Mixture Quality. The Engineer will conduct a quality assurance program in accordance with Subsection 401.02.6.2.

411.02.4.3--Acceptance Procedure for Mixture Quality. All obviously defective material or mixture will be subject to rejection by the Engineer. Such defective material or mixture shall not be incorporated into the finished work. If the defective material has already been placed in the work, the material shall be removed and replaced at no additional cost to the State.

The Engineer will base final acceptance of the asphalt mixture production on the results of the Contractor's testing for total voids and V_{be} @ N_{Design} , gradation, and asphalt content as verified by the Engineer in the manner hereinbefore described and the uniformity and condition of the completed pavement. Areas of pavement that exhibit nonuniformity or failures (materials or construction related) such as but not limited to segregation, bleeding, shoving, rutting over 1/8 inch, raveling, slippage, or cracking will not be accepted. Such areas will be removed and replaced at no additional cost to the State.

Bituminous mixture placed prior to correction for deficiencies in V_{be} and total voids @ N_{Design} , gradation, or asphalt content, as required in Subsection 411.02.3.8 and determined by the Engineer satisfactory to remain in place will be paid for in accordance with the following pay factors times the contract unit price per ton.

Pay Factor for Mixture Quality *

Item	Produced in Warning Bands	Produced Outside JMF Limits (Allowed to Remain in Place)
Gradation	0.90	0.75
Asphalt Content	0.85	0.75
Total Voids @ N_{Design}	0.70	0.50
V_{be} @ N_{Design}	0.90	0.75

* The minimum single payment will apply.

411.02.4.4--Acceptance Procedure for Density. The density requirement for UTAP shall be roll to refusal. Refusal is defined as the number of roller passes to maximize the in-place unit weight of the mixture. On the first day of production and every three production days thereafter, a 500-foot test strip shall be evaluated to determine the required number of roller passes. Three random sites within the test strip shall be selected and monitored with the nuclear density gauge to determine refusal.

411.02.4.5--Acceptance Procedure for Pavement Smoothness. Prior to placement of UTAP, the Contractor shall determine the existing surface Mean Roughness Index at no additional cost to the State. The finished UTAP lift shall have a mean roughness index no greater than that of the existing surface.

411.02.5--High Speed Inertial Profiling System. The high speed inertial profiling system shall meet the applicable requirements of Subsection 401.02.6.9.

411.02.6--Surface Correction. In the event surface correction is needed it shall be accomplished by removal and replacement in accordance with Subsection 403.03.4. All such corrections shall be at no additional cost to the State.

The finished pavement surface will be measured for riding quality.

411.03--Construction Requirements. Mississippi DOT has adopted the “Hot-Mix Asphalt Paving Handbook” as the guideline for acceptable UTAP construction practices.

411.03.1--Weather Limitations. The mixture shall not be placed when weather conditions prevent the proper handling and finishing or the surface on which it is to be placed is wet or frozen. At the time of placement, the air and pavement surface temperature limitations shall be equal to or exceed 55°F for UHMA and 40°F for UWMA, regardless of the compacted lift thickness.

When paving operations are discontinued because of rain, the mixture in transit shall be protected until the rain ceases. The surface on which the mixture is to be placed shall be swept to remove as much moisture as possible and the mixture may then be placed subject to removal and replacement at no additional cost to the State if contract requirements are not met.

411.03.2--Tack Coat. Tack coat shall meet the requirements of Subsection 401.03.1.2.

411.03.3--Bituminous Mixing Plants. Bituminous mixing plants shall meet the applicable requirements of Subsection 410.03.2.

411.03.4--Hauling Equipment. Hauling equipment shall meet the requirements of Subsection 401.03.3. Truck scales shall meet the requirements of Subsection 401.03.2.1.11.

411.03.5--Bituminous Pavers. Bituminous pavers shall meet the requirements of Subsection 401.03.4.

411.03.6--Rollers. All rollers shall meet the requirements of Subsection 401.03.5.

411.03.7--Preparation of Grade. The foundation upon which UTAP pavement is to be placed shall be prepared in accordance with Subsection 401.03.6.

411.03.8--Preparation of Mixture. The temperature of the mixture, when discharged from the mixer, shall not exceed 340°F for UHMA and 280°F for UWMA.

411.03.9--Spreading and Finishing. Spreading and finishing of UTAP shall be in accordance with Subsection 401.03.10.

411.03.10--Joints. Joints shall be constructed in accordance with Subsection 401.03.12.

411.04--Method of Measurement. Ultra-thin asphalt pavement will be measured by the ton.

Tack coat will be measured and paid as set out in Section 407.

411.05--Basis of Payment. Ultra-thin asphalt pavement, measured as prescribed above, will be paid for at the contract unit price per ton, which price shall be full compensation for completing the work.

Payment will be made under the following items:

411-A: Ultra-Thin Asphalt Pavement -per ton

SECTION 412 - PRE-GRINDING

412.01--Description. This work shall consist of grinding existing pavement surfaces to substantially eliminate bumps/knots in the existing pavement which results will improve riding characteristics of the finished pavement surface. The work shall be accomplished in accordance with these specifications and in reasonably close conformity to any details on the plans or in the contract documents.

Pre-grinding will be allowed, and paid for, on certain projects in which a pay item for pre-grinding is included in the bid items. Pre-grinding will be allowed at the Contractor's option on all other projects, but at no cost to the State. The Contractor may elect to pre-grind bumps in the existing pavement surface to improve riding characteristics prior to placement of the new asphalt pavement. It is the intent of this specification to remove bumps which cannot be eliminated during the paving operation but not to pre-grind areas that can be corrected with the asphalt overlay.

412.02--Blank.

412.03--Construction Requirements. Prior to any paving operations, the Contractor shall run a profile of the existing pavement as required in Subsection 403.03.2.1. This profile shall be used to determine if and where any areas are located with a short interval MRI value of 160 inches per mile or more. With approval of the Engineer, these areas may be ground prior to placement of the asphalt overlay.

Equipment for pre-grinding shall meet the requirements set forth in Section 406 of the Standard Specifications, or other equipment approved by the Engineer.

The Contractor shall establish positive means for removal of grinding residue. Solid residue shall be removed from pavement surfaces before it is blown by traffic action or wind. Residue shall not be permitted to flow across lanes used by public traffic or into gutters or drainage facilities, but may be allowed to flow into adjacent ditches.

412.04--Method of Measurement. When a pay item is included in the contract, Pre-Grinding of existing pavement will be measured by the square foot of area approved by the Engineer.

412.05--Basis of Payment. Pre-Grinding, measured as prescribed above, will be paid for at the contract fixed price per square foot, which price shall be full compensation for all

labor, tools, equipment, profiling, cleanup, and all incidentals necessary to complete the work.

Payment will be made under:

412-A: Pre-grinding - per square foot

SECTION 413 - SEALING AND FILLING JOINTS AND CRACKS

413.01--Description. This work consists of routing, sawing and/or cleaning, sealing joints and cracks in existing pavement as designated by pay items in the contract proposal and as detailed on the plans and described herein. All work shall be in reasonably close conformity with these specifications and the details shown on the plans, or as directed.

When called for on the plans, this work shall also consist of saw cutting, cleaning and sealing transverse joints in new bituminous concrete overlays. Bituminous concrete pavement joints shall be constructed over, and in line with, the existing underlying transverse portland cement concrete joints in accordance with plans, specifications, and as directed by the Engineer.

This work may also consist of cleaning and filling joints in existing concrete pavement as designated by pay items in the contract proposal and as detailed and described herein or on the plans. This specification addresses existing PCC pavements with and without an existing asphalt overlays, whether to be overlaid under this contract or not.

413.02--Materials. Unless otherwise designated on the plans or in the contract documents, the joint sealing material may be cold or hot poured material meeting the requirements of Subsection 707.02.1.

The joint sealing material for sealing transverse joints in asphalt pavement shall be a hot-poured elastic type conforming to the requirements of Subsection 707.02.1.3.

The bituminous joint filling material for cleaning and filling joints shall be hot poured material meeting the requirements of Subsection 707.02.1.3, or the type designated on the plans. When asphalt is specified to fill joints, the mixture used shall be either 9.5-mm or 12.5-mm asphalt, or the same as that specified for the wearing course to be placed under this contract, if applicable.

Unless otherwise specified in the plans or in the contract documents, the aggregate materials shall be size 89. The aggregate material shall conform to the applicable requirements of Section 703.

413.03--Construction Requirements.

413.03.1--Equipment. The equipment shall be that necessary for routing, sawing, cleaning and pouring the joint material as specified. When required, heating equipment shall meet the requirements of Subsection 702.03. Pouring equipment shall be subject to the approval of the Engineer and shall be capable of pouring the joints and cracks to the required elevation while the material is at the proper temperature. Cleaning equipment shall consist of mechanical or hand operated devices capable of thoroughly cleaning the

joints, cracks and adjacent surfaces to the satisfaction of the Engineer. Air compressors shall be equipped with suitable traps and/or filters capable of removing moisture and oil from the compressed air.

The equipment for cleaning and filling joints shall be that necessary for exposing the PCC joint by removing any existing asphalt over the joint by milling or other approved methods, cleaning the joint by removing existing materials from the joint, and placing the specified joint filler materials in accordance with these specifications. Heating equipment shall meet the requirements of Subsection 702.03. Pouring equipment shall be subject to the approval of the Engineer and shall be capable of pouring the joints to the required elevation while the material is at the proper temperature. Cleaning equipment shall consist of mechanical or hand operated devices capable of removing all existing joint materials (soil, asphalt, debris) to the depth specified herein, without causing damage to the existing joint faces or the surface of the PCC pavement. Prior to filling the joint, it shall be blown free of all loose material by compressed air. Air compressors shall be equipped with suitable traps and/or filters capable of removing moisture and oil from the compressed air.

413.03.2--Construction Methods.

413.03.2.1--Cleaning and Sealing Joints and Cracks. Joints and cracks to be sealed shall be cleaned by routing, sawing and/or sand blasting to the minimum dimensions specified. Other methods of cleaning joints and cracks shall be approved by the Engineer. The surface which is to receive the new joint sealing material shall be dry and free of all lubricants, tar, asphalt, discoloration and stain as well as all other forms of contamination leaving a clean newly exposed surface. The adjacent surfaces of the pavement shall be cleaned to the extent necessary to prevent foreign matter from entering the joint before pouring. If necessary, re-cleaning shall be performed immediately prior to pouring.

Prior to pouring, suitable baffles shall be inserted in the top portion of the open joint, or other approved methods used as necessary, to control the flow of the material into the joint.

Should a joint or crack be deeper than the required dimension, a backer rod of the appropriate size shall be inserted into the opening to prevent the material from being placed in excess of the required depth.

Cracks shall be cleaned and sealed in the same manner as for joints. The Engineer may permit small cracks to be cleaned only by compressed air and sealed with joint sealing material.

Traffic shall not be allowed to travel over the sealed joints/cracks until the joint sealing material is dry enough to prevent tracking. When approved by the Engineer, the Contractor may place concrete sand or other approved material over the joint/crack to prevent tracking.

413.03.2.2--Cleaning and Filling Joints. Joints to be filled shall be cleaned by routing, sawing and/or sand blasting to the minimum dimensions specified. Other methods of cleaning joints shall be approved by the Engineer. The surface which is to receive the new joint sealing material shall be dry and free of all lubricants, tar, asphalt, discoloration

and stain as well as all other forms of contamination leaving a clean newly exposed surface. The adjacent surfaces of the pavement shall be cleaned to the extent necessary to prevent foreign matter from entering the joint before pouring. If necessary, re-cleaning shall be performed immediately prior to pouring.

The flow of the material into the joint shall be controlled before pouring by the insertion of baffles in the top portion of the open joint, or other approved methods can be used as necessary.

Should a joint or crack be deeper than the required dimension, a backer rod of the appropriate size shall be inserted into the opening to prevent the material from being placed in excess of the required depth.

After the joint is filled to the required depth with joint sealing material, add aggregate material until the joint is even with the adjacent roadway.

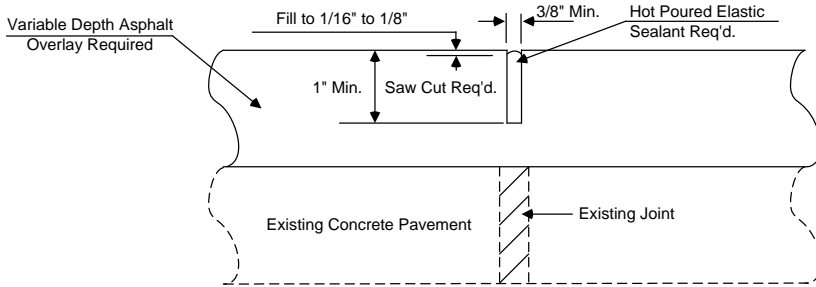
Traffic shall not be allowed to travel over the sealed joints/cracks until the joint sealing material is dry enough to prevent tracking. When approved by the Engineer, the Contractor may place concrete sand or other approved material over the joint/crack to prevent tracking.

413.03.3--Sawing and Sealing Transverse Joints in Asphalt Pavement.

413.03.3.1--General. The Contractor's operation shall be conducted so that sawcutting of transverse joints, cleaning, and sealing is a continuous operation. The entire sawing and sealing operation shall be completed within seven (7) days after the placement of the final wearing course, unless the approved traffic control plan or sequence of operations provide otherwise. Traffic shall not be allowed on sawed unsealed joints in the final wearing course.

When intermediate lifts must be exposed to traffic for over seven (7) days, the Contractor shall be required to make an interim 1/8-inch wide saw cut which is one third (1/3) as deep as the asphalt layer. This interim saw cut does not require sealing. Costs of any interim cut(s) shall be included in the pay item for sawing and sealing transverse joints in asphalt pavement.

The detail for sawing and sealing transverse joints in asphalt pavement shall be as shown below. No sawing and sealing of transverse joints will be required in Open Graded Friction Courses (OGFC). However, the lift under the OGFC will require sawing and sealing.



DETAIL OF SAWING AND SEALING TRANSVERSE JOINTS

Saw cutting shall be done only after the asphalt has cooled to ambient temperature.

413.03.3.2--Sawcutting of Transverse Joints. The Contractor shall sawcut transverse joints in the pattern and to the dimensions shown on the plans or as directed by the Engineer. The sawcut joints shall be directly over the existing portland cement concrete pavement joints and shall be accurately located by a method employing pins and stringline. The pins shall be accurately located prior to paving. Details of the Contractor's method for locating the sawcuts shall be subject to the approval of the Engineer.

The blade or blades shall be of such size and configuration that the desired dimensions of each sawcut can be made with one pass. No spacers between blades will be allowed. Either dry or wet cutting will be allowed.

The transverse sawcut joints shall normally extend the full width of the pavement unless otherwise shown on the plans or directed by the Engineer. Existing transverse joints that are offset at the longitudinal joint by more than one inch, measured between the centers of the joint cavities, shall require separate sawcuts terminating at the longitudinal joint.

413.03.3.3--Cleaning. Dry sawed joints shall be thoroughly cleaned with a stream of air sufficient to remove dirt, dust or deleterious matter adhering to the joint walls or remaining in the joint cavity. Wet sawed joints shall be thoroughly cleaned with a 50 psi minimum, water blast immediately after sawing to remove any sawing slurry, dirt or deleterious matter adhering to the joint walls or remaining in the joint cavity. Wet sawed joints shall be blown with air to provide dry joint surfaces prior to sealing.

All sawing slurry from the wet sawing process shall be immediately flushed from the pavement surface. Dry dust and material from the dry sawing process shall be blown or brushed off the pavement surface.

The Contractor shall be required to provide protective screening, subject to the approval of the Engineer, if cleaning operations are capable of causing damage to or interference with traffic in adjacent lanes.

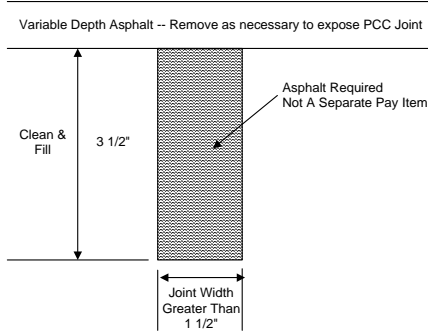
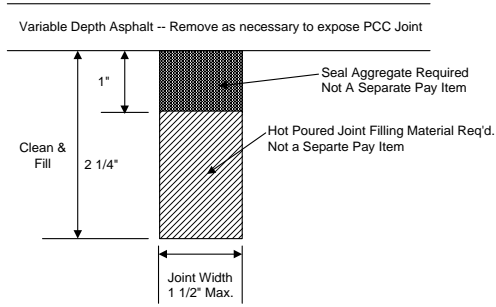
413.03.3.4--Sealing. Just prior to sealing, each joint shall be thoroughly cleaned of all foreign material and the joint faces shall be clean and surface dry when the seal is

applied.

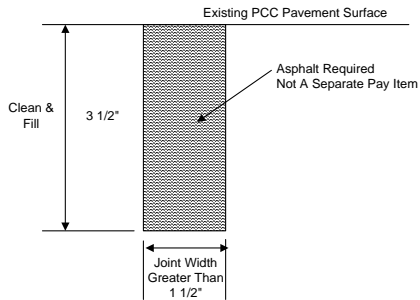
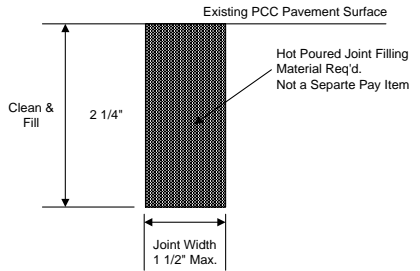
Sealant material shall be at the pouring temperature recommended by the manufacturer when applied to the joints. Hot applied sealant material shall be stirred during heating so that localized overheating does not occur.

The sealant shall fill the joint such that, after cooling, the sealed joint conforms to the details shown on the plans or as directed by the Engineer. The pouring shall be performed in such a manner that the material will not be spilled on the exposed surfaces of the asphalt pavement. Any excess material on the surface of the asphalt pavement shall be removed immediately and the pavement surface cleaned. The use of sand or similar material as a cover for the seal will not be permitted. Poured joint sealing material shall not be placed when the air temperature in the shade is less than 50°F., unless approved by the Engineer.

413.03.4--Cleaning and Filling Joints. Any existing asphalt over the joint shall be removed by milling or other approved methods so as to expose the PCC joint for cleaning and filling. All existing joint materials (soil, asphalt, debris) and any loose, spalled or delaminated materials shall be removed to the depth specified herein, without causing damage to the existing joint faces or the surface of the PCC pavement. Joints shall be filled immediately upon cleaning. The joint shall be filled to the specified depth with the required filler(s) as shown in the applicable detail. When asphalt or aggregate is placed as joint filler, the asphalt or aggregate shall be slightly mounded in the joint and compacted as directed by the Engineer to seat the asphalt or aggregate in the joint. After compaction, excess material (asphalt or aggregate) shall be removed and the pavement surface cleaned as necessary, so as to leave the asphalt or aggregate filler flush with the existing PCC pavement. Any existing asphalt over the joint which requires removal shall be replaced with either 9.5-mm or 12.5-mm asphalt or the same mixture as that specified for the wearing course to be placed under the contract, if required. The asphalt shall be properly compacted with a roller or other mechanical compaction device approved by the Engineer, either prior to opening to traffic, or prior to placement of the subsequent overall asphalt course. Placement of any required subsequent overall asphalt course shall begin upon completion of the cleaning and filling operation. For PCC pavements without existing asphalt overlays in place and which are not to be overlaid with asphalt under the contract, joints shall be cleaned and filled as described above and as shown on the applicable detail.



Joint Cleaning And Filling Detail For PCC Pavements With Existing Asphalt Overlay



Joint Cleaning And Filling Detail For PCC Pavements Without Existing Asphalt Overlay

Joints less than one-half inch in width will not be cleaned and filled.

413.04--Method of Measurement. Joint sealer material will be measured by the gallon for separate payment only when the proposal has a pay item for joint material.

Accepted joints and cracks, cleaned, sealed and/or filled, will be measured by the linear foot or mile as indicated in the contract proposal.

Cleaning and filling joints in PCC pavement will be measured by the linear foot or mile of joint. Removal of existing asphalt over the joint, joint filler aggregate, bituminous material, and the replacement of asphalt over the joint, if applicable, will not be paid for separately but will be included in the unit price per linear foot for cleaning and filling joints in PCC pavement.

Sawed and sealed joints in new asphalt pavement will be measured by the linear foot of joint complete in place and accepted by the Engineer. Sawing and joint sealant material will not be paid for as separate pay items but will be included in the unit price per linear foot for sawing and sealing transverse joints in asphalt pavement.

413.05--Basis of Payment. Joint sealer material will be paid for by the gallon when measured as prescribed above, which price shall be full compensation for all materials, equipment, tools, labor and incidentals necessary to complete the work.

Joints and cracks, cleaned, sealed and/or filled, will be paid for by the linear foot or mile as prescribed in above, which price shall be full compensation for all materials, equipment, tools, labor and incidentals necessary to complete the work.

Sawing and sealing transverse joints in new asphalt pavement, accepted and measured as prescribed, will be paid for at the contract unit price per linear foot; which price shall be full compensation for locating and transferring the location of existing joints to establish new joint locations, for all required sawing, for furnishing all materials, including joint sealant materials, for all cleaning, pouring, trimming, cleanup and disposal of all excess and waste, for protective screening; for all pertinent operations necessary and incidental to the construction as indicated herein, and for all equipment, tools, labor, and incidentals necessary to complete the work.

Cleaning and filling joints in PCC pavement, measured as prescribed above, will be paid for at the contract unit price per linear foot or mile, which price shall be full compensation for furnishing all materials including filler aggregate and bituminous material, for all work required to expose the PCC joint, for cleaning, filling, and compacting the joint, for placing any required asphalt over the joint prior to the placement of the subsequent overall asphalt course, if applicable, and the cleanup and disposal of all excess and waste; for all pertinent operations necessary and incidental to the construction as herein indicated, and for all equipment, tools, labor and incidentals necessary to complete the work.

The cost of maintenance of traffic and protective services as required by the Department's Traffic Control Plan shall be included in the cost of items bid. This shall include all required individual traffic control devices.

Payment will be made under:

413-A: Joint Sealer Material	- per gallon
413-B: Cleaning and Sealing Joints	- per linear foot or mile
413-C: Cleaning and Sealing Cracks	- per linear foot or mile
413-D: Cleaning and Filling Joints *	- per linear foot or mile
413-E: Sawing and Sealing Transverse Joints in Asphalt Pavement	- per linear foot

* Indicated if PCC Pavement

SECTION 423 - GROUND-IN RUMBLE STRIPS

423.01--Description. This work consists of grinding rumble strips at the locations indicated on the plan, in accordance with the details on the plans, and the requirements set out herein.

423.02--Blank.

423.03--Construction Requirements.

423.03.1--Equipment. The equipment shall consist of a rotary type cutting head capable of cutting rumble strips to the dimensions shown on the plans. The cutting head shall have the cutting tips arranged in such pattern as to provide a relatively smooth cut of approximately 1/8 of an inch between peaks and valleys. The cutting head(s) shall be on its own independent suspension from that of the power unit to allow the tool to self-align with the slope of the shoulder and/or any irregularities in the shoulder surface.

The finished rumble strips shall be cut to the dimensions as shown on the plans within the allowable tolerance and be perpendicular to the direction of travel. The rumble strips shall be placed in relation to the roadway according to the patterns shown on the plans.

Adequate back-up equipment such as mechanical sweeper/vacuum, water truck, etc. and personnel shall be provided to remove all grindings from the shoulder.

423.03.2--Construction Details. The cutting tool shall be equipped with guides to provide a consistent alignment of each cut in relation to the edge line and to provide uniformity and consistency throughout the project. The alignment of the cuts shall not deviate from the path of the edge line.

When the contract requires shoulder paving, the rumble strips shall be cut into the finished shoulder after the final course has been placed, otherwise, rumble strips shall be cut into the existing shoulder material. The debris/grindings generated from the cutting shall be picked up and removed on a daily basis by use of a sweeper/vacuum or other method approved by the Engineer. The shoulder shall be cleaned prior to opening the adjacent lane to traffic. Any other method of cleaning debris from the shoulder or roadway other than picking up shall be approved by the Engineer prior to beginning

construction. The use of the material from the rumble strips as RAP in the composition of asphalt mixtures shall require approval by the State Materials Engineer.

The Contractor shall demonstrate to the Engineer the ability to achieve the desired surface inside each depression without tearing or snagging the asphalt prior to beginning the work. Areas damaged by the Contractor's operations shall be corrected and/or repaired as directed by the Engineer at no additional cost to the State.

When placed on concrete shoulders, the Contractor shall adjust the spacing of the rumble strips to ensure that the depressions are not cut across a concrete shoulder joint.

This construction operation will encroach on the lane adjacent to the shoulder receiving the rumble strips. Therefore, construction on roadways under traffic will either require a lane closure or be considered as a moving operation. Traffic control shall be handled in accordance with the appropriate standard drawings shown in the plans or contract documents.

423.04--Method of Measurement. Rumble strips, ground-in, completed in accordance with the plans and specifications, will be measured by the mile, which price shall be full compensation for all materials, equipment, tools, disposal of grinding debris, any associated traffic control, and all incidentals necessary to complete the work. Length of measurement will start at the beginning of a continuous series of rumble strips and will terminate at the end of the continuous series. The length used to measure rumble strips will be the horizontal length computed along the stationed control line. Each shoulder on which rumble strips have been ground will be measured separately with the measurements from each shoulder combined to obtain the pay length for rumble strips.

423.05--Basis of Payment. Rumble strips, measured as prescribed above, will be paid for at the contract unit price per mile, which price shall be full compensation for completing the work.

The price for rumble strips shall include the cost of any required maintenance of traffic and protective services.

Payment will be made under:

- | | |
|-------------------------------------------|------------|
| 423-A: Rumble Strips, Ground-In | - per mile |
| 423-B: Rumble Strips, Ground-In, Concrete | - per mile |

DIVISION 500 - RIGID PAVEMENT

SECTION 501 - CONCRETE PAVEMENT

501.01--Description. This work consists of pavement composed of concrete, with or without reinforcement as specified, constructed in accordance with these specifications and in reasonably close conformity with the lines, grades, thicknesses, and cross sections shown on the plans or established by the Engineer. This work also consists of replacing or repairing damaged or deteriorated dowels and wooden joint filler boards.

501.02--Materials. Materials shall meet the applicable requirements of Division 700 and the following Subsections:

Fine Aggregate	703.01 and 703.02
Coarse Aggregate	703.01 and 703.03
Cement	701.01 and 701.02
Water	714.01
Air Entraining Admixtures & Additives	713.02
Calcium Chloride	714.02
Joint Filler	707.02
Curing Materials	713.01
Reinforcing Steel and Dowel Bars	711.02
Dowel Adhesive	714.11

501.02.1--Composition of Concrete.

501.02.1.1--General. The concrete mix design shall be submitted by the Contractor to the Engineer for approval prior to production. The mix proportions shall be based on a laboratory batch as described below.

- a) The combination of materials shall be those intended for use in the proposed work. Materials shall be from approved sources. Aggregate gradations, specific gravities and bulk densities shall be reported.
- b) Trial mixtures having proportions and consistencies suitable for the proposed work shall be made using the ACI 211.1 as a guide to proportion the mix design.
- c) Trial mixtures shall be designed to produce a slump within $\pm 3/4$ in. of the maximum permitted, and for air-entrained concrete, 6.0 ± 0.5 percent total air content. The temperature of freshly mixed concrete in trial mixtures shall be reported.
- d) For each proposed mixture, at least three compressive test cylinders shall be made and cured in accordance with AASHTO T 126. Each change of water-cement ratio shall be considered a new mixture. The cylinders shall be tested for strength in accordance with AASHTO T 22 and shall meet the required 28 day strength.
- e) The strength of laboratory trial mixes shall exceed 4700 psi.
- f) The laboratory trial batch mixtures shall have been made within the last three months before being submitted for approval.

501.02.1.2--Design of Mix. The mix shall be designed to meet the requirements as set out in the following table.

Design Property	Requirements
Minimum Coarse Aggregate Volume / Cubic Yard Concrete, %	72
Coarse Aggregate Size	467 or 57
Maximum Water / Cementitious Ratio	0.48
Maximum Slump, inches	3
Total Air Content, %	3 - 6
Minimum Compressive Strength, psi	3500

501.03--Construction Requirements.

501.03.1--Batching Plant and Equipment. Concrete batching and handling equipment shall meet the applicable requirements of AASHTO M 157.

501.03.2--Blank.

501.03.3--Blank.

501.03.4--Blank.

501.03.5--Placing, Spreading, and Finishing Equipment.

501.03.5.1--Finishing Machine. The finishing machine shall be equipped with at least two oscillating type reverse screeds.

501.03.5.2--Vibrators. Vibrators, for full width vibration, may be the surface pan type or the internal type with either immersed tube or multiple spuds. They may be attached to the spreader, paver, or the finishing machine, or may be mounted on a separate carriage. They shall not come in contact with the joint, reinforcing steel, load transfer devices, subgrade, or side forms. The frequency of the surface vibrators shall be at least 3,500 impulses per minute, and the frequency of the internal type shall be at least 5,000 impulses per minute for tube vibrators and at least 7,000 impulses per minute for spud vibrators.

When spud type internal vibrators, either hand operated or attached to spreaders or finishing machines, are used adjacent to forms, they shall have a frequency of not less than 3,500 impulses per minute.

501.03.5.3--Slip-Form Paver. Slip-form pavers shall be self-propelled and equipped to spread, strike-off, consolidate, screed, and float-finish the freshly placed concrete so that a minimum of hand-finishing will be necessary. The equipment shall be adjustable as to crown and superelevation, and shall shape and compact the concrete into the required cross section. The crown adjustment shall be readily controllable for accuracy in crown transitions.

The paver shall operate on tracks having sufficient contact area to prevent slippage under load. The length of ground contact per track and the arrangement of tracks shall be adequate to meet the straightedge and other riding quality requirements specified.

Screeding shall be accomplished by using either oscillating screeds or an extrusion device,

or a combination thereof.

The slip-form paver shall be equipped with traveling side or trailing forms, of sufficient dimension and strength and of proper shape, to support the concrete laterally for a sufficient length of time during placing and finishing. If trailing forms are used they shall be rigidly supported laterally.

The slip-form paver shall be equipped with automatic guidance and grade controls, which operate by sensing from a taut line set to line and grade.

Variation from the requirements detailed herein may be permitted when approved by the Department, provided the proposed variation is an improved feature for which general acceptance by the industry has been established.

501.03.5.4--Steel Placing Equipment. Equipment, as approved by the Engineer, for machine placement of reinforcement shall be factory made by a recognized manufacturer of construction equipment and shall be capable of positioning the steel at the designated location.

501.03.5.5--Transverse Texturing Device. Transverse texturing shall be produced by either tining or grooving as indicated in the plans or in the contract documents.

Other types of texturing equipment may be approved by the Department provided it produces a texture equivalent to that specified.

501.03.5.5.1--Transverse Tining. This equipment shall be a metal tine finishing device having flat steel wire tines capable of being operated to produce uniform, parallel grooves in newly placed pavement.

501.03.5.5.2--Transverse Grooving. This equipment shall be a self-propelled mechanical sawing device using diamond blades. The blades shall be arranged in such a manner to produce grooves 1/8-inch wide and 3/16-inch deep spaced in the following sequence: 3/4-inch, 1 1/8-inch, 5/8-inch, 1-inch, 5/8-inch, 1 1/8 -inch, 3/4-inch in six-inch repetitions across the width of the sawing device.

501.03.6--Miscellaneous Equipment.

501.03.6.1--Concrete Saw. When sawing joints is elected or specified, the Contractor shall provide sawing equipment adequate in number of units and power to complete the sawing to the required dimensions using an “early entry” dry cut saw approved by the Engineer.

501.03.6.2--Forms. Straight side forms shall be metal and have a thickness of at least 7/32 inch and shall be furnished in sections at least 10 feet in length. Forms shall have a depth equal to the specified edge thickness of the pavement and a base width of at least 80 percent of the depth of the forms. Flexible or curved forms of proper radius shall be used for curves of 100-foot radius or less. Flexible or curved forms shall be of a design acceptable to the Engineer. Forms shall be provided with adequate devices for secure setting so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Flange braces shall extend outward on the base not less than 2/3 the height of the form. Forms with battered top surfaces, and bent,

twisted, or broken forms shall be removed from the work. Repaired forms shall not be used until inspected and approved. Forms shall not be built-up more than one inch. The top face of the form shall not vary from a true plane more than 1/8 inch in 10 feet, and the upstanding leg shall not vary from a vertical plane more than 1/4 inch. The forms shall contain provisions for secure setting and for locking the ends of abutting form sections together tightly.

501.03.7--Preparation of Grade. The foundation upon which the concrete pavement is to be placed shall be prepared within the tolerances set out in Subsection 321.03 for at least two feet beyond the proposed pavement edge.

501.03.8--Setting Forms.

501.03.8.1--Base Support. The foundation under the forms shall be hard and true to grade so that the form, when set, will be firmly in contact for its whole length and at the specified grade. A grade at the form line which is found to be below the established grade shall be filled to grade with granular materials or bituminous plant mixture in lifts of 1/2 inch or less for the full width of the base of the form and at least 18 inches outside the base of the form, and thoroughly compacted. Imperfections or variations above grade shall be corrected by tamping or by cutting as necessary.

501.03.8.2--Form Setting. Forms shall be set sufficiently in advance of where concrete is being placed. After the forms have been set to correct grade, the grade shall be thoroughly tamped, mechanically or by hand, at both the inside and outside edges of the base of the forms. Forms shall be staked into place with at least three pins for each 10-foot section. A pin shall be placed at each side of every joint. Form sections shall be tightly locked and free from play or movement in any direction. The forms shall not deviate from true line by more than 1/4 inch at any point. Excessive settlement or springing of forms under the finishing machine will not be tolerated. Forms shall be cleaned and oiled prior to the placing of concrete.

501.03.8.3--Grade and Alignment. The alignment and grade of the forms shall be checked and corrections made by the Contractor immediately before placing the concrete. When a form has been disturbed or a grade has become unstable, the form shall be reset and rechecked.

501.03.9--Conditioning of Base.

501.03.9.1--Conditioning for Formed Pavement. High areas shall be trimmed to proper elevation. Low areas, within the tolerances set out in Subsection 321.03.7 shall be filled with concrete integral with the pavement. The finished grade of the base shall be maintained in a smooth and compacted condition until the pavement is placed.

Unless the base course is waterproof, it shall be uniformly moist when the concrete is placed.

501.03.9.2--Conditioning for Slip-Form Pavement. The base shall be brought to the tolerances set out in Subsection 321.03.7. If the density of the base is disturbed, it shall be corrected by additional compaction before concrete is placed. The grade shall be prepared sufficiently in advance of the placing of the concrete to avoid delays. If traffic is allowed to use the prepared grade, the grade shall be checked and corrected immediately ahead of

the placing of the concrete.

Unless the base course is waterproof, it shall be uniformly moist when the concrete is placed.

501.03.10--Handling, Measuring and Batching Materials. The batch plant site, layout, equipment, and provisions for transporting material shall be sufficient to assure a continuous supply of material to the work. Stockpiles shall be built up in layers of not more than five feet in thickness. Each layer shall be completely in place before beginning the next, which shall not be allowed to "cone" down over the next lower layer. Aggregates from different sources and of different gradings shall not be stockpiled together.

Aggregates shall be handled from stockpiles or other sources to the batching plant in a manner that will assure uniform grading of the material. Aggregates that have become segregated shall not be used until properly rebled. Aggregates contaminated with earth or foreign material shall not be used. All aggregates produced or handled by hydraulic methods and washed aggregates, shall be stockpiled or binned for draining at least 12 hours before being batched. Rail shipment requiring more than 12 hours will be accepted as adequate binning only if the car bodies permit free drainage. In case the aggregates contain a high or nonuniform moisture content, storage or stockpile periods in excess of 12 hours may be required by the Engineer.

The fine aggregate and each size of coarse aggregate shall be separately weighed into hoppers in the quantities set by the job-mix. Cement shall be measured by weight. Separate scales and hoppers, with a device to indicate the complete discharge of the batch of cement into the batch box or container, shall be used for weighing the cement.

Unless otherwise permitted by the contract, batching plants shall be equipped to proportion aggregates and bulk cement by weight using approved automatic and interlocked proportioning devices.

For on-site mixing, aggregates shall be transported from the batching plant to the mixer in batch boxes, vehicle bodies, or other containers of adequate capacity and construction to properly carry the volume required. Partitions separating batches shall be adequate and effective to prevent spilling from one compartment to another while in transit or being dumped. When bulk cement is used, the Contractor shall use a suitable method of handling the cement from weighing hopper to transporting container so as to assure the correct cement content in each batch. Bulk cement shall be transported to the mixer in separate and tight compartments carrying the full amount of cement required for the batch. Cement in original shipping packages may be transported on top of the aggregates with each batch containing the required number of sacks. Batches shall be delivered to the mixer separately and intact. Each batch shall be dumped into the mixer without loss of cement and, when more than one batch is carried on a truck, without spilling of material from one batch compartment into another.

Water may be measured either by volume or by weight. Unless the water is to be weighed, the water-measuring equipment shall include an auxiliary tank from which the measuring tank shall be filled. The measuring tank shall be equipped with an outside tap and valve to provide for checking the setting, unless other means are provided for readily and accurately determining the quantity of water in the tank. The volume of the auxiliary tank shall be at least equal to that of the measuring tank.

Methods and equipment for adding air entraining agent or other admixtures into the batch shall be approved by the Engineer.

The accuracy for measuring materials shall be in accordance with AASHTO M 157.

501.03.11--Mixing Concrete. The mixer shall be of an approved type and capacity. Mixing time shall be measured from the time all materials, except water, are in the drum. Ready-mixed concrete shall be mixed and delivered in accordance with requirements of Section 804.

When mixed at the site of the work or in a central mixing plant, the mixing time must provide a satisfactory mixture, and unless otherwise specified in writing by the State Materials Engineer, the mixing time shall be not less than 50 seconds. When deemed necessary to ensure a satisfactory mix, the State Materials Engineer may designate a mixing time suitable to obtain a satisfactory mixture. Four seconds will be added to the specified mixing time if timing starts the instant the skip reaches its maximum raised position. Mixing time ends when the discharge chute opens. Transfer time in multiple drum mixers is included in the mixing time. The contents of an individual mixer drum shall be emptied before a succeeding batch is placed therein.

The mixer shall be operated at the drum speed shown on the manufacturer's name plate on the mixer. All concrete mixed less than the specified time shall be discarded and disposed of by the Contractor at no cost to the State. The volume of concrete mixed per batch shall not exceed the mixer's nominal capacity in cubic feet, as shown on the manufacturer's standard rating plate on the mixer, except that an overload of up to 10 percent may be permitted provided concrete test data for strength, segregation, and uniform consistency are satisfactory, and provided no spillage of concrete takes place.

The batch shall be so charged into the drum that a portion of the mixing water enters in advance of the cement and aggregates. The flow of water shall be uniform and all water shall be in the drum by the end of the first 15 seconds of the mixing period. The throat of the drum shall be kept free of accumulations that might restrict the free flow of materials into the drum.

Mixed concrete from a central-mixing plant shall be transported in truck mixers, truck agitators, or nonagitator trucks having approved bodies. The elapsed time from when water is added to the mix until the concrete is deposited at the site of the work shall not exceed 30 minutes, 45 minutes when a retarder is used, when the concrete is hauled in nonagitator trucks, nor 60 minutes when hauled in truck mixers or truck agitators.

Retempering concrete by adding water or by other means will not be permitted. However, when concrete is delivered in transit mixers or agitators and if permitted by the Engineer, additional water may be added to the batch materials and additional mixing performed to increase the slump to meet the specified requirements, provided all these operations are performed within 45 minutes after the initial mixing operation and the total amount of water in the concrete does not exceed the mix design amount. Concrete that exceeds the maximum slump at time of placement shall not be used. Admixtures for increasing the workability or for accelerating the set will be permitted only when specifically provided for in the contract, or when permitted in writing by the Engineer.

501.03.12--Limitations of Mixing. Except in emergencies, no concrete shall be mixed or placed when the natural light will be insufficient for finishing. In case of an emergency, the Engineer may permit finishing during periods of insufficient light provided adequate and approved lighting is furnished by the Contractor.

Concrete shall not be placed on a frozen foundation, nor shall frozen aggregate be used in the concrete.

During periods of cold or expected cold weather, the limitations for beginning a concrete pour and the limitations for temperature control of the mix and its components shall be in accordance with the provisions of Subsection 804.03.16.1.

During periods of hot weather or arid atmospheric conditions the provisions of Subsection 804.03.16.2 shall be applicable.

501.03.13--Placing Concrete.

501.03.13.1--General. Concrete shall be mechanically spread in an approved manner so as to distribute the concrete uniformly without segregation. On roadside areas such as driveways and parking areas for weigh stations or roadside parks, etc. and on other small or irregular areas the concrete may be placed by other approved methods.

The rate of delivery of the concrete shall be such that the interval between the discharge of the successive loads shall not exceed 20 minutes, and when air temperature is 90°F or higher the interval shall not exceed 15 minutes. Concrete that has begun to set up shall not be placed in the work.

All concrete materials that may fall on or be worked into the surface of a completed slab shall be removed immediately by approved methods.

501.03.13.2--Formed Pavement. The concrete shall be deposited on the grade in a manner that will require as little rehandling as possible.

For paneled pavement, placing shall be continuous between transverse joints without the use of intermediate bulkheads. For continuously reinforced pavement, placing shall be continuous between construction joints without use of intermediate bulkheads. Necessary hand spreading shall be performed with shovels and not rakes. Workers shall not be allowed to walk in the freshly mixed concrete with boots or shoes coated with earth or foreign substances.

When concrete is to be placed adjoining a previously constructed lane of pavement and mechanical equipment will be operated upon the existing lane of pavement, that lane shall have attained the age of 14 days, exclusive of days on which the air temperature does not reach 35°F, or shall have attained a flexural strength of 600 pounds per square inch. If only light finishing bridges or other similar light equipment is partially carried on the existing lane, paving in the adjoining lanes will be permitted after three days.

Concrete shall be thoroughly consolidated against and along the faces of all forms and along the full length and on both sides of all joint assemblies, by means of vibrators inserted in the concrete. Vibrators shall not come in contact with a joint assembly, reinforcing steel, the base, or a side form. In no case shall the vibrators be operated longer than 15 seconds

in one location.

Concrete shall be deposited as near to expansion and contraction joints as possible without disturbing them, but shall not be dumped onto a joint assembly unless the hopper is well centered on the joint assembly.

The Contractor shall have available at all times materials for the protection of unhardened concrete in the event of rain.

501.03.13.3--Slip-Form Pavement. The Contractor shall have sufficient forms available on the project for use in the event of an emergency.

In order that the concrete may be properly protected against the effects of rain before it has sufficiently hardened, the Contractor shall have available at all times materials for the protection of the edges and surface of the unhardened concrete. Protective materials shall include standard metal forms, or wood planks having a nominal thickness of at least two inches and a nominal width of not less than the thickness of the pavement, and covering material such as burlap or cotton mats, curing paper, or plastic sheeting material. When rain appears imminent, all paving operations shall stop, and all available personnel shall begin placing forms against the sides of the pavement and covering the surface of the unhardened concrete with the protective covering.

The concrete shall be of uniform consistency and placed, shaped, consolidated, and float finished by an approved slip-form paver. The slip-form paver shall be operated off of a taut stringline or wire set by the Contractor to true grade and alignment, except that if the grade at each form line, plus the width of the track of the paver, has been constructed within the tolerance allowed at the form line in Subsection 321.03.7 the automatic control devices on the paver will not be required.

The equipment shall vibrate the concrete for the full width and depth of the strip of pavement being placed. Vibration shall be accomplished with vibrating tubes or arms working in the concrete or with a vibrating screed or pan operating on the surface of the concrete. No appreciable slumping of the in-place concrete will be allowed, and, if necessary, forms shall be trailed behind the paver to prevent slumping. If trailing forms are used, they shall be rigidly supported laterally.

The slipform paver shall be operated with as nearly a continuous forward movement as possible. If, for any reason, it is necessary to stop the forward movement of the paver, the vibratory and tamping elements shall be stopped immediately.

Where sections of pavement are to be subsequently abutted with other lanes of pavement involving longitudinal or nearly longitudinal joints, the concrete adjacent to these joints shall be placed and finished as required by standard paving methods or by use of false forms, adjacent to the slip forms. The false forms shall be metal of sufficient gage to maintain the proper shape and continuity of the form line and shall be approved by the Engineer. The use of false forms shall be subject to satisfactory performance. If the Contractor is able to construct the pavement without measurable edge slump or misalignment, the Engineer may waive the use of the false form.

When required, bracing of the forms shall be accomplished so there will not be more than 10 feet of unbraced false forms. False forms shall remain in place of a minimum of 90

minutes or until forms can be removed without damaging the adjacent concrete.

501.03.14--Test Specimens. The Contractor shall furnish the concrete necessary for test specimens. The specimens shall be made and cured as specified in Subsection 804.02.13.1.1 thru Subsection 804.02.13.1.5 at the frequency in TMD 20-04-00-000. Testing personnel shall meet the requirements in Subsection 804.02.9. Laboratory and test equipment shall meet the requirements in Subsection 804.02.8.

501.03.15--Strike-Off of Concrete and Placement of Reinforcement.

501.03.15.1--General. Reinforcing steel shall be free from dirt, oil, paint, grease, mill scale, and loose or thick rust which could impair bond of the steel with the concrete.

501.03.15.2--Bar Mat Reinforcement. When the pavement is placed in two layers, the entire width of the bottom layer shall be struck off to the length and depth that will permit the sheet of bar mat to be laid full length on the concrete in its final position without further manipulation. The reinforcement shall then be placed directly upon the bottom layer, after which the top layer shall be placed, struck off, and screeded. All concrete in the bottom layer which has been placed more than 30 minutes without being covered with the top layer shall be removed and replaced with freshly mixed concrete at no additional costs to the State. When the pavement is placed in one layer, the reinforcement may be placed in the plastic concrete after spreading, by approved mechanical or vibratory means, or it may be positioned in advance of concrete placement on supports that will withstand, without displacement, all depositing, spreading, and vibrating operations.

501.03.15.3--Continuous Reinforcement. Steel for continuously reinforced pavement shall be placed by the first of the following methods or conditionally by the second method:

- (a) Steel shall be placed sufficiently in advance of the paving operation. It shall be supported on approved chairs, positioned, and tied in accordance with the plans.
- (b) Machine placement of steel for slip-form paving will be permitted provided the Contractor satisfactorily demonstrates that the equipment used will position the steel in accordance with the plans with the exception that transverse bars will be permitted to be placed on top of longitudinal bars.

501.03.16--Joints. Joints shall be constructed of the type and dimensions and at the locations required by the plans, or as directed.

Sawing of joints shall commence as possible after the concrete has hardened and before uncontrolled shrinkage cracking occurs. The saw blades, and skid plates if early entry method is used, shall be changed as often as necessary to control and minimize spalling/raveling. A sufficient number of saws, replacement blades and skid plates shall be available at the project site to ensure that the sawing operations will proceed until completion without interruption.

Any damage to the concrete resulting from the sawing operations shall be corrected immediately after the sawing is complete at no additional costs to the State.

501.03.16.1--Longitudinal Joints. Deformed steel tie bars or transverse bars of specified length, size, spacing, and material shall be placed perpendicular to the longitudinal joints. They shall be placed by approved mechanical equipment or rigidly secured by chairs or

other approved supports to prevent displacement. Tie bars shall not be painted or coated with asphalt or other material, or enclosed in tubes or sleeves.

When adjacent lanes of pavement are constructed separately, longitudinal construction joints shall be constructed in accordance with the details shown on the plans. Tie bars, except those made of rail steel, may be bent at right angles against the form of the first lane constructed and straightened into final position before the concrete of the adjacent lane is placed.

The longitudinal center joint shall be installed so that its ends are in contact with transverse joints, if any.

Longitudinal joints shall be constructed by sawing or forming in accordance with the plans.

501.03.16.2--Transverse Expansion Joints. The expansion joint filler shall be continuous from form to form and shaped to the subgrade and to the keyway along the form. Preformed joint filler shall be furnished in lengths equal to the pavement width or equal to the width of one lane. Damaged or repaired joint filler shall not be used unless approved by the Engineer.

The expansion joint filler shall be held in a vertical position. An approved installing bar, or other device, shall be used if required to secure preformed expansion joint filler at the proper grade and alignment during placing and finishing of the concrete. Finished joints shall not deviate more than one-fourth inch in the horizontal alignment from a straight line. If joint fillers are assembled in section, there shall be no offsets between adjacent units. Plugs of concrete will not be permitted within the expansion space.

501.03.16.3--Transverse Contraction Joints. Transverse contraction joints shall consist of planes of weakness created by forming or sawing grooves in the surface of the pavement as shown on the plans and shall include load transfer assemblies when specified.

501.03.16.4--Transverse Construction Joints. Transverse construction joints shall be constructed when there is an interruption of more than 30 minutes in the concreting operation. Construction joints shall not be constructed within 10 feet of expansion joints, contraction joints, or planes of weakness. If sufficient concrete has not been mixed at the time of interruption to form a slab of at least 10 feet long, the excess concrete back to the last preceding joint shall be removed and disposed of as directed.

501.03.16.5--Load Transfer Devices. When dowel assemblies are used, the dowels shall be held in position parallel to the surface and center line of the slab.

For the slip-form method of concrete placement, dowel bars may be placed in the full thickness of pavement immediately following the paver with a vibratory inserter in lieu of using dowel assemblies. The vibratory dowel bar inserter shall be approved by the Engineer. The inserter shall vibrate the dowels into place accurately, at the proper location both vertically and longitudinally. An oscillating surface correcting beam shall follow immediately behind the inserter to correct surface deformation caused by the inserter. When a dowel bar inserter is used, a skewed joint may be permitted with the approval of the Engineer.

The entire length of each dowel will be thoroughly coated with an approved lubricant to

prevent adherence to the concrete.

501.03.16.6--Dowel Replacement. When designated on the plans, dowel replacement work shall consist of replacing damaged or deteriorated dowels in reconstructed contraction joints and both dowels and wooden joint filler boards in reconstructed expansion joints.

Dowel bars shall be the size and length designated on the plans. Wooden joint filler board shall conform to the dimensions shown on the plans.

New expansion boards shall be drilled to fit the new dowels installed. Special care shall be taken to ensure that all dowels in the joint remain parallel to the surface of the concrete.

501.03.17--Final Strike-Off, Consolidation and Finishing.

501.03.17.1--Sequence. The sequence of operations shall be the strike-off and consolidation, floating and removal of laitance, straight-edging, and final surface finish.

Concrete, as soon as placed, shall be struck off and screeded. An approved portable screed shall be used. A second screed shall be provided for striking off the bottom layer of concrete if reinforcement is used and the pavement is placed in two layers.

The screed for the surface shall be at least two feet longer than the maximum width of the slab to be struck off. It shall be of approved design, sufficiently rigid to retain its shape, and be constructed of metal or of other suitable material shod with metal.

Consolidation shall be attained by the use of a suitable vibrator or other approved equipment.

In operation the screed shall be moved forward with a combined longitudinal and transverse shearing motion, and manipulated so that neither end is raised from the side forms during the striking off process. If necessary, this shall be repeated until the surface is of uniform texture, true to grade and cross section, and free from porous areas.

In general, the addition of superficial water to the surface of the concrete to assist in finishing operations will not be permitted. If the application of water to the surface is permitted, it shall be applied as a fog spray by means of approved spray equipment.

501.03.17.2--Finishing at Joints. The concrete adjacent to joints shall be compacted or firmly placed without voids or segregation against the joint material, and also under and around all load transfer devices, joint assembly units, and other features designed to extend into the pavement. Concrete adjacent to joints shall be mechanically vibrated as required in Subsection 501.03.13.2.

After the concrete has been placed and vibrated adjacent to the joints, the finishing machine shall be brought forward, operating in a manner to avoid damage or misalignment of joints. If uninterrupted operation of the finishing machine, to, over, and beyond the joints causes segregation of concrete, damage to, or misalignment of the joints, the finishing machine shall be stopped when the front screed is approximately eight inches from the joint. Segregated concrete shall be removed from in front of and off the joint, and the front screed shall be lifted and set directly on top of the joint and the forward motion of the finishing

machine resumed. When the second screed is close enough to permit the excess mortar in front of it to flow over the joint, it shall be lifted and carried over the joint. Thereafter, the finishing machine may be run over the joint without lifting the screeds, provided there is no segregated concrete immediately between the joint and the screed or on top of the joint.

501.03.17.3--Machine Finishing. Unless otherwise specified, full width vibration shall be performed. If uniform and satisfactory density of the concrete is not obtained by the vibratory method at joints, along forms, at structures, and throughout the pavement, the Contractor shall furnish equipment and methods which will produce pavement conforming to the specifications.

501.03.17.4--Hand Finishing. Unless otherwise specified, hand finishing methods, other than the hand floating method described below, will not be permitted except under the following conditions:

In the event of breakdown of the mechanical equipment, hand methods may be used to finish the concrete already deposited on the grade when the breakdown occurs.

Narrow widths or areas where operation of mechanical equipment is impractical may be finished by hand methods.

501.03.17.5--Floating. After the concrete has been struck off and consolidated, it shall be further smoothed and trued by means of a longitudinal float, using one of the following methods as specified:

- (a) **Hand Method.** The hand-operated longitudinal float shall be at least 12 feet long and six inches wide, properly stiffened to prevent flexibility and warping. The longitudinal float, operated from foot bridges spanning but not touching the concrete, shall be worked with a sawing motion while held in a floating position parallel to the road centerline, and passing gradually from one side of the pavement to the other. Movement ahead along the centerline of the pavement shall be in successive advances of not more than one-half the length of the float. Excess water and soupy material shall be wasted over the sides on each pass.
- (b) **Mechanical Method.** The mechanical longitudinal float shall be of a design approved by the Engineer, and shall be in good working condition. The float shall be accurately adjusted to the required crown, and coordinated with the adjustments of the transverse finishing machine so that a small amount of mortar is carried ahead of the float at all times. The float shall pass over each area of pavement at least two times, but excessive operation over a given area will not be permitted. Excess water and soupy material shall be wasted over the sides on each pass.

As an alternative to the mechanical method, the Contractor may use a machine composed of a cutting and smoothing float, or floats, suspended from and guided by a rigid frame. The frame shall be carried by four or more visible wheels riding on and constantly in contact with the side forms, or track line of a slip-form paver.

If necessary, following one of the preceding methods of floating, long-handled floats having blades at least five feet long and six inches wide may be used to smooth and fill in open-textured areas in the pavement. Long-handled floats shall not be used to float the entire surface of the pavement in lieu of, or to supplement, one of the preceding methods

of floating. When strike-off and consolidation are done by the hand method and the crown of the pavement will not permit the use of the longitudinal float, the surface shall be floated transversely by means of the long-handled float. Care shall be taken not to work the crown out of the pavement during the operation. After floating, excess water and laitance shall be removed from the surface of the pavement by a straightedge 10 feet or more in length. Successive drags shall be lapped one-half the length of the blade.

501.03.17.6--Straight-Edge Testing and Surface Correction. After the floating has been completed and while the concrete is still plastic, the surface of the concrete shall be tested with a 10 foot straightedge. For this purpose the Contractor shall furnish and use an accurate 10-foot straightedge swung from handles three feet longer than one-half the width of the slab. The straightedge shall be held in contact with the surface in successive positions parallel to the road centerline and the whole area gone over from one side of the slab to the other as necessary. Advance along the road shall be in successive stages of not more than one-half the length of the straightedge. All depressions found shall be immediately filled with freshly mixed concrete, struck off, consolidated, and refinished. High areas shall be cut down and refinished. Special attention shall be given to assure that the surface across joints meets the requirements for smoothness. Straightedge testing and surface corrections shall continue until the entire surface is found to be free from observable departures from the straightedge, and the slab conforms to the required grade and cross section.

501.03.18--Final Finish. The surface finish of the concrete shall be that designated on the plans and in the bid schedule of the contract. If a finish is not designated, the finish shall be a drag finish.

501.03.18.1--Drag Finish. This finish shall consist of a uniform surface of gritty texture produced by dragging a seamless strip of damp burlap or cotton fabric longitudinally along the full width of pavement. For pavement 16 feet or more in width, the drag shall be mounted on a bridge which travels on the forms or track line. The dimensions of the drag shall be such that a strip of burlap or fabric at least three feet wide is in contact with the full width of pavement surface while the drag is used. The drag shall consist of at least two layers of burlap with the bottom layer approximately six inches wider than the upper layer. The drag shall be maintained in a condition that will produce a surface of uniform appearance with corrugations approximately one-sixteenth inch in depth. Drags shall be maintained clean and free from encrusted mortar. Drags that cannot be cleaned shall be discarded and new drags substituted.

501.03.18.2--Broom Finish. A broom finish shall be applied when the water sheen has practically disappeared. The broom shall be drawn from the center to the edge of the pavement with adjacent strokes slightly overlapping. The brooming operations shall produce corrugations in the surface that are uniform in appearance and not more than 1/16 inch in depth. Brooming shall be completed before the concrete has set to a degree that the surface will be torn or unduly roughened by the operation. The finished surface shall be free from rough and porous areas, irregularities, and depressions. Brooms shall be of the quality, size, and construction and operated so as to produce a surface finish meeting the approval of the Engineer. Subject to satisfactory results being obtained and approval of the Engineer, the Contractor will be permitted to substitute mechanical brooming in lieu of manual brooming as herein described.

501.03.18.3--Belt Finish. When straight-edging is complete and the water sheen has

practically disappeared and just before the concrete becomes nonplastic, the surface shall be belted with a two-ply canvas belt eight inches wide and at least three feet longer than the pavement width. Hand belts shall have suitable handles to permit controlled, uniform manipulation. The belt shall be operated with short strokes transverse to the road centerline and with a rapid advance parallel to the center line. Subject to satisfactory results being obtained and approval of the Engineer, the Contractor will be permitted to substitute mechanical belting in lieu of manual belting as herein described.

501.03.18.4--Transverse Tine Finish. The surface shall first be given a drag finish. After completion of the drag finish, the pavement shall be given an additional texture by transverse tining.

The final surface texture shall be produced with a metal tine finishing device meeting the requirements of Subsection 501.03.5.5. The texturing device shall be so constructed and operated as to produce uniform parallel grooves perpendicular to the centerline of the pavement 1/2 inch on centers and having a depth of 1/8 inch, plus or minus 1/32 inch.

The metal tine device shall be operated by approved mechanical means when texturing main roadway pavement lanes. Manual methods may be used for texturing small irregular areas inaccessible to the texturing machine.

The depth of the finished grooves will be determined by the use of a standard commercial tire tread depth measuring gauge with 1/32 inch graduations that can be easily and accurately read, a brass wire brush, and a steel straightedge approximately 1/4 inch x 1 inch x 12 inches. The Contractor shall furnish this equipment for use by and subject to the approval of the Engineer. The method of measuring the depth of grooves will be as set out in Department SOP.

If for any reason the concrete hardens to the extent that the tining equipment does not provide grooving in accordance with these requirements, or if rainfall damages the finish and the Engineer permits the concrete to remain in place, the Contractor shall use other approved devices such as saws to construct the grooves substantially in accordance with the requirements specified herein.

501.03.18.5--Transverse Grooved Finish. After the concrete has cured for a minimum of seven (7) days, areas to be transverse grooved shall be grooved with a sawing device meeting the requirements of Subsection 501.03.5.5.2. Grooves shall be perpendicular to the centerline of the roadway and extend as close as possible to the edge but in no case more than two (2) feet from the edge, gutter line, etc. The tolerance for the width of the groove is +1/16" to -0" and the tolerance for the depth and spacing of the grooves is $\pm 1/16$ ".

501.03.18.6--Edging at Forms and Joints. After the final finish, but before the concrete has taken its initial set, the pavement along each side of each slab, and on each side of transverse expansion joints, formed joints, transverse construction joints, and emergency construction joints shall be worked with an approved tool and rounded to the radius required by the plans. A well-defined and continuous radius shall be produced and a smooth, dense, mortar finish obtained. The surface of the slab shall not be unduly disturbed by tilting of the tool during use.

At all joints, all tool marks appearing on the slab adjacent to the joints shall be eliminated by brooming the surface. In doing this, the rounding of the corner of the slab shall not be

disturbed. All concrete on top of the joint filler shall be completely removed.

All joints shall be tested with a straightedge before the concrete has set, and correction made if one side of the joint is higher than the other, or if they are higher or lower than the adjacent slabs.

501.03.19--Surface Test. It is the intent of these specifications that the finished surface will have good riding qualities.

The smoothness of the surface will be determined by using an Inertial Profiling System (IPS) that meets the requirements of Subsection 401.02.6.9 to measure and record roughness data in each designated location. Roughness data for each longitudinal profile will be reported as a mean roughness index (MRI). MRI is calculated by averaging the international roughness index (IRI) values from the two wheelpath profiles. The surface shall be tested and corrected to a smoothness index as described herein with the exception of those locations or specific projects that are excluded from smoothness testing with an IPS.

The smoothness of the surface will be determined for traffic lanes, auxiliary lanes, climbing lane and two-way turn lanes. Areas excluded from a smoothness test with the IPS are acceleration and deceleration lanes, tapered sections, transition sections for width, shoulders, crossovers, ramps, side street returns, etc. The roadway pavement on bridge replacement projects having 1,000 feet or less of pavement on each side of the structure will be excluded from a smoothness test. Pavement on horizontal curves having a radius of less than 1,000 feet at the centerline and pavement within the super elevation transition of such curves are excluded from smoothness testing. Smoothness testing shall terminate 15 feet from each transverse joint that separates the pavement from a bridge deck, bridge approach slab or existing pavement not constructed under the contract.

During initial paving operations, either when starting up or after a long shut down period, the pavement surface will be tested with profilograph as soon as the concrete has cured sufficiently to allow testing. Membrane curing damaged during the testing operation shall be repaired by the Contractor. The purpose of this testing is to aid the Contractor and the Engineer in evaluating the paving methods and equipment. Smoothness measurements must be performed at the posted speed limit or 50 miles per hour (± 5 miles per hour), whichever is lower. This speed requirement will be waived for all lightweight profilers. Measurements will be made in both wheel paths of exterior and interior lanes. The wheel paths shall be designated as being located three feet (3') and nine feet (9') from centerline or longitudinal joint, respectively. Beginning and ending latitude and longitude coordinates shall be required on each smoothness test. Testing will also be required on sections that have been surface corrected. No smoothness testing shall be performed when there is moisture of any kind on the pavement surface.

The surface will be accepted on a continuous basis for pavement smoothness. Continuous reporting is based upon all MRI values for a specified running interval. These values are averaged and presented at the midpoint of the specified running interval. The last 15 feet of a day's work may not be obtainable until the work is continued and for this reason may be included in the subsequent section.

Smoothness tolerances shall be applied to concrete pavements based on the following pavement categories:

Category A applies to the following pavement constructions.

- New construction projects

Category B applies to the following pavement constructions.

- Rehabilitation projects

For all projects, the surface smoothness data shall be reported by two MRI methods.

1. A continuous 528-foot long interval MRI report
2. A continuous 25-foot short interval MRI report

Category A projects shall have a long interval surface MRI of not more than 60 inches per mile. Areas of the surface with localized roughness greater than 130 inches per mile as determined by the continuous short interval report will be identified for correction by the Project Engineer.

Category B projects shall have a long interval surface MRI of not more than 70 inches per mile. Areas of the surface with localized roughness greater than 140 inches per mile as determined by the continuous short interval report will be identified for correction by the Project Engineer.

Areas of localized roughness exceeding the continuous 25-foot interval thresholds shall be corrected regardless of the 528-foot interval MRI value of the section. Surface correction by grinding shall be performed in accordance with Subsection 401.02.6.7. The Contractor shall also make other necessary surface corrections to ensure that the final mean roughness index of the section meets the above requirements.

Corrections shall be made using an approved profiling device or by removing and replacing the pavement as directed by the Engineer. Corrective work shall be performed at no additional cost to the State.

Each area or section of pavement removed shall be at least 10 feet in length and at least the full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joints that is less than 10 feet in length shall also be removed and replaced. The new surface shall be textured as specified in the contract.

Where surface corrections are made, the Contractor shall reestablish the surface texture to a uniform texture equal in roughness to the surrounding uncorrected pavement. This work shall be at no additional cost to the State.

Corrective work shall be completed prior to determining pavement thickness.

501.03.20--Curing and Protection. Immediately after the finishing operations have been completed and as soon as marring of the concrete will not occur, the entire surface of the newly placed concrete shall be covered and cured in accordance with one of the following methods. On hot or windy days, and when directed by the Engineer, the surface of the fresh concrete shall be kept damp by fogging with water until the normal curing operation

can be performed. In all cases in which curing requires the use of water, the curing shall have prior right to all water supplies. Failure to provide sufficient cover material of whatever kind the Contractor may elect to use, or lack of water to adequately take care of both curing and other requirements, shall be cause for immediate suspension of concreting operations. The concrete shall not be left exposed for more than 1/2 hour between stages of curing or during the curing period. Unless otherwise specified, the curing period shall be 72 hours.

501.03.20.1--White Pigmented Membrane. The entire surface of the pavement shall be sprayed uniformly with white pigmented curing compound immediately after the finishing of the surface and before the set of the concrete has taken place. The curing compound shall not be applied during rainfall or when there is a water sheen on the pavement.

Curing compound shall be applied under pressure at the rate of one gallon to not more than 150 square feet for all surface finishes except transverse grooving. For transverse groove finishes, the application shall be at the rate of one gallon to not more than 120 square feet. The spraying equipment shall be of the fully atomizing type equipped with a tank agitator. At the time of use, the compound shall be in a thoroughly mixed condition with the pigments uniformly dispersed throughout the vehicle. During application, the compound shall be stirred continuously by effective mechanical means. Hand spraying of odd widths or shapes and on concrete surfaces exposed by the removal of forms will be permitted. Curing compound shall not be applied to the faces of joints to be sealed, and those faces shall be cured by other approved means for at least 72 hours.

The curing compound shall be of such character that the film will harden within 30 minutes after application. Should the film become damaged from any cause within the curing period, the damaged portions shall be repaired immediately with additional compound.

Upon removal of side forms, the sides of the slabs exposed shall be protected immediately to provide a curing treatment equal to that provided for the surface.

501.03.20.2--White Polyethylene Sheeting. The top surface and sides of the pavement shall be entirely covered with polyethylene sheeting. The pieces used shall be lapped at least 18 inches. The sheeting shall be so placed and weighted down that it will remain in direct contact with the surface covered. The sheeting shall be wide enough to extend 18 inches beyond the edges of the slab being cured.

501.03.20.3--Curing in Cold Weather. When concrete is being placed and the air temperature may be expected to drop below 35°F, a sufficient supply of straw, hay, grass, or other suitable blanketing material shall be provided to protect the work. The Contractor shall be responsible for the quality and strength of the concrete placed during cold weather, and all concrete injured by frost action shall be removed and replaced at no additional cost to the State. The Department reserves the right to perform destructive or nondestructive testing for evaluation of damage caused by cold weather.

501.03.20.4--Protection of Pavement. The Contractor shall protect the pavement from both public traffic and traffic caused by employees and agents. This shall include watchmen to direct traffic and the erection and maintenance of warning signs, lights, pavement bridges, or crossovers, etc. The plans or special provisions will indicate the location and type of device or facility required to protect the work and provide adequately for traffic. The Contractor shall have materials available at all times to protect unhardened

concrete from rain.

All damage to the pavement, occurring prior to final acceptance, shall be repaired or the pavement replaced.

501.03.21--Removing Forms. Except for auxiliary forms used temporarily in widened areas or unless otherwise provided, forms shall not be removed from freshly placed concrete until it has set for at least 12 hours. Forms shall be removed carefully so as to avoid damage to the pavement. After the forms have been removed, the sides of the slab shall be cured as outlined in one of the methods indicated in the previous subsection. Honeycombed areas shall be satisfactorily repaired.

501.03.22--Sealing Joints. Joints to be sealed shall be filled with joint sealing material meeting the requirements of Subsections 707.02.1.3 or 707.02.1.4, as shown on plans, and Subsection 707.02.1.5 before the pavement is opened to traffic, and as soon after completion of the curing period as is feasible.

501.03.22.1--Cleaning. Joints shall be clean, dry and frost free when the sealant is applied. Formed joints shall be thoroughly cleaned to remove all form release agents, curing compound residue, laitance, or any other foreign materials. All joints shall be thoroughly cleaned by sandblasting each face separately to the depth of the sealer and backer rod. The cleaning operation of existing joints shall ensure that the concrete joint surfaces which are to receive the new joint sealant and backer rod are free of all debris, discoloration and stain; as well as any and all other forms of contamination. If a clean exposed concrete surface cannot be obtained by sandblasting, the joints shall be refaced with a power driven concrete saw with diamond and/or abrasive blades. The refaced joints shall be washed and sandblasted as set forth above. Immediately prior to installation of the backer rod, the joints shall be cleaned with compressed air which is free of moisture and oil. Wiping fingers on cleaned surface of joints shall not show evidence of dust. The joints shall be completely free of sand, oil and moisture.

Material in expansion joints shall be removed to the required depth with a power saw and/or router in such a manner as not to damage the expansion material which is to remain in place.

501.03.22.2--Installing Backup Material. After the final cleaning, a resilient rod type backup material shall be installed with a positioning device to ensure conformity with the dimensions shown on the plans. The rod shall be compatible with the sealant and no bond or reaction shall occur between the rod and the sealant.

501.03.22.3--Installing Sealant. The installation of the sealant is to be performed as soon after placing the backer rod as reasonably possible to ensure that joints are still clean and dry. In the event a joint does become contaminated, damp, or wet, the backer rod is to be removed and the joint cleaned and dried with a new backer rod reinstalled prior to placing the sealant. The ambient temperature at time of placement must be 40°F or higher. The sealant shall be applied by pumping only. The pump shall be of sufficient capacity to deliver the necessary volume of material to completely fill the joint to the specified width and height of sealant in one pass. The nozzle shall be of sufficient size and shape to introduce the sealant inside the joint with sufficient pressure to prevent voids occurring in the sealant and force the sealant to make contact with the joint faces. The sealant shall be tooled to provide the specified recess depth, thickness and shape as shown on the plans.

Sufficient force or pressure shall be applied to the sealant in this tooling operation to force the sealant against the joint faces to ensure satisfactory wetting and bonding. The sealant shall be placed to reasonably close conformity with dimensions and shape shown on the plans. Any unreasonable deviation will be cause for rejection and necessary corrective action will be made by the Contractor.

501.03.22.4--Cleaning Pavement. After a joint has been sealed, all surplus sealant on the pavement shall be promptly removed.

501.03.23--Opening to Traffic. The Engineer will decide when the pavement may be opened to traffic. The pavement shall not be opened to traffic until test specimens have attained a compressive strength of 3500 pounds per square inch. If such tests are not performed, the pavement shall remain closed to traffic for 14 days, or 28 days if Type IP cement or Type I or II cement with fly ash is used, from the date of placement. Prior to opening to traffic, the pavement shall be cleaned.

501.03.24--Tolerance in Pavement Thickness. The thickness of the pavement will be determined from cores taken in accordance with Subsection 501.03.24.1 and tested in accordance with Subsection 700.03. Holes remaining in the pavement after coring shall be completely filled by the Contractor, at no additional cost to the State, with concrete of the same quality as used to construct the pavement.

It is anticipated that when concrete pavement is placed over an asphalt treated base, the concrete may penetrate the asphalt treated base. Volumes of concrete that penetrate the asphalt treated base will not be included in the volume of concrete pavement to be paid for.

When cores are taken to determine the thickness of concrete pavement, it is anticipated a layer of asphalt treated base will adhere to the bottom of the core. Prior to determining the thickness of the concrete pavement, all particles of asphalt treated base will be removed from the bottom of the core. Measurement of core thicknesses will be made from top of concrete pavement to the top of the asphalt treated base.

501.03.24.1--Thickness Determination. For the purpose of establishing adjusted unit prices for pavement, units to be considered separately are defined as 1000 linear feet of pavement in each traffic lane. Each traffic lane will be divided into units of 1000 feet of pavement, excluding exceptions and omissions, beginning at the end of the pavement nearest the Beginning of Project. The last unit in each lane will be the length remaining except that if the length is less than 100 feet, it will be included in the previous unit. Each project under the same contract will be separated into units independently of the other projects. One core will be taken at random by the Department in each unit. If the measurement of the core from a unit is not deficient more than 0.2 inch from the plan thickness, full payment will be made. When the measurement is deficient by more than 0.2 inch and not more than 1.0 inch from the plan thickness, that measurement will represent the one-third of the section in which it falls, and one additional core will be taken at random in each of the remaining thirds of the section. The average thickness of these three cores will determine the average thickness for that unit. An adjusted unit price as provided in Subsection 501.05.2 will be paid for the unit represented.

Other areas such as intersections, entrances, crossovers, ramps, etc., will be considered as separate units, and the thickness of each unit will be determined separately. Small irregular unit areas may be included as part of another unit. The areas to be included in each unit

will be predetermined. At points the Engineer may select at random in each unit, one core will be taken for each 1000 square yards of pavement, or fraction thereof, in the unit. If the core taken is not deficient more than 0.2 inch from the plan thickness, full payment will be made. If the core is deficient in thickness by more than 0.2 inch but not more than 1.0 inch from plan thickness, two additional cores will be taken at random from the area represented and the average of the three cores determined. If the average measurement of these three cores is not deficient more than 0.2 inch from the plan thickness, full payment will be made. If the average thickness of the three cores is deficient more than 0.2 inch but not more than 1.0 inch from the plan thickness, an adjusted unit price as provided in Subsection 501.05.2 will be paid for the area represented by these cores.

In calculating the average thickness of the pavement, measurements which are in excess of the specified thickness by more than 0.2 inch will be considered as the specified thickness plus 0.2 inch, and measurements which are less than the specified thickness by more than 1.0 inch, excluding exploratory cores, will be considered as the specified thickness minus 1.0 inch in the average.

When the measured thickness of a core is less than the plan thickness by more than 1.0 inch, the actual thickness of the pavement in this area will be determined by taking exploratory cores at not less than 10 foot intervals parallel to the centerline in each direction from the affected location until in each direction a core is found which is not deficient by more than 1.0 inch. Areas found deficient in thickness by more than 1.0 inch will be evaluated by the Engineer; and if in the judgment of the Engineer, the deficient areas warrant removal, they shall be removed and replaced with pavement of the thickness shown on the plans without cost to the Department. If the Engineer determines that the deficient areas do not warrant removal, the pavement may be left in place with no payment to the Contractor, or may be removed and replaced at the Contractor's option. Exploratory cores for deficient thickness will not be used in averages for areas for adjusted unit price.

501.03.24.2--Alternate to Coring. For contracts that involve the placement of less than 7,500 square yards of pavement, cores will not be taken unless the State Materials Engineer elects to do so.

For such contracts, the Project Engineer's measurements will be used to determine the pavement thickness as follows:

The Engineer will accurately measure, by taut stringline or instrument from referenced grades, and record the grade on which the pavement is to be placed. After the pavement is in place, the Engineer will accurately measure and record the grade of the top of the pavement above each point where the initial measurements were made.

From the measurements thus made, the thickness of each area will be determined, unless the State Materials Engineer elects to take the cores as provided in this subsection. In the latter case the measurements made from cores will govern.

501.03.24.3--Pavement Cracking. Concrete pavement with full-depth cracks or misplaced joints shall be removed and replaced at no additional expense to the Department. Load transfer devices shall be established in these replaced panels in a manner sufficient to meet the designed load transfer requirements of the original pavement.

Any partial depth surface cracking or other surface distress shall be immediately repaired

by the Contractor at no additional expense to the Department. The Contractor shall submit to the Engineer for concurrence, a plan describing the materials and methods to be used when making these repairs. Concurrence with the plan does not relieve the Contractor from providing a satisfactory repair at the time of final inspection of the project. Should the repair fail to produce satisfactory results prior to the final inspection of the project, the Contractor shall develop and submit a new plan for repairing the cracked or distressed areas.

501.04--Method of Measurement. Concrete pavement will be measured by the square yard complete in place and accepted. The width for measurement will be the plan width, including widening where called for, or as otherwise authorized in writing by the Engineer. The length will be measured horizontally in accordance with Section 109.

Where integral or raised edge curb is constructed, the width of the pavement will include the width of the curb.

When specified for payment, expansion joints complete and accepted, will be measured by the linear foot.

Reinforced concrete lug anchors will be measured by the linear foot.

Reinforcement and other materials for which no pay item is included in the contract will not be measured for separate payment.

When rehabilitating existing pavement, dowels will be measured per each and wooden joint filler board shall be measured by the linear foot. All concrete removed will be measured by the square yard under pay item 202-B.

When a pay item is included in the contract, transverse grooving will be measured by the square yard, complete in place and accepted. For bridge decks, the quantity will be computed by measuring the limits of transverse grooving shown in the plans. When not shown, the quantity will be computed by measuring the bound area between the face of barrier rail and the length of the span. For concrete and bridge end pavements, the quantity will be computed by measuring by the limits of transverse grooving shown in the plan. When not shown, the quantity will be computed by measuring the bound area between the edge of pavement and the length of the pavement.

501.05--Basis of Payment.

501.05.1--General. Concrete pavement will be paid for at the contract unit price per square yard, adjusted when applicable in accordance with Subsections 501.05.2 and 501.05.3.

Expansion joints will be paid for at the contract unit price per linear foot.

Reinforced concrete lug anchors will be paid for at the contract unit price per linear foot.

Transverse grooving, measured as prescribed above, will be paid for at the contract unit price per square yard, which price shall be full compensation for all grinding, cleaning and sweeping, and for all labor, equipment, tools and incidentals necessary to complete the work.

When rehabilitating existing pavement, dowel bars and expansion board will be paid for at the contract unit price per each and linear foot, which shall be full compensation for furnishing all labor, equipment, tools and materials to complete the work. No separate payment will be made for cutting off dowel bars left in the existing pavement. Unless otherwise noted, the price for dowel replacement work shall include the cost of continuous maintenance of traffic and protective services as required by the Department's Traffic Control Plan. This shall include all required individual traffic control devices.

The prices thus paid shall be full compensation for completing the work.

Payment will be made under:

- 501-A: ___" Reinforced Cement Concrete Pavement,
 _____ Finish - per square yard
- 501-B: ___" Plain Cement Concrete Pavement, _____ Finish - per square yard
- 501-C: ___" Continuously Reinforced Cement Concrete
Pavement, _____ Finish - per square yard
- 501-D: Expansion Joints with Dowels - per linear foot
- 501-E: Expansion Joints without Dowels - per linear foot
- 501-F: Concrete Lug Anchors - per linear foot
- 501-G: Dowels, Drilled and Installed - per each
- 501-H: Dowels, Installed - per each
- 501-I: Joint Filler, Wooden Board - per linear foot
- 501-J: Blank
- 501-K: Transverse Grooving - per square yard

501.05.2--Price Adjustments for Thickness. Where the average thickness of pavement determined in accordance with Subsection 501.03.24.1, or with Subsection 501.03.24.2, is deficient in thickness by more than 0.2 inch, but not more than 1.0 inch, payment will be made at an adjusted price as specified in the following table:

Thickness Deficiency Inches	Proportional Part of Contract Price Allowed
0.0, 0.1, 0.2	100 percent
0.3	80 percent
0.4	72 percent
0.5	68 percent
0.6, 0.7, 0.8	57 percent
0.9, 1.0	50 percent

When the thickness of an area of pavement is deficient by more than 1.0 inch and, in the judgment of the Engineer, the deficient area should be removed, the area shall be removed and replaced at no additional costs the State with pavement of the specified thicknesses. If, in the judgment of the Engineer, the deficiency does not warrant removal, the deficient area may be left in place with no payment to the Contractor, or may be removed and replaced at no additional cost to the Department, at the Contractor's option.

501.05.3--Price Adjustments for Smoothness. For all concrete projects, when the MRI for the final surface is less than or equal to forty-five inches per mile (45.0 inches / mile) on the long interval report, a unit price increase will be added. The adjusted unit price will be computed using the contract unit price of the concrete pavement. This adjusted unit price will apply to the total area for the lane width represented by given segment. Projects will be considered for incentive pay based on the following guidelines for the long interval surface lift MRI.

Mean Roughness Index (inches / mile)	Contract Price Adjustment (Per Square Yard of PCC Pavement)
less than 30.0	plus 0.64 percent
30.0 to 35.0	plus 0.48 percent
35.1 to 40.0	plus 0.32 percent
40.1 to 45.0	plus 0.16 percent
45.1 to 50.0	100 percent
Over 50.0	100 percent (With Correction to Required MRI)

In addition to the above pay incentive factors, a project may be subject to a disincentive when the MRI for the final surface exceeds the allowable tolerance. This applies to all project categories and will correlate to the maximum allowed long interval MRI.

Mean Roughness Index (inches / mile)	Adjustment Price (Per Square Yard of PCC Pavement)
Above 20.1 Over	REMOVE AND REPLACE
15.1 to 20.0 Over	minus 3.2 percent
10.1 to 15.0 Over	minus 2.4 percent
5.1 to 10.0 Over	minus 1.6 percent
0.1 to 5.0 Over	minus 0.8 percent
Required Surface MRI	100 percent

Note: All incentives and disincentives will be based on a single smoothness test, following all required localized roughness (short interval) corrective action, of the newly paved surface.

Corrective action must be taken on those sections that exceed the 'Remove and Replace' threshold on the Long Continuous Interval as directed by the Project Engineer. Additional smoothness testing shall be required on sections following replacement and will be required to meet *at least* the maximum surface MRI short of 'Remove and Replace' tolerance.

For concrete pavement other than main-line pavement, the surface will be tested using a

10-foot straightedge at locations selected by the Engineer. The variation of the surface from the testing edge of the straightedge between any two contacts, longitudinal or transverse with the surface, shall not exceed 1/4 inch. Irregularities exceeding the specified tolerances shall be corrected, at no additional cost to the State, by the Contractor with an approved profiling device or by other means as directed by the Engineer. Following correction, the area will be retested to verify compliance with the specified tolerances.

SECTION 502 - CONCRETE BRIDGE END PAVEMENT

502.01--Description. This work consists of bridge end pavement of concrete with reinforcement as shown on the plans, constructed in one course on a prepared base in accordance with these specifications, and in reasonably close conformity with the lines, grades, thickness, and cross section shown on the plans or as directed.

502.02--Materials. On bituminous paving contracts, concrete for this work may be Class "B" Structural Concrete meeting the applicable requirements of Subsection 804.02. Sampling and testing of concrete for acceptance and control purposes shall be in accordance with Subsection 804.02.3.

Reinforcing steel shall meet the requirements of Subsection 711.02.

502.03--Construction Requirements.

502.03.1--General. The requirements specified for concrete pavement in Section 501, shall apply in all respects to bridge end pavement except where otherwise indicated in the specific requirements below, or on the plans.

When the plans specify a certain thickness of asphalt under the bridge end pavement, the Contractor may substitute Class "B" Structural Concrete base in lieu of the asphalt. The concrete base shall be constructed in one course on a prepared base in accordance with these specifications, and in reasonably close conformity with the lines, grades, thickness, and typical cross-sections as shown on the plans or as directed. The concrete base will be allowed to cure 24 hours prior to placement of the bridge end pavement. A one-inch premolded expansion joint will be required along the face of the paving bracket. See Section 403 for measurement and payment of substituted concrete base material.

502.03.2--Specific Requirements.

502.03.2.1--Final Screeding and Finishing. The final screeding shall be performed by hand methods. The concrete shall be screeded longitudinally using the bridge floor for a gauge on one end, and a temporary bulkhead cut and securely installed true to crown and grade on the other end. In the event the concrete pavement, adjacent to the bridge end pavement, has been previously poured, the end of the pavement shall be used as a gauge in lieu of the temporary bulkhead. The final finish of the bridge end pavement shall be that designated on the plans. If a finish is not designed, the finish shall be transverse tined finish.

502.03.2.2--Joints. Concrete bridge end pavement shall be constructed monolithically, unless construction joints are specifically indicated on the plans.

502.04--Method of Measurement. Concrete bridge end pavement, complete in place and accepted, will be measured as specified in Subsection 501.04.

502.05--Basis of Payment. Concrete bridge end pavement will be paid for at the contract unit price per square yard in accordance with the methods as provided in Subsection 501.05, which price shall be full compensation for completing the work.

Payment will be made under:

502-A: Reinforced Cement Concrete Bridge End Pavement - per square yard

SECTION 503 - REPLACEMENT OF CONCRETE PAVEMENT

503.01--Description. This work consists of replacing continuously reinforced concrete pavement (CRCP), jointed reinforced concrete pavement (JRCP), or plain jointed concrete pavement (JCP) and the removal and replacement of base materials at locations designated on the plans or as determined by the Engineer, all in accordance with the plans and specifications.

503.02--Materials. Materials shall meet the requirements of Subsection 700.01 and the following Subsections of Division 700, Materials and Tests.

Cement	701.01 and 701.02
Fine Aggregate	703.01 and 703.02
Coarse Aggregate	703.01 and 703.03
Concrete Admixtures	713.02
Water	714.01
Concrete Reinforcement Bars	711.02
Longitudinal Joint Filler	707.02
Curing Materials	713.01

503.03--Construction Requirements.

503.03.1--Equipment. Equipment shall meet the requirements set out in Section 501 for hand placement and finishing concrete pavement. Batching and mixing equipment shall meet the applicable requirements of Section 804. On-site mixers or truck mixers will be permitted.

503.03.2--Removal of Existing Pavement.

503.03.2.1--General. Existing pavement shall be removed in accordance with details shown on the plans and as specifically set out herein. Removal will be measured for payment as set forth in Section 202. The Contractor shall dispose of the concrete in accordance with Section 201.

Equipment and methods used in all of the work shall not damage any of the underlying base and materials that are to remain in place. All materials which are removed from the roadway shall be disposed of daily.

503.03.2.2--Jointed Reinforced Concrete Pavement (JRCP). The removal of existing

reinforced concrete pavement shall be accomplished by sawing the full thickness of the pavement along the edge of the repaired areas as shown on the plans and/or as directed by the Engineer.

503.03.2.3--Continuously Reinforced Concrete Pavement (CRCP). The pavement within the lap area shall not be disturbed, damaged, or removed until the continuity of the concrete and steel has been severed between the failed area and the lap area. This shall be accomplished by sawing the full thickness of the pavement along the edge of the lap area. Jack hammers used for cutting and removal of the concrete in the lap area shall not exceed 20 pounds.

The concrete in the lap area shall be removed in such a manner to result in a near vertical face at the saw line of the repair area. A chipping type removal is required to prevent spalling the bottom of the pavement to remain. Any spalling in excess of one and one-half inches shall be corrected by enlarging the repair area at no additional cost to the State. All shattered and damaged concrete shall be removed and the exposed faces cleaned.

The reinforcing steel in the lap area shall not be bent more than four inches in twenty inches from its original position. Where more than 10 percent of the steel is damaged in the lap area along any one edge of a removed area, the patch shall be enlarged at no additional cost to the State to provide the specified lap. Where less than 10 percent of the steel is damaged, the bars may be repaired by welding.

The steel shall be inspected for excessive rusting and evidence of distress during the removal process. The Engineer may enlarge the patch to remove deteriorated steel from the lap area. When the patch is enlarged by the Engineer, payment will be made for such removal.

503.03.2.4--Plain Jointed Cement Concrete Pavement (JCP). The removal of existing plain concrete pavement shall be accomplished by sawing the full thickness of the pavement along the edge of the repaired areas as shown on the plans and/or as directed by the Engineer.

503.03.3--Removal of Base Material. Base material referred to herein and on the plans shall be all types of material below the pavement that requires removal and backfill. The material shall be removed to the dimensions and depths designated by the Engineer. Removal of all undercut materials shall be in accordance with Section 202 and measured for payment by the square yard of base. The Contractor shall dispose of the material in accordance with Section 201.

503.03.4--Installation of Smooth Dowel Bars. Smooth dowel bars shall be installed in accordance with details shown on the plans and as specifically set out herein.

The commercial grout system used shall be one of the systems specified in Subsection 714.11.7. Installation and acceptance procedures are also included therein.

After the dowel bars are installed, the placement of reinforcing steel and any other work that may disturb the setting of the grout will not be permitted.

503.03.5--Installation of Tie Bars. The tie bars, except when directed otherwise on the plans, shall be No. 5 deformed bars, 30 inches long, placed on 24-inch centers and grouted

using a commercial grout. The drilled holes shall be partially filled with an epoxy grout and the tie bars inserted to ensure that the holes are completely filled.

The commercial grout system used shall be one of the systems specified in Subsection 714.11.7. Installation and acceptance procedures are also included therein.

After the tie bars are installed, the placement of reinforcing steel and any other work that may disturb the setting of the grout will not be permitted.

503.03.6--Base and Pavement Replacement. Repair of the base and pavement shall conform to the requirements set forth herein and details shown on the plans. The exposed faces of the concrete pavement, the soil cement base and/or polyethylene covering the base repair shall be sprayed with water just prior to pouring the new slab.

The applicable provisions of Section 501 shall be adhered to with the following exceptions:

- (a) Concrete. Structural concrete for pavement repair shall be made of cement or cement with additives and/or admixtures. The use of additives or admixtures shall be in accordance with the manufacturer’s instructions. The Contractor shall submit a proposed concrete mix design to the Mississippi Department of Transportation Materials Division for approval at least two weeks prior to use on the project.

This concrete shall also meet the requirement for a compressive strength of 3500 psi within 72 hours. To meet these requirements, a Type F or G high range water reducing admixture shall be used. If the ambient temperature is less than 50°F, the addition of a Type C or E acceleration admixture shall be used. The usage of admixtures shall be in accordance with manufacturer’s instructions.

Air Content	3 to 6%
Slump	8” maximum*

* No requirement for an initial slump before the addition of the high range water reducer.

Field verification trial mix results must be provided to the Engineer prior to placement if there is no previous data to verify strength.

- (b) Forms. The forms may be metal or wood. Where at all possible, the forms shall be metal. Metal form shall meet the requirements of Subsection 501.03.6.2 and the wood forms shall be made of 2 x 8 lumber. Forms shall be graded to a specified elevation as directed by the Engineer.
- (c) Longitudinal Joints. Where a repair area is required to extend across a longitudinal joint, a preformed or sawed longitudinal joint shall be constructed and sealed as shown on the plans or as directed by the Engineer.
- (d) Consolidating and Finishing. All concrete shall be thoroughly consolidated by internal vibration. Finishing may be performed by either machine or hand methods. All patches less than 20 feet in length shall be screeded longitudinally unless otherwise permitted by the Engineer.

The surface of the pavement shall be finished as designated elsewhere in the contract and in accordance with the applicable portions of Section 501.

The screed shall be metal of a type used on bridges for finishing short patches and may be a mechanical or bridge type on long patches exceeding 20 feet. All replacement concrete shall be checked longitudinal with a 10-foot straightedge in accordance with Subsection 501.03.19 for concrete pavement other than main-line pavement.

- (e) Curing and Protection. Concrete cylinders used to represent the minimum compressive strength shall be field cured and cured by the same methods used on that portion of the roadway it represents. If the ambient temperature is less than 50°F, the field cured cylinders shall be placed in an insulated box.

The concrete repair area shall be cured up until the time of opening to traffic. All exposed surfaces, including vertical surfaces, shall be cured immediately after finishing operations have been completed.

Curing and protection shall be in accordance with Subsection 501.03.20. White pigmented curing compound shall be used and the sprayer shall be equipped with a container having a capacity of not less than five gallons and maintain a constant pressure by mechanical means. Curing time shall be continued until the concrete has attained the required compressive strength as evidenced by test specimens.

- (f) Concrete Saw Cuts. The saw cut shall be at the locations and depth shown on the plans.
- (g) Contraction Joint Assembly. Contraction joint assemblies shall be installed as per the details shown in the plans.
- (h) Concrete Placement. Limitations on placing continuously reinforced concrete pavement are set forth in the following schedule:

CONCRETE PAVING SCHEDULE DURING DAYTIME HOURS

<u>Predicted High Temperature</u>	<u>Hours of Daytime Placement</u>
Below 70°F	Daylight hours
70° - 84°F	12:00 Noon to Sundown
85° - 89°F	1:30 PM to Sundown
90°F & Above	3:00 PM to Sundown

Note: The National Weather Service's predicted high temperature for the day shall govern. Unless lighting provisions have been made for nighttime work, sufficient time must be allowed for the finishing operation prior to sundown but no less than 30 minutes will be permitted.

CONCRETE PAVING SCHEDULE DURING NIGHTTIME HOURS

During nighttime operations, concrete pours may be made anytime between sundown and sunrise without regard to predicted high temperatures.

503.03.7--Opening to Traffic. The traffic lane shall be opened within 72 hours of concrete placement and may be opened earlier if a 2500 psi compressive strength is obtained and verified by a cylinder break or maturity meter probe. The approval of the Engineer must be obtained prior to opening the lane. Side forms shall be removed and the shoulder repaired with asphalt pavement, and the area cleared of equipment and waste materials prior to opening to traffic.

The sampling and testing frequency for concrete test cylinders shall be at least two cylinders per day per section of lane for which an individual lane closure is effected and concrete pavement is replaced.

The Contractor must make arrangements to have the concrete compressive cylinders tested by an acceptable commercial laboratory. Results from laboratory tests may be accepted verbally to expedite the opening of traffic to a section of closed roadway, but the Contractor must furnish the Engineer with certified test reports within three days. Any misrepresentation of test cylinders which allows traffic to be opened in areas that did not meet minimum requirements will result in the Contractor removing and replacing the repair(s) represented by the cylinder at no additional cost to the State.

If the Contractor has previously developed the strength/maturity relationship for the mixture, an approved maturity meter probe may be used to determine concrete strengths. A maturity meter probe shall be inserted into the last concrete placed that represents the pavement area to be tested. The maximum amount of concrete which may be represented by a maturity meter probe is 50 cubic yards. The pavement may be opened to traffic when maturity meter reading indicates that the required in place strength is obtained.

Procedures for using the maturity meter and developing the strength/maturity relationship shall follow the requirements of AASHTO T325. Validation of the maturity curves shall be made at least once for every 500 cubic yards produced of each concrete mixture used. Validation of the maturity curve shall be considered acceptable when the results of compressive strength tests are within 10% of the predicted value determined by the maturity curve. If the 10% requirement is not met, the existing maturity curve shall no longer be used and a new maturity curve shall be developed prior to continuing to use the maturity method to estimate the in-place compressive strength.

Technicians using the maturity meter or calculating strength/maturity graphs shall be required to have at least two hours of training prior to using the maturity equipment. Training and maintaining a list of approved maturity technicians shall be the responsibility of the Mississippi Concrete Industries Association.

503.04--Method of Measurement. Replacement of the concrete pavement will be measured for payment by the square yard complete in place. Saw cuts will be measured for payment by the linear foot when a pay item is included in the contract proposal. Concrete for base repair will be measured by the cubic yard complete in place. Smooth dowel bars and tie bars will be measured per each complete in place.

No separate measurement will be made for reinforcing steel, wire mesh, longitudinal joints, polyethylene sheeting and asphalt pavement for repair of shoulders and maintenance of traffic items required.

The plans may also provide for welding of the reinforcing steel as an optional method available to the Contractor. This method reduces the width of the lap area from 20 inches to eight inches which will reduce the size of the repair areas. If the Contractor elects to use the optional method, the subsequent reduction in plan quantities will not be justification for adjustment of contract unit prices as provided in Subsection 104.02.

503.05--Basis of Payment. The accepted quantities of saw cuts, concrete for base repairs, smooth dowel bars, tie bars, and concrete pavement will be paid for at the contract unit prices which shall be full compensation for completing the work, furnishing all labor, equipment, tools, materials, and bituminous plant mix required for shoulder repair. Removal and disposal of pavement and base materials shall be made under appropriate items under Section 202.

The price for each item of work shall include the cost of continuous maintenance of traffic and protective services as required by the Department's Traffic Control Plan. This shall include all required individual traffic control devices.

Payment will be made under:

503-A: ___" and Variable <u>Type</u> Concrete Pavement, <u>Type</u> Finish	- per square yard
503-B: Saw Cut, Longitudinal Joints	- per linear foot
503-C: Saw Cut, ___"	- per linear foot
503-D: Concrete for Base Repair	- per cubic yard
503-E: Tie Bars, No. ___ Deformed, Drilled and Epoxied or Grouted	- per each
503-F: ___" Smooth Dowel Bars, Drilled and Epoxied or Grouted	- per each

SECTION 508 - SILICONE SEALED JOINTS

508.01--Description. This work shall consist of cleaning and sealing joints in accordance with the plans and these specifications.

508.02--Materials. The silicone sealant material used in this construction shall meet the requirements of Subsection 707.02.1.4. The backer rod shall meet the requirements of Subsection 707.02.1.5.

508.03--Construction Requirements.

508.03.1--Cleaning. Joints shall be clean, dry and frost free when the sealant is applied. Formed joints shall be thoroughly cleaned to remove all form release agents, curing compound residue, laitance, or any other foreign materials. All joints shall be thoroughly cleaned by sandblasting each face separately to the depth of the sealer and backer rod. The cleaning operation of existing joints shall ensure that the concrete joint surfaces which are to receive the new joint sealant and backer rod are free of all debris, discoloration and stain, as well as any and all other forms of contamination. If a clean exposed concrete surface cannot be obtained by sandblasting, the joints shall be refaced with a power driven concrete saw with diamond and/or abrasive blades. The refaced joints shall be washed and sandblasted as set forth above. Immediately prior to installation of the backer rod, the joints shall be cleaned with compressed air which is free of moisture and oil. Wiping fingers on cleaned surface of joints shall not show evidence of dust. The joints shall be completely free of sand, oil and moisture.

Material in expansion joints shall be removed to the required depth with a power saw and/or router in such a manner as not to damage the expansion material which is to remain in place.

508.03.2--Installing Backup Material. When shown as a requirement of the contract and after the final cleaning, a resilient rod type backup material shall be installed with a positioning device to ensure conformity with the dimensions shown on the plans. The rod shall be compatible with the sealant and no bond or reaction shall occur between the rod and the sealant. Unless otherwise designated, the rod diameter shall be one-eighth of an inch (1/8") greater than the joint width.

508.03.3--Installing Silicone Sealant. The installation of the sealant is to be performed as soon after placing the backer rod as reasonably possible to ensure that joints are still clean and dry. In the event a joint does become contaminated, damp, or wet, the backer rod is to be removed and the joint cleaned and dried with a new backer rod reinstalled prior to placing the sealant. The ambient temperature at time of placement must be 40°F or higher. The sealant shall be applied by pumping only. The pump shall be of sufficient capacity to deliver the necessary volume of material to completely fill the joint to the specified width and height of sealant in one pass. The nozzle shall be of sufficient size and shape to introduce the sealant inside the joint with sufficient pressure to prevent voids occurring in the sealant and force the sealant to make contact with the joint faces. This is especially critical in large joints. The sealant, if not of the self-leveling type, shall be tooled to provide the specified recess depth, thickness and shape as shown on the plans. Sufficient force or pressure shall be applied to the sealant in this tooling operation to force the sealant against the joint faces to ensure satisfactory wetting and bonding. The sealant shall be placed to reasonably close conformity with dimensions and shape shown on the plans. Any unreasonable deviation will be cause for rejection and necessary corrective action will be made by the Contractor.

508.03.4--Cleaning Pavement. After a joint has been sealed, all surplus sealant on the pavement shall be promptly removed.

508.03.5--Opening to Traffic. Traffic shall not be permitted over the sealed joints until the sealant is tack free.

508.04--Method of Measurement. Silicone sealed joints will be measured by the linear foot.

508.05--Basis of Payment. Silicone sealed joints will be paid for at the contract unit price per linear foot, which shall be full compensation for satisfactorily completing the work.

The price for this work shall include the cost of continuous maintenance of traffic and protective services as required by the Department's Traffic Control Plan. This shall include all required individual traffic control devices.

Payment will be made under:

508-A: Silicone Sealed Joints - per linear foot

SECTION 510 - REPAIR OF CONCRETE PAVEMENT

510.01--Description. This work consists of surface preparation, including cleaning, and placement of polymer concrete in spalled areas of concrete pavement, or other areas directed by the Engineer, in accordance with these specifications and in reasonably close conformity with the lines and grades of the existing pavement.

510.02--Materials. The polymer concrete shall be one of the approved materials listed in the MDOT's "Approved Products List" under the List of Approved Rapid Setting Commercial Grouts and Patching Compounds for use in the repair of punch-outs (spall repairs) in concrete pavements.

510.03--Construction Requirements.

510.03.1--Surface Preparation. All spall areas one inch in diameter or larger shall be cleaned and prepared for receiving the polymer concrete. The Contractor shall remove all loose, cracked or deteriorated concrete from the spalled areas using a mason or shop hammer and if necessary, a jack hammer not larger than 20 pounds. Spalled areas shall first be sand blasted, or other method approved by the Engineer, until concrete exhibits an obvious color change, and then air blasted to remove all loose debris.

510.03.2--Manufacturing and Placing of Polymer Concrete. Spalled areas must be completely dry prior to priming and placement of polymer concrete. Priming resin shall be mixed according to the manufacturer's published recommendations. The entire area of spalls plus an additional two inches around the circumference of the area shall be primed using a brush. Priming resin may be allowed to gel prior to placing resin/aggregate. The resin shall be mixed with the aggregate in accordance with the manufacturer's recommendation until the aggregate is thoroughly wetted with the resin.

The Contractor shall first fill, tamp, trowel and screed the spalled area parallel to the centerline of the roadway, then apply a surface coat of dry graded aggregate and tamp into wetted aggregate to provide skid resistance.

The polymer concrete shall be allowed to cure for two (2) hours prior to opening the area to traffic.

510.04--Method of Measurement. Graded aggregate and resin used in polymer concrete pavement repair of spalled areas will be measured by the cubic foot of aggregate and by

the gallon for resin. Catalyst will not be measured for separate payment.

510.05--Basis of Payment. Graded aggregate and resin, measured as provided above, will be paid for at the contract unit price per cubic foot of aggregate and gallon of resin, which price shall be full compensation for all surface preparation, cleaning, priming, placing of polymer concrete, disposal of all surplus material; and for all materials, equipment, tools, labor and incidentals necessary to complete the work.

Payment will be made under:

510-A: Graded Aggregate - per cubic foot

510-B: Resin - per gallon

SECTION 511 - PREROLLING EXISTING PAVEMENT

511.01--Description. This work consists of prerolling existing pavement to determine construction procedures required under other provisions of the contract.

511.02--Blank.

511.03--Construction Requirements.

511.03.1--Equipment. The roller shall consist of a single-axle trailer-type roller or a loaded truck having a single rear axle. The axle shall be loaded to a gross weight equal to or greater than the maximum legal load for a tandem axle on the highway on which the project is located but not to exceed 25 tons, and the Contractor shall provide the means necessary for the Engineer to determine that these weight requirements are being met.

The wheels shall be equipped with pneumatic tires capable of being inflated to a minimum inflation pressure of 100 psi. Tires may contain liquid if the Contractor so desires. The Contractor shall provide the Engineer with verification of gross axle weight and tire pressures.

If a trailer type roller is used, it shall be towed by a rubber tired prime mover capable of maintaining a speed of two miles per hour. The prime mover with roller attached shall be capable of executing a 180° turn within a width of 30 feet.

511.03.2--Protection. Rolling shall be conducted so as to avoid damage to existing structures and features designated to remain. Damage to such structures and features shall be repaired or the items replaced, in kind, at no additional cost to the State. The loaded roller shall not encroach upon bridge end pavement or, in the absence of bridge end pavement, within 20 feet, or greater distance when directed, of bridge abutments except under specific authority granted to cross a bridge.

Live loadings on any bridge shall not exceed the statutory loading permitted on the bridge except the Department may consider an overload permit for individual cases. All pertinent information, including proposed frequency and size of loadings and type and exact location of bridges shall be furnished the Department in order that a comprehensive study may be made.

Loading limits on bridges under the jurisdiction of agencies other than the Department are set by the agencies, independently of statutory limits and the Department.

511.03.3--Construction Methods. The sequence of rolling and the operating speed of the roller shall meet the approval of the Engineer. A roller coverage is defined as a single pass over a single traffic lane.

Generally, one coverage will be sufficient to determine slabs requiring treatment. Extra coverages may be required when necessary to confirm slabs to be treated.

It is the intent of this specification to hold the rolling operation to a minimum, and rolling coverages considered unnecessary by the Engineer are to be omitted.

Prerolling may begin as early as 4:00 A.M. and continue as long as the surface temperature of the pavement remains below 85°F.

The above work shall be included and correlated with the general sequence of operations set out in Subsection 403.03.5.2.

511.04--Method of Measurement. Prerolling will be measured by the square yard. The area of prerolling will be computed by using the horizontal length along the centerline of the roadway and the width, unless otherwise specified, of the concrete pavement in or under the traffic lane being prerolled.

Only areas designated by the Engineer to be rolled will be measured for payment. Preliminary and stability testing as provided in Section 512 will not be included in measurement for prerolling.

511.05--Basis of Payment. Prerolling will be paid for at the contract unit price per square yard, which shall be full compensation for completing the work.

Payment will be made under:

511-A: Prerolling - per square yard

SECTION 512 - PRESSURE GROUTING CONCRETE PAVEMENT

512.01--Description. This work consists of locating unstable concrete pavement, drilling of holes and the pumping of a slurry type grout mixture to stabilize and underseal the pavement. The grout mixture shall form a hard and insoluble mass that will effectively fill the voids. Pavement that remains unstable after an initial undersealing and stabilizing attempt shall be re-grouted as directed by the Engineer.

When an asphalt overlay is required, it shall be the Contractor's responsibility to schedule operations in such a manner that the first course of overlay will be placed at the earliest practicable time and no later than fourteen days after the pavement has been stabilized.

When designated on the plans, this work shall also consist of drilling holes in the shoulder adjacent to cracks at the edge of the pavement and the pumping of a slurry type grout

mixture to fill the cracks to the surface of the cement treated shoulder. If in the Engineer's opinion, the type of grout being used proves to be unsatisfactory, the Contractor shall switch to a Type 5 grout at no change in contract price.

512.02--Materials. Materials used in the work shall meet the requirements specified in the following Sections or Subsections:

Cement Types I or III	701
Calcium Chloride, Type I *	714.02
Fly Ash, Class C or F	714.05
Water	714.01.1 and 714.01.2
Fine Aggregate **	703.18
Limestone Dust	512.02.1

* The Materials Engineer may approve other commercially available accelerators which may be substituted for calcium chloride.

** Fine aggregate shall meet the requirements of Subsection 703.18 except that mortar making properties are not required.

512.02.1--Limestone Dust. The source of the material shall be approved by the Engineer and meet the following gradation requirements:

SIEVE	PERCENT PASSING
No. 30	95 - 100
No. 200	20 - 100

512.02.2--Proportioning Grout Mixture. The bid item will designate the type or types of grout mixture which shall consist of proportions listed in the table below. The mixing water shall be that quantity which will produce a grout of such consistency that the time of efflux from the flow cone will be a minimum of 16 seconds and a maximum of 22 seconds. Upon approval of the Engineer, a wetting agent may be added to the water to reduce surface tension and increase flowability of the grout mixture.

The consistency will be determined by Mississippi Test Method MT-56. Cement, fly ash, limestone dust, and/or fine aggregate may be added in the proper proportions to a mixed batch to produce the required consistency provided the cement factor is not reduced to less than specified.

**Grout Mixtures
Percent by Weight Of Dry Materials**

Dry Materials	Types	
	5	6
Cement	30	25
Fly Ash	70	-
Fine Sand	-	75
Calcium Chloride	*	*

* As prescribed in Subsection 512.03.1

It shall be the Contractor's responsibility to have the grout mixture in its final position

within one hour after adding the mixing water.

512.03--Construction Requirements.

512.03.1--Weather Limitations. Pressure grouting shall not be performed when the subgrade contains an abnormal amount of moisture as evidenced by standing water on the pavement or in joints or cracks. The air temperature shall be above 40°F in the shade or 35°F and rising before starting any grout pumping operation.

The following temperature ranges shall control the quantity of calcium chloride to be included in the grout mixture:

<u>Atmospheric Temperature</u>	<u>Percent Calcium Chloride By Weight Of Cement</u>
35 - 55°F	5
56 - 69°F	4
70 - 79°F	3
80 - 89°F	2
90°F and above	1

The quantity shall be as prescribed unless otherwise directed by the Engineer. Upon approval of the Engineer, the calcium chloride may be reduced in quantity or eliminated as required with the use of Class "C" fly ash. The calcium chloride shall be thoroughly pre-mixed in the mixing water.

512.03.2--Equipment. The equipment shall be that customarily used in pressure grouting of earthen embankments or mud-jacking of concrete pavement. It shall consist of no less than the following:

- (a) Air compressors of sufficient capacity for operating pneumatic equipment.
- (b) Pneumatic equipment with a drill size that is compatible with the size of the pump discharge nozzle. The equipment shall be in satisfactory operating condition and operated in such a manner as to prevent unnecessary damage to the pavement.
- (c) Equipment for accurately measuring and proportioning by volume or weight the component materials of the grout.
- (d) A mixer capable of thoroughly mixing the grout in an approved manner. A batch type and concrete mixing trucks may be used for Type 6 grout mixtures. A colloidal mixer must be used for Type 5 grout mixtures.
- (e) A positive action pump capable of forcing grout into voids and cavities beneath the pavement. The pump shall be capable of producing a discharge pressure range of 50 to 200 pounds per square inch of the end of the discharge pipe. The pumping system shall be equipped with a pressure gauge so that any instantaneous change in pressure can be detected by the inspector.
- (f) A stop watch and flow cone conforming to the dimensions and other requirements set out in the Department's SOP for Mississippi Test Method: MT 56.
- (g) Testing equipment shall consist of a tandem axle truck with dual wheels and the rear axles shall be loaded to 50 kips evenly distributed. The measuring equipment shall consist of no less than two gauges mounted on a measuring device that is capable of detecting movement of 0.001 of an inch. A driver and sufficient personnel shall be available to assist in preliminary testing, when required by the contract, and stability testing.

- (h) Equipment to measure pavement lift shall consist of no less than four gauges mounted on a measuring device or devices that is capable of detecting movement on each side of a joint or crack and the adjoining shoulder simultaneously. The equipment shall make such measurements to 0.001 of an inch.

512.03.3--Testing.

512.03.3.1--General. When testing is required, it is intended to locate all pavements having a deflection exceeding 0.030 of an inch. Testing may begin as early as 4:00 A.M. and continue as long as the surface temperature of the pavement remains below 85°F.

512.03.3.2--Preliminary Testing by the Department. When the pavement has been tested and marked by the Department, preliminary testing will not be required by the Contractor.

512.03.3.3--Preliminary Testing by the Contractor. When the contract includes a unit bid price for testing and it has not been performed by the Department, all of the project or designated areas shall be tested by the Contractor. Testing shall be performed as follows:

One set of gauges will be positioned on each side of a joint or crack near the pavement edge. The gauges will be zeroed with no load on either side of the joint or crack. The test truck will then be moved into position and stopped with the center of the nearest test axle about one foot from the joint or crack and the outside test wheel about one foot from the pavement edge. The gauges will be read and the test truck will then move across the joint or crack to a similar position for a second reading of the gauges. This operation will be repeated for each joint or crack to be tested. The inspector will be responsible for reading the gauges and subsequent recording. All locations with movement of more than 0.030 of an inch will require pressure grouting.

When testing shoulders, gauge positioning and testing shall be the same as indicated above for roadway pavement. The Engineer may adjust the position of the gauges to meet field conditions.

512.03.3.4--Stability Testing. After the designated areas have been pressure grouted in accordance with these specifications, they shall be retested in accordance with Subsection 512.03.3.3 when the contract includes a unit bid price for testing.

Any undersealed pavement with movement of 0.030 of an inch or more shall be re-grouted and tested as directed.

Any pavement which continues to show movement in excess of that specified after two properly performed groutings may be accepted, or the slab may be removed and replaced as directed by the Engineer.

512.03.4--Drilling Holes. The hole pattern and pumping sequence shown on the plans shall be used, except when modified to use drilling holes made from previous undersealing work. The Contractor may alter the hole pattern with the Engineer's approval. However, only the actual number of holes drilled will be measured for payment.

The holes shall be of a size and shape that best provide a positive seal for the pumping nozzle. The holes shall be drilled to a depth of approximately eight inches below the

bottom of the concrete for the initial undersealing unless the Engineer approves an alternate depth. The number, depth and location of holes for undersealing after the initial operation shall be approved by the Engineer.

When pressure grouting cracks located in the shoulders at the edge of the pavement, the holes in the shoulders shall be located as shown on the plans or as directed by the Engineer. These holes are to be drilled below the treated base.

512.03.5--Cleaning Holes. Prior to pumping the grout, compressed air shall be used to remove debris and to help provide a passage for the grout.

512.03.6--Pumping the Grout. The nozzle of the discharge hose shall be secured in the hole in a manner that provides a seal adequate to maintain the grout pressure underneath the slab. The nozzle end shall not extend below the bottom of the concrete. Pumping will continue until a clear flow of grout protrudes from an adjacent hole, joint or crack, or until the pavement begins to lift. This procedure will be repeated in other holes until all voids are supposedly filled. Plugging of holes during grouting operations will not be permitted.

Additional evidence that grouting should cease is a rapid rise of the pavement, or a rise of the adjacent shoulder. A minimum lifting of the pavement will generally be required to move grout into the cavities and voids, however, the lifting shall not exceed 0.050 of an inch. Movement of the pavement and adjacent shoulder will be monitored by the Contractor with equipment as required by Subsection 512.03.2(h). Care shall be taken not to crack the pavement by differential lifting. During pumping, very close attention shall be given to the lift measuring device to prevent excessive pumping pressures.

Moderate to major pavement cracks or pavement broken during the pumping operation due to the Contractor's negligence will be repaired or removed and replaced at the Contractor's expense.

512.03.7--Clean Up and Opening to Traffic. Deposits of mud and/or grout on the pavement or shoulders shall be removed and the surface cleaned before traffic is permitted on the section. Other debris, bags, spillage, etc., shall be removed from the right-of-way each day.

Traffic shall not use the undersealed pavement for at least three hours after grouting. Grouting operations shall cease at least three hours before sundown or earlier as necessary to permit the grout to harden at least three hours.

512.03.8--Permanently Sealing Holes. When pavement is not to be overlaid all grout shall be removed from the holes to the bottom surface of the concrete pavement and filled with a stiff sand-cement mixture or an approved quick setting patching material. Filled holes that ravel out or become damaged shall be repaired. All holes from previous undersealing work that were used by the Contractor shall also be similarly repaired at no cost to the Department.

512.03.9--Stability Tests. The test shall not be conducted until the undersealed pavement has been open to traffic for at least twelve hours. These tests shall be conducted in accordance with Subsection 512.03.3.4. Based upon these test results the pavement will be accepted or designated for further undersealing or replaced as directed by the Engineer.

512.04--Method of Measurement. Holes drilled at locations and to the depths shown on the plans or directed by the Engineer will be measured per each. Additional holes required for subsequent undersealing operations will be measured per each.

Cement incorporated into the grout mixture will be measured by the pound.

Calcium chloride incorporated into the completed work in accordance with the provisions of the contract will not be measured for separate payment. Costs associated with calcium chloride shall be included in other items bid.

When required, preliminary testing in accordance with Subsection 512.03.3.3 will be measured by the mile, calculated as a linear horizontal measure for each lane of roadway.

Stability testing at each joint or crack in accordance with Subsection 512.03.3.4 will be measured per each lane joint or each lane crack, up to a maximum of three tests.

512.05--Basis of Payment. Holes will be paid for at the contract unit price per each, which price shall be full compensation for drilling and sealing the hole.

The cement incorporated into the grout mixture will be paid for at the contract unit price per pound, which price shall be full compensation for furnishing materials to be incorporated into the specified type of grout mixture, for all hauling, mixing, pumping and clean-up required to stabilize the pavement.

Preliminary testing will be paid for at the contract unit price per mile, which price shall be full compensation for furnishing all testing equipment, the load test truck and necessary personnel to assist in the testing.

Stability testing will be paid for at the contract unit price per each test and shall be full compensation for furnishing all testing equipment, the load test truck and necessary personnel to assist in the testing.

Cost for maintenance of traffic and individual traffic control devices as required by the Department's Traffic Control Plan shall be included in the unit prices for pressure grouting and will not be measured for separate payment under the provisions of Sections 618 and 619.

Payment will be made under:

512-A: Holes *	- per each
512-B: Cement Pressure Grout Slurry, Type _____	- per pound
512-C: Preliminary Testing	- per mile
512-D: Stability Testing, Lane Joint	- per each
512-E: Stability Testing, Lane Crack	- per each

* Indicate "In Shoulders" when holes are required in shoulders

DIVISION 600 - INCIDENTAL CONSTRUCTION

600.01--General. Unless otherwise specified, all testing of hydraulic cement concrete in Division 600 shall be in accordance with the requirements of Subsection 601.02.1.

SECTION 601 - STRUCTURAL CONCRETE

601.01--Description. This work consists of furnishing and placing hydraulic cement concrete for specified structures in accordance with these specifications and in reasonably close conformity with the lines, grades, and dimensions shown on the plans or established by the Engineer.

Structural concrete will be divided into two groups. One group will be designated as Structural Concrete. The other group will be designated as Structural Concrete, Minor Structures. Unless otherwise specified in the contract, Structural Concrete, Minor Structures, will include inlets, catch basins, junction boxes, pipe headwalls, and pipe collars, regardless of the concrete quantity required for each of these structures; and other small structures containing less than 3.00 cubic yards of concrete each.

601.02--Materials.

601.02.1--General. Materials for structural concrete and their use, care, and handling shall be in accordance with Subsection 804.02. Sampling and testing will be in accordance with TMD-20-04-00-000 or TMD-20-05-00-000, as applicable.

601.02.2--Classification of Concrete. Concrete for this work shall be the class specified on the plans or in the bid schedule of the contract. Classes of concrete are identified in Subsection 804.02.6.

601.02.3--Precast Units. Design standards normally contemplate that structural concrete will be cast in place. However, the Contractor may request approval from the Engineer to furnish and install precast units in lieu of cast-in-place units. The request shall be accompanied by detailed drawings of the precast units and design data certified by a registered Professional Engineer as to structural and functional adequacy.

The foundation for precast units shall be carefully shaped to the precise contour and grade of the bottom of the unit before the unit is placed.

Precast units which are to be joined to other units shall be designed and manufactured with proper and adequate joints. Joints shall be sealed with a joint material meeting the applicable requirements of Section 707.

MDOT Drawing Sheet Nos. PCU-1 and PCU-2 address Department's approved precast drainage units. The Contractor must make a request to the Project Engineer for approval to use precast units other than the ones shown on Drawing Sheet No. PCU-1 or PCU-2. Precast drainage unit tops are only allowed on units shown on Drawing Sheet No. PCU-1. Cast-In-Place drainage unit tops are required on units shown on Drawing Sheet No. PCU-2.

No additional payment will be allowed for precast units approved for use. Pay items and quantities will be as in cast in place in accordance with design standards.

601.03--Construction Requirements.

601.03.1--Composition of Concrete. The composition of the concrete shall be in accordance with Section 804.

601.03.2--Batching. Measuring and batching of component materials shall be in accordance with the applicable provisions of Section 804.

601.03.3--Mixing and Conveying Concrete. Concrete shall be mixed and conveyed in accordance with the applicable provisions of Subsection 804.03.5.

601.03.4--Cold or Hot Weather Concreting. Requirements for placement, protection, and curing of concrete during cold or hot weather are stipulated in Subsection 804.03.16.

601.03.5--Consistency. The slump of the concrete, determined in accordance with the provisions of Subsection 700.03, shall conform to the applicable requirements of Section 804.

601.03.6--Falsework and Forms.

601.03.6.1--Falsework. Falsework shall be in accordance with the applicable provisions of Subsection 804.03.13.

601.03.6.2--Forms. Forms shall conform to the requirements of Subsection 804.03.14.

601.03.6.3--Removal of Falsework, Forms, and Housing. The removal of falsework, forms, and the discontinuance of heating, shall be in accordance with the provisions and requirements of Subsection 804.03.15, except that the concrete shall conform to the following compressive strength requirements:

Wingwall and Wall Forms not Under Stress	1000 psi
Wall Forms under Stress	2200 psi
Backfill and Cover clear	2400 psi

In lieu of using concrete strength cylinders to determine when falsework, forms, and housings can be removed, an approved maturity meter may be used to determine concrete strengths by inserting probes into concrete placed in a structure. The minimum number of maturity meter probes required for each structural component shall be in accordance with Subsection 804.03.15. Procedures for using the maturity meter and developing the strength/maturity relationship shall follow the requirements of Subsection 804.03.15. Technicians using the maturity meter or calculating strength/maturity graphs shall meet the requirements of Subsection 804.03.15.

When the walls and top slab of box culverts and box bridges are not to be poured monolithically, extreme care shall be used when forming and pouring the top slab on walls in which the concrete has not attained its full design strength. In order to prevent damage to fresh concrete, either of the following methods of forming and pouring may be used:

- (a) Subject to approval by the Engineer, the wall forms and deck forms may be so constructed and separately supported and braced that the walls may be poured and

the wall forms removed as for wall forms not under stress. The Engineer may require a detailed plan of the proposed method of forming for approval. When this method of forming is used, the deck forms shall be in place and adequately and independently supported throughout before pouring the walls. Deck forms shall overlay the top edge and be flush with the face of the inside wall forms, but shall not be dependent upon any part of the inside wall forms for support. The intersection of the wall and deck forms shall be mortar tight. The wall forms may be constructed slightly less than the specified inside clear height of the structure and wedged upward from the bottom of the riser wall to permit easier removal. When this method is used, the concrete in the wall shall be poured flush with the top of the deck form.

- (b) At the option of the Contractor, the walls may be formed, adequately braced, and poured before the deck forms are in place. In this case the forms may be removed as for walls not under stress. Before erecting any part of the forming for the top slab, the concrete in the walls shall have attained the age or the strength specified for the removal of wall forms under stress.
- (c) The Contractor may elect to form and adequately support and brace the wall and deck forms as a composite unit before pouring the walls. In this case the outside forms may be removed as indicated for wall forms not under stress provided adequate provisions are made for forming the outer (vertical) surfaces for the subsequent deck pour. The inside wall forms shall remain in place as indicated for wall forms under stress.

601.03.6.4--Damage to Previously Placed Concrete. In the event previously placed concrete is damaged, all work on the affected structure shall cease immediately for an engineering assessment of the damage and the corrective work to be performed. No additional work shall be performed until this determination has been made, and the Engineer has given the Contractor approval to proceed with the corrective work and subsequent construction. All corrective work required shall be performed by the Contractor at no additional cost to the State.

601.03.7--Foundations and Footings. Foundations for structures shall be prepared in accordance with the requirements and provisions of Section 206.

All footings shall be poured "dry." Where footings can be placed in the "dry" without the use of cribs or cofferdams, the Engineer may permit back forms to be omitted, and concrete poured against the faces of the excavation.

601.03.8--Placing Reinforcing Steel. Reinforcing steel shall be placed in accordance with the requirements of Section 602 and as shown on the plans.

601.03.9--Handling and Placing Concrete. Handling and placing concrete shall be in accordance with the provisions of Subsection 804.03.6.

601.03.10--Expansion and Fixed Joints. All expansion and fixed joints shall conform to the applicable provisions of Subsection 804.03.18.

601.03.11--Finishing Concrete Surfaces. Unless otherwise authorized, the surface of the concrete shall be finished immediately after form removal.

Surface finishes shall conform to the applicable provisions of Subsection 804.03.19.

601.03.12--Curing Concrete. Concrete shall be cured in accordance with the provisions of Subsection 804.03.17.

601.04--Method of Measurement. Accepted quantities of structural concrete will be measured by the cubic yard. Except for changes ordered in writing by the Engineer, the neat dimensions shown on the plans will be used for computing volumes. The quantity of concrete in fillets, scorings, and chamfers one square inch or less in cross sectional area will be neglected in measurements.

No deductions will be made for the volume of concrete displaced by reinforcement, pipe or other conduits less than eight inches in nominal diameter, pipe posts, structural steel posts, or joint material.

When both Pay Item Numbers 601-A and 601-B are included in the contract, measurement of concrete for Pay Item No. 601-B will be limited to inlets, catch basins, junction boxes, pipe headwalls, and pipe collars, regardless of the concrete quantity required for each of these structures; and other small structures containing less than 3.00 cubic yards of concrete each.

601.05--Basis of Payment. Structural concrete will be paid for at the contract unit price per cubic yard which shall be full compensation for completing the work.

Payment will be made under:

- | | |
|--------------------------------------------------------|------------------|
| 601-A: Class ___ Structural Concrete | - per cubic yard |
| 601-B: Class ___ Structural Concrete, Minor Structures | - per cubic yard |

SECTION 602 - REINFORCING STEEL

602.01--Description. This work consists of furnishing and placing reinforcing steel in accordance with these specifications and in reasonably close conformity with the dimensions, bending, spacing, and other requirements shown on the plans.

Synthetic structural fibers meeting the requirements of Subsection 711.04 may be used in lieu of wire mesh in some items of construction. Substitution of fibers for wire mesh will be allowed in the construction of paved ditches, paved flumes, paved inlet apron, driveways, guard rail anchors and pile encasements. Substitution in any other items of work must be approved by the State Construction Engineer prior to use.

602.02--Materials. Reinforcing steel shall conform to the requirements of Section 711 and Subsection 805.02.

602.03--Construction Requirements.

602.03.1--Bar List and Order Lists. The bar lists and bending schedules shown on the plans are primarily for the purpose of estimating quantities. Lengths of box culverts and box bridges, and depths of inlets, etc. shown on the plans are also approximate. The Contractor shall verify the quantity, size, and shape of the reinforcement for compliance

with the structural drawings and make the necessary corrections, if any, before ordering. In the case of box culverts, box bridges, inlets, etc., verification shall be made after the Engineer has furnished the Contractor with a list of the staked lengths or depths for structures. Errors in the bar list and bending schedule shall not be cause for adjustment of the contract unit price, and the Contractor shall be fully responsible for all expenses caused by the Contractor's failure to furnish the proper size, shape, length, and quantity of reinforcing steel required.

When stipulated in the contract, or at the option of the Contractor when not stipulated, order lists and bending diagrams shall be furnished to the Engineer for approval. In these cases no materials shall be ordered until the lists and bending diagrams have been approved. The approval of order lists and bending diagrams by the Engineer will in no way relieve the Contractor of the responsibility for the correctness of the lists and diagrams. All expense incident to the revision of materials furnished in accordance with such lists and diagrams to make them comply with the design drawings and lengths as staked by the Engineer shall be borne by the Contractor.

602.03.2--Protection of Materials. Steel reinforcement shall be protected in accordance with Subsection 805.03.1.

602.03.3--Bending. Bending shall be in accordance with Subsection 805.03.2.

602.03.4--Placing and Fastening. The steel reinforcement shall be accurately placed in the positions shown on the plans and firmly held during the placing and setting of concrete. Bars shall be tied at all intersections, except where spacing is less than one foot in each direction alternate intersections may be tied.

All reinforcing steel shall be securely spaced from the forms and between layers by means of approved precast mortar blocks of minimum size for adequacy, or metal spacers or devices.

Where possible, all spacer devices shall be arranged so that they cannot be detected in the completed structure. Metal devices that are in contact with the exterior surface of the concrete shall be one of the types specified in Subsection 711.02.7. Gravel, pieces of broken stone or brick, metal pipe, and wooden blocks shall not be used for spacers or chairs.

Reinforcement shall be accurately and securely placed to the dimensions shown on the plans, within a tolerance of one-half inch, then inspected and approved by the Engineer prior to the placing of concrete. Concrete placed in violation of this provision may be rejected and its removal required.

Substitution of different size bars will be permitted only with specific authorization by the Engineer. If steel is substituted, it shall have a cross sectional area equivalent to or greater than the design area.

602.03.4.1--Splicing. Except where shown on the plans, splicing of bars will not be permitted without the written approval of the Engineer. Splices, when permitted, shall be staggered as far apart as possible.

Unless otherwise shown on the plans, spliced bars shall be lapped 20 diameters. In lapped splices, the bars shall be placed in contact and wired together in a manner that will maintain

the minimum clear distance specified between bars and to the surface of the concrete.

Welding of reinforcing steel will be permitted only if detailed on the plans or if authorized by the Engineer in writing. If welded, it shall conform to AWS Recommended Practices for Welding Reinforcing Steel, Metal Inserts, and Connections in Reinforced Concrete Construction.

602.03.4.2--Lapping of Mesh and Bar Mats. Sheets of mesh or bar mat reinforcement shall overlap each other sufficiently to maintain a uniform strength and shall be securely fastened at the ends and edges. The edge lap shall be at least one mesh in width.

602.04--Method of Measurement. Reinforcing steel will be measured in pounds based on the computed weight of the reinforcement shown on the plans or authorized. In cases where a structure is measured and paid for by the unit, complete in place, no measurement of reinforcing steel will be made.

The weight of plain or deformed bars and bar mats will be computed from the weights shown in the table of areas and weights in AASHTO M31.

The weight for payment of steel fabric reinforcement will be computed from the theoretical weight of plain wire. If the weight per unit of area of the fabric is shown on the plans, that weight will be used for measurement.

The weight for payment of structural steel reinforcement will be the theoretical weight of the material used.

No allowance will be made for clips, wire, separators, wire chairs, and other material used in fastening the reinforcing in place. If bars are substituted upon the Contractor's request and as a result more steel is used than specified, only the quantity specified will be measured.

When splice laps, other than those shown on the plans, are made for the convenience of the Contractor, the extra steel will not be included in the measurement.

602.05--Basis of Payment. Reinforcing steel will be paid for at the contract unit price per pound which shall be full compensation for completing the work.

Payment will be made under:

602-A: Reinforcing Steel - per pound

SECTION 603 - CULVERTS AND STORM DRAINS

603.01--Description. This work consists of the construction or reconstruction of pipe culverts, precast box culverts, cattlepasses, storm drains, sewers, downspouts, special sections and headwalls, hereinafter referred to as "conduit," in accordance with these specifications and in reasonably close conformity with the lines and grades shown on the plans or established. It shall also consist of furnishing all materials, except those specified to be furnished by the State, and joining the work to other conduit, catch basins, manholes, inlets, etc., as may be required to complete the work as designated.

This work shall also consist of constructing conduits for the encasement of underground utilities or for other use by the method of jacking or boring in accordance with these specifications and in reasonably close conformity with the lines and grades specified on the plans or established.

When alternate pipe is shown in the contract, the Contractor may select an alternate pipe from the alternate pipe group (type) shown in the plans or contract documents. The type of pipe used for alternate pipe shall meet the material requirements of Subsection 603.02 for the type of pipe selected.

603.02--Materials. Conduit shall conform to the design and dimensions shown on the plans, and materials shall meet the requirements specified in the following sections or subsections:

Bituminous coated corrugated aluminum pipe and pipe arches.....	709.11
Bituminous coated corrugated metal pipe and pipe arches.....	709.03
Bituminous coated paved invert corrugated aluminum pipe and pipe arches.....	709.12
Bituminous coated paved invert corrugated metal pipe and pipe arches.....	709.04
Bituminous plastic sealer for joints.....	707.05
Cast iron pipe.....	709.01
Concrete arch pipe end sections.....	708.04
Concrete for headwalls.....	601
Concrete pipe cattlepasses.....	708.03
Corrugated aluminum pipe and pipe arches.....	709.09
Corrugated metal pipe and pipe arches.....	709.02
Corrugated poly vinyl chloride (PVC) pipe.....	708.17
Corrugated polyethylene pipe.....	708.17
Elbows and branch connections for concrete pipe.....	708.23
Flexible plastic gaskets for joints.....	707.06
Joint mortar.....	714.11
Joints for sanitary sewers.....	603.03.4
Metal end sections, elbows, and branch connections.....	709.18
Non-reinforced concrete pipe.....	708.02.4
Polymer coated corrugated metal pipe and pipe arches.....	709.05
Precast box culverts.....	708.22
Reinforced concrete arch pipe.....	708.14
Reinforced concrete elliptical pipe.....	708.15
Reinforced concrete end sections.....	708.04
Reinforced concrete pipe.....	708.02.5
Reinforcing steel.....	602
Rubber type gaskets.....	707.04
Steel pipe.....	709.19

When material requirements provide for modifications of design, acceptable modified designs will be shown on the plans.

603.03--Construction Requirements.

603.03.1--Excavation. Except for conduit to be installed by jacking and boring, trenches

shall be excavated in accordance with the requirements of Section 206 to a width sufficient to allow for proper jointing of the conduit and thorough compaction of the bedding and backfill material under and around the conduit. Where feasible, trench walls shall be vertical.

The completed trench bottom shall be firm for its full length and width. Where required, in the case of cross drains, the trench shall have the camber specified.

Where conduit is to be placed in embankment, the excavation shall be made after the embankment has been completed to the specified height above the flow line of the conduit. In all cases the height above flow line shall be at least one foot.

In the case of pipe to be jacked or bored, only the trench excavation and bedding as set out in Subsection 603.03.9 shall be performed.

603.03.2--Bedding. Except for conduit placed in a vertical position or jacked or bored, the conduit bedding shall conform to one of the classes specified. When no bedding class is specified the requirements for Class C bedding or Class C modified bedding, as applicable shall apply.

Non-rigid pipe used in cross drains and storm drains shall have a Class B bedding. Non-rigid pipe used in side drains shall have a Class C bedding. No separate measurement will be made for pipe bedding. Costs associated with pipe bedding shall be included in the cost of the pipe.

CLASS A bedding consists of a continuous concrete cradle conforming to plan details, and constructed on an approved foundation.

CLASS B bedding consists of bedding the conduit to a depth of at least 30 percent of the vertical outside dimension of the conduit. The thickness of bedding material beneath the pipe shall be at least four inches. The bedding material shall be sand or selected sandy soil, all of which passes a 3/8 inch sieve and not more than 10 percent of which passes a No. 200 sieve. The layer of bedding material shall be shaped to fit the conduit for at least 15 percent of its total height. Recesses in the trench bottom shall be shaped to accommodate the bell when bell and spigot type conduit is used.

CLASS C bedding consists of bedding the conduit to a depth of at least 10 percent of its total height. The bed shall be shaped to fit the conduit and shall have recesses shaped to receive the bell if bell and spigot type pipe is used.

CLASS C MODIFIED bedding consists of bedding corrugated conduit to a depth of at least 10 percent of its total height. A bedding blanket of approved silty loam, sandy loam, concrete sand, or other approved sand or sandy soil shall be roughly shaped to fit the bottom of the pipe. Minimum thickness before placing pipe shall be as follows:

- 1 inch for 1/2 inch deep corrugations
- 2 inches for 1 inch deep corrugations
- 3 inches for 2 inches or 2 1/2 inches corrugations

For structural plate pipe the length of bedding arc need not exceed the width of the bottom plate.

Bedding for precast concrete box culverts shall consist of at least two inches of Class 9, Group C, or better, granular material placed between graded forms set at least one foot outside each outside wall of the box culvert. The granular material shall be shaped to fit the bottom of the precast box culvert sections by screeding off the graded forms. After placement of the precast box culvert sections on the graded bedding, the forms may be removed and reused.

603.03.3--Laying Conduit. The conduit laying shall begin at the staked location of the downstream end of the conduit line. The lower segment of the conduit shall be in contact with the shaped bedding throughout its full length. Bell or groove ends of rigid conduits and outside circumferential laps of flexible conduits shall be placed facing upstream. Flexible conduits shall be placed with longitudinal laps or seams at the sides. Transverse joints for all types of coated flexible conduits shall maintain pipe alignment during construction and prevent infiltration of backfill material during the life of the structure.

Paved or partially lined conduit shall be laid so that the longitudinal center line of the paved segment coincides with the flow line. Elliptical and elliptically reinforced conduits shall be placed with the major axis within five degrees of a horizontal plane through the longitudinal axis of the conduit.

Construction requirements for end sections shall conform to the requirements for placing the pipe to which they are joined.

At the Contractor's option, subject to the written approval of the Engineer, concrete headwalls conforming to the Department's Standard Drawings may be substituted for premanufactured end sections without change in compensation.

603.03.4--Joining Conduit.

603.03.4.1--Storm Drainage. Rigid conduits may be either bell and spigot or tongue and groove design unless one type is specified. The method of joining conduit sections shall be such that the ends are fully entered, and the inner surfaces are reasonably flush and even. Unless otherwise specified, joints shall be sealed with rubber type gaskets, bituminous plastic sealer, or flexible plastic gaskets.

Joints for precast concrete box culverts shall be made with bituminous plastic sealer.

Rubber type gaskets shall be installed so as to form a flexible watertight seal.

For joints to be sealed with bituminous plastic, the joining ends shall be wiped clean and dry. The plastic compound shall be applied cold to the entire surface of tongues and grooves, the entire surface of bells and spigots, and the entire area of metal pipes to be covered by connecting bands. Sections of concrete pipe shall be forced together, and sections of metal pipe banded together, with excess compound extruding both inside and outside the pipe. Excess compound shall be removed from interior surfaces, and the exterior shall be finished reasonably flush. After pipe has been joined with bituminous plastic compound, roofing felt or other approved suitable fabric shall be placed over the outside joints to avoid mixing of soil with the compound.

For joints to be sealed with flexible plastic gasket material, the pipe shall be installed in a

dry trench. Joints shall be made in such a manner that a slight internal extrusion of the plastic gasket will occur for the full circumference when the sections of pipe are forced together. Installation shall be in accordance with these specifications and the manufacturer's instructions. Plastic gasket material shall be applied only to surfaces which are dry. A primer of the type recommended by the manufacturer of the plastic gasket shall be applied to the tongue and groove and to the end surfaces, and the surface to be primed shall be clean and dry when the primer is applied. During cold weather the joint surfaces and the gasket shall be lightly heated, without damage to the pipe or joint material, immediately prior to forcing the sections of pipe together. During hot weather the Contractor shall place kraft or other approved paper over the joints to avoid mixing soil with the plastic gasket material.

For joints constructed of either bituminous plastic sealer or flexible plastic material, special care shall be taken to provide an equal uniform joint between pipe sections and to prevent one section from supporting the other. Backfilling operations may follow immediately. Pickup holes in pipe shall be plugged using a plastic sealer covered with suitable fabric, or a method approved by the Engineer.

Flexible steel conduits shall be firmly joined by coupling bands. The ends of flexible conduits fabricated with helical corrugations shall be adapted by reforming and/or modification for circumferential corrugated coupling bands. The width and thickness of corrugated bands for both circumferential and helical corrugated flexible conduits shall be in accordance with AASHTO M 36 except that the bands shall be no less than 10½ inches in width.

In lieu of the preceding requirements and in addition to being supplied or recommended by the pipe manufacturer, coupling bands for joining corrugated polyethylene pipe shall be in accordance with AASHTO M 294 and shall meet or exceed the soil-tightness requirements of the AASHTO Standard Specifications for Highway Bridges, Section 26, paragraph 26.4.2.4 (e).

Corrugated polyethylene pipe may also be furnished with bell & spigot type joints with O-ring rubber gasket meeting ASTM F 477 placed on the spigot end. At least two (2) corrugations of the spigot end must insert into the bell end.

Joints and fittings for poly (vinyl chloride) (PVC) pipe shall meet the requirements of ASTM F 949.

603.03.4.2--Pipe With Gaskets. Unless otherwise specified, joints for pipe requiring gaskets shall conform to the following:

- (a) Pipes requiring gaskets shall be constructed to accommodate the gasket in accordance with the recommendations of the manufacturer of the gasket. Rubber gaskets shall comply with Subsection 707.04, and flexible plastic gaskets shall comply with Subsection 707.06.
- (b) In municipalities and other local governments having codes and specifications for joining sanitary sewer conduit, the local codes and specifications shall be applicable.
- (c) Depending upon the type of pipe specified and the joint to be used, the Contractor shall perform the joining in accordance with the recommendations of the manufacturer of the joint material to the extent that the line will be water proofed

both from infiltration and exfiltration insofar as is practicable. Evidence of leakage shall be corrected immediately.

- (d) Evidence of leakage or suspected leakage may be cause for requiring the Contractor to perform testing to determine the leakage present. In the case of sanitary sewer lines, leakage exceeding the tolerance permitted under the local governing code, or in the absence of such code the tolerances permitted by MDEQ, Office of Pollution Control, will not be allowed.

Leakage in excess of the tolerances permitted shall be corrected by reworking the line as necessary. Retesting may be required if deemed by the Engineer to be indicated. All testing shall be at no additional cost to the Department.

603.03.5--Relaid Pipe. These construction specifications shall equally apply to relaid conduits. In addition, conduit salvaged for relaying shall be cleaned of all foreign material prior to reinstallation. All pipe damaged through carelessness or negligence on the part of the Contractor shall be replaced by new pipe or approved pipe at no additional cost to the Department.

Pipe and end sections designated for removal and relaying shall be removed in accordance with the provisions of Subsection 202.03.4.

603.03.6--Field Strutting. Where required by the plans, the vertical diameter of round flexible pipe shall be uniformly increased five percent by means of jacks applied after the entire line of pipe has been installed on the bedding but before backfilling. The vertical elongation shall be uniformly maintained by means of sufficient sills and struts or by sufficient horizontal ties as specified. Only horizontal ties shall be used for paved invert pipe.

Ties and struts shall be removed after the embankment is completed and compacted.

603.03.7--Backfilling. Conduit shall be inspected before backfill is placed. Conduit found to be out of alignment, unduly settled, or damaged shall be taken up and relaid or replaced. After approval of conduit, it shall be backfilled with specified material in accordance with Subsection 203.03.8.6.

Backfill of non-rigid corrugated polyethylene and poly (vinyl chloride) (PVC) pipe used in cross drains and storm drains shall be performed using one of the following methods:

1. Flowable fill meeting the requirements of Section 612 of the Standard Specifications. If flowable fill is used, care shall be taken to prevent the pipe from "floating."
2. Crushed stone aggregate meeting the requirements of Subsection 703.04.3 of the Standard Specification.

No separate measurement will be made for backfilling pipe. Costs associated with backfilling pipe will be included in the cost of the pipe.

603.03.8--Imperfect Trench. Under this method, the embankment shall be completed to a height above the conduit equal to the vertical outside diameter of the conduit plus one foot. A trench equal in width to the outside horizontal diameter of the conduit shall then be excavated to within one foot of the top of the conduit with the trench walls being as

nearly vertical as possible. This trench shall be loosely filled with highly compactable soil. Straw, hay, corn stalks, leaves, brush, or sawdust may be used to fill the lower one-fourth to one-third of the trench. Construction of the remainder of the embankment shall then proceed in a normal manner.

603.03.9--Pipes and Encasements Jacked or Bored. No pipe shall be placed by jacking or boring unless so designated in the contract.

When jacking or boring is designated, the area of placement shall be carefully investigated so as not to interfere with existing underground utilities. Care shall also be taken to keep the disturbed area of construction to a minimum.

The line and grade and the limits, if any, of placement to be made by conventional open trench methods for each line of pipe will be established as provided in Subsection 105.08. Unless otherwise shown on the plans, sections of steel pipe shall be joined by welding for the full circumference of the pipe to form a continuous, rigid, watertight structure of the required length. Welding shall be performed in accordance with Subsection 810.03.5.

603.03.9.1--Jacking. The designated strength of the pipe to be jacked is determined for the final loading under the embankment. Additional reinforcement or strength of pipe required to withstand jacking pressure shall be the responsibility of the Contractor. Extra strength pipe furnished by the Contractor shall be at no additional cost to the Department.

Pipe larger than a 3½-inch ID shall not be pushed or jacked without boring or otherwise removing the soil as the pipe is advanced.

Suitable pits or trenches, when required, shall be excavated for the jacking operation and for placing the end joints of pipe. Where necessary, they shall be securely sheeted and braced to prevent caving.

Where pipe is required to be installed under railroads, highways, streets or other facilities by jacking or boring methods, construction shall be done in a manner that will not interfere with the operation of the facility or weaken the roadbed or structure.

Jacks for forcing the pipe through the roadbed shall have a jacking head constructed in such a manner as to apply uniform pressure around the ring of the pipe. The pipe to be jacked shall be set on guides braced together to properly support the section of the pipe and direct it to the proper line and grade. In general, roadbed material shall be excavated just ahead of the pipe, the excavated material removed through the pipe, and the pipe then forced through the roadbed into the excavated space.

When requested, the Contractor shall furnish for the Engineer's approval a plan showing proposed method of handling. The plan shall include the design for the jacking head, and show the jacking support or back stop, arrangement and position of jacks, pipe guides, etc. complete in assembled position. The approval of this plan by the Engineer will not relieve the Contractor from the responsibility of obtaining the specified results.

The diameter of the excavation shall conform to the outside circumference of the pipe as closely as practicable. Voids that develop during the installation operation and that are determined by the Engineer to be detrimental to the work shall be pressure grouted with an approved mix.

The distance that the excavation extends beyond the end of the pipe will depend upon the character of the excavated material, but shall not exceed two feet in any case. This distance shall be decreased on instructions from the Engineer if the character of the material being excavated makes it desirable.

The pipe shall be jacked from the low or downstream end. Variation in the final position of the pipe from the line and grade established will be permitted only to the extent of two percent in lateral alignment and one percent in vertical grade, provided that the final grade of flow line is in the direction designated.

The Contractor may use a cutting edge around the head end that extends a short distance beyond the pipe end and has inside angles or lugs to keep the cutting edge from slipping back into the pipe.

When jacking of pipe is begun, the operation shall be carried on without interruption, insofar as practicable, to prevent the pipe from becoming firmly set in the embankment.

All pipe damaged in jacking operations shall be removed and replaced by the Contractor at no additional cost to the State.

Pits or trenches excavated to facilitate jacking operations shall be backfilled immediately after the jacking has been completed.

603.03.9.2--Boring. The boring shall proceed from a pit provided for the boring equipment and workmen. Excavation for pits and installation of shoring shall be as outlined under jacking. The location of the pit shall meet the approval of the Engineer. The holes are to be bored mechanically. The boring shall be done using a pilot hole. By this method an approximate two-inch pilot hole shall be bored the entire length of the crossing and shall be checked for line and grade on the opposite end of the bore from the work pit. This pilot hole, when approved, shall serve as the centerline of the larger diameter hole to be bored. Excavated material shall be placed near the top of the working pit and disposed of as required. The use of water or other fluids in connection with the boring operation will be permitted only to the extent to lubricate cuttings as provided herein. Jetting will not be permitted.

In unconsolidated soil formations, a gel-forming colloidal drilling fluid consisting of at least 10 percent of high grade carefully processed bentonite may be used to consolidate cuttings of the bit, seal the walls of the hole, and furnish lubrication for subsequent removal of cuttings and installation of the pipe immediately thereafter.

Allowable variation from line and grade shall be as specified under jacking. Precise measures are to be taken to prevent overcutting. Overcutting in excess of one-half inch shall be remedied by pressure grouting.

603.03.9.3--Grouting, Backfilling, and Cleanup. After the jacked conduit is in place, all joints in concrete pipe shall be cleaned carefully and pointed from the inside to afford a smooth continuous interior surface.

Extension of the line beyond that required to be jacked or bored shall be by conventional methods as set out in this section.

As soon after jacking as possible, the interstices around the outside of the pipe shall be filled by pressure grouting. The grout mixture shall consist of fine sand or silt, Type I cement of not less than 15 percent by volume, and water. The grout shall be placed through holes bored at such intervals that the grout can be determined as rising in an adjacent hole at least six inches above the top of the pipe. The water content of the grout shall be the minimum necessary to provide proper placement. Grouting shall be performed by qualified personnel with equipment especially designed for the purpose.

At the end of each day's grouting operation, or at the completion of the grouting operation for each line of pipe, whichever occurs first, the conduit shall be carefully inspected on the inside and all grout that penetrated the pipe shall be removed and the inside surface wiped clean. Other waste grout that will impair the work shall be removed and disposed of.

After successive operations are completed, all sheeting, shoring, etc. shall be removed, excavations backfilled to the surface of the existing ground or as directed, the backfill compacted in accordance with the specifications, and all surplus material disposed of to the satisfaction of the Engineer.

603.04--Method of Measurement. The lengths of pipe and precast box culverts will be measured by the linear foot by multiplying the number of commercial lengths installed by the nominal length per section, with the exception that portions of commercial lengths extending more than four feet beyond the ends of conduit actually required or at the face of structures will not be measured for payment.

Unless otherwise indicated on the plans, sections of lines of conduits placed by conventional methods will not be measured as pipe jacked or bored.

End sections, headwalls, elbows, branch connections, and other appurtenances for which pay items are listed will be measured by the number of units of the kind and size specified. Concrete collars used for connecting non-rigid pipe to concrete end sections will not be measured for payment and the costs shall be absorbed in the cost of other pay items.

Pipe removed and relaid will be measured by the linear foot. End sections removed and relaid will be measured by the unit.

Excavation for conventionally installed conduits will be measured and paid for as set out in Section 206. Excavation for conduits placed by jacking or boring will not be measured for separate payment.

Excavation for precast box culverts will be measured in cubic yards as set out in Section 206 for cast-in-place box culverts of comparable sizes.

603.05--Basis of Payment. Accepted quantities of pipe and precast box culverts will be paid for at the contract unit price per linear foot. End sections, headwalls, elbows, branch connections, and other appurtenances for which pay items are listed in the contract will be paid for at the contract unit price per each.

Pipe removed and relaid will be paid for at the contract unit price per linear foot. End sections removed and relaid will be paid for at the contract unit price per each.

The prices thus paid shall be full compensation for completing the work. Materials or work for which a pay item is not included and are necessary to complete the work under this section shall be furnished or performed and shall be considered incidental to the completed construction.

Payment will be made under:

FERROUS METAL CONDUIT

603-A: ___ " Steel Pipe, Wall Thickness _____ - per linear foot

603-B: ___ " Cast Iron Pipe, Class _____, Description - per linear foot

ALTERNATE CONDUIT

603-ALT: ___ " Type _____ Alternate Pipe - per linear foot

CONCRETE CONDUIT

603-CA: ___ " Reinforced Concrete Pipe, Class _____ - per linear foot

603-CB: ___ " Reinforced Concrete End Section - per each

603-CC: ___ " Non-Reinforced Concrete Pipe, Class _____ - per linear foot

603-CD: 48" x 72" Concrete Pipe Cattlepass - per linear foot

603-CE: ___ " x ___ " Concrete Arch Pipe, Class _____ - per linear foot

603-CF: ___ " x ___ " Concrete Arch Pipe End Section - per each

For conduit required to be jacked or bored, the appropriate pay item listed above will contain the term "Jacked or Bored", as applicable.

For conduit required to have rubber type or flexible type gasket, the appropriate pay item listed above will contain the term "Rubber Type Gasket" or "Flexible Type Gasket", as applicable.

CORRUGATED FERROUS METAL CONDUIT

603-MA: ___ " * Coated Corrugated Metal Pipe, _____ Gage,
_____ Corrugation - per linear foot

603-MB: ___ " * Coated Corrugated Metal End Section,
_____ Gage - per each

603-MC: ___ " x ___ " * Coated Corrugated Metal Arch Pipe,
_____ Gage, _____ Corrugation - per linear foot

603-MD: ___ " x ___ " * Coated Corrugated Metal End
Section, _____ Gage - per each

- 603-ME: ___" * Coated Paved Invert Corrugated Metal
Pipe, _____ Gage, _____ Corrugation - per linear foot
- 603-MF: ___" * Coated Paved Invert Corrugated Metal End
Section, _____ Gage - per each
- 603-MG: ___" x ___" * Coated Paved Invert Corrugated Metal
Arch Pipe, _____ Gage, _____ Corrugation - per linear foot
- 603-MH: ___" x ___" * Coated Paved Invert Corrugated Metal
End Section, _____ Gage - per each

* Type Coating to be shown as either Zinc, Aluminum, Polymeric or Bituminous.

NOTE: The gage of pipe specified for various coating types will vary according to the Department's design policy.

CORRUGATED NON-FERROUS METAL CONDUIT

- 603-NA: ___" Corrugated Aluminum Pipe, _____ Gage,
_____ Corrugation - per linear foot
- 603-NB: ___" Corrugated Aluminum End Section, _____ Gage - per each
- 603-NC: ___" x ___" Corrugated Aluminum Arch Pipe,
_____ Gage, _____ Corrugation - per linear foot
- 603-ND: ___" x ___" Corrugated Aluminum End Section,
_____ Gage - per each
- 603-NE: ___" Bituminous Coated Corrugated Aluminum Pipe,
_____ Gage - per linear foot
- 603-NF: ___" Bituminous Coated Corrugated Aluminum End
Section, _____ Gage - per each
- 603-NG: ___" x ___" Bituminous Coated Corrugated Aluminum
Arch Pipe, _____ Gage, _____ Corrugation - per linear foot
- 603-NH: ___" x ___" Bituminous Coated Corrugated Aluminum
End Section, _____ Gage - per each
- 603-NI: ___" Bituminous Coated Paved Invert Corrugated
Aluminum Pipe, _____ Gage, _____ Corrugation - per linear foot
- 603-NJ: ___" Bituminous Coated Paved Invert Corrugated
Aluminum End Section, _____ Gage - per each
- 603-NK: ___" x ___" Bituminous Coated Paved Invert Corrugated
Aluminum Arch Pipe, _____ Gage, _____ Corrugation - per linear foot

603-NL: ___" x ___" Bituminous Coated Paved Invert Corrugated Aluminum End Section, _____ Gage - per each

CORRUGATED POLYETHYLENE CONDUIT

603-PE: ___" Corrugated Polyethylene Pipe - per linear foot

CORRUGATED POLY VINYL CHLORIDE CONDUIT

603-PVC: ___" Corrugated Poly Vinyl Chloride Pipe - per linear foot

PRECAST BOX CULVERTS

603-PA: ___' x ___' Precast Concrete Box Culvert - per linear foot

603-PB: ___' x ___' Precast Concrete Box Culvert End Section - per each

RELAI D PIPE

603-RA: ___" Pipe Removed and Relaid - per linear foot

603-RB: ___" End Section Removed and Relaid - per each

SPECIALS AND CONCRETE HEADWALLS

603-SA: Special Section, Description - per each or linear foot

603-SB: Size Branch Connection Type & Description - per each

603-SC: Size & Type Headwall, Per Plans - per each

SECTION 604 - MANHOLES, INLETS AND CATCH BASINS

604.01--Description. This work consists of the construction of manholes, inlets, and catch basins in accordance with these specifications and in reasonably close conformity with the details, lines, grades, and dimensions shown on the plans or established by the Engineer.

Precast sectional manholes shall consist of furnishing and assembling precast sections for manholes, together with necessary fittings, bases, and connections, all constructed in accordance with these specifications and in reasonably close conformity with the details, lines, grades and dimensions shown on the plans, or established.

604.02--Materials. The materials used in this construction shall meet the requirements specified in the following Section or Subsections:

Masonry Brick, Grade SM	706.01
Mortar	714.11
Concrete	601
Reinforcing Steel	711.00 and 711.01

Gray Iron Castings	716.04
Bar Gratings	716.14

All bars, anchors, frames, hangers, etc. for castings and plates shall be approved prior to installation.

Inlet and outlet pipes shall be of the type, class and size indicated on the plans and shall conform to the requirements as set out in Section 603 for the particular type, class, and size of pipe specified.

Precast units will be considered for use under the provisions of Subsection 601.02.3. Precast (sectional) manholes shall conform to the requirements of AASHTO M 199.

604.03--Construction Requirements.

604.03.1--Brick Masonry. Brick masonry shall be constructed in conformity with the details shown on the plans and in accordance with the provisions of Section 611.

Where irons or other fittings enter the brick work, they shall be placed as the work is laid up, thoroughly bonded, accurately spaced, and lined. Upon completion of the masonry and setting of castings and fittings, the inside and outside surfaces of the masonry shall be neatly plastered with mortar 1/2 inch thick. Plastering shall have a uniform, smooth finish and shall be neatly pointed to all fittings.

604.03.2--Concrete Masonry. Unless otherwise specified, concrete masonry shall be constructed of Class "B" concrete in accordance with the requirements of Section 601.

604.03.3--Reinforcement. Reinforcement shall be placed as indicated on the plans or as directed and in accordance with the provisions of Section 602.

604.03.4--Optional Construction. When plan standards indicate portions of the structure may be constructed of either brick masonry or concrete, the Contractor may use either concrete or brick masonry for these portions, provided the plan dimensions for wall thickness, etc. are maintained. In either case the masonry, whether concrete or brick, will be measured for payment as stipulated in Subsection 604.04.

604.03.5--Inlet and Outlet Pipes. Unless otherwise directed, inlet and outlet pipes shall extend through the walls of manholes and catch basins for a sufficient distance beyond the outside surface to allow for connections and shall be cut flush with the wall on the inside surface and neatly pointed.

The concrete, or brick and mortar, shall be constructed around the pipes so as to prevent leakage and to form a neat connection.

604.03.6--Castings, Gratings, and Fittings. All castings and gratings shall be carefully handled. Injurious cracks, chips, surface mars, etc. that render them unsuitable for use or unsightly after being placed will be cause for rejection.

The castings, gratings, and fittings shall be placed as indicated on the plans or as directed to line and grade and in such a manner that subsequent adjustments will not be necessary.

When castings or gratings are to be set in concrete or cement mortar, all anchors or bolts shall be in the correct place and position before the concrete or mortar is placed, and they shall not be disturbed while the concrete or mortar is hardening.

Castings and gratings placed on previously constructed masonry shall be set in mortar beds or anchored to the masonry as shown on the plans or directed. The bearing surface of the original masonry shall present an even surface and conform to line and grade so that the entire face or back of the casting will come in contact with the masonry.

Castings and gratings shall be set firm and snug so that they will not rattle, shake, or move unnecessarily.

604.03.7--Precast Manholes. As trenches are opened for the pipe conduit, truly leveled bases shall be prepared at each manhole site. The bases may be cast-in-place or may consist of precast base units. In either case, the seated base shall be truly horizontal. Inverts shall be smooth and accurately shaped to a semi-circular bottom conforming to the inside of the adjacent conduit, and extend upward at least half of the diameter of the conduit, or as shown on the plans. Joints shall be sealed in accordance with Section 603.

Steps in the manhole may be of cast-iron, aluminum, wrought iron, plastic or other material approved by the Engineer. All steps shall be built into the walls of precast sections in straight alignment to form a continuous ladder with a maximum distance of 16 inches between steps.

Each precast section shall have not more than two holes for handling. The holes shall be plugged with mortar after installation.

Concrete covers may be precast, or cast at the site. The covers shall be cast accurately to the dimensions and design indicated on the plans.

604.03.8--Excavation and Backfill. Excavation shall be performed as required for proper construction. Backfill shall be performed in accordance with the provisions of Subsection 203.03.8.6.

604.03.9--Cleaning Up. Upon completion, all structures shall be thoroughly cleaned of accumulations of silt, debris, and foreign matter. All surplus material shall be removed, and the site and the structure shall be maintained in a clean and neat condition until release of maintenance.

604.04--Method of Measurement. When either concrete masonry or brick masonry is permitted, and when concrete is specified, measurement will be by the cubic yard in accordance with Subsection 601.04 for Structural Concrete - Minor Structures.

Precast manholes will be measured per linear foot of depth from the flowline of the manhole to the top of the cover, or as indicated on the plans.

Reinforcing steel will be measured per pound in accordance with Subsection 602.04.

When brick masonry only is specified, measurement will be by the cubic yard or per thousand (M) brick in accordance with Subsection 611.04.

Excavation will not be measured for payment as a separate item. The cost of excavation shall be included in the unit price for concrete or brick masonry.

Castings, gratings and metallic manhole covers will be computed in pounds from the dimensions shown on the plans and based on the unit weights of metals set out in Section 810.

Fittings will not be measured for separate payment. Their cost shall be included in the price for concrete or brick masonry.

604.05--Basis of Payment. Structural concrete, reinforcing steel, and brick masonry will be paid for at the respective contract unit price in accordance with Subsections 601.05, 602.05, or 611.05 as applicable.

Precast Manholes will be paid for at the contract bid price per linear foot of depth, which price shall be full compensation for all necessary excavation, sheeting, cribbing, shoring, bracing, well-pointing, furnishing and assembling all elements of the manhole including concrete bases and covers except metallic cover and frame, for all other items of work necessary and incident to the complete construction and for all equipment, labor, tools and incidentals necessary to complete the work.

Castings and gratings will be paid for at the contract unit price per pound for castings or gratings, complete in place, which prices shall be full compensation for completing the work.

Payment will be made under:

- 604-A: Castings - per pound
- 604-B: Gratings - per pound
- 604-C: Precast Manhole, ___" Diameter - per linear foot

SECTION 605 - UNDERDRAINS

605.01--Description. This work consists of furnishing all materials and constructing underdrains in accordance with these specifications and in reasonably close conformity with the lines and grades indicated on the plans or established by the Engineer; furnishing materials and constructing filter beds as specified; furnishing materials and constructing drainage structures; and furnishing and installing plastic pipe drain structure and drain structure outlets, vents and miscellaneous appurtenances as shown on the drawings in the plans, and as specified herein. This work also includes the video inspection and reporting of drain system installation.

605.02--Materials.

605.02.1--Drain Tile and Pipe. Drain tile and pipe shall be of the classes and sizes indicated and shall meet the requirements of the following Subsections:

Bituminous Coated Corrugated Aluminum Alloy Pipe for Underdrains 709.13

Bituminous Coated Corrugated Metal Pipe for Underdrains	709.07
Concrete Drain Tile	708.06
Corrugated Aluminum Pipe for Underdrains	709.10
Corrugated Metal Pipe for Underdrains	709.06
Corrugated Polyethylene Drainage Tubing	708.19
Geotextile	714.13
Perforated Concrete Pipe	708.05
Plastic Pipe for Underdrains	708.18
Polymer Coated Corrugated Metal Pipe for Underdrains	709.08
Porous Concrete Pipe	708.07
Semi-circular Perforated Plastic Pipe for Underdrains	708.20

605.02.2--Material for Bedding and Covering. Bedding and covering material shall conform to the requirements of Section 704. Unless otherwise specified, Type C shall be used.

605.02.3--Appurtenances. Appurtenances such as flush-out units, small animal guards, signs, etc. shall be as shown on the plans and shall be of new, good commercial quality materials approved by the Engineer.

605.02.4--Edge Drain Pipe and Fittings.

605.02.4.1--General. Pipe for edge drains and fittings shall be four-inch nominal size, and shall be either Schedule 40 or Schedule 80 polyvinyl chloride (PVC) plastic pipe conforming to the requirements of ASTM D 1785.

Fittings, except for "Y" fittings, shall be socket-type fittings conforming to the requirements of ASTM D 2467 for Schedule 80 pipe and ASTM D 2466 for Schedule 40 pipe.

The Contractor may elect to furnish one of the following perforated pipe in lieu of the pipe listed above. Regardless of the pipe used, it shall be four-inch nominal size.

- a) Pipe conforming to Subsection 708.18 of the Standard Specifications with SDR number ranging from 23.5 to 35 and having a minimum pipe stiffness value of 50 psi
- b) Corrugated polyethylene drainage tubing or corrugated high density polyethylene (HDPE) pipe conforming to the requirements of AASHTO M 252, Type SP with the stipulation that the minimum pipe stiffness value shall be 50 psi. The pipe and fittings shall be made of virgin polyethylene compounds that conform to the requirements of cell class 324420C as defined and described in ASTM D 3350, except that the carbon black content shall not exceed 5%. Compounds that have higher cell classifications in one or more properties are acceptable provided product requirements are met.

Pipe used for the edge drain outlet/vents shall be either PVC or corrugated high density polyethylene (HDPE) pipe. PVC pipe shall meet the requirements of ASTM D 1785 as stated above, and HDPE pipe shall meet the requirements of AASHTO M 252 as stated above.

All "Y" fittings shall be smooth interior wall fittings fabricated from pipe conforming to

the requirements of the edge drain outlet pipe. The fitting shall provide an unobstructed passageway through both legs of the "Y".

Edge drain outlet and vent covers shall consist of commercial quality 3 x 3 galvanized hardware cloth, 0.063-inch wire or equal. The outlet and vent covers shall be installed at the end of each outlet pipe and vent pipe.

The Contractor shall furnish to the Engineer three copies of the manufacturer's certified test reports and certification covering each shipment of pipe stating the amount furnished and that the pipe, fittings, couplings, etc. comply with the requirements of the specifications.

605.02.4.2--Untreated Permeable Material. The untreated permeable material used to backfill the edge drain pipe and outlet/vent trenches shall be Type 57 filter material and shall conform to the requirements of Subsection 703.03, Coarse Aggregate for Portland Cement Concrete, for Size 57 coarse aggregate. The type of aggregate may also be slag or granite. Mixing of different types of aggregate will not be permitted.

605.02.4.3--Filter Fabric. The filter geotextile used with edge drains and edge drain outlets shall be Type V geotextile meeting the requirements of Subsection 714.13.

605.02.4.4--Miscellaneous. Concrete for aprons shall be Class "C" concrete meeting the requirements of Subsection 804.02.10.

Mortar placed where edge drain outlets and vents connect to drainage pipes and existing drainage inlets shall conform to the provisions of Subsection 714.11.5, Masonry Mortar, except that the sand and cement shall be commercial quality.

605.02.5--Prefabricated Sheet Drain.

605.02.5.1--General. Prefabricated sheet drain shall be geocomposite drainage material with a high compressive strength molded core and non-woven geotextile fabric attached to both sides of the core to provide soil intrusion protection for subsurface drainage interception.

Prefabricated sheet drain shall be one listed on the Department's APL.

605.02.5.2--Marking, Shipment, and Storage. Each roll or container of prefabricated sheet drain shall be visibly labeled with the name of the manufacturer, trade name of the product and quantity of the material. During shipment and storage the prefabricated sheet drain shall be protected from direct sunlight, and temperatures above 120°F or temperatures below 0°F. The prefabricated sheet drain shall be maintained in a heavy duty protective covering and elevated, limiting soil and water contact. Prolonged storage requires storage in a safe enclosed area to protect it from damage.

605.03--Construction Requirements.

605.03.1--Pipe Installation.

605.03.1.1--Preparation of Trench. Trenches shall be excavated to the dimensions and grade shown on the plans or as directed. In the event the dimensions of the trench are not

indicated on the plans, the trench shall be at least as wide as the outside diameter of the pipe plus eight inches on each side, and shall be of sufficient depth to allow proper installation of the pipe and covering.

If bell and spigot pipe is used, recesses shall be cut to allow uniform bearing of the pipe on the bottom of the trench.

605.03.1.2--Pipe Laying.

605.03.1.2.1--General. Except where settlement occurs due to reasons beyond the control of the Contractor, the Contractor shall be responsible for the alignment and grade of pipe underdrains. Where settlement occurs due to improper excavation, bedding or backfill, negligence, or carelessness on the part of the Contractor, the pipe shall be taken up and properly relaid or replaced without extra compensation.

605.03.1.2.2--Drain Tile. Drain tile shall be firmly embedded on the bottom of the trench, conforming to line and grade, and with the ends approximately 1/4 inch apart. If, in the judgment of the Engineer, the soil is of such a composition that it will wash into the joints, the joints shall be wrapped with strips of tar paper approximately four inches wide. Bedding or cover material shall then be placed around the paper to prevent its displacement. No additional compensation will be allowed for this operation.

605.03.1.2.3--Bell and Spigot Type. Concrete pipe of the bell and spigot type shall be firmly embedded on the bottom of the trench, with the bell ends upgrade, and shall have close fitting joints. No mortar will be required in the joints.

605.03.1.2.4--Perforated Pipe. Unless otherwise indicated on the plans, perforated pipe shall be laid with the perforated side down. Unless otherwise specified, perforated pipe shall be laid on a four-inch bed of approved filter material.

605.03.1.2.5--Corrugated Metal Pipe. Corrugated metal pipe shall be laid with the separate sections firmly joined together by connecting bands of an approved type.

605.03.1.2.6--Laterals. Laterals and other connections shall be made with suitable special sections.

605.03.1.2.7--Dead Ends. Dead ends of pipe underdrains shall be closed with a suitable plug of concrete or prefabricated end cap placed around the end of the pipe to prevent soil and/or water intrusion.

605.03.1.2.8--Underdrain Outlets. When indicated on the plans non-perforated underdrain outlets shall be joined to the underdrains.

605.03.1.3--Appurtenances. Underdrain appurtenances such as elbows, "T" and "Y" connections, flush-out units, small animal guards, signs, etc. shall be constructed in accordance with the details shown on the plans and shall be of good quality workmanship.

605.03.1.4--Pipe Covering. After the pipe underdrain has been laid, it shall be covered immediately with the specified filter material to the dimensions shown on the plans. The remainder of the trench, if any, shall be filled with the specified material, placed in six-inch layers, and compacted to the specified density.

605.03.2--Blind Drains. Trenches for blind drains shall be excavated to the width and depth shown on the plans. The trench shall be filled with filter material to the depth required by the plans. The remaining upper portion of trench shall be filled with either granular or impervious material as specified. All filling material shall be thoroughly compacted, and if under the pavement structure the material shall be compacted to the density specified in the contract.

605.03.3--Combination Storm Drain and Underdrain. Where the plans indicate that a conduit is to serve as a combination storm drain and underdrain, the conduit shall in general be constructed in accordance with Section 603. Modifications of Section 603 to provide that the conduit also serve as an underdrain shall be performed under this section. Modifications shall be as shown on the plans.

The Contractor shall carefully grade and shape the compacted backfill for the lower portion of the pipe so that water entering the filter material will be adequately drained into the unsealed portion of the joints. In no case shall the surface of the compacted backfill be below the sealed portion of the joints. After the lower portion of the joint has been backfilled, compacted, and shaped as indicated above, filter material shall be placed for the full depth shown on the plans.

Each layer of filter material shall be compacted to the satisfaction of the Engineer.

Upon completion of the placement and compaction of the filter material, superimposed materials shall be placed immediately, or a temporary covering of approved material shall be placed and compacted in order to prevent unnecessary infiltration of loose material into the upper portion of the filter material. Should appreciable contamination occur because of failure to adequately protect the surface of the filter material, that portion of the work considered to be unsatisfactory shall be removed and replaced with satisfactory work at no additional cost to the Department.

If temporary materials used to protect the upper portion of the filter material do not meet the requirements for the superimposed course, the temporary materials shall be carefully removed to expose clean filter materials immediately prior to placement of the required superimposed course.

605.03.4--Filter Beds. Excavation for filter beds shall be made to the elevation and dimensions indicated on the plans. The surface of the excavated area on which the filter bed is to be placed shall be smooth, firm, and well drained. Filter material of the types shown on the plans shall be placed, thoroughly compacted, and shaped to the dimensions indicated on the plans. Unless otherwise specified, compaction shall be to the satisfaction of the Engineer.

When impervious material or other materials are specified to be placed over the filter material, the compacted filter material shall be covered as soon as practicable with this material and compacted to the required design soil density in accordance with Section 203.

605.03.5--Edge Drain Installation. Edge drains, edge drain outlets, vents, untreated permeable material, and filter geotextile shall be installed in accordance with the details shown on the plans or in the contract documents, as specified herein and applicable contract documents. The vertical tolerance (height) for the trench shall be plus or minus one-half

inch. The horizontal tolerance (width) shall be plus one inch.

Surfaces to receive filter fabric, immediately prior to placing, shall be free of loose or extraneous material and sharp objects that may damage the filter geotextile during installation.

The geotextile shall be stretched, aligned and placed in a wrinkle-free manner.

Adjacent rolls of the geotextile shall be overlapped from 12 to 18 inches. The preceding roll shall overlap the following roll in the direction the material is being spread.

Should the geotextile be damaged during placing, the torn or punctured section shall be either completely replaced or shall be repaired by placing a piece of geotextile that is large enough to cover the damaged area and to meet the overlap requirement.

Damage to the geotextile resulting from the Contractor's vehicles, equipment or operations shall be replaced or repaired by the Contractor at no additional cost to the State.

Pipe and fittings shall be joined by solvent cementing with commercial quality solvent cement and primer specifically manufactured for use with rigid PVC plastic pipe and fittings. The solvent cement and primer used shall be made by the same manufacturer. The color of the primer shall contrast with the color of the pipe and fittings. The solvent cement and primer shall be used in accordance with the manufacturer's printed instructions.

When corrugated polyethylene drainage tubing is used, joints shall be made with snap-on or split couplings, corrugated to engage the pipe corrugations, and shall engage a minimum of four corrugations, two on each side of the pipe joint.

When poly vinyl chloride corrugated sewer pipe is used, joints shall be made in accordance with the pipe manufacturer's recommendations and ASTM F 949.

The backfill of the trench along the pavement edge, across the shoulder and outside the shoulder shall be as shown in the details of the drawings.

The Contractor may dispose of the trenched materials on the slopes provided all material passes a three-inch ring and blends into the existing or reconstructed roadway slopes. Otherwise, the material must be disposed of outside the right-of-way.

The edge drain and edge drain outlets and vents shall be clean at the time of installation and shall be free of obstructions after installation.

605.03.6--Edge Drain Inspection. The edge drain system shall be inspected by the Contractor after all roadway construction items are completed within a given section of roadway. A video record and written report for each line inspected shall be furnished to the Engineer. The line location (station number), distance traversed by the camera, and pipe deficiency shall be recorded on a compact disc or other approved media and in a written report. As a minimum, fifty percent (50%) of the entire edge drain system shall be video inspected. Video inspection shall be performed in the presence of the Engineer or the Engineer's representative.

Video equipment used for inspecting the edge drain system shall be capable of the

following minimum requirements:

- (1) Providing color video inspection of pipelines for 4-inch inside diameter pipe in a wet, corrosive environment and negotiating a 90° bend in a smooth bore or corrugated pipe. The color camera must have a minimum 400-line horizontal resolution.
- (2) Video inspecting up to 300 linear feet of edge drain pipe, by pushing, pull cabling, jetting or tractoring the camera through the line and recording the condition on video tape.
- (3) Equipped with a video monitor capable of allowing live viewing of the video inspection.
- (4) Displaying and recording on the video tape, the date, line identification, footage and type of pipe deficiency.
- (5) Recording the distance traversed by the camera to within 0.5 feet, allowing for overlapping of distances if a reversal is required to permit full-length inspection.

A written report of the drain system inspection shall be completed on the Department's Edge Drain and Edge Drain Outlet/Vent Inspection Form, or other form approved by the Engineer.

Any foreign materials that restricts the movement of the inspection equipment or impairs the quality of the video within the drain system shall be flushed from the system. Flushing of the drain system will be by water jetting or other methods approved by the Engineer. Costs associated with flushing the system will not be made under separate payment. The system shall be re-inspected after flushing in the same manner as the initial inspection as described above. Re-inspection of the system shall be at no additional cost to the State.

Any drain system pipe that can't be cleared from obstructions, damaged or does not conform to the lines and grades shown on the plans shall be replaced at no additional cost to the State.

605.03.7--Prefabricated Sheet Drain. Prefabricated Sheet drain shall be placed in the areas designated and as directed in the plans. Unless otherwise directed by the Engineer, the prefabricated sheet drain may be installed longitudinally, either horizontally or vertically, in the direction of flow.

Prefabricated sheet drain shall be placed on a smooth soil surface, free of sharp objects or protrusions. Prefabricated sheet drain material shall be pinned or otherwise secured in place prior to cover placement. A 12-inch cover thickness is required prior to equipment trafficking. No equipment shall be permitted directly on the material. Begin cover placement at the lowest relative grade level to reduce material displacement. Cover placement shall begin immediately, or otherwise protected from ultraviolet degradation.

Material overlap(s), when required, shall be shingled with the upper gradient prefabricated sheet drain above the lower gradient prefabricated sheet drain providing a minimum 6-inch overlap, unless otherwise directed on the plans. Duct tape shall be used to secure material overlaps.

605.04--Method of Measurement. Tile or pipe underdrains, including all special sections and connections, and blind drains will be measured from end to end by the linear foot along

their center lines.

Appurtenances, specified as pay items, will be measured by the unit indicated. All necessary appurtenances not listed as pay items will not be measured for separate payment.

Excavation for pipe underdrains will be measured and paid for under the provisions of Section 206 for the widths shown on the plans. Excavation for blind drains and filter beds will be measured and paid for in accordance with the provisions of Section 203.

Measurement and payment for conduit required to be used as combination storm drain and underdrain will be made in accordance with Section 603, except for those features modified as provided in this section.

Measurement of filter materials used in the construction of underdrains, combination storm drains and underdrains, and filter beds will be made as follows:

- (a) In the case of underdrains and combination storm drains and underdrains, the measurement will be made complete-in-place and computed from plan dimensions. No deduction will be made for the volume occupied by pipe or portion of pipe for pipes eight inches and less in diameter. Deductions will be made for pipes larger than eight inches in diameter.
- (b) In the case of filter beds, the material of the required types will be measured by the cubic yard (LVM) or by the ton as indicated in the proposal, from which will be deducted all quantities determined by the Engineer to have been placed in excess of that necessary because of the failure of the Contractor to establish and maintain the grades, lines, slopes, and other dimensions in reasonably close conformity with those shown on the plans or established by the Engineer. In computing the volume of quantities to be deducted from LVM measurement, the Engineer will determine the excess by the best procedure deemed appropriate and convert the results to LVM as provided in Subsection 109.01.

When measurement by the ton is indicated on the plans and in the proposal, measurement will be based on the dry unit weight in accordance with Subsection 304.04.

Except when specifically indicated as a pay item, no measurement for payment will be made for filter material for blind drains.

When designated as a pay item in the contract, geotextile for subsurface drainage will be measured by the square yard based on plan dimensions.

Edge drains and edge drain outlets/vents, complete in place, will be measured by the linear foot along the line of the trench. On slopes the length to be paid for will be the slope length of the trench.

Edge drain inspection will be measured by the linear foot of edge drain and edge drain outlet/vent inspected. The length to be paid for will be the slope length of the trench.

The Class "C" Concrete for concrete edge drain aprons shall be measured by the cubic yard.

Prefabricated sheet drain shall be measured by the square yard installed and shall be the

covered surface area not including overlaps.

Wire mesh covers, pipe and pipe fittings, couplings, untreated permeable material, geotextile fabric, granular material, bituminous pavement mixture, trenching, disposal of trenched materials and other miscellaneous appurtenances used for edge drain installation will not be measured separately for payment.

605.05--Basis of Payment. Tile and pipe underdrains and blind drains, measured as prescribed above, will be paid for at the contract unit price per linear foot. Appurtenances listed as pay items will be paid for at the contract unit price for the units specified.

Filter material for underdrains and combination storm drains and underdrains, measured as prescribed above, will be paid for at the contract unit price per cubic yard (FM).

Filter material for filter beds, measured as prescribed above, will be paid for at the contract unit price per cubic yard (LVM) or ton.

Excavation for tile or pipe underdrains will be paid for in accordance with the provisions of Subsection 206.05. Excavation for blind drains will be paid for in accordance with the provisions of Subsection 203.05.

Geotextile for subsurface drainage, measured as prescribed above, will be paid for at the contract unit price per square yard.

Edge drain and edge drain outlets/vents, measured as prescribed above, will be paid for at the contract unit price per linear foot, which price shall be full compensation for furnishing all labor, materials, tools, equipment, and incidentals and for doing all the work involved in constructing edge drains and edge drain outlets/vents complete in place, including wire mesh covers, pipe and pipe fittings, couplings, untreated permeable material, geotextile fabric, granular material, bituminous pavement mixture, trenching, disposal of trenched materials and other miscellaneous appurtenances as shown on the plans and as specified herein.

Edge drain inspection, measured as prescribed above, will be paid for at the contract unit price per linear foot of edge drain and edge drain outlet/vent inspected, which price shall be full compensation for furnishing all labor, equipment, VHS tapes, tools and incidentals necessary to complete the work.

Class "C" concrete for edge drain aprons as shown on the plans and as specified herein shall be paid for under Pay Item No. 221-A, Concrete Paved Ditch.

Prefabricated sheet drains, measured as prescribed above, will be paid for at the contract unit price per square yard, which price shall be full compensation for all materials, installation, labor, tools, equipment, and incidentals necessary to complete the work.

The prices thus paid shall be full compensation for completing the work.

Payment will be made under:

605-A: ____ " Concrete Drain Tile for Underdrains, Class ____ - per linear foot

Section 605

Section 605

605-B: ___" Perforated Concrete Pipe for Underdrains, Class ____	- per linear foot
605-C: ___" Porous Concrete Pipe for Underdrains	- per linear foot
605-D: ___" Perforated Corrugated Metal Pipe for Underdrains, Type ____	- per linear foot
605-E: ___" Non-perforated Corrugated Metal Pipe for Underdrains, Type____	- per linear foot
605-F: ___" Bituminous Coated Perforated Corrugated Metal Pipe for Underdrains, Type____	- per linear foot
605-G: ___" Bituminous Coated Non-perforated Corrugated Metal Pipe for Underdrains, Type____	- per linear foot
605-H: Edge Drain	- per linear foot
605-I: Edge Drain Outlets/Vents	- per linear foot
605-J: Edge Drain & Edge Drain Outlet/Vent Inspection	- per linear foot
605-K: Blank	
605-L: Blank	
605-M: ___" Perforated Corrugated Aluminum Pipe for Underdrains, Type____	- per linear foot
605-N: ___" Non-perforated Corrugated Aluminum Pipe for Underdrains, Type ____	- per linear foot
605-O: ___" Perforated Sewer Pipe for Underdrains, SDR ____	- per linear foot
605-P: ___" Non-perforated Sewer Pipe for Underdrains, SDR ____	- per linear foot
605-Q: ___" Perforated Corrugated Polyethylene Drainage Tubing for Underdrains	- per linear foot
605-R: ___" Non-perforated Corrugated Polyethylene Drainage Tubing for Underdrains	- per linear foot
605-S: ___" Semi-circular Perforated Plastic Pipe for Underdrains	- per linear foot
605-T: ___" Perforated Pipe for Underdrains, Optional*	- per linear foot

* Meeting the requirements for Pay Item Numbers 605-B, Standard Strength; 605-D, Type III; 605-K, Type SJ or TJ; 605-M, Type III; 605-O, SDR 35, 41 or 42; 605-Q,

or 605-S.

605-U: ___" Non-perforated Pipe for Underdrains, Optional** - per linear foot

** Meeting the requirements for Pay Item Numbers 605-E, Type III; 605-L, Type SJ or TJ; 605-N, Type III; 605-P, SDR 35, 41 or 42; or 605-R.

605-V: ___" Blind Drains - per linear foot

605-W: Filter Material for Combination Storm Drain and/or Underdrains, Type ___ - per cubic yard

605-X: Filter Material for Filter Beds, Type ___ - per cubic yard or ton

605-Y: Impervious Material, Type ___ - per cubic yard or ton

605-Z: Underdrain Appurtenances, Description - per lump sum, each, etc.

605-AA: Geotextile for Subsurface Drainage, Type ____, AOS ____ - per square yard

605-BB: Prefabricated Sheet Drain - per square yard

*** When not designated, see Subsection 714.13.

SECTION 606 - GUARD RAIL

606.01--Description. This work consists of furnishing and erecting complete sections of guard rail in accordance with these specifications and in reasonably close conformity with the lines and grades shown on the plans or established by the Engineer. This work shall also include the installation of reflectors on guard rail posts and the installation of guard posts.

When the work requires the removal and replacement of guardrail on a facility opened to traffic, the materials necessary for replacement will be on hand before removal begins. The Contractor shall not begin work on any section of guardrail until preparations have been made to complete the installation of the section, including posts, rail, anchors, and hardware as a continuous operation. Once work has been initiated on a section, the work shall be prosecuted to its completion unless inclement weather or other conditions beyond the control of the Contractor interfere with the work. Uncompleted guardrail or special end sections shall not be left exposed to the travelling public without the approval of the Engineer. If approval is granted, the uncompleted section must satisfactorily be marked with drums, barricades, or other devices, as directed by the Engineer, at no additional cost to the Department. In no case will uncompleted guardrail or special end sections be allowed to remain over a weekend or holiday period.

606.02--Materials. Unless otherwise specified, all materials shall conform to the requirements shown on the plans and set forth in Section 712. Reflectors shall be of the type, size, and color designated on the plans and shall conform to the requirements of

Subsection 721.07.

When not designated, guard rail posts, meeting the requirements of Subsection 712.06, may be wood or steel but shall be of the same type for the entire project. Posts for bridge end sections shall be of the same type as the guard rail line posts. Posts for cable anchorage sections may be wood or steel but shall be of the same type for the entire project.

Terminal end sections, installed as per manufacturer's recommendations, shall be NCHRP Report 350 or MASH approved.

Terminal end sections shall be Flared or Non-Flared and shall be one listed on the Department's APL. The end sections shall be installed in accordance with the manufacturer's recommendation. Prior to installation, the Contractor shall provide two copies of the manufacturer's installation details to the Project Engineer. The Project Engineer will keep one copy in the project file and provide one copy to the District Maintenance Engineer. The installation details shall be engineering drawings, a minimum of 11" X 17" in size. Reflective adhesive sheeting with alternating black and yellow stripes (sloping downward at an angle of 45 degrees in the direction traffic is to pass) shall be required on the end of the terminal section. The type of terminal section installed shall be written on the device with a Permanent Marking Stick or some other means of permanent identification.

606.03--Construction Requirements.

606.03.1--Erection of Guard Posts. Generally, guard post will be constructed of timber post. However, in certain circumstances, guard post may be constructed of steel with special requirements as detailed on special design sheets in the plans. The posts shall be set plumb and firm to the depth indicated and accurately lined, spaced, and graded. After the posts are in place, the holes shall be backfilled with suitable material which shall be thoroughly compacted in approximate six inch layers by tamping. Posts shall not be sawed or cut after treatment. If set posts are found to be in improper position with reference to alignment or grade, they shall be removed and reset properly. If the posts are found too high they may be driven to the proper elevation provided the tops of the posts are protected by suitable driving caps.

Wood guard rail posts and guard posts may be erected by driving or by a combination of drilling and driving when after demonstration at the project site the Engineer approves the results as being equal to or better than the results that can be obtained by erecting posts in drilled holes and backfilling. Acceptability of driving or combined drilling-driving will be contingent on the following conditions:

- (a) Use of approved and proven mechanical driving equipment;
- (b) Maintenance of acceptable results without impairing the structural integrity of adjacent materials or structures;
- (c) Use of drills to penetrate courses that may resist penetration by driving. When drills of nominal post-size are used the void between the post and the edge of the hole shall be filled with Grade AC-13 asphalt. Holes larger than nominal post-size drilled through paved surfaces or cement treated courses shall be properly backfilled with hot or cold bituminous pavement;
- (d) Out-of-tolerance posts shall be pulled and properly replaced or reset, and all disrupted portions of the roadbed structure restored as directed; and

- (e) Mutilated posts shall be pulled and properly replaced, and all disrupted portions of the roadbed structure restored in kind or as directed.

Steel guard rail posts may be erected by driving, provided an approved driving head is used.

The top inside edges of posts shall be set within 1/4 inch of correct vertical and horizontal alignment.

Guard rail posts on bridges shall be plumb and accurately spaced and lined.

Where sections of rail are located on curves, the posts shall be erected so as to obtain the designated panel lengths measured along the face of the rail.

606.03.2--Anchorage. Anchors and braces shall be furnished and placed as shown on the plans.

606.03.3--Erection of Rails. All fabrication and forming of rail elements shall be completed prior to application of the shop paint. Field punching, cutting, burning, or welding will not be permitted, except where specifically authorized by the Engineer and subject to the conditions thereof.

The rail shall be erected in a manner that results in a smooth, continuous, taut rail that conforms to the line and grade shown on the plans or established. In the erection of rail, consideration shall be given to the prevailing temperature and the anticipated rise and fall of temperature ultimately affecting the length of the rail.

Where required, ends of rail shall be flared within the limits shown on the plans or established.

Bolts and clips used for fastening rails or fittings to posts shall be drawn up tightly, and all bolts, except "take up" device bolts, shall be of such length as to not project beyond the nut more than the limits shown on the plans. Sawing of ends of bolts to meet this requirement will be permitted.

606.03.4--Repairing Rails and Fittings. Where the galvanizing on guardrail or fittings has been damaged, the coating shall be repaired by re-galvanizing or the surface repaired by painting with two coats of zinc oxide paint approved by the Engineer.

606.03.5--Reflectors. Reflector units shall be installed in conformity with details shown on the plans and in accordance with the manufacturer's recommendations. Where holes are required to be bored in posts or other units, the holes shall be bored prior to the required painting. The reflectors shall be installed after all painting is completed.

606.04--Method of Measurement. Guard rail will be measured by the linear foot along the face of the rail from center of end posts for each complete section and will include posts and other elements of the completed section.

Special sections will be measured per each or linear foot, as indicated on the plans.

Guard posts will be measured by the unit per each post installed. Such measurement will

include reflectors as specified, backfill, clean up, and any required additional hardware such as caps and chain necessary to complete the work.

606.05--Basis of Payment. Guard rail will be paid for at the contract unit price per linear foot for each designated type. Special sections will be paid for at the contract unit price per linear foot or per each, as applicable. Guard posts will be paid for at the contract unit price per each.

These prices shall be full compensation for completing the work.

Payment will be made under:

- 606-A: Guard Post - per each
- 606-B: Guard Rail, Designation - per linear foot
- 606-C: Guard Rail, Cable Anchor, Designation - per each
- 606-D: Guard Rail, Bridge End Section, Designation - per each
- 606-E: Guard Rail, Terminal End Section - per each
- 606-F: Guard Rail, * Designation - per linear foot or each
- 606-G: Special Sections, Designation - per linear foot or each

* Indicate Remove, Replace, or Remove and Replace

SECTION 607 - FENCES AND CATTLE GUARDS

607.01--Description. This work consists of furnishing materials and constructing fences, gates, and cattle guards in accordance with the plans and these specifications and in reasonably close conformity with the lines and grades indicated on the plans or established. Fencing shall include satisfactory connections with all intersecting fences, bridges, and culvert headwalls.

This work also consists of fencing designed and constructed primarily as screening or glare barrier. In this case certain modifications or amendments to these specifications shall be made as shown on the plans or in the proposal; otherwise, the requirements of these specifications shall be applicable.

607.02--Materials.

607.02.1--Type "A" Fence. Materials for Type "A" fence shall meet the requirements of the following subsections:

Woven Wire (Hog Wire)	712.03
Barbed Wire	712.02
Staples	712.15
Tension Wire	712.04.3

Tie Wire 712.04.2

607.02.2--Chain Link Fence. Materials for chain link fence shall meet the requirements of Subsection 712.04.

607.02.3--Posts and Lumber. The size of posts and lumber shall be as designated on the plans.

Unless otherwise specified, concrete posts for Type "A" fence shall be used in interchange areas. In other areas, either wood or concrete posts for Type "A" fence may be used, provided the same type is used throughout the project.

Posts shall meet the requirements of Subsection 712.05 for the type specified or permitted.

607.02.4--Gates. Gates shall meet the requirements of Subsection 712.12 for the type specified.

607.02.5--Concrete for Anchors and Footings. Concrete for anchors and footings shall be Class "C" conforming to the requirements of Section 804, except that the requirements for size and gradation of aggregate may be modified, and small, one-half cubic yard or less, batches may be mixed by approved hand methods.

607.02.6--Cattle Guards. Materials for cattle guards will be specified on the plans and in the contract documents.

607.03--Construction Requirements.

607.03.1--General. The Contractor shall perform the clearing and grubbing necessary to construct the fence to the required grade and alignment. Clearing and grubbing shall be in accordance with Section 201.

A herbicide shall be used for sprout control of cut stumps. Paint or spray freshly cut stump surface thoroughly covering cambium area next to bark until the herbicide runs down around the root collar. Treat stump as soon as practical after cutting for more effective control but no later than day of cutting except when spraying must be postponed due to inclement weather. Pine stumps and all other stumps larger than 15 inches in diameter do not require spraying for control of sprouting. Permissible herbicides are 2,4-D (amine); picloram +2,4-D; ammonium sulfamate; and dicamba. Specific requirements such as mixing, diluting, rate, application, use restrictions, safety precautions, etc. will be in accordance with the manufactures printed container label.

Re-spraying will be required when the herbicide is washed off by rain within eight hours of application or diluted to such an extent that it is rendered ineffective.

At locations where breaks in a run of fencing are required, or at intersections with existing fences, appropriate adjustment in post spacing shall be made to conform to the requirements for the type of closure indicated.

All posts shall be set plumb and to the required grade and alignment. Cutting of the tops of the posts will be allowed only with the approval of the Engineer and under the conditions specified by him.

Wire or fencing shall be stretched taut and firmly attached to posts and braces by the method indicated on the plans. All wire shall be installed to the required elevations.

At each location where an electric transmission, distribution, or secondary line crosses the fence, the fence shall be grounded by a copper-coated steel rod at least eight feet long and at least 1/2 inch in diameter. The rod shall be installed directly below the point of crossing and driven vertically until the top is six inches below the ground surface. A No. 6 solid copper conductor or equivalent shall be used to connect each fence element to the grounding rod. The connections shall be either brazed or fastened with approved non-corrosive clamps.

When a power line runs parallel or nearly parallel to the fence, the fence shall be grounded at each end or gate post or at intervals not to exceed 1,500 feet.

Fences shall generally follow the contour of the ground, with the bottom of fence fabric not less than one inch or more than six inches from the ground surface. Grading shall be performed where necessary to provide a neat appearance. Where abrupt changes in the ground profile in low areas make it impractical to maintain the ground clearance shown on the plans, longer posts may be used and multiple strands of barbed wire stretched thereon. The vertical clearance between strands of barbed wire shall be as shown on the plans.

On tangent sections fabric or wire shall be placed on faces of posts opposite the highway, and on curve sections on the faces of posts opposite the center of curvature.

607.03.2--Concrete and Timber Posts.

607.03.2.1--General. Post holes shall be of sufficient diameter to allow proper compaction of backfill. The backfill shall be made with the best soil available and shall be thoroughly tamped until the post is firm and rigid in position.

Round wood posts shall be set with the large end down and shall be plumbed to within a tolerance of 1/4 inch per foot in height. The top shall be set to within 1/2 inch of the specified alignment on the side on which the wire is to be attached.

Concrete and square wood posts shall be set plumb and to within 1/2 inch of the specified alignment on the side to which the wire is to be attached.

Fence posts not specified to be set in concrete may be erected by driving, drilling, or combination, when after demonstration at the project site the Engineer approves the results as being equal to or better than what can be obtained by erecting in dug holes and backfilling.

The use of mechanical driving equipment shall not require removal of more desirable trees or more grading than is required for dug holes.

607.03.2.2--Line Posts. When specified or directed, line posts at the low point of a grade or in depressions where the pull on the fence tends to lift the post shall be anchored in concrete.

607.03.2.3--Brace Bays. When the distance between end, gate, or corner posts exceeds

500 feet on tangent fences and 250 feet on curved fences, brace bays shall be erected.

607.03.2.4--Concrete Anchors. The surface of concrete anchors shall be shaped to drain away from the post. Anchors shall be covered with suitable earth and allowed to cure five days before installation of wire or fabric.

607.03.3--Metal Posts and Concrete Footings. Unless otherwise specified or permitted, holes for concrete footings shall be wetted sufficiently to prevent absorption of moisture from concrete. The concrete shall be finished above the ground to shed water and covered with four inches of loose earth. The footings shall be allowed to cure for seven days before erection of fabric.

When the ground is not firm, side forms will be required. Forms may be removed within 24 hours. Immediately after stripping the forms, moistened earth shall be tamped solidly around the footing, and four inches of loose earth shall be placed over the footing.

The distance between end, corner, intermediate brace, or gate posts shall not exceed 1,000 feet, and each such post shall be braced and trussed to the adjacent line posts.

If specified, metal posts shall be erected without concrete footings. In this case, posts shall be driven plumb to within 1/2 inch of the specified alignment by means of an approved post driver. Posts that are bent or otherwise damaged shall be removed and replaced.

607.03.4--Installing Wire.

607.03.4.1--Woven Wire Fabric. Stretching shall be with an approved stretcher that will produce approximately equal tension in each line wire. The fabric shall be stretched until the tension is just below the point of producing displacement in the tension crimps. At each end, corner, or gate post, each strand of line wire shall be wrapped around the post and securely fastened by winding the free end around the wire near the post. Splicing shall be accomplished by the use of either a wrapped splice or a corrosion resistant, compressed sleeve type splice meeting the approval of the Engineer. When a wrapped splice is used, the vertical wires adjacent to each end shall be brought together and the end of each horizontal wire wrapped with at least six complete turns around the other corresponding horizontal wire.

607.03.4.2--Barbed Wire. Either a wrapped splice or the compressed sleeve type splice described above may be used for barbed wire. When the wrapped splice is used, each end shall be wrapped with at least six complete turns around the other wire.

607.03.4.3--Chain Link Fabric. Continuous mesh shall be afforded by weaving and fastening rolls of fabric together with a single wire strand of the size and type in the fabric.

607.03.5--Gates. Posts and footings or anchorages shall be installed in the manner prescribed for the post type used.

When the type latching device so requires, a concrete "keeper" or footing, minimum 12 x 12 x 15 inches of the type necessary to seat the drop-bar firmly, shall be constructed.

607.03.6--Finished Fence. The tops of all posts shall be at a uniform grade and at a uniform distance above the top wire.

All surplus excavated material and debris resulting from construction shall be disposed of as directed and the fence left in a neat and orderly condition.

607.03.7--Cattle Guards. Construction details for cattle guards will be set out in the contract documents.

607.04--Method of Measurement. Type "A" woven wire fence, of the height specified, will be measured by the linear foot of completed fence which includes woven wire, barbed wire, and other appurtenances shown on the plans. Measurement will be made along the bottom of the woven wire fabric, and openings will be excluded from the measurement.

Chain link fence, of the height specified, will be measured by the linear foot of completed fence. Measurements will be made along the bottom of the chain link fabric, and openings will be excluded.

Barbed wire fence of the number of strands specified will be measured by the linear foot of completed fence. Measurements will be made along the completed fence, and openings will be excluded.

Single strand barbed wire indicated for separate payment will be measured by the linear foot.

Gates will be measured by the unit.

Posts, including tops and footings of metal posts, will be measured by the unit.

Concrete anchors for use with timber or concrete posts will be measured by the unit.

Pickets will be measured by the linear feet of completed fence containing pickets. Lattice will be measured by the linear feet of completed fence containing lattice.

Cattle guards will be measured per each.

Excavation and backfill for footings, anchorages, and cattle guards; stretcher bars; top rails; post tops; barbed wire integral to specified fences; bottom tension wires or rails; tie wires; tension wires; truss rods with turnbuckles; connectors; bands; compression braces; hinges; latching devices; hardware; reflectors; paint; painting; and other accessories and incidentals necessary to complete the work will not be measured for separate payment.

Required clearing and grubbing and grading will not be measured for separate payment unless so indicated on the plans.

607.05--Basis of Payment. Fencing items will be paid for at the contract unit prices for the respective items, which shall be full compensation for completing the work.

Payment will be made under:

607-A: ___" Type "A" Woven Wire Fence	- per linear foot
607-B: ___" Type ___ Chain Link Fence *	- per linear foot

607-C: ___” Type ___ Chain Link Fence, <u>Glare Barrier / Screening</u>	- per linear foot
607-D: Barbed Wire Fence, <u>No. Strands & Materials</u>	- per linear foot
607-E: Barbed Wire, Single Strand	- per linear foot
607-G: Gate, <u>Size & Type</u> *	- per each
607-H: Pickets, <u>Height, Size and Material</u>	- per linear foot
607-L: Lattice, Height, <u>Size, Material, etc.</u>	- per linear foot
607-P1: Line Posts, <u>Length, Size & Material</u>	- per each
607-P2: Brace Posts, <u>Length, Size & Material</u>	- per each
607-P3: Gate Posts, <u>Length, Size & Material</u>	- per each
607-W: Cattle Guards	- per each
607-Z: Concrete Anchors	- per each

* Indicate when arms with barbed wire is required

SECTION 608 - CONCRETE SIDEWALKS

608.01--Description. This work consists of constructing concrete sidewalks on a prepared subgrade in accordance with the plans and specifications. This work may also include the placement of detectable warning panels / truncated domes in concrete sidewalk as shown on the plans or as directed by the Engineer. Lines and grades shall be as shown on the plans or established. "Subgrade" in this section shall mean the prepared foundation on which the sidewalk is constructed.

608.02--Materials. All material furnished for use shall comply with appropriate requirements of the 700 series of these specifications, and the following:

Concrete shall be Class B meeting the requirements of Section 804 or Class P or PA meeting the requirements of Section 501.

Reinforcing steel shall meet the applicable requirements of Sections 602 and 711 and plan details.

Detectable warning panels shall meet the requirements of plans, specifications, and the requirements of the Americans with Disabilities Act (ADA). The panels shall be precast, modular, or prefabricated.

608.03--Construction Requirements.

608.03.1--Equipment. The Contractor may use forms or, if requested in writing and

approved by the Engineer, an approved automatic extrusion type paving machine.

Forms shall be wood or metal. If wood, they shall be dressed on all sides, and be free of bulges, warps, and loose knots. If metal, they shall be of approved section and have a flat surface on top. The depth of the forms shall be equal to the depth of the sidewalk. Adequate means shall be provided for securely fastening the ends of forms together.

Prior to use, an automatic extrusion machine must be demonstrated to produce a consolidated concrete section conforming to the dimensions, cross section, line, and grades shown on the plans or established.

608.03.2--Excavation and In-Grade Preparation. Excavation shall be made to the required depth and to a width that will permit the installation and bracing of forms. The foundation shall be shaped and compacted at the proper moisture content to a firm, even surface conforming to the lines, grades, and sections shown on the plans or established. All soft, spongy, or other unsuitable materials encountered shall be removed and replaced with acceptable material.

608.03.3--Setting Forms. Forms shall be set to the required line and grade and rigidly held in place by stakes or braces. Ends of adjoining form sections shall be flush. Forms and division plates shall be cleaned and oiled before placing concrete against them.

608.03.4--Handling, Measuring, Proportioning, and Mixing Materials. The method of handling, measuring, proportioning, and mixing concrete materials shall conform to Section 501 or Section 804. Where reinforcement is required, it shall be placed in accordance with Section 602.

608.03.5--Placing Concrete. A template resting upon the side forms and having its lower edge at the elevation of the subgrade shall be drawn along the forms to shape and grade the subgrade before concrete is deposited. The subgrade shall be moist and free of debris and foreign material before concrete is deposited upon it. The concrete mixture shall be placed on the prepared subgrade to the depth required to complete the sidewalk in one course. It shall then be vibrated and/or tamped and struck off with an approved straightedge resting upon the side forms and drawn forward with a sawing motion. The surface shall be given a Class 6 float finish as set out in Section 804.

The edges of sidewalk shall be rounded with an edging tool having a radius of 1/2 inch. Expansion joints shall be edged with an edger having a radius of 1/4 inch.

608.03.6--Joints. Expansion joints shall be of the dimensions specified and shall be filled with the type of premolded expansion joint filler specified. Sidewalks shall be divided into sections by dummy joints formed by a jointing tool or other acceptable means. These dummy joints shall extend into the concrete for at least one inch and shall be approximately 1/8 inch wide. Joints shall match as nearly as possible adjacent joints in curb or pavements. Dummy joints may be sawed in lieu of forming with a jointing tool.

Construction joints shall be formed around all appurtenances such as manholes, utility poles, etc. extending into and through the sidewalk. Premolded expansion joint filler 1/4 inch thick shall be installed in these joints. Expansion joint filler of the thickness indicated shall be installed between concrete sidewalks and fixed structure such as a building or bridge. This expansion joint material shall extend for the full depth of the walk.

608.03.7--Protection and Curing. Concrete shall be protected and cured in accordance with the requirements of Subsection 501.03.20 or by other approved methods.

Placement, protection, and curing of concrete during cold or hot weather shall conform to the limitations, conditions, and requirements set out in Section 804.

608.03.8--Backfilling and Cleaning Up. When the concrete has set sufficiently, the sides of the walk shall be backfilled and compacted to the required elevation with suitable material. All surplus material shall be disposed of as directed, and the completed work and the site shall be left in a neat and presentable condition.

608.03.9--Detectable Warning Panel. Detectable warning panels shall be installed on the concrete sidewalk at the locations shown on the detail drawings in the plans and in accordance with the manufacturer’s recommendations.

608.04--Method of Measurement. Concrete sidewalks of the type specified will be measured for payment by the square yard. Transition slopes, turning space, and ramps necessary for ADA curb cuts will be measured as concrete sidewalk.

Detectable warning panels will be measured by the square foot of actual panel placed. Concrete sidewalk under the panels will be paid for as sidewalk per square yard. Excavation, backfill, expansion joint material, and other miscellaneous items will not be measured for separate payment.

608.05--Basis of Payment. Concrete sidewalks, measured as prescribed above, will be paid for at the contract unit price per square yard, which shall be full compensation for all labor, equipment, materials, and incidentals necessary to complete the work.

Detectable warning panels, measured as prescribed above, will be paid for per square foot, which price shall be full compensation for all materials, labor, equipment, and incidentals necessary to complete the work.

Payment will be made under:

- 608-A: Concrete Sidewalk, Without Reinforcement - per square yard
- 608-B: Concrete Sidewalk, With Reinforcement - per square yard
- 608-C: Detectable Warning Panels per square foot

**SECTION 609 - CONCRETE GUTTER, CURB,
AND COMBINATION CURB AND GUTTER**

609.01--Description. This work consists of constructing curb, gutter, and combination curb and gutter in accordance with these specifications and in reasonably close conformity with the lines, grades, dimensions, and cross sections shown on the plans or as established.

609.02--Materials. Concrete for detached curb, gutter, and combination curb and gutter shall meet the requirements of Section 601. Concrete for curbs integral with concrete

pavement shall meet the requirements of Section 501.

Mixtures for bituminous curb shall be in accordance with Sections 401 and 403 and, unless otherwise specified or approved, shall be a Type ST, 12.5 mm mixture.

609.03--Construction Requirements.

609.03.1--Excavation and In-Grade Preparation. Excavation and in-grade preparation for gutter, curb, and combination curb and gutter shall be performed in accordance with the applicable provisions of Section 321.

609.03.2--Cast-in-Place Hydraulic Cement Concrete.

609.03.2.1--Forms. Forms, except for divider plates and templates, may be wood or metal. All forms shall be full depth, straight, and free of warp and shall be securely staked, braced, and sufficiently tight to prevent leakage of mortar. All forms shall be cleaned thoroughly and oiled before placing concrete against them.

Lumber for wood forms shall be sound, free of bulges, loose knots, and warps, and of uniform width. All lumber shall be dressed commercial lumber at least two inches thick, except the Engineer may permit the use of flexible material on short radii.

Metal forms shall be of approved sections and shall have a flat surface on top. They shall present a smooth surface and be of sufficient strength when braced to withstand the weight of the concrete without bulging or displacement. Special care shall be exercised to keep metal forms free from rust, grease, or other foreign matter that would discolor the concrete.

Metal templates or dividing plates shall be of sufficient thickness and of such design as to hold the forms rigidly in place and to produce a smooth vertical joint after the plates are removed. They shall be of the full dimensions shown on the plans for curb, gutter, or combination curb or gutter.

609.03.2.2--Proportioning, Mixing, and Placing Concrete. Unless otherwise specified, concrete used for detached curb, gutters, and combination curb and gutter shall be Class "B" proportioned, mixed, and placed in accordance with the provisions of Section 601.

Concrete used for curb integral with concrete pavement shall be proportioned, mixed, and placed in accordance with the provisions of Section 501.

The concrete shall be placed on a moist grade and consolidated by vibration or other acceptable methods. Weep holes shall be placed through curbs where indicated on the plans or as directed.

609.03.2.3--Extruded Construction. Concrete curb and curb and gutter may be constructed by the use of a curb forming machine. Such a machine shall conform to (a), (b), and (e) of Subsection 609.03.3.2, and in addition, its continued use shall be contingent upon it producing curb with the specified section, line, and grade. If these conditions cannot be met, construction shall be by conventional methods.

In the event a curb forming machine is used, minor modifications in the concrete mix design may have to be made to improve placement, subject to approval of the State

Materials Engineer.

609.03.2.4--Sections and Joints. Concrete curb, gutter, or combination curb and gutter shall be constructed in uniform sections of the length specified on the plans. These lengths may be reduced where necessary for closure but no section less than six feet will be permitted. The templates shall be accurately set before placing the concrete and, to the extent possible, allowed to remain in place until the concrete has set sufficiently to hold its shape. The templates shall be removed while the forms are still in place.

Expansion joints shall be formed of premolded joint filler of the specified thickness, and shall be placed in line with expansion joints in the adjoining pavement or structure and at other locations designated on the plans. All joint fillers shall be cut to full cross section and shall extend for full depth, width, and length. All expansion joint material protruding after the concrete is finished shall be trimmed as directed. Immediately after removal of forms, the outer edges of filled joints shall be carefully exposed.

609.03.2.5--Finishing. The concrete shall be finished smooth and even by an approved float. Forms on the face of curbs shall be removed as soon as the concrete will hold its shape, and the surface shall be finished with a float to a smooth even texture. Plastering will not be permitted. Strike-off templates of the form and shape of the gutter shall be used to shape the top surface of gutters. Before final finishing the surface of gutters shall be checked with a 10-foot straightedge, and all irregularities of more than 1/8 inch in 10 feet shall be corrected.

Edges on the faces of curbs shall be rounded with finishing tools having the radii shown on the plans. Edges where templates have been removed or expansion joint material has been placed shall be finished with an edging tool having a radius of 1/4 inch. All exposed surfaces against which some rigid type of construction is to be made shall be left smooth and uniform so as to permit free movement of the curb, gutter, or combination curb and gutter.

All tool marks shall be removed with a wetted brush or wood float. The finished surface shall be a uniform color free from discolorations.

609.03.2.6--Protection and Curing. Concrete shall be cured for at least 72 hours. Curing shall be by moist cotton or burlap mats, waterproof paper, white polyethylene sheeting, straw curing as set out in Subsection 501.03.20, or by other approved methods.

The Contractor shall have materials available at all times for the protection of unhardened concrete against rain. During the curing period all traffic, both pedestrian and vehicular, shall be kept off the concrete. Vehicular traffic shall be kept off for such additional time as the Engineer may direct. The Contractor shall protect the work from damage until release of maintenance. All sections damaged before release of maintenance shall be removed and reconstructed by the Contractor without extra compensation.

609.03.3--Bituminous Curbing.

609.03.3.1--Preparation of Bed. When curbing is to be constructed on a newly placed bituminous surface, the curb may be laid if the surface is clean.

When curbing is to be constructed on concrete or bituminous pavement that is not newly

placed, the bed shall be thoroughly swept and cleaned by compressed air. The surface shall be dry, and immediately prior to placement of the curb shall be tacked with bituminous material of the type and grade approved by the Engineer. The rate of application of the tack coat material shall be between 0.05 to 0.15 gallons per square yard of surface. The Contractor shall prevent the tack coat material from spreading to areas outside that to be occupied by the curb.

609.03.3.2--Placing. Bituminous curbing shall be constructed with a self-propelled curbing machine or paver with curbing attachments designed to extrude and compact the material in accordance with the typical section on straight and curved alignments.

The automatic curb machine shall meet the following requirements and shall be tentatively approved prior to its use. Its continued use shall be contingent upon its production of curbing meeting the specified requirements.

- (a) The weight of the machine shall be such that the required compaction is obtained without the machine riding above the specified grade.
- (b) The machine shall be capable of laying the curb to the dimensions and position specified.
- (c) The machine shall be capable of ironing the curbs smoothly with a heat-jacketed mold and of compacting the curb to at least 90 percent of theoretical density.
- (d) When curbing is to be placed on an existing bituminous surface the machine shall be capable of preheating the surface.
- (e) The machine shall form curbing that is uniform in texture, shape, and density.
- (f) The Engineer may permit construction by other means for short sections, sections with short radii, or for other reasons warranted by the Engineer. The resulting curbing shall conform in all respects to the curbing produced by the use of the machine.

609.03.3.3--Painting. When painting is required, it shall consist of two coats of the specified traffic paint meeting requirements of Section 625. Glass beads shall also conform to the requirements of Section 625 and shall be applied onto the top coat of paint in a manner that will embed the beads sufficiently to adhere to the painted surface.

609.03.4--Backfilling and Cleaning Up. After the concrete has set sufficiently or the bituminous curb has cooled, the areas on the sides of the curb, gutter, and combination curb and gutter shall be filled to the required elevation with the specified materials and compacted as specified or directed.

All surplus material shall be disposed of as directed, and the entire area shall be left in a neat and satisfactory condition.

609.04--Method of Measurement. Concrete gutter, curb, combination curb and gutter, and bituminous curb will be measured by the linear foot along the face of the curb or flow line of the gutter. Deduction will be made for driveway openings.

Concrete integral curb, complete in place, will be measured by the linear foot along the face of the curb including the full length of curb returns for driveways.

No deduction in length will be made for drainage structures such as catch basins and inlets installed in the curbing.

Excavation, backfill, expansion joint material, and other related miscellaneous items will not be measured for separate payment. The cost thereof shall be included in the unit prices bid for other items.

609.05--Basis of Payment. Concrete gutter, curb, combination curb and gutter, and bituminous curb will be paid for at the contract unit prices per linear foot, complete in place, which shall be full compensation for completing the work.

Payment will be made under:

609-A: Concrete Gutter, <u>Designation</u>	- per linear foot
609-B: Concrete Curb, Type _____	- per linear foot
609-C: Concrete Integral Curb, Type _____	- per linear foot
609-D: Combination Concrete Curb and Gutter *	- per linear foot
609-E: Bituminous Curb	- per linear foot

* Type may be specified

SECTION 610 - HIGH TENSION CABLE BARRIER

610.01--Description. This work shall consist of constructing high tension cable barrier by designing, laying out, furnishing and installing posts, cables, terminal sections (end terminals), and any special connections and fittings required in the contract documents. This also includes maintenance and repair of the system until final acceptance of the project.

Cable barrier shall be staked and laid out by the Contractor in accordance with the plans or as directed by the Engineer.

High tension cable barrier shall meet the requirements of NCHRP Report 350, Test Level 4 (TL-4), or MASH criteria. The Contractor shall provide a copy of the FHWA letter of approval for the system prior to installation.

The high tension cable barrier system shall be a four (4) wire rope system with maximum post spacing of 10.5 feet, center to center, and be appropriate for applicable field conditions and speed rating.

In addition to certifications, the Engineer may opt to sample any materials to be used in the work at any time ranging from the point of manufacture to the construction site for whatever testing or inspection the Engineer deems necessary.

The Contractor shall select and install only one single manufacturer's high tension cable barrier system for the entire project. Terminal sections and high tension cable barrier shall be produced by the same manufacturer.

610.02--Materials. High tension cable barrier shall meet the following general

requirements.

Concrete, minimum Class C	Section 804
Reinforcing Steel	Section 602
Anchor Bolts and Nuts	Subsection 810.02.21
Galvanizing (Bolts, Nuts & Washers)	AASHTO M 232
Fittings (Steel) Hardware	Subsection 712.06
Reflective Sheeting	Subsection 721.07

610.02.1--Cable. The cable shall be ¾-inch, 3 x 7, pre-stretched galvanized wire rope meeting the requirements of AASHTO M 30 / ASTM A741, Type I, Class A coating, with a Modified Breaking Strength equal to 39,000 pounds in accordance with the following:

- Pre-stretched to exhibit a minimum modulus of elasticity of 21,661,553 psi based on a steel surface area of a fixed 0.2394877 square inches, and
- Testing must be done in accordance with ISO 12076-202 Wire Rope Modulus of Elasticity “Initial (as manufactured)”, with no bedding of the rope permitted in testing.

610.02.2--Posts. Steel posts shall be socketed in metal or plastic sleeves installed in a concrete footing. Steel posts, blocks, and metal sleeves shall conform to AASHTO M 270, Grade 36, and shall be galvanized in accordance with ASTM A 123. Welding and repair welding for all steel fabrication shall be performed by certified welders and meet the requirements of AWS D1.1. All fabrication shall be completed prior to galvanizing.

Posts shall be domestic hot-rolled mild steel, or cold-formed from hot-rolled mild steel. A fitting gasket, profiled to fit tightly around each post, shall be provided to prevent debris from entering the socket.

610.02.3--Turnbuckles. Turnbuckles shall be threaded to accept the fittings described above. Turnbuckles shall be of the solid or closed body type with two inspection holes to determine threaded rope terminal penetration. Turnbuckles shall allow for a terminal penetration depth equivalent to or greater than the depth of the tested system, shall develop minimum tensile load without yielding to 36,800 pounds, and shall be galvanized, after threading, to ASTM A153, or stainless steel.

610.02.4--Mechanical Anchor Fittings. Fittings shall be provided at the anchor terminations of each wire rope and shall be of the same type as used in the connection to the turnbuckles. The fittings shall develop minimum tensile load of the entire wire rope of 36,800 pounds without yielding, shall be capable of release and reuse, and shall be galvanized to ASTM A153 after threading.

610.02.5--End Terminals. End terminals shall be NCHRP Report 350 compliant meeting Test Level 3 (TL-3) or MASH requirements and having an FHWA letter of acceptance. Each of the four cables of the system shall have anchor connections at the terminal end section. The four cables shall not terminate at the end section with a common cable. All welding shall be performed by a certified welder in accordance with AWS D1.1.

610.02.6--Delineation. The sheeting for delineation shall be Type III retroreflective sheeting meeting the requirements of Section 721 of the Standard Specifications. Sheeting shall be available in standard colors of white and yellow and may be installed on cable

barrier posts or on delineator posts, which are attached to the cable barrier post in accordance with the manufacturer's recommendations.

When used, delineator posts shall be made of high impact fiberglass reinforced composite, engineering blended plastic or thermosetting polymers that are reasonably unaffected by long term U.V. exposure and shall be of good workmanship free of burrs, discoloration, contamination and other objectionable marks or defects that affect appearance or serviceability.

610.02.7--Fittings. Threaded terminals may be wedged or swaged fitting. Swaged fitting may be shop or field swaged. The engagement depth shall be equivalent to or greater than the depth of the tested system and shall be threaded to fit the system turnbuckles. Fully fitted ropes shall develop a Minimum Breaking Load (MBL) of 36,800 pounds. Threaded terminals shall be galvanized, after threading, to ASTM A 153, or stainless steel. At all locations where the cable is connected to a cable socket with a wedge type connection, one wire of the wire rope shall be crimped over the base of the wedge to hold it firmly in place.

610.03--Construction Requirements. A manufacturer's representative shall be present during the initial installation of all components (posts, anchors, tensioning) of the cable barrier system. Upon completion of the entire system, a manufacturer's representative shall inspect and certify in writing that the cable barrier system was installed in accordance with the design and manufacturer's recommendation.

610.03.1--Cable. The Contractor shall install high tension cable barrier system according to the manufacturer's design and recommendations. Prior to construction, the Contractor shall provide the Engineer with two copies of the manufacturer's most current product manuals covering installation and maintenance of the barrier system including detailed drawings.

Turnbuckles shall be included to allow for tensioning of the cables. For installations greater than 1000 feet in length, at least one turnbuckle per 1000-foot strand shall be included. For installations less than 1000 feet in length, one turnbuckle per strand shall be included near the center of the installation.

Cable Barrier Tensioning. The cable barrier system shall be placed and tensioned immediately after initial installation per the manufacturer's recommendations. The tension shall be rechecked approximately two (2) to three (3) weeks after initial tensioning and adjusted, if necessary. Concrete shall have a minimum compressive strength of 3,000 psi prior to applying tension to the cables. The compressive strength shall be verified by cylinder tests. The Contractor shall maintain a log showing the date, time, location, temperature, and final tension reading. The log shall be signed by the person performing the readings. The log shall be given to the Project Engineer at the conclusion of the tensioning period.

The Contractor shall be responsible for providing the Project Engineer with an inventory table of all high tension cable barrier installed prior to the final inspection of the project. The inventory should include the following data: County, Route, Date Installed, System Name, Manufacturer, Beginning and Ending Latitude/Longitude at each terminal (DECIMAL), and the tension (LBS) of each cable taken near every turnbuckle in a section.

Cable Splices. Only one splice per cable is allowed between end anchor assemblies. Cable

splices shall be staggered a minimum of 20 feet from splices on adjacent cables. Cable splices shall be made in accordance with the recommendations of the manufacturer of the splice hardware.

610.03.2--Posts. The posts shall be installed plumb and in accordance with the manufacturer's recommended location, spacing, and elevation.

All posts shall be socketed steel posts. Sleeves for insertion of socketed posts shall be set in concrete foundations. All posts shall have a means of holding the wire ropes at the design height.

Post foundations shall be to the size and shape recommended and designed by manufacturer based on soil types and ground conditions. The contract documents may include information regarding the existing soil, but is the Contractor's responsibility to supply the designer of the cable barrier with all the soil information needed to design the cable system. The depth must be determined by the manufacturer's Design Engineer for the project's existing soil condition, but the minimum size shall not be less than 12 inches in diameter by 36 inches in depth (12" x 36").

610.03.3--Terminal Section. Concrete for end terminals shall be a minimum Class C in accordance with Section 804 of the Standard Specifications.

End terminal foundations shall be placed in excavations of natural, undisturbed ground, to the size and shape required by the manufacturer based on soil types and ground conditions. The contract documents may include information regarding the existing soil, but is the Contractor's responsibility to supply the designer of the cable barrier with all soil information needed to design the cable system. If over-excavation is unavoidable, the sides must be vertical and additional concrete shall be used to completely fill the excavated area. Alternatively, foundations may be formed and cast, then backfilled by a means that achieve a compacted density acceptable to the Engineer.

Exposed concrete shall be finished in accordance with the manufacturer's recommendations and as directed by the Engineer.

610.03.4--Delineating High Tension Cable Barrier. High tension cable barrier installations shall be delineated with retroreflective sheeting. Unless otherwise indicated, the delineation shall be applied to the last five posts at each end of an installation and throughout the remainder of the installation at a maximum spacing of 50 feet. The delineation shall provide a minimum of seven (7) square inches of area per post when viewed on a line parallel to the roadway centerline. The delineation shall be attached near the top of the post as recommended by the manufacturer. For median installations, the sheeting shall be applied to both sides of the post. For roadside installations, the sheeting shall be applied only to the side of the post facing traffic. The sheeting shall be yellow or white and shall be the same color as the adjacent edge line.

The Contractor may elect to attach delineators to the posts in accordance with the manufacturer's recommendations.

610.03.5--Installation Training. The Contractor shall provide a minimum of eight (8) hours of instruction on the installation, maintenance and repair of the system. This training shall be provided in a location central to the project and the local District Office. The

scheduling and location of this training shall be approved by the Engineer. The Project Engineer will advise the District Maintenance Representatives of the training location and schedule.

The Contractor shall provide on-site field instruction by the manufacturer of the system using a minimum 2000-foot section of the system. The amount of this training will be as necessary to provide field training on all aspects of the system installation, including grading, line post installation, wire rope installation and tensioning, and terminal or anchor installation. Upon completion of the cable barrier system or within ten (10) days of the Maintenance Release, the Contractor shall deliver to the Project Engineer one new cable tensioning device/meter for future Department maintenance activities. This device shall become the property of the Department and its cost shall be included in other items bid.

610.03.6--Cable Barrier Repair. The Contractor shall maintain and repair the cable barrier until final inspection of the project. Should the cable barrier be damaged, the Contractor shall repair the barrier immediately. The cable barrier post shall be replaced and the cable re-installed to the post. When the damage is caused by the traveling public to a complete-in-place section of cable barrier, the repair will be paid for under pay item Cable Barrier Post Repair.

610.04--Method of Measurement. Cable barrier will be measured by the linear foot. The length of cable barrier will be the length of installation not including lengths of high tension cable barrier terminal sections. Cable barrier terminal section will be measured per each. Cable barrier post repair will be measured by each replacement post required to repair the cable barrier.

610.05--Basis of Payment. Cable barrier, measured as prescribed above, will be paid for at the contract bid price per linear foot, which price shall be full compensation for all materials, equipment, tools, staking, lay out, and labor necessary to complete installation of the cable barrier, including post foundations, delineators, other hardware, any excavation and backfilling, and training necessary to complete the work.

Cable barrier terminal section, measured as prescribed above, will be paid for at the contract bid price per each, which price shall be full compensation for all materials, equipment, tools, staking, lay out, and labor necessary to complete the installation of the cable barrier terminal section, including post foundations, delineators, anchors, reinforcing steel, other hardware, any excavation and backfilling, and training necessary to complete the work.

Cable barrier post repair, measured as prescribed above, will be paid for at the contract bid price per each post, which price shall be full compensation for all labor, tools, replacement posts, post connectors, delineators, foundation repairs, miscellaneous hardware, and incidentals necessary to complete the repair of a damaged section of cable barrier.

Payment will be made under:

610-A: Cable Barrier	- per linear foot
610-B: Cable Barrier Terminal Section	- per each
610-C: Cable Barrier Post Repair	- per each

SECTION 611 - BRICK MASONRY

611.01--Description. This work consists of constructing brick masonry structures in accordance with these specifications and in reasonably close conformity with the lines, grades, dimensions, and details shown on the plans or as directed.

611.02--Materials. Masonry brick shall be new, whole brick of standard commercial size with straight and parallel edges and square corners. They shall be Grade SW or Grade SM as specified and shall meet the requirements of Subsection 706.01.

Unless otherwise specified, the following use requirements shall govern:

- (a) Grade SW brick shall be used in exposed masonry.
- (b) Grade SM brick shall be used in catch basins, inlets, manholes, and other sewer or drainage structures.

Mortar for brick masonry shall conform to the applicable requirements of Subsection 714.11.

611.03-Construction Requirements.

611.03.1--Excavation. Excavation for brick masonry shall be performed in accordance with the provisions of Subsection 604.03.7.

611.03.2--Laying Brick. Brick masonry shall not be constructed in freezing weather or when bricks contain frost except by written permission of the Engineer and subject to the conditions set forth.

Brick for exposed surfaces, corners, etc. shall be selected for color and uniformity.

Mortar shall be mixed only in quantities required for immediate use. See Subsection 714.11.5 for more information on masonry mortar.

Brick shall be laid upon prepared foundations in accordance with the design indicated on the plans or as directed. All brick shall be thoroughly cleaned and saturated with water immediately prior to laying. They shall be laid in courses and in a manner that will thoroughly bond them into the fresh mortar by means of the "shove joint" method. "Buttered" or plastered joints will not be permitted. The arrangement of headers and stretchers shall be that which will thoroughly bond the mass. Unless otherwise specified, brick work shall be of alternate headers and stretchers with consecutive courses breaking joints. Other types of bonding, such as for ornamental work, will be specified on the plans.

All joints shall be completely filled with mortar. They shall not be less than 1/4 inch nor more than 1/2 inch in thickness, and the thickness shall be uniform throughout. All joints shall be finished properly as the work progresses, and on exposed walls they shall be neatly struck using the "weather" joint.

Bats or spalls shall not be used except for shaping around irregular openings or when unavoidable to finish out a course. When used to finish out a course, full bricks shall be placed at the corners and the bats placed in the interior course. Filling materials for the interior of the walls shall be the same quality as used in the face of the unit unless otherwise

indicated on the plans or directed.

Weep holes shall be constructed as shown on the plans or as directed.

In case a brick is moved or the joint broken after laying, the brick shall be taken up, the mortar thoroughly cleaned from the brick bed and joint, and the brick relaid in fresh mortar.

In hot or dry weather, brick masonry shall be protected and kept wet for a period of at least 48 hours after the brick are laid.

Only expert bricklayers shall be used for this work, and all details of the construction shall be in accordance with approved and satisfactory practice.

All exposed masonry shall present an even, uniform, neat, and workmanlike appearance, and the exposed surfaces shall be thoroughly cleaned of all mortar and scars and the surface left the natural color of the brick.

611.03.3--Backfill. Backfill for brick masonry shall be in accordance with the provisions of Subsection 203.03.8.6.

611.04--Method of Measurement. Brick masonry will be measured by the cubic yard or by the thousand. The unit for measurement will be indicated on the bid sheet.

When measurement is by the cubic yard, the volume will include the mortar.

When measurement is by the thousand, the mortar will not be measured for payment.

When either concrete masonry or brick masonry is permitted under Subsection 604.03.4, measurement will be made in accordance with Subsection 604.04.

Excavation for brick masonry will not be measured for payment.

611.05--Basis of Payment. Brick masonry will be paid for at the contract unit price per cubic yard or per thousand, as indicated, which shall be full compensation for completing the work.

When brick masonry is used as an optional item of construction under Subsection 611.04, payment will be made as provided in Subsection 601.05.

Payment will be made under:

611-A: Brick Masonry - per cubic yard or thousand

SECTION 612 - FLOWABLE FILL

612.01--Description. This work shall consist of furnishing and placing a flowable fill material. Uses include, but are not limited to, placement under existing bridges, around or within box culverts or pipe culverts, or at other locations shown on the plans.

612.02--Materials. All materials shall meet the requirements of the following

Subsections, or as stated herein:

Fine Aggregate.....	*
Portland Cement	701.01 and 701.02
Fly Ash	714.05
Air Entraining Admixtures **	713.02
Water	714.01.1 and 714.01.2
Calcium Chloride **	714.02

* The gradation of the fine aggregate shall be fine enough for the fine aggregate to stay in suspension in the mortar to the extent required for proper flow and shall conform to the following grading:

Sieve Size	% Passing
1/2 inch	100
No. 200	< 1

** High air generators shall be used, as required, in order to increase the total air content to 25 – 35%. Only approved high air generators shall be used to obtain the required air content. Either a Type C or E chemical admixture or maximum 1.0% calcium chloride by weight of the total cementitious materials may be added as required by the application and with the approval of the Engineer. Calcium chloride may not be used where the flowable fill comes into contact with metal. Adding the Type C or E chemical admixture or calcium chloride does not require a different or new mixture design from one previously approved.

612.02.1--Mixture Design. Flowable fill is a mixture of portland cement, fine aggregate, water, and, as required to obtain the required total air content, either high air generators or air entraining admixtures. Fly ash shall be used for Non-Excavatable applications. Flowable fill contains a low cementitious content for reduced strength development.

At least 30 days prior to production of flowable fill, the Contractor shall submit to the Engineer proposed flowable fill mixtures design following the mixture design submittal procedures listed in the Department’s *Concrete Field Manual*.

The concrete producer shall assign a permanent unique mixture number to each flowable fill mixture design. All flowable fill mixture designs will be reviewed by the Materials Division prior to use. Flowable fill mixture designs disapproved will be returned to the Contractor with a statement explaining the disapproval.

Once approved, a flowable fill mixture design may be transferred to other projects without additional testing provided the material sources have not changed. Allowable changes in material sources shall meet the requirements of the Department’s *Concrete Field Manual*, Section 5.7. For allowable changes in material sources, the mixture design shall be re-verified following the requirements of Subsection 612.02.1.2.

612.02.1.1--Proportioning of Mixture Design. The mixture design proportions shall be determined based on batches mixed using production equipment.

Table 1, “Flowable Fill Mixture Design Proportioning Guide”, is a guide for proportioning flowable fill, except where noted.

Table 1
Flowable Fill Mixture Design Proportioning Guide

Material	Excavatable	Non-Excavatable
	Amount (lbs/yd ³)	
Cement	75 – 150 *	75 – 150 *
Fly Ash	-	150 – 600 *
Fine Aggregate	**	**
Water	***	***

- * Guideline for proportioning. The actual amount may vary from the amount listed the Table 1.
- ** Fine aggregate shall be proportioned to yield one cubic yard of mixture as verified by unit weight.
- *** Mixture designs shall produce a consistency that will result in a flowable self-leveling product at time of placement.

Each mixture design shall be verified using production equipment prior to submittal of the mixture design for review. During the verification, the mixture design shall meet the requirements of the “Performance Requirements Flowable Fill Design” listed in Table 2. The verification performance data and the corresponding batch ticket shall be submitted with the mixture design.

Table 2
Performance Requirements for Verification of Flowable Fill Mixture Designs

Mixture Property	Performance Requirement		Required Test Method
	Excavatable	Non-Excavatable	
Consistency	Approximate 8-inch spread		(see below)
Total Air Content (%)	25 – 35	5 – 15	AASHTO T121
28 Day Compressive Strength (psi)	-	Minimum 125	AASHTO T22 and T23
Unit Weight (lbs/ft ³)	90 – 110	100 – 125	AASHTO T121

The consistency of the fresh mixture shall be that of a thin slurry. The consistency shall be tested by filling to the top a three-inch diameter by six-inch high cylinder that is open on both ends. With the mixture in the cylinder, immediately pull the cylinder straight up. The correct consistency of the mixture will produce a spread meeting the requirements in Table 2 with no segregation.

612.02.1.2--Verification of Mixture Design. The verification shall be performed by the Contractor prior to submittal of the mixture design proportions for review. The verification performance data and the corresponding batch ticket shall be submitted with the mixture design. The verification shall be performed using the batching and mixing equipment anticipated to be used during production of the mixture for the project. In addition to the performance requirements listed in Table 2, the verification shall meet the batching tolerance requirements for the material weights listed in the Department’s *Concrete Field Manual*.

Adjustments of the proportions of fine aggregate and/or water shall be made to achieve suspension of the fine aggregate.

The requirements in Table 2 for consistency, percent total air content, compressive strength, and unit weight are for verification of the mixture design proportion purposes only and are not intended for jobsite acceptance requirements.

612.02.2--Acceptance of Mixture. The acceptance of the mixture at the job site will be based on the performance of the flowable fill mixture placed and will be at the discretion of the Engineer. For acceptance of the mixture at the job site, the mixture shall be self-leveling and shall not settle, segregate, or have excessive bleed water.

612.02.3--Manufacturing. Flowable fill will be batched, mixed, and transported in accordance with the requirements of Section 804.

612.02.4--Sampling and Testing. The yield shall be determined by testing the first load placed on each production day in accordance with AASHTO T121. If adjustments are made to the mixture design proportions to correct for yield, the yield shall be determined on the next load with the adjusted proportions.

612.03--Construction Requirements. Prior to placing flowable fill, each end of the structure shall be plugged leaving an opening at each end no larger than necessary to accommodate the filling equipment. Flowable fill shall be discharged from the mixer by any reasonable means into the area to be filled. Unless otherwise approved by the Engineer, filling will begin on the downstream end of the structure and continue until no further material will enter the structure. The flowable fill will then be continued from the upstream end of the structure.

612.04--Method of Measurement. Flowable fill will be measured by the cubic yard, which will be determined from the yield in accordance with the requirements of Subsection 612.02.4. The yield will be calculated by dividing the actual batch weights of each load by the unit weight of the mix, which will be determined by testing the first load placed on each production day.

612.05--Basis of Payment. Flowable fill, measured as prescribed above, will be paid for at the contract unit price per cubic yard, which price shall be full compensation for furnishing all labor, equipment, tools and materials to complete the work.

Payment will be made under:

612-A: Flowable Fill, Excavatable - per cubic yard

612-B: Flowable Fill, Non-Excavatable - per cubic yard

SECTION 613 - ADJUSTMENT OF CASTINGS, GRATINGS, AND UTILITY APPURTENANCES

613.01--Description. This work consists of furnishing all materials and adjusting existing catch basins, inlets, manholes and other designated structures in accordance with these specifications and in reasonably close conformity with the lines, grades and dimensions

shown on the plans or as established.

613.02--Materials. New materials used in this construction, unless otherwise stipulated, shall conform to the requirements set out in Section 604.

613.03--Construction Requirements.

613.03.1--General. Construction requirements shall be, insofar as applicable, as described in Section 604. Castings, gratings, frames, covers, and other metal units shall be cleaned before resetting.

Where a casting, grating, or utility appurtenance is to be lowered, the masonry shall be removed to sufficient depth so that a set of proper dimensions may be reconstructed to receive the casting, grating or utility appurtenance at the new grade. Where the castings, grating or utility appurtenance is to be raised less than one foot, a new ring of masonry may be added without disturbing the old masonry. The use of metal rings to raise appurtenances will be allowed with approval of the Engineer. Where the distance to be raised exceeds one foot, the old masonry shall be removed to sufficient depth, as directed, to permit a neat and workmanlike extension to the new grade.

The Contractor shall replace, at no additional cost to the State, all units or parts indicated to be salvaged and reused that are damaged as a result of the Contractor's operation.

613.03.2--Cleaning Up. Upon completion of the adjustment, all surplus material shall be removed, and the structure and site of the work shall be left in a neat and clean condition. The entire structure shall be thoroughly cleaned of accumulations of silt, debris, or foreign matter of any kind and shall be kept clean until the final inspection.

613.04--Method of Measurement. Adjustment of castings, gratings, utility appurtenances, etc. for which pay items are included in the contract will be measured on a lump sum basis or by the number of units, as specified.

613.05--Basis of Payment. Adjustment of castings, gratings, and utility appurtenances for which pay items are included in the contract will be paid for at the contract lump sum price or at the contract unit price per each, as indicated, which shall be full compensation for completing the work.

Payment will be made under:

613-A: Adjustment of Castings, Gratings and Utility Appurtenances	- lump sum
613-B: Adjustment of Castings	- per each
613-C: Adjustment of Gratings	- per each
613-D: Adjustment of <u>Description</u>	- lump sum or per each

SECTION 614 - CONCRETE DRIVEWAYS

614.01--Description. This work consists of furnishing all materials and constructing

cement concrete driveways on a prepared grade in accordance with these specifications, at the locations, and in reasonably close conformity with the lines, grades, and typical sections as shown on the plans or as established.

614.02--Materials. Unless otherwise stipulated, the materials used in this construction, in addition to conforming to the requirements of Division 700 for materials specified and used, shall conform to the following:

- (a) Concrete. The materials used in the manufacture of concrete shall conform to the requirements for the type of concrete pavement used in the roadway as set out in Section 501, or shall conform to the requirements for Class "B" concrete as set out in Section 804, as shown on the plans and in the proposal, or as otherwise indicated in the contract.
- (b) Expansion Joint Filler. Expansion joint filler shall be either premolded or poured and shall conform to the requirements as set forth in Section 707 for the particular type specified.

614.03--Construction Requirements.

614.03.1--Equipment. The equipment shall conform to the requirements of Section 501 or Section 804, as applicable. All small tools, such as edgers, floats, tamps, etc., shall be approved tools of such quality and quantity as to assure their adequacy in the performance of acceptable work. Approved equipment, necessary and required, shall be on the project in good working condition before construction will be permitted to start.

614.03.2--Preparation of Grade. In-grade preparation shall be performed in accordance with the applicable provisions and requirements of Section 321, unless otherwise specified or directed by the Engineer, within the tolerances set out in Subsection 321.03.7, extending such preparation, unless otherwise specified, to at least two (2) feet beyond the edges of the proposed concrete driveway.

614.03.3--Forms. Forms and forming shall conform to the requirements of Subsection 608.03.3.

614.03.4--Manufacturing and Placing Concrete. The concrete used in the construction of driveways shall be manufactured, proportioned and placed in accordance with the requirements of Section 501 or Section 804 as shown on the plans and in the proposal.

Prior to the placing of any concrete the grade shall be tested with a template cut true to cross-section of the proposed construction, all irregularities corrected and compacted, and the entire grade sprinkled with water.

Immediately after mixing, the concrete shall be deposited in a single layer on the moist grade to such depth that after finishing it shall be of the full thickness required. The edges, sides, etc., shall be thoroughly spaded, and the surfaces tamped sufficiently to compact the concrete and bring mortar, for finishing, to the surface.

Curb returns for driveways shall be constructed to the dimensions and section shown on the plans or as directed, using the same concrete mixture as used for the driveway slab. They shall be constructed monolithic with the slab as specified for integral curb in Section 609.

614.03.5--Finishing. The concrete shall be struck-off with a transverse template resting upon the side forms, and shall be floated, with an approved float, in such a manner that excess water, laitance, or other inert material shall be removed from the surface. When the surface of the concrete is free from water and just before it obtains its set, it shall be finished with a wooden float so as to produce a sandy texture.

The edges of the concrete at expansion joints shall be edged with an edger having a radius of one-half (1/2) inch.

Curb returns shall be finished as specified for integral curb in Section 609.

614.03.6--Expansion Joints. Expansion joints shall be formed of premolded joint filler or poured filler of the specified thickness, and shall be placed at the locations indicated on the plans. All joint fillers shall be cut to full cross-section and shall extend to the full depth, width and length of the construction. Any expansion joint material extruding after the concrete is finished, shall be trimmed as directed.

614.03.7--Protection and Curing. After the concrete is completed, it shall be protected and cured in accordance with the requirements of Subsection 501.03.20 or other approved method.

Conditions governing the placement of concrete and the requirements for the placement, protection and curing of concrete during cold or hot weather shall conform to the limitations, conditions and requirements of Subsection 804.03.16 as applicable.

614.03.8--Backfilling and Cleaning Up. When the concrete has set sufficiently, the sides of the driveway shall be backfilled to the required elevation with suitable material, which shall be tamped in layers of not more than six (6) inches until firm and solid. All surplus material shall be disposed of as directed, and the completed work and the site shall be left in a neat and presentable condition.

614.04--Method of Measurement. Concrete driveways of the type specified will be measured for payment by the square yards. Driveway areas shall be defined as follows:

- (a) Where the driveway joins pavement and integral curb construction, the driveway area shall include the entire paved area behind the normal back of curb line.
- (b) Where the driveway joins combined curb and gutter construction, the driveway area shall include the entire paved area back of the normal line of the inside face of the gutter. The division line between combined curb and gutter and driveway area shall be that point designated as the beginning of the curb return.

614.05--Basis of Payment. Concrete driveways, measured as prescribed above, will be paid for at the contract unit price per square yard, which price shall be full compensation for curb returns; all backfilling and disposal of surplus materials; and for all materials, forms, equipment, tools, labor and incidentals necessary to complete the work.

Payment will be made under:

614-A: Concrete Driveway, Without Reinforcement * - per square yard

614-B: Concrete Driveway, With Reinforcement *

- per square yard

* Thickness may be specified

SECTION 615 - CONCRETE BARRIER

615.01--Description. This work consists of furnishing all materials and constructing concrete barrier in accordance with these specifications and the details shown on the plans and in reasonably close conformity with the dimensions, lines, grades, and elevations shown on the plans or established by the Engineer.

615.02--Materials. Materials used in this work shall be in accordance with the applicable requirements of Section 700 or as shown on the plans.

Unless otherwise specified, concrete for barrier, cast-in-place or slipform placement, shall be Class "B" meeting the requirements of Section 804.

Concrete for precast barrier using the dry-cast plant manufacturing process shall produce 5,000 psi compressive strength in 28 days.

615.03--Construction Requirements.

615.03.1--General. Cast-in-place barrier shall be constructed in accordance with the requirements of Subsection 813.03.2.2 and applicable requirements of Section 804.

Barrier constructed by slipform placement shall be constructed in accordance with the requirements of Subsection 615.03.2 and applicable requirements of Section 804.

Precast barrier shall be constructed in accordance with applicable requirements of Section 804 and the requirements of Subsection 813.03.2.3, except concrete material requirements will be as set forth in Subsection 615.02. Precast concrete barriers must meet the requirements of NCHRP Report 350 or MASH.

Joints shall be as shown on the plans, and the surface finish shall be Class 2, rubbed or spray finish, in accordance with the requirements of Subsection 804.03.19.3.

615.03.2--Slipform Placement. When concrete median barrier is placed by the slipform method, the slipform machine shall be crawler mounted for stability and shall include automatic sensing and control equipment for controlling line and grade. Continuation of placement by the slipform method shall be contingent upon quality workmanship and good configuration, lines and grades with very little hand finishing required. The Contractor shall be fully responsible for placement at no additional cost to the State, any and all barrier not conforming to the requirements of the contract. To improve placement characteristics, the State Materials Engineer may make minor modifications in the concrete mix design for this type of placement.

615.04--Method of Measurement. Concrete barrier of the type specified will be measured by the linear foot out to out of the barrier. This measurement shall include all elements of the barrier and its foundation.

615.05--Basis of Payment. Concrete barrier, of the type specified, will be paid for at the contract unit price per linear foot, complete-in-place, which shall be full compensation for completing the work.

Payment will be made under:

615-A: Concrete Description Barrier - per linear foot

615-B: Precast Concrete Description Barrier - per linear foot

SECTION 616 - MEDIAN AND ISLAND PAVEMENT

616.01--Description. This work consists of constructing paved medians and islands on prepared grades in accordance with these specifications and in reasonably close conformity with the lines, grades, and sections shown on the plans or established. When so indicated on the plans, this work shall also consist of painting the surface, or portions thereof, of the median or island.

616.02--Materials.

616.02.1--Concrete. The materials used in the manufacture of concrete shall conform to the requirements of Section 804 for the class of concrete specified. Unless otherwise specified, Class "C" concrete shall be used.

616.02.2--Joint Filler. Joint filler shall be the type specified on the plans and shall conform to the requirements of Section 707. Unless otherwise specified, the filler shall be ½-inch premolded filler meeting the requirements of Subsection 707.02.2.

616.02.3--Asphalt Pavement. Asphalt pavement shall be in accordance with the applicable materials and construction requirements of Sections 401 and 403.

616.03--Construction Requirements.

616.03.1--Equipment. The equipment shall conform to the applicable requirements of Sections 401, 501, and 804, except that approved modified placement, shaping, compacting, and finishing equipment will be permitted. All small tools, such as edgers, floats, tamps, etc., shall be approved tools of such quality and quantity as to assure their adequacy in the performance of acceptable work. Approved required equipment shall be on the project in good working condition before construction will be permitted to start.

616.03.2--Preparation of Grade. Unless otherwise specified, in-grade preparation shall be performed in accordance with the applicable provisions of Section 321. After completion of grade preparation, the entire area shall be treated with a soil sterilant as follows:

- (a) Soil sterilant material shall be applied at the maximum rate recommended on the manufacturer's label for perennial weed control. Any granular or pelletized type soil sterilant that is approved by the Engineer may be used. The approved material shall be uniformly spread over the entire area immediately prior to placing the pavement.

- (b) The chemical compounds shall be delivered to the job in unbroken containers with the manufacturer's label thereon.
- (c) The Contractor shall be responsible for performing all precautions as shown on the label of the containers and shall be liable for any injury or damage caused from handling or using the material until acceptance of the project.
- (d) Furnishing and placement of soil sterilant shall be absorbed in the cost of the other bid items.

616.03.3--Forms. Forms will not ordinarily be required. If specified or necessary, forms and forming shall be in accordance with the requirements of Subsection 608.03.3.

616.03.4--Manufacturing and Placing Concrete. Concrete for this work shall be manufactured and placed in accordance with the requirements of Section 501 or Section 804 except that approved modified methods of placement, shaping, and compacting will be permitted. Concrete surfaces shall be given a Class 6 float finish in accordance with Subsection 804.03.19.5.

The fresh concrete shall be deposited in a single layer on a moist grade. The edges, shall be thoroughly spaded, and the surface shall be tamped sufficiently to compact the concrete and bring mortar for finishing to the surface.

The finished surface shall conform closely to the typical section indicated on the plans and shall not have irregularities that would prohibit complete surface drainage, including drainage over adjacent curb.

The edges of the concrete at expansion joints shall be edged to a radius of 1/2 inch.

616.03.5--Expansion Joints. Unless otherwise shown on the plans, expansion joints shall be formed of premolded joint filler of the specified thickness. All joint fillers shall be cut to full cross section and shall extend to full depth, width, and length. All expansion joint material extruding after the concrete is finished shall be trimmed as directed.

In the event the locations are not shown on the plans, joints shall be placed between all edges of the median or island pavement and the surrounding curb or pavement. Where applicable, joints shall be placed to match expansion and contraction joints in adjacent curb or pavement.

616.03.6--Protection and Curing. After the pavement is finished, it shall be protected and cured in accordance with the requirements of Subsection 501.03.20 or by other approved method.

Placement, protection, and curing of concrete during cold and hot weather shall conform to the limitations, conditions and requirements of Subsection 804.03.16.

616.03.7--Manufacturing and Placing Bituminous Pavement. Asphalt pavement used in construction of median and island pavement shall be manufactured and placed in accordance with the requirements of Sections 401 and 403, except that approved modified methods of placement, shaping, and compacting will be permitted. The pavement shall consist of the layers and types shown on the plans. The surface of the finished pavement shall conform closely to the typical section indicated on the plans and shall not have irregularities that would prohibit complete surface drainage, including drainage over

adjacent curb.

616.03.8--Cleaning Up. All surplus material shall be disposed of as directed, and the completed work and the site shall be left in a neat and presentable condition.

616.03.9--Markings. When specified, pavement markings on median and island pavement shall be made as detailed or as directed by the Engineer, and shall conform to the provisions and requirements of the applicable sections for the markings specified.

616.04--Method of Measurement. Median and island pavement of the type specified will be measured in square yards.

Excavation will not be measured for separate payment, and the cost thereof is to be included in the price of other items of work.

Pavement markings, if required, will be measured and paid for in accordance with the applicable sections for the markings specified.

616.05--Basis of Payment. Median and island pavement of the type specified will be paid for at the contract unit price per square yard, which shall be full compensation for completing the work.

Payment will be made under:

616-A: Concrete Median and/or Island Pavement, Thickness - per square yard

616-B: Bituminous Median and/or Island Pavement, Thickness - per square yard

SECTION 617 - RIGHT-OF-WAY MARKERS

617.01--Description. This work consists of furnishing and placing right-of-way markers and permanent easement markers in accordance with the plans and these specifications and at points designated on the plans, or as directed. The work also shall include the removal of right-of-way markers from their original locations and resetting at new locations as specified or established.

Generally, Type “A” markers shall be placed in the ground and Type “B” markers shall be placed in concrete areas. The estimated quantity of markers will be shown on the plans, and it is the Contractor’s responsibility to verify the type and number of markers required.

617.02--Materials. The right-of-way marker and permanent easement markers shall be constructed using a reinforcement bar of the size indicated and a brass or bronze cap as indicated on the plan sheet. The cap shall be Mark-It® Model C/M-HS-3-1/4B, Berntsen® 6000 Series, or approved equal. The cap shall be stamped with information indicated on the plans. The rebar shall meet the requirement of Section 711 of the Standard specifications.

Right-of-way markers for placement in concrete shall be Mark-It® model C/M-SS-3-1/4B, Berntsen® C Series, or approved equal brass or bronze stem designed marker. The cap shall be stamped with information indicated on the plans.

The witness post shall be made of fiberglass or Poly Vinyl Chloride (PVC) and shall not rust, rot or corrode within the service temperature range of -40°F to 140°F. It shall be of the color and size indicated in the plans or contract documents. The color shall not be painted on the marker but shall be pigmented into the material composition of the post. The post shall feature ultra violet (U.V.) inhibitors to eliminate cracking, peeling and deterioration of the post.

617.03--Construction Requirements.

617.03.1--General. Markers shall be manufactured in accordance with the details shown on the plans and the requirements of this section.

Prior to installation, the rebar shall be checked to assure there are no large burrs or mushrooming on the end that will receive the brass cap. Any burrs shall be filed or ground off before installation. The Contractor shall use rebar drivers to eliminate mushrooming of the rebar during the driving operations.

Type "B" markers may be installed in freshly placed concrete or placed in cured concrete by drilling and anchoring. The marker shall be anchored using a bonding material recommended by the manufacturer of the marker.

The Contractor shall use specially designed post drivers or other means necessary to eliminate damage to the witness posts during installation. The Contractor will not be required to place witness posts in concrete.

All letters, symbols, and other markings shall be as shown on the plans and shall be neatly imprinted in the caps.

The markers shall be set at the locations designated on the plans, or as directed by the Engineer with assistance as needed by the District Surveyor. The markers shall be set to within 1/4 inch of the lines indicated or established and a minimum of two inches below to a maximum of six inches below the natural ground elevation.

The layout and placement of right-of-way markers shall be performed by, or under the supervision of, or directed by, a Licensed Professional Surveyor who is duly licensed and entitled to practice as a Professional Surveyor in the State of Mississippi and shall have responsible charge for these duties. The duties performed by said Professional shall conform to the definitions under the practice of "land surveying" in Mississippi Law. The location of the markers shall be as shown in the plans. Accuracy standards for placement of markers shall be 0.05 feet relative to the project control established by the Department using either State Plane Coordinate monuments or centerline control monuments used for construction or those accuracies as listed in the Mississippi State Board of Licensure for Professional Engineers and Surveyors publication entitled "Standards of Practice for Surveying in the State of Mississippi." The more stringent of these two accuracy standards will apply and shall be used. The Contractor shall not engage the services of any person in the employ of the Department for the performance of any of the work covered by this Section or any person who has been employed by the Department within the past six months, except those who have legitimately retired from service with the Department during this period.

The Department will establish, one time only, State Plane Coordinate System horizontal control monuments. It shall be the responsibility of the Contractor to establish additional control as may be required to facilitate the staking of the right-of-way. Control monuments set by the Contractor shall meet the minimum standards of surveying as required by the Mississippi State Board of Licensure for Professional Engineers and Surveyors. The accuracy of the control established by the Contractor shall be not less than 1:20,000 relative to the control provided by the Department. The Contractor shall reference, guard and protect control points from damage and obliteration. The Contractor shall verify the accuracy of the control points before proceeding with the installation.

617.03.2--Removal of Existing Markers. Existing right-of-way markers and permanent easement markers specified to be removed shall be removed in accordance with the plans or as directed by the Engineer without additional compensation.

617.03.3--Certification. After all markers are installed, the Licensed Professional Surveyor tasked with responsible charge for this installation shall submit a written certification to the Engineer certifying that all right-of-way markers were set at the locations designated on the plans, or otherwise directed by the Department, and to the specified tolerances. The certification shall also include a copy of the right-of-way plan sheets with the right-of-way marker / permanent easement table(s) completed for all locations in which the Licensed Professional Surveyor installed right-of-way markers and permanent easement markers. The table shall be completed showing the as-built (in-place) northing and easting location based on the State Plane Coordinate System. Each right-of-way plan sheet shall be signed and stamped by the Licensed Professional Surveyor.

The Licensed Professional Surveyor tasked with responsible charge will furnish a signed and stamped Final Right-of-Way Plat meeting the minimum standards of surveying for a Class A, B, or C survey as required by the Mississippi State Board of Licensure for Professional Engineers and Surveyors. In no incidence shall the standards for surveying be less accurate than a Class C survey.

The Final Right-of-Way Plat shall show all horizontal control points, whether provided by the Department or by the Contractor. In addition, the as-built project alignment shall be shown with stationing, curve data, and State Plane Coordinates for the BOP, PC's, PT's, and EOP.

617.04--Method of Measurement. Right-of-way markers and permanent easement markers will be measured by the unit.

Markers shall be measured for payment as follows:

- 50% of the quantity placed upon completion of the installation of the marker and witness post.
- Remaining 50% of the quantity placed upon the submission of the Final Right-of-Way Plat.

617.05--Basis of Payment. Right-of-way markers and permanent easement markers, measured as prescribed above, will be paid for at the contract unit price per each, which shall be full compensation for all the components and imprinting necessary for the right-of-way marker / permanent easement markers, the witness post and surveying decals, right-of-way plat, all labor, materials and incidentals necessary to furnish a complete in-place

right-of-way marker.

Payment will be made under:

617-A: Right-of-Way Marker - per each

617-B: Permanent Easement Marker - per each

SECTION 618 - MAINTENANCE OF TRAFFIC AND TRAFFIC CONTROL PLAN

618.01--Description.

618.01.1--General. This work consists of maintaining two-way through and local traffic at all times, except as provided herein or in other contract documents. It consists of constructing, maintaining in good condition, and removing temporary structures, approach roads, and other facilities required for maintenance of traffic and the furnishing of temporary materials therefore, unless otherwise indicated in the contract.

This work includes furnishing, erecting, maintaining in good condition, and removing all required construction signs, barricades, and temporary traffic stripe.

When specified on the plans, the Contractor will construct, maintain and remove all detour bridges as indicated in the plans and contract documents. This work shall consist of the furnishing of materials, construction, maintenance and removal of bridges with payment as described hereinafter.

Unless shown otherwise in the plans, through and local traffic shall be maintained throughout the project at all times on existing facility, detours and completed permanent facility indicated on the plans and as necessary to carry out construction within the intent of the plans and contract. Minimum requirements of the Traffic Control Plan are shown on the plans.

Upon receipt of the Final or Partial Maintenance Release, as documented in writing by the State Construction Engineer, the Contractor shall have fifteen (15) calendar days in which to remove all construction signs on the project. It is agreed that if the signs are not removed within the fifteen (15) calendar days the signs shall be considered abandoned and shall become the property of the Mississippi Transportation Commission, which may remove, use, and/or dispose of such signs as it sees fit.

The Contractor shall place and maintain appropriate construction signs for any additional work on the project after the Partial or Final Maintenance Release has been issued. These construction signs will not be measured for separate payment. Payment for these signs shall be included in pay item no. 618-A, Maintenance of Traffic.

618.01.2--Traffic Control Management. This work also consists of complying with the contract requirements of the Department's Traffic Control Plan. The purpose of the Traffic Control Plan is to maintain through and local traffic safely through construction zones. In addition to this section, the plan includes: Subsections 104.04, 105.15, 107.07, and 107.10; Section 619; special provisions modifying this section and supplements thereto; individual

plan sheets applicable to the plan; and Part VI of the Manual on Uniform Traffic Control Devices (MUTCD). All traffic control devices shall comply with Part VI of the latest edition of the MUTCD.

The Department will designate a responsible person at the project level to monitor the Contractor's compliance with the plan.

The Contractor shall designate a Traffic Control Supervisor (TCS) who will be responsible for monitoring and maintaining the effectiveness of the plan. The Contractor shall also designate a substitute who is authorized to act in the absence of the TCS. The TCS and substitute must be able to be reached at all times when not on the Project.

Prior to or at the pre-construction conference, the Contractor shall designate a TCS who will be responsible for monitoring and maintaining the effectiveness of all traffic control related activities on the project. The TCS may have other assigned duties, but shall be readily available at all times to perform duties of the TCS as required. The Contractor may assign a Traffic Control Technician (TCT) to assist the TCS with traffic control related activities on the project. The TCS shall be responsible for the overall traffic control management on the project which includes that of subcontractors.

A minimum of one TCS or TCT shall be on the project at all times during working hours, except in the following type of projects where a TCS shall be required during working hours.

- Interstate projects
- Four-lane highways projects
- Multilane roads projects, excluding turn lanes, with speeds 45 mph or greater
- Night work projects

The Engineer shall be furnished with the telephone numbers and email addresses of the Contractor's TCS and TCT.

Prior to the commencement of work on the project, the Contractor shall submit proof of certification of the TCS and the TCT as applicable. Certification as either a TCS or a TCT may be obtained by one of the following methods:

- a) American Traffic Safety Services Association (ATSSA),
- b) Construction industry association training recognized by the Department, or
- c) Traffic Control Supervisor or Traffic Control Technician training conducted by the Department.

Re-certification as a TCS or TCT will be required every four (4) years.

At a minimum, the TCS shall have the following duties:

- a) Ensure that all traffic control devices are in compliance with the plans, specifications and latest edition of the MUTCD,
- b) Correct all traffic control safety hazards immediately after discovery,
- c) Monitor the work to ensure that no potential hazards exist due to the Contractor's operations,

- d) Monitor and evaluate both the daytime and nighttime performance of all traffic control devices installed on the project, and take corrective actions on all deficiencies and note such actions on the inspection form,
- e) Be available to the Engineer on a 24-hour basis and present on the site within one (1) hour for emergencies during non-working hours,
- f) Attend regular scheduled project meetings,
- g) Perform daily daytime inspections and weekly nighttime inspections on projects with predominantly daytime work, and perform daily nighttime inspections and weekly daytime inspections on project with predominantly nighttime work,
- h) Document the results of the inspections on the form(s) provided by the Department. The form(s) shall be submitted to the Engineer on a weekly basis. The Engineer should be made aware of the scheduled inspection times in order to attend if deemed necessary,
- i) Coordinate traffic control operations when multiple Contractors are simultaneously working on the project, and
- j) Assist the Service Patrol Operator, if provisions are in the contract, with traffic control.

The Department reserves the right to remove a TCS or TCT from a project for a failure to satisfactorily comply with the Plans or specifications. In the event that the Contractor's TCS or TCT is not meeting the requirements of the Plans or specifications, the Project Engineer will notify the Contractor in writing, describing the TCS or TCT's deficient performance. If the deficient performance should continue, the Department may take any or all actions listed below:

- a) stop all work requiring traffic control,
- b) require the Contractor to designate a new TCS or TCT, or
- c) remove the TCS or TCT from the project; this person shall not be eligible to be named on any other project for a 6-month period from the date of removal.

The Department may temporarily suspend all activities on the project with the exception of erosion control and necessary maintenance of traffic until a new TCS or TCT is assigned.

A TCS or TCT shall be assigned to only one (1) project. When special conditions exist, such as two (2) adjoining projects or two (2) projects in close proximity, the Contractor may request in writing that the State Construction Engineer approve the use of a TCS or TCT for both projects.

This in no way modifies the requirements of Subsection 105.05 regarding the assignment and availability of the superintendent.

The Engineer, or other appropriate personnel as required, will review and analyze accidents to determine if corrective action to the Traffic Control Plan is needed. In the event corrective action is indicated, the Contractor shall proceed immediately with same.

The location and spacing of signs shown on the traffic control plan are approximate and, with approval of the Engineer, may be adjusted as necessary to fit field conditions.

Because of the required work at the beginning and end of a project, it may be necessary to erect construction signs or lane closure signs outside the limits of the project.

618.01.3--Lump Sum Detour.

618.01.3.1--General. When specified on the plans, the Contractor will construct, maintain and remove all detour roads and bridges as indicated in the plans and contract documents. This work shall consist of the design, furnishing of materials, construction, maintenance and removal of detour roads and bridges as described herein.

The plans will indicate the required opening size for the bridge, traffic data, horizontal alignment, finish grade and typical section.

The final riding surface of the detour road shall be asphalt pavement.

Limits of the lump sum detour shall be all work right of the right edge of pavement, or left of the left edge of pavement as applicable, necessary to construct the detour.

Temporary erosion control items, signing items and striping items will not be included in the cost of the lump sum detour. These items will be paid for under appropriate pay items. However, the grassing associated with the detour will be included in the cost of the detour. Prior to opening the detour road to traffic, areas adjacent to the detour shall be grassed.

618.01.3.2--Design and Documentation. The Contractor will be responsible for the design of the detour bridge(s) and the pavement structure design. The Contractor has the option to select any type of embankment material they choose. The pavement structure shall be designed based on the selected type of embankment.

Prior to beginning any work on the detour, the Contractor shall provide the Project Engineer with a Project Management Plan that includes design drawings, calculations and other necessary supporting data used in the design of the detour. The purpose of the Contractor's Project Management Plan is to provide sufficient information to adequately inform the Department of proposed project activities. The design data shall address all items of work and materials incorporated in the detour. No official approval of the Project Management Plan will be given by the Department. The design information is for informational purposes only. The design shall be prepared and stamped or sealed by a Professional Engineer registered in the State of Mississippi who is proficient in roadway and bridge design.

The plan shall include but not be limited to a complete set of detour bridge design drawings with calculations, minimum geometric and loading requirements, and all other requirements shown on detour bridge sheets in the plans. It shall also include embankment design and test data, base and pavement design and test data, proposed asphalt Job Mix Formula (JMF), the method of developing the JMF, all JMF testing, a list of materials and their test properties, a quality control plan and construction plan that includes lift thicknesses. The proposed job mix formula (JMF) shall be signed by a Certified Mixture Design Technician (CMDT).

Where the plan shows Load and Resistance Factor Design (LRFD) methodology, Dynamic Pile Driving Analysis with signal matching (PDA) shall be performed by the Contractor for the test piles specified in the plan.

Prior to opening the detour to traffic, the Contractor shall provide the Department with copies of records for all quality control testing of mixture properties and all roadway embankment, gravel and asphalt density tests conducted during the construction of the detour. A certification shall also be provided stating that the testing records are true and accurate.

After construction of the detour bridge and prior to opening it to the traveling public, the Contractor shall furnish the Engineer with a written certification from the Registered Professional Design Engineer that the bridge has been built in accordance with the Design plans.

618.01.3.3--Detour Bridge Piling. Detour bridge piling shall be installed in accordance with the details of the detour bridge design and resulting data from the test piles.

The Contractor shall install out-of-place test piles in accordance with the requirements shown on the bridge detour plan sheets. The length of the test piles shall be determined by the Contractor. Should a test pile be of insufficient length and the length cannot be extended, a new test pile will be driven. In this case, no additional payment will be made for driving an additional test pile, or extending a test pile.

618.01.4--Detour Bridge Railing. If the Contractor elects to utilize the Load and Resistance Factor Design (LRFD) designed 19-foot or 31-foot Precast Concrete Bridge Span Unit Standards as published by the Office of State Aid Road Construction, only the Solid Type Barrier Rail (New Jersey Shape) with the appropriate adjacent connecting exterior span unit will be acceptable for use on MDOT detour bridges. Other railing types published by the Office of State Aid Road Construction **will not** be acceptable for use on MDOT detour bridges.

Bridge railing for use on other type detour bridge designs shall have a minimum LRFD rating of Test Level Two (TL-2) and shall be crash tested to meet the requirements of NCHRP Report 350 or MASH. The Contractor shall bear the responsibility of ensuring compatibility between the bridge, bridge end section, and guardrail type selected. Official certification that the railing meets these requirements shall be included in the detour bridge submittal.

618.02--Materials. Unless otherwise specified, the Contractor shall provide all materials for the construction and maintenance of detours required for the maintenance of traffic, except the Engineer may permit the Contractor to use excavation from the roadbed, or other designated sources, that is available at the time of construction of detours without detriment to the work and provided the excavation is ultimately placed in its final position in the roadbed in an uncontaminated condition. No additional compensation will be made to the Contractor for the extra handling of the material.

Unless otherwise specified, the applicable material requirements set out in Division 700 and in Section 619, or in other contract documents, shall apply to all materials used in temporary traffic facilities. The Contractor shall select and use materials that with adequate maintenance or replacement will provide a satisfactory facility for the entire period the temporary facility is required.

618.03--Construction Requirements.

618.03.1--General. All detours shall be constructed and maintained in such a manner that they will adequately carry the traffic required.

Requirements for temporary traffic facilities shown on the plans, or set forth in these specifications, shall be understood to be the minimum requirements anticipated. Actual

traffic conditions may require work or devices in addition to those shown on the plans.

Traffic lanes shall be kept free of dust and, when deemed necessary, they shall be sprinkled with water, or some other dust palliative shall be applied.

Unless otherwise specified, temporary structures and roads shall be sufficiently strong to safely carry the load permitted on the highway under construction. Structures shall be provided with suitable curbs, rails, or other devices as required for the protection of traffic. Unless otherwise specified, walkways required for pedestrians shall have a clear width of four feet, or as shown on the plans, and shall be protected from vehicular traffic in the manner specified or directed.

Unless otherwise specified, the Contractor shall remove all temporary detours, satisfactorily dispose of all surplus materials, grade, finish, and dress the disturbed areas to the required section, and complete all work incidental thereto prior to release of maintenance.

618.03.2--Barricades, Signs, and Flaggers. The Contractor shall construct, erect, maintain, clean, repair and replace as necessary all barricades, warning signs and other traffic control devices specified or ordered.

Flaggers shall be provided as necessary to handle traffic in accordance with the contract documents and latest edition of the MUTCD. Flaggers shall have proof of certification and a valid identification available while performing flagging duties. Failure to provide a certified flagger or produce evidence of certification shall be reason for the Engineer to suspend all work associated with the flagging operation. Flagger certification can be obtained by one of the following methods:

- a) American Traffic Safety Services Association (ATSSA),
- b) Construction industry association flagger training recognized by the Department, or
- c) Flagger training conducted by the Department.

Re-certification as a flagger will be required every four (4) years.

Temporary construction signs shall be removed as their use becomes inapplicable. However, placing temporary signs and their supports flat on the ground outside the shoulder break line will be allowed.

The plans will usually contain a line diagram indicating the designation and location of construction signs that are to remain fixed in place for the duration of the maintenance period of the contract.

Such signs and all other signs and devices of a temporary nature shall be in accordance with Section 619, the plans, and the MUTCD, as applicable.

618.03.3--Safe Movement of Traffic. The Contractor shall limit construction operations to such length as necessary to meet the traffic handling requirements of the contract.

On two-lane roadways, traffic may be alternately routed over a single lane in such a manner as to provide safe movement of the traffic with minimum delay. In such case, flaggers will be required and, when deemed necessary, an approved pilot vehicle with sign meeting the

requirements of the plan standards shall be provided and operated to control the speed and sequence of movement of the traffic.

A longitudinal pavement edge that traffic is expected to move across should have an elevation difference of not more than $2\frac{1}{4}$ inches. If the pavement edge is more than $1\frac{1}{2}$ inches and less than or equal to $2\frac{1}{4}$ inches, uneven pavement signs will be required as shown in the plans or contract documents. If the pavement edge is less than or equal to $1\frac{1}{2}$ inches, no uneven pavement signs will be required. Transverse pavement joints shall be sufficiently tapered to allow for the safe movement of traffic.

When a paving operation produces a longitudinal pavement edge that traffic is expected to move across, the adjacent lane shall be constructed to eliminate any uneven pavement edge within 48 hours, unless prohibited by weather conditions or an emergency arises.

All failed areas that have been removed and all trenches shall be filled and compacted to the elevation of the existing pavement before work is discontinued for the day. In emergencies, the Engineer may permit the use of approved temporary materials for backfill, provided the temporary materials will be adequate to facilitate normal safe movement of traffic. Separate measurement for payment will not be made for the furnishing, placing, maintaining, removing, and disposing of such temporary materials.

Except under the following conditions, no portion of the roadway intended to be used for maintenance of traffic shall be blocked after work hours. In exceptional cases when all efforts have been made to restore the surface of the roadway and because of equipment failure or other uncontrollable causes complete restoration is not possible before work must be discontinued for that day, the Contractor shall provide adequate warning signals, barricades, other appropriate devices, and flaggers, appropriately placed or stationed for the protection of the public. The Engineer may also require the use of a pilot vehicle as provided herein.

The Contractor shall be required to place granular material on the shoulders at any time a differential of two and one-quarter ($2\frac{1}{4}$) inches or more exists between the present pavement edge and the shoulder grade. This condition may exist prior to any preliminary leveling, after the placement of the preliminary leveling, after the placement of the surface course. In locations where a $2\frac{1}{4}$ -inch differential exists between the pavement edge and the shoulder material and along a section which lies outside a work zone delineated with traffic control devices such as drums, this condition shall be corrected by the placement of the shoulder material to correct the differential.

All centerline, lane lines, edge lines and no-passing stripes that have been covered or removed during the day's operations shall be replaced with temporary stripe before work is discontinued for the day or as soon thereafter as weather conditions will permit, except that:

- (1) Replacement of no-passing stripes may be delayed for a period not to exceed three (3) days for a two or three lane road.
- (2) Temporary edge lines on projects requiring shoulders constructed of granular material may be delayed for a period not to exceed three (3) days.

Temporary edge lines placed on the final pavement course of projects requiring paved shoulders with surface treatment may be placed on the adjacent shoulder as close to the

permanent location as possible until the surface treatment is placed. When the edge lines are obliterated by the placement of the surface treatment, the edge lines shall be placed in the permanent stripe location. The replacement of edge lines may be delayed for a period not to exceed three (3) days for a two or three-lane roads.

Temporary no-passing stripe is not considered a major item of work and such stripe eliminated because of placing the next course prior to expiration of the 3-day period shall not result in a monetary adjustment to the Contractor as provided in Subsection 104.02. All temporary stripe shall be placed in accordance with the plans and Subsection 619.03.2.

In addition to the temporary no-passing stripe, the Contractor shall erect standard "DO NOT PASS," "NO-PASSING ZONE," and "PASS WITH CARE" signs in accordance with plan details or as specified in the MUTCD. These signs shall be erected prior to the obliteration of the no-passing stripe and shall be maintained in good order until the Engineer permits their removal.

Permanent pavement markings are to be applied no sooner than 10 days nor later than 45 days after placement of the final lift of pavement. When shoulder paving or placement of granular material adjacent to the pavement edge is required and upon approval of the Engineer, the permanent edge stripe may be delayed until a section, not to exceed five miles, of the shoulder work is complete. When the project length is less than five miles, the edge stripe shall be placed no later than 15 days after completion of the adjacent shoulder.

Permanent pavement markings on surface treatment shall be delayed until the maximum amount of seal aggregate has embedded and all loose material is broomed from the surface. All temporary stripe shall be maintained in good order until placement of the permanent pavement markings or placement of the next pavement course or until removed. Maintenance of temporary stripe may require more than one application over the life of the project. Payment will be made for one application only.

618.03.4--Contractor's Responsibility. The Contractor shall be responsible for protection against loss or damage from any cause to all temporary structures including approaches, and shall maintain them in a satisfactory condition until their use is no longer required. If a temporary structure or approach is damaged due to high water or other reasons, it shall be replaced by the Contractor at no additional cost to the State. For temporary structures and approaches constructed of materials and to the grades and sections indicated on the plans and in accordance with the applicable construction requirements of the contract and that have been adequately maintained, consideration will be given under the conditions and provisions of Subsection 107.17.

The Contractor shall maintain the surface of the existing facility and connections thereto on which the Contractor is required to maintain traffic. Such maintenance shall be in accordance with the provisions of Subsections 104.04 and 105.14 and other applicable requirements and shall be subject to the provisions of Subsection 105.15. All costs for such maintenance and surface repairs shall be included in the contract price for Maintenance of Traffic. Repair of structural failures in the pavement foundation, or a structure beneath the surface not resulting from the Contractor's failure to comply with the requirements or limitations of the contract, or from the Contractor's operations, will be the responsibility of the Department. The Department may, however, at its discretion require the Contractor to make repairs and will pay for such repairs at the contract unit prices for

the items and quantities of work involved or as Extra Work.

618.03.5--Detour Bridge. When specified on the plans, the Contractor will construct, maintain and remove all detour bridges as indicated in the plans and contract documents. This work shall consist of the design, furnishing of materials, construction, maintenance and removal of detour bridges as described herein.

Prior to beginning any work on the detour bridge, the Contractor shall provide the Project Engineer with a Project Management Plan which will include design drawings, calculations and other necessary supporting data used in the design of the detour bridge. The purpose of the Contractor's Project Management Plan is to provide sufficient information to adequately inform the Department of proposed project activities. The design data shall address all items of work and materials incorporated in the detour bridge. No official approval of the Project Management Plan will be given by the Department. The design information is for informational purposes only. The design shall be prepared and stamped or sealed by a Professional Engineer registered in the State of Mississippi proficient in roadway and bridge design.

The plan shall include but not be limited to a complete set of detour bridge design drawings with calculations, minimum geometric and loading requirements, and all other requirements shown on detour bridge sheets in the plans. Where the plan shows Load and Resistance Factor Design (LRFD) methodology Dynamic Pile Driving Analysis with signal matching (PDA) shall be performed by the Contractor for the test piles specified in the plan.

After construction of the detour bridge and prior to opening it to the traveling public, the Contractor shall furnish the Engineer with a written certification from the Registered Professional Design Engineer that the bridge has been built in accordance with the Design plans.

Detour bridge piling shall be installed in accordance with the details of the detour bridge design and resulting data from the test piles.

The Contractor shall install out-of-place test piles in accordance with the requirements shown on the bridge detour plan sheets. The length of the test piles shall be determined by Contractor. Should a test pile be of insufficient length and the length cannot be extended, a new test pile will be driven. In this case, no additional payment will be made for driving an additional test pile, or extending a test pile.

618.04--Method of Measurement

618.04.1--General. This work will be measured as a unit lump sum quantity consisting of continuous maintenance and protective services. The percentages of the contract lump sum price allowed on progress estimates will be determined by the percentage of the combined total monetary value of all direct bid items, excluding those items identified in the bid schedule as dependent items, earned during the current (same) estimate period. However, when the construction and traffic control signs have been erected the Contractor will be allowed payment at least equal to the value of the signs as computed at the fixed price for additional construction signs included in the contract.

For contracts containing pay items for individual traffic control devices, measurement of these items will be in accordance with Subsection 619.04.

In the event the Engineer determines that actual field and traffic conditions require fixed-in-place signs in addition to those shown on the line diagram of the plans, they shall be furnished, erected, and maintained, and measurement of these signs will be made by the square foot.

618.04.2--Construction And Removal Of Detour. Construction and removal of detour, including detour road and bridge, will be measured as a lump sum quantity, consisting of furnishing all labor and materials, construction, repair and replacement of each detour as deemed necessary during the life of the project.

Temporary erosion control items, signing, striping items and piling items will not be included in the cost of the lump sum detour. These items will be paid for under appropriate pay items.

Detour bridge piling, exclusive of those measured as test piles, will be measured by the linear foot. No measurement for payment will be made for cut-off of a detour bridge piling.

Detour bridge PDA test pile will be measured as a lump sum quantity. Piles measured as test piles will not be included in the measurement of pay length for detour bridge piling. No measurement for payment will be made for cut-off of a detour bridge test pile.

After the permanent bridge is opened to traffic, the detour road and bridge shall be removed. If embankment material used in the construction of the detour road(s) is used to construct the final roadway section, no separate payment will be made for the material. All Contractor furnished material shall remain the property of the Contractor and shall be removed from the site unless otherwise approved by the Engineer.

Percentages for construction and removal of each detour will be applied as follows:

Construction of Detour.....	80%
Removal of Detour	20%

Each month the Engineer will estimate the percentage of construction and removal of each detour and apply the percentage as indicated herein to the Contractor’s monthly estimate.

618.04.3--Detour Bridge. Construction and removal of detour bridges, excluding test piles and piling, will be measured as a lump sum quantity, consisting of furnishing all labor and materials, construction, repair and replacement as deemed necessary during the life of the project.

Detour bridge piling, exclusive of those measured as test piles, will be measured by the linear foot. No measurement for payment will be made for cut-off of a detour bridge piling.

Detour bridge PDA test pile will be measured as a lump sum quantity. Piles measured as test piles will not be included in the measurement of pay length for detour bridge piling. No measurement for payment will be made for cut-off of a detour bridge test pile.

The removal of the detour bridge shall be as follows:

After the permanent bridge is opened to traffic, the detour bridge shall be removed. All

Contractor furnished material shall remain the property of the Contractor and shall be removed from the site.

Percentages for construction and removal of each detour bridge commensurate with the magnitude of the work will be applied as follows:

Construction of Detour Bridge	80%
Removal of Detour Bridge	20%

Each month the Engineer will estimate the percentage of construction and removal of each detour bridge and apply the percentage as indicated herein.

618.05--Basis of Payment. Maintenance of traffic, will be paid for at the contract lump sum price which will also include compensation for complying with the requirements of the Traffic Control Plan.

Individual traffic control devices included in the contract as pay items will be paid for in accordance with Subsection 619.05.

For contracts not containing pay items for individual traffic control devices, additional construction signs ordered by the Engineer will be paid for at the fixed contract unit price indicated in the bid schedule.

Construction and removal of detour, measured as provided above, will be paid for at the contract lump sum price, which price shall be full compensation for furnishing all labor and materials, design, construction, repair, replacement and removal when ordered by the Engineer.

Detour Bridge Piling, measured as prescribed above, will be paid for at the contract unit price per linear foot, which price shall be full compensation for furnishing all labor, materials, equipment, and incidentals necessary to complete the work.

Detour Bridge PDA Test Pile, measured as prescribed above, will be paid for at the contract lump sum price, which price shall be full compensation for furnishing all labor, materials, equipment, and incidentals necessary to complete the work.

Additional maintenance responsibilities covering maintenance of the embankment, base and paving on detour roads will be measured and paid for as set out in Section 618.

These prices shall be full compensation for completing the work.

Payment will be made under:

- 618-A: Maintenance of Traffic - lump sum
- 618-B: Additional Construction Signs - per square foot
- 618-C: Construction and Removal of Detour Bridge - lump sum
- 618-D: Construction and Removal of Detour - lump sum

618-E: Detour Bridge Piling

- per linear foot

618-F: Detour Bridge PDA Test Pile

- lump sum

SECTION 619 - TRAFFIC CONTROL FOR CONSTRUCTION ZONES

619.01--Description. This work consists of furnishing, placing, maintaining or replacing as necessary, removing when no longer applicable and installation at other locations all traffic control devices including pavement marking materials (paint, tape, markers, etc.) in accordance with contract provisions and as directed by the Engineer.

619.02--Materials. Certification of traffic control devices shall be in accordance with the provisions of Subsection 619.02.13.

619.02.1--Painted Traffic Stripe. Painted traffic stripe shall meet the applicable requirements of Sections 710 and 720.

The temporary traffic paint can be waterborne paint or fast dry solvent traffic paint meeting the requirements set out in Section 710.

When using fast dry solvent traffic stripe, no paint can be sprayed or placed on the ground during set-up or clean-up.

619.02.2--Pavement Marking Tape. Preformed pavement marking materials must be listed on the Department's APL and meet the requirements of Subsection 720.05.

619.02.3--Reflective Raised Pavement Markers. Raised pavement markers must be on the Department's APL and shall meet the applicable requirements of Subsection 720.03.

619.02.4--Construction Signs. Construction signs shall meet the applicable requirements of Sections 618 and 721 and the following:

Sign supports may be steel beams, structural steel pipe, steel U-section posts, 4-inch x 4-inch wood posts, portable easels, or barricades as required for installation. Breakaway bases shall be provided for all steel beams and pipe posts. Portable sign supports may be used for daylight operations, moving work areas, or other short-term activities. Standards for height of construction signs shall be those shown for roadside signs in Chapter 6F of the MUTCD. Signs mounted on portable supports or barricades may be at lower heights but the bottom of the sign shall be no less than one foot above the traveled way.

Unless specified otherwise, fluorescent orange reflective sheeting, meeting the requirements of Subsection 721.06, shall be used on all construction signs regardless of whether used during daytime or nighttime hours.

Unless otherwise specified on the plans, the material on which the reflective sheeting is to be applied shall be as a minimum, 16-gauge steel, 0.080-inch aluminum, or 5/8-inch high density overlaid plywood. Ungalvanized steel, exterior grade plywood and lumber shall have a minimum of two coats of paint on front, back, and edges. High density overlaid plywood shall have the edges painted. The material to which reflective sheeting is to be applied shall be prepared in accordance with the recommendations of the sheeting

manufacturer.

For new signs, the Contractor shall furnish the Engineer with three certified copies of a statement or test report from the producer indicating that the signs meet the requirements of the specifications.

Previously used signs will be accepted on the basis of reflectivity and legibility. Reflectivity for these signs may be tested by the Engineer in accordance with the procedures set out below or by the Central Laboratory. If tested by the Central Laboratory, the reflective sheeting shall have at least 50 percent of the reflectivity specified for new sheeting. Tests performed in the Central Laboratory will be for reflectance only, and the Contractor shall pay the testing charges. Legibility in all cases will be determined by the Engineer.

The determination for reflectivity and legibility by the Engineer will be made from the driver's seat of an automobile with the headlamps on low beam between the hours of one hour after sunset and one hour before sunrise at the distance specified below. The signs shall be mounted at the specified height for each type sign as it is being tested. Should the Contractor elect to have the signs tested in place, each sign not meeting the requirements of these specifications shall be immediately removed and replaced. The Engineer will certify by letter to the State Materials Engineer that the signs have been tested and accepted under this procedure.

A sign will be considered as meeting the reflectivity requirements of this specification when the shape and color of the sign can be unquestionably identified at a distance of 1500 feet from the sign. In cases where grade or alignment will not permit a sight distance of 1500 feet, the distance for specification compliance shall be the furthestmost point at which the complete sign becomes visible.

If there is a question as to a sign being acceptable, the sign may be sent to the Central Laboratory for verification. Testing charges will be borne by the State when the verification test determines that the sign is acceptable.

Legibility will be acceptable when the sign letters and numerals are capable of being read at a distance determined by the following formula:

$$D = 50 H$$

D = Distance in Feet

H = Letter/numeral height in inches

619.02.5--Advance Warning Flashing Arrow Panels. Flashing arrow panels shall meet the requirements of Section 6F.61 of the MUTCD.

619.02.6--Median Barrier and Delineators. New precast concrete median barrier shall meet the requirements of the plans, contract documents, and Section 615 except the surface may be a Class 1 ordinary surface finish unless designated otherwise. When precast concrete median barriers are no longer needed at one location, as determined by the Engineer, the barriers shall be removed and reset at other designated locations. When barriers have to be stored until needed at another location, payment for removing and resetting will not be made until they are reset at their designated location. The Contractor shall furnish the storage area.

The Engineer may allow the installation of used barriers for temporary traffic control upon an inspection and determination that the barrier units are structurally adequate for their intended purpose and they meet the requirements of this Section. Barriers with small chips or fractures not affecting their integrity may be accepted.

Precast concrete barriers used on construction projects purchased or manufactured after October 1, 2002 must meet the requirements of NCHRP Report 350 or MASH. Precast median barriers purchased or manufactured prior to October 1, 2002 may be used until they complete their normal service life.

Certification of precast concrete barriers shall be as required in Subsection 619.02.13.

Portable median barrier shall be a highly portable, crashworthy barrier especially designed and used as a temporary barrier on highway construction projects. The barriers shall be designed so that it can be filled with water when in use and be easily drained for moving and transporting. The barrier shall be NCHRP Report 350 or MASH approved for the speed rating indicated on the plans or in the contract documents.

The Contractor shall furnish the Engineer three copies of the manufacturer's certification stating that the portable median barriers furnished meets the requirements of this Section.

Delineators shall be listed on the Department's APL and meet the requirements of the plans and Section 6F.68 of the MUTCD.

619.02.7--Channelization Devices, Barricades, and Warning Lights. Channelization devices, vertical panels, tubular markers, cones, drums, barricades and temporary raised islands shall meet the requirements of the plans and Sections 6F.63 through 6F.75 of the MUTCD. Drums shall be constructed of lightweight, deformable material capable of retaining reflective sheeting. Reflective sheeting for drums shall be Type III meeting the requirements of Subsection 721.06. Warning lights shall meet the requirements of Section 6F.83 of the MUTCD.

The use of 2-inch nominal thickness timber for rails on Type III barricades has not been approved by NCHRP or MASH as a crashworthy device. Therefore, the use of 2-inch nominal thickness timbers will not be allowed for rails on Type III Barricades. Timber rails for Type III Barricades shall be as follows.

- For barricades up to four feet (4') wide, the maximum thickness of timber rails shall be one inch (1") and the material shall be pine timber or ¾-inch ACX plywood.
- For barricades more than four feet (4') wide, timber rails shall be constructed of ¾-inch ACX plywood.

A list of crashworthy Type III Barricades can be found at the following FHWA website.

http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/wzd/

619.02.8--Traffic Signals and Flashers. Traffic signals and flashers shall meet the requirements of the plans and Section 6F.84 & 6F.81 of the MUTCD.

619.02.8.1--Portable Traffic Signals. Portable traffic signals shall be trailer mounted

units that provide for easy transportation and quick setup and deployment. Each unit shall be self-contained. The types of portable traffic signals are as follows.

- Type 1 portable traffic signal shall include one signal head that is mounted on the vertical upright of the trailer.
- Type 2 portable traffic signal shall include two signal heads per trailer with one signal head mounted on an overhead mast arm that can be extended over the travel lane, and the other signal head shall be mounted on the vertical upright of the trailer.
- Type 3 portable traffic signal shall be the same as Type 2 mentioned above but with enhanced capabilities as mentioned in each applicable section below.

The portable traffic signals shall be MUTCD Compliant and utilize standard ITE signal heads, and adhere to the ITE Specifications and Standards for Vehicle Traffic Control Signal Heads, Light Emitting Diode (LED) Circular Signal Supplement. The units shall be solar powered and be able to communicate with other portable signals via wireless communications. The unit shall include all the major components listed below or be able to perform the functions of these components. The major components of the unit shall include but are not limited to the trailer, telescoping mast arm (on Type 2), signal head(s) and back plates, traffic signal controller with operating software, solar charging system with batteries, input and output devices, flasher units, conflict monitor, relays, communications system and other equipment required for the safe operation and installation of the unit.

619.02.8.1.1--Signal Heads. The signal heads and all applicable components of the portable traffic signal shall meet the physical display and operational requirements of conventional traffic signals as specific in the Manual on Uniform Traffic Control Devices (MUTCD). The signal heads shall meet the requirement laid out in the Mississippi Standard Specification for traffic signal heads and associated MDOT material specifications for traffic signal heads.

For Type 1, Type 2 and Type 3 signals, the signal heads shall have the ability to be rotated 180 degrees to face in the opposite direction and shall have the ability to rotate and lock in approximately 10 degree increments to position the signal head for the optimum visibility to motorists.

For Type 1 signals, the signal head shall be mounted to the vertical upright of the trailer at a minimum height of eight feet (8') from the bottom of the signal head unit to the road surface.

For Type 2 signals, each unit shall contain two signal heads with one signal head mounted on an overhead mast arm that can be extended over the travel lane with a minimum clearance of 17 feet measured from the bottom of the signal head unit to the road surface. The lower signal head shall be mounted to the vertical upright of the trailer at a minimum height of eight feet (8') from the bottom of the signal head unit to the road surface.

For Type 3 signals, each unit shall be the same as Type 2 mentioned above but with enhanced capabilities as mentioned below.

619.02.8.1.2--Controller and Operating Requirements. The portable traffic signal (Types 1, 2, and 3) shall include a controller that is in compliance with NEMA TS 1 Performance Standard. The controller shall have an easy to read front panel indicator

display for showing and programming the configuration settings and controller status. The controller shall be capable of operating the portable traffic signal system in a fixed time, traffic actuated or manual control mode. Each portable traffic signal in a connected system shall have the capability to serve as either the master or remote signal. Each portable traffic signal shall include a Conflict Monitor Unit (CMU), or Malfunction Management Unit (MMU) to ensure phase conflicts do not exist during operation.

For Type 1 and Type 2 signals, a minimum of five (5) automatic time-of-day timing plans within a 24-hour period should be available in fixed time mode. The operating system should have the ability to control a minimum of four (4) traffic phases with programmable cycle time adjustments and user adjustable red, amber, minimum green and maximum green times. The operating system shall also have the capability of facilitating standby modes of red, red flash and yellow flash.

For Type 3 signals, a minimum of ten (10) automatic time-of-day timing plans within a 24-hour period should be available in fixed time mode. The operating system should have the ability to control a minimum of 16 traffic phases with programmable cycle time adjustments and user adjustable red, amber, minimum green and maximum green times. The operating system shall also have the capability of facilitating standby modes of red, red flash and yellow flash.

The system shall also have the ability to operate in vehicle actuation mode when vehicle detectors are used. The operating system shall have the capability to allow the Portable Traffic Signal to be connected to and controlled by a standard NEMA controller.

The system shall have the capability to be configured and controlled remotely using a flagger radio remote control at a distance up to ¼ mile from the master.

The system shall have the capability of remote monitoring for reporting, at a minimum, signal location and status, battery voltage and system defaults. The remote monitoring shall have capability to alert designated individuals if a fault condition occurs.

The operating system shall include password protection to prevent unauthorized programming.

619.02.8.1.3--Wireless Communications. The portable traffic signals shall communicate with other portable traffic signals in the system via license-free wireless 900 MHZ radio link communications as specified in Subsection 662.02.2 of the radio Interconnect System specification. The radio units shall maintain communications at a minimum distance of one (1) mile. The radio system shall conform to the applicable Federal Communications Commission requirements and all applicable state and local requirements.

The portable traffic signals shall be in direct communication at all times either by wireless or hardwire connection to provide for the required conflict monitor.

619.02.8.1.4--Power Requirements. The portable traffic signal shall be equipped with a solar power array, charging unit and battery system. The number and size of batteries shall be sufficient to operate the Type 1 and Type 2 signals for a minimum of 21 days and Type 3 signals for minimum of 30 days without additional charging or assist from the solar array. An on-board battery charger shall be compatible with both the solar array and with a 120V AC power source.

For Type 1 and Type 2 signals, the solar panel array shall provide for a minimum of 440 watts of solar collection capability.

For Type 3 signals, the solar panel array shall provide for a minimum of 480 watts of solar collection capability and shall include a tilt and rotate system to optimally position the panels.

All instrumentation for the electrical system and battery compartment shall be mounted in a lockable weatherproof enclosure. Solar panels shall be secured to the mounting brackets for theft prevention.

619.02.8.1.5--Trailer and Lift System. For Type 1 and Type 2 signals, the trailer and all mounted components shall conform to the wind loading requirements of 80 mph minimum as described in the AASHTO Standard Specifications for Highway Signs, Luminaries and Traffic Signals. For Type 3 signals, the trailer and all mounted components shall conform to the wind loading requirements 90 mph minimum as described in the AASHTO Standard Specifications for Highway Signs, Luminaries and Traffic Signals. The trailer shall be made of structural steel and shall include four (4) leveling/stabilizer jacks capable of lifting the trailer a minimum of six inches (6”).

The trailer shall be equipped with a hydraulic or electric lift system sufficient for one person to be able to raise and lower the vertical upright and/or horizontal mast arm to and from the operating position.

For Type 2 and Type 3 signals, the trailer shall be equipped to provide legal and safe transport on the public highway system at speeds up to 55 mph.

All exterior metal surfaces, except signal heads and back plates, shall be powder-coat painted highway safety orange.

619.02.9--Impact Attenuators. Impact attenuators must be listed on the Department's “Approved Sources of Materials”.

Approved impact attenuator systems shall meet standardized testing defined in NCHRP Report 350 or MASH. In addition, documentation from FHWA must accompany the devices, indicating that the devices meet the appropriate crash test criteria and can be used on the National Highway System (NHS). Prior to installation, the Contractor shall provide two copies of the manufacturer’s installation details to the Project Engineer. The Project Engineer shall keep one copy in the project file and provide one copy to District Maintenance Engineer. The installation details shall be engineering drawings, a minimum of 11"x17" in size. Reflective adhesive sheeting with alternating black and yellow stripes (sloping downward at an angle of 45 degrees in the direction traffic is to pass) shall be required on the end of the attenuator section. The type of system installed shall be written on the device with a Permanent Marking Stick or some other means of permanent identification.

When an impact attenuator is no longer needed at one location, as determined by the Engineer, the attenuator shall be removed. When the contract documents contain provisions for the removal and resetting of impact attenuators, the attenuator shall be removed and reset at other designated locations. When an impact attenuator is stored until

needed at another location, payment for removing and resetting will not be made until the attenuator is reset at the designated location. The Contractor shall furnish the storage area.

Replacement Packages. Replacement packages shall consist of spare parts of the expected type and number needed to repair one hit for every three attenuators in place.

619.02.10--Temporary Guardrail. Temporary guardrail shall meet the requirements of the plans and the applicable requirements of Sections 606 and 712.

619.02.11--Snap-Back Delineators. Snap-back delineators shall be selected from the list of surface mounted flexible delineator posts as shown on the Department's "Approved Sources of Materials".

619.02.12--Terminal End Section. Terminal end sections, installed as per manufacturer's recommendations, must meet the requirements of NCHRP Report 350 or MASH. When specified in the plans, the terminal end sections shall be the type specified, unless otherwise approved by the Engineer.

Terminal end sections shall be Flared or Non-Flared and shall be one listed on the Department's APL. The end sections shall be installed in accordance with the manufacturer's recommendation. Prior to installation, the Contractor shall provide two copies of the manufacturer's installation details to the Project Engineer. The Project Engineer will keep one copy in the project file and provide one copy to the District Maintenance Engineer. The installation details shall be engineering drawings, a minimum of 11" X 17" in size. Reflective adhesive sheeting with alternating black and yellow stripes (sloping downward at an angle of 45 degrees in the direction traffic is to pass) shall be required on the end of the terminal section. The type of terminal section installed shall be written on the device with a Permanent Marking Stick or some other means of permanent identification.

619.02.13--Certification of Traffic Control Devices. The Contractor will be required to certify that the traffic control devices used on the project meets certain requirements. The traffic control devices shall be certified in accordance with the following requirements:

Category 1 Traffic Control Devices. Category 1 traffic control devices are defined as low-mass, single-piece traffic cones, tubular markers, single-piece drums with or without lights and hardware, and delineators.

The Contractor shall certify to the Project Engineer by a letter ONLY stating that the Category 1 traffic control devices, furnished and used, meet the requirements of NCHRP Report 350 or MASH.

All documentation supporting the certification is to be kept on file by the Contractor subject to review by the Department at any time. Support documentation shall be kept on file for two years after the completion of the project.

The Contractor may self-certify Category 1 Traffic Control Devices. In order to make the self-certification, the Contractor shall have as a minimum the following support documentation regarding the certification:

1. A title, e.g., "Certification of Crashworthiness";
2. Name and address of vendor making the certification;
3. Unique identification of the certificate such as serial number, with numbered pages and the total number of pages;
4. Description and unambiguous identification of the item tested;
5. Identification of the basis for self-certification process used and to what test level of NCHRP Report 350 or MASH. This basis as crash test experience with similar devices or years of demonstrably safe operational performance;
6. A signature and title, or an equivalent identification of the person(s) accepting responsibility for the content of the certification, however produced, and the date of issue;
7. A statement that the certification shall not be reproduced except in full.

All documentation supporting the self-certification is to be kept on file by the Contractor subject to review by the Department at any time. Support documentation shall be kept on file for two years after the completion of the project.

The Contractor's letter to the Project Engineer shall state that all Category 1 traffic control devices, furnished and used, meet the requirements of NCHRP Report 350 or MASH.

Category 2 Traffic Control Devices. Category 2 traffic control devices are defined as barricades with or without lights and signs, intrusion detectors, vertical panel assemblies, portable sign supports, drums with warning lights, and cones with warning lights not meeting Category 1.

The Contractor shall certify to the Project Engineer by a letter ONLY stating that the Category 2 traffic control devices, furnished and used, meet the requirements of NCHRP Report 350 or MASH. The Contractor's letter shall state that all Category 2 traffic control devices, furnished and used, meet the requirements of NCHRP Report 350 or MASH.

Category 3 Traffic Control Devices. Category 3 Traffic Control Devices are items similar to Category 2 but weigh more than 100 pounds. Category 3 Traffic Control Devices include concrete barrier, portable barriers, truck mounted attenuators (TMAs), work zone crash cushions, and fixed sign supports.

Category 3 traffic control devices, furnished and used, must meet the requirements of NCHRP Report 350 or MASH. The Contractor shall furnish a letter ONLY certifying that the Category 3 traffic control devices meet the requirements of NCHRP Report 350 or MASH.

619.02.14--Changeable Message Sign. This work shall consist of furnishing, testing, and maintaining a trailer-mounted electronic Portable Changeable Message Sign (PCMS) assembly. The sign display shall be a LED, full matrix sign. If more than one portable changeable message sign is required for this project, they shall all be of the same model and from the same manufacturer. All parts and materials used to construct the portable changeable message signs shall be interchangeable.

The PCMS shall be a trailer-mounted, solar powered, portable changeable message sign.

Each PCMS shall include the following main components:

- a) Sign Housing
- b) LED Modules
- c) LED Drivers
- d) Battery Bank
- e) Sign Controller
- f) Trailer
- g) AC Charger
- h) Solar Panel
- i) Solar Panel Charger

The LED display shall be a full matrix sign with a minimum of 28-pixel rows x 50-pixel columns. The pixel spacing shall be such that three (3) lines of text (5 columns x 7 rows, 8 characters) shall each have a nominal height of 18 inches.

The PCMS shall include a remote communications interface as specified herein. The PCMS shall be provided with a local serial and USB connection within the sign control cabinet so that a laptop computer using the remote software can communicate directly with the sign CPU.

This subsection incorporates normative references to other standards as outlined in Section 1 of the NEMA TS-4 standard and as listed below.

NEMA TS4-2004, Hardware Standards for Dynamic Message Signs (DMS) with NTCIP Requirements. All NEMA TS-4 requirements that are applicable to portable signs shall be used.

NTCIP Standards.

If a conflict exists between the standards referenced and this Specification, this Specification shall govern.

The definitions of the terms used within this Specification are as defined in Section 1 of the NEMA TS-4 standard.

If required in the contract, the PCMS shall include a speed radar unit as specified herein.

619.02.14.1--Mechanical Construction. Each PCMS shall meet the following minimum requirements.

Weather-Tight Enclosure. The entire sign and trailer assembly, including each component / equipment exposed to weather, shall be fully protected. It shall withstand the effects of sand, dirt, dust, moisture, hose-directed water, ice, snow and UV radiation (UVA and UVB). It shall withstand the effects of high wind loading and blowing rain as specified herein with all outriggers and/or leveling jacks in place. The sign and all components shall be watertight. Space shall be provided for manuals to be stored in a weatherproof environment.

Wind Loading. Wind loading requirements for the portable sign housing and trailer assembly shall be as specified in Section 3.3.2.1.2 of the NEMA TS-4 standard.

Welding. All welding on all major structural components (aluminum or steel) shall be performed by certified welders and in accordance with SAE/AWS D8.8 American Welding Society.

Protective Coatings. Protective coatings or processes, such as anodizing, e-coating, powder coat painting, plating, etc., shall be incorporated to protect all sign, cabinet, and trailer metal surfaces from corrosion. Any non-protected metallic fasteners shall be made of stainless steel or aluminum. All components shall be of similar material, or be isolated to reduce galvanic reactions.

Temperature and Humidity. Each PCMS shall be designed to operate continuously in extreme ambient temperature ranges and at high humidity levels.

Operating ambient temperature range of the portable sign and trailer assembly shall be -29°F to +165°F. Storage temperature range shall be from -40°F to +185°F. The portable sign shall be capable of continued operation within the operating temperature ranges specified without the need for active systems (i.e., fans). Operating relative humidity level of the portable sign shall be up to 95% non-condensing.

Sign Face. Sign face material shall be protected by a non-glaring polycarbonate material of at least ¼-inch thickness. It shall be replaceable and manufactured of material rated for outside use and resistant to UV degradation (exposure to the sun).

All electronics and pixels shall be protected from damage due to moisture.

Sign Housing Construction. The portable sign housing, including its front face panels, shall be designed to conform to the requirements of minimum NEMA Type 3R, as described in the latest edition of NEMA 250.

It shall comply with the latest structural AASHTO requirements.

It shall be constructed of aluminum sheeting that shall not be less than 1/8-inch thick with all seams continuously welded by the inert gas process.

The front of the sign housing shall have a flat black matte finish.

Weep holes shall be provided in the housing to allow moisture from condensation to escape.

The sign housing and cabinets shall be designed to keep insects out.

The sign housing shall be constructed in such a manner as to prohibit stray light from reducing legibility.

All sides of the sign housing shall have a maintenance-free finish.

Alignment of the sign housing shall be capable of being horizontally adjusted to position the sign a full 360 degrees. It shall be capable of rotating and locking at any selected horizontal angle up to 360 degrees. A sight alignment tube/device shall be mounted to

horizontally position the sign display. A positive brake assembly with lockable control arm shall be provided to position the sign display in the desired position.

It shall allow easy access to all components contained within the display housing without the removal of any external parts. Door locks shall be rigidly mounted. Gasketing shall be provided on all door openings and shall be dust-tight, permanently bonded to the door metal, and shall not stick to the mating metal surface. A gasket channel shall be provided to support the gasket on the door.

Trailer. Each PCMS trailer shall meet all requirements for trailers as outlined in Section 3.3.3 of the latest NEMA TS-4 standard as well as the following minimum requirements.

- (a) All trailers shall meet the requirements of FMVSS, Part 571 and SAE J684 for transport safety including, but not limited to the use of brakes, safety chains, coupling device, and lights. PCMS manufacturer shall provide instructions stating procedures necessary to ensure safe transport.
- (b) The structural frame shall be capable of supporting the gross vehicle weight (GVW) load of the trailer corresponding to the axle and tire ratings in accordance with FMVSS, Part 571.
- (c) The tires shall be radial ST “Special Trailer” rated. The wheels shall be 15-inch steel wheels with five lug bolts per wheel. Each trailer wheel shall be equipped with one locking lug nut. A minimum of four keys for the locking lug nuts shall be supplied for each trailer.
- (d) The trailer shall be provided with a minimum of four outriggers or leveling jacks. One outrigger or leveling jack shall be mounted near each corner of the trailer. The length of the leveling jacks shall be such that when the trailer is level, all four jacks and the tongue jack can be lowered into the vertical position. The jacks shall be screw type jacks with a minimum 25-inch lift. Each jack shall include a swivel mechanism that allows the jacks to swing up to a horizontal position for towing. The swivel mechanism shall secure the jack in both vertical and horizontal positions through a lock pin.
- (e) The trailer shall also be provided with a trailer stand mounted on the tongue of the trailer. The stand shall be corrosion resistant. It shall include a 6-inch wheel that allows horizontal positioning of the trailer. The stand shall be welded, not bolted, to the tongue of the trailer.
- (f) The trailer shall be provided with legal tail/brake lights, signals, and license plate mounting bracket. The trailer shall be supplied with an electrical harness assembly for connection to the tow vehicle and shall be terminated in a connector type to be specified by the Engineer.
- (g) The trailer shall be provided with a 2-inch “hammer blow coupler” style hitch in accordance with SAE J684 and interchangeable with a 2½-inch Pintle coupler / ring meeting SAE J847.
- (h) The trailer spring leafs shall be rated at a minimum of 3500 pounds.
- (i) The trailer shall be equipped with a sign display lift and control console. The lift shall be electric, hydraulic lift, or combination of both with manual backup lift. The lift shall be capable of lifting the display a minimum of seven feet (7') above the roadway surface. A mast safety pin shall be provided to prevent the sign display from falling in the event of an electric or hydraulic system failure.
- (j) The trailer shall have a minimum of 6,000-pound capacity hydraulic surge brake system along with a breakaway latch.

- (k) Illumination shall be provided as an integral part of the sign or trailer assembly to change the sign controller data in darkness.
- (l) The trailer shall contain batteries and photovoltaic (solar) panels as specified herein.

Photovoltaic (Solar) Panel System. Each PCMS shall include solar panels. A solar bank shall be assembled using multiple solar panels. All photovoltaic panels shall be listed in accordance with UL 1703, or equivalent. The solar cell bank shall have a minimum capacity of 240 watts. The solar cell bank shall be mounted on a frame capable of being tilted at a minimum of one direction up to 61 degrees with zero degrees being horizontal. Solar cells shall be laminated between ethylene vinyl acetate and tempered glass. The solar panel shall incorporate an extruded aluminum frame. The solar battery charge controller shall include the following three state charger modes:

- Bulk
- Absorption
- Float

Battery Requirements. Each PCMS shall include batteries for primary energy storage on trailers. The battery bank capacity shall be a minimum of 900 amp/hours at 12VDC at a 20-hour rate of discharge. The batteries shall be heavy duty deep cycle type rated for 80% discharge. A battery power disconnect shall be provided.

Battery enclosures shall be vented to prevent the accumulation of explosive gases. The battery cabinets must be lockable with a standard padlock.

AC Charging System. Each PCMS shall have an AC battery charging sub-system. The system shall be UL listed and operate from a standard 120VAC generator meeting all NEC requirements for portable equipment.

The solar battery charger shall include the following three state charger modes:

- Bulk
- Absorption
- Float

The AC battery charger shall have sufficient capacity to charge the battery bank from 80% discharged to fully charged in 24-hours, and operate the sign simultaneously. The AC battery charger shall be equipped with a male plug-in and a 50-foot long extension cord constructed of a minimum 12-gauge wire for this purpose.

619.02.14.2--Controller to Sign Interface. Each PCMS shall meet all applicable controller to sign interface requirements as outline in Section 4 of the NEMA TS-4 standard.

619.02.14.3--Display Properties. Each PCMS shall have a cone of vision (viewing angle) from the center (reference axis) shall be a minimum 15 degrees with the half-power viewing angle defined such that at a given distance from the LED, luminous intensity measured at any point at an angle of 7.5 degrees from the LED's center axis is no less than half the luminous intensity measured directly on the LED's center axis.

The minimum word legibility requirements shall be 1232 feet or greater under daytime light conditions and within the cone of vision as specified. Legibility is defined as the ability to discern the content of a display using a “word message.” The minimum word legibility requirement shall be documented either by a Department approved independent testing laboratory or by participation in the NTPEP test program.

The minimum visibility requirements shall be 3000 feet or greater under daytime light conditions and within the cone of vision as specified. Visibility is defined as the ability to recognize that a display exists. The minimum visibility requirement shall be documented either by a MDOT approved independent testing laboratory or by participation in the NTPEP test program.

The PCMS shall be capable of displaying standard fonts and font alphabets as specified in Sections 5.6.1 and 5.6.2.3 of the NEMA TS-4 standard and adhere to NTCIP 1203. The PCMS shall also support moving arrows.

Any NTPEP test results shall be for the PCMS model being used and shall be within the last three completed test cycles.

619.02.14.4--Optical Components. The pixels for the PCMS shall be manufactured using Light Emitting Diodes (LED). Changes to displays shall be performed by turning the LEDs in a pixel either on or off. The discrete LED shall be an untinted, non-diffused, solid-state lamp that uses Aluminum Indium Gallium Phosphide (AlInGap) technology manufactured by Avago Technologies (formerly Agilent Technologies), Toshiba Corporation, Nichia Corporation, or functional equivalent. Horizontal and vertical spacing between modules shall be such that the horizontal and vertical pitch between all pixels is equal. A failure of one pixel shall not affect the operation of any other pixel.

All LEDs used to create a display in a single portable sign shall have a nominally rated LED life of 100,000 hours of operation under field conditions. This shall include operating temperatures between -29°F to +165°F. LED life shall be defined as the time it takes for the LED light output to degrade to half of the LED's initial light output. The current through an LED shall be limited to the manufacturer's recommendation under any conditions. Each LED character module shall be rated for use over the environmental range specified herein, including heat absorption due to sunlight. The LEDs shall be protected from the outside environmental conditions, including moisture, snow, ice, wind, dust, dirt, and UV rays (UVA and UVB). All LEDs shall be mounted so that they present a uniform and legible display.

Pixels shall be replaceable in modular groupings (modules). All modules within a sign shall be the same size and interchangeable. The replacement of any module shall be possible with no more than simple non-vendor-specific hand tools, such as screw drivers or wrenches, without any physical modification to the module.

619.02.14.5--PCMS Controller and Storage Cabinets. All PCMS controller and storage cabinets shall be a minimum of NEMA 3R rated and be completely encased and lockable with a standard padlock as specified herein. A separate lockable storage cabinet shall be provided to house various accessories. The controller cabinet shall be manufactured to withstand all types of adverse weather conditions and shall be designed and installed to keep insects out. All components inside the controller cabinet shall be accessible without disconnecting any unassociated wires or components. The controller cabinet shall be

illumination. The keyboard terminal and control panel shall be housed. Lighted keys and terminal displays are acceptable.

All controls in the controller cabinet shall be labeled. The cabinet shall have a voltmeter gauge to indicate the current battery charge status. It shall have an amp gauge to indicate the current/charging status. It will be acceptable to have a display via digital readout on a control console or panel.

619.02.14.6--Electronics and Electrical. Each PCMS shall meet all applicable electronics and electrical requirements as outlined in Section 8 of the NEMA TS-4 standard.

Sign Controller. The PCMS shall include a local sign controller with firmware. The local control interface shall have a keyboard capable of allowing full programming and control of the PCMS locally. It shall have a separate serial RS-232 or USB connection to allow a laptop computer using the remote control software to communicate directly with the sign controller.

Local and remote interfaces shall be password protected to safeguard against unauthorized use.

It shall perform and report the following minimum sign diagnostics both through the local interface and Remote Control Subsystem.

- LED brightness controls
- Sign status
- Communications status
- Battery voltage
- Photocell ambient light level.

It shall automatically report a low battery alarm to a remote user through the Remote Control Subsystem. It shall have an alarm for the controller door open and over temperature.

It shall store and display both textual and graphical symbols. It shall store a minimum of 20 pre-programmed messages and graphics. It shall display preprogrammed (by manufacturer) MUTCD symbolic messages and standard arrows. It shall schedule predetermined sequences of messages based on a programmed time and date. Each sequence shall display up to four (4) programmed messages (text and/or graphics). It shall display conventional one, two, or three-line messages for display with a choice of a minimum of three font sizes. Character width shall be proportional to the letter type. The one line message font size shall be capable of displaying messages in full size to utilize the maximum area of display.

It shall allow for automatic and manual controls to adjust the brightness of the LEDs. Automatic control shall be capable of varying the LED brightness by sensing the ambient light level using photocells. Manual brightness control shall be password protected to safeguard against unauthorized use.

It shall display a preprogrammed default message or no message at all, after a power recovery from a power failure. The sign shall shut down its LED display if internal cabinet temperatures reach a level that is determined unsafe by the manufacturer.

All communications and power cabling shall be either shielded or routed within conduit to minimize potential EMI/RFI effects.

Remote Control Subsystem. The PCMS shall be supplied with all the hardware and software necessary to control the PCMS from a remote central station.

It shall have a cellular phone and/or modem capable of communication using the Department's provided cellular service provider. The Contractor shall coordinate with the Department for a cellular service provider. The Contractor shall be responsible for establishing cellular service and providing activated phone number(s) as directed and approved by the Department. The Contractor shall pay for cellular service for this project until the Final Maintenance Release as documented by the State Construction Engineer at which time it will be turned over to the Department.

The cellular service type shall be CDMA/1xRTT or GSM/GPRS, as directed by the Department.

It shall be capable of supporting connection and remote control, programming and diagnostics via the Internet.

The subsystem shall have all necessary hardware such as external antenna, communications cables, and controller interface and NTCIP Sign controller software. The central station software must meet the following minimum requirements:

- 1) Windows XP compatible
- 2) Capable of running on any desktop or laptop.
- 3) Capable of controlling all PCMS functions through windows and GUIs (Graphical User Interface)
- 4) NTCIP compatible as specified herein.

Communications. In addition to any protocols that may be available from the PCMS Manufacturer, each sign controller shall support NTCIP as follows:

- NTCIP Protocol and Command Sets. This specification references several standards through their NTCIP designated names and numbers. Each NTCIP Component covered by these specifications shall implement the most recent version of the standard that is available as of project advertisement date, including any and all prepared amendments to the standards as of the same date.

Profile Implementation Conformance Specifications (PICS) for each NTCIP standard required shall be submitted for review and approval to the Department.

- RS-232 Interface. Communication interfaces using RS-232 shall conform with the following minimum requirements:

1101 – NTCIP Simple Transportation Management Framework (STMF)
 1203 - NTCIP Object Definition for Portable Dynamic Message Signs
 2301 - NTCIP AP-STMF
 2201 - NTCIP TP-Transportation Transport Profile
 2103 – NTCIP SPPPP/RS232
 2104 - NTCIP SP-PMPP/RS232

- Subnet Level. For each communication interface, the NTCIP Components may support additional Subnet Profiles at the manufacturer's option. At any time, only one Subnet Profile shall be active on a given communication interface. The NTCIP Component shall be configurable to allow the field technician to activate the desired Subnet Profile.
- Transport Level. For each communication interface, the communication interface may support additional Transport Profiles at the manufacturer's option. Response data-grams shall use the same Transport Profile used in the request. Each communication interface shall support the receipt of data-grams conforming to any of the identified Transport Profiles at any time.
- Application Level. For each communication interface, all interfaces shall comply with NTCIP 1101 and shall meet the requirements for Conformance Level 1 (NOTE -See Amendment to standard). Optionally, the NTCIP Component may support SNMP traps. A communication interface may support additional Application Profiles at the manufacturer's option. Responses shall use the same Application Profile used by the request. Each communication interface shall support the receipt of Application data packets at any time allowed by the subject standards.
- Information Level. For all communication interfaces, the information level protocol shall provide Full, Standardized Object Range Support of all objects required by these specifications unless otherwise indicated below. The maximum Response Time for any object or group of objects shall be 200 milliseconds. All communication interfaces shall implement all mandatory objects of all mandatory Conformance Groups as defined in NTCIP 1203 and its respective amendments. Table 1 indicates the modified object requirements for these mandatory objects. Table 2 shows the required minimum support of messages that are to be stored in permanent memory. The sign shall blank if a command to display a message contains an invalid Message CRC value for the desired message. Table 3 specifies the support of the required MULTI tags and itsranges.

The protocol shall also implement all mandatory objects of the following optional conformance groups of NTCIP 1201.

- Time Management Conformal Group
- Report Conformal Group. Table 4 indicates the modified object requirements.
- Implement all objects of the Font Configuration Conformance Group, as defined in NTCIP 1203. Table 5 indicates the modified object requirements for this conformance group.
- Implement all objects of the PCMS Configuration Conformance Group, as defined in NTCIP 1203.
- Implement all objects of the Multi Configuration Conformance Group, as defined in NTCIP 1203. Table 6 indicates the modified object requirements for this conformance group.
- Implement all objects of the Multi Error Configuration, as defined in NTCIP 1203.
- Implement all objects of the Illumination/Brightness.
- Sign Status, as defined in NTCIP 1203.

- Status Error, as defined in NTCIP 1203.
- Pixel Error Status, as defined in NTCIP 1203.
- The sign display shall be capable of displaying preprogrammed MUTCD) symbolic messages and standard arrows. Since the display of graphics is currently not defined within the NTCIP Standards or its amendments, the vendor shall propose and provide detailed documentation (i.e., interface protocol description level) concerning the display of the specified graphical shapes.
- Implement the optional objects listed in Table 7.

**Table 1
Modified Object Ranges for Mandatory Objects**

Object	Reference	Project Requirement
ModuleTableEntry	NTCIP 1201 Clause 2.2.3	Shall contain at least one row with moduleType equal to 3 (software). The moduleMake shall specify the name of the manufacturer, the moduleModel shall specify the manufacturer's name of the component and the modelVersion shall indicate the model version number of the component.
MaxGroupAddresses	NTCIP 1201 Clause 2.7.1	Shall be at least 1
CommunityNamesMax	NTCIP 1201 Clause 2.8.2	Shall be at least 3
PCMSNumPermanentMsg	NTCIP 1203 Clause 2.6.1.1.1.1	Shall be at least 20*
PCMSMaxChangeableMsg	NTCIP 1203 Clause 2.6.1.1.1.3	Shall be at least 50. Each message shall support at least 4 pages per message.
PCMSFreeChangeableMemory	NTCIP 1203 Clause 2.6.1.1.1.4	Shall be at least 70 when no messages are stored.
PCMSMessageMultiString	NTCIP 1203 Clause 2.6.1.1.1.8.3	The PCMS shall support any valid MULTI string containing any subset of those MULTI tags listed in Table 4.
PCMSControlMode	NTCIP 1203 Clause 2.7.1.1.1.1	Shall support at least the following modes: <ul style="list-style-type: none"> ▪ local ▪ external ▪ central ▪ centralOverride

Table 2
Content of Permanent Messages

Perm. Msg. Num.	Section 12 Description
1	Permanent Message #1 shall blank the display (i.e., command the sign to use PCMSMessageType 7). It shall have a run-time priority of 50.

Table 3
Required MULTI Tags

Code	Feature
f1	Field 1 - time (12hr)
f2	Field 2 - time (24hr)
f8	Field 8 - day of month
f9	Field 9 – month
f10	Field 10 - 2 digit year
f11	Field 11 - 4 digit year
Fl (and /fl)	flashing text on a line by line basis with flash rates controllable in 0.5 second increments.
Fo	Font
J12	justification - line – left
J13	justification - line – center
J14	justification - line – right
J15	justification - line – full
Jp2	justification - page – top
Jp3	justification - page - middle
Jp4	justification - page - bottom
Nl	New line
Np	New page, up to 2 instances in a message (i.e., up to 4 pages/frames in a message counting first page)
Pt	page times controllable in 0.5 second increments.

Table 4
Modified Object Ranges for the Report Conformance Group

Object	Reference	Project Requirement
maxEventLogConfigs	NTCIP 1201 Clause 2.5.1	Shall be at least 50
eventConfigurationMode	NTCIP 1201 Clause 2.4.3.1	The NTCIP Component shall support the following Event Configuration Modes: <ul style="list-style-type: none"> ▪ onChange ▪ greaterThanValue ▪ smallerThanValue
maxEventLogSize	NTCIP 1201 Clause 2.5.3	Shall be at least 200
maxEventClasses	NTCIP 1201 Clause 2.5.5	Shall be at least 16

**Table 5
Modified Object Ranges for the Font Configuration Conformance Group**

Object	Reference	Project Requirement
numfont	NTCIP 1203 Clause 2.4.1.1.1.1	Shall be at least 3*
maxFontCharacters	NTCIP 1203 Clause 2.4.1.1.1.3	Shall be at least 127**

* Upon delivery, the first font shall be a standard 18-inch font. The second font shall be a double-stroke 18-inch font. The third font shall be a 28-inch font.

** Upon delivery, the first three font sets shall be configured in accordance with the ASCII character set for the following characters:

- "A" thru "Z" - All upper case letters.
- "a" thru "z" - All lower case letters.
- "0" thru "9" - All decimal digits.
- Space (i.e., ASCII code 0x20).
- Punctuation marks shown in brackets [. , ! ? - ' ' " " / ()]
- Special characters shown in brackets [# & * + < >]

**Table 6
Modified Object Ranges for the MULTI Configuration Conformance Group**

Object	Reference	Project Requirement
defaultBackgroundColor	NTCIP 1203 Clause 2.5.1.1.1.1	The PCMS shall support the following background colors: <ul style="list-style-type: none"> ▪ black
defaultForegroundColor	NTCIP 1203 Clause 2.5.1.1.1.2	The PCMS shall support the following foreground colors: <ul style="list-style-type: none"> ▪ amber ▪ orange
defaultJustificationLine	NTCIP 1203 Clause 2.5.1.1.1.6	The PCMS shall support the following line justification: <ul style="list-style-type: none"> ▪ Left ▪ Center ▪ Right ▪ Full
defaultJustificationPage	NTCIP 1203 Clause 2.5.1.1.1.7	The PCMS shall support the following forms of page justification: <ul style="list-style-type: none"> ▪ Top ▪ Middle ▪ Bottom

defaultPageOnTime	NTCIP 1203 Clause 2.5.1.1.1.8	The PCMS shall support the full range of these objects with step sizes no larger than 0.5 seconds
defaultPageOffTime	NTCIP 1203 Clause 2.5.1.1.1.9	The PCMS shall support the full range of these objects with step sizes no larger than 0.5 seconds
defaultCharacterSet	NTCIP 1203 Clause 2.5.1.1.1.10	The PCMS shall support the following character sets: <ul style="list-style-type: none"> ▪ eightBit

Table 7
Optional Object Requirements

Object	Reference	Project Requirement
globalSetIDParameter	NTCIP 1201 Clause 2.2.1	
eventConfigLogOID	NTCIP 1201 Clause 2.5.2.7	
eventConfigAction	NTCIP 1201 Clause 2.5.2.8	
eventClassDescription	NTCIP 1201 Clause 2.5.6.4	
defaultFlashOn	NTCIP 1203 Clause 2.5.1.1.1.3	The PCMS shall support the full range of these objects with step sizes no larger than 0.5 seconds
defaultFlashOff	NTCIP 1203 Clause 2.5.1.1.1.4	The PCMS shall support the full range of these objects with step sizes no larger than 0.5 seconds
PCMSSWReset	NTCIP 1203 Clause 2.7.1.1.1.2	
PCMSMessageTimeRemaining	NTCIP 1203 Clause 2.7.1.1.1.4	
PCMSShortPowerRecoveryMessage	NTCIP 1203 Clause 2.7.1.1.1.8	
PCMSLongPowerRecoveryMessage	NTCIP 1203 Clause 2.7.1.1.1.9	
PCMSShortPowerLossTime	NTCIP 1203 Clause 2.7.1.1.1.10	

PCMSResetMessage	NTCIP 1203 Clause 2.7.1.1.1.11	
PCMSCommunicationsLossMessage	NTCIP 1203 Clause 2.7.1.1.1.12	
PCMSTimeCommLoss	NTCIP 1203 Clause 2.7.1.1.1.13	
PCMSEndDurationMessage	NTCIP 1203 Clause 2.7.1.1.1.15	
PCMSMemoryMgmt	NTCIP 1203 Clause 2.7.1.1.1.16	The PCMS shall support the following Memory management Modes: <ul style="list-style-type: none"> ▪ normal ▪ clearChangeableMessage ▪ clearVolatileMessages
PCMSMultiOtherErrorDescription	NTCIP 1203 Clause 2.7.1.1.1.20	If the vendor implements any vendor-specific MULTI tags, the PCMS shall be provided with documentation that includes meaningful error messages within this object whenever one of these tags generates an error.
PCMSIllumLightOutputStatus	NTCIP 1203 Clause 2.8.1.1.1.9	
watchdogFailureCount	NTCIP 1203 Clause 2.11.1.1.1.5	
PCMSStatDoorOpen	NTCIP 1203 Clause 2.11.1.1.1.6	
fanFailure	NTCIP 1203 Clause 2.11.2.1.1.8	
fanTestActivation	NTCIP 1203 Clause 2.11.2.1.1.9	
tempMinCtrlCabinet	NTCIP 1203 Clause 2.11.4.1.1.1	
tempMaxCtrlCabinet	NTCIP 1203 Clause 2.11.4.1.1.2	

tempMinSignHousing	NTCIP 1203 Clause 2.11.4.1.1.5	
tempMaxSignHousing	NTCIP 1203 Clause 2.11.4.1.1.6	

NTCIP Compliance Documentation. Software shall be supplied with full documentation, including a CD-ROM containing ASCII versions of the following Management Information Base (MIB) files in Abstract Syntax Notation 1 (ASN.1) format.

- (a) The relevant version of each official standard MIB Module referenced by the device functionality shall be included. If the device does not support the full range of any given object within a Standard MIB Module, a manufacturer specific version of the official Standard MIB Module with the supported range indicated in ASN.1 format in the SYNTAX and/or DESCRIPTION fields of the associated OBJECT TYPE macro shall be provided. The filename of this file shall be identical to the standard MIB Module, except that it will have the extension ".man".
- (b) A MIB Module in ASN.1 format containing any and all manufacturer-specific objects supported by the device with accurate and meaningful DESCRIPTION fields and supported ranges indicated in the SYNTAX field of the OBJECT-TYPE macros shall be provided. This includes a MIB containing any other objects supported by the device.
- (c) Additionally, the manufacturer shall provide a test procedure that demonstrates how the NTCIP compliance of both, the data dictionaries (NTCIP 1201, 1203, and their amendments) and the communications protocols have been tested. The manufacturer shall allow the use of any and all of this documentation by any party authorized by the Department for systems integration purposes at any time initially or in the future, regardless of what parties are involved in the systems integration effort.

619.02.14.7--Operational Security. The Contractor shall change the manufacturer's default passwords for all levels of access. The passwords for each level of access shall be different. The individual passwords shall be at least eight (8) characters in length, contain both upper and lowercase alphabetic characters (A-Z, a-z), have at least one (1) numerical character (0-9), and have at least one (1) special character (~!@#\$\$%^&*()_-=+). The passwords shall not 1) spell a word or series of words that can be found in a standard dictionary, 2) spell a word with a number added to the beginning and the end, or 3) be based on any personal information such as user id, family name, pet, birthday, etc. The Contractor shall provide the Project Engineer will a listing of all passwords for each PCMS prior to the PCMS being placed on the project. If multiple PCMS are used on a project, they shall each have distinct passwords.

619.02.14.8--Additional Equipment Requirements. When the contract requires the PCMS to include a speed radar unit, the radar shall operate in the "K" band, in an "approach only" mode. In conjunction with the radar, the sign shall be capable of displaying the vehicle speeds. The unit shall be programmable to allow the interruption of user-defined messages by the vehicle speed display and/or alternate messages whenever a settable speed threshold is exceeded. The radar unit shall be encased in an aluminum enclosure with a polycarbonate lens, and the metal portion shall receive the same protective coating, priming, and painting as the rest of the sign.

619.02.14.9--System Documentation. For each PCMS, the Contractor shall provide two (2) user manuals. The user manual shall include description and samples for all operational functions, software required to operate the sign on site and remotely, all wiring diagrams, a parts lists, the sign specifications, warranty information, maintenance information and schedule, and a trouble shooting table.

Each copy shall be bound and shall contain laminated sheets.

619.02.15--Glare Paddles. Glare paddles shall be those listed on the Department's APL".

619.03--Construction Requirements.

619.03.1--General. Traffic control devices shall be furnished and utilized in accordance with the Traffic Control Plan (TCP) as referenced in Section 618. Upon failure of the Contractor to adequately maintain traffic control devices and safe movement of traffic through the construction zones, the provisions of Subsection 105.15 will be invoked.

619.03.2--Temporary Stripe. Temporary stripes are pavement markings, temporary in nature, that are used to direct traffic from its customary path, to be removed from the pavement course under use for further temporary traffic control, to be covered by the next pavement course and/or to be replaced by permanent stripes. Temporary stripes shall be 4-inch paint or preformed tape as designated on the plans or when not designated, the use of paint or tape will be at the Contractor's option. Temporary stripes on surface treatments shall be paint.

All temporary stripe shall be placed in accordance with the plans and the requirements set out in Section 625, except that alignment of temporary stripe placed on underlying courses shall have a tolerance of four inches in fifty (50) feet from true alignment for skip stripes and edge lines and one inch in fifty (50) feet from true alignment for no-passing stripes and lane lines. When preformed tape is used on the final pavement course for temporary traffic markings, it shall be removed at no additional cost to the State.

Temporary paint stripe requiring removal shall be removed by carefully controlled blast cleaning, approved grinding or other approved methods in such a manner that the surface to which the stripe is applied will not be unnecessarily marred or damaged. Preformed tape is to be removed in accordance with the manufacturer's recommendations.

Temporary paint stripe placed on the final pavement course may be left in place and covered with permanent stripe of the same color provided the temporary stripe has been satisfactorily placed in the proper location. Under this condition, any remaining temporary paint stripe not covered by the permanent stripe shall be removed at no additional cost to the State.

Painted traffic stripe removed from the final asphalt pavement surface shall be sealed with an approved sealant. The Engineer may wave the sealant requirement when the area to be sealed is insignificant. This sealing operation shall be performed at no additional costs to the State.

All temporary pavement markings placed and measured for payment under this section

shall include any required removal. Removal of all temporary stripe will not be measured for separate payment.

Existing pavement markings conflicting with temporary markings shall be removed. Removal of such materials (paint, tape, marker, etc.) will be measured and payment made under Section 202. When measuring removal of pavement markings for payment, the skips will not be included in the measurement.

619.03.3--Portable Traffic Signals.

619.03.3.1--Installation. The Contractor shall be responsible for placing the portable traffic signal(s) in the appropriate location based as shown in the plans and meeting the MUTCD and ITE standards for visibility to motorists and for safe operation.

The Contractor shall be responsible for providing all hardware, software, communications equipment and licenses to operate a complete system. All equipment shall be installed according to the manufacturer's recommendations.

The Contractor shall be responsible for transport, setup, configuration, operation and monitoring of the portable traffic signals throughout the entire project. The Engineer shall approve all timing and settings that are used for operation of the signal.

It may be necessary to relocate the portable traffic signals during the project. The cost of the relocation shall be included in the lump sum price bid.

619.03.3.2--Conformance / Testing. Each portable traffic signal shall undergo testing to verify conformance with this specification. The Contractor shall conduct a Project Testing Program as required below. All costs associated with the Project Testing Program shall be included in overall contract prices; no separate payment will be made for any testing.

619.03.3.2.1--General Requirements. This work shall meet the following general requirements.

- 1) The Contractor is responsible for planning, coordinating, conducting and documenting all aspects of the Project Testing Program. The Project Engineer and/or their designee(s) are only responsible for attending and observing each test, and reviewing and approving the Contractor's test results documentation. The Project Engineer and/or their designee(s) reserve the right to attend and observe all tests.
- 2) Each test shall fully demonstrate that the equipment being tested is clearly and definitely in full compliance with all project requirements.
- 3) Test procedures shall be submitted and approved for each test as part of the project submittals. Test procedures shall include every action necessary to fully demonstrate that the equipment being tested is clearly and definitely in full compliance with all project requirements. Test procedures shall cross-reference to these specifications or the project plans. Test procedures shall contain documentation regarding the equipment configurations and programming.
- 4) No testing shall be scheduled until approval of all project submittals and approval of the test procedures for the given test.
- 5) The Contractor shall provide all ancillary equipment and materials as required in the approved test procedures.

- 6) The Contractor shall request in writing the Project Engineer's approval for each test occurrence a minimum of 14 days prior to the requested test date. Test requests shall include the test to be performed and the equipment to be tested. The Project Engineer reserves the right to reschedule test request if needed.
- 7) All tests shall be documented in writing by the Contractor in accordance with the test procedure and submitted to the Project Engineer within seven (7) days of the test. Any given test session shall be considered incomplete until the Project Engineer has approved the documentation for that test session.
- 8) All tests deemed by the Project Engineer to be unsatisfactorily completed shall be repeated by the Contractor. In the written request for each test occurrence that is a repeat of a previous test, the Contractor shall summarize the diagnosis and correction of each aspect of the previous test. The test procedures for a repeated test occurrence shall meet all the requirements of the original test procedures, including review and approval by the Project Engineer.
- 9) The satisfactory completion of any test shall not relieve the Contractor of responsibility to provide a completely acceptable and operating system that meets all requirements of this project.

619.03.3.2.2--Portable Traffic Signal Pre-Installation Test (PIT). The Contractor shall perform PIT on the portable traffic signals units as they arrive from the factory. The goal of the PIT is to verify that the portable traffic signals were not damaged during shipping and that all components are working.

619.03.3.2.3--Portable Traffic Signal Stand Alone Test (SAT). The Contractor's comprehensive SATs for the portable traffic signals shall be completed once the signal has been location on the site where it will be utilized. The SAT shall be sufficient to demonstrate compliance with all requirements specified herein.

619.03.3.3--System Maintenance and Support. The portable traffic signal(s) shall be maintained and supported by the Contractor throughout the duration of the project. The Contractor shall provide MDOT with a 24/7 contact to respond to any issues and shall be required to respond within two (2) hours to any call from the Engineer or designated representative concerning any request for correcting any deficiency in the signal system. Equipment damaged or otherwise not functioning shall be repaired or replaced immediately upon notification by MDOT. Sufficient spare parts to repair common components of the portable traffic signal such as heads, controller, load switch, relays, etc. shall be available on site. All equipment installation, service, repair, relocation and removal are the responsibility of the Contractor.

619.03.3.4--System Documentation. For each type signal, the Contractor shall provide the Engineer with a user manual. The user manual shall include description and samples for all operational functions, software required to operate the signal on site and remotely (if applicable), all wiring diagrams, a parts lists, the signal specifications, maintenance information and schedule, and a trouble-shooting guide.

619.03.4--Reflective Pavement Markers. Reflective pavement markers for construction zones shall be secured to the pavement by an approved adhesive. The portion of the highway surface to which the marker is to be bonded shall be free of dirt, grease, oil, moisture, loose or unsound layers and any other material that would adversely affect the bond of the adhesive. Clean pavement need not be blast-cleaned unless the surface contains an abnormal amount of asphalt or the surface is contaminated with dirt, grease, oil, or any

other material that would adversely affect the bond of the adhesive. Necessary cleaning shall be performed by blast cleaning.

When a pressure-sensitive pad is used, a primer shall be applied directly to the road surface with a brush or sprayer but is not to be applied when the ambient temperature is lower than 50°F. No marker shall be installed when the relative humidity of the air is greater than 80 percent or when the pavement is not surface dry. Traffic shall not be permitted to run over the primed area until after the markers have been installed. After priming, allow one minute for the primer to dry, then peel the release paper from the pressure-sensitive pad and immediately place the marker in the correct position on the primed road surface and apply light pressure. Drive slowly over the located marker with one wheel of a truck to help set it in place. Traffic may be allowed immediately.

All markers shall be installed in a uniform line, with controls established by the Engineer. The Engineer will establish controls for each line of markers by setting control points at not less than approximately 600-foot intervals on tangents and 50-foot intervals in curves. All additional work necessary to establish intermediate control points and individual marker points shall be performed by the Contractor. On curves, the line of markers on lane lines and edge lines shall follow the normal curvature of the curve and placement on chords or other variations from the normal curvature will not be permitted, unless specifically shown on the plans or ordered by the Engineer.

Reflective markers shall be installed in such a manner that the reflective face of the marker is perpendicular to a line parallel to the roadway centerline. No markers shall be installed over longitudinal or transverse joints of the pavement surface.

All markers placed out of alignment shall be removed and replaced by a new marker.

619.03.5--Impact Attenuators. Impact attenuators shall be installed and maintained by experienced workmen familiar with the installation of impact attenuators. Installation shall be in accordance with the recommendations of the manufacturer. Each impact attenuator shall also include one replacement package. A replacement package shall consist of the quantity of materials necessary to repair one hit for every three attenuators in place. The Contractor shall use these parts to maintain the attenuator during the construction period. When it becomes necessary to install a replacement package, the Contractor shall order an additional replacement package to have available for future use. All unused parts and the attenuators shall become the property of the Contractor upon completion of the project.

619.03.6--Temporary Guardrail. Temporary guardrail shall be installed in accordance with the plans and the applicable provisions of Section 606.

The sites where temporary guardrail has been removed shall be restored to their original condition or as provided in the contract documents.

Salvage of temporary guardrail designated to become the property of the Department shall be in accordance with Subsection 202.03.

619.03.7--Maintenance of Traffic Signs. All signs, whether placed new or previously used, shall meet the requirements of this specification on each inspection. Signs failing to comply with these requirements shall be replaced at no additional cost to the State.

619.03.8--Snap-Back Delineators. Snap-back delineators shall be installed in accordance with the manufacturer's recommendations and at the locations shown on the plans or directed by the Engineer. Delineators that are damaged by traffic to the extent that they are non-functional shall be replaced as quickly as possible.

619.03.9--Portable Median Barrier. Portable median barriers shall be installed in accordance with the manufacturer's recommendations. The barriers shall be installed at the locations shown on the plans, or as directed by the Engineer.

619.03.10--Changeable Message Sign. Each changeable message sign shall be installed and continuously operated at the location selected by the Engineer on State right-of-way. The Contractor is advised that selected locations may be outside the planned limits of the project. The Contractor shall perform all work necessary for preparation of the site selected and approved by the Engineer, to ensure maximum safety and sign visibility for the traveling public and may be required to remove any temporary work at a later date as directed by the Engineer. The Contractor will also place a minimum of two plastic drums in advance of the sign and one beside the sign as long as it is in use. The Contractor shall be required to move the sign to a new location if directed by the Engineer.

The Contractor may be permitted to bring electric power from outside the normal right-of-way for operation of the equipment if the Department determines that the installation operation will not be hazardous to the traveling public. The Contractor will be required to secure a permit from the Department prior to any work by the power company on the right-of-way. The entire cost of providing electrical service, power to operate the equipment, and removal of the power source from the right-of-way shall be borne by the Contractor.

The changeable message sign(s) will remain the property of the Contractor after the Engineer determines that there is no further need for the sign(s) on the project.

619.03.11--Glare Paddles. Glare paddle installation shall consist of furnishing, installing, maintaining, removing and relocating glare paddles as required. Glare paddles shall be placed atop precast median barriers, or other devices, at locations shown in the plans, or as directed by the Engineer.

The paddles shall be six to nine inches (6" to 9") in width, 24 to 36 inches in height, and spaced a maximum of 24 inches apart. The paddles shall be attached to the top of the devices in accordance with manufacturer's recommendations at a 22 degree angle. A yellow high-intensity reflective strip shall be attached vertically to each side of one of the paddles such that the spacing is 10 feet apart. Unless otherwise directed, these strips shall be placed on the edge of the paddle adjacent to traffic. These reflective strips shall be made of 2-inch by 12-inch material conforming to the requirements of Subsection 721.06 of the Standard Specifications.

All glare paddles shall be properly maintained. Maintenance will include replacement of damaged or missing blades, improper reflectorization, and any other portions of the installation that may fail, for the entire length of time that the paddles are in place. Cleaning of the reflective material shall be accomplished by any means that does not damage the paddles and in a manner that is not hazardous to traffic. Cleaning shall be accomplished on an as-needed basis or as ordered by the Engineer.

The Contractor shall relocate the glare paddles as required during construction at no additional cost to the State.

After completion of the work, glare paddles and attachments shall remain the property of the Contractor.

619.04--Method of Measurement. Traffic control devices will be measured one time only by the units indicated. When moved from the original location to other locations, as required by the contract or as directed by the Engineer, traffic control devices will not be measured for additional payment except when the contract includes the pay item, "Remove and Reset". The total pay quantity for each traffic control device excluding traffic stripe shall not exceed the maximum number of installations in place at any given time during the life of the contract. Unless otherwise provided, replacement of devices will not be measured for payment.

Temporary stripe, completed and removed in accordance with the requirements of this Section, will be measured by the mile or by the linear foot, as indicated, from end-to-end of individual stripes. In the case of skip lines, the measurement will include skips. The length used to measure centerline, lane lines and edge stripes will be the horizontal length computed along the stationed control line. Detail traffic stripe will be measured by the linear foot from end-to-end of individual stripes. Measurement will be made along the surface of each stripe and will exclude nominal skip intervals where specified. Stripes more than four inches in width will be converted to equivalent lengths of four-inch stripe.

Legend, which is to include railroad markings, pedestrian crosswalks and stop lines, will be measured by the square foot or linear foot. Pay areas of individual letters and symbols will usually be shown on the plans and measured by the square foot. Transverse railroad bands, pedestrian crosswalks and stop lines will generally be measured by the linear foot, and stripes more than four inches in width will be converted to equivalent lengths of four-inch widths.

Each impact attenuator installation, including one replacement package, will be measured per each installation as shown on the plans. Replacement packages, excluding the package included with the initial attenuator, will be measured per each in accordance with these specifications.

Initial snap-back delineators will be measured per each. Replacement will be measured as follows:

- (a) Replace reflective material measured as 1/4 unit.
- (b) Replace complete tube measured as 1/3 unit.
- (c) Replace shock cord adapter measured as 1/3 unit.

Changeable message signs, as described above, will be measured per each. When directed, separate measurements will be made for items included in the contract and required for temporary site preparation for the sign as referenced in Subsection 619.03.10. Materials for which no pay items are included in the contract will not be measured for separate payment. Separate measurements will not be made for moving the changeable message sign to a new location, but materials used for which pay items are included in the contract and are necessary for repositioning the sign as directed by the Engineer will be measured

for separate payment. Removal of materials used for site preparation for changeable message signs will not be measured for separate payment.

Portable traffic signals of the type specified will be measured per each.

The lengths of median barrier, including remove and reset median barrier, will be measured per linear foot by multiplying the number of commercial lengths installed by the nominal length of the barrier.

619.05--Basis of Payment. Traffic control devices will be paid for at the contract unit price for the units specified. Devices that have been measured for payment and subsequently require repair or replacement will be dropped from payment on future estimates unless satisfactorily repaired or replaced.

Payment for devices for which no pay items are contained in the contract will be included in the unit prices of contract items and/or in the lump sum contract price for Maintenance of Traffic.

Payment for items required by the Engineer for temporary location of the changeable message sign, and for which pay items are included in the contract, will be made by the individual pay item. No additional payment will be made for working outside the planned indicated project limits.

Payment for removal of materials used for site preparation at changeable message sign locations shall be included in the contract price for Maintenance of Traffic.

Portable traffic signals of the type specified will be paid for at the contract unit price per each, which price shall be full compensation for furnishing, installing, testing, operating, relocating a complete portable traffic signal as required, integration, configuration, and all other materials, equipment, labor, tools and incidentals necessary to complete the work.

The prices thus paid shall be full compensation for completing the work.

Payment will be made under:

619-A1:	Temporary Traffic Stripe, Continuous White, <u>Description *</u>	- per linear foot or mile
619-A2:	Temporary Traffic Stripe, Continuous Yellow, <u>Description *</u>	- per linear foot or mile
619-A3:	Temporary Traffic Stripe, Skip White, <u>Description*</u>	- per linear foot or mile
619-A4:	Temporary Traffic Stripe, Skip Yellow, <u>Description*</u>	- per linear foot or mile
619-A5:	Temporary Traffic Stripe, Detail, <u>Description*</u>	- per linear foot
619-A6:	Temporary Traffic Stripe, Legend, <u>Description*</u>	- per square foot or linear foot

619-B:	Blank	
619-C1:	Red-Clear Reflective Raised Pavement Marker	- per each
619-C2:	Two-Way Yellow Reflective Raised Pavement Marker	- per each
619-C3:	One-Way Clear Reflective Raised Pavement Marker	- per each
619-C4:	One-Way Yellow Reflective Raised Pavement Marker	- per each
619-C5:	Yellow Clear Reflective Raised Pavement Marker	- per each
619-C6:	Red-Clear Reflective High Performance Raised Marker	- per each
619-C7:	Two-Way Yellow Reflective High Performance Raised Marker	- per each
619-C8:	One-Way Clear Reflective High Performance Raised Marker	- per each
619-C9:	One-Way Yellow Reflective High Performance Raised Marker	- per each
619-C10:	Yellow Clear Reflective High Performance Raised Marker	- per each
619-D1:	Standard Roadside Construction Signs, Less than 10 Square Feet	- per square foot
619-D2:	Standard Roadside Construction Signs, 10 Square Feet or More	- per square foot
619-D3:	Remove and Reset Signs, All Sizes	- per each
619-D4:	Directional Signs	- per square foot
619-D5:	Directional Signs, Overhead, <u>Location</u>	- lump sum
619-E1:	Flashing Arrow Panel, Type _____	- per each
619-E2:	Sequencing Chevron Panel, <u>Size</u>	- per each
619-E3:	Changeable Message Sign *****	- per each
619-F1:	<u>**</u> Median Barrier, <u>***</u>	- per linear foot
619-F2:	Remove and Reset <u>**</u> Median Barrier, <u>***</u>	- per linear foot
619-F3:	Delineators, <u>Mounting</u> , <u>Description</u>	- per each
619-F4:	Snap-Back Delineator	- per each

619-F5: Snap-Back Delineator, Replacement	- per each
619-G1: Blank	
619-G2: Barricades, Type I	- per each
619-G3: Barricades, Type II	- per each
619-G4: Barricades, Type III, *****	- per linear foot
619-G5: Free Standing Plastic Drums	- per each
619-G6: Warning Lights, Type A	- per each
619-G7: Warning Lights, Type B	- per each
619-G8: Warning Lights, Type C	- per each
619-H1: Traffic Signal, <u>Location</u>	- lump sum
619-H2: Traffic Signal, Portable, Type ____	- per each
619-H3: Hazard Identification Beacons	- lump sum
619-J1: Impact Attenuator, <u>Speed Rating</u>	- per each
619-J2: Impact Attenuator, <u>Speed Rating</u> , Replacement Package	- per each
619-J3: Remove and Reset Impact Attenuator *****	- per each
619-K1: Installation and Removal of Guardrail, Type____, Class____	- per linear foot
619-K2: Installation and Removal of Guardrail, Type____ Bridge End Section	- per each
619-K3: Installation and Removal of Guardrail, Type____ Cable Anchorage	- per each
619-K4: Installation and Removal of Guardrail, Terminal End Section	- per each
619-L: Glare Paddles	- per linear foot

* The description for temporary traffic stripe will be shown as "paint" or "tape." In the case of "tape" the type will also be designated. When the description is not designated, the use of "paint" or "tape" will be at the Contractor's option.

** Indicate Concrete or Portable

*** Indicate Speed Rating, Color, etc. if applicable

**** Indicate if barricade is to remain with "Permanent"

***** Indicate when options are required

SECTION 620 - MOBILIZATION AND REQUISITE WORK

620.01--Description. Mobilization consists of moving all labor, equipment, supplies, and incidentals to the project site. It also includes all mobilization pre-construction costs that are necessary direct costs to the project and are of a general nature rather than directly attributable to other pay items.

Requisite work consists of the preparation for and the performance of construction necessary as a requisite to the performance of other items of work and the cost of such work when no other provisions are made in the contract for payment therefore. Such work shall include, but is not limited to, all obligations, preparation, construction and all other costs of requisite work for which no compensation is provided in other items of work.

620.02--Blank.

620.03--Blank.

620.04--Method of Measurement.

620.04.1--Mobilization. Measurement for payment will be in accordance with the following schedule:

- (a) When one percent (1%) of the original contract amount is earned from other bid items exclusive of those listed as dependent items, twenty five percent (25%) of the amount bid for mobilization, or two and one-half percent (2.5%) of the original contract amount, whichever is lesser, will be paid.
- (b) When ten percent (10%) of the original contract amount is earned from other bid items exclusive of those listed as dependent items, fifty percent (50%) of the amount bid for mobilization, or five percent (5%) of the original contract amount, whichever is lesser, will be paid.
- (c) When twenty five percent (25%) of the original contract amount is earned from other bid items exclusive of those listed as dependent items, ninety percent (90%) of the amount bid for mobilization, or nine percent (9%) of the original contract amount, whichever is lesser, will be paid.
- (d) When seventy five percent (75%) of the original contract amount is earned from other bid items exclusive of those listed as dependent items, one hundred percent (100%) of the amount bid for mobilization, or ten percent (10%) of the original contract amount, whichever is lesser, will be paid.
- (e) Upon completion of all work, the remaining amount bid for mobilization will be paid.

In the event the contract is terminated under the provisions of Subsection 108.09, the percentages listed will not be used in computing total payment, but the percentage of original contract amount, exclusive of dependent items, earned at the time of termination will be applied to the lump sum price bid for mobilization.

620.04.2--Requisite Work. For monthly estimates, the Engineer will estimate the percentage of requisite work completed. Upon satisfactory completion of all requisite work, measurement will be considered as 100 percent.

620.05--Basis of Payment. Mobilization and requisite work will be paid for at the contract

lump sum prices, which shall be full compensation for completing the work. When not listed as pay items, the cost of this work shall be included in the prices for other items bid.

Payment will be made under:

620-A: Mobilization - lump sum

620-B: Requisite Work - lump sum

SECTION 621 - FIELD LABORATORY

621.01--Description. When required in the contract, this work consists of providing, for the exclusive use of the Engineer, one or more approved field laboratory buildings or portable trailers in which to house the equipment necessary to conduct required tests. It shall also include the furnishing of utilities as herein provided and the removal of the facilities after the work has been completed. Unless otherwise specified, the building or trailer will remain the property of the Contractor.

621.02--Blank.

621.03--Construction Requirements. Unless otherwise indicated in the contract, each field laboratory shall be at least seven and one-half feet wide, seven feet high inside, and shall contain at least 150 square feet of floor space. Each unit shall be floored, roofed, and weather-tight and shall contain the following:

- (a) At least three windows, each having at least six and one-half square feet of opening.
- (b) At least one door with lock and two keys.
- (c) A suitable work bench with adequate drawers.
- (d) Sink with running water supply as necessary for running tests.
- (e) Adequate ventilation and lighting, and facilities for providing reasonable temperature control.
- (f) Adequate supply of gas and electric current as required for testing.

In addition to the above, the Contractor shall provide toilet facilities within one hundred feet of each field laboratory.

Each unit shall be located as specified, and in the case of central mixing or other plants, the unit shall be so located that the details of the Contractor's or producer's plant operations are in plain view of and visible from at least one window. Where the Contractor's operations are such that the Engineer deems it advisable to do so, the Contractor shall move the unit to other suitable location(s). The Engineer shall be the sole judge as to the number of laboratory units required.

621.04--Method of Measurement. Each specified field laboratory conforming to the requirements of the contract will be measured by the unit complete in place.

621.05--Basis of Payment. Field laboratories furnished as specified will be paid for at the contract unit price per each, which price shall be full compensation for all materials, equipment, tools, labor, utilities, and incidentals necessary to provide each unit, for moving

the unit(s) to other suitable locations, and for removal from the work before final acceptance.

Payment will be made under:

621-A: Field Laboratory - per each

621-B: Field Laboratory, Per Plans - per each

SECTION 622 - ENGINEER'S FIELD OFFICE BUILDING

622.01--Description. When required in the contract, this work shall consist of furnishing and maintaining a field office building for the exclusive use by the Engineer. The field office shall consist of a building, house, mobile office or trailer, approved by the Engineer, and in reasonably close conformity with these specifications.

When so indicated in the contract by pay item designation: LO (Laboratory and Office Building) this work shall also consist of the furnishing and maintaining of a combination field laboratory and field office building in reasonably close conformity with the requirements of these specifications.

In all cases where not specifically provided otherwise, this work shall also consist of furnishing appliances and utilities as herein provided, and the removal of the facilities after the work has been completed. It is understood by the Contractor that the building or trailer remains the property of the Contractor furnishing such facility.

622.02--Materials. All materials and appurtenances required shall be of good commercial quality, approved by the Engineer; however, sampling and testing will not be required.

622.03--Construction Requirements.

622.03.1--Types of Field Office Buildings. Field office buildings shall be designated as Type 1, Type 2 or Type 3. Combination field laboratory and field office buildings shall be designated as Type 2 LO, or Type 3 LO.

622.03.1.1--Type 1, Type 2 and Type 3 Field Office Buildings. Type 1, Type 2 or Type 3 Field Office Buildings shall meet the following minimum requirements:

A. Dimensions. All measurements shown are clear inside dimensions as follows:

Building	Constructed on or for Project linear feet, minimum			Commercially Produced linear feet, minimum		
	Width	Length	Head-Room	Width	Length	Head-Room
Type 1	8.0	10.0	8.0	7.5	9.5	7.0
Type 2	10.0	30.0	8.0	9.5	29.5	7.0
Type 3	12.0	50.0	8.0	11.5	49.5	7.0

B. Doors and Windows.

1. Each building shall be provided with at least one standard height solid entrance door complete with lock and at least two keys. The opening shall also be provided with a self-closing screen door. Type 3 Building shall have at least two such doors and screens.
2. Each wall, unless predominately occupied by a door shall be provided with at least one hinged, jalousied, or sliding window that is glazed, screened and fitted with venetian blinds. Each window shall have an area of at least 6.5 square feet of opening, except toilet area, which may be 3.25 square feet.

Type 1 Building shall have at least three windows.

Type 2 Building, at least six windows.

Type 3 Building, at least 10 windows.

C. Walls and Roof. If constructed on or for the project, walls and roof of all types shall be constructed with 2 x 4 studs and rafters.

1. Both sides of walls shall be covered with 3/8-inch thick plywood, exterior grade on the outside. No open cracks or knotholes will be permitted. If commercially produced, standard wall construction will be accepted.
2. Roof: The roof shall be water tight and shall slope at least one inch in twelve inches (1:12) in one direction away from the door if practicable. It shall have at least 12-inch eaves. If commercially produced, an arched roof without eaves will be accepted.
3. At least 1¼-inch thick rock wool, fiber glass or other non-flammable insulating material shall be placed in the walls and ceiling. This material shall be in all wall and ceiling cavities not occupied by a door or window.

D. Ceiling. The ceiling on all types shall be covered on the inside of the roof rafters with 3/8" minimum thickness plywood if constructed on the project. Standard ceiling will be accepted if commercially produced.

E. Floor. When the floor is made of timber, it shall be a minimum of 12 inches above the ground on 2 x 6 joists. Open cracks, open knotholes, etc. will not be permitted.

F. Heater. The heater may be oil fired, gas or electric. Oil and gas units shall be properly vented to the outside, provided with adequate outside fuel storage and shall be connected thereto with suitable feed lines. Gas units may be connected to a commercial gas main, if available. The heater shall be capable of furnishing sufficient heat to maintain an inside temperature of 72 to 78°F.

G. Work Table, Desk, Chairs, Filing Cabinet, Plan Rack and Locker. Work tables shall be provided, with the tops measuring at least 3' 0" x 7' 6", and shall be stable and constructed with 3/4-inch plywood covered on top with smooth masonite. The height shall be approximately 3' 0" above the floor. One such table shall be provided for a Type 1 Building, 2 or more for a Type 2 Building, and 3 or more for a Type 3 Building. At the option of the Contractor, portable engineers' drafting tables of comparable size may be provided in lieu of the tables indicated hereinabove.

For Type 3 Buildings, the Contractor shall also furnish one 30-inch x 60-inch minimum

size office desk and swivel chair plus two straight chairs and shall also furnish a metal four-drawer vertical filing cabinet, one plan holder rack, one approved locker with separate lock and key for storing Engineer's instruments, two clothes lockers or closets, and one fire extinguisher.

H. Stools. Two stools of the proper height shall be furnished for each work site.

I. Miscellaneous Storage Shelves. Except for Type 3 buildings, six linear feet of storage shelves for books, etc., shall be furnished. If two 3-foot shelves are furnished, they shall be no less than 12 inches apart vertically. Type 3 Buildings shall have six linear feet of shelves in each end.

J. Toilet Facilities. Type 2 and Type 3 Buildings shall have satisfactory indoor enclosed toilet facilities meeting the sanitary code of the local governmental agency having jurisdiction in the area where the unit is to be used. For Type 1 Buildings, the Contractor shall provide at the site of the building outdoor toilet facilities meeting the applicable sanitary code.

K. Utilities. All utilities, including water, sewage, gas and electricity, shall be connected to their service source ready for use prior to the Engineer's occupancy.

Water service shall be potable quality or a separate drinking water supply shall be furnished. Lighting shall be adequate to provide not less than 70-foot candles of light on all working surfaces. Not less than one electrical convenience outlet shall be provided for each desk and table plus two additional outlets each in the office space and laboratory space. Heating and cooling shall be thermostatically controlled. The Contractor shall have one telephone installed in the name of the Engineer.

The telephone service shall be capable of providing service to the Project Office, District Office, Contractor's Field or Main Office, and the Central Offices in Jackson.

The Contractor shall provide a broadband connection to the internet. The service shall be capable of providing a downstream speed of at least 12 Mbps and an upstream speed of at least 1 Mbps.

The Contractor shall provide an all-weather access road to the field office and laboratory and parking for not less than six full-sized automobiles.

For the duration of the contract, the Contractor shall maintain the field office and laboratory, shall provide janitor service at least once each week, and shall supply all heating fuel, electricity, water, and telephone service.

L. Air Conditioner. For Type 2 and Type 3 Buildings, an air conditioning unit shall be furnished and shall be capable of furnishing sufficient cooling to adequately maintain an inside temperature of 72 to 78°F.

622.03.1.2--Type 2 LO and Type 3 LO Field Office Buildings. Type 2 LO or Type 3 LO buildings shall meet the requirements specified hereinabove for Type 2 or Type 3, respectively, and in addition shall meet the following minimum requirements:

A. Dimensions. Type 2 LO buildings shall have dimensions of not less than those

specified for Type 2 above and, in addition, shall be partitioned into two rooms. One room for laboratory space shall consist of not less than 125 square feet floor space, shall consist of not less than 150 square feet floor space, including toilet, with the combined total floor space of not less than that specified for Type 2 above. Each Type 2 LO building shall have two entrance doors as described in Subsection 622.03.1.1, B, 1.

Type 3 LO Buildings shall have dimensions of not less than those specified for Type 3 above, and, in addition, shall be partitioned into two rooms. One room for laboratory space shall consist of not less than 150 square feet of floor space and the other room for office space shall consist of not less than 400 square feet of floor space, including toilet, with the combined total floor space of not less than that specified for Type 3 above.

Each LO building shall have a swinging or sliding door between the specified two rooms.

B. Construction and Facilities. Type 2 LO or Type 3 LO buildings shall be constructed, equipped and utilities provided as set out in Subsection 622.03.1.1, B through L, except that the portion indicated to be used as a field laboratory shall be modified to provide minimum laboratory facilities as specified in Subsection 621.03.

Heating and cooling facilities shall be such as to provide the temperatures specified in Subsection 622.03.1.1, F and L, in each room.

The Contractor may furnish larger buildings than the type specified, provided all inside arrangements meet minimum requirements and are approved by the Engineer.

When a Type 2 LO or Type 3 LO building is specified, the Contractor may furnish either a single building partitioned as indicated to provide the required space, or separate units, one in accordance with the construction details of Section 621 and the other in accordance with this Section 622 for Type 2 or Type 3, depending upon whether Type 2 LO or Type 3 LO is specified.

When separate units are furnished, each unit shall be equipped, located and services provided as if each were specified.

622.03.2--Location. Engineer's field office building Type 1 shall be located within or near the project limits as directed by the Engineer. As the work progresses the offices shall be moved to other locations at the direction of the Engineer.

Types 2 and 3 office buildings and Types 2 and 3 LO buildings may be located within the project limits or near the project as directed by the Engineer. Whenever possible the building shall be located within 1,000 feet of a source of electric power provided by the Contractor and the Contractor shall provide such electric power to the building as indicated hereinabove. When the Engineer determines it is necessary to so locate the building that electric power must be transmitted for exclusive use by the Engineer for a distance in excess of 1,000 feet, the cost for that part of the distance in excess of 1,000 feet shall be considered Extra Work.

622.03.3--Ownership and Use. Whether owned, leased or rented by the Contractor, possession of each building will remain with the Contractor who provides the building. The building(s) and all appurtenances shall be furnished, located and made ready for use by the Engineer as a first item of work. The building(s) shall be reserved for the exclusive

use of the Engineering Personnel for such time as considered necessary, but no longer than the date of final release from maintenance on the project. The use, location, relocation and removal shall be under the direction and control of the Engineer and no portion of the building shall be occupied, or otherwise used by the Contractor, unless permitted by the Engineer in writing and subject to any provisions or limitations set forth in such written permission. When no longer needed, and upon specific instructions of the Engineer, each building shall be removed from the project.

622.04--Method of Measurement. Each specified Engineer's field office building conforming to the requirements of the contract and including all facilities and utilities as specified will be measured as a unit lump sum quantity.

When a Type 2 LO or Type 3 LO building is specified and the Contractor furnishes separate units as provided in Subsection 622.03.1.2, B, no additional measurement will be made because of the separate units but will be made as if the specified single unit had been furnished.

622.05--Basis of Payment. The Engineer's field office buildings or combination field laboratory and office building furnished as specified and measured as prescribed above will be paid for at the contract unit price per each, which price shall be full compensation for all materials, design, construction, furnishing, maintaining; for all fuel, water, sewage disposal, telephone service, electricity, including transformer if necessary, moving to and from the project and movements on the project, all as specified or directed by the Engineer as provided in the contract, and for all costs incidental thereto. When the Engineer determines that the necessary location of the building is such that electrical current must be carried for the exclusive use of the Engineer for a distance in excess of 1,000 feet from its source, the cost of furnishing service lines in excess of 1,000 feet will be paid for as Extra Work.

Payment for each Engineer's field office building or LO building provided in accordance with the contract will be made in two installments. Sixty-five (65) percent of the contract price will be paid on the first monthly estimate after occupancy by the Engineer and the remaining thirty-five (35) percent will be paid when the use of the building has been concluded by the Engineer as provided herein.

Payment will be made under:

622-A: Engineer's Field Office Building, Type ____ - per each

622-B: Engineer's Field Office Building, Type ____ LO - per each

SECTION 623 - DRAINAGE WICKS

623.01--Description. This section shall cover the work of furnishing and installing drainage wicks of the types, sizes and at the designated locations, all in accordance with the details specified on the plans and in these specifications or as directed by the Engineer. This section shall also cover the work of drilling holes through the embankment layer at locations specified on the plans or directed by the Engineer. Jetting methods will not be permitted.

The Engineer may vary the depths, spacings or number of drainage wicks to be installed, and may revise the plan limits for this work as necessary.

623.02--Materials. The drainage wick shall be a prefabricated type composed of a drainage plastic core wrapped in a non-woven geotextile. The core shall be fabricated with suitable drainage channels.

The non-woven geotextile wrap shall meet the following minimum specifications:

<u>Property</u>	<u>Value</u>	<u>Test Method</u>
Tensile Strength	30 lbs./in.	ASTM D 4632
Permittivity	0.15 sec ⁻¹	ASTM D 4491

The core material shall be constructed in such a manner that the filter geotextile has a minimum surface area of 3.50 square inches per inch that is not in contact with the core material. The core channels shall have a minimum free volume of 0.16 cubic inch per inch.

The Contractor will be required to furnish to the Engineer three copies of a certified test report from the producer, showing all data required to indicate compliance with the above specifications and with certification that the material meets such specifications.

The certifications by the manufacturer or distributor will be prima-facie evidence of the materials meeting the specified requirements. All drainage wick materials will, however, be subject to approval by the Engineer.

623.03--Construction Requirements.

623.03.1--Equipment. In general, it shall be the Contractor's responsibility to select the proper size and amount of equipment to provide the desired results, but certain basic items shall be provided, as outlined herein. The type of carrier to be used will depend upon the desired installation force, but it shall be equipped with a mandrel or sleeve of minimum cross sectional area not to exceed fourteen square inches which will protect the wick material from tears, cuts and abrasions during installation.

The Contractor shall secure approval of all equipment prior to beginning work and any equipment found unsatisfactory shall be promptly replaced or supplemented. All equipment approved for use shall be on a trial basis. If the equipment proves unsatisfactory after a short test section, it shall be removed, replaced or supplemented as deemed necessary to accomplish the desired results.

623.03.2--Installation. At least two weeks prior to the installation of the drainage wicks, the Contractor shall submit details of the sequence and method of installation to the Engineer for review and approval. Approval by the Engineer of the sequence and method of installation shall not necessarily constitute acceptance for the duration of the project. If, at any time, the Engineer considers that the method of installation does not produce a satisfactory drainage wick, the Contractor shall alter the installation method and/or equipment as necessary to comply with these specifications.

The Contractor will be permitted to use augers or other approved methods to loosen stiff upper soils prior to the installation of the drainage wicks. These holes shall have a

maximum diameter just large enough to permit the mandrel or sleeve carrying the wick and wick anchorage to penetrate the embankment and shall extend not more than two feet into the underlying highly compressible soil.

The drainage wick shall be installed at the designated locations using a mandrel or sleeve that completely encloses the drainage wick, thereby protecting it from tears, cuts and abrasions during installation. The mandrel, with the wick inside, shall be forced vertically into the ground to an elevation specified on the plans or directed by the Engineer. The mandrel shall be retracted leaving the wick in place to function as a vertical drain. The wick shall be cut neatly at its upper end with an eight-inch length of wick material protruding above the existing embankment surface.

The equipment shall be carefully checked for plumbness prior to advancing each wick and must not deviate more than one inch per foot from the vertical. Wicks that are out of their proper location by more than six inches, damaged in construction or improperly completed shall be rejected by the Engineer, and no compensation will be allowed for said rejected wicks.

The Contractor shall provide a suitable means of making a linear determination of the depth of the drainage wick at any given time and of the quantity of wick material used at each vertical drain location.

The Contractor shall observe precautions necessary for protection of instrumentation devices and shall replace at no additional cost to the State any equipment that is damaged or becomes unreliable as a result of the Contractor's operations.

Embankment or surcharge to be placed over an area in which drainage wicks are installed shall be allowed to settle the period of time as specified on the plans. In the case of bridge approach embankment fills, no end bent piling may be driven until the specified waiting period has elapsed. The waiting period begins when the total embankment and/or surcharge has been constructed to grade.

If no settlement monitoring devices are specified on the plans, the Contractor may propose to provide, install and maintain subsidence/settlement plates and essential appurtenances for the Engineer to measure the amount of settlement that occurs. If the data taken from these settlement plates show that the amount of settlement is sufficient, or that the rate of settlement has declined to the point that little additional settlement will occur during the specified waiting period, the Contractor will be relieved of the total waiting period requirement. In the case of bridge approach embankment fills, the end bent piling may then be driven without further delay. The settlement measuring devices shall be approved by the Engineer.

623.04--Method of Measurement. Drainage wicks will be measured by the linear foot for the full length of drainage wicks, complete and in place. No separate measure for payment will be made for loosening of stiff upper soils by augering or other approved methods.

623.05--Basis of Payment. Drainage wicks, measured as prescribed above, will be paid for at the contract unit price per linear foot, which price shall be full compensation for all drilling of holes, furnishing all materials, installation of drainage wicks and for all labor, equipment, tools and incidentals necessary to complete the work.

Payment will be made under:

623-A: Drainage Wicks

- per linear foot

SECTION 625 - PAINTED TRAFFIC MARKINGS

625.01--Description. This work consists of furnishing materials and applying reflectorized painted traffic markings and high build painted traffic markings in reasonably close conformity with these specifications and the details shown on the plans or established.

625.02--Materials. Paint shall be the color specified and shall meet the applicable requirements of Section 710.

Application of permanent painted traffic markings shall require Class B (High-Visibility) glass beads. Otherwise, Class A (Standard) glass beads shall be required. Glass beads shall meet the requirements of Subsection 720.01.

Blue - ADA marking material shall meet the requirements of Section 710 with the exception that the color shall be Blue - ADA.

625.03--Construction Requirements.

625.03.1--Equipment. All paint shall be applied by approved mechanical equipment providing constant agitation of paint, traveling at controlled speeds, with one or more paint "guns" synchronized to begin and cut off paint flow automatically for skip lines, and subject to manual control for continuous lines of varying length. The machine, or a separate machine, shall be equipped with a glass bead dispenser adjusted and so synchronized with the paint applicator as to distribute the beads uniformly on the painted lines within 10 seconds. Calibration charts and devices for measurement of tanks shall be provided by the Contractor for determining the quantity being applied.

All painting equipment and operations shall be under the control of an experienced technician thoroughly familiar with the equipment, materials, and marking layouts.

625.03.2--Preparation of Surface. All areas to be painted shall be thoroughly cleaned. Cleaning may be done by hand brooms, rotary brooms, air blast, scrapers, or whatever combination of equipment is necessary to clean the pavement thoroughly without damage to the surface. Before edge striping, particular care shall be taken to remove all vegetation, loose soil, and the like from the area to be painted. Should other methods fail, the surface shall be wetted with a water jet and scrubbed as necessary to dislodge all foreign material. After washing, the surface shall be allowed to dry thoroughly, and all films of dried mud apparent after surface drying shall be removed before application of paint. Painting shall follow as closely as practicable after the surface has been cleaned and dried, but no paint shall be applied until the surface has been inspected and permission given to proceed. The cost for preparing the surface shall be included in the contract unit prices for the marking items.

Upon request, the Engineer will establish control points for markings, by type and color,

at necessary intervals not to exceed 600 feet. The Contractor shall preserve and apply markings in conformity with control points established.

625.03.3--Application. The paint shall be applied when the ambient temperature is no less than 50°F, the pavement surface is properly prepared and the temperature of the pavement surface is no less than 50°F.

For four-inch temporary traffic stripe, paint and Class A glass beads shall be uniformly applied at the rate of not less than one gallon of paint and six pounds of beads per 264 linear feet of four-inch stripe. For six-inch permanent traffic stripe, paint and Class B glass beads shall be uniformly applied at the rate of not less than one gallon of paint and twelve pounds of beads per 176 linear feet of six-inch stripe. For six-inch permanent high build traffic stripe, paint and Class B glass beads shall be uniformly applied at the rate of not less than one gallon of paint and twelve pounds of beads per 140 linear feet of six-inch stripe.

The length and width of lines shall be within a tolerance of plus or minus three inches and plus or minus 1/8 inch, respectively. For skip markings, the tolerance for intervals shall not exceed the line length tolerance.

Markings applied at less than minimum material rates, deviating from true alignment by more than one inch in 50 feet, exceeding stipulated length and width tolerances, and showing light spots, faulty distribution of beads, smears, or other deficiencies or irregularities shall be removed and replaced. Removal methods shall be in accordance with Subsection 619.03.2.

625.03.4--Protection. The newly painted markings shall be protected so that, insofar as possible, paint will not be picked up by the tires of passing vehicles. Warning signs shall be placed at the beginning of a wet line and at points well in advance of the marking equipment. For the benefit of the Contractor, small flags or other similarly effective small objects may be placed near freshly applied lines at frequent intervals to reduce crossings by traffic. Damaged portions of stripes shall be effaced and replaced by the Contractor at no additional cost to the State.

Operations shall be conducted so that traffic can move without undue hindrance. When public traffic is being maintained, warning signs at the starting end shall be moved forward as sections of stripe dry sufficiently to prevent pick-up under traffic. Reference is made to Subsection 710.02.2.2 for the particular paint involved.

625.03.5--Detail Traffic Stripe. Detail traffic stripe shall be those short stripes, exclusive of lane and edge striping of the main facility, at exit and entrance ramps, turnouts, turn bays, and other locations indicated on the plans. When shown on the plans or directed by the Engineer, detail stripe of the color, width, and length shall be placed in accordance with the provisions and requirements of this section.

625.03.6--Legend. Legend shall be applied by the use of templates cut to the dimensions shown on the plans, or by other methods approved by the Engineer that will provide a clean cut, uniform, and workmanlike appearance. All other requirements for legend shall be in accordance with the applicable materials and construction requirements of this section.

Legend that fails to have a uniform, satisfactory appearance either by day or by night shall be corrected by the Contractor or removed and replaced at no additional cost to the State.

625.04--Method of Measurement. Painted traffic markings, of the type specified, will be measured by the linear foot, square foot, or mile, from end-to-end of individual stripes.

In the case of skip lines the measurement will include skips. The length used to measure centerline, lane lines and edge stripes will be the horizontal length computed along the stationed control line.

Detail traffic stripe will be measured by the linear foot from end-to-end of individual stripes. Measurement will be made along the surface of each stripe and will exclude nominal skip intervals where specified. Stripes more than six inches in width will be converted to equivalent lengths of six-inch stripe.

Legend, which includes railroad markings, pedestrian crosswalks and stop lines, will be measured by the square foot or linear foot. Pay areas of individual letters and symbols will usually be shown on the plans and measured by the square foot. Transverse railroad bands, pedestrian crosswalks and stop lines will generally be measured by the linear foot, in which case, stripes more than six inches in width will be converted to equivalent lengths of six-inch widths.

625.05--Basis of Payment. Painted traffic markings will be paid for at the contract unit price per mile, linear foot, or square foot as applicable, which price shall be full compensation for completing the work.

Payment will be made under:

625-A: Traffic Stripe, Skip White *	- per linear foot or mile
625-B: Traffic Stripe, Skip Yellow *	- per linear foot or mile
625-C: Traffic Stripe, Continuous White *	- per linear foot or mile
625-D: Traffic Stripe, Continuous Yellow *	- per linear foot or mile
625-E: Detail Traffic Stripe * **	- per linear foot
625-F: Legend * **	- per square foot or linear foot

* Indicate High Build if applicable

** Indicate Blue - ADA if applicable

SECTION 626 - THERMOPLASTIC TRAFFIC MARKINGS

626.01--Description. This work consists of furnishing materials and placing thermoplastic pavement markings of the type specified in reasonably close conformity with these specifications and the details shown on the plans or established.

All pavement marking material, excluding edge lines over rumble strips, shall be applied using the extrusion/ribbon method. Edge lines placed over rumble strips shall be applied using the atomization/spray method.

Cold plastic traffic markings may be used in lieu of hot applied thermoplastic markings. Substitution will only be allowed for pay items 626-A through H. Substituted cold plastic markings shall be of the same color and width as that required for the hot applied stripe. Unless otherwise specified, the markings, whether hot applied or cold plastic, shall be of the same type of material for the entire project. Material and construction requirements for substituted cold plastic traffic markings shall meet the requirements of Section 628 of the Standard Specifications. The layout and spacing for substituted cold plastic traffic markings will remain as shown in the plans, or in the contract documents, for hot applied thermoplastic markings. Measurement of substituted cold plastic traffic markings shall be made in accordance with Section 628 of the Standard Specifications. Payment for substituted cold plastic traffic markings shall be made at the unit price for the appropriate hot applied thermoplastic marking.

626.02--Materials. The Department reserves the right to perform additional testing of thermoplastic traffic marking materials at any time. Upon request of the State Materials Engineer, samples of the thermoplastic compound, glass beads and epoxy resin shall be furnished.

Blue - ADA thermoplastic marking material shall meet the requirements of Subsection 720.02 with the exception that the color shall be blue-ADA. In lieu of the above material requirements, the Contractor may use hot applied thermoplastic materials meeting the satisfaction of the Engineer.

626.02.1--Thermoplastic Material. Thermoplastic material shall meet the requirements of Subsection 720.02, except an alkyd resin shall be used in the formulation when used in construction of stop lines, crosswalks, and legends.

626.02.2--Glass Beads. Glass beads shall meet the requirements of Subsection 720.01. Unless otherwise noted, Class A glass beads shall be used.

626.03--Construction Requirements.

626.03.1--Thermoplastic Traffic Stripe.

626.03.1.1--Equipment. Equipment for hot application shall be of sufficient size and stability to ensure smooth, uniform, properly aligned markings of the dimensions specified.

The application equipment shall be capable of automatic placement of intermittent and continuous line patterns in single or double line applications simultaneously. The intermittent timer mechanism shall provide a variable ratio of materials applied and variable cycle length such that accurate placement of new patterns, or replacement of existing patterns can be achieved.

When edge lines are placed over rumble strips, the equipment must be able to apply the marking material using the atomization/spray method instead of extrusion/ribbon method. To ensure the proper alignment of the rumble stripes, the Contractor will be required to place a layout line to be followed during installation of the edge lines over the rumble strips.

The equipment shall also be capable of applying the top dressing of glass beads in a manner

that firmly embeds them into the surface of the thermoplastic material for at least one half of the diameter of the larger gradation sizes of the beads. The dispensing equipment shall be equipped with an automatic cut-off control for the application of the beads that is synchronized with the cut-off of the thermoplastic material.

626.03.1.2--Construction Details. Application of thermoplastic material shall be made only in periods of dry weather and when the temperature of the pavement surface is at least 55°F. The pavement shall be surface dry, to the satisfaction of the Engineer, before application will be permitted. The application temperature of the thermoplastic material shall be between 400° and 450°F.

Upon request, the Engineer will establish the control points for markings at necessary intervals not to exceed 600 feet on tangents and more often on curves. All additional work necessary to establish intermediate control points shall be performed by the Contractor. On curves, unsightly variations from the normal curvature will not be permitted unless specifically shown on the plans or ordered by the Engineer.

Immediately before application, the areas to receive markings shall be cleaned thoroughly in accordance with Subsection 625.03.2. On areas of pavement cured with compound, the membrane shall be removed completely by shot blasting, sand blasting or other approved method.

Unless otherwise directed by the Engineer, traffic stripes that are coincidental with the thermoplastic stripe shall be removed prior to placement of the thermoplastic material, except that temporary paint stripe may be left in place when satisfactorily placed in the proper location. Any temporary stripe not covered shall be removed. Payment for removal of stripe, except temporary stripe, will be made under Section 202.

When thermoplastic material is to be applied to concrete pavements or bridge surfaces, a binder-sealer of the type and amount recommended by the manufacturer of the thermoplastic material shall be applied prior to placement of the thermoplastic material. On other pavement surfaces, a binder-sealer shall be applied under those conditions recommended by the manufacturer of the thermoplastic material.

The thickness of the thermoplastic material, when measured above the surface plane of the pavement, shall be within tolerance of the specified thickness. Unless otherwise specified in the plans or contract documents, the thickness shall be 90 mils for edge lines, center lines, lane lines, barrier lines and detail stripe including gore markings, and 120 mils for crosswalks, stop lines, and railroad, word and symbol markings. The measured thickness at the center of the line shall be no less than the specified thickness with the edge of the line not thinner than 75% of the specified center thickness and will be checked at intervals of one mile or less as directed by the Engineer.

Any thermoplastic traffic marking less than the required thickness shall be corrected by overlaying with an additional application of thermoplastic material. Any such required overlay will be no less than 30 mils. Although a tolerance of 25 percent from center to edge is allowed, a consistent underrun of any amount in thickness will not be acceptable.

Additional beads by the drop-on method shall be applied at a rate of not less than three pounds of beads per 100 feet of six-inch stripe. When double drop thermoplastic stripe is

called for in the contract, additional beads by the drop-on method shall be applied as follows:

- Class A glass beads at a rate of not less than three pounds of beads per 100 feet of six-inch stripe. Class B glass beads at a rate of not less than three pounds of beads per 100 feet of six-inch stripe.
- The Class B glass beads shall be applied to the newly placed stripe first, followed by the application of the Class A glass beads.

All newly applied thermoplastic material shall be protected from traffic until the material is sufficiently dry so as not to sustain damage from vehicle tires. Any material so damaged, marred or picked up by traffic shall be repaired, and the thermoplastic material tracked onto the pavement shall be removed.

The length and width of lines shall be within a tolerance of plus or minus three inches and plus or minus 1/8 inch, respectively. For skip markings, the tolerance for intervals shall not exceed the line length tolerance.

626.04--Method of Measurement. Thermoplastic stripe completed in accordance with the plans and specifications will be measured by the mile or by the linear foot, as indicated, from end-to-end of individual stripes. In the case of skip lines the measurement will include skips. The length used to measure centerline, lane lines and edge stripes will be the horizontal length computed along the stationed control line.

Detail traffic stripe will be measured by the linear foot from end-to-end of individual stripes. Measurements will be made along the surface of each stripe and will exclude skip intervals where skips are specified. Stripes more than six inches in width will be converted to equivalent lengths of six-inch stripe.

Legend, which is to include railroad markings, pedestrian crosswalks and stop lines, will be measured by the square foot or linear foot. Pay areas of individual letters and symbols will usually be shown on the plans and measured by the square foot. Transverse railroad bands, pedestrian crosswalks and stop lines will generally be measured by the linear foot, in which case, stripes more than six inches in width will be converted to equivalent lengths of six-inch widths.

626.05--Basis of Payment. Thermoplastic traffic markings will be paid for at the contract unit price per mile, linear foot, or square foot, as applicable, which shall be full compensation for completing the work.

Payment will be made under:

626-A: 6" Thermoplastic * Traffic Stripe, Skip White	- per linear foot or mile
626-B: 6" Thermoplastic * Traffic Stripe, Continuous White	- per linear foot or mile
626-C: 6" Thermoplastic * Edge Stripe, Continuous White	- per linear foot or mile
626-D: 6" Thermoplastic * Traffic Stripe, Skip Yellow	- per linear foot or mile
626-E: 6" Thermoplastic * Traffic Stripe, Continuous Yellow	- per linear foot or mile

626-F: 6" Thermoplastic * Edge Stripe, Continuous Yellow - per linear foot or mile

626-G: Thermoplastic * Detail Stripe, Color ** - per linear foot

626-H: Thermoplastic * Legend, Color ** - per linear foot or square foot

* Indicate Double Drop if applicable

** Indicate Blue - ADA if applicable

SECTION 627 - RAISED PAVEMENT MARKERS

627.01--Description. This work consists of furnishing and placing pavement markers of the types, colors, shapes, and dimensions specified and in reasonably close conformity with the location, lines, and details shown on the plans or as directed by the Engineer.

627.02--Materials. Pavement and jiggle markers of the types specified shall conform to the applicable requirements of Subsection 720.03 and shall be listed on the Department's APL.

Type B through G High Performance reflective markers shall be listed on the Department's APL for high performance raised pavement markers.

The bituminous adhesive for pavement markers shall meet the requirements of Subsection 720.03.7.

627.03--Construction Requirements.

627.03.1--General. Unless waived by the State Construction Engineer on the basis of known performance qualifications, the Contractor or approved Subcontractor shall certify to the Engineer that sufficient experience has been acquired in the placement of the required markers, or the Contractor or approved Subcontractor shall require the manufacturer of the markers to have a qualified technical representative on or immediately available to the project during the application of the markers to assist the Contractor's personnel in the proper application of the adhesive and markers and to render technical assistance to the Engineer as may be deemed desirable.

Any such waiver shall be subject to the conditions set forth in the waiver.

627.03.2--Construction Details. The markers shall be installed when the relative humidity of the air is 80% or less, the pavement surface is dry and the temperature of the pavement surface is no less than 50°F. Other pavement marking materials, such as thermoplastic, cold plastic and paint, shall be placed prior to installation of markers.

The portion of the highway surface to which the marker is to be bonded shall be cleaned so as to be free of dirt, curing compound, grease, oil, moisture, loose or unsound layers, paint and any other material which would adversely affect the bond of the adhesive.

The bituminous adhesive shall be melted and heated in either thermostatically controlled double boiler type units utilizing heat transfer oil or thermostatically controlled electric

heating pots. Direct flame melting units shall not be used. The melter/applicator unit shall be suited for both melting and pumping application through heated applicator hoses.

The adhesive shall be heated to between 375°F and 425°F and applied directly to the pavement surface from the melter/applicator by either pumping or pouring. It is important that application temperature be maintained between 375°F and 425°F as lower temperatures may result in decreased adhesion while higher temperatures may damage the adhesive.

The adhesive should be applied in a puddle approximately two-thirds to three-fourths the diameter of the marker. Markers should be applied to the adhesive within 10 seconds to assure bonding. The marker shall be placed in position by applying downward pressure until the marker is firmly seated with the required adhesive thickness and squeeze out. Excessive adhesive squeeze out shall be removed from the pavement and adhesive on the exposed surfaces of the markers shall be immediately removed. Soft rags moistened with mineral spirits conforming to Federal Specification TT-T-291 or kerosene may be used if necessary, to remove adhesive from exposed faces of pavement markers. No other solvent shall be used.

All markers shall be installed in a uniform line, with controls established by the Engineer. The Engineer will establish controls for each line of markers by setting control points at not less than approximately 600-foot intervals on tangents and 50-foot intervals on curves. All additional work necessary to establish intermediate control points and individual marker points shall be performed by the Contractor, including smoothing out minor irregularities in any line established by the Engineer. On curves, the line of markers on lane lines and edge lines shall follow the normal curvature of the curve and placement on chords or other variations from the normal curvature will not be permitted, unless specifically shown on the plans or ordered by the Engineer.

Reflective markers shall be installed in such a manner that the reflective face of the marker is perpendicular to a line parallel to the roadway centerline. No markers shall be installed over longitudinal or transverse joints of the pavement surface.

The marker shall be protected against impact until the adhesive has hardened. The Engineer shall be the judge as to the minimum time necessary to cure the adhesive for sufficient set to bear traffic.

The adhesive may be reheated and reused. However, the pot life at application temperatures shall not be exceeded.

Clean-out of equipment and tanks may be performed using petroleum solvents such as diesel fuel or similar materials. CAUTION: Be sure that all heating is off before cleaning operations are begun. All solvent must be removed from the equipment tanks and lines before the next use of the melter.

627.04--Method of Measurement. Raised pavement markers of the type specified will be measured per each as determined from actual count in place.

627.05--Basis of Payment. Raised pavement markers of the type specified will be paid for at the respective contract unit price per each, which shall be full compensation for completing the work.

Payment will be made under:

627-A:	Type A, Non-Reflective White Raised Jiggle Markers	- per each
627-AY:	Type AY, Non-Reflective Yellow Raised Jiggle Markers	- per each
627-B:	Two-Way Clear Reflective Raised Markers	- per each
627-C:	Red-Clear Reflective Raised Markers	- per each
627-D:	Two-Way Yellow Reflective Raised Markers	- per each
627-E:	One-Way Clear Reflective Raised Markers	- per each
627-F:	One-Way Yellow Reflective Raised Markers	- per each
627-G:	Yellow-Clear Reflective Raised Markers	- per each
627-H:	Chip Seal Reflective Raised Markers	- per each
627-J:	Two-Way Clear Reflective High Performance Raised Markers	- per each
627-K:	Red-Clear Reflective High Performance Raised Markers	- per each
627-L:	Two-Way Yellow Reflective High Performance Raised Markers	- per each
627-M:	One-Way Clear Reflective High Performance Raised Markers	- per each
627-N:	One-Way Yellow Reflective High Performance Raised Markers	- per each
627-O:	Yellow-Clear Reflective High Performance Raised Markers	- per each
627-P:	Two-Way Blue Reflective High Performance Raised Markers	- per each

SECTION 628 - COLD PLASTIC PAVEMENT MARKINGS

628.01--Description. This work consists of furnishing materials and installing cold plastic pavement markings of the type specified in reasonably close conformity with the plans and these specifications.

Cold plastic traffic markings may be used in lieu of hot applied thermoplastic markings. Substitution will only be allowed for pay items 626-A through H. Substituted cold plastic markings shall be of the same color and width as that required for the hot applied stripe. Unless otherwise specified, the markings, whether hot applied or cold plastic, shall be of the same type of material for the entire project. Material and construction requirements for

substituted cold plastic traffic markings shall meet the requirements of this section of the Standard Specifications. The layout and spacing for substituted cold plastic traffic markings will remain as shown in the plans, or in the contract documents, for hot applied thermoplastic markings. Measurement of substituted cold plastic traffic markings shall be made in accordance with this subsection of the Standard Specifications. Payment for substituted cold plastic traffic markings shall be made at the unit price bid for the appropriate hot applied thermoplastic marking.

628.02--Materials. Cold plastic marking material shall meet the requirements of Subsection 720.04. High performance cold plastic marking material shall meet the requirements of Subsection 720.07.

628.03--Construction Requirements.

628.03.1--Equipment. The material manufacturer shall furnish a mechanical applicator for the application of 16-inch wide film. When high performance profile cold plastic pavement markings are used, the manufacturer shall provide application equipment, manual or automatic as necessary for the job requirements. These applicators shall be capable of applying markings to the required alignment and dimensions shown on the plans or in the contract documents. The mechanical applicator shall be provided on location at the time designated and for the duration of the application period. The material manufacturer shall provide technical assistance for operation and maintenance of the mechanical applicator at the discretion of the Engineer.

628.03.2--General. The free-air temperature shall be at least 60°F. The pavement surface shall be dry and clean. All dirt, loose particles of pavement, and other foreign material shall be removed prior to application of the pavement marking material. All longitudinal stripes shall be mechanically applied. Detail stripe and legend may be applied manually. Only butt splices without overlay will be permitted for multiple piece and line type markings. Except for legend, the specified width of the markings shall be made in a single tape application. Where possible the markings shall be placed adjacent to rather than on longitudinal construction joints in the pavement. Placement tolerance will be as set out in Subsection 625.03.3. Markings not meeting these tolerances shall be removed and replaced at the Contractor's expense.

628.03.3--Application. Both mechanical and manual application shall be in accordance with the manufacturer's instructions. A liquid contact shall be used at the rate recommended by the manufacturer for detail stripe and legend symbols. Liquid contact cement shall not be used elsewhere unless specified by the manufacturer. When liquid contact cement is used, the newly placed markings shall be protected from traffic for the period of time recommended by the manufacturer of the cement.

628.04--Method of Measurement. Cold plastic pavement markings will be measured for payment in accordance with Subsection 626.04.

628.05--Basis of Payment. Cold plastic pavement markings will be paid for at the contract unit price per mile, linear foot or square foot, as applicable, which shall be full compensation for completing the work.

Payment will be made under:

628-A: 6" Cold Plastic Traffic Stripe, Skip White	- per linear foot or mile
628-B: 6" Cold Plastic Traffic Stripe, Continuous White	- per linear foot or mile
628-C: 6" Cold Plastic Traffic Stripe, Skip Yellow	- per linear foot or mile
628-D: 6" Cold Plastic Traffic Stripe, Continuous Yellow	- per linear foot or mile
628-E: Cold Plastic Detail Stripe, <u>Color</u>	- per linear foot
628-F: Cold Plastic Legend, White	- per square foot or linear foot
628-G: 6" High Performance Cold Plastic Traffic Stripe, Skip White	- per linear foot or mile
628-H: 6" High Performance Cold Plastic Traffic Stripe, Continuous White	- per linear foot or mile
628-I: 6" High Performance Cold Plastic Traffic Stripe, Skip Yellow	- per linear foot or mile
628-J: 6" High Performance Cold Plastic Traffic Stripe, Continuous Yellow	- per linear foot or mile
628-K: High Performance Cold Plastic Detail Stripe, <u>Color</u>	- per linear foot
628-L: High Performance Cold Plastic Legend, White	- per square foot or linear foot

SECTION 629 - VEHICULAR IMPACT ATTENUATORS

629.01--Description. This work consists of furnishing all materials, components and accessories and installing impact attenuator systems meeting all of the requirements specified on the plans or in the contract documents, and assembled and constructed at the location(s) indicated on the plans or as established by the Engineer.

This work shall also include the installation of median barrier end sections in accordance with the plans, specifications, and the manufacturer's recommendations.

629.02--Materials. Materials used in the construction of the vehicular impact attenuator system shall all be new and shall conform to the applicable requirements of the respective section(s) of Section 700, as may be supplemented by requirements in other contract documents for the particular system installation.

Approved impact attenuator systems shall meet standardized testing defined in NCHRP Report 350 or MASH. In addition, documentation from FHWA must accompany the devices, indicating that the devices meet the appropriate crash test criteria and can be used on the National Highway System (NHS). Prior to installation, the Contractor shall provide two copies of the manufacturer's installation details to the Project Engineer. The Project

Engineer shall keep one copy in project file and provide one copy to District Maintenance Engineer. The installation details shall be engineering drawings, a minimum of 11"x17" in size. Reflective adhesive sheeting with alternating black and yellow stripes (sloping downward at an angle of 45 degrees in the direction traffic is to pass) shall be required on the end of the attenuator section. The type of system installed shall be written on the device with a Permanent Marking Stick or some other means of permanent identification.

The impact attenuators used must be as shown on the Department's APL. Replacement packages shall consist of spare parts of the expected type and number needed to repair one hit for each attenuator unit installed.

629.03--Construction Requirements. The system assembly shall be constructed in accordance with the requirements for the fabrication and construction of the attenuator system as detailed on the plans and in the contract documents. For manufactured products specified, unless otherwise indicated in the contract, the system shall be fabricated and installed in accordance with the manufacturer's recommendation. In such case, the Contractor shall obtain the manufacturer's recommended installation instructions, including erection diagrams, and shall furnish the Engineer with a complete copy of such recommended installations and instructions.

In the fabrication and construction of any vehicular impact attenuator system, sharp edges, projections, and any misfits of fabrication or construction shall be avoided.

Installation of impact attenuators shall be accomplished by experienced workmen in accordance with the recommendations of the manufacturer. As a replacement supply, the Contractor shall furnish a spare parts package. The quantity and materials of this package will be that necessary to repair one hit for each attenuator unit installed. The Contractor shall use these parts to maintain the attenuator until release of maintenance. Upon completion of the work the replacement packages shall become the property of the Contractor.

The median barrier end section and vehicular attenuator back-up wall shall be constructed in accordance with the plans, the manufacturer's recommendations, applicable provisions of Section 615 and other applicable provisions of the Standard Specifications.

629.04--Method of Measurement. Vehicular impact attenuators will be measured as a unit for each complete attenuator installed and accepted. One replacement package shall be included in the bid price for each attenuator.

Median barrier end sections and vehicular attenuator back-up wall will be measured as a unit for each complete and accepted section.

Foundations for attenuators and median barrier end sections are considered parts of the respective units and will not be measured for separate payment.

629.05--Basis of Payment. Vehicular impact attenuators, median barrier end sections and vehicular attenuator back-up wall will be paid for at the contract unit price per each. In the event an additional replacement package is required during the life of the contract, 25% of the lump sum price will be allowed to place the unit back in operation. Payment for the above listed units shall be full compensation for the work and materials required under this Section.

Payment will be made under:

- 629-A: Vehicular Impact Attenuator, Speed Rating - per each
- 629-B: Median Barrier End Section - per each
- 629-C: Vehicular Impact Attenuator Back-up Wall - per each

SECTION 630 - TRAFFIC SIGNS AND DELINEATORS

630.01--Description. This work consists of furnishing and installing delineators, traffic signs, sign supports, framing, and panels in reasonably close conformity with the requirements shown on the plans and set out in these specifications.

The work and materials shall conform to the requirements of the MUTCD, current on the date of receipt of bids, except as modified by these specifications or as shown on the plans.

The Bidder or the Bidder's proposed supplier may be required to show satisfactory evidence of successful experience in fabrication of reflectorized multi-panel highway signs prior to award of the contract. Bidders may also be required to show evidence of successful experience or capability in erection of reflectorized multi-panel highway signs.

630.01.1--Contractor Designed Supports. When specified as Contractor Designed Metal Overhead Sign Supports, the Contractor will be responsible for the design of the metal overhead sign support(s) and overhead sign support(s) on bridges. The design shall meet the latest requirements of the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals.

The Contractor shall submit to the Director of Structures, State Bridge Engineer, a design using steel. The design shall be a rectangular box truss connected at both the top and bottom to the vertical support posts. With the exception of cantilever mounts, overhead support structures shall have two vertical support posts at each end of the truss. Design drawings, calculations and other necessary supporting data shall be submitted as soon as possible after the Pre-Construction Conference. The controlling sign configuration and total area of design sign shall be labeled on the design drawings. The design shall be prepared by a Professional Engineer registered in the State of Mississippi proficient in the design of overhead sign structures.

The Contractor shall provide a detailed cross section at the location of each new sign truss. At the locations where the truss will span existing roadways, the Contractor shall obtain a surveyed cross section extending beyond the limits of the truss. The cross section will show the horizontal dimensions and elevations of ditches, edge of travel lanes, shoulder lines, pavement crown lines, barriers and retaining walls, etc. The truss and signs shall be located on the cross section and shall include both vertical and horizontal dimensions to the finished roadway surface. The overhead sign truss details provided in the plans or documents will not be acceptable as the Contractor's detailed cross section. The cross section information shall be of sufficient accuracy to verify the sign truss dimensions required for each specific location. This information shall be submitted for review with the sign truss shop drawings and calculations.

The Contractor is responsible for designing and constructing modifications to barriers and retaining walls as necessary to carry sign truss loads for sign truss assemblies attached to such structures. Barrier faces must smoothly transition back to the existing barrier section as specified in the plans. All designs and proposed modifications must be stamped by the Contractor's engineer and submitted to the Engineer for review.

Bridge information plans are provided to assist the Contractor's Engineer in designing attachments to bridges. All bridge attachments must be submitted to the Director of Structures, State Bridge Engineer through the Project Engineer for review. Use of chemical adhesive anchors is prohibited. Mechanical anchors are permissible as approved by the Director of Structures, State Bridge Engineer. Mounting holes for sign assemblies attached to prestressed concrete girders shall be placed at locations where the prestressing strands are not damaged by drilling. Mounting sign assemblies to steel girders by welding is prohibited. A limited number of mounting holes may be drilled only in the steel girder webs at locations that do not interfere with existing members such as bolts, stiffeners, and splice plates. Attachments that cause concentrated loads on girder webs will be spread out along the web both vertically and horizontally by use of steel plates so as to not cause distortion in the web. Drilling in steel girder bottom flanges is prohibited.

The design wind speed shall be as shown in the design specifications with a minimum of 90 mph. In addition to the loads required in the design specifications, overhead sign supports shall be designed to support a uniform load of 40 pounds per linear foot applied vertically to the truss to which the signs are attached, extending along the truss across the roadway below from points four feet outside each outer edge of exterior travel lane, unless otherwise specified. Appropriate damping or energy absorbing devices shall be installed in the event that an overhead structure is erected without installation of the permanent sign panels or if the area of permanent sign panels installed is not sufficient to prevent detrimental wind-induced vibration.

The larger of the following sign configurations shall be used in the design of overhead sign support structures:

- 1) The sign dimensions and configuration shown in the contract plans
- 2) Sign Height: 20 feet; Sign Width: Outer Edge of Exterior Travel Lane to Outer Edge of Exterior Travel Lane plus six (6) feet
- 3) Sign Height: 20 feet; Sign Width: Post to Post Clear Spacing minus 60 feet

The sign widths in configurations 2) and 3) should be located symmetrically about the center of the truss.

630.02--Materials. Materials for signs and delineators shall meet the requirements of Section 721.

Although certain particular brands, makes of materials, devices, processes, and/or equipment are named herein for the purpose of establishing minimum acceptable standards, it is neither implied nor intended that those named are to be considered to the exclusion of comparable brands, materials, devices, processes, or equipment.

All warranties, guaranties, and instruction sheets normally furnished by the manufacturer for materials and supplies used in the work shall be delivered to the Engineer prior to final

acceptance of the project.

Material for Contractor designed metal overhead sign supports shall meet the following:

Reinforcing Steel. Reinforcing steel used in reinforced concrete footings shall be in accordance with Subsection 602 and meet the requirements of ASTM A 615, Grade 60.

Anchor Bolts. Material for anchor bolts shall meet the requirements of ASTM A 36. Anchor bolts shall be hot-dipped galvanized in accordance with ASTM A 153, Class C. Threads and nuts for anchor bolts shall be lubricated with a visible dye so that a visual check can be made for proper lubrication prior to installation.

Structural Steel. Material for posts, chords and bracing members shall meet the requirements of ASTM A 501 or ASTM A 53, Grade B. Material for structural shapes, plates, posts and chord caps shall meet the requirements of ASTM A 36. Material for round tapered monotube shall meet the requirements of ASTM A 595, Grade A.

630.02.1--Fabrication of Signs and Sign Panels. Signs shall be fabricated in a properly equipped shop owned and operated by the Contractor or approved Subcontractor or supplier.

630.02.2--Fabrication of Aluminum Extrusions and Sheets. The fabrication of aluminum extrusions and sheets shall generally conform to or be equivalent to the fabrication methods and practices recommended in the handbook of the major producers of aluminum materials and the following specific requirements:

- (a) Materials shall be sawed or milled. Sheets 1/2 inch or less in thickness may be sawed, blanked, sheared, or milled.
- (b) Flame cutting will not be permitted.
- (c) Re-entrant cuts shall be avoided wherever possible. If used, they shall be filleted by drilling prior to cutting.
- (d) Holes in extrusions shall be drilled.
- (e) Holes in sheet aluminum may be drilled to finish size or they may be blanked to finished size provided the diameter of the blanked hole is at least twice the thickness of the metal being blanked.
- (f) Aluminum shall be free of buckles, warp, dents, cockles, burrs, ragged breaks, and defects resulting from fabrication. Cut edges shall be true and smooth. The surface shall be flat.
- (g) Before placing aluminum in contact with steel, the steel surface shall be coated by galvanizing. Aluminum alloys shall not be placed in contact with copper, copper base alloys, lead, or nickel.
- (h) In handling, precautions shall be taken to prevent scratches, gouges, and abrasion.

630.02.3--Preparation of Aluminum for the Application of Reflective Sheeting. Extruded aluminum and flat sheet aluminum sign panels to which reflective sheeting is to be applied shall be prepared as follows:

Preliminary Cleaning. The panel shall be completely submerged in a six percent (6%) solution of an inhibited alkaline cleaner at 160°F to 180°F for three minutes, followed by a thorough rinse with clean, running cold water. A grease solvent such as mineral spirits or naphtha, conforming to ASTM D 235, or trichloroethylene, conforming to ASTM D 4080,

may be used.

Surface Preparation. For flat sheet aluminum, preliminary cleaning shall be followed by a surface treatment with a six to eight percent (6% to 8%) solution of phosphoric acid applied to the surface by immersion or brushing. The solution shall be allowed to remain on the surface for five minutes and then thoroughly rinsed with running cold water followed by hot water tank rinse.

Drying. The panels shall be dried by the use of forced warm air.

Handling. Metal shall not be handled except by device or clean canvas gloves between all cleaning and etching operations and the application of reflective sheeting. There shall be no opportunity for metal to come in contact with grease, oils, or other contaminants prior to painting.

630.02.4--Preparation of Aluminum for Painting. Aluminum that is to be painted shall be cleaned and prepared by a process conforming to ASTM D 1730, Type B Chemical Treatment. Metal shall not be handled except by device or clean canvas gloves between all cleaning and etching operations and the application of paint. There shall be no opportunity for metal to come in contact with greases, oils, or other contaminants prior to painting.

630.02.5--U-Section Posts. Ground mounted U-section posts shown in the plans or referenced in the contract documents may be steel U-section posts or Tubular Type posts meeting the requirements of Subsection 721.02.2. Regardless of whether U-section posts or Tubular Type posts are used, measurement and payment will be under pay item 630-C, Steel U-Section Posts.

630.02.6--Blank.

630.02.7--Reflective Sheeting. Reflective sheeting shall be applied to properly treated base panels with mechanical equipment in a manner specified for by the sheeting manufacturer. Type II adhesive coated sheeting shall be pre-perforated.

Sign faces comprising two or more pieces of panels of reflective sheeting shall be carefully matched for color at the time of sign fabrication to provide uniform appearance and brilliance during both day and night. Alternate, successive width sections of either sheeting or panels must be reversed and consecutive to ensure that corresponding edges of reflective sheeting lie adjacent on finished sign. Non-conformance may result in non-uniform shading and an undesirable contrast between adjacent width of applied sheeting, which will not be acceptable.

At splices, Type I adhesive coated sheeting shall be over-lapped at least 3/16 inch. Type II adhesive coated sheeting may be spliced with an overlap of at least 3/16 inch or butted with a gap not to exceed 1/32 inch. Only butt splices will be permitted with transparent screen processing. Sheeting applied to extruded sections shall extend over top edges and down side legs a minimum of 1/16 inch.

Reflective sheeting splices and sign edges shall be sealed with materials supplied and in the manner specified by the sheeting manufacture.

630.02.8--Removable Copy. Route markers used on structural panels with removable copy shall be made up as standard route markers on flat sheet metal as specified and shall be riveted to the structural panel. These route markers will not be paid for as separate signs but shall be considered as part of the major sign to which they are affixed.

630.02.9--Silk Screening. Where specified on the plans, sign letters, numerals, symbols, and border shall be applied to the sign panel by direct or reverse silk screen method. The letters shall be in accordance with the plans and series letters as set out by "Standard Alphabets for Highway Signs" which can be obtained from FHWA.

Unless otherwise specified, all silk screen legend shall be on silver-white or yellow reflective sheeting background.

Screening shall be accomplished in the manner specified by the sheeting manufacturer. Processing may be accomplished either before or after application of the sheeting to the flat, smooth base panels.

630.02.10--Packing, Storing and Shipping Signs. Signs shall be slip sheeted and packed in such a manner as to ensure their arrival at their destination in undamaged condition. Signs shall be stored on edge in a cool, dry place, and shall not be allowed to become wet during shipment or storage.

630.02.11--Shop Drawings. The Contractor shall submit for the approval of the Engineer scale drawings of all sign faces, showing arrangements and spacing of all letters, numerals, symbols, and border. For each type of sign support to be used with each different type of sign panel, the Contractor shall submit detailed drawings of the proposed method of attaching the sign to the supports on all signs not detailed on the plans.

630.02.12--Welding. Any welding shall conform to the requirements of Subsection 630.03.8. Welding for Contractor designed metal overhead sign supports shall conform to the latest edition of AWS D1.1 for structural steel.

630.03--Construction Requirements.

630.03.1--Construction Stakes. Unless the contract requires construction staking by the Contractor, the Engineer will furnish and set construction stakes for signs and will furnish the Contractor with all required information relating to lines and grades.

The Contractor shall check all leading dimensions and clearances measured from such stakes and thereafter will be responsible for orientation, elevation, offset, and level of all signs so erected.

630.03.2--Sign Positioning. The glossy surface on sign faces may produce specular reflection. Signs shall be positioned to eliminate or minimize specular reflection.

630.03.2.1--Overhead Signs. Unless otherwise directed by the Engineer, signs shall be erected at right angles to the road and so that the sign face is tilted back or is vertical as determined by the approach grade of the roadway or as shown on the plans.

630.03.2.2--Ground-Mounted Signs. Signs shall be erected so that the sign face is truly vertical and at 93 degrees away from the center of the lane that the sign serves and the

direction of travel unless otherwise directed by the Engineer. Where lanes divide and on curves, sign faces shall be oriented so as to be most effective both day and night and to avoid the possibility of specular reflection.

630.03.2.3--Vertical and Horizontal Clearances. All signs shall be installed so as to meet the vertical and horizontal clearances shown on the plans or if not shown the minimum clearance given in the MUTCD shall apply.

630.03.3--Excavation. The Contractor shall perform the excavation required for sign installation to neat lines by suitable means.

630.03.4--Posts. All posts shall be set at the required line and grade. Unless otherwise shown on the plans, all posts except delineator posts shall be set in Class "B" concrete. Any required reinforcing steel will be shown on plans. Exposed concrete shall be finished with a steel float to the slope shown on the plans.

Footings for overhead sign supports shall be Class "B" concrete and shall be in accordance with the required dimensions, alignment, grades, reinforcement, and method of placement shown on the plans.

Treated timber posts shall be set in holes of the specified depth and of sufficient diameter to allow proper tamping and compaction or backfill. The backfill shall be made with the most suitable earth available and shall be tamped until the post is firm and rigid in a vertical position.

Pipes used for posts shall be capped by suitable means to exclude moisture.

630.03.5--Framing. Framing for ground-mounted signs shall be as shown on the plans. Holes may be field punched as permitted by the Engineer. All steel used for framing shall be galvanized.

630.03.6--Erection of Signs. Signs shall be erected in a neat and workmanlike manner.

After installation is complete, signs will be inspected at night by the Engineer. If specular reflection is apparent on a sign, its positioning shall be adjusted by the Contractor to eliminate this condition.

630.03.7--Erection of Delineators. The location of each type of delineators shall be as shown on the plans. The post shall be driven and a driving cap used to protect the curb. Posts shall be driven vertically and driving caps used to protect the posts. Delineator shall be attached to the posts as shown on the plans by means of a huck or cherry tool and aluminum fastener.

630.03.8--Overhead Sign Supports.

630.03.8.1--Fabrication. Metal overhead sign support structures shall be steel. They shall be fabricated as shown on the plans in a properly equipped plant. All welds shall be performed in the shop by certified welders. Welding for steel structures shall conform to the requirements of Subsections 810.03.5 and 810.03.6.

Unless a particular edition of the AASHTO specifications is indicated on the plans, the

edition current at the time of receipt of bids shall be applicable.

Each Contractor-designed metal overhead sign support structure shall be match-marked and assembled in the shop for inspection prior to shipment.

630.03.8.2--Shop Drawings. Shop drawings of the structures shall be submitted for review in accordance with Subsection 810.02.2. They shall show the required vertical camber for the horizontal support and method of fabricating, including welding procedure.

Shop drawings and design calculations for Contractor designed metal overhead sign supports shall be submitted to the Bridge Engineer in triplicate for review prior to fabrication. Shop drawings shall show all members, connections (welds), footings and details necessary for a complete structure. The required truss camber and method of fabricating shall also be shown.

630.03.8.3--Inspection and Testing. Unless waived in writing by the Engineer, inspection of the fabrication will be required. Each structure shall be match marked and assembled in the shop prior to inspection. Steel structures to be galvanized shall be match marked and assembled for inspection prior to galvanizing. Additional inspections for galvanized steel structures may be required before and/or after galvanizing. The Engineer shall be notified at least 24 hours prior to the time that an inspection is scheduled. The structures shall be checked for alignment, sound welds, and general workmanship. Four copies of a certification by the galvanizer that galvanizing meets the appropriate specification shall be furnished to the State Materials Engineer. Mill test reports on material in primary members shall be submitted in accordance with Subsection 810.03.25.

Shop inspection is required for Contractor designed metal overhead sign supports to ensure that fabrication and welding comply with the contract requirements. A commercial testing laboratory retained by the Department will perform the inspection but such inspection does not relieve the fabricator of any responsibility regarding compliance with the contract requirements. A pre-fabrication conference shall be required unless waived by the Bridge Engineer. No fabrication of any structure shall begin until approved drawings and welding procedures have been distributed, the pre-fabrication conference held, and authorization for the work to begin given by the Bridge Engineer.

630.03.9--Removal of In-Place Signs, Markers and Posts. The Contractor shall salvage existing signs, markers, and posts and stockpile them at the locations shown on the plans. Signs and markers shall be removed from posts and stacked on edge with paper separators between units. Posts shall be pulled without being bent and stockpiled off the ground. Care shall be taken with all handling, hauling, and storing to avoid damage. This work shall be incidental to items of the contract, and separate payment will not be allowed.

630.03.10--Bolt Connections for Contractor Designed Metal Overhead Sign Supports. High-strength bolts shall meet the requirements of ASTM A 325, Type I and shall be no larger than one inch (1") in diameter; bolts other than high-strength shall meet the requirements of ASTM A 307, Grade A. Nuts for all bolts shall meet the requirements of ASTM A 563. Nuts for high-strength bolts shall be heavy hex, Grade DH. Nuts for all other bolts shall be hex, Grade A. All nuts shall be lubricated with a visible dye so that a visual check can be made for proper lubrication prior to installation. All washers shall meet the requirements of ASTM F 436. All fasteners (bolts, nuts and washers) shall be galvanized in accordance with ASTM A 153, Class C. All connections using high strength

bolts require Direct Tension Indicators (DTIs). DTIs shall meet the requirements of ASTM F 959 and shall be mechanically galvanized in accordance with ASTM B 695, Class 50 coating.

630.03.11--Galvanizing for Contractor Designed Metal Overhead Sign Supports.

Steel assemblies shall be galvanized after fabrication in accordance with the latest requirements of ASTM A 123. Damage to the galvanized coating shall be repaired subsequent to erection by a method approved by the Bridge Engineer. Holes may be drilled in structural steel members as needed for venting during galvanizing. Such holes shall be in accordance with the following requirements:

- (a) No holes shall be greater than eleven sixteenths inch (11/16") in diameter;
- (b) holes for bracing members of columns and trusses may be drilled in either the wall of the bracing member or the wall of the column post or truss chord at each end, except for trusses;
- (c) No holes shall be drilled in the wall of vertical diagonals and no holes shall be drilled in wall of chords at either end of horizontal struts, horizontal diagonals or interior diagonals;
- (d) Holes drilled in the wall of vertical struts for trusses shall face toward the center of the truss;
- (e) Holes drilled in the wall of all other bracing members shall be located so that they face downward when the structures are erected;
- (f) When necessary, one hole for a member may face upward if there is an opposite hole facing downward;
- (g) No bracing member shall have more than one hole at each end; and
- (h) Holes shall be drilled and shall be located at a distance not to exceed the outside diameter of the member from the end of the member.

630.03.12--Final Cleaning Up. The Contractor shall remove all rejected and unused materials and debris from the right-of-way. Shoulders and slopes shall be restored to their original condition. Excess excavation shall be disposed of off the right-of-way at the Contractor's expense unless otherwise directed by the Engineer. Before final inspection, the Contractor shall perform such touching up of paint finishes, cleaning of exposed sign and support surfaces, and other cleaning up as may be necessary to ensure the effectiveness and neat appearance of the work.

630.04--Method of Measurement. Standard sheet aluminum signs will be measured by the square foot of sign face for each specified thickness.

Extruded aluminum signs, including removable copy, will be measured by the square foot of sign face.

Built-up steel panel signs, including removable copy, will be measured by the square foot of sign face. Structural steel used in building up the sign panel system will not be measured for separate payment.

In determining the area of sign faces, no deduction will be made for corner radii or mounting holes. The area of octagonal signs, U.S. shields, and Interstate shields will be computed as the area of the circumscribing square or rectangle. The area of the triangular signs will be computed as the area of the triangle.

Steel U-section posts, square tube posts, and square tube post inner sleeve will be measured by the linear foot of each specified size.

Timber posts will be measured by the unit.

Structural steel beams for vertical sign supports will be measured by the linear foot of each specified size.

Structural steel angles and bars, or channels, used for lateral bracing of vertical sign supports, will be measured by the pound.

Steel pipe posts will be measured by the linear foot of each specified size.

Concrete for overhead sign support foundations will not be measured for separate payment. Such costs shall be included in the cost of the overhead sign assembly. Concrete for roadside signs will be measured in cubic yards in accordance with Section 601. In computing the volume, the neat dimensions shown on the plans will be used except for variations as may be ordered by the Engineer.

Reinforcement, when called for on the plans, will be measured in pounds in accordance with Section 602.

Excavation will not be measured for separate payment and the cost thereof shall be considered incidental to and included in the unit prices for footings, posts, etc.

Paint and painting will not be measured for separate payment and the cost thereof shall be included in unit prices for items painted.

Metal overhead sign support assemblies will be measured by the unit.

Delineators and object markers will be measured by the unit, including post, fastener, and single or multiple units as specified.

630.05--Basis of Payment. Signing items, measured as prescribed above, will be paid for at the respective contract unit or lump sum price, which price shall be full compensation for completing the work.

Payment will be made under:

630-A: Standard Roadside Signs, <u>Description</u>	- per square foot
630-B: Interstate Directional Signs, <u>Description</u>	- per square foot
630-C: * Posts, <u>Weight</u>	- per linear foot
630-C1: Square Post Inner Sleeve	- per linear foot
630-D: Structural Steel Beams, <u>Description</u>	- per linear foot
630-E: Structural Steel Angles and Bars, <u>Description</u>	- per pound

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630-F: Delineators, <u>Mounting</u> , <u>Description</u>	- per each
630-G: Type ____ Object Markers, <u>Description</u> , <u>Mounting</u> , <u>Color</u>	- per each
630-H: Treated Timber Posts, <u>Size and Length</u>	- per each
630-I: Metal Overhead Sign Supports, Assembly No. ____, <u>**</u>	- lump sum
630-J: Overhead Sign Supported on Bridge, Assembly No. ____, <u>**</u>	- lump sum
630-K: Welded & Seamless Steel Pipe Posts, <u>Size</u>	- per linear foot

* Specify Steel U-Section or Square Tube
** Indicate when the sign is "Contractor Designed"

SECTION 631 – TRAFFIC SIGNAL SYSTEMS - GENERAL

631.01--Description. This section together with the pay item sections covering individual components and the plans are intended to describe and include materials and work necessary for completion of traffic signal installations and modifications. All work, materials, or methods which may be necessary for completion of the traffic signal system which are not specifically mentioned in these specifications or on the plans shall be furnished as incidental to the pay items of the contract and the cost included in the respective contract prices bid.

631.01.1--Scope of Work. Work shall consist of furnishing and installing, modifying, or removing all components, equipment, and incidentals necessary for a fully functioning, tested and approved traffic control signal system, including communications connections as applicable in the plans.

Where there is an existing system involved, the Contractor shall reuse, take ownership, immediately remove, or stockpile materials from the project site, as indicated in the plans or contract documents. Stockpiled materials shall be safely stored at a specified location. Stockpile locations shall be determined and approved by the Engineer. Any existing materials or items not addressed for payment under pay items for Removal of Obstructions or Removal of Existing Traffic Signal Equipment shall be considered incidental and their reuse or removal cost included in other respective contract prices bid.

All installations shall be carried out in strict conformity with all requirements stated or implied on the plans and in the specifications. Upon completion the signal installation shall present a neat and finished appearance. All work and materials shall be subject to inspection at all times.

The locations shown on plans, unless otherwise noted, are approximated and based on the best available information at the time of design. Slight alterations or relocation of items may be required based on site conditions or as directed by the Engineer.

631.02--Materials.

631.02.1--General. All provided materials shall be of high quality and quality workmanship. All materials shall be new, unused, and in strict accordance with the specifications and contract documents. All units of any one item used, shall be of the same make and model.

Any reference to a specific manufacturer's product is intended to indicate the quality of acceptable materials. Any such reference is in no way restrictive of any product that meets requirements of the applicable specifications, plans, and contract documents.

The Contractor may propose the alternate use of other manufacturer's materials on a basis of equality for the purpose intended as long as these proposed alternate materials are fully compliant with the contract documents, plans, and specifications. The allowance of any alternate materials will be subject to approval by the Engineer.

631.02.2--Equipment List and Engineering Data. The Contractor shall submit to the Engineer five (5) printed copies and an electronic copy of the list of materials which the Contractor proposes to install. The list shall identify the manufacturer and contain the quantity, model, and identifying descriptions of each item. Adequate engineering data, essential shop drawings, and schematic diagrams shall be provided for review. This list and accompanying engineer data and supplemental drawings will hereby be referred to as the "submittal."

The submittal shall be delivered within thirty (30) days of contract execution. The Engineer shall report findings to the Contractor within fifteen (15) days of submittal receipt. If additional information is requested by the Engineer, the Contractor shall provide the additional information within seven (7) days of the request. The Engineer shall report findings concerning the additional information to the Contractor within fifteen (15) days.

If during the review process, the Engineer requires the Contractor to submit product samples, the product samples shall remain the property of the Contractor only if requested in writing at the time of submission. At the completion of review, the article will be returned to the Contractor without cost to the State. A product sample request shall be considered as a request for additional information.

The Engineer will notify the Contractor in writing of the submittal review findings. Any approval given will be an indication that the Engineer has considered that the materials or products, if manufactured and furnished in accordance with the data submitted, could be certified by the manufacturer in accordance with the provisions and requirements of Subsection 106.04, and any approval given shall be subject to such subsection and other applicable provisions of the contract.

631.02.3--Regulations and Code. All work and materials shall be performed in strict accordance with applicable requirements of Local Codes, ASTM, ICEA, IMSA, ITE, NEC, NEMA, UL and the local electric utility. Abbreviations are contained in Subsection 101.01. When terms are not clearly defined herein, their meaning shall be understood to be that defined or used by the industry or trade. Clarifications should be made in writing to the Engineer prior to the work being performed.

After January 1, 2018, the Contractor shall have at least one certified IMSA Traffic Signal Construction Technician Level II employee overseeing the construction of all traffic signal work.

631.02.4--Operations. The Contractor shall furnish all labor, tools, equipment, means to power equipment, barriers, and related items required or necessary to perform the work under the contract in an expeditious, careful, and safe manner.

The Contractor shall conduct the work at all times in such a manner as to ensure the least possible inconvenience to traveling public, and to property owners on the streets, alleys, and other public places where the construction will take place.

If underground utilities are in place or are encountered during excavation or other operations, all necessary protection from injury and damage thereof shall be provided by the Contractor. In order to facilitate such protection, it shall be the responsibility of the Contractor to solicit the assistance and cooperation of the owners of any utility or structure that may be in conflict with any of the Contractor's operations, and the Contractor shall fully cooperate with such utility in accordance with the provisions and requirements of Subsection 107.18. The Contractor shall save the Department harmless from any additional cost incurred because of injury or damage by Contractor operations to any utility or structure. The repairs of any utility must be satisfactory to the owners, and insofar as intended function, physical condition and presence of the repaired utility shall be satisfactory to the Engineer.

Unless otherwise specified in the contract, for any traffic signal system where an existing system is used to provide control of the movement of the traffic, the following shall be applicable:

- (a) All existing traffic control devices affected by the contract shall remain in full operation until all elements of the traffic signal system required for that contract are complete, inspected and tested for proper functionality. Upon initial inspection and acceptance testing of the complete traffic signal installation, the Contractor shall request the start of the 30 day burn-in period to commence as outlined in Subsection 631.03.4 of this specification. Any noted deficiencies found within that 30 day period shall be corrected to the satisfaction of the Engineer. Final acceptance will not be made until each traffic signal installation has operated satisfactorily for at least 30 consecutive days. The 30 day burn-in period must commence within the Contract Time, and before substantial completion of the project is granted. With approval of the Engineer, traffic control devices at individual sites within the system may be activated if all operation requirements listed above are met for that site. Activation of individual sites shall not be considered if interference with other elements of the system or operations may occur;
- (b) No part of the existing traffic signal system shall be deactivated, altered, dismantled, or removed without the confirmed permission of the Engineer. If it is necessary for the Contractor to modify a component of existing signal facilities because of construction operations, the Contractor shall first obtain approval of the Engineer for proposed procedures before making adjustments and relocations as made necessary by the required construction;
- (c) Until such time as the existing traffic signal site or facilities within a project are modified in any way by the Contractor, the Department or the local agency will retain responsibility for ongoing operation and maintenance of that existing traffic signal facilities. At all times during the life of a project, the Department or the local agency will furnish electric power for operation of the existing facilities.

Prior to any modification at any existing traffic signal installation, the Contractor shall inform the Engineer of any signal equipment in conflict with the work so that the Contractor will not be held responsible for its repair. At such time the Contractor has received approval per paragraph (b) above and begins modifying an existing traffic signal installation in any way, the responsibility for maintenance and repair of that modified signal and all other traffic signal installations located within the project limits shall become that of the Contractor.

When notified of needed traffic signal repair, the Contractor shall, within one (1) hour, contact the Engineer with the details of their proposed response to the notification. The Contractor shall remain in contact with the Engineer until necessary repairs have been made. The Engineer in conjunction with the Traffic Engineering Division may waive the required one (1) hour response on a case by case basis, and at the request of the Contractor.

At the start of work, the Contractor shall provide the Engineer with the names and telephone numbers of those responsible for maintenance of the existing and new signals. The Contractor shall have at least one person who can be contacted 24 hours a day, and seven (7) days per week;

- (d) Where damage is caused by the Contractor's operations, the Contractor shall at no additional cost to the Department or local agency repair or replace damaged facilities promptly in accordance with these specifications. Should the Contractor fail to perform the required repairs or replacements immediately, MDOT or the local agency may, at its discretion, perform the repairs or replacements and such cost of repairs or replacements will be deducted from moneys due or to become due to the Contractor;
- (e) It shall be the Contractor's responsibility at the time of installation to fully cover all heads and signs to the satisfaction of the Engineer. All covers shall be of material and function specifically designed for covering traffic signal heads, including all integrated straps and security restraints to ensure covers stay in place. The signal head covers shall be an outdoor-hardened material that contrasts with the color of the head that clearly designates the signal is not in "stop and go" mode. The signal head covers shall be approved by the Engineer prior to placement. Garbage bags, plywood or any other materials not specifically designed for covering traffic signal heads shall not be allowed. The signal head covers shall remain in place until the Engineer gives permission for uncovering in advance of pre-turn on inspection procedures;
- (f) A new traffic signal installation shall be put in flash operation for a period of three (3) to seven (7) days prior to the activation of the signal's "stop and go" operation. Activation of new traffic signals shall be during a mid-week weekday (Tuesday – Thursday) during a non-peak time and shall be coordinated with the Engineer. Upon initial inspection and acceptance testing of the new traffic signal installation, the Contractor shall request the start of the 30 day burn-in period to commence, as outlined in Subsection 631.03.4 of this specification. Any noted deficiencies found within that 30 day period shall be corrected to the satisfaction of the Engineer. The 30 day burn-in period must commence within the Contract Time, and before substantial completion of the project is granted;
- (g) The provisions and requirements herein contained for the deactivation of an existing system shall be applicable to all types of existing signal systems, whether individual or combination of signal controls; and

- (h) If signal timings are not provided in the plans, the Contractor shall request timings from the Engineer at least fourteen (14) days in advance of the system activation. No timings shall be used that have not been provided or approved by the Engineer. Printed documents containing the timings and all other controller settings shall be left in the cabinet.

The Contractor shall require the manufacturer to begin the warranty or guaranty period of warranties and guaranties, as required in Subsection 106.01.2, not sooner than completion and acceptance of the 30 day burn-in period. If there are any discrepancies between the manufacturer warranty begin date and the system activation date, then the Contractor shall furnish the Engineer, in a form approved by the Department, similar warranties and guaranties as covenants under the contract and contract bond for an extended period of time equal to the period of time between the manufacturer warranty begin date and the system activation date.

631.02.5--Electrical Service. It shall be the Contractor's responsibility to make the necessary arrangements with the local power company to provide the power supply assembly for any new installation. The Contractor shall pay for, at no cost to the Department, all deposits, hook-up charges, or other service fees required by the power company for the establishment of new service. The Contractor shall be responsible for payment of the monthly service bill during the life of the project. The cost of all such fees shall be considered incidental and absorbed within existing pay items. The Department or the local agency will be responsible for payment of the monthly service bill for the new power service installation after Project Acceptance.

When electric power service exists and is used for the operation of an existing system, the monthly service fees shall continue to be paid by the Department or the local agency. If the existing power service is intended for use with a new signal system, then any service charge fees shall be the responsibility of the Contractor. Similarly, if an existing power service is to be disconnected any service charge fees shall be the responsibility of the Contractor. The cost of all such fees shall be considered incidental and absorbed within existing pay items.

631.03--Construction Requirements.

631.03.1--General. The installation of the various types of equipment shall be carried out in compliance with the requirements stated in the sections herein covering the individual components required to complete the traffic signal system and in conformity with the details shown on the plans. Upon completion of the work, all equipment shall present a neat and workmanlike finished appearance. Upon completion of the work and before final payment is made, the Contractor shall remove all excess materials from excavation, reshape disturbed portions of the highway, replace grass or sod in-kind, and leave the project site in a neat and sightly condition.

631.03.2--Electrical Service Equipment. The power supply assembly shall consist of all equipment mounted on a service pole or pedestal as shown on the plans and as required by the service provider. The configuration and installation of the equipment mounted on the assembly shall meet the safety requirements and approval of the utility company or municipality furnishing power for operation.

Service poles shall consist of wood poles with required pole line hardware, conduit, ground

rods, guy wires and anchors and all other accessories and appurtenances mounted on the pole, except those items furnished by the utility company or municipality, or as specified separately in the contract or plans.

Main disconnect switches shall be separately housed on the power supply assembly. Circuit breaker cabinets and meters shall not be installed on the street or walk side of the pole or pedestal. Electrical service equipment shall meet the requirements of Subsection 722.13.

631.03.3--Performance Tests. The Contractor shall provide certified documentation of the results of the following performance tests to the Engineer at the Engineer's request. All testing required must be performed with a Department representative present. The Engineer and/or the Engineer's representative reserve the right to attend and observe all tests.

631.03.3.1--Circuit Continuity and Short Circuit. All circuits shall be tested to determine that they are continuous and free from short circuits, cross-circuits, or any other improper connection. No continuity shall exist between any conductor and another conductor including ground.

631.03.3.2--Freedom from Unspecified Grounds. All circuits shall be tested to determine whether they are free from undesirable grounds.

631.03.3.3--Resistance to Ground. All non-grounded conductors shall be tested with a 1000-volt DC megohmmeter. The insulation resistance measured to ground shall be a minimum of ten (10) megohms for each conductor terminating at the signal controller cabinet. Loop detector wires tests shall be performed only after the installation of roadway loop sealant.

631.03.3.4--Ground Resistance. The resistance to ground shall be tested to the standards set forth in Subsection 722.09.

631.03.4--Satisfactory Performance Period. Contractor shall develop a turn-on procedure, compliant turn-on plan, and receive the Engineer's acceptance of that plan prior to the signal installation being placed in operation. Final acceptance will not be made until each traffic signal installation has operated satisfactorily for at least 30 consecutive days under actual traffic conditions. During each 30-day performance period, if failure should occur in any system component, the cause of the failure shall be determined and reported to the Engineer. Upon acceptance of the cause of failure by the Engineer, the necessary replacement(s) and repairs shall be made and all failed components presented to the Engineer for inspection. Upon successful repair, the system shall be operated satisfactorily for an additional 30 consecutive days. Contract time shall not be stopped due to the restart of the satisfactory performance period(s).

Time to perform the satisfactory performance period has been included in the Contract Time.

When the Contractor has satisfactorily completed all items of work on the project including the satisfactory performance period, the Engineer will make a final inspection of the completed work in accordance with Subsection 105.20. At the request of the Engineer, the Contractor shall be present at the time of final inspection. If all items of work are found to be satisfactory, the Executive Director will release the Contractor from maintenance.

Project acceptance shall not occur prior to this final inspection and the burn-in period has been completed.

Final acceptance is also subject to the guaranty and warranty provisions of Section 100, Subsection 631.02.4, and other provisions of the contract.

631.03.5--Training. Training requirements, if any, shall be listed and described under the specific section of the specifications to which they apply. The Contractor shall refer to the contract documents and plans for alternate or additional training requirements when none are listed in the specifications.

SECTION 632 - TRAFFIC SIGNAL CABINET ASSEMBLIES

632.01--Description. This work consists of furnishing, assembling, configuring and installing all component materials and software required to form completed traffic signal controller assemblies, closed loop master controller assemblies and signal system installation of the types specified, in conformity with these specifications, to ensure fully operational traffic signal installations as shown on the plans.

632.02--Materials.

632.02.1--Cabinet Assembly. Cabinet Assemblies shall meet the NEMA 3R requirements and be constructed principally of 0.125-inch thick, 5052-H32 aluminum. The aluminum shall have a mill finish per NEMA TS-2 7.7.3. Intermittent welds may be used for construction and any un-welded cabinet seams shall be sealed with clear RTV silicone. All external fasteners shall be stainless steel and no holes will be allowed in top of cabinet.

The door handles shall be stainless steel or cast aluminum. Door hinges shall be of the continuous type with a stainless steel hinge pin. Rivets are not be used to attach the hinge. The main door stop rod shall be constructed using stainless steel. The door stop mechanism shall be adjustable and capable of being securely latched in multiple opened positions including 90 degrees and a maximum of 120 degrees. The brackets attaching the stop rod to the door and cabinet shall be aluminum and welded in place. The main door cylinder lock shall be a #2 key type lock. Two (2) traffic industry standard No. 2 keys shall be provided with each cabinet and shall be made using heavy duty key blanks. An access door which allows access to the back side of the terminal facility shall be provided unless a pole mounted cabinet is required.

Extruded aluminum channels permanently attached to the right and left cabinet sides shall be provided for attaching adjustable shelving and mounting of other component panels. The cabinet shall have two (2) shelves installed. Both shelves shall be provided with the front edge pre-drilled with 0.25-inch holes located twelve (12) inches apart.

When base mounted, a 2-chamber cabinet with a traffic signal controller and an Uninterruptible Power Supply (UPS) system will be specified in the plans. The signal controller side of the dual chambered cabinet shall be provided with a rear access door to the terminal facility unless otherwise stated in the plans or contract documents.

632.02.2--Physical Features.

632.02.2.1--Pull Out Drawer. A pull out drawer shall be installed and centered under the bottom shelf. The drawer shall be made of 0.080-inch thick, 5052-H32 aluminum and come out on full extension drawer slides. The pull out drawer shall provide an approximate 16-inch x 14-inch working area and have the ability to bear a constant 25 pound burden. There shall be a compartment for document storage. The lid shall be hinged at the rear, to gain access to the storage area. The drawer will be used to store documents as well as support a notebook computer. The drawer slides shall be of the full extension ball bearing type. Dimensions of the drawer shall be large enough to support a notebook computer and a drawer of sufficient size to hold at least two (2) copies of the cabinet drawings and other related cabinet documentation. The surface of the lid shall have a non-slip surface.

632.02.2.2--Cabinet Lighting. Cabinets shall be provided with a minimum of two (2) white light LED modules. One (1) lighting module shall be installed along the front top section of the cabinet and the second lighting module shall be installed underneath the bottom cabinet shelf in such a location as to provide direct lighting of the load bay area of the cabinet but must not interfere with the cabinet drawer operation.

Both LED lighting modules shall be controlled by a NEMA rated, commercial quality, pushbutton door switch. The cabinet lighting shall turn on when the cabinet main door is opened and shall turn off when the main door is closed or an ON/OFF NEMA rated, commercial quality, toggle switch mounted on the inside cabinet door service panel shall be provided to turn both LED lighting modules on or off.

632.02.2.3--Police Panel Switches. Police panel switches shall be provided with all controller cabinets. All switches shall be hard wired and labeled as to their function.

NORMAL-FLASH: When this switch is in the FLASH position, all signal indications shall transfer to the flashing mode. AC power shall be removed from the load switches when the signal indications transfer to the flashing mode.

The controller unit shall operate in accordance with appropriate specifications during the flashing mode. When the switch is placed in the NORMAL position, transfer from the flash mode to normal operation shall be made in accordance with uniform code flash requirements.

SIGNAL ON-OFF: AC power shall be removed from the signal heads and the intersection will become dark when this switch is in the OFF position.

MANUAL CONTROL ON-OFF: When this switch is in the ON position, a logic ground shall be applied to the manual control enable input of the controller unit.

INTERVAL ADVANCE INPUT JACK: A manual jack shall be installed on the police panel. The jack shall inter-mate with a 3-circuit, ¼-inch diameter phone plug. The tip and ring (middle) circuits of the jack shall be connected to the logic ground and the interval advance inputs of the controller unit. When the manual hand cord is plugged into the jack and the pushbutton is pressed, logic ground shall be connected to the interval advance input of the controller unit.

When specified in the contract documents, a manual pushbutton with cord shall be provided. The cord shall have a minimum length of three (3) feet. It shall have a ¼-inch diameter, three circuit plug connected to one end and a manual pushbutton enclosed in a

hand held enclosure at the other end. A complete cycle (push-release) of the manual pushbutton shall terminate the controller unit interval which is active except the vehicular yellow and red clearance intervals. Cycling the push-button during the vehicular yellow or all red clearance intervals shall not terminate the timing of those intervals.

632.02.2.4--Service Panel Switches. Service panel switches shall be hard wired and clearly labeled to identify as to their functions. Service panel switches shall be mounted on the service panel located on the inside of the main cabinet door. Alternate switch locations may be described in the plans or contract documents but final switch design and location shall be approved by the Engineer prior to cabinet fabrication.

NORMAL-FLASH: When this switch is in the FLASH position, all signal indications shall transfer to the flashing mode. AC power shall be removed from the load switches when the signal indications transfer to the flashing mode.

The controller unit shall operate in accordance with appropriate specifications during the flashing mode. When the switch is placed in the NORMAL position transfer from the flash mode to normal operation shall be made in accordance with uniform code flash requirements.

CONTROLLER ON-OFF: When this switch is in the OFF position, AC power shall be removed from the controller. When this switch is returned to the ON position, the controller unit shall perform normal start up functions and resume normal operation in accordance with the applicable specification.

STOP TIME-RUN-NORMAL: A 3-position manual switch shall be provided which places the controller into Stop Time mode manually or through remote input.

VEHICLE DETECTORS: A 3-position switch shall be provided for each vehicle and pedestrian detector circuit. All switches shall be located on a panel mounted on the inside of the main cabinet door. The switch panel shall be labeled CALL SWITCH. Labeling of phase number and intended function (vehicles or pedestrian calls) shall be provided for each switch.

The vehicle detector switch functions are defined as follows:

Locked Call	Call is continually placed into the controller unit.
Off (center)	Vehicle detector is connected to the controller unit vehicle detector input, i.e. normal detector operation.
Momentary Call	Call is continuous as long as the switch is manually held in this position.

632.02.2.5--Police and Service Panel Locations. The police and service panels shall be constructed of 5052-H32 0.125-inch thick aluminum.

The police panel shall be located behind the police door which is enclosed within the main door. The police door shall be hinged and provided with a neoprene gasket seal. Access to any portion or equipment contained behind the main cabinet door shall not be accessible through any part of the police panel. The police panel shall be of appropriate dimensions to accommodate all switch or devices described within this specification, the plans or

contract documents. The police door shall be provided with a treasury #2 key type lock and two (2) keys for the police door lock shall be provided with each cabinet.

The service panel shall be mounted on the inside portion of the main cabinet door, adjacent to the back side of the police panel or on the left hand side of the cabinet.

632.02.2.6--Cabinet Ventilation. Cabinets shall be vented to allow dissipation of the heat generated by the equipment contained within. All cabinets shall have a thermostatically controlled exhaust fan located at the top of the cabinet that is capable of 100 cubic feet per minute air displacement. The thermostat shall be mounted on the inside top of the cabinet and shall have a nominal temperature range from 80°F to 170°F.

The intake vent shall be louvered or equivalent design to prevent rain infiltration. The vent area will be located along the bottom portion of the cabinet door. A 16-inch x 12-inch x 1-inch disposable pleated air filter shall be provided on the inside portion of the cabinet and shall fully cover the vent area.

632.02.2.7--Air Filter Assembly. Air filters shall be one piece and shall be held firmly in place against the cabinet door in order to prevent dust from bypassing the perimeter of the filter and shall fully cover the vent area. Wing nuts or thumbscrews are preferred. Air filter shall be a 16-inch x 12-inch x 1-inch disposable pleated filter.

632.02.2.8--Cabinet Sizes.

632.02.2.8.1--Type I Cabinet. A Type I cabinet, 51”H x 30”W x 18”D, may be used for both pole and base mounted cabinets that require a maximum eight (8) position load bay.

632.02.2.8.2--Type II Cabinet. A Type II cabinet, 51”H x 30”W x 18”D, may be used for both pole and base mounted cabinets that require a maximum twelve (12) position load bay.

632.02.2.8.3--Type III Cabinet. A Type III cabinet, 56”H x 44”W x 27”D, shall be used for base mount installations and shall require a sixteen (16) position load bay.

632.02.2.8.4--Type IV Cabinet. A Type IV dual chamber cabinet, 56”H x 57”W x 29”D, shall be used for base mount installations and shall require a sixteen (16) position load bay.

632.02.2.8.5--Type V Cabinet. A Type V cabinet, 77”H x 44”W x 27”D, shall be used for base mount installations and shall require a sixteen (16) position load bay.

632.02.3--Power Distribution Panel. The power panel shall be wired to provide the necessary power to all equipment. It shall be manufactured from 0.125-inch thick, 5052-H32 aluminum. The power panel shall house the following components: Main Breaker, Auxiliary Breakers, and Terminal Block. The panel shall be of such design so as to allow a technician to easily access the main and auxiliary breakers.

A 3-position terminal block with a removable insulated cover accepting up to AWG #4 stranded wire shall be supplied for accepting only the incoming power lines. This terminal block shall be in advance of and supply only the 15-amp main breaker, 10-amp and 5-amp Auxiliary breakers, AC neutral buss and earth ground buss.

632.02.3.1--Ground and Neutral Busbars. Cabinet grounding shall meet the requirements set forth in Subsection 722.09 for grounding and ground rods. A solid copper ground busbar shall be mounted on the side of the cabinet wall adjacent to the power panel for the connection of chassis ground wires. If more than one (1) ground busbar is used in a cabinet, a minimum of a AWG #6 copper wire shall be used to bond them.

The copper ground busbar shall have a minimum of thirteen (13) connector points, each capable of securing at least one (1) AWG #6 conductor.

A solid copper neutral busbar shall be mounted on the side of the cabinet wall adjacent to the power panel for the connection of AC neutral wires.

The copper neutral busbar shall have a minimum of thirteen (13) connector points, each capable of securing at least one (1) AWG #6 conductor.

632.02.3.2--Terminal Strips. Conductors shall be terminated on terminal strips with insulated terminal lugs. When two (2) or more conductors are terminated on field wiring terminal strip screws, a terminal ring lug shall be used for termination of those conductors. The voltage and current rating of terminal strips shall be greater than the voltage and current rating of the wire which is terminated on the terminal strip.

632.02.3.3--Cabinet Receptacles. A 3-wire 115 Volt AC (15A) Ground Fault Circuit Interrupt (GFCI) duplex receptacle shall be provided in the cabinet for maintenance use. It shall be securely mounted near the bottom right side of the cabinet and easily accessible.

Two (2) 3-wire 115 Volt AC (15A) non-GFCI protected outlets shall be installed, one on each side of the cabinet. These two (2) outlets are used for communication or other auxiliary equipment.

632.02.3.4--Operating Line Voltage. All equipment shall be designed to operate from a 120 volt, 60 cycle AC supply. Operation shall be satisfactory at voltages from 105 volts to 130 volts. All operating voltages into and out of the controller shall be NEMA level DC voltages except for the controller AC power source (Connector A, Pin p – AC-Control and Pin U – AC Common).

632.02.3.5--Circuit Breakers. Circuit breakers shall meet the requirements set forth in Subsection 722.07. A 15-amp main breaker, with a minimum of 10,000 amp interrupting capacity, shall be provided for all cabinets to supply power to the controller, MMU, signals, and rack power supply.

Two (2) auxiliary breakers shall be provided. The first breaker, 10-amp, shall supply power to the fan, light, GFCI utility receptacle and two (2) auxiliary standard receptacles. The second breaker, 5-amp, shall be installed to supply power for the Controller Unit and MMU2. The above circuit breakers line side shall be jumpered together and will be fed from an external main circuit.

632.02.3.6--Main Line Arrestors. Surge protection shall be provided that meets the requirements set forth in Subsection 722.12. A main line arrestor shall be provided to reduce the effects of voltage transients on the AC power line. It shall be installed after the circuit breaker. The main line arrestor shall be sufficient to protect all equipment and devices as per the plans and the following minimum specifications.

- Multi-stage Hybrid Design
- Series induction filtering
- Thermally protected Metal Oxide Varistors (TMOV's)
- Operating Voltage: 120 VAC
- Clamping Voltage: 395 VAC
- Operating Current: 15 A
- Peak Surge Current: 50 kA/Mode, 100 kA/Phase
- Operating Frequency: 47-63Hz
- EMI Attenuation: 40 dB Typ
- SPD Technology: TMOV's w/ W-C Filter
- Modes of Protection: L-N, L-G, N-G
- Status Indication: Power On & TMOV's Functional
- Connection Type: ¼-20 Stainless Steel Stud
- Operating Temperature: -40°F to +185°F

632.02.3.7--Solid State Main Line Relay (SSR). A normally-open, 75-amp, hybrid SSR shall be provided on the power distribution panel. The relay shall include a LED indicator to verify circuit power.

632.02.4--Terminal Facilities Board. The Terminal Facility shall be a hardwired load bay for NEMA TS2 Type 1 actuated controllers. The load bay shall include either eight (8), twelve (12) or sixteen (16) load switch positions, as specified by the plans, and shall be centered along the back of the cabinet below the bottom shelf.

All wires terminated behind the backboard, as well as any additional panels, shall be soldered. No pressure or solderless connectors shall be used, unless they are soldered to the wire and tab after connection.

632.02.4.1--Load Switches and Flashers. Solid State Load Switches, compatible with low wattage LED signals, shall be provided for the sequence called for on the plans. The load switch sockets shall be wired for triple-signal load switches conforming to NEMA TS1-1994 and NEMA TS2-2003 requirements.

The flasher socket shall be wired for and provided with a Type 3, two (2) circuit Solid State Flasher conforming to NEMA TS1-1994 and NEMA TS2-2003 requirements. It shall be possible to flash either the amber or red indication on any load switch outputs. It shall be possible to easily change the flash indication from the front side of the panel using readily available tools such as a screwdriver. A nominal flash rate of 50 to 60 FPM shall be provided. Flash rate shall be stable when used with generators or inverters.

Support(s) shall be provided to support the Flasher and Load Switches at some point approximately half of the total length from the panel surface. Sufficient area beneath the Load Switch or Flasher shall be clear in order to allow for free flow of air across the Load Switches or Flasher. Load Switches and Flashers must be provided with LED indicator lights on the side facing the cabinet door.

632.02.4.2--Flash Transfer Relay. All flash transfer relays, as a minimum, shall meet NEMA TS1 requirements. The number of relays that shall be supplied with each cabinet

shall accommodate the number of signal phases as indicated in the project plans. The coil of the flash transfer relay must be de-energized for flash operation.

632.02.5--Cabinet Wiring. Controller cabinets shall be wired in accordance with the signal phasing plans. If phases are indicated as omitted for future use, or if phases are not shown to be used in the plans, the cabinet shall be wired for use of the phases shown as future or unused. Load Switches shall not be provided for future or unused phases.

Wiring in the cabinets shall conform to the requirements of the National Electrical Code (NEC) and all of these specifications. All conductors in the cabinet shall be stranded copper. All wiring shall be laced. All wiring shall be in accordance as specified by Section 636 and Subsection 722.03 for Electric Cable and IMSA Specification 19 and/or 20 for Signal Wiring.

Connector harnesses for controller, conflict monitor, vehicle detectors, and accessory equipment (including NEMA defined Card Rack with power supply and pre-wired optical detection slots) shall be provided and wired into the cabinet circuitry. Connecting cables for controller and conflict monitor harnesses shall be sleeved in a braided mesh. All wires shall be securely terminated on terminal strips. The lay of the interconnect cable between the components must be such that when the door is closed, it does not press against the cables or force the cables against the various components inside the cabinets.

All communication wiring shall be bundled and routed independently of all other wiring. All live conductors shall be covered with suitable insulating material. All equipment grounds shall run directly and independently to the grounding bus.

All wires shall be cut and terminated as close as possible to the proper length before assembly. Consideration of equipment location adjustments must be made when determining appropriate wire lengths. Excessive lengths of wire or cable shall not be allowed. All line voltage conductors used in controller cabinet shall conform to the following color code:

AC Neutral: White
 AC Hot: Black
 Safety Ground: Green

632.02.5.1--Signal Terminal Arrestor Grounding Bar. A field terminal arrestor grounding bar shall be provided along the back portion of the cabinet for the installation of signal arrestors. This bar shall be attached using a AWG #10 stranded copper to the earth ground circuitry.

632.02.5.2--Signal Terminal Arrestors. The field terminal arrestor shall be a three (3) circuit protective device intended for use on traffic control load relay outputs. The arrestor shall be furnished with three (3) leads and a grounding stud which will be used to attach the arrestor to the grounding bar. The field terminal arrestor shall meet the following minimum specifications:

- Operating Voltage: 120 VAC
- Clamping Voltage: 475 VAC
- Peak Surge Current: 10 kA
- Operating Frequency: 47 – 63 Hz

- SPD Technology: MOV's
- Connection Type: Wire Leads
- Lead Wire: 14 AWG 12" Length
- Ground Stud: 10 x 32 5/8" Length
- Operating Temperature: -40°F to +185°F

632.02.6--Accessory Components.

632.02.6.1--Traffic Actuated Controller Unit. The fully actuated controller unit shall, at a minimum, meet the requirements of both NEMA TS1 – 1989 and NEMA TS2 -2003 requirements for actuated controller units. The controller shall be of the TS2 Type 2 configuration. The controller shall be provided with the multiple communication interface devices or properties as defined below.

- 10 Base-T Ethernet with front panel RJ-45 connector
- IEEE defined MAC address
- EIA-232 port
- Serial Fiber options for both single and multi-mode (optional as per plans)
- FSK 1200 bps modem (optional as per plans)
- D connector with 37 pin configuration for TS1 compatibility
- USB port for signal controller database upload/download to the controller flash
- Controller
- NTCIP Compliant

The controller unit must have an alphanumeric backlit LCD display with a minimum of eight (8) lines at 40 characters per line. The controller must be air-cooled with sufficient ventilation openings and capable of operating between -30°F and 165°F. The controller unit must be provided with a time-of-day clock, automatic daylight savings time adjustment and a power supply for maintaining SRAM during a power outage. The controller unit shall be capable of being used in a Closed-Loop System and must be capable of operating in the role of master controller in a Closed Loop System. The controller unit firmware shall be fully compatible with the Department's existing Traffic Signal Management Software. The Contractor shall ensure all controller firmware versions are compatible with the existing Traffic Signal Management Software that the Regional Department staff currently utilizes prior to submitting the controller for approval. The Contractor shall notify the Department if any special controller configuration or firmware is needed prior to submitting the controller for approval based on project requirements.

Where Flashing Yellow Arrow (FYA) operations are being used, all traffic signal controller firmware shall be capable of delaying the onset of the flashing yellow arrow.

All operator entered data shall be stored and backed up on to a flash memory device provided with the controller unit at no cost. This flash memory device shall require no battery to support value storage. No internal components of circuitry shall require battery support. The database shall be able to be backed up to a USB drive via the USB drive on the controller.

Traffic Actuated Controllers shall be of the Type shown on the plans. Type 1 Controllers shall have a Linux based processor and a minimum of one (1) USB port. Type 2 Controllers shall have the same features as Type 1 Controllers with the addition of an ATC backplane

and a minimum of three (3) additional USB ports. Type 3 Controllers shall have all features of the Type 2 Controller with the addition of the ATC module. Actuated controllers should have Master controller capability and shall be designated with 'M'.

632.02.6.2--Closed Loop Master Controller Unit. When called for in the plans, this work also consists of furnishing, installing and configuring the equipment, software and accessories necessary to connect one (1) traffic Closed-Loop Master Controller to its corresponding central or portable PC-based Traffic Computer Facility Control System via a communications connection. The communications or network connection device will be either existing or provided by the Contractor.

632.02.6.2.1--General. The Master shall monitor intersections in the system, display status and operational state and provide traffic flow data from intersection vehicle detectors. The Master shall include all communications equipment and software necessary to provide reporting to a remote terminal as well as upload/download of all local intersection data and provide timing synchronization. Communications to local controllers from the Master and from the Master to the central-office computer facility shall be by FSK, 900 MHz Radio, Broadband Radio, Serial Fiber, Ethernet, Fiber, Cell Modem or Leased Line, as indicated in the plans. The Master shall be able to run on the same controller simultaneously operating the intersection, with the local signal control software, on any given controller unit.

632.02.6.2.2--System Configuration. The system architecture shall be designed to minimize the effect of equipment failures on system operation and performance. The system consists of four (4) principal elements:

- Local System Intersection Controllers
- Communication (Telemetry Links)
- On-Street Master(s)
- Central-Office Computer Software

632.02.6.2.3--Local System Intersection Controller. The local system intersection controllers connected to the Master controller unit shall be capable of controlling a fully actuated two (2) to sixteen (16) phase intersection and shall meet or exceed NEMA TS1-1989 and TS2-2003 standards for fully actuated traffic control units. The local controller shall have internal communication capability with direct access to the data memory. The local system controller shall be capable of processing controller and detector data and provide all necessary intersection control functions. The local system intersection controller shall meet the requirements of the Traffic Actuated Controller Unit.

632.02.6.2.4--Communications (Telemetry) Links. The communications links for the "Closed-Loop" System shall perform the following functions:

- Provide the medium (radio/fiber/hardwire/etc.) for two-way communications between the On-Street Master and the local intersection controllers.
- Provide the medium for two-way communication between the On-Street Master and the central-office computer facility.
- Error checking shall be included in both mediums to assure transmission and reception of valid data.

632.02.6.2.5--On-Street Master. The On-Street Master may be located at an intersection and connected via the communication network to at least 32 local intersection controllers. The Master shall be capable of implementing Traffic Responsive Control, Time Base Control, Manual Control or Remote Control modes of operation.

Analysis of sampling sensor data from at least 64 system detectors and corresponding selection of the best Traffic Responsive timing pattern shall be provided by the On-Street Master during the Traffic Responsive mode of operation.

Automatic and continuous monitoring of system activity shall be provided by the On-Street Master to include both Master and intersection alarm conditions.

System parameter entry shall be provided via the On-Street Master including all Master and local intersection assignment and group parameters. Master parameters shall include:

- System coordination setup and pattern data entry by group
- System time base event scheduler
- System traffic responsive computational and pattern selection setup by group
- Intersection system group and detector assignments

The On-Street Master shall provide comprehensive system report generation including, as a minimum: system, intersection, detector and failure status and history reports in addition to system performance reporting.

A RS-232C interface shall be provided on the On-Street Master to allow for printing of reports or for interconnecting to a remote central site.

To enhance overall system operation and increase system management flexibility, the On-Street Master shall also support two-way dial-up communications to a central office computer for control, monitoring, data collection and for timing pattern updating purposes, all from a remote central office location. Continuous, seven (7) days/week - 24 hours/day, system monitoring shall be enhanced by the On-Street Master's capability to automatically dial-up the central office computer upon detection of user defined critical alarm conditions.

632.02.6.2.6--System Functional Requirements.

632.02.6.2.6.1--Operator Interface. In order to provide ease in programming and operation, the system shall provide a simplified user-friendly menu format at each local, master and central office facility. No special programming skills shall be required for the user to fully access and operate this control and monitoring system at any level.

All programming, both of the local intersection controllers and the On-Street Master(s) shall be via a front panel keyboard and display, driven by English Language menus. All data change entries will be automatically verified against established ranges prior to acceptance to prevent programming data errors. Data access shall be controlled by user-definable access controls.

632.02.6.2.6.2--System Traffic Control. The system shall have the capability of controlling a minimum of sixteen (16) vehicle phases and eight (8) pedestrian phases. The

system shall have the capability of implementing a minimum of four (4) timing rings, fifteen (15) alternate sequences, and sixteen (16) offsets.

The system shall provide the capability of selecting any of the following operational modes on a group basis:

- Traffic Responsive
- Time Base (Time-of-Day/Day-of-Week)
- Remote (External Command)
- Manual (Operator Entry)

The system shall be capable of implementing system FLASH and system FREE operation. The system shall have the capability to command, on/off based on time, up to eight (8) independent special functions.

632.02.6.2.6.3--Detectors. The system shall have the capability of accepting and processing data from at least 632 system detectors for Traffic Responsive program selection.

632.02.6.2.6.4--Pattern Selection. In addition to providing Manual and Remote program selection capability, the Master shall provide for Traffic Responsive and Time Base modes of operation for timing pattern selection.

632.02.6.2.6.4.1--Traffic Responsive Mode. Traffic plan selection in the Traffic Responsive mode shall be user-enabled and supplied with the controller, per the plans and specifications. The pattern selection shall be based on sampling detector volume and occupancy analysis by the On-Street Master.

632.02.6.2.6.4.2--Time Base Mode. The system shall provide the capability of implementing time-of-day, day-of-week and week-of-year control for each of the two (2) groups using an internal time clock referenced to the 60-Hz AC power line frequency for its time base. The Time Base mode shall contain automatic adjustment for leap year and daylight savings time changes.

The system Time Base mode shall provide, as a minimum, 100 events each capable of requesting any of the 48 traffic control patterns along with Traffic Responsive override enable or auxiliary events consisting of enable/disable any of up to four (4) system-wide special functions and setting sample and log interval time periods.

632.02.6.2.6.5--System Control Priority. The system coordination control (program-in-effect) for each group shall be selected on a priority basis. The priority from highest to lowest shall be as follows:

- Manual Control Entry
- External Control (Remote Command)
- Time Base Control (Time-of-Day/Day-of-Week) (Traffic Responsive control will prevail whenever Traffic Responsive Override Enable is active and the selected cycle length is greater than that being commanded by Time Base)
- Traffic Responsive Control

632.02.6.2.6.6--Measures of Effectiveness. The system shall have the capability to report selected Measures of Effectiveness (MOE's) on an intersection basis. MOE calculations shall be made on all phases by the local system intersection controller and as a minimum shall include measures such as: volume, number of stops, delays and green utilization. These measures shall be calculated on the basis of the active timing plan. Alternate ways of reporting MOE'S may be approved on a case-by-case review.

632.02.6.2.6.7--Uploading and Downloading. The system shall provide, for any selected local system intersection controller, the capability of uploading and downloading any or all, new or modified local intersection parameters from the central-office computer and the Department Central Traffic Signal Management Software, and shall include, as a minimum, all: Phase Timing and Unit Data; Coordination Data, Time Base Data; Preemption Data, System Communication Parameters, System Traffic Responsive Data, and any other System Data residing at the intersection such as Detector Diagnostic Values, Report Parameters and Speed Parameters.

During either uploading or downloading operations, normal traffic control operations shall not be suspended. All data shall be continually accessible and may be displayed at the On-Street Master or the central office computer.

632.02.6.2.6.8--System Monitoring and Diagnostics. The system shall automatically and continually monitor system activity and log/report occurrences of Master and intersection alarm conditions. All alarm condition events shall include at the intersection, (Master and central-office computer) an alpha-numeric description of the event as well as the time and date of occurrence.

As a minimum, monitored master alarms conditions shall include:

- Insufficient or Improper Data
- Failed Computational Channels
- Failed System Detectors
- Intersection Communication Failure
- Failed Controllers
- Minimum of six (6) special user defined alarms for user application flexibility
- Monitored intersection alarms conditions shall include as a minimum:
 - Cycle Faults and Failures
 - Coordination Failures
 - Voltage Monitor
 - Conflict, Local and Remote Flash Conditions
 - Preempt
 - Local Free
 - Minimum of six (6) special user defined alarms for additional user flexibility.

When the Master detects a critical alarm condition, as defined by the user, it shall automatically dial-up the central office computer and report the condition. On a BUSY or NO ANSWER, the system may be programmed, at user option, to alert a secondary computer.

The system shall also automatically and continually monitor, verify and attempt to correct Sync Pulse, Time Base Clock and Pattern-In-Effect.

The system shall provide capabilities to perform diagnostics on system and local detectors, communications and intersection operations. When a fault has been detected, an indication shall be provided. It shall be possible to isolate the fault to the failed unit from controls and indicators available on the Master unit. Auxiliary equipment such as a data terminal or CRT shall not be required to identify the failure.

632.02.6.2.6.9--Real Time Display. The Master shall provide for any selected local system intersection controller, real-time status information on its front panel. Real-time intersection status information shall include simultaneous display of: vehicle and pedestrian signal and detector status by phase, overlap signal status and cars waiting count by phase. Real-time controller status information shall include simultaneous display of: two (2) Ring Active timers, On/Next, Call/Recall and Hold/Omit Status by phase, Coordination, Preempt and Stop Time Status.

632.02.6.2.6.10--System Management. The system, without hardware changes but with its ability to directly modify Master and intersection parameters, shall provide the user system configuration and operational controls of the following functions: add/delete controllers and system detectors, enable Traffic Responsive mode, assign intersections to groups, assign system detectors to computational channels and channels to pattern select routines, and assign special and/or standard detectors as system detectors for use with computational channels or to track activity.

632.02.6.2.6.11--System Logging and Reports. The system shall automatically and continually process system data and log/report on occurrence of changes in intersection status, system detector status, communications status, controller status and local detector status in addition to system program changes, Traffic Responsive computations, measures of effectiveness and performance.

632.02.6.2.6.12--Security. The On-Street Master shall provide for a user-specified security code entry before any data may be altered. In order to view any parameter, security code entry shall not be required. Security access shall be automatically rescinded approximately ten (10) minutes after either access was gained or the last parameter change was entered. The Master and local controller shall have the ability via keyboard to disable security code requirements, allowing for perpetual access without requiring hardware changes.

632.02.6.2.7--Design Characteristics. The On-Street Master shall be designed to operate in either an office or field environment and shall be suitably housed in a separate enclosure or in a local intersection cabinet. The Master shall be designed to meet the following electrical and mechanical requirements:

632.02.6.2.7.1--Programming and Security. Operator programmable data entry shall be accomplished through panel keyboard(s). The Master shall prevent the alteration of keyboard set variables prior to the user having entered a specific access code through the keyboard. The Master shall maintain user-programmable variables in non-volatile memory with a battery-backed RAM to assure continued efficient system operation.

632.02.6.2.7.2--Test and Repair. To enhance maintenance and trouble-shooting activities, On-Street Masters shall include resident diagnostics as a standard. No extender-cards, special tools or PROMs shall be necessary to fully maintain these components. The

Master unit design shall ensure that all printed circuit boards be readily accessible for maintenance testing purposes. All fuses, connectors and controls shall be accessible from the front of the Master unit.

632.02.6.2.8--Traffic Signal System Software. All Traffic Signal System Software shall be compatible with the latest version of the Department's existing Master and local controllers and existing Traffic Signal Management Software for the Department region.

632.02.6.2.8.1--Traffic Signal Closed Loop Software. The Traffic Signal Closed-Loop Software shall provide the ability to manage Master and local controller databases including the uploading and downloading of data parameters. The software shall provide status information and provide reporting capabilities for Master and local controller data, alarms and logs.

632.02.6.2.8.2--Traffic Signal System Workstation Software. The Traffic Signal System Workstation shall provide the ability to manage Master and local controller databases including the uploading and downloading of data parameters. The software shall provide status information and provide reporting capabilities for Master and local controller data, alarms and logs.

The Traffic Signal System Workstation Software shall also be capable of operating as a network-connected user workstation to existing centralized signal systems and their associated databases.

When disconnected from the centralized signal system, the software shall be capable of running as a standalone system similar to the Closed-Loop Software. Under this mode, the software shall provide management, report and status functions for Master and local controllers. Under Standalone Mode of operation the software shall allow for its own database(s) for data management without the need for connecting to a centralized signal system database.

632.02.6.2.9--Services. Technical services shall be provided, as required, to assist in installation and initial setup of the Closed-Loop Master System and its sub-components. Technical assistance with database migration and/or setup, as well as the development of graphics (such as master maps and local intersection depictions) and the assignment of associated attributes such as detectors, phasing, signals, etc., shall be provided as required. Additionally, training shall be provided on a basic or advanced target user level, as required.

632.02.6.3--Malfunction Management Unit (MMU2). The Malfunction Management Unit (MMU2) shall be a shelf-mountable, sixteen (16) channel, solid-state, IP addressable MMU. The MMU2 shall accomplish the detection of, and response to, improper and conflicting signals and improper operating voltages in a traffic signal controller assembly, including support for four (4) section Flashing Yellow Arrow (FYA) left turn displays. The MMU2 shall be capable of running a minimum of twelve (12) different modes of FYA operation.

The MMU2 shall meet or exceed Section 4 requirements of the NEMA Standards Publication No. TS2-2003 including NEMA TS2 Amendment #4-2012 and provide downward compatibility to NEMA Standards Publication No. TS1-1989: Type 12 Operation, in addition to those specifications set forth in this document.

The MMU shall include a graphics based Liquid Crystal Display (LCD) to view the current monitor status and navigate the unit's menus. An RJ-45 Ethernet Port shall be provided for communications.

A built-in Diagnostic Wizard shall be provided that displays detailed diagnostic information regarding the fault being analyzed. This mode shall provide a concise view of the signal states involved in the fault, pinpoint faulty signal inputs and provide guidance on how the technician should isolate the cause of the malfunction. The Diagnostic Wizard shall be automatically invoked when the MMU2 is in the fault mode and the HELP button is pressed. It shall also be automatically invoked when the MMU2 is in the Previous Fail (PF) event log display and the HELP button is pressed.

A built-in Setup Mode shall be provided that automatically configures the Dual Indication Enable, Field Check Enable, Red Fail Enable and Minimum Yellow Plus Red Clearance Enable parameters from user input consisting only of channel assignment and class (vehicle, ped, pp-turn, FYA, etc.) responses.

The MMU2 shall be capable of operating in the Type 12 mode with SDLC communications enabled on Port 1. The Channel Status display shall operate in the Type 12 configuration and provide the Field Check function for up to four (4) Pedestrian Walk inputs.

In the interest of reliability and repair ability, printed circuit board mounted MS connectors shall not be acceptable. Internal MS harness wire shall be a minimum of nineteen (19) strand AWG 22 wire.

632.02.6.4--NEMA defined Card Rack and Power Supply. A minimum of one (1) NEMA compliant detector card rack with ten (10) slot positions shall be provided in each cabinet. The detector rack shall be installed on the bottom shelf of the cabinet. The power supplies for the NEMA defined card slots shall be provided as a 175W minimum with four (4) independent regulated channels of 24 VDC each rated at 0.75 amps over the full NEMA operating temperature range of -30°F to +165°F. The output should be regulated to 24 VDC +/- 15%. Each of the four (4) outputs shall be independently fused, each with a separate LED for displaying output and fuse status for each of the four (4) outputs. Each of the four (4) outputs shall be protected against voltage transients by a minimum 1500 watt suppressor. All card racks shall be wired for the type detection shown in the plan sheets.

632.02.6.4.1--Optical Detection Pre-Wired Card Slots. There shall be two (2) additional slots to the right of the standard NEMA defined slots. The two (2) additional slots shall be fully wired, whether or not emergency vehicle preemption power supply and phase selector modules are included in the project plans, for use with emergency vehicle preemption power supply and phase selector modules.

Card Guides shall be provided on the top and bottom of the card rack for each connector position.

632.02.6.5--In-Cabinet Network.

632.02.6.5.1--Communications Arrestor. The Controller Cabinet network shall consist of an SDLC connection between the Controller Unit and MMU2. Surge suppression for

this network shall meet the requirements set forth in Subsection 722.12 and the following minimum requirements below:

- Operating Voltage: 5 VDC
- Clamping Voltage: 8 VDC
- Operating Current: 1.5 A
- Peak Surge Current: 47 A (10x1000 μ s)
- Frequency Range: 0 to 20 MHz
- Insertion Loss: < 0.1 dB at 20 MHz
- SPD Technology: SAD
- Connection Type: DB-15
- Operating Temperature: -40°F to +185°F

632.02.6.6--System Communications.

632.02.6.6.1--Traffic Signal Ethernet Switch. When specified in the plans or contract documents, a traffic signal Ethernet switch shall be installed in the cabinet assembly. It shall meet the requirements for the type specified in Section 663. Ethernet patch cables of sufficient length shall be provided for all supplied Ethernet ready cabinet components. The switch and all components shall be connected and configured.

642.02.6.6.2--Fiber Optic Patch Panel. When specified in the plans or contract documents, fiber optic attenuator patch cords shall be installed in the cabinet assembly as specified in Section 661.

632.02.6.6.3--Wireless Communications. When specified in the plans or contract documents, wireless communication components shall be installed in the cabinet assembly and shall be as specified in Section 662.

632.02.6.6.4--Serial Port Server or Terminal Server. When specified in the plans or contract documents, serial port servers shall be installed in the cabinet assembly and shall be as specified in Subsection 663.02.2.

632.02.6.6.5--GPS Clock. This work includes furnishing a Global Positioning System (GPS) Synchronization clock that can be used to sync the internal clocks in traffic signal controllers when coordination is desired, but communication is not necessary. The GPS Clock System shall provide GPS based time and date synchronization to provide coordination of traffic controllers to a common time base. The system shall process GPS Time data using a tamper/vandal resistant GPS antenna and correct for Time Zone, Daylight Savings Time, Leap Years, and GPS Leap Seconds. The processed time information shall be sent to the traffic controller in the native format for the respective controller. A contact closure synchronization pulse with variable pulse width shall be available for a once per day update. If the GPS antenna is blocked for up to one (1) hour prior to scheduled time of synchronization, the system shall synchronize the traffic controllers with less than 0.4 seconds variance from the accuracy provided under normal operation with GPS satellites in view.

- The GPS Clock shall also meet the following minimum specifications:
- Input Voltage: 9-24 VDC
- Current Draw: 150 mA (max) at 12 VDC : 125 mA (max) at 24 VDC

- Contact Closure: 750 mA at 30 VDC
- Temperature Rating: -29.4°F to +167°F

GPS unit shall be mounted to the traffic signal controller cabinet as per the manufacturer's recommendation. Any and all holes created in the cabinet for the purpose of mounting the GPS unit shall be sealed to the satisfaction of the Engineer at no direct pay.

632.02.6.6.6--Power-Over-Ethernet Arrestor. Surge suppression that meets the requirements set forth in Subsection 722.12 shall be provided. In addition, the following minimum specifications shall be supplied for loads that require Power-Over-Ethernet with isolated shielded or non-shielded cable:

- Operating Voltage: 48 VDC
- Clamping Voltage: 68 VDC
- Operating Current: 0.75 A per Pin Continuous
- Peak Surge Current: 10 kA
- Insertion Loss: < 0.1 dB
- SPD Technology: GDT, SAD, with series PTC
- Modes of Protection: All Lines (1-8) Protected (L-L) and (L-G): Signal High-Low; High-Ground; Low-Ground
- Transmission Speeds: 10BaseT; 100BaseT; 1000BaseT
- Connection Type: RJ-45
- Operating Temperature: -40°F to +185°F

632.02.7--Detector Panel. A vehicle detector harness shall be provided to connect the detector panel to the card rack. The detector panel shall accept the connection of sixteen (16) field loop inputs and four (4) pedestrian detector inputs.

632.02.7.1--Detector Input Arrestors. Field Loop and Pedestrian input arrestors shall meet the requirements set forth in Subsection 722.12. Field loop arrestors shall have differential and common mode protection and be provided with the following minimum specifications:

- Operating Voltage: 75 VDC
- Clamping Voltage: 130 VDC
- Peak Surge Current: 250 A
- SPD Technology: Silicon Break-Over
- Operating Temperature: -40°F to +185°F

Pedestrian input arrestors shall be a four (4) circuit device provided with the following minimum specifications:

- Operating Voltage: 30 VDC
- Clamping Voltage: 36 VDC
- Operating Current: 0.15 A
- Peak Surge Current: 10 kA (8 x 20 μ s)
- Frequency Range: 0 to 20 MHz
- Insertion Loss: < 0.1 dB at 20 MHz
- SPD Technology: GDT, SAD, with Series PTC

- Connection Type: Terminal Block with compression lugs; Terminals accept up to 10 AWG
- Operating Temperature: -40°F to +185°F

632.02.8--System Detectors. The controller shall have the ability to receive input data from up to eight (8) special system detectors in addition to the normal actuated controller unit phase detectors. The user shall have the option to assign any of the phase detectors as “system detectors”.

632.02.9--Preemption. The cabinet shall be completely wired to accept and service calls from preemption phase selector modules, associated optical detector units and GPS units. Optical detector units and GPS unit cabinet components shall be as specified in Section 639. Provision for two (2) standard card modules shall be accommodated in a separate card rack for preemption. The preemption card rack shall provide a minimum of eight (8) positions.

Provisions shall also be made in the cabinet to accommodate Railroad Preemption when specified in the plans or contract documents. Railroad Preemption shall meet the requirements set forth in Section 639. While it is not necessary that a Railroad Preemption interface board be provided with the cabinet, the cabinet and back panel shall be designed so that a Railroad Preemption interface panel that uses a relay to isolate the track switch from the controller cabinet circuitry can be installed. Preempt 1 and 2, in the case of gate down preemption, shall be reserved for Railroad Preemptions; all subsequent preemptions shall be reserved for Emergency Vehicle, Fire Station, or Police Preemption.

632.02.10--Uninterruptable Power Supply. When specified in the plans or contract documents an Uninterruptable Power Supply (UPS) System shall be installed in the cabinet assembly. The UPS shall be installed in the cabinet and meet the requirements set forth in Section 633.

632.03--Construction Requirements.

632.03.1--Mounting. Traffic Signal Cabinet Assemblies shall be Wall or Pole Mounted, Base Mounted on a Concrete Cabinet Pad, or Mounted using a Composite Enclosure as specified below and as shown in the plans.

632.03.1.1--Wall or Pole Mounted. Wall or pole mount hardware shall be provided for mounting cabinets in specific installations as indicated in the design plans. Wall or pole mounted cabinets shall be manufactured with rigid tabs, rigid brackets or other acceptable configuration for attachment of the cabinet to the wall or pole support. Rigid attachment devices must allow for field alignment of cabinet to the wall or pole support.

632.03.1.2--Concrete Cabinet Pad. Concrete foundations shall be constructed of Class B concrete in specific installations as indicated in the design plans.

Cabinets for installation on a concrete base shall be manufactured with rigid tabs, rigid brackets or other acceptable configuration for attachment of the cabinet bottom to its flat support structure. Rigid attachment devices must allow for field alignment of cabinet with the support base. Concrete base construction details shall be provided in the design plan drawings.

632.03.1.3--Composite Enclosure. Cabinets for installation on a composite enclosure base shall be manufactured with rigid tabs, rigid brackets or other acceptable configuration for attachment of the cabinet bottom to its' flat support structure. Rigid attachment devices must allow for field alignment of cabinet with the composite enclosure. Composite enclosure attachment details shall be provided as shown in the plans.

632.03.2--Documentation. Documentation packages shall be delivered for each unit at the same time as the equipment to which it pertains.

A minimum of two (2) sets of complete schematic drawings and equipment documentation shall be supplied with each cabinet. The first copy shall be placed in a clear re-sealable print pouch of sufficient size to accommodate one (1) complete set of folded cabinet prints and placed in the pull-out drawer of the cabinet and the second copy shall be provided to the Department. Comprehensive controller data shall be included as part of the cabinet documentation package and shall be placed in the cabinet drawer pouch.

The documentation packages shall contain a schematic wiring diagram of the controller cabinet assembly and all auxiliary equipment. The schematic wiring diagram, including a symbols legend, shall show in detail all integrated circuits, transistors, resistors, capacitors, inductors as well as switches and indicators. All parts shown shall be easily identified on both in the cabinet and on the schematic diagram. Model numbers shall be used on schematic diagram when available.

A complete physical description of the signal cabinet assembly shall be provided to include at least the physical dimensions of the unit, weight, temperature ratings, voltage requirements, power requirements, material of construction, and complete performance specifications.

A complete set of operation guides, user manuals, and performance specifications shall be provided.

Detailed programming instructions, preventative maintenance requirements, and troubleshooting procedures shall also be provided for the controllers. These documents shall fully cover all programming procedures and programmable options capable of being made to the controllers and associated traffic control equipment. Instructions for modifications within the range of the capabilities of the unit such as changes in phases or sequences and programming matrix boards shall be included.

An intersection diagram shall be provided on the cabinet door showing geometric configuration, lane use assignments, controller cabinet and signal pole locations, vehicle and pedestrian signal head locations, vehicle and pedestrian detector zone locations, ring-barrier phasing diagram, and detector channel assignments. The intersection diagram shall be labeled with, at a minimum, a North Arrow, main street name(s), side street name(s), signal pole numbers, vehicle and pedestrian head type(s), detector zone designations, volume density and phase recall requirements, flash sequence. All field wires within the cabinet shall be labeled to coincide with those shown on the intersection diagram.

632.04--Method of Measurement. Traffic Signal Cabinet Assemblies will be measured as a unit per each.

Remove and Replace Existing Traffic Signal Cabinet Assembly will be measured as unit per each.

Modify Existing Traffic Signal Cabinet will be measured as a unit per each..

Solid State Traffic Actuated Controller of the type specified in the project plans will be measured as a unit per each.

Signal Software Licenses of the type specified in the project plans will be measured as a unit per each.

Malfunction Management Units of the type specified in the project plans will be measured as a unit per each.

Card Racks of the type specified in the project plans will be measured as a unit per each.

Global Positioning System (GPS) Clocks as specified in the project plans will be measured as a unit per each.

All pay items shall be inclusive of all materials, work, system integration, testing and incidentals necessary for a complete and operable unit in place and accepted. All removal, turn on, and acceptance of equipment, devices, traffic signals, and traffic signal assemblies shall follow Section 631 Traffic Signal Systems-General prior to payment.

632.05--Basis of Payment. Traffic Signal Cabinet Assembly, measured as prescribed above, will be paid for at the contract unit price per each for each type(s) specified in the contract, which price shall be full compensation for furnishing, installing, configuring, wiring, testing, and mounting foundation construction, cabinets, relays, terminals, circuit breakers, modules, coordination and time base control programs, connectors wiring, overlap equipment, load switches, power cables, power supplies, controller mechanism and housing, GPS clock, mounting material, all other materials, and all equipment, labor, tools, and incidentals necessary to complete the work.

Remove and Replace Existing Traffic Signal Cabinet Assembly, measured as prescribed above, will be paid for at the contract unit price per each for each type(s) specified in the contract, which price shall be full compensation for furnishing, installing, configuring, wiring, testing, and mounting foundation construction, cabinets, relays, terminals, circuit breakers, modules, coordination and time base control programs, connectors wiring, overlap equipment, load switches, power cables, power supplies, controller mechanism and housing, GPS clock, mounting material, all other materials, removal, disposal, transfer, storage, and/or resetting of components that are existing, all other components included in the traffic signal cabinet, and all equipment, labor, tools, and incidentals necessary to complete the work.

Modify Existing Traffic Signal Cabinet, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing, installing, configuring, and mounting all components, wiring, and devices; rewiring, reconfiguring, removal, disposal, transfer, storage, and/or resetting of existing components and devices, installing or changing coordination and time base control programs in the traffic signal cabinet assemblies, testing, final cleanup, all equipment, labor, tools, and incidentals necessary to complete the work.

Solid State Traffic Actuated Controller, measured as prescribed above, will be paid for at the contract unit price per each for each type(s) specified in the contract, which price shall be full compensation for all labor, equipment, tools, materials inclusive of the controller mechanism(s) and housing(s), all power cables, power supplies, wiring, factory and manufacturing inspection, attachment hardware, testing, storage, packaging, shipping, warranty, and all work, equipment, and appurtenances, and all incidentals necessary to provide a fully functional traffic controller ready for use. It shall also include all documentation including operations and maintenance manuals and other material necessary to document the operation of the traffic controller.

Signal Software Licenses, measured as prescribed above, will be paid for at the contract unit price per each for each type(s) specified in the contract, which price shall be full compensation for all labor, equipment, tools, materials inclusive of furnishing, installing and configuring the Signal Software, all power cables, power supplies, wiring, factory and manufacturing inspection, testing, storage, packaging, shipping, warranty, appurtenances, and all incidentals necessary to provide fully functional Signal Software ready for use. It shall also include all documentation including operations and maintenance manuals and other material necessary to document the operation of the Signal Software.

Malfunction Management Unit, measured as prescribed above, will be paid for at the contract unit price per each for each type(s) specified in the contract, which price shall be full compensation for all labor, equipment, tools, materials inclusive of furnishing, installing and configuring the Malfunction Management Unit(s), all power cables, power supplies, wiring, attachment hardware, factory and manufacturing inspection, testing, storage, packaging, shipping, warranty, and all work, equipment, and appurtenances, and all incidentals necessary to provide a fully functional Malfunction Management Unit ready for use. It shall also include all documentation including operations and maintenance manuals and other material necessary to document the operation of the Card Rack.

GPS Clock, measured as prescribed above, will be paid for at the contract unit price per each for each type(s) specified in the contract, which price shall be full compensation for all labor, equipment, tools, materials inclusive of furnishing, installing and configuring the Global Positioning System (GPS) Clock(s), all power cables, power supplies, wiring, attachment hardware, factory and manufacturing inspection, testing, storage, packaging, shipping, warranty, and all incidentals necessary to provide a fully functional GPS Clock ready for use. It shall also include all documentation including operations and maintenance manuals and other material necessary to document the operation of the GPS Clock.

Payment will be made under:

- | | |
|------------------------------------------------------------------------------------------------------------|------------|
| 632-A: Solid State Traffic Signal Cabinet Assembly,
Type __ Cabinet, Type __ Controller | - per each |
| 632-B: Remove and Replace Existing Traffic Signal Cabinet Assembly,
Type __ Cabinet, Type __ Controller | - per each |
| 632-C: Modify Existing Traffic Signal Cabinet Assembly | - per each |
| 632-D: Solid State Traffic Actuated Controller, Type __ | - per each |

632-E: Single-user Workstation Signal Software License	- per each
632-F: Single-user Server Signal Software License	- per each
632-G: Malfunction Management Unit	- per each
632-H: Card Rack, ___ Position	- per each
632-I: GPS Clock	- per each

SECTION 633 - UNINTERRUPTABLE POWER SUPPLY

633.01--Description. This section describes the minimum requirements for battery backup systems including uninterruptable power supply and power conditioner.

633.01.1--Uninterruptable Power Supply (UPS). If required by the contract documents or design plans, the cabinet assembly shall be provided with a UPS System.

The UPS system shall be a turn-key, true on-line, solid state, microprocessor controller power conditioner and/or UPS system. The system shall continuously regenerate and condition the AC sine wave, where 100% of the power to the load, whether on utility or batteries, is generated by the on-board inverter. The UPS system shall be capable of operating, up to the rated power levels, in extreme environments (-40°F to +165°F) with existing cabinet equipment, including any and all signal heads whether Incandescent, LED or Neon.

633.02 Materials. The UPS system shall consist of three (3) major components: the Electronics Module, the Manual By-pass Switch, and the Battery System.

633.02.1--Electronics Module. The Electronics Module shall be provided as follows:

- True Sinewave, Micro Processor controlled high frequency inverter.
- A temperature compensated battery charger.
- Local and remote control of UPS functions.
- Local and remote communicates capabilities.
- Utility By-pass Switch for by-passing the UPS for repair or removal.

633.02.2--The Manual Bypass Switch. A Manual By-pass Switch shall be provided as follows:

- The UPS shall incorporate an automatic, internal safety by-pass capability and a Manual By-pass Switch.
- An optional interface connector shall be available that allows an external generator or vehicle inverter to supply utility power when commercial utility has failed.
- The UPS shall supply 120 VAC, 60 Hz, True Sinewave power when connected to either a generator or digital inverter power system

633.02.3--The Battery System. The battery shall be comprised of extreme temperature, deep cycle, AGM-VRLA (Absorbed Glass Mat – Valve Regulated Lead Acid).

633.02.4--UPS Operation.

633.02.4.1--UPS System. A UPS System shall be provided as follows:

- 1) The Unit shall be capable of on-site programming without the use of attached computers.
- 2) On-line technology shall be supported and 100% of the load shall flow through the inverter 100% of the time to isolate and protect the attached equipment.
- 3) Power connection shall be made to the front or back of the UPS chassis to support NEMA cabinetry.
- 4) The UPS system shall be capable of providing continuous, fully conditioned and regulated sinusoidal (AC) power to selected devices such as signal controllers, modems, communication hubs, NTCIP adapters and video equipment.
- 5) The UPS system shall be sized with a maximum rating to be capable of supporting all cabinet systems, regardless of power factor rating, without overdriving the poorer power factor LED heads which may cause early degradation, low luminosity or early signal failure and meeting minimum run time requirements during power loss/failure of commercial power.
- 6) Upon loss of utility power, the UPS system shall switch to battery power. In cases of UPS system failure, while on utility, the UPS system will auto-by-pass and remain in that mode until repaired. Should the battery power deplete such that it is not sufficient to power the equipment, the unit will auto-shutdown and return to normal operating mode once the utility power is restored.
- 7) The By-pass Switch shall enable removal and replacement of the UPS system without shutting down the traffic control system (i.e. "hot swap" capability). The UPS system shall support generator input without going to batteries.
- 8) The UPS system shall be capable of starting when no utility AC is available, i.e. starting while on batteries ("cold starting"),
- 9) Existing cabinet Flasher Modules and Flash Transfer Relays shall be utilized.
- 10) To facilitate emergency crews and police activities, the UPS system shall be compatible with the police panel functions.
- 11) The UPS system shall not duplicate or assume Flash Operation or Flash Transfer Relay functions.
- 12) The UPS system shall deliver 120 VAC output when the AC input is between 75 to 175 VAC without going to batteries.
- 13) NEMA Style Cabinet mounting method shall be shelf mounted.

633.02.4.2--System Batteries. The system batteries shall meet the following:

- a) The battery system shall consist of extreme temperature, deep cycle, Gel or AGM-VRLA (Valve Regulated Lead Acid) batteries that have been field tested.
- b) The battery system may consist of one (1) or more strings (typically four (4), six (6) or eight (8) batteries per string) of extreme temperature, deep cycle, Gel or AGM VRLA (Valve Regulated Lead Acid) batteries.
- c) Batteries shall be capable of operating at extreme temperatures from -40°F to +165°F.
- d) The batteries shall be provided with appropriate interconnect wiring and corrosion-resistant mounting trays and/or brackets.
- e) The interconnect cables shall be protected with abrasion-resistant nylon sheathing.
- f) The interconnect cables shall connect to the base module via a quick-release

connector.

- g) Battery construction shall include heavy duty, inter-cell connections for low-impedance between cells, and heavy duty plates to withstand shock and vibration.
- h) The top cover shall use tongue and groove construction and shall be epoxied to the battery case for maximum strength and durability.

633.02.4.3--Electrical Specifications.

633.02.4.3.1--Input Specification. The following are input electrical specifications.

Nominal Input Voltage	120 VAC, Single Phase
Input Voltage Range	75 VAC to 155 VAC (without drawing energy from batteries)
Input Frequency	50 or 60 Hz
Input Configuration	3-Wire (Hot, Neutral & Ground)
Maximum Input Current	30 amps

633.02.4.3.2--Output Specification. The following are output electrical specifications.

Nominal Output Voltage	120 VAC, Single Phase
Power Rating	1.25 - 2.0 KVA continuous watts
Output Frequency	50 or 60 Hz
Output Configuration	Keyed, connectors and duplex receptacle
Output Wave Form	True Sine wave
Fault Clearing	Current limit and automatic shutdown
Short Circuit Protection	Current limit and automatic shutdown
Efficiency	85% at full load

633.02.4.4--UPS Electronics Module, Physical Specifications. The following are the physical specification for the UPS.

Height: 3.5" to 5.25"
 Depth: 8.75" to 10.5"
 Width: 15.5" to 19"

633.02.4.5--Environmental Specifications. The UPS system shall meet or exceed NEMA temperature standards from -40°F to +165°F.

The UPS system shall be field proven to meet or exceed NEMA temperature standards.

633.02.4.6--Battery Specifications.

The UPS system batteries shall be field tested and proven to meet or exceed NEMA temperature standards of -40°F to +165°F. Hydrogen gas emissions shall meet Mil-Spec, MIL-B-8565J.

633.02.4.7--Communications, Controls and Diagnostics. The UPS system shall provide standard Alarm Function Monitoring indicating loss of utility power, inverter failure, low battery condition and USB connectivity for system up/down loads. An RS232 or USB Interface shall be provided that allows full interactive remote computer monitoring and control of the UPS functions.

The UPS shall have an Ethernet communication interface for user configuration and management.

A Confirmation Light shall be included on the external top of the cabinet enclosure.

633.02.4.8--Warranty. The UPS System and Cabinet Assembly shall be protected by a minimum 2-year warranty.

633.02.4.9--Options. The UPS shall include an optional SNMP interface that provides Web-based Ethernet access.

633.03--Construction Requirement. The Contractor shall be responsible for all testing and documentation required for establishing approval and acceptance of the product.

Field tests shall be performed with various ITS devices as noted in design plans to verify that each device operates optimally. As a minimum, the following tests shall be conducted:

1. Verify Output (Amp- Hours)
2. Verify Daily load requirement (Amp-Hours)
3. Verify Loss of Load Probability (LOLP) of the designed power supply
4. Verify the Battery Reserve Days
5. Verify the Average Battery State of Charge
6. Verify the statistical Interval to Loss of Load

633.04--Method of Measurement. Uninterrupted power supply of the type specified will be measured as a unit per each.

633.05--Basis of Payment. Uninterrupted power supply, measured as prescribed above, will be paid for at the contract unit prices per each, which price shall be full compensation for all labor, tools, materials, equipment, furnishing all materials and installation, all modules, battery(s), connection hardware, grounding, wiring, all related appurtenances as necessary, and all incidentals necessary to provide a UPS service to each site. This price shall also include coordination efforts necessary to complete the work.

Payment will be made under

633-A: Uninterruptable Power Supply per each

SECTION 634 - TRAFFIC SIGNAL AND ITS EQUIPMENT POLES

634.01--Description. This work consists of furnishing all component materials required to form completed independent traffic signal equipment poles and extensions of the types specified for assembling, constructing, erecting and installing same in conformity with these specifications to ensure support poles in accordance with the design(s) and at the lines and grades shown on the plans or as directed by the Engineer.

This work also consists of furnishing and installing support poles and foundations for Intelligent Transportation Systems (ITS) equipment. This work shall consist of assembling, constructing, erecting and installing ground mounted equipment poles with foundations, and equipment poles attached to existing or proposed structures, in conformity

with these specifications and in accordance with the design(s) shown on the plans or as directed by the Engineer.

634.02--Materials. The materials used in construction shall conform to the general requirements of these specifications and the specific requirements set out herein.

634.02.1--Poles. All poles shall meet the applicable requirements of Subsection 722.02. Determination of required sizes, lengths, and gauges of poles shall be the responsibility of the Contractor in accordance with the plans and specifications. The various pole types are as follows:

- Type I – Strain
- Type II – Single mast arm
- Type III – Double mast arm
- Type V – Pedestal pole for traffic signal
- Type VI – Pedestal pole for pedestrian signal
- Type VII – Pedestal pole for detector equipment
- Type VIII – Galvanized Steel Poles for Cameras
- Type IX – Galvanized Steel Pole for Detectors
- Type X – Aluminum Pole for Detector
- Type XI – Structure-mounted ITS equipment

Signal pole heights shall be as specified in the plans. If a luminaire is required, the pole type designation shall be followed by “(L)” to indicate that a luminaire shall be included with the pole (example: Type III (L) – Double Mast Arm with Luminaire). If Luminaire is included, the luminaire type shall be as directed in the plans.

634.02.1.1--Traffic Signal Poles. Traffic signal poles shall meet the requirements of Subsection 722.02. The traffic signal equipment pole shaft extension shall meet the requirements in the plans.

All poles shall meet the design requirements of Subsection 722.02.3 unless specified otherwise in the plans.

Poles shall be provided with the following elements or accessories:

- Self-supporting straight, upsweep mast arm(s), or in accordance with Plan details. Where possible, the mast arms shall match the adjacent signal poles in the area unless otherwise stated;
- Stainless steel tag attached to the pole shaft using $\frac{3}{16}$ -inch stainless steel pop rivets with properties and information as follows:
 - Minimum $\frac{1}{16}$ inch thickness
 - Minimum $\frac{1}{4}$ -inch stamped legend with following information:
 - Manufacturer name
 - Month/year of manufacture
 - Unique identifying number for future manufacturer reference
 - External project number from the plans cover sheet (*example: STP-XXXX-XX...*)
- Tag installed on shaft side opposite the mainline highway and located approximately 48 inches above the foundation;

- Minimum size of six (6) inches wide by 18 inches tall reinforced handhole with included terminal block(s);
- A one-half inch coarse thread grounding stud shall be located on the interior side of the pole handhole opening;
- J-hook provided near top of pole for wire strain relief;
- Shaft and arm end caps;
- Nut covers shall be provided to cover the top anchor bolt nut and washer;
- Tapered poles and mast arms shall taper uniformly along their length;
- Other required features, elements or accessories as shown in the plans;
- Consideration shall be given for all parts of the structure;
- Consideration shall be given for all possible loading combinations including wind loads;
- Computations shall include design stresses and allowable stresses for all components which comprise the proposed structure;
- All complete shop drawings and design computations shall bear the stamp of a Professional Engineer registered in the State of Mississippi;
- Shop drawings shall be approved by the Engineer prior to fabrication. Approval of the shop drawings does not relieve the Contractor of responsibility for the design, fabrication and erection of the structure;

For each pole shown in the plans, the following information shall be provided:

- Top/bottom diameter, taper rate, wall thickness, section modulus, moment of inertia, and cross sectional area for each pole section.
- The centroid, weight, projected area, drag coefficient, velocity pressure, and wind force of each trapezoidal pole section.
- The axial force, shear force, primary moment, total moment, axial stress, bending stress, allowable axial stress, allowable bending stress, allowable shear stress and combined stress ratio (CSR) at each pole section.
- The pole's angular and linear deflection at each section.

Pole and arm finish may be hot-dip galvanized, hot-dip galvanized followed by powder coating of the color specified in the plans, or other coating as approved by the Engineer as specified in the plans. Powder coating shall be provided with a minimum of two coats. Manufacturer provided touch-up paint in the specified color shall be provided when powder coating is required. If no finish details are provided in the plans, then the poles and arms shall be provided with a hot-dip galvanized finish.

634.02.1.2--Galvanized Steel Poles for Cameras. Ground mounted camera poles and foundations, conduits, connections, clamps, anchor bolts, shoe bases and all other members shall be designed and fabricated in accordance with the standards and requirements listed below. Design and materials documentation shall be furnished as part of the approval request submittal. Certifications shall be furnished upon request by the Engineer.

Poles shall be designed in accordance with the *AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals*, current edition, including all interims and updates. Design life shall be 50 years for all poles. The design wind speed for all parts of the structure shall be as shown in the design specifications with a minimum of 90 mph. For projects that are in areas with higher wind standards, the higher standard shall be used. The pole shall meet design wind loading with camera(s) installed.

The Contractor shall submit manufacturer's shop drawings, layout drawings and specifications for equipment and appurtenances for approval by the Engineer no later than thirty (30) days after notice to proceed.

Pole fabricator shall be certified under Category I, "Conventional Steel Structures" as set forth by the American Institute of Steel Construction Quality Certification Program. Proof of this certification shall be provided to the Engineer.

All welding shall be in accordance with Sections 1 through 8 of the American Welding Society (AWS) DI. 1 Structural Welding Code. Tackers and welders shall be qualified in accordance with the American Welding Society Structural Welding code. Tube longitudinal seam welds shall be free of cracks and excessive undercut, performed with automatic processes and be visually inspected. Longitudinal welds suspected to contain defects shall be magnetic particle inspected. All circumferential butt welded pole and arm splices shall be ultrasonically and radio graphically inspected. All inspection records shall be furnished to the Engineer.

Camera pole system shall consist of a pole, anchor bolts, base plate, ground rod array, communication and power conduits to nearest pull box, grounding conduit, spare conduit and foundation.

Design computations for the camera poles shall be complete and shall include but not be limited to the following:

- Consideration shall be given for all parts of the structure.
- Consideration shall be given for all possible loading combinations including wind loads.
- Computations shall include design stresses and allowable stresses for all components which comprise the proposed structure.
- Top of pole deflection shall not exceed one (1) inch deflection from center due to 30 mph (non-gust) winds for the 50-foot poles.
- All complete shop drawings and design computations shall bear the stamp of a Professional Engineer registered in the State of Mississippi.
- Shop drawings shall be approved by the Engineer prior to fabrication. Approval of the shop drawings does not relieve the Contractor of responsibility for the design, fabrication and erection of the structure.
- The Engineer reserves the right to reject a pole design if the calculated deflection exceeds that specified herein.
- The foundation design shall be based on actual soil conditions from soil borings conducted by the Contractor. The cost of the soil borings shall be included in the cost of the pole.
- The calculations shall include a pole, base plate and anchor bolt analysis. The pole calculations shall be analyzed at the pole base, 5-foot pole intervals, and at each slip joint splice.

For each pole shown in the plans, the following information shall be provided:

- Top/bottom diameter, taper rate, wall thickness, section modulus, moment of inertia, and cross sectional area for each pole section.

- The centroid, weight, projected area, drag coefficient, velocity pressure, and wind force of each trapezoidal pole section.
- The axial force, shear force, primary moment, total moment, axial stress, bending stress, allowable axial stress, allowable bending stress, allowable shear stress and combined stress ratio (CSR) at each pole section.
- The pole's angular and linear deflection at each section.

634.02.1.2.1--Pole Mounted Cabinet Access Conduit Nipple. Each pole shall be manufactured with a two (2)-inch diameter rigid threaded nipple for conduit connection to a pole-mounted cabinet.

The height of this nipple above the base of the pole shall be such that a cabinet mounting height of three (3) feet above ground can be provided.

634.02.1.2.2--Hand Holes. Hand hole openings shall be reinforced with 2-inch wide hot rolled steel bar. The opening shall be rectangular and 5-inch X 8-inch nominal.

The cover shall be 11-gauge steel and shall be secured to a clip-on lock with a tamper-proof screw.

The reinforcing rim shall be provided with a ½-inch tapped hole and ½-inch hex head cap screw for grounding.

Hand holes on poles with pole-mounted cabinets and transformers shall be placed toward oncoming traffic. For all other poles, hand holes shall face away from traffic.

The section with hand holes shall be reinforced to have equivalent section modulus as the section without the hand hole.

634.02.1.2.3--Cable Supports (J-Hooks & Eyelets). Top and bottom J-hooks and eyelets shall be located within the pole directly aligned with each other.

634.02.1.2.4--Base Plate. Base plates shall conform to ASTM A572 (50 ksi minimum yield).

Plates shall be integrally welded to the tubes with a telescopic welded joint or a full penetration butt weld with backup bar.

Plates shall be hot dip galvanized.

634.02.1.2.5--Anchor Bolts. Anchor bolts shall conform to the requirements of AASHTO M314-90 (105 ksi minimum yield). The upper 12 inches of the bolts shall be hot dip galvanized per ASTM A153.

Each anchor bolt shall be supplied with two (2) hex nuts and two (2) hardened washers.

The strength of the nuts shall equal or exceed the proof load of the bolts.

The top nut shall be torqued so as to produce 60% yield stress of anchor bolt.

The Contractor shall use non-shrink grout, or other methods as approved by the Engineer, between bottom of base plate and top of concrete foundation.

Pole heights shall be as indicated in the plans.

634.02.1.3--Galvanized Steel Poles for Detectors. Ground mounted detector poles and foundations, conduits, connections, clamps, anchor bolts, shoe bases and all other members shall be designed and fabricated in accordance with the standards and requirements listed below. Design and materials documentation shall be furnished as part of the approval request submittal. Certifications shall be furnished upon request by the Engineer.

Poles shall be designed in accordance with the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals*, current edition, including all interims and updates. Design life shall be 50 years for all poles. The design wind speed for all parts of the structure shall be as shown in the design specifications with a minimum of 90 mph.

The Contractor shall submit manufacturer's shop drawings, layout drawings and specifications for equipment and appurtenances for approval by the Engineer no later than thirty (30) days after notice to proceed.

Pole fabricator shall be certified under Category I, "Conventional Steel Structures" as set forth by the American Institute of Steel Construction Quality Certification Program. Proof of this certification shall be submitted to the Engineer.

Poles shall be formed from a single sheet of hot rolled weldable grade steel, galvanized in accordance with ASTM A 123. Unless otherwise noted in the plans, poles shall be made from steel meeting the requirements of ASTM A 572 Grade 55, or A 595 Grade A. Minimum yield strength shall be 48,000 psi after fabrication. Design wind loading shall be as indicated on the plans. The pole shall meet design wind loading with detector(s) installed.

Poles shall have a constant taper of 0.14-inch nominal per foot.

All poles shall be equipped with a breakaway device which conforms to the latest AASHTO and FHWA requirements, which have been approved by same. At the request of the Engineer, the Contractor shall submit a manufacturer's certification with the pole shop plans stating that the device meets, or exceeds, these standards.

Pole heights shall be as indicated in the plans.

Detector pole system shall consist of, but not be limited to a pole, anchor bolts, breakaway base, base plate, ground rod array, communication and power conduit to nearest pull box, grounding conduit, spare conduit and foundation as shown in the plans.

Anchor bolts, washers and hex nuts shall be made of steel in accordance with ASTM F 1554, Grade 55, and shall be galvanized as per ASTM A 153. Anchor bolts shall be provided for each pole with two (2) hex nuts and washers per bolt. Anchor bolts shall be "L" shaped; minimum yield strength shall be 50,000 psi. A bolt layout template shall be provided by the manufacturer for proper bolt installation. The number of anchor bolts and design yield strength shall be as recommended by the manufacturer.

634.02.1.4--Aluminum Poles for Detectors. Ground mounted detector poles and foundations, conduits, connections, clamps, anchor bolts, breakaway bases and all other members shall be designed and fabricated in accordance with the standards and requirements listed below. Design and materials documentation shall be furnished as part of the approval request submittal. Certifications shall be furnished upon request by the Engineer.

Poles shall be designed in accordance with the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals*, current edition, including all interims and updates. Design life shall be 50 years for all poles. The design wind speed for all parts of the structure shall be as shown in the design specifications with a minimum of 90 mph. The pole shall meet design wind loading with detector(s) installed.

The Contractor shall submit manufacturer's shop drawings, layout drawings and specifications for equipment and appurtenances for approval by the Engineer no later than thirty (30) days after notice to proceed.

Poles shall be spun or formed from aluminum seamless tubing meeting requirements of ASTM B 210, Alloy 6063-T4 and after fabrication shall have mechanical properties not less than those specified for Alloy 6063-T6. The poles may also be formed from aluminum plates or sheets meeting the requirements of ASTM B 209, Alloys 5052-H34 or 5086-H34.

External surface of poles shall have a satin-type finish, clean and smooth, with all details defined and true to pattern.

Poles shall have a constant taper of 0.14 inch nominal per foot.

All poles shall be equipped with a breakaway device which conforms to the latest AASHTO and FHWA requirements, which have been approved by same. At the request of the Engineer, the Contractor shall submit a manufacturer's certification with the pole shop plans stating that the device meets, or exceeds, these standards.

Pole heights shall be as indicated in the plans.

Detector pole system shall consist of, but not be limited to a pole, anchor bolts, breakaway base, base plate, ground rod array, communication and power conduit to nearest pull box, grounding conduit, spare conduit and foundation as shown on the plans.

Anchor bolts, washers and hex nuts shall be made of steel in accordance with ASTM F 1554, Grade 55, and shall be galvanized as per ASTM A 153. Anchor bolts shall be provided for each pole with two (2) hex nuts and washers per bolt. Anchor bolts shall be "L" shaped; minimum yield strength shall be 50,000 psi. A bolt layout template shall be provided by the manufacturer for proper bolt installation. The number of anchor bolts and design yield strength shall be as recommended by the manufacturer.

634.02.1.5--Structure-Mounted ITS Equipment Poles. Structure-mounted equipment poles and conduits, connections, clamps, mounting hardware and all other members shall be designed and fabricated in accordance with the standards and requirements listed below. Design and materials documentation shall be furnished as part of the approval request submittal. Certifications will be furnished upon request by the Engineer.

Poles shall be designed in accordance with the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals*, current edition, including all interims and updates. Design life shall be 50 years for all poles. The design wind speed for all parts of the structure shall be as shown in the design specifications with a minimum of 90 mph. For projects that are in areas with higher wind standards, the higher standard is required. The pole shall meet design wind loading with all equipment installed.

The Contractor shall submit manufacturer's shop drawings, layout drawings and specifications for equipment and appurtenances for approval by the Engineer no later than ninety (90) days after notice to proceed.

Pole fabricator shall be certified under Category I, "Conventional Steel Structures" as set forth by the American Institute of Steel Construction Quality Certification Program. Proof of this certification shall be submitted to the Engineer.

All welding shall be in accordance with Sections 1 through 8 of the American Welding Society (AWS) D1.1 Structural Welding Code. Tackers and welders shall be qualified in accordance with the American Welding Society Structural Welding code. Tube longitudinal seam welds shall be free of cracks and excessive undercut, performed with automatic processes, and be visually inspected. Longitudinal welds suspected to contain defects shall be magnetic particle inspected. All circumferential butt welded pole and arm splices shall be ultrasonically and radio graphically inspected. All inspection records will be furnished to the Engineer.

ITS equipment pole system shall consist of a pole, connectors, clamps, mounting hardware, ground wires and rods, grounding conduit, and communication and power conduits to nearest pull box.

Design computations for structure-mounted poles shall be complete and shall include but not be limited to the following:

- Consideration shall be given for all parts of the structure.
- Consideration shall be given for all possible loading combinations including wind loads.
- Computations shall include design stresses and allowable stresses for all components which comprise the proposed structure.
- Top of pole deflection shall not exceed 1-inch deflection from center (2-inch deflection diameter) due to 30 mph (non-gust) winds.
- All complete shop drawings and design computations shall bear the stamp of a Professional Engineer registered in the State of Mississippi.
- Shop drawings shall be approved by the Engineer prior to fabrication. Approval of the shop drawings does not relieve the Contractor of responsibility for the design, fabrication and erection of the structure.
- The Engineer reserves the right to reject a pole design if the calculated deflection exceeds that specified herein.
- The calculations shall include a pole, base plate, and anchor bolt analysis. The pole calculations shall be analyzed at the pole base, 5-foot pole intervals, and at each slip joint splice.

For each pole shown in the plans, the following information shall be given:

- Top/bottom diameter, taper rate, wall thickness, section modulus, moment of inertia, and cross sectional area for each pole section.
- The centroid, weight, projected area, drag coefficient, velocity pressure, and wind force of each trapezoidal pole section.
- The axial force, shear force, primary moment, total moment, axial stress, bending stress, allowable axial stress, allowable bending stress, allowable shear stress and combined stress ratio (CSR) at each pole section.
- The pole's angular and linear deflection at each section.

634.02.1.5.1--Hand Holes. Hand hole openings shall be reinforced with 2-inch wide hot rolled steel bar. The opening shall be rectangular and 5" x 8" nominal.

The cover shall be 11-gauge steel and shall be secured to a clip-on lock with a tamper-proof screw.

The reinforcing rim shall be provided with a ½-inch tapped hole and ½-inch hex head cap screw for grounding.

Section with hand hole to be reinforced to have equivalent section modulus as the section without the hand hole.

634.02.1.5.2--Cable Supports (J-Hooks & Eyelets). Top and bottom J-hooks and eyelets shall be located within the pole directly aligned with each other.

Pole heights shall be as indicated in the plans.

634.02.1.6--Traffic Signal Strain/Mast Arm Poles. Traffic signal strain/mast arm poles, mast arms, and extensions shall be steel meeting the requirements of Subsection 722.02.

634.02.1.7--Wood Poles. Wood poles shall meet the requirement in accordance with plan details and Subsection 722.02.7.

634.02.1.8--Foundations. Cast-in-place foundations for concrete, steel, and/or aluminum shafts shall be provided as specified on the plans, and shall be cast of reinforced Class "B" structural concrete or Class "DS" Concrete, as specified on the plans, conforming to the requirements of Sections 601 and 602. All reinforcement steel shall be in accordance with Section 711. The sizes for the foundation and reinforcement shall be as shown in the plans.

Anchor bolts, washers and hexagon nuts for use in the foundation shall conform to Subsections 722.02 and 722.11. The anchor bolts shall be galvanized only through the threaded section and a minimum of six (6) inches below the top of the concrete foundation. Conduit for electric cable shall comply with the requirements for such materials as set out in Subsection 722.05.

634.03--Construction Requirements.

634.03.1--Foundations. Pole foundations shall be constructed as per the details in the plans, these specifications, and Section 803. Casings, as required, will be in accordance with Section 803. Excavation for concrete foundations or butts shall be opened vertically

in accordance with the methods of Section 801 with a tolerance of plus two (2) inches from neat lines and grades as shown in the plans or required by local conditions. Adjacent earth shall be compacted sufficiently to withstand the loadings set out under Subsection 722.02.3. Before placing concrete, the Contractor shall place reinforcing bars, conduit and anchor bolts, all in accordance with plan details, and tied rigidly in place. Prior to placing concrete, the anchor bolt orientation shall be verified so that the tensile load is divided between a minimum of two (2) anchor bolts. The foundation bolts shall be set in the concrete foundation to fit the bolt circle of each type of pole and shall be supported with a template to provide the proper bolt circle for the applicable pole. All reinforcing steel shall be wire tied together or may be wire tied to the anchor bolts. Concrete foundations shall be formed, cast and cured in accordance with Section 601. Concrete pours will be continuous and will only take place with the Engineer present. The final top surface shall be finished smooth, and sloped to drain.

Due to soil conditions in certain locations, as noted on the plans, concrete shall be placed with a tremie. When a tremie is used, it shall perform in accordance with the requirements in Subsection 803.03.2.7.2 and 804.03.6.1.

It may be necessary to use slip casing to keep the holes open. Casing will be required in portions of the holes that are not stable. Casings authorized by the Engineer shall be of specified size and adequate strength to accommodate the drilling equipment and to withstand ground-pressures and removal operations without deformation of the poured shaft. When removed, the casings shall revert to the Contractor for disposal.

The finished top surface of each foundation shall be ± 3 inches from the pavement edge elevation at the foundation location. Where foundations are constructed in areas where the pavement edge elevation and shoulder edge elevation differ more than twelve (12) inches, taller poles should be evaluated to minimize exposed foundation.

All signal support poles shall be installed at locations shown in the plans or as directed by Engineer.

634.03.2--Setting and Aligning Poles. Poles anchored to the concrete foundation or with precast butts shall have sufficient rake so as to assume a vertical position when the load is applied. Poles with precast butt shall be wet-tamped in place with crushed aggregate, concrete or satisfactory cement stabilized soil, as directed. Poles set on concrete foundations shall not be installed until a minimum 70% of the 28-day concrete compressive strength has been achieved. A minimum of two successful cylinder tests must be performed to verify minimum required strength and test results must be accepted by the Engineer.

For poles installed on concrete foundations, the following procedure for installing nuts shall be followed:

1. Verify that the nuts can be turned onto the bolts past the elevation corresponding to the bottom of each in-place leveling nut and be backed off by the effort of one person on a 12-inch long wrench or equivalent, without employing a pipe extension on the wrench handle.
2. Clean and lubricate the exposed threads of all anchor bolts. Clean and lubricate the threads and bearing surfaces of all leveling nuts. Re-lubricate the exposed threads of the anchor bolts and the threads of the leveling nuts if more than 24 hours has

elapsed since earlier lubrication, or if the anchor bolts and leveling nuts have become wet since they were first lubricated.

3. Turn the leveling nuts onto the anchor bolts and align the nuts to the same elevation.
4. Place structural plate washers on top of the leveling nuts; one washer corresponding to each anchor bolt.
5. Install the base plate onto the leveling nut washers, place structural plate washers on top of the base plate; one (1) washer corresponding to each anchor bolt, and turn the top nuts onto the anchor bolts.
6. Tighten top nuts to a “snug-tight” condition in a star pattern. Snug-tight is defined as the maximum nut rotation resulting from the full effort of one person on a 12-inch long wrench or equivalent. A star tightening pattern is one in which the nuts on opposite or near opposite sides of the bolt circle are successively tightened in a pattern resembling a star.
7. Tighten leveling nuts to a “snug-tight” condition in a star pattern. The distance from the bottom of the leveling nuts to the top of the concrete must not exceed one (1) anchor bolt diameter.
8. Before final tightening of the top nuts, mark the reference position of each top nut in a snug-tight condition with a suitable marking on one flat with a corresponding reference mark on the base plate at each bolt. Then incrementally turn the top nuts using a star pattern until achieving the required nut rotation specified in the following table. Turn the nuts in at least two (2) full tightening cycles (passes). After tightening, verify the nut rotation. Do not exceed the value specified in the following table by more than 20 degrees.

Anchor Bolt Diameter (inch)	Nut Rotation from Snug-Tight Condition
Less than or equal to 1.5 inches	1/3 Turn
Greater than 15 inches	1/6 Turn

9. Tighten each retainer or jam nut until it is in firm contact with the top surface of the anchor bolt nut then while preventing the anchor bolt nut from rotating, tighten the jam nut until it is snug tight.

After alignment of pole on the concrete foundation is completed and accepted by the Engineer, the entire area between the bottom of the pole base flange and the top of the concrete foundation shall be protected, using an acceptable method, to prevent foreign objects from entering the described area. Careful aligning of the poles shall be considered a most essential feature of the installation of the assembly and shall be as nearly perfect as practicable.

634.03.3--Installation of Traffic Signal and ITS Equipment Poles. All equipment shall be installed according to the manufacturer’s recommendations. Materials and associated accessories/adapters shall not be applied contrary to the manufacturer’s recommendations and standard practices. Equipment poles shall be installed as indicated in the plans and shall conform to the following requirements:

1. All poles shall be installed in accordance with the National Electric Safety Code and the latest AASHTO standards.
2. Foundations for ground mounted poles:
 - The Contractor shall submit a design for each pole foundation that has been sealed by a Professional Engineer registered in the State of Mississippi.

- Excavation for concrete foundations shall be opened vertically in accordance with the methods of Section 206 with a tolerance of plus two (2) inches from neat lines and grades as shown in the plans or required by local conditions. Adjacent earth shall be compacted sufficiently to withstand the loadings set out in Subsection 634.03.1.
 - If soil conditions require the use of any shoring or sonotube for proper installation of the foundations, the cost of the shoring or sonotube shall be included in the cost of the pole and foundation.
 - Before placing concrete, the Contractor shall place reinforcing bars, conduit and anchor bolts, all in accordance with plan details, and held rigidly in place by approved methods.
 - Concrete foundations shall be formed, cast and cured in accordance with the provisions of Section 601. The top surface shall be finished smooth, and sloped to drain.
 - Conduit shall be installed in the pole foundation for access and includes spare conduit or as shown in the plans.
 - A minimum of one (1) 2-inch spare conduit shall be installed in all pole foundations as shown in the plans. Spare conduits in pole foundations shall be sealed with blank duct plugs.
3. Grounding System:
- The Contractor shall supply and install a grounding system with ground rod array at the base of all poles as shown on the plans.
 - The ground rod array system shall be connected to the pole through an appropriate ground clamp.
 - An AWG #6 copper stranded bonding wire shall be installed between the pole and the field cabinet providing a common ground system for each site.
 - All ground bonding wires shall be un-spliced.
4. The installation method for the CCTV poles and cameras shall be such that the camera can be rotated as needed around the pole for optimum placement.

634.04--Method of Measurement. Traffic signal equipment pole of the type specified will be measured as unit quantities per each.

Traffic signal equipment pole shaft extension of the type specified will be measured as a unit quantity per each.

Traffic signal equipment pole mast arm extension, as indicated, will be measured as a unit quantity per each.

Pole foundations of the size specified will be measured by the cubic yard, which measurement shall be the area bounded by the vertical planes of the neat lines of the foundation.

Camera pole with foundation and detector pole with foundation will be measured as a unit quantity per each. No separate payment will be made for camera and detector pole foundations. Measurement for progress payments for camera and detector poles may be made as follows.

- 1) 25% of the contract unit price upon complete installation of foundations;
- 2) Final 75% of the contract unit price upon complete installation of pole system

Structure-mounted equipment pole will be measured as a unit quantity per each.

Slip casings of the size specified will be measured by the linear foot from the ground elevation to the bottom of the strata needing to be cased.

Wooden poles will be measured as a unit quantity per each.

634.05--Basis of Payment. Traffic signal equipment pole and traffic signal equipment pole extension of the type specified, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing all materials, erecting, installing, connecting and testing poles, pole bases, shaft, mounting attachments necessary to extend a shaft, mast arms, caps, covers, ground wire, ground rods, hardware and for all equipment, tools, labor and incidentals necessary to complete the equipment pole.

Traffic signal equipment pole mast arm extension, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing all materials, for installing the mast arm extension, mounting attachments necessary to extend the arm, and for all equipment, tools, labor, and incidentals necessary to complete the work.

Traffic signal pole foundations, measured as prescribed above, will be paid for at the contract unit price per cubic yard, which price shall include full compensation for structure excavation, reinforcing steel, anchor bolts; for placing, curing, and installing concrete; for replacing sod and final clean-up; and for all equipment, labor, tools and incidentals necessary to complete the foundation.

Camera pole with foundation and detector pole with foundation, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing all materials, for excavating, backfilling, replacing sod, and for all constructing, placing, curing, erecting, installing, connecting and testing; for foundations, poles, pole bases, conduit inside foundation as indicated on the plans, connections to support structures, caps, covers, ground wire, ground rods, hardware and for all equipment, tools, labor and incidentals necessary to complete the work, including remote and local control of the camera site complete in place and ready for use.

No separate payment will be made for camera and detector pole foundations.

Structure-mounted equipment pole, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing all materials, for all constructing, placing, erecting, installing, connecting and testing, for poles, conduit between structure attachment location as indicated in the plans; wiring between pole-mounted devices and field cabinet; all structure-mounting hardware indicated in the plans, caps, covers, ground wire, ground rods, hardware and for all equipment, tools, labor and incidentals necessary to complete the work, including remote and local control of the camera site complete in place and ready for use.

Slip casings, measured as prescribed above, will be paid for at the contract price per linear foot, which price shall be full compensation for all materials, tools, equipment, labor, and incidentals necessary to complete to work.

For wooden poles, attachment brackets and equipment as well as guy wire and anchors shall be included in cost of pole.

Payment will be made under:

634-A: Traffic Signal Equipment Pole, Type __, __' Pole, __' Arm *	- per each
634-B: Traffic Signal Equipment Pole Shaft Extension, ___' **	- per each
634-C: Pole Foundations, Class ___ Concrete	- per cubic yard
634-D: Slip Casing, ___" Diameter	- per linear foot
634-E: Camera Pole with Foundation, ___' Pole	- per each
634-F: Detector Pole with Foundation, ___' Pole	- per each
634-G: Traffic Signal Equipment Pole Mast Arm Extension, ___' **	- per each
634-H: ITS Equipment Pole, Structure Mounted, ___' Pole	- per each
634-I Wood Pole, Class ___ Height _____'	-per each

* Multiple Arms may be indicated

** Additional information may be indicated

SECTION 635 - TRAFFIC SIGNAL HEADS

635.01--Description. This work consists of furnishing traffic signal heads of the type specified in the plans and installing them in accordance with these specifications and the details shown in the plans or as directed.

635.02--Materials. Materials furnished for traffic signal head installation shall conform to the requirements of Subsection 722.14.

635.03--Construction Requirements.

635.03.1--Construction Details. Traffic signal heads shall be mounted on the messenger cable, mast arms, or pedestal poles and connected to the signal supply cable as indicated on the plans and as required in these specifications.

Initial location and alignment of signal heads shall be performed as indicated on plans. Final positioning and aligning shall be performed by field observation to obtain optimum visibility of the signal faces by approach traffic.

Ample slack shall be left in the signal supply cable to provide for field adjustment of head alignment and to form drip loops after heads are in final position.

Traffic signal heads not in use shall be adequately covered by the Contractor to the satisfaction of the Engineer. The signal heads shall be covered with a durable, outdoor-hardened material designed for the specific signal head configuration. The color of this covering shall contrast with the color of the signal head. The covering material shall be approved by the Engineer and clearly designate to drivers that the covered signal heads are not in stop and go mode.

635.04--Method of Measurement. Traffic signal heads of the types specified will be measured as a unit quantity per each.

635.05--Basis of Payment. Traffic signal heads of the types specified, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing housing, mounting attachments, lens, lamps, reflectors, visors, sockets, socket wiring, back plates where specified, turn-signal signs, tether cable, and all other materials; for installing, mounting, connecting, aligning, testing, and for all equipment, labor, tools, and incidentals necessary to complete the work.

Payment will be made under:

635-A: Traffic Signal Head, Type ____ - per each

SECTION 636 - ELECTRICAL CABLE

636.01--Description. This work consists of furnishing new or removal of existing cable(s), erecting, installing and/or relaying electric cable "mains" in conformity with these specifications and true to locations, line and grades as shown on the plans or as directed. It shall include excavating, laying or relaying of cable(s), placing tracer cable or tape, backfilling, replacing sod, aerial supports and/or pull-through conduits as applicable.

636.02--Materials. The materials used in this construction shall be of the type and size indicated on the plans and shall conform to the applicable requirements of Subsection 722.03.

636.03--Construction Requirements. Except where indicated on the plans or approved by the Engineer, cables shall be spliced with a water proof enclosure only in pole bases, pull boxes or controller cabinets. At each splice, sufficient slack shall be left in the cable for re-splicing. The greatest care shall be exercised in handling all cable to avoid damage to the conductor and its coverings. No sharp bends shall be permitted to form; reels shall not be dropped; and cable with discernable damage in any part shall be rejected. All connections shall be made with approved terminal blocks meeting the applicable requirements of Subsection 722.08.

636.03.1--Direct Buried Cable. Trenches shall be excavated by hand or mechanical methods to the depth and width indicated on the plans, or as directed. The cable shall be laid on a six (6)-inch cushion as shown on the plans or as directed and covered with a similar layer. A minimum cover of 24-inches total is required. The electric cable shall be "snaked" laid in the trench. The earth backfill then shall be placed in layers of eight inches (8") or less, and each layers compacted by approved methods to the density of adjacent ground. Cable placed under traveled roadways shall be pulled through previously placed conduit, and such pulling shall be incidental to work.

The ground surface of backfilled trenches shall be neatly dressed, all excess soil shall be removed from the right-of-way, and sod shall be replaced over the finished trench, all as directed.

636.03.2--Support of Aerial Conductor Cable. Aerial conductor cable normally shall be supported by messenger cable affixed by approved devices to supporting structures. In all cases, the cost of messenger cable and other support devices will be included in the contract unit price bid for Electric Cable.

636.03.3--Cable and Conduit. Cable lengths required shall be obtained by accurate measurement of the runs with liberal allowances made for slack in boxes, slack for terminating, and waste due to wire-grip damage. Open ends of cables shall be rubber taped at all times to avoid penetration of water or moisture into the strands of the cable. Pull-in guides, cable feeders or drawing-in protectors shall be employed to prevent damage to the cable at the duct mouth. An individual pull-in grip shall be used on each single conductor in the cable core to provide equal strain on each conductor. Cable whose jacket insulation or conductors have been damaged or displaced by pull-in grip shall be cut off and discarded before terminating. Cable shall be fed manually into the pull-in guide, cable feeder, or protector in such manner as to avoid excessive friction on the cable. Pulling shall be instantly stopped if undue tension occurs. Powdered talc, water or other lubricant, approved by the cable manufacturer, shall be used to facilitate pulling in runs over 200 feet, and may be used if desired on shorter runs. In no case shall grease be used as cable lubricant.

636.03.4--Identifying and Tagging. Individual phases of each signal circuit shall be identified by appropriate identifying marks, at points near each end of the cables and in each hand hole or pull box.

All cable entering controller cabinets, pull boxes and poles shall be identified with permanent labels or tags indicating the function of each conductor and which pole, pull box, or controller it goes to.

All single-wire conductors and cables shall have clear, distinctive and permanent markings on the outer surface throughout the entire length giving the manufacturer's name or trademark, the insulation type - letter designation, the conductor size, voltage rating and the number of conductors in the cable.

When required in the plans, the installation of tracer cable shall be in accordance with the requirements herein, per the manufacturer's recommendation, or as directed by the Engineer. When tracer cable is installed in an open trench, a non-detectable warning tape will be placed directly over the buried cable, four (4) to six (6) inches below finished grade.

636.03.5--Excavating Existing Cable. Existing cable and conduit, if indicated on the plans, shall be removed by hand trenching, exercising extreme care to prevent damage to cable in trenching and relaying in the new trench. After cable has been removed from existing location, the trench shall be backfilled and compacted to the density of adjacent soil.

636.03.6--Field Tests. The cable shall be tested for failure in accordance with Subsection 631.03.3. The test shall be made after cable has been installed and before connections have been made.

636.03.6.1--Interpreting the Test. If a cable fails, the fault shall be located and the cable replaced between terminal points. If failure occurs in conduit, all cables in that conduit between the nearest pulling points on each side of the failure shall be withdrawn. If, in the opinion of the Engineer, the other cables in the same conduit have not been damaged, they may be reinstalled, but the cable which failed shall be replaced with new cable. After replacement of the faulty cable, and any damaged cables, all cables of that circuit shall be retested.

636.04--Method of Measurement. Electric cable of the type specified, constructed as specified on the plans, will be measured by the linear foot. Measurement will be computed horizontally and vertically along the pole, conduit or messenger cable which the electric cable is placed, from center to center of the several installations comprising the circuits. No extra length will be allowed for cable inside signal heads, drip loops, or sag in aerial supported cable. Tracer tape used with tracer cable will not be measured for separate payment but shall be included in the contract price for Tracer Cable. The terminals for the measurements of lengths will be considered specifically as the center of the pull boxes, poles, signal heads or controller cabinets.

Electric cable removal, repair, and removed and relaid will be paid by per linear foot.

Excavation, sod and backfill will not be measured for separate payment but shall be included in the contract unit price per linear foot for associated Electric Cable pay items.

Messenger cable and other supporting devices for Aerial Electric Cable will not be measured for separate payment, but shall be included in the cost of other items bid.

636.05--Basis of Payment. Electric cable of the type specified, measured as prescribed above, will be paid for at the respective contract unit price per linear foot, which price shall be full compensation for furnishing, installing, connecting and testing all materials; for pulling through conduit and poles; for attaching to messenger cable; for final cleanup; and for all labor, equipment, tools, and incidentals necessary to complete the work.

Electric cable removal, repair, and removed and relaid, measured as described above, will be paid for at the contract unit price per linear foot, which price shall be full compensation for excavation, removing existing cable and its protective covering; for excavating new trench; for laying cable as indicated on the plans; for backfilling old trench; for backfilling new trenches with selected sand, sand clay or clay gravel as indicated on the plans; for replacement of sod or grassing as appropriate; for final cleaning up; and for all labor, equipment, tools, testing, and incidentals necessary to complete the work.

Payment will be made under:

636-A: Electric Cable, Direct Burial, Type, AWG ____, ____ Conductor - per linear foot

636-B: Electric Cable, Underground in Conduit, Type, AWG ____, ____ Conductor - per linear foot

636-C: Electric Cable, Aerial Supported, <u>Type</u> , AWG ____, ____ Conductor	- per linear foot
636-D: Electric Cable, Aerial Supported in Conduit, <u>Type</u> , AWG ____, ____ Conductor	- per linear foot
636-E: Electric Cable, Underground in Conduit, Tracer Cable	- per linear foot
636-F: Electric Cable, Repair	- per linear foot
636-G: Underground Cable and Conduit, Removed	- per linear foot
636-H: Underground Cable and Conduit, Removed and Relaid	- per linear foot

SECTION 637 - TRAFFIC SIGNAL CONDUIT AND PULL BOXES

637.01--Description. This work consists of furnishing all component materials required to install enclosures and conduit in conformity with these specifications and at the locations and grades indicated on the plans or as directed. Enclosures shall house and protect equipment such as splice cases, excess cable and pull box equipment.

637.02--Materials.

637.02.1--Pull Box / Enclosures. Grade level pull box, enclosures, structural junction boxes and covers shall meet the requirements of Subsection 722.06 and shall conform to the specific requirements set out hereunder.

For grade level pull boxes and enclosures only, ANSI/SCTE 77 Tier 15 (15,000-pound design load, 22,500-pound test load) and Tier 22 (22,500-pound design load, 33,750-pound test load) enclosures with minimum size dimensions as shown in the detail drawings on the plans shall be installed for use in traffic signal construction. Enclosure boxes shall be open bottom. The cover supplied shall have a design load equal to that of the enclosure box. When multiple “Tiers” are specified the boxes must physically accommodate and structurally support compatible covers while possessing the highest Tier rating. In no assembly can the cover design load exceed the design load of the enclosure box. Stainless steel hex bolts and nuts shall be provided to secure the cover. Bolts and nuts shall withstand a minimum torque of 35 foot-pounds and a minimum of 750 pounds straight pull-out as a means to secure the cover to the box. The inside of the cover and the box shall be permanently marked (by impress or ink) with manufacturer’s name or logo, ANSI/SCTE Tier level and model number.

If required by the Engineer, independent third party verification or test reports stamped by a registered Professional Engineer certifying that all test provisions of this specification have been met will be submitted with each submittal. All covers shall be provided with legend “Traffic Signal”, or as specified in plans, and the appropriate ANSI/SCTE Tier level embossed on their surface.

Surface mounted junction boxes shall meet the requirements of Subsection 722.06 and shall conform to the specific requirements set out hereunder. Boxes shall be of size and characteristics as indicated on the plans.

637.02.02--Conduit. All conduits shall meet the requirements of Subsection 722.05 and shall conform to the specific requirements set out hereunder. Furnishing and installing plastic and steel conduit shall be in accordance with these specifications and close conformity with the lines shown on the plans or as established by the Engineer.

The Contractor may, at no additional cost to the Department, use larger size conduit, in which case it shall be for the entire length of the run with no reducing couplings permitted. Conduits for fiber optic cable shall be clear of obstructions. Water based lubricants shall be used to reduce the potential for outer sheath corrosion.

637.03--Construction Requirements.

637.03.1--Pull box/Enclosures. All enclosures shall be installed in accordance with the manufacturer's recommendations and as shown on the plans. Enclosures shall not be located in the roadway, sidewalk, driveway or other pathway surfaces unless specifically required on the plans. Enclosures shall not be located in drainage collection areas and locations where drainage runoff occurs should be avoided whenever possible. The final grade of enclosure covers shall be flush with adjacent material when they must be installed within sidewalks, islands or barrier walls. The final grade of enclosure covers located in soil or sodded areas shall be approximately one (1) inch higher than adjacent earth or sodded areas. Enclosures located in soil or sodded areas shall be installed with a supporting poured concrete collar, as shown by details on the plans. Enclosures installed in driveways, sidewalks or similar areas shall also be installed with a poured concrete collar between the edge of the enclosure and the edge of the adjacent excavated material. When practical, enclosures shown in the near vicinity of concrete curbing shall be placed adjacent to the back of the curb. Positions of grade-level enclosures are shown on the plans in their relative positions only and if needed shall be repositioned with the approval of the Engineer. A minimum 1-foot depth of crushed gravel underlayment material shall be installed underneath all open bottom enclosures in accordance with details shown in the plans. Underlayment materials may be required in other installations if shown with details in the plans. All enclosure covers shall be secured to the enclosure box using bolts as indicated in detailed drawings in the plans.

All pull boxes provided shall be of the following minimum dimensions for each respective pull box type.

Pull Box Type	Nominal Minimum Dimensions
	Width (inches) x Length (inches) x Depth (inches)
Type 1	11" x 18" x 12"
Type 2	13" x 24" x 18"
Type 3	17" x 30" x 24"
Type 4	24" x 36" x 24"
Type 5	30" x 48" x 24"

637.03.2--Conduit. All material installed shall follow the following guidelines.

Blank duct plugs shall be used to seal the ends of all conduits immediately upon conduit placement. This includes, but is not limited to, intermediate/incomplete sections of conduit prior to conduit splicing or termination in pull boxes and empty conduits in pull boxes prior to cable installation.

All conduits shall either be sealed with blank duct plugs or filled with duct putty or sealant, as approved by the Engineer.

Conduit shall be installed in a straight line horizontal path between pull boxes and/or foundations except where shown otherwise in the plans.

637.03.2.1--Conduit Duct Bank. Continuous flexible conduit installation in earth shall be trenched, horizontal directional bored or drilled, or plowed at the Contractor's discretion, unless otherwise noted on the plans, at a minimum depth of 24-inches from the top of the conduit.

Conduit duct banks shall be installed by configuring individual continuous flexible conduits into a continuous duct bank from termination point to termination point as shown in the Standard Details and other contract documents.

All continuous flexible conduit located under the paved roadway in the plans shall meet the following requirements.

- a) The conduit shall be placed at a minimum depth of 30 inches.
- b) Backfill shall meet Standards for a paved roadway.
- c) All areas shall be completely restored daily according to the time frames set under the approved Traffic Control Plan.

If a drainage or utility conflict arises, the Contractor shall submit a plan for resolving the conflict to the Engineer for review and approval.

Every effort shall be made to minimize coupling. Couplings will be permitted only with the Engineer's prior approval.

Bored or drilled conduit shall meet the following requirements:

- a) All conduits under railroad tracks shall be horizontal directional bored or drilled at a minimum of ten (10) feet below the railroad bed. It is also the Contractor's responsibility to determine any additional requirements from the railroad owner and shall meet those requirements in addition to those included in the plans and these Specifications. Any required steel casings or other materials needed to meet the railroad authority requirements shall be included in the cost of the conduit.
- b) All conduits to be installed under streams shall be horizontal directional bored or drilled. No open trenching through an area deemed to be a current or wet weather stream will be allowed. All conduit bored under streams shall be a minimum depth of five (5) feet below the stream bed.
- c) Bore Logs will be required for each bore location.
- d) The Contractor shall submit a proposed bore log format to the Engineer for review and approval.

Conduit shall be placed in the straightest orientation possible, reducing bends, twists, rises, and waves. Conduits shall be held in place during backfilling when necessary to keep straight and at the proper depth. Where field conditions require the trench to change direction and bends are necessary, the bends shall be formed in the trench and should be

smooth and even and shall not have less than a 4-foot radius, as measured to the inside surface of the conduit.

Every conduit shall be tested after the conduit is installed and before cable or pull tape is installed. Testing shall be performed on all conduit types in these Specifications, including but not limited to, each cell of multi-cell conduits, each conduit in duct banks, and each conduit. All testing shall be performed using the procedures and mandrel size recommended by the conduit manufacturer. Testing shall be performed in the presence of the Engineer. Payment for all testing shall be included in the cost of the conduit.

637.03.2.2--Rigid Galvanized Steel Conduit. Structural and Exposed conduit runs shall be 2-inch rigid galvanized steel unless otherwise required by the plans.

All conduit runs on structures and poles shall be properly terminated into the respective device, or a duct seal shall be installed so as to seal the conduit from moisture, insects, rodents and other foreign material. The costs of the galvanized steel conduit, and all associated fittings shall be included in the cost other items.

Bushings shall be installed in conduit at all exposed conduit terminations for protection of the conductors.

637.03.2.3--Aerially Supported Traffic Signal Conduits. The following requirements are applicable to aerially supported installations:

- a) Conduit entering pull boxes shall terminate two inches inside of the box wall and not less than two inches above the bottom. Conduit entering through the bottom of a pull box shall be located as near the sides and ends as possible to leave the major portion of the box clear. Conduits shall ride freely through boxes for allowance of expansion and contraction.
- b) Expansion fittings as detailed on bridge structure plans shall be installed where conduit crosses an expansion joint in the structure. Where it is deemed inadvisable to install expansion fittings in closely confined areas, the Engineer may permit the installation of approved bronze flexible tubing instead; expansion joints and tubing shall be the same size as the conduit.
- c) All assemblies on concrete structures shall be grounded through a bonding jumper to the rigid metal lighting conduit, which in turn shall be bonded to the steel superstructure or run to the ground.
- d) All conduit, junction boxes, pull boxes, etc., must be attached to bridge structures by means of studs driven by approved methods.
- e) Aerial conduit shall be supported by messenger cable suspended from approved supporting devices when shown on the plans or directed.

637.03.2.4--Marking Tape. As shown in the plans Standard Details, marking tape shall be installed above all underground conduit installed by trenching or plowing.

Marking tape shall be installed in continuous manufactured lengths. No splicing or overlapping will be permitted.

A minimum of four (4) feet of marking tape shall be installed into pull boxes where trenched conduit is terminating. Marking tape shall enter under the lower edge of the pull box.

Marking tape will not be required when conduit is bored or plowed.

637.03.2.5--Conduit Detection Wire. One (1) conduit detection wire is required with all conduits installed by any installation method, including trenching, directional boring, or plowing. Conduit detection wire will be required with all conduits installed by any installation method, including trenching, directional boring, or plowing.

Only one (1) conduit detection wire will be required per installed conduit segment regardless of the number of conduits installed in that segment.

Conduit detection wire shall be installed in conduit.

Conduit detection wire will not be required for structure mounted conduit, except where underground segments of structure mounted conduit are greater than 20 feet in length.

Conduit detection wire will not be required for conduit segments between pull boxes and pole/sign structure foundations, except where conduit segments are greater than 20 feet in length.

The conduit detection wire shall be continuous and unspliced between pull boxes and shall enter the pull boxes at the same location as the conduit with which it is installed, entering under the lower edge of the pull box.

Four (4) feet of conduit detection wire shall be coiled and secured in each pull box or vault.

Testing, as requested by the Engineer, shall be as follows:

- a) a continuity or tone test shall be performed after installation to confirm that a continuous run of conduit detection wire was installed between pull boxes or vaults.
- b) a test plan shall be prepared, supplying equipment, conducting the test and documenting the results. A test plan shall be submitted at least 15 working days prior to the desired testing date. Testing shall not begin until the Engineer has approved the test plan. All tests shall be conducted in the presence of the Engineer.

637.03.2.6--Pull Tape. Pull tape shall be installed into each empty conduit and empty cell within a multi-cell conduit.

The pull tape shall be installed after conduit testing has been completed.

Five (5) feet of slacked pull tape shall be installed and secured in each empty conduit or cell at each pull box.

The pull tape shall be secured by tying it to the blank duct plug for the conduit in which it is installed.

637.03.2.7--Duct Plugs. Blank duct plugs shall be installed in each empty conduit that enters a pull box, ground-mounted cabinet, pole foundation, hub, or building entrance.

Cable duct plugs shall be installed in each conduit containing fiber optic or RDS communications cable that enters a pull box, ground-mounted cabinet, hub, or building entrance.

Cable duct plugs shall not be used on conduits containing power service conductors.

637.04--Method of Measurement. Pull Box Enclosures of the type specified will be measured as unit per each.

Conduit of the type specified will be measured per linear feet to the nearest foot. All conduit types shall be measured along the conduit by the following:

- a) From center of pull box to center of pull box this includes any vertical conduit runs as indicated on plans.
- b) From center of pull box to three (3) feet from a foundation or cabinet. Conduit inside foundation and three (3) feet from a foundation or cabinet shall be included with the foundation.
- c) Continuous Flexible Conduit (Conduit Duct Bank) will be measured by the linear foot for each type of conduit bank indicated after installation and shall include the type and number of conduit indicated below.
 - Conduit Bank: Three (3) – 2-inch Continuous Flexible Conduits
 - 2” Conduit: One (1) – 2-inch Continuous Flexible Conduit or PVC Schedule 40 Conduit.
 - 2” Conduit w/Bank: One (1) – 2-inch Continuous Flexible Conduit installed in the same trench as the related Conduit Bank Type as specified in the Plan Sheet.
 - Conduit Bank Bored: Three (3)– 2-inch Continuous Flexible Conduits
 - 2” Conduit Bored: One (1) – 2-inch Continuous Flexible Conduit
- d) Messenger cable and other supporting devices for aerial supported signal conduit will not be measured for separate payment but shall be incidental to and included in the contract unit price for traffic signal conduit, aerial supported.

Note: Separate encasement for borings is not required unless necessary for proper installation due to poor soil conditions. If encasement is needed in those situations the cost of the encasement shall be included in the cost of the conduit.

637.05--Basis of Payment. Pull Box Enclosures, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing all materials including the cover, installing, crushed gravel underlayment, poured concrete collars, replacement of sod or existing grassing, final clean-up and for all equipment, tools, labor and incidentals necessary to complete the work.

Conduit / Duct Bank, measured as prescribed above, will be paid for per linear feet, which price shall be full compensation for all materials, equipment, labor, trenching, installing, backfilling trench, plowing, directional boring, restoration, marking tape, pull tape, duct plugs, fittings, conduit detection wire, testing, bore logs, and all other incidentals necessary for the installation of the conduit system.

Rigid Galvanized Steel, measured as prescribed above, will be paid for per linear feet, which price shall be full compensation for all materials, equipment, labor, all related materials including but not limited to couplings, mounting straps, bonding to ground, etc.,

that is installed on sign structures, poles or between the pull boxes, and all other incidentals necessary for the installation of the conduit system.

Equipment cabinets will be included in the cost of other items and will not be measured separately.

Marking Tape, Conduit Detection Wire, Pull Tape, Duct Plugs and Sealant will be included in the cost of the conduit and will not be measured separately.

Payment will be made under:

637-A: Pull Box Enclosure, <u>Type</u> , <u>Tier</u>	- per each
637-B: Pull Box Enclosure, Structure Mounted, <u>Type</u>	- per each
637-C: Traffic Signal Conduit, Underground, <u>Type</u> , <u>Size</u>	- per linear foot
637-D: Traffic Signal Conduit, Underground Drilled or Jacked, <u>Type</u> , <u>Size</u>	- per linear foot
637-E: Traffic Signal Conduit, Structural Conduit, <u>Type</u> , <u>Size</u>	- per linear foot
637-F: Traffic Signal Conduit, Aerial Supported, <u>Type</u> , <u>No.</u> , <u>Size</u>	- per linear foot
637-G: Traffic Signal Conduit, Underground Encased in Concrete, <u>Type</u> , <u>Size</u>	- per linear foot
637-H: Traffic Signal Conduit Bank, Underground, <u>Type</u> , <u>No.</u> , <u>Size</u>	- per linear foot
637-I: Traffic Signal Conduit Bank, Underground Drilled or Jacked, <u>Type</u> , <u>No.</u> , <u>Size</u>	- per linear foot
637-J: Traffic Signal Conduit Bank, Structural Conduit, <u>Type</u> , <u>No.</u> , <u>Size</u>	- per linear foot

SECTION 638 - FLASHER ASSEMBLIES

638.01--Description. This work consists of furnishing all components and materials required to assemble flasher assemblies and School Zone Flasher Beacon assemblies, including options for solar powered applications, in accordance to these specifications and the details shown on the plans.

638.01.1--Operational Specifications. The two flashers on the flasher assembly shall alternate on and off when receiving a signal from the traffic controller. The flasher assembly shall have beacons that flash at a rate of not less than 50 or more than 60 times per minute. The illuminated period of each flash shall not be less than 50% of the dwell time. The yellow signals shall be flashed alternately. The beacons shall have a night dimming feature.

The School Zone Flasher Beacon assembly shall be activated by an integrated, programmable microcontroller (Time Switch Unit). The Time Switch Unit shall store at least 500 days of flash data.

638.02--Materials. Materials for the assembly shall meet the following Sections/Subsections:

Traffic Signs and Sign Posts.....	721
Pull Boxes.....	722.06
Traffic Signal Heads.....	722.14

638.02.1--Solar/Battery Unit. All solar/battery units associated with flasher assemblies shall include two (2) 10-watt solar panels no larger than the footprint of the housing. The solar engine shall house two (2) field-replaceable, sealed lead-acid batteries no greater than 24 Ah each. The solar panel and battery system shall be 12 Volt DC. The solar panel shall meet the design qualification and type approval of photovoltaic modules in accordance with IEC 61215. This specification includes radiation testing, thermal testing, and mechanical testing for environmental conditions such as UV-exposure, thermal cycling, as well as degradation of maximum power output.

638.02.2--Solar Engine. All solar engine units associated with Flasher Assemblies shall be constructed from powder coated aluminum. The solar panels shall be integrated into the solar engine. The solar engine shall have the provision to mount an external device for remote activation. The system shall have the capability to power such device. The solar engine must contain sufficient space to house a third party device inside a sealed enclosure located inside the solar engine.

638.02.3--Time Switch Unit. All time switch units associated with School Flasher Assemblies shall be of solid state circuitry, continuous duty with a 7-day cycle clock operating from the 120 volt AC service line. Time switch unit shall automatically compensate for daylight savings time changes.

638.02.4--Hardwired option. Flasher assemblies shall have the option to operate on 120 volt AC electrical service. Flasher assemblies operating on 120 volt AC shall be in accordance with Section 632.

638.03--Construction Requirements. Flashing Assemblies shall be installed at the locations and as indicated in the plans and in conformance with the requirements herein.

638.03.1--Tests and Warranties. After completion of flasher units, the Contractor shall demonstrate by tests to the Engineer's satisfaction that:

- All circuits are continuous and free from short circuits,
- That all circuits are free from unspecified grounds,
- That the resistance to ground of non-grounded conductors is at least one (1) megohm at 60°F measured with a 1000 ohms per volt megger, and
- That the ground resistances are not more than 25 ohms.

The system, including battery packs, solar panel, LED modules and all components, shall be guaranteed for a minimum of three (3) years.

638.03.2--Solar/Battery Unit. The solar engine shall be installed, generally oriented South, and in accordance with the manufacturer’s specifications. All batteries and electronics shall be mounted in the solar engine, with no external control cabinet or battery cabinet will be required. The solar engine shall be vented to provide cooling of the battery and electronic system. Venting shall be covered by wire mesh to prevent intrusion of insects.

638.03.3--Time Switch Unit. The time switch unit shall be installed in a sealed enclosure that is mounted in the solar engine or alternatively in an external enclosure and in accordance with NEMA standards.

638.04--Method of Measurement. The Flasher Assembly and School Zone Flasher Assembly will be measured as a unit quantity per each system installed.

638.05--Basis of Payment. Flasher Assembly and School Zone Flasher Assembly, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing labor, equipment, materials, solar powered options, the sign(s), the post, the post base and foundation, the flashing beacons, sign supports, solid state flasher unit(s), flasher panel, and applicable conduit and wiring on the post itself, stubbed out to the first pullbox, controller programming, final clean-up; and all incidentals necessary to complete the work.

Conduit, pullboxes, and wiring necessary for communication from the traffic controller to the assembly shall be paid for under other item as shown in the plans.

Payment will be made under:

- 638-A: Flasher Assembly * - per each
- 638-B: School Zone Flasher Assembly - per each
- 638-C: Flasher Assembly – Solar Powered - per each
- 638-D: School Zone Flasher Assembly – Solar Powered - per each

* Additional information may be included

SECTION 639 - TRAFFIC SIGNAL PREEMPTION SYSTEMS

639.01--Description. This item consists of providing Railroad Signal Preemption, Type 1 and Type 2 Emergency Vehicle Preemption for the traffic signal controller in accordance with Plan details, the Standard Specifications, these specifications, and as directed by the Engineer.

The Type 1 Emergency Vehicle Preemption for the traffic signal controller shall utilize Radio/GPS to identify the presence of designated priority vehicles and cause the traffic signal controller to advance to and/or hold a desired traffic signal display selected from phases normally available. The Type 2 Emergency Vehicle Preemption for the traffic signal controller shall use optical communication to identify the presence of designated priority

vehicles and cause the traffic signal controller to advance to and/or hold a desired traffic signal display selected from phases normally available.

639.02--Materials. All connections and equipment shall be new and constructed using the highest quality, commercially available components and techniques to assure high reliability and minimum maintenance of the emergency vehicle and railroad signal preemption systems.

The requirements for the emergency preemption vehicle equipment in Subsection 639.02.2.1 are to be furnished and installed by the local maintaining agencies and not the responsibility of the Contractor. However, it is the responsibility of the Contractor to provide the intersection preemption equipment required in Subsection 639.02.2.2 and 639.03 that is compatible with the equipment listed in Subsection 639.02.2.1.

639.02.1--Railroad Preemption. The Railroad Signal Preemption shall consist of the minimum following components:

- Coordination
- Flagger (as required)
- Application Submittals (as required)
- Connections to hardware (as required)

639.02.2--Type 1 and Type 2 Emergency Vehicle Preemption. Emergency Vehicle Preemption Systems shall consist of the following principal Intersection Equipment components: Detectors/Receivers, Multimode Phase Selectors, and Auxiliary Interface Panel. The function intended for use with this system includes Emergency Vehicle Preemption to the traffic signal.

639.02.2.1--Vehicle Equipment.

639.02.2.1.1--Type 1 Emergency Vehicle Preemption.

639.02.2.1.1.1--Antenna. A GPS receiver and antenna shall obtain the vehicle position, speed and heading from the GPS satellite system operated by the Department of Defense (DOD). The time information from the GPS satellites shall also be used to synchronize the frequency hopping of the 2.4 GHz radio.

The Radio/GPS antenna cables shall consist of a pair of 25-foot coax cables with factory terminated SMA connectors. One of these connectors shall have a pin and the other shall have a socket.

639.02.2.1.1.2--Vehicle Control Unit. The vehicle control unit shall provide the interface between the vehicle and the priority control system. The vehicle control unit shall also interface with the Radio/GPS module. The vehicle control unit shall monitor the status of the vehicle turn signal via an interface cable that will connect between the vehicle control unit and the left and right turn signal lines in the vehicle. The vehicle control unit shall also monitor the disable input line as well as the remote activation input. Power to the vehicle equipment shall be provided through the vehicle control unit.

The vehicle shall transmit the following information when within range of an equipped intersection:

- The priority level of the vehicle equipment. This shall be either high priority or low priority. The priority level shall be factory set. Each vehicle control unit shall be capable of setting 254 different agency IDs and 15 different vehicle type classifications with 9,999 different identification numbers per class.
- The location, speed and heading of the vehicle.
- The status of the vehicle's turn signal.
- The radio channel as assigned by the intersection and the serial number of the Vehicle Control Unit.

The vehicle shall be capable of being wired so that the GPS data is available either while the equipment is requesting priority or when not requesting priority. The vehicle control unit shall be equipped with an ON/OFF switch to activate the system and request priority. The switch shall be depressed to activate the system. In addition, a remote activation line shall be provided to interface with other vehicle equipment. This line shall have +12 VDC applied to request priority. The equipment shall be configured to activate with the light bar/remote activation line or via the ON/OFF switch.

The vehicle equipment shall be supplied complete with a 20-foot minimum installation cable as well as a 15-foot minimum vehicle interface cable.

The vehicle control unit shall include multi-purpose communication ports compliant with the RS-232 communication standard. These ports shall enable unit configuration to be set into the vehicle control unit and read from vehicle control unit. It also shall allow real-time communication between the vehicle control unit and the interface computer as well as interfacing with other devices. One of the ports shall be configured to output GPS data at a user selectable baud rate in the NMEA format while the vehicle control unit is turned On. It shall output the following messages (depending on the baud rate):

- GGA Global Positioning System Fix Data (2400 baud and higher)
- GSA GPS DOP and active satellites (2400 baud and higher)
- GSV Satellites in view (4800 baud and higher)
- RMC Recommended Minimum Navigation Information (1200 baud and higher)

The vehicle control unit shall also have a series of indicator lights that will operate as follows:

- A power indicator as well as an indicator light in the switch will indicate that the equipment is powered On.
- A GPS indicator will indicate the status of GPS reception.
- An indicator will indicate the status of the communication between the vehicle control unit and the Radio/GPS unit.
- A disable indicator will indicate if the vehicle equipment is in a Disable mode. The disable indicator and the indicator in the power switch will flash green or any other color as approved by the Engineer.
- The indicators shall be capable of being programmed to provide feedback for the following:
 - Phase selector has received preemption request.
 - Another vehicle approaching the intersection has received the preemption request.

- Phase selector has received preemption request and another equipped vehicle is approaching the intersection from another direction.

The vehicle control unit shall be equipped with a disable input that, when activated, will cause the radio to transmit that the vehicle is in Disable mode, thereby eliminating the possibility of the priority request continuing after the priority vehicle has arrived at its destination. The disable input shall be programmable to operate in either a latching or non-latching mode. The disable input shall be programmed so that the input may be activated by applying ground or by applying +12 VDC. Operation of the disable input shall be programmable using software. Additional inputs shall be included to temporarily switch the vehicle control unit to low priority and to Probe Mode. The vehicle equipment shall operate over a temperature range of -30°F to 165°F and a relative humidity range of 5% to 95%. Windows™ based software shall be available for programming the vehicle control unit through its RS-232 compatible multi-purpose port.

639.02.2.1.1.3--Radio. The Radio shall operate in the reserved Industrial, Scientific and Medical (ISM) communications band, requiring no license. A 2.4 GHz spread spectrum/frequency hopping radio shall provide the communications from the vehicle to the intersection when within range of a Radio/GPS equipped intersection. The radio shall have a transmit power of not more than one (1) watt. The radio shall have an unobstructed range of at least 2,500 feet. The radio shall meet FCC Part 15 rules. Radio link association and coordination among intersections and vehicles shall be automatic.

639.02.2.1.2--Type 2 Emergency Vehicle Preemption.

639.02.2.1.2.1--Emitter. The emitter shall include a multi-purpose communication port compliant with the SAE J1708 communication standard. This port shall enable unit configuration to be set into the emitter and read from the emitter. It also shall allow real-time communication between the vehicle and the emitter.

An ON/OFF switch (available for each emitter) shall be equipped with an indicator light providing internal diagnostics to assist in troubleshooting.

While operating, the emitter shall conduct self-diagnostics designed to monitor data transmission integrity by checking for missing pulses. Any failures of the self-diagnostic tests shall be displayed by flashing of the ON/OFF switch indicator light.

The emitter shall be equipped with a disabling input that, when activated, will cause the emitter to stop flashing. This input shall eliminate the possibility of inadvertent signal transmission after the priority vehicle has arrived at its destination. The disable input shall be programmable to operate in either a latching or non-latching mode. Operation of the disable input shall be programmable using software.

The emitter shall provide operating modes that allow it to be powered on with the strobe/LEDs for activation of the preempt.

The emitter shall be powered by the DC voltage supplied from the battery of the vehicle, 10 to 32 volts DC.

The unit shall be equipped with a weatherproof in-line fuse holder and a weatherproof quick-disconnect plug.

The emitter shall contain visible light LEDs which may be user configured as follows:

- Flash at emitter flash rate during normal operation.
- Flash at diagnostic rate when unit has failed or is in disable mode.
- Off during normal operation, flash at diagnostic rate when unit has failed or is in Disable mode. The visible LEDs will be Off during normal operation.
- Flash once per second for ten (10) seconds at power up.
- Always Off: The visible LEDs will remain Off at all times.

The Emitter shall be supplied complete with a two (2) foot installation cable.

The flash sequence generated by the emitter shall carry three (3) types of information:

- The first type shall be one (1) of three (3) distinctly different base frequencies of:
 - 10Hz for a low priority emitter;
 - 14Hz for a high priority emitter; or
 - 12Hz for Probe frequency.
- The second type of information generated by the emitter shall be a vehicle classification and identification code that is interwoven into the base frequency flashes. Setting the vehicle classification and identification code shall be accomplished through Emitter Programming Software.
- The third type of information generated by the emitter shall be reserved for setting the intersection detection range. A specially equipped emitter control module with a range setting command switch will enable the Engineer to activate the range code from the vehicle.

The emitters shall use infrared LEDs with an angle of half intensity of ± 10 degrees to provide precise directionality control. The emitter shall operate over a temperature range of -30°F to $+165^{\circ}\text{F}$. The emitter shall operate over a relative humidity range of 5% to 95%. Windows™ based software shall be available at no charge for programming the emitter through its SAE J1708 compatible multi-purpose port.

639.02.2.2--Intersection Equipment.

639.02.2.2.1--Multimode Phase Selector. The multimode phase selector recognizes inputs from both infrared and Radio/GPS activation methods at the intersection and supplies coordinated inputs to the controller.

The multimode phase selector shall be designed to be installed in the traffic controller cabinet and is intended for use directly with numerous controllers. These include Type 170/2070 controllers with compatible software, NEMA controllers, or other controllers along with the system card rack and suitable interface equipment and controller software.

The multimode phase selector shall include the ability to directly sense the green traffic controller signal indications through the use of dedicated sensing circuits and wires connected directly to field wire termination points in the traffic controller cabinet. This connection shall be made using the Auxiliary Interface Panel.

The multimode phase selector will be a plug-in, 4-channel, multiple-priority, multi-modal device intended to be installed directly into a card rack located within the controller cabinet. The multimode phase selector shall be capable of using existing infrared or Radio/GPS system card racks. The multimode phase selector shall be powered from either +24 VDC or 120 VAC.

The multimode phase selector shall support front-panel RS-232, USB and Ethernet interfaces to allow management by on-site interface software and central software. An RS-232 port shall be provided on the unit. Additional RS-232 communication ports shall be available using the Auxiliary Interface Panel.

The multimode phase selector shall have the capability of storing a minimum of 10,000 priority control calls. When the log is full, the phase selector shall drop the oldest entry to accommodate the new entry. The multimode phase selector shall store each call record in non-volatile memory and shall retain the record if power terminates.

The multimode phase selector shall support a minimum of 5,000 code pairs (agency ID, vehicle ID) for each of the priority levels, high and low, providing unique vehicle identification and system security implementation at the vehicle level.

The multimode phase selector shall include several programmable control timers that will limit or modify the duration of a priority control condition, by channel. The control timers will be as follows:

- Max call time
- Off approach call hold time
- Lost signal call hold time
- Call delay time

The multimode phase selector shall have the ability to enable or disable all calls of all priority levels. This shall be independently settable by channel.

A unique intersection name, which shall be broadcast, shall be settable for each Multimode Phase Selector.

Up to 25 different radio channels shall be available to be assigned to the multimode phase selector.

The multimode phase selector shall operate in a mode that shall vary the output based on the status of the approaching vehicle's turn signal. Additional outputs available on an auxiliary interface panel may be needed. Settings shall be available for this mode as follows:

- Output mappings for each channel.
- Separate setting for high and low priority levels.
- Separate settings for each left turn, right turn or straight signal status for each of the four (4) channels and priority levels.

The multimode phase selector's default values shall be programmable by the operator on-site or at a remote location.

The multimode phase selector shall be capable of three (3) levels of signal discrimination, as follows:

- Verification of the presence of the signal of either high priority or low priority.
- Verification that the vehicle is approaching the intersection within a prescribed Estimated Time of Arrival (ETA).
- Determination of when the vehicle is within the prescribed range, either by intensity level or distance from the intersection.

The multimode phase selector shall include one (1) opto-isolated NPN, or sinking, output per channel that provides the following electrical signal to the appropriate pin on the card edge connector:

- 6.25Hz \pm 0.1Hz 50% on/duty square wave in response to a low priority call.
- A steady ON in response to a high priority call.
- The multimode phase selector will also have the option of providing separate outputs for High and Low priority calls for controllers that do not recognize a 6.25 Hz pulsed low priority request.
- Additional outputs or output modes shall also be available on the Auxiliary Interface Panel in case of need for additional modes of operation.

The multimode phase selector shall accommodate the following three (3) methods for setting range thresholds for High and Low priority signals.

- Based on the approaching vehicle's Estimated Time of Arrival (ETA). This shall be settable between zero (0) and 255 seconds in one (1) second increments.
- Based on the approaching vehicle's distance from the intersection. This shall be settable in one (1) foot increments.
- Based on emitter intensity the system shall accommodate setting a separate range from 200 feet to 2,500 feet with range set points for both High and Low priority signals.

The multimode phase selector will have the following indicators:

- A status indicator that illuminates steadily to indicate proper operation.
- A link indicator on the multimode phase selector illuminates if other radios are within range.
- A radio indicator that indicates the status of the communication between the vehicle control unit and the Radio/GPS unit. The indicator illuminates to indicate that there is communication between the vehicle control unit and the Radio/GPS unit. The indicator illuminates to indicate that a GPS signal has been acquired and the 2.4 GHz radio is on the air.
- LED indicators (one (1) for high priority, one (1) for low priority) for each channel display active calls as steady ON and pulse to indicate pending preemption requests.

The multimode phase selector shall have a test switch for each channel to test proper operation of High or Low priority.

The multimode phase selector shall utilize the time obtained from the GPS satellites to time stamp the activity logs. The user will set the local time zone (offset from GPS time) via the interface software.

The interface software shall have the capability to set the multimode phase selector to automatically adjust the GPS time offset for changes in daylight savings time.

An auxiliary interface panel shall be available to facilitate interconnections between the multimode phase selector and traffic cabinet wiring as well as provide additional outputs.

A multimode phase selector port may be configured to output GPS data at a user selectable baud rate in the NMEA 0183format. It will output the following messages depending on the baud rate:

- GGA - Global Positioning System Fix Data (2400 baud and higher)
- GSA- GPS DOP and active satellites (2400 baud and higher)
- GSV - Satellites in view (4800 baud and higher)
- RMC - Recommended Minimum Navigation Information (1200 baud and higher)

The following diagnostic tests are incorporated in the multimode phase selector:

- Power up built in test
- Communications port tests
- Preemption output test call
- Detector response test

The multimode phase selector shall be capable of call bridging.

When used with a GPS radio unit, the multimode phase selector shall relay a priority request to the next adjacent intersection based on the direction indicated by the vehicle's turn signals.

The multimode phase selector shall support evacuation mode for Low priority calls.

The multimode phase selector shall allow relative priority.

639.02.2.2.2--Card Rack. The required card rack shall provide simplified installation of a multimode phase selector into controller cabinets that do not already have a suitable card rack.

The card rack shall be factory wired with one (1) connector, located behind the card slot, and one (1) connector on the front of the card rack.

The card rack connector on the front shall provide for connections to the traffic controller. The Contractor shall verify card rack requirements with the Engineer prior to submitting this equipment.

One (1) version of the card rack shall contain a 24 VDC power supply to power the phase selector. The power supply shall be capable of being powered by 100-240 VAC 50-60 Hz.

Another version of the card rack shall pass 120 VAC through to the rear card rack connector. This version shall provide labeled terminal blocks for connecting the primary infrared detectors to a phase selector.

Additionally, there shall be an optional card rack with a built-in Electromechanical Relay for use in switching high current loads such as flashers and gate operators. The relay shall be capable of switching the following loads.

<u>Resistive:</u>	10 A, 240 VAC	<u>General Use:</u>	7.5 A, 120 VAC
	10 A, 30 VDC		7.5 A, 240 VAC
			7 A, 30 VDC
			1/6 hp, 120 VAC
			1/3 hp, 240 VAC

639.02.2.2.3--Electrical and Environmental Requirements. All equipment supplied as part of the priority control system intended for use in the controller cabinet shall meet the following electrical and environmental specifications spelled out in the NEMA Standards Publication TS2 2003, Part 2: v02.06:

- Line voltage variations per NEMA TS2 2003, Paragraph 2.1.2.
- Power source frequency per NEMA TS2 2003, Paragraph 2.1.3.
- Power source noise transients per NEMA TS2 2003, Paragraph 2.1.6
- Temperature range per NEMA TS2 2003, Paragraph 2.1.5
- Humidity per NEMA TS2 2003, Paragraph 2.1.5
- Shock test per NEMA TS2 2003, Paragraph 2.2.9.
- Vibration per NEMA TS2 2003, Paragraph 2.2.8
- Non-Destructive Transient immunity NEMA TS2 2003, Paragraph 2.1.8.
- Input-output terminals NEMA TS2 2003, Paragraph 2.1.7.
- FCC Part 15 Subpart B Class A EMC Standard
- Canada ICES-003, Issue 4:2004 Class A EMC Standard
- EN50293: 2000 Electromagnetic Compatibility--Road Traffic Signal Systems--Product Standard.
- EN 61326-1:2006 EMC Standard.
- EN 55011:2007 +A2:2007 EMC Standard.

639.02.2.2.4--Type 1 Emergency Vehicle Preemption.

639.02.2.2.4.1--Intersection Radio/GPS Module. A GPS receiver and antenna shall obtain the intersection position from the GPS satellite system operated by the DOD. The time information from the GPS satellites shall be used to synchronize the frequency hopping of the 2.4 GHz radio and to time stamp the activity log. The GPS receiver and the GPS antenna shall reside inside of the Radio/GPS module.

A 2.4 GHz spread spectrum/frequency hopping radio shall provide the communications from the intersection to the vehicle as well as from intersection to intersection, or as shown in the plans.

As an alternate, the following Radio/GPS unit and Radio GPS antenna may be used in the intersection.

The Radio/GPS antenna shall be a hemispherical dome with a pair of 15-foot coax cables with factory terminated SMA connectors. One (1) of these connectors shall have a pin and the other will have a socket. This antenna shall include one (1) element for receiving the GPS signal and one (1) element for transmitting and receiving the radio signal. This antenna, along with the radio/GPS module, may also be used in the intersection.

The radio shall have a maximum transmit power of not more than one (1) watt. The radio shall have an unobstructed range of at least 2,500 feet. The radio will meet FCC Part 15 rules. The radio and the radio antenna shall reside inside of the Radio/GPS module.

The Radio/GPS module shall be housed in an impact resistant polycarbonate housing that will include a water resistant wire entry point. It shall contain a water resistant access cover to facilitate cable termination.

The Radio/GPS module shall be designed for mounting at or near an intersection on mast arms and span wire poles. Additional hardware may be needed.

The Radio/GPS module shall communicate to the multimode phase selector via a Radio/GPS cable up to 250 feet in length.

639.02.2.2.4.2--Radio/GPS Cable. The Radio/GPS cable shall deliver sufficient power from the multimode phase selector to the Radio/GPS module and will deliver the necessary quality signal from the Radio/GPS module to the multimode phase selector over a non-spliced distance of 250 feet.

Coaxial cable will not be permitted for this cable.

The Radio/GPS cable shall deliver sufficient power from the vehicle control unit to the Radio/GPS module and will deliver the necessary quality signal from the Radio/GPS module to the vehicle control unit over a non-spliced distance of 50 feet.

The cable shall be of durable construction to satisfy the following installations:

- Direct burial.
- Conduit and mast arm.
- Exposed overhead (supported by messenger wire)

The outside diameter of the cable shall not exceed 0.4 inches. The insulation rating of the cable shall be 300 volts minimum.

The temperature rating of the detector cable will be -40°F to +194°F.

The conductors shall be AWG #20 (7x28) stranded and individually tinned. The cable shall be shielded and have a drain wire to provide signal integrity and transient protection.

When the aluminum enclosure version of the Radio/GPS module is used, the Radio/GPS cable assembly shall use a 15-pin connector that will mate with the connector on the Radio/GPS module.

639.02.2.2.5--Type 2 Emergency Vehicle Preemption.

639.02.2.2.5.1--Optical Detector.

639.02.2.2.5.1.1--General. The optical detector shall be a light-weight, weather proof device capable of sensing and transforming pulsed optical energy into electrical signals for use by the traffic signal phase selection equipment.

639.02.2.2.5.1.2--Functional Requirements. The optical detector unit shall perform the following functions and meet the requirements listed below.

- a) The unit shall be high-impact polycarbonate construction with stainless steel and/or brass hardware. The unit shall be designed for easy mounting at or near an intersection on mast arm, pedestal, pole, or intersection span wire.
- b) The unit shall accept optical signals from one (1) or two (2) directions and provide a single electrical output signal, as specified in the plans. The unit shall include a design feature to allow aiming of the two optical sensing inputs for hills, skewed approaches or slight curves.
- c) The unit shall have built-in terminal strip to simplify wiring connections. The unit shall receive power from the traffic signal phase selector equipment and have internal voltage regulation to be operational from 16 to 40 volts AC.
- d) The unit shall be responsive to the optical emitter at a distance of 1,800 feet. The unit shall deliver the necessary electrical signal to the traffic signal phase selector equipment via up to 1,000 feet of optical detector cable.
- e) The unit shall employ replacement circuit board assembly and photocells to facilitate repair.

639.02.2.2.5.2--Optical Detector Cable. The optical detector cable shall meet the requirements listed below.

- (a) The cable shall guarantee delivery of the necessary quality signal from the optical detector to the traffic signal phase selector equipment over non-spliced distance of 1,000 feet. The cable shall guarantee sufficient power to the optical detector over a non-spliced distance of 1,000 feet.
- (b) The cable shall be of durable construction for installation by direct burial, in conduit or mast arm, or exposed overhead supported by messenger wire. The weight of the cable shall have a minimum insulation rating of 600 volts and a temperature rating of 80°C.
- (c) The cable shall have three (3) conductors of AWG 20 stranded, individually tinned copper color coded as follows.
 1. Orange for delivery of optical detector power (+)
 2. Blue for optical detector power return (-)
 3. Yellow for optical detector signal

The conductors will be shielded with aluminized polyester and have an AWG #20 stranded and individually tinned drain wire to provide signal integrity and transient protection. The shield wrapping shall have 20% overlap to ensure integrity following conduit and mast arm pulls.

639.03--Construction Requirements.

639.03.1--Railroad Preemption. The Contractor shall secure all items that are required to complete the installation. The Contractor shall coordinate with the railroad company for the connection of the Railroad Signal Preemption to the railroad controller's contact closure termination point as indicated in the Plans. The Contractor shall contact the railroad company prior to starting any construction to obtain any requirements for the connection.

During construction, the Contractor shall meet all railroad requirements to provide the connection including:

- Boring, Jacking, or Trenching of casing pipe, conduit, roll pipe, or any other required materials.
- Conduit connections into cabinet
- Contact closure cable connections on termination blocks

When required by the railroad company and any agreements, the Contractor shall furnish a Flagger to accommodate work within the railroad right of way. The Contractor shall schedule all work to minimize time within the right of way.

639.03.2--Type 1 and Type 2 Emergency Vehicle Preemption.

639.03.2.1--Vehicle Equipment. Equipment shall be the responsibility of the local maintaining agency for all necessary equipment and installation.

639.03.2.2--Intersection Equipment. The Contractor shall install, configure, and demonstrate a fully functional Emergency Vehicle Preemption System as shown in the Plans. Contractor shall install all equipment according to the manufacturer's recommendations. The Type 1 intersection equipment including, the multimode phase selector, intersection Radio/GPS module, associated Radio/GPS cabling, and card rack shall be installed per the manufacturer's recommendations or as outlined in the plans and/or contract documents. The Type 2 intersection equipment including, the multimode phase selector, intersection optical detector, associated optical detector cabling, and card rack shall be installed per the manufacturer's recommendations or as outlined in the plans and/or contract documents. All installation requirements of the equipment manufacturer shall be followed unless otherwise directed by the Engineer. All necessary equipment shall be mounted in the cabinet and configured according to the Plans, Contract Documents, and manufacturer's recommendations. The completed installation shall present a neat and positive appearance and shall not in any way interfere with the proper operation of the traffic signal system installation of which it is part.

639.04--Method of Measurement. Railroad Signal Preemption, Optical Detector, Multimode Phase Selector, Radio/GPS Module will be measured per each. Optical Detector Cable and Radio/GPS Cable will be measured by the linear foot, which measurement will be computed horizontally and vertically along the pole, conduit or messenger cable which the electric cable is placed, from center to center of the several installations comprising the circuits. No extra length will be allowed for cable inside signal heads, drip loops, or sag in aerial supported cable. The terminals for the measurements of lengths will be considered specifically as the center of the pull boxes, poles, signal heads or controller cabinets.

639.05--Basis of Payment. Railroad Signal Preemption, Optical Detector, Multimode Phase Selector, Radio/GPS Module, Optical Detector Cable and Radio/GPS Cable, measured

as prescribed above, will be paid for at the contract price per each or linear foot, which price shall be full compensation for coordinating and accommodating railroad requirements, providing hardware, sealing; testing, cabling, connections, documentation, configuration, flagger, training, materials, labor, tools, equipment, and all other incidentals necessary to complete the work and provide a fully functional preemption system.

Payment will be made under:

639-A: Railroad Signal Preemption	- per each
639-B: Optical Detector	- per each
639-C: Multimode Phase Selector	- per each
639-D: Radio/GPS Module	- per each
639-E: Optical Detector Cable	- per linear foot
639-F: Radio/GPS Cable	- per linear foot

SECTION 640 - INDUCTIVE LOOP VEHICLE DETECTION SYSTEMS

640.01--Description. This work consists of furnishing all component materials required to form complete independent vehicle inductive loop detection systems as specific herein. This includes assembling, constructing, testing, and installing same in conformity with these specifications to ensure properly operating units in accordance with the design or as directed.

640.02--Materials. Materials shall include shielded cable, vehicle loop assemblies and loop detector amplifiers and shall conform to the requirements of this Section.

640.02.1--Conduit. Conduit shall be in accordance with Section 637.

640.02.2--Inductive Loop Detection System. Inductive Loop Detection System shall consist of the following principal components: two (2) or more turns of insulated loop wire wound in shallow slot sawed in the pavement, lead-in cable from the curbside pull box to the intersection controller cabinet, and an electronics unit housed in a nearby controller cabinet. The functions intended for use with this system include Vehicle Detection and Data Collection – special detection.

640.02.2.1--Loop Detector Wire. Loop detector wire shall be cross-linked polyethylene insulated loop detector wire rated at 600 volts that meets the requirements of IMSA Specification No. 51-3.

640.02.2.2--Loop Detector Lead-In Cable and Shielded Cable. Loop detector lead-in cable shall be shielded cable conforming to IMSA Specification No. 50-2, for polyethylene insulated, polyethylene jacketed Loop Detector Lead-in Cable. Unless otherwise indicated, the cable shall be AWG # 14, 2-conductor or AWG #18, 4-conductor.

640.02.2.3--Sealant. Sealant material shall be a polyurethane sealant conforming to the

requirements herein. The material shall be manufactured specifically for this use and shall be used in accordance with the manufacturer's instructions. The material shall be dielectric, have no detrimental effect on cable insulation, and bond to either portland cement or bituminous concrete paving with minimal shrinkage. The material shall, when cured, retain flexible characteristics and accommodate movement associated with portland cement and bituminous concrete pavements. The material shall not track in hot weather and shall be suitable for applying when the surface temperature is between 50°F and 130°F. The material shall be resistant to the effects of weather, vehicular abrasion, motor oils, gasoline, antifreeze solution, brake fluid, and deicing chemicals normally encountered.

The polyurethane sealant shall be a one-part moisture curing compound requiring no mixing or application of heat prior to or during installation. The sealant shall meet the following additional requirements.

Properties	Requirement	Test Procedure
Viscosity (uncured)	30,000 cps	ASTM: D 1048 (B)
Tack-Free Time (uncured)	24 hrs., maximum	ASTM: D 1640
Hardness, Shore A (cured)	85	ASTM: D 2240
Elongation (cured)	250%	ASTM: D 412
Tensile Strength (cured)	500 psi, minimum	ASTM: D 412

Packaging	Minimum Shelf Life
Liter Ply Packs	9 Months
Five Gallon Containers	12 Months

If deemed necessary during the review process, the Engineer may require the Contractor to submit manufacturer's certification to meet the above requirements.

640.02.2.4--Loop Detector Amplifiers. Loop Detector Amplifiers shall be rack-mounted, digital, solid-state, self-tuning inductive loop detector cards with extend and delay output features. The Loop Detector Amplifier Card shall have the following minimum features and operational requirements.

640.02.2.4.1--Tuning. The amplifier card shall tune automatically upon the application of power in accordance with NEMA TS2 2003 v02.06 Section 6.5.2.20.

640.02.2.4.2--Modes of Operation. Each amplifier card channel shall be capable of functioning in both presence and pulse mode in accordance with NEMA TS2 2003 v02.06 Section 6.5.2.17.

640.02.2.4.3--Sensitivity Control. Each channel of the amplifier card shall meet NEMA TS2 2003 v02.06 Section 6.5.2.15 requirements for sensitivity controls.

640.02.2.4.4--Crosstalk Avoidance. The amplifier card shall be capable of preventing crosstalk between channels of the same unit in accordance with NEMA TS2 2003 v02.06 Section 6.5.2.23.

640.02.2.4.5--Outputs. Each output device shall conform to NEMA TS2 2003 v02.06 Section 6.5.2.26 requirements.

640.02.2.4.6--Controls and Indicators. All amplifier card controls and indicators shall be in accordance with NEMA TS2 2003 v02.06 Section 6.5.2.25.

640.02.2.4.7--Self-Tracking. The amplifier card shall automatically accommodate after-tuning changes in the loop/lead-in in accordance with NEMA TS2 2003 v02.06 Section 6.5.2.21.

640.02.2.4.8--Detection of Continuous Traffic Queues. Each amplifier card channel shall provide unlimited detection of continuous traffic without loss of detection in long peak-hour traffic queues. Vehicle movement over the loop shall re-start presence hold time.

640.02.2.4.9--Built-in Noise Rejection Circuitry. The amplifier card electronics shall be adequately protected from transient voltages and currents which may occur on both power lines and loop leads.

640.02.2.4.10--Loop Detector Amplifier Tests. Each amplifier card shall conform to the performance requirements set forth in NEMA TS2 2003 v02.06 Section 2.8.

640.02.2.4.11--Channel Labeling. A space for labeling each channel shall be provided on the front of each detector card. Each channel shall be labeled with its associated phase.

640.02.2.4.12--Delay and Extension Timing. When called for in the plans, the amplifier card shall contain the necessary electronics to provide delayed call and extended call operation. Timing shall be digital and selection of delayed, extension or normal detector operation shall be accomplished via front panel control. Delay and Extension timing shall be settable on a per channel basis with the timing programmed independently. Detector card delay timing capabilities shall be provided in accordance with NEMA TS2 2003 v02.06 Section 6.5.2.24.1. Detector card extension timing capabilities shall be provided in accordance with NEMA TS2 2003 v02.06 Section 6.5.2.24.2.

640.02.2.4.13--Communications. The amplifier card shall be equipped with a front panel RS232 serial port for transmission of data.

640.02.2.4.14--Software. The detection device shall be provided with vendor PC software necessary to completely configure the detector sensor and accessory devices. The software shall be capable of operating on a PC operating system using the communication ports on the detector card(s). The software shall provide access to read or change configuration settings, fault identification, monitor real-time activity, and to retrieve traffic data, if present.

Vendor supplied PC software for interfacing with the amplifier card shall be capable of displaying loop system operating characteristics on a per channel basis, including collecting and sorting speed, volume and occupancy data from each channel.

640.03--Construction Requirements. The Contractor shall install, configure, and demonstrate a fully-functional Vehicle Detection System as shown in the plans. The Contractor shall install all equipment according to the manufacturer's recommendations.

640.03.1--Inductive Loop Detection System Installation.

640.03.1.1--Loop Detector Amplifier(s). Each loop detector amplifier shall be mounted in the cabinet card rack.

640.03.1.2--Saw Cuts. A chalk line or equivalent method shall be used to outline the perimeter of the loop on the pavement and routes for lead-in cables. The saw cut in the pavement shall not deviate by more than one (1) inch from the chalked line. All saw cuts shall be cleaned, free of any dust, dirt, or other debris and completely dry prior to installation of the loop wire, loop wire twisted pair lead, or lead-in cable. There shall be no cutting dust, grit, oil, free water or other contaminants in the saw cut. Loop wire shall be installed in saw cuts in the roadway made by a diamond or abrasive power saw. The slot width and depth shall be as indicated in the plans; however, in all cases the slot shall be of sufficient depth to provide for a minimum of 1-inch cover between the top of the loop wires and the roadway surface. The saw cuts shall be overlapped so that the slot has full depth at all corners. All corners where loop wires turn shall be diagonally cut so that there are no jagged edges or protrusions that may damage the wire.

Where possible, the loop assembly shall be placed prior to the final surface lift of asphalt. Where lead-in cable is required to pass through the curbside, it shall be installed in ¾-inch rigid steel conduit. Saw cutting through the curb shall not be permitted.

640.03.1.3--Loop Wire. All loops shall be wound in a clockwise manner and the first turn of the loop wire shall be placed in the bottom of the saw cut, with each subsequent turn placed on top of the preceding turn. The loop wire shall be pushed to the bottom of the saw cut with a non-metallic tool which will not damage the insulation. The clockwise “lead” of each loop shall be tagged and identified. Alternate polarity shall be used on adjacent loops. The hold down material shall be non-metallic, placed in the saw slot using segments one (1) to two (2) inches long, spaced 12 inches apart, and the distance from the top of the hold down material to the final surface of the roadway is not less than 1½ inches. Loop wire shall not have any cuts, nicks, abrasions or breaks in the insulation before or after installation in the slot. Any wire having defects in the insulation shall be replaced at Contractor's cost. Loops shall have sufficient turns of loop wire to conform to the following tables unless the manufacturer of the loop detector being used specifically recommends different inductance values. Loop location and configuration shall be as shown on the plans unless otherwise directed.

Rectangular Loop Inductance (µh) for 3 Turns

Loop Size (feet) W x L	@ f = 1 kHz	@ f = 20 kHz	@ f = 40 kHz	@ f = 60 kHz
6 x 6	74.46	74.39	74.28	74.25

Rectangular Loop Inductance (μh) for 2 Turns

Loop Size (feet) W x L	@ $f = 1$ kHz	@ $f = 20$ kHz	@ $f = 40$ kHz	@ $f = 60$ kHz
6 x 20	83.80	83.71	83.59	83.59
6 x 30	117.66	117.58	117.57	117.83
6 x 40	151.48	151.47	151.72	152.49
6 x 50	185.28	185.41	186.12	187.75

Quadrapole Loop Inductance (μh) for 2 Turns

Loop Size (feet) W x L	@ $f = 1$ kHz	@ $f = 20$ kHz	@ $f = 40$ kHz	@ $f = 60$ kHz
6 x 50	421.56	425.01	436.39	457.72

640.03.1.4--Loop Sealant. All saw cuts with the wire installed shall be inspected and approved by the Department designee before the sealant is installed.

The Contractor shall install the sealant in strict adherence to the manufacturer's recommendation and these specifications.

No sealant shall be installed during inclement weather or under any condition that might introduce moisture into the saw slots.

The viscosity of the sealant shall be such that it can be readily poured into the slot, completely surround the wires, displace all air and fill the slot so that the sealant is flush with the roadway surface. The finished sealed slot shall be waterproof and present a neat workmanlike appearance.

The sealant shall be sufficiently hardened before allowing traffic on it.

640.03.2--Shielded Cable. Shielded cable from the loop lead-in to the detector amplifier shall be of one continuous length and installed in conduit or aerially supported on messenger cable and spliced to the loop lead-in wires in the pull boxes or equal weather-tight enclosures.

All splices in pull boxes shall be carefully made to ensure constant low resistance and shall be insulated by means of a waterproof splice. The loop lead-in shall be spliced to the shielded cable using butt splice crimp connectors. The connectors shall then be coated with a waterproof adhesive. Each splice shall then be separately wrapped with an all-weather electrical tape and a self-bonding electrical tape. Finally, both splices shall be wrapped together with an all-weather electric tape and coated with a waterproof adhesive.

Shielded cable shall be solidly fastened with ring lugs to the terminal strip in the detector equipment cabinet or controller cabinet. Both ends of the shielded drain wire shall be cut off flush and waterproofed so as to not come in contact with the pull box or ground.

All work performed shall present a neat and workmanlike appearance.

Installation of shielded cable in conduit or aerial shall comply with applicable provisions

of Section 637.

640.03.2.1--Splicing. Loop wire, including twisted pair loop wire, shall be one continuous length of wire with no splices. There shall be no splices in the shielded cable unless otherwise directed by the Engineer or shown on the plans.

640.03.2.2--Terminations. Lead-in cables or twisted pair loop wire shall be terminated using insulated terminal lugs on a terminal strip, which is located in the controller or detector cabinet. A calibrated ratchet type crimping tool shall be used to attach the lugs to the conductors of the lead-in cable or twisted loop wire.

640.03.2.3--Loop Assembly Identification. Loop lead-in wires or shielded cable terminating in controller cabinets, detector cabinets or pull boxes shall be uniquely identified by an insulated, waterproof tag. Identification shall indicate the lane and the direction of traffic it detects.

640.03.2.4--Inductive Loop Detector Testing and Turn-on. After the loop wire, and lead-in have been assembled in place and before sealing the saw slot, a continuity check and a resistance check on the loop to ground shall be made. Resistance to ground shall be not less than 10 megohms. This same test shall be made after the slot is sealed. An inductance test in the presence of the Department designee shall also be made to ensure that the required inductance values are achieved.

After installing shielded cable to the loop lead-in, the same tests as required for the loop and loop lead-in shall be performed for the shielded cable shall be performed for the shielded cable.

640.04--Method of Measurement. Vehicle Loop Assembly and Shielded Cable will be measured by the linear foot computed horizontally along the saw slot, regardless of number of turns, in which the loop wire or shielded cable is installed and will not include the loop lead-in to the pull box. The length of the loop lead in to the pull box will be considered incidental and absorbed in the vehicle loop assembly.

Loop Detector Amplifiers will be measured as a unit per each.

640.05--Basis of Payment. Vehicle Loop Assembly and Shielded Cable, measured as prescribed above, will be paid for at the contract unit price per linear foot, which price shall be full compensation for furnishing all materials, drilling and/or sawing, installing, sealing, connecting lead-ins, testing, all equipment, tools, labor and incidentals necessary to complete the work.

Loop Detector Amplifiers, measured as prescribed above shall be paid for at the contract unit price for each. This price shall be full compensation for furnishing all materials; for all drilling and/or sawing; installing; sealing; connecting lead-in; testing; and for all equipment, tools, labor and incidentals necessary to complete the work.

Payment will be made under:

- 640-A: Vehicle Loop Assembly - per linear foot
- 640-B: Shielded Cable, AWG __, __ Conductor - per linear foot

640-C: Loop Detector Amplifier *

- per each

* Additional information may be indicated

SECTION 641 - RADAR DETECTION SYSTEMS

641.01--Description. This work shall consist of providing all labor, materials, equipment, and incidentals necessary to furnish, install, test, train and operate Radar Detection Systems, including Signal Radar Detection Systems (SRDS) and Intelligent Transportation Systems (ITS) Radar Detection Systems (IRDS). These systems will provide roadway monitoring capabilities via electromagnetic microwave radar signals through the air. The signals bounce off vehicles in their paths and the signal is returned to the detector. The returned signals are processed to determine traffic parameters. All radar units shall be supplied from the same manufacturer per construction project.

641.01.1--Signal Radar Detection Systems. SRDS provide traffic parameters necessary to the traffic signal controller operation for vehicle detection.

Type 1 SRDS radar detection shall be used for basic vehicle detection at signalized intersections as described below in this specification. Type 2 SRDS radar detection shall have all of the functionality of the Type 1 SRDS stop bar detection with additional features described below in this specification.

The SRDS shall utilize a matrix of radar signals for two-dimensional coverage and shall track vehicles through each type of detection's specified Area of Coverage. The SRDS shall report real-time detection of both moving and stopped vehicles.

641.01.2--ITS Radar Detection Systems. IRDS shall provide data, including, but not limited to speeds, volume, lane occupancy and classification.

641.02--Materials.

641.02.1--Radar Design. The IRDS and the SRDS stop bar microwave shall operate in the 24.0 to 24.25 GHz frequency band. The advance radar has the option to either be in the 24 GHz band or in the 10.5 GHz band. Neither stop bar nor advanced radar shall interfere with any existing or proposed traffic signal control and Intelligent Transportation System (ITS) equipment. Should frequencies of other ITS equipment be in the same band, or conflict with detection, the Contractor shall move and space the less critical ITS device, as designated by the Engineer so as not to interfere with vehicle detection.

The radar units shall operate in all weather conditions and comply with the applicable standards stated in the NEMA TS 2-2003 standard for shock, vibration, and temperature. All units shall be rated for up to 95% relative humidity, non-condensing.

The radar units shall be FCC certified under CFR 47, part 15.

641.02.1.1--Cabinet Interface Unit (CIU) Design. The CIU shall be a module that provides power and communication to the radar sensors and/or signal controller through contact closure devices, Ethernet and/or the SDLC port of the signal controller. The CIU

shall include all power cables, jumpers and terminal blocks needed to connect up to four (4) radar sensors to the signal cabinet. The CIU shall have a 10/100 Ethernet port to allow connection to the local network. Any variation of necessary communications ports or sensor connecting terminals shall be approved by the Engineer.

The CIU shall operate in the harsh conditions of a signal cabinet, and comply with the applicable standards stated in the NEMA TS2-2003 standard for shock, vibration, and temperature.

641.02.2--Area of Coverage - SRDS.

641.02.2.1--Stop Bar Radar Detection. Type 1 SRDS stop bar radar sensor shall track vehicles through a field of view that extends out a minimum of 100 feet

The Type 1 SRDS stop bar radar sensor shall be able to detect and report presence in lanes located within a minimum 100-foot from the face of the detector. Any variance of the detectable area shall be approved by the Engineer.

The Type 1 SRDS stop bar radar sensor shall be able to detect up to four (4) lanes with eight (8) or sixteen (16) individual zones as indicated in the plans.

Type 2 SRDS stop bar radar sensor shall have all the functionality of the Type 1 stop bar sensor with the addition of the following:

- Type 2 SRDS stop bar radar sensor shall detect true presence of vehicles whether in motion or still without using Locking or Latching Algorithms.
- Type 2 SRDS stop bar radar sensor shall report presence in lanes with a minimum 90 degree arc from the face of the detector.
- Type 2 SRDS stop bar radar sensor shall be able to detect a minimum of ten (10) lanes.

641.02.2.2--Advanced Radar Detection. The Type 1 SRDS advanced radar sensor shall be able to detect and report vehicle information such as range and speed when mounted within 50 feet of the center of the lanes of interest. Variance of this distance shall be approved by the Engineer per the application.

The Type 1 SRDS advanced radar sensor shall be forward fired and be able to detect and report vehicle information when mounted at heights above the road surface, as per Manufacturer recommendations.

The Type 1 SRDS advanced radar sensor shall be able to detect and report vehicles on the roadway up to 600 feet from the detector.

The Type 2 SRDS advanced radar sensor shall have all the functionality of the Type 1 advanced with the following additions:

- Type 2 SRDS advanced radar sensor shall be able to detect and report heavy vehicles on the roadway up to 900 feet from the detector.
- Type 2 SRDS advanced radar sensor shall be able to detect Estimated Time of Arrival (ETA) for vehicles. The advanced radar sensors shall support user

configurable upper and lower ETA filters for each zone. The sensors shall support the configuring of ETA filters in increments of 0.1 seconds.

641.02.3--Area of Coverage-IRDS. The IRDS's field of view shall cover an area with a minimum detection range of six (6) feet from the IRDS and a maximum detection range of 250 feet from the IRDS.

641.02.4--Detection Zones--SRDS.

641.02.4.1--Stop Bar Detection. The stop bar radar sensors shall be able to detect and report presence for vehicles at the stop bar.

The sensors shall be able to detect and report presence in up to eight (8) or sixteen (16) individual zones as indicated in the plans. The number of lanes used and detection zones shall be set-up and selected from the Graphical User Interface and manually configured via software provided with the detection unit. The detection zones shall also have the ability to be auto-configured by the software tool.

Count zones shall also be able to be set up in the stop bar radar detection unit as a 'spot' type of radar detection zone. The software configuration tool included with the sensor shall allow all zones to be set up as required by the plans.

641.02.4.2--Advanced Detection. The advanced radar sensors shall be able to simultaneously detect and report information from a minimum of 25 vehicles on the roadway when they are serially sequenced between the near and far boundaries. The number of lanes and detection zones shall be set-up and selected from the Graphical User Interface.

The advanced radar sensors shall detect range, speed, and vehicle Estimated Time of Arrival (ETA) to the stop bar for vehicles or clusters of vehicles moving in the user-selected direction of travel. The detector shall also detect occupancy or density of the detection zones.

The advanced radar sensors shall provide vehicle call and extend data on up to eight (8) channels that can connect to contact closure modules compliant with NEMA TS-1, NEMA TS-2, and 170/2070 controller cabinets.

641.02.5--Detection Zones--IRDS. The minimum number of detection zones defined shall range from twelve (12) to 22, for simultaneous detection, as indicated in the plans. The range resolution of each zone shall be no greater than 1.3 feet, and the zone width shall be user defined within a range of six (6) to twenty (20) feet for the area of coverage limits described above.

641.02.6--Capabilities - SRDS. Sensors shall not require roadway modification for placement. The advanced detection should provide easy integration with the stop bar detection and vice versa into the same intersection to form one (1) method/system of detection.

The radar sensors shall distinguish and omit wrong way traffic from activating an assigned detector output.

641.02.6.1--Stop Bar Detection. The stop bar radar unit shall be suitable for mounting on roadside poles or mast arms and provide the following:

- 1) Presence indication of moving or stopped vehicles in its detection zones, provided by contact closure to existing controllers.
- 2) Assign a minimum of four (4) detector outputs per radar unit and capable of using two (2) or four (4)-channel interface modules to the detector rack for contact closure activation.
- 3) A cabinet interface module for multiple radar units may be provided in lieu of individual two (2) and four (4)-channel contact closure interface modules, and as shown in the plans.
- 4) Maintain a detection accuracy of 95% for each detection zone set-up on the graphical user interface.

641.02.6.2--Advanced Detection. The advance radar unit shall be suitable for mounting on signal pole uprights or mast arms and provide the following activation within the signal cabinet:

- 1) Assign a minimum of four (4) detector outputs per radar unit and capable of using two (2) or four (4)-channel interface modules to the detector rack for contact closure activation.
- 2) A cabinet interface module for multiple radar units may be provided in lieu of individual two (2) and four (4)-channel contact closure interface modules, and as shown in the plans.

The advanced radar sensors shall turn on an alert output when the user defined zone output combinational logical is satisfied.

The advanced radar sensors shall turn on normal channel output when any of the channel's alerts is on and the channel's delay and extend time constraints are satisfied.

641.02.7--Capabilities--IRDS. The IRDS shall be a true presence detector. It shall be suitable for mounting on roadside poles or on overhead structure and provide the following:

- 1) Presence indication of moving or stopped vehicles in its detection zones shall be provided by contact closure to existing controllers.
- 2) Traffic data, periodically accumulated over user defined time intervals in a 10 to 600 second range, shall be transmitted to the TMC via the communications network.
- 3) Traffic data shall be available simultaneously with detection zone contact closures and serial communications.
- 4) Side-fired configuration data shall include the following in each of a minimum of 12 detection zones (lanes): Volume, lane occupancy, and average speed, as well as vehicle classification by length in up to six (6) user-defined classes.
- 5) IRDS in forward-looking configuration shall monitor traffic in one lane and be capable providing the following data: Volume, occupancy, average speed and travel direction in the lane.
- 6) The unit shall be furnished with the required software for data collection, processing, configuration and set-up and data logging and retrieval. An operator shall be able to use the software to set detector count periods, sensitivities and other operational

features and parameters. The software shall be capable of providing both manual and automatic setup and calibration.

641.02.7.1--Measurement Accuracy. The following error levels shall be achievable and demonstrated during testing:

Parameter	Error Percentage
Volume	±8%
Average Speed	±10% or ±5 mph
Lane Occupancy	±20%

641.02.8--Environmental Conditions and Protection. The radar unit shall maintain accurate performance in all weather conditions, including rain, freezing rain, snow, wind, dust, fog, and changes in temperature and light, including direct light on sensor at dawn and dusk. All radar sensors shall not require cleaning or adjusting in order to maintain performance. Except as stated otherwise herein, the equipment shall meet all its specified requirements during and after subjecting to any combination of the NEMA TS2-2003 standard and the following:

- 1) Ambient temperature range of -40°F to +165°F
- 2) Relative humidity from 5 to 95%, non-condensing
- 3) Rain and other precipitation up to 1.0 inch/hour
- 4) Power surge protection devices (SPD) shall be included with the radar sensors and shall meet Subsection 722.12 requirements for 24 VDC and signal/data line surge protection for Ethernet, RS-485, RS-422 and RS-232 data lines.

641.02.9--Mechanical. The radar sensors shall not exceed five pounds (5 lbs) in weight. All external parts of the radar sensors shall be ultraviolet-resistant, corrosion resistant, and protected from fungus growth and moisture deterioration.

The radar sensors shall be classified as watertight according to the NEMA 250 Standard. The enclosure shall conform to test criteria set forth in the NEMA 250 standard for type 4X enclosures.

Each of the radar sensors shall be able to withstand a drop of up to five (5) feet without compromising its functional and structural integrity. The sensor shall not require adjustments to maintain performance unless roadway geometry changes.

The radar sensors shall be mounted directly onto a mounting assembly fastened to a pole or other solid structure. The assembly shall provide the necessary degrees of rotation to ensure proper installation. The assembly shall be constructed of weather-resistant materials and shall be able to support a 20-pound load.

641.02.10--Electrical. The radar sensors shall consume less than 10 W and shall operate with a DC input between 12 VDC and 28 VDC for IRDS and 9 VDC and 32 VDC for SRDS, or POE. POE injectors shall be approved by the Engineer.

Surge Protection Devices (SPD) shall be provided to protect the equipment from surges in the radar sensors 24 VDC power supply and the signal line RS232, RS 485, or Ethernet communications wiring. Surge suppression shall be UL 1449 listed and meet all requirements of Subsection 722.12 for surge protection devices.

641.02.11--Radar Design--SRDS. The radar units shall be designed to provide detection over a large area and to discriminate lanes. The circuitry shall be void of any manual tuning elements that could lead to human error and degraded performance over time. The radar shall not rely on temperature compensation circuitry to maintain transmit frequency stability.

The bandwidth of the transmit signal of the radar sensor shall not vary by more than one percent (1%) under all specified operating conditions and over the expected life of the sensor. The stop bar radar sensor shall provide at least four (4) RF channels so that multiple units can be mounted in the same vicinity without causing interference between them.

641.02.12--Communication Ports. The radar sensor shall have Ethernet, RS-485, or RS-232 ports for communication from the unit to the cabinet. The IRDS shall be upgradable (optional) to include integral 10/100 Base-T Ethernet supporting TCP, UDP, IP, ARP, ICMP.

Within the cabinet, all remote communications to Ethernet switches shall be IP Ethernet with RJ-45 connections. For SRDS, any external device needed to convert serial to IP Ethernet within the cabinet for remote communications shall be provided with the radar sensor unit at no additional cost.

The radar sensor shall support the upload of new firmware into the unit's non-volatile memory. The sensor shall support user defined or automatic configuration of the com ports.

641.02.13--Radar Communication Cabling. The sensor communication cable shall be provided between the sensor and the cabinet. Up to 100 feet of length of communication cable shall be included in the cost of the sensor unit. Anything over 100 feet of cable shall be paid per the unit cost of the pay item for Radar Detection Communication Cable, as shown on the plans or details. The manufacturer is responsible for obtaining plan sets and ensuring cable lengths are properly measured and accounted for in the bid price for each sensor unit and as shown on the plans.

The cable shall have a single continuous run with no splices. The cable shall be terminated only on the two (2) farthest ends of the cable. The communication cable shall meet the following specifications:

- Ethernet shall be double shielded, outdoor rated direct burial Ethernet cable with runs not exceeding 250 feet. If ranges exceed 250 feet, extenders may be used at the approval of the Engineer.
- The RS-485 conductors shall be a twisted pair and not exceed 2000 feet. The RS-232 and RS-485 conductors shall have nominal capacitance conductor to conductor of less than 71 pF/Ft at 1 Khz. The RS-232 and RS-485 conductors shall have nominal conductor DC resistance of less than 16.5 ohms at 68°F.

641.02.14--Electrical Isolation and Surge Protection. All communication and power lines shall be installed using surge protection devices (SPD), as stated in specification Subsection 722.12.

641.02.15--Configuration--SRDS. The radar sensor can either have an on screen interactive or automatic configuration setup. The auto setup shall automatically define traffic lanes, stop bars, and detection zones without requiring user intervention. The auto-configuration process shall automatically define traffic lanes or detection zones by detecting the relative position of vehicles with the sensor's field of view.

The radar sensor shall also allow the ability of the user to manually adjust the sensor configuration. The graphical interface shall operate on a MS Windows™ based software. The software shall automatically negotiate the baud rate, the correct serial communication port, operate over a TCP/IP connection, support dial-up modem connectivity, give the operator the ability to save/back up the sensor configuration to a file or load/restore the configuration from a file, and provide a virtual connection option so that the software can be used without connecting to an actual sensor.

641.02.15.1--Stop Bar Detection. The stop bar sensor shall support the configuring of lanes, stop bars, and detection zones in 1-foot increments and as stated in these specifications for lane detection.

641.02.15.2--Advanced Detection. The advance radar sensor can either have an on screen interactive or automatic setup. The auto setup shall have a method for automatically configuring the sensitivity of detection between 5-foot and 7.5-foot increments. The advanced radar sensor shall support the configuring of zones in at least 5-foot increments.

The advanced radar sensor shall support user configurable high-speed and low-speed detection filters for each zone. These speed filters shall be configured in 1-mph increments.

641.03--Construction Requirements. Radar Detection System sites shall be constructed to withstand and operate in sustained winds of up to 90 mph and a 30% gust factor. For projects that are in areas with higher wind standard, the higher standard shall be used.

641.03.1--SRDS Installation Requirements. The stop bar and advanced radar sensors shall be mounted as shown in the plans or per the manufacturer's recommendations on poles or structures. Mounting brackets shall be provided with the radar sensor and shall be attached to the pole, structure or mast arm with approved stainless steel bands.

The Contractor shall install detector units on a pole, structure, or mast arm at the manufacturers recommended height above the road surface or as shown in the plans so that the masking of vehicles is minimized and that all detection zones are contained within the specified elevation angle as suggested by the manufacturer.

Unused conductors in the communications cable shall be ground or terminated in the cabinet in accordance with the manufacturer's recommendations. Terminated conductors shall be individually doubled back and taped, then loosely bundled and secured if not specifically called out in the manufacturer's recommendations. If required by the plans and installation methods, impedance termination and testing of multi drop runs shall be required per RS485 multidrop standards.

641.03.1.1--Cabinet Interface Unit. Where required, the Contractor shall install any contact closure modules and cabinet interface modules needed to connect the sensor(s) to the signal controller within the signal cabinet environment shown in the plans. Sensors

(up to 4) shall be connected to the cabinet interface module and the cabinet interface unit shall be connected to the signal controller per the manufacturer's requirements for the particular signal cabinet environment shown in the plans at no additional cost, or as approved by the Engineer.

641.03.2--IRDS Installation Requirements. All equipment shall be installed according to the manufacturer's recommendations, the plans and as follows:

- 1) The IRDS shall be mounted in side-fired or front facing configuration on poles as shown in the plans, using mounting brackets. The brackets shall be attached with approved 3/4-inch wide stainless steel bands.
- 2) The Contractor shall install the detector unit on a pole at the manufacturer's recommended height above the road surface so that the masking of vehicles is minimized and that all detection zones are contained within the specified elevation angle as suggested by the manufacturer.
- 3) When installing a detector near metal structures, such as building, bridges, or sign supports, the sensor shall be mounted and aimed so that the detection zone is not under and does not pass through any structure to avoid distortion and reflection.
- 4) The IRDS mode of operation, detection zones and other calibration and set up will be performed using a MS Windows™ based software and a Notebook PC. The software shall allow verification of correct setup and diagnostics. It shall include facilities for saving verification data and collected data as well as saving and retrieving sensor setup from disk file.
- 5) Unused conductors in the ITS Radar Detector Communication Cable shall be grounded or terminated in the cabinet in accordance with the manufacturer's recommendations. Terminated conductors shall be individually doubled back and taped, then loosely bundled and secured.
- 6) The Contractor shall provide the Department with a written inventory of items received and the condition in which they were received. Inventory shall be inclusive of make, model, and serial numbers, MAC address, and installation GPS coordinates. All equipment shall be installed according to the manufacturer's recommendations or as directed by the Department.
- 7) Any new, additional or updated drivers required for the existing ATMS software to communicate and control new IRDS installed by Contractor shall be the responsibility of the Contractor.

641.03.3--Radar Sensor Test Requirements. The Contractor shall conduct a Project Testing Program as required below. All costs associated with the Project Testing Program shall be included in overall contract prices; no separate payment will be made for any testing.

The Contractor shall be responsible for planning, coordinating, conducting and documenting all aspects of the Project Testing Program. The Project Engineer and/or the Project Engineer's representative are only responsible for attending and observing each test, and reviewing and approving the Contractor's test results documentation. The Project Engineer and/or the Project Engineer's representative reserve the right to attend and observe all tests.

Each test shall fully demonstrate that the equipment being tested is clearly and definitely in full compliance with all project requirements.

Test procedures shall be submitted and approved for each test as part of the project submittals at the request of the Engineer. Test procedures shall include every action necessary to fully demonstrate that the equipment being tested is clearly and definitively in full compliance with all project requirements. Test procedures shall contain documentation regarding the equipment configurations and programming.

No testing shall be scheduled until approval of all project submittals and approval of the test procedures for the given test.

The Contractor shall provide all ancillary equipment and materials as required in the approved test procedures.

The Contractor shall request in writing the Project Engineer's approval for each test occurrence a minimum of 14 days prior to the requested test date. Test requests shall include the test to be performed and the equipment to be tested. The Project Engineer reserves the right to reschedule test request if needed.

All tests shall be documented in writing by the Contractor in accordance with the test procedure and submitted to the Project Engineer within seven (7) days of the test. Any given test session is considered incomplete until the Project Engineer has approved the documentation for that test session.

All tests deemed by the Project Engineer to be unsatisfactorily completed shall be repeated by the Contractor. In the written request for each test occurrence that is a repeat of a previous test, the Contractor shall summarize the diagnosis and correction of each aspect of the previous test that was deemed unsatisfactory. The test procedures for a repeated test occurrence shall meet all the requirements of the original test procedures, including review and approval by the Project Engineer.

The satisfactory completion of any test shall not relieve the Contractor of responsibility to provide a completely acceptable and operating system that meets all requirements of this project.

Test shall include verification of detection for each lane of traffic or zone per site.

641.03.4--Standalone Acceptance Test (SAT). The Contractor shall perform a complete SAT on all equipment and materials associated with the field device site, including but not limited to electrical service, conduit, pull boxes, communication links (fiber, leased copper, wireless), control cables, poles, etc. A SAT shall be conducted at every field device site. Where applicable, a SAT shall be conducted for a fully installed and completed connection to the designated Traffic Management Center (TMC) or central data/video collection site.

The SAT shall demonstrate that all equipment and materials are in full compliance with all project requirements and fully functional as installed and in final configuration. The SAT shall also demonstrate full compliance with all operational and performance requirements of the project. All SATs will include a visual inspection of the cabinet and all construction elements at the site to ensure they are compliant with the specifications.

641.03.5--Warranty. The Signal Radar Detection sensors shall be warranted to be free of manufacturer defects in materials and workmanship for a period of one (1) year from the date of Final Acceptance. Equipment covered by the manufacturer's warranties shall have

the registration of that component placed in the Department's name prior to Final Inspection. The Contractor shall be responsible for ensuring that the vendors and/or manufacturers supplying the components and providing the equipment warranties recognize the Department as the original purchaser and owner/end user of the component from new. During the warranty period, the supplier shall repair or replace with new or refurbished material, at no additional cost to the State, any product containing a warranty defect, provided the product is returned postage-paid by the Department to the supplier's factory or authorized warranty site. Products repaired or replaced under warranty by the supplier shall be returned prepaid by the supplier.

During the warranty period, technical support shall be available from the supplier via telephone within four hours of the time a call is made by the Department, and this support shall be available from factory certified personnel. During the warranty period, updates and corrections to control unit software shall be made available to the Department by the supplier at no additional cost.

641.03.6--MDOT Employee Training. The supplier of the radar detection sensors shall, at a minimum, provide an 8-hour operations and maintenance training class with suitable documentation for up to eight (8) persons selected by the Department, if shown and quantified in the plans. The training shall be at the discretion and approved by the Engineer. The training must include both classroom style training and hands-on training in the field of the maintenance and troubleshooting procedures required for the system. The training should also consist of a hands-on demonstration of all software configuration and functionality where applicable. The operations and maintenance class shall be scheduled at a mutually acceptable time and location.

641.03.7--Maintenance and Technical Support. The supplier shall maintain an adequate inventory of parts to support maintenance and repair of the radar detection sensor(s). The manufacturer of the radar detection system must provide, and have a parts support system capable of providing parts for a period of five (5) years from the date of system acceptance. Spare parts shall be available for delivery within 30 days of placement of an acceptable order at the supplier's then current pricing and terms of sale of said spare parts.

The suppliers shall maintain an ongoing program of technical support for the Radar Detection System. This technical support shall be available via telephone or via personnel sent to the installation site upon placement of an acceptable order at the supplier's then current pricing and terms of sale of said technical support services.

641.04--Method of Measurement. The Radar Detection System, of the type specified, will be measured as a unit per each.

Radar Detection Communication Cable will be measured by the linear foot, measured horizontally along the conduit. The first 100 feet of Radar Detection Communication Cable shall be included in the pay item. Any addition linear foot will be paid per the cabling pay item.

Radar Detection Training will be measured per lump sum.

641.05--Basis of Payment. Radar Detection System of the type specified, measured as prescribed above, will be paid for at the contract unit price bid per each, which price shall be full compensation for furnishing all materials, construction installation, connecting,

testing, for all equipment, tools, labor and incidentals required to complete the work. Work shall include furnishing, installing, system integration, testing and training (if required) of complete radar sensor system that includes the unit, the first 100 feet of the composite power/communications cabling between the unit and the cabinet, surge protection devices, communication converters (if required), all conduit, risers and weatherhead between the radar sensors and the cabinet, interconnection wiring, power supply, connections to support structures (includes all incidental components, attachment hardware, mounting brackets, mounting arms, bolts, or any other items to mount the radar sensor as intended), satisfactory completion of testing and training requirements and all work, equipment and appurtenances as required to effect the full operation including remote and local control of the radar site complete in place and ready to use. The price bid shall also include all system documentation including: shop drawings, operations and maintenance manuals, wiring diagrams, block diagrams and other material necessary to document the operation of the radar sensor. Cabinet Interface Units shall be provided, and installed as specified in the plans, which shall be inclusive of any testing, connections, terminations, and testing required for interfacing the radar sensors and signal controller within the signal cabinet environment.

Radar Detection Communication Cable will be paid at the contract unit price per linear foot, which price shall be full compensation for all labor, materials, equipment tools, furnishing, installing, system integration, connections, testing, and all incidentals necessary to complete the work.

Radar Detection Training, measured as prescribed above, will be paid for as a lump sum unit price.

Payment will be made under:

641-A: Signal Stop Bar Radar Detection, ___ Sensor, Type ___	- per each
641-B: Signal Advanced Radar Detection, ___ Sensor, Type ___	- per each
641-C: ITS Radar Detection, ___ Sensor	- per each
641-D: Radar Detection Communication Cable	- linear foot
641-E: Radar Detection Training	- lump sum

SECTION 642 - MAGNETOMETER DETECTION SYSTEM (MDS)

642.01--Description. This work consists of furnishing all components and materials required to enable a wireless, battery-powered Magnetometer Detection System that detects vehicles and bicycles on a roadway using battery powered magnetometer type sensors with wireless communications to transmit detection information. The system shall detect vehicles on a roadway using only changes in the earth's magnetic field and provide detection outputs to a roadside master device before the data is relayed to a freeway cabinet, a local traffic controller cabinet, a Central Software System, and/or data server as required as required by the application. The application of the MDS shall be shown in the plans or project specifications. These specifications cover both intersection presence-based vehicle detection used for traffic controller input, as well as freeway system or advanced system

detection data collection of volume, occupancy and speed. This specification sets forth the minimum requirements for the system.

The detection system shall provide accurate roadway data as needed to support the traffic management application. All wireless, battery-powered Magnetometer Vehicle Detection Systems (MDS) shall consist of one or more battery-powered wireless Vehicle Sensor Nodes (VSN) installed in-pavement with reusable enclosure. The MDS may also consist of one (1) or more Repeaters (RPs) mounted on poles on the side of the roadway.

The MDS shall also consist of either:

- One (1) or more Access Points (AP) mounted on the side of the roadway, one (1) or more Access Boxes, and one (1) or more Contact Closure Interface Card(s) (with Expansion Card System (EX) if required); or
- One (1) or more Access Point Contact Closure (APCC) Interface cards (with an Expansion Card System (EX) if required), one (1) or more Isolator Modules (ISO), and one (1) or more Serial Port Protocol Digital Radios (DR) mounted on the side of the roadway; or
- Equivalent system as approved by the Engineer

The MDS may also include Input/Output (I/O) Modules if Access Point Contact Closure cards are used. All MDS shall also include CAT6 Outdoor Ethernet Cable, Epoxy Sealant for installation, and applicable operating and configuration software. Software shall operate on a conventional laptop PC. Communications between the sensors and the DR or RP and between the RP and DR or another RP shall be via radio. Detection data shall be relayed using contact closure signals. Data shall be capable of being relayed to a Central Software System or central server over standard IP networks. The MDS shall also include any incidental items necessary for a complete and operable unit in place and accepted.

642.02--Materials.

642.02.1--Functional Capabilities. The VSN shall detect a vehicle by measuring a change in the x, y, and z axis components of the earth's magnetic field near the VSN caused by a stopped or passing vehicle. The VSN shall communicate the detection information to the AP, DR, or RP via wireless radio. The VSN shall transmit detection information within 150-ms of a detected event. The VSN shall communicate time-stamped ON and OFF vehicle detection events. The VSN shall automatically re-transmit a detected event if no acknowledgment is received from the AP or APCC/DR. The VSN shall automatically recalibrate in the event of a detector lock. If radio connection is lost due to stopped vehicles near the VSN, each VSN shall be capable of re-establishing radio link with supporting AP or APCC/DR or RP in less than two (2) seconds. Each MDS system shall consist of one (1) or more VSN's located as identified on the plans. Communications between a VSN and DR or AP can be direct, via a single repeater, or via two (2) repeaters operating in tandem.

The Radio Frequency (RF) link among the AP, DR, RP, and VSN shall conform to the following:

- The RF link shall utilize an IEEE approved wireless communications protocol.
- The center frequencies, bandwidths, and transmit power levels of the radio links shall allow operation in an unlicensed frequency band.

- Frequency channels which are user configurable shall be employed by the sensors, APs or APCCs and RPs to avoid interference with other devices operating in the unlicensed band.
- The AP or DR to VSN (or RP to VSN) RF range shall be at least 150 feet for an DR/AP/RP installed at 20 feet above the roadway and at least 125 feet at 18 feet above the roadway.
- The RP to AP or DR RF range shall be at least 750 feet when both units are installed 18 feet above the roadway with clear line of sight.

For freeway applications and where advanced system detection is provided, per the plans and specifications, detection data shall be relayed to a central software system or central server. In this case each installation of the wireless, battery-powered Magnetometer Vehicle Detection System shall provide the following measurements, as required by the application:

- Vehicle volume (count) per lane over a specified time interval
- Lane occupancy (percent) over a specified time interval
- Vehicle speed (mph or kph) when more than one sensor is deployed in a lane
 - Per-vehicle speed
 - Median speed over a specified time interval
 - Mean speed over a specified time interval
 - Distribution of speeds over a specified time interval
- Vehicle classification when more than one (1) sensor is deployed in a lane
 - Per-vehicle length
 - Report distribution of vehicle lengths over a specified time interval
 - The time interval for measurements shall be selectable from 30 seconds to 24 hours

Each VSN shall transmit a unique identifying code. Each sensor in an installation shall be capable of being individually configured with its own sensitivity level. Sensitivity of the VSN shall be adjustable as may be required to detect bicycles and/or motorcycles. The VSN shall respond within 100 seconds when the AP or APCC/DR is powered on and transmitting.

Two (2) types of sensor applications of sensors shall be available from the manufacturer. Type A shall provide all sensor functions, including data collection functions. Sensors used for this application shall provide for advanced system detection or stop bar detection. In the advanced system detection scenario a single Type A VSN shall be configurable to approximate the detection zones of 6-foot x 6-foot. In the stop bar detection scenario multiple Type A VSNs shall be configurable to emulate 6-foot x 6-foot to longer lengths.

Type B sensors shall support presence detection only. Sensors used for this application shall provide for stop bar detection. In this scenario single or multiple Type B VSNs shall be configurable to emulate 6-foot x 6-foot to longer lengths. The plans shall dictate the sensor type required.

The AP or APCC shall have the capability to transmit detection information to central software or a centralized server through several types of communication media, as required by the application. The AP shall be capable of communicating over a cellular data connection, or an Ethernet connection. The APCC shall be capable of simultaneously

communicating detection data via the contact closure interface, Ethernet interface, and cellular data modem interface, as applicable. The APCC cards shall provide sensor information processing and support the interface between a DR and the traffic controller using contact closure signals, or, for freeway applications, mounted in a stand-alone cabinet with direct IP communications. The AP or APCC shall have the capability to transmit detection information to 170, 2070, and NEMA TS1 and TS2 traffic controllers to provide real time detection information via a standard contact-closure based input shelf. The VSN, RP, DR, APCC or AP shall be capable of accepting software and firmware upgrades.

642.02.2--VSN Hardware. The VSN shall consist of a magnetometer, a microprocessor, a wireless transmitter and receiver, battery, an “enclosure case”, and epoxy sealant for installation. The VSN components shall be contained within a single housing. The VSN housing shall meet NEMA 6P and IEC IP68 standards. The VSN components shall be fully encapsulated within the housing to prevent moisture from degrading the components. The VSN shall be able to operate at temperatures from -37°F to +176°F. The VSN shall be designed to operate from its battery for an average of 10 years of life under normal traffic conditions.

642.02.3--Repeater Hardware. The RP (if required) shall extend the effective communication range of the sensor to the AP or DR an additional 750 feet. The RP communicating directly to an AP or APCC/DR shall support at least 10 sensors while an RP communicating to an AP or APCC/DR via an intermediate RP (i.e., tandem operation) shall support at least six (6) sensors. If the RP is battery powered, the RP battery shall be field replaceable. The RP shall operate in the -37°F to +176° temperature range. All RP Components shall be contained within a single housing. The RP shall meet NEMA 4X and IEC IP67 standards. If battery powered, the RP shall be designed to operate from its battery for a minimum of seven (7) years of life under normal traffic conditions.

642.02.4--AP Hardware. The AP shall be the master device of the sensor network. The AP shall be able to communicate to up to 48 VSN’s and 15 RP’s. The AP shall operate in the -37°F to +176°F temperature range. The AP shall meet NEMA 4X and IEC IP67 standards. It shall contain a weatherproof connector on the bottom of the device, which shall be shipped with a cover firmly attached to provide protection from the elements. The AP shall communicate via the following options: The controller via the Contact Closure Interface Card(s), Ethernet to a Central computer/server, or simultaneously to both the controller and the Central computer/server.

642.02.5--Contact Closure Interface Card (CCI) and Expansion Card System (EX) Hardware. The Contact Closure Cards and Expansion Cards, collectively called Contact Closure Interface Card(s) (CCI), shall provide detector outputs to the controller. The CCI shall directly plug in to the standard 170/2070 Input Files and NEMA detector racks and detection file type shall be selectable via dipswitch. Each CCI card shall provide up to four (4) channels of detection. Additional contact closure input channels shall be provided via Expansion Cards (EX) daisy chained to the CCI (user configurable from one (1) to four (4) outputs each). All required EX cards to handle the number of sensors or controller channels as indicated in the plans or project specifications shall make up the Expansion Card System. The CCI shall be able to provide pulse or presence detection outputs.

The front panel of the CCI shall provide:

- Status LED's displaying
 - Detection Channel Status
 - Line Quality
 - Fault Monitor

The CCI shall be powered by 11 to 26 VDC. The CCI shall be surge protected to GR-1089 standards. The CCI card(s) shall operate -37°F to +176° temperature range. The CCI shall operate in up to 95% humidity (non-condensing).

642.02.6--Access Box. The access box shall provide a communication link between the AP and CCI card(s). The access box shall provide the ability for remote communications.

642.02.7--Access Point Contact Closure (APCC) Interface Card and Expansion Card System (EX) Hardware. The APCC shall also serve as the master device of the MDS, where AP type configurations are not specified. It shall provide all the higher level processing and interface functions of the MDS system and shall only require a single detection rack width slot. All required EX cards to handle the number of sensors or controller channels as indicated in the plans or project specifications shall make up the Expansion Card system.

Each APCC card shall provide detector data as contact closure signals to the traffic controller. The APCC card shall be capable of plugging directly in to standard 170/2070 input files and NEMA detector racks or shall be supplied within a standard enclosure to supply power for use in freeway applications. The APCC and EX cards front panel shall be configurable either via software or via front panel switches to provide presence/pulse mode, delay timing and extension timing. The front panel of the APCC and EX card system shall provide LED's to monitor:

- Detection Channel Status
- Line Quality
- Fault Monitor

APCC and EX card system shall operate at temperatures from -37°F to +176°F, and in humidity up to 95% (non-condensing).

642.02.8--Digital Radio Hardware. The Serial Port Protocol Digital Radio (DR) shall support at least 48 sensors with a 0.125 second latency. It shall contain a weatherproof connector on the bottom of the device, which shall be shipped with a cover firmly attached to provide protection from the elements. The DR shall operate at temperatures from -37°F to +176°F, and DR shall be contained within a single housing that conforms to NEMA Type 4X and IEC IP67 standards.

642.02.9--Isolator (ISO) Module. If required, an Isolator Module may be used in between each DR and APCC to extend communications range and protect the APCC card from transient surges. The Isolator Module shall extend the communication range between the APCC and DR from 30 feet to 2000 feet. The Isolator Module shall provide electrical isolation of 1500V, surge protection of up to 1500V, and shall provide AC power cross protection.

642.02.10--Input/Output (I/O) Module. The MDS may include I/O modules to expand the capabilities of an APCC by providing additional communication options, memory

options and a battery backed real time clock. The module shall include a RS232 port for serial communications. As an option, it may also allow for detection data shall be communicated as IP data over either GSM-based cellular data services via a GPRS cellular modem or over CDMA based cellular data services via a 1xRTT cellular modem.

642.02.11--Configuration Software. The MDS shall include the software necessary to configure the VSN. The MDS shall include the software necessary to configure the RP, AP, APCC, EX, CCI and DR.

642.02.12--Epoxy. The MDS shall also include the necessary epoxy for installation. The epoxy used for installation of the sensor(s) shall be a two part poly-urea based joint sealant having self-leveling characteristics. Surfaces the epoxy will be bonding to shall be free of debris, moisture, and anything else which might interfere with the bonding process. The epoxy used shall be approved by the manufacturer of the detection system.

642.03--Construction Requirements.

642.03.1--Installation. The flush mount sensors shall be installed in the roadway using the following procedure. The roadway shall be core drilled to provide a hole, 2.5 inches deep. The hole shall be cleaned out per the manufactures recommendation and leveled prior to placement so that the sensors will remain flush once installed. A small layer of epoxy to cover the bottom of the hole shall be applied. The sensor shall then be placed on top of this layer of epoxy in the correct orientation. The sensor shall be fully encapsulated with the epoxy to the lip of the cored hole. The AP or DR and RP shall be installed within range of the sensors as specified by the manufacturer. Once the installation is complete, the Contractor shall provide documentation to the Engineer that includes an intersection diagram of sensor IDs and their placement.

642.03.2--Removal. The direction of traffic flow shall be permanently marked on top of the sensor prior to removal. The sensor and its epoxy coating shall be removed from the roadway by coring a hole to a depth of 2.50 inches with the sensor and epoxy being contained in the center of the core. The core shall then be extracted from the roadway using a pry bar as needed and retained for reinstallation upon completion of roadwork.

642.03.3--Reinstallation. Cores containing previously removed sensors shall be reinstalled by coring a 5-inch hole in the roadway to a depth of 2.5 inches. The core shall be placed inside the hole in the correct orientation. The sensor shall be fully encapsulated with the epoxy to the lip of the cored hole. The sensors shall be configured as needed to provide vehicle detection and operate with existing system AP or APCC, DRs, and RP's, as well as existing cabinet components.

642.03.4--Limited Warranty. The supplier shall provide a limited 5-year warranty on the detection system from the point of the project final acceptance. During the warranty period, technical support shall be available from the supplier via telephone within 24 hours of the time a call is made by a user, and this support shall be available from factory-authorized personnel or factory-authorized installers. During the warranty period, standard updates to the software shall be available from the supplier without charge.

642.03.5--Testing and Accuracy Requirements. At the Engineer's request, the Contractor or Supplier shall provide a Wireless Magnetometer Vehicle Detection System that meets the below minimum accuracy requirements for all conditions. Accuracy

measurements for the testing shall be done with an appropriate sample size of vehicles, over a specific time period.

At the Engineer’s request, the Contractor shall submit to the Engineer the Test Plan for Accuracy testing at the location(s) that is site specific to the plans. The test plan shall take into account the roadway type (freeway, arterial), location (urban, rural), and traffic conditions in order to determine appropriate testing length and sample size. The following conditions shall be met for each sensor installed:

1) Measurement Accuracy

The following error levels shall be achievable and demonstrated during testing.

<u>Parameter</u>	<u>Error Percentage</u>
Presence	±2%
Lane Occupancy	±5%
Volume	±8%
Average Speed	±10%
Length Classification limits	±10%

2) Testing

At the Engineer’s request, plans shall be developed and submitted to the Project Engineer for consideration and approval for post-installation testing. The plans test shall include all functional requirements and the accuracy requirements. The testing shall prove that all in-pavement sensors are configured appropriately. The following post installation test procedures shall be utilized after the MDS is installed in its entirety as shown in the plans and is integrated with the existing traffic signal control central software. No post-installation testing shall begin until all MDS systems in the project have been configured/calibrated to gather speed, volume, classification, and occupancy, or presence, as dictated by the application and programmed to communicate on the Department’s ITS network. Including the accuracy testing requirement, at a minimum, provide the following on the test plan to be submitted and approved by the Engineer:

- a. Inspect all detection system field components to ensure proper installation and cable termination.
- b. Verify that field construction has been completed as specified in the plans.
- c. Inspect the quality and tightness of ground and surge protector connections.
- d. Check power supply voltage and outputs and ensure device connections are as specified in the plans.
- e. Verify that the installation of cables and connections between all AP’s to CCI cards, and DR’s to APCC’s are per manufacturer recommendations and as specified in the plans
- f. Demonstrate that each Wireless In-Pavement Vehicle Detection System is fully operational and gathering the required data types at the specified interval to the central software or controller, as required by the application.

642.03.6--Maintenance and Support. The supplier shall maintain a sufficient inventory of parts to provide support and maintenance of the system. These parts shall be available for delivery within 30 days of receipt of a purchase order by the supplier at the supplier’s then current pricing and terms of sale.

The supplier shall maintain an ongoing program for customer support for the system. This support shall be via telephone, email or personnel sent to the installation upon receipt of an purchase order at the suppliers then current pricing and terms of sale for technical support services.

Installation and/or training support shall be provided by a factory authorized representative. All documentation shall be provided in the English language.

642.04--Method of Measurement. Magnetometer Detection System will be measured as a unit per each for system installation.

Magnetometer Detection System Component of the type specified will be measured as a unit per each.

Magnetometer Detection System Component Removal and Reinstallation will be measured as a unit per each.

642.05--Basis of Payment. Magnetometer Detection System, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing all materials, controller modifications, connectors, wiring, software, epoxy sealant, testing, equipment, labor, tools, and all incidentals necessary to complete the work.

Magnetometer Detection System and Magnetometer Detection System Components, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for all materials, connectors, modifications, hardware, connectors, wiring, cabling, mounting brackets, testing, equipment, labor, tools, and all incidentals necessary to complete the work.

Magnetometer Detection System Component Removal and Reinstallation, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for all work necessary to completely remove and reinstall an existing component, any necessary epoxy sealant, controller modifications, connectors, wiring, software programming, and all incidentals necessary to satisfactorily remove and reinstall an existing component.

Payment will be made under:

- 642-A: Magnetometer Detection System - per each
- 642-B: Magnetometer Detection System Component, _____ - per each
- 642-C: Magnetometer Detection System Component Removal and Reinstallation, _____ - per each

SECTION 643 - VIDEO VEHICLE DETECTION SYSTEM

643.01--Description. This section specifies the minimum requirements for Video Detection Systems (VDS) and Multi-Sensor Detection Systems (MSDS) furnished and installed in accordance with the design(s) for the location(s) designated on the project

plans, in any related notice to bidders, or as directed. The work shall consist of providing all labor, materials, equipment, and incidentals necessary to furnish, install, test, and operate VDS and/or MSDS that are integrated with the Department's Traffic Management/Operations Centers (TMC).

The Type 1 Video Detection System will provide roadway monitoring capabilities via digitized video images transmitted over an Ethernet network and will provide traffic data collection of vehicle parameters including, but not limited to, speed, presence, occupancy, volume, video snapshots and MPEG-4 streaming video of the intersection. All of the real-time data shall be reported locally or remotely and be viewable from a customized, secure, user-friendly website hosted by the VDS vendor. The Type 1 Video Detection System will be used at all intersections where traffic data collection is required. The work shall consist of providing all labor, materials, equipment, and incidentals necessary to furnish, install, and test Video Detection Systems. This work consists of furnishing and installing Video Detection System equipment complete and ready for service.

The Type 2 Video Detection System will provide presence or pulse detection for Traffic Signal Controller inputs. The Type 2 Video Detection System will be used at intersections that only require presence detection for traffic signal control. The work shall consist of providing all labor, materials, equipment, and incidentals necessary to furnish, install, and test Video Detection Systems. This work consists of furnishing and installing video detection system equipment complete and ready for service.

The Type 3 Video Detection System will provide presence or pulse detection of vehicles and bicycles for Traffic Signal Controller inputs. The Type 3 Video Detection System will be used at intersections that only require presence detection of vehicles and/or bicycles for traffic signal control. The Type 3 Video Detection System shall consist of a single integrated camera with video detection processor. The work shall consist of providing all labor, materials, equipment, and incidentals necessary to furnish, install, and test Video Detection Systems. This work consists of furnishing and installing video detection system equipment complete and ready for service.

The Multi-Sensor Detection System (MSDS) will provide detection of vehicles on a roadway using a Multi-Sensor Detection System for Traffic Signal Controller inputs. The Multi-Sensor System shall utilize two (2) different sensors of different technologies, video imaging and radar, to detect and track vehicles. The module shall process information from both video imaging and radar sensors simultaneously in real-time. The work shall consist of providing all labor, materials, equipment, and incidentals necessary to furnish, install, and test the Multi-Sensor Detection Systems. This work consists of furnishing and installing Multi-Sensor Detection System equipment complete and ready for service.

643.02--Materials.

643.02.1--Materials Type 1 Vehicle Detection System.

643.02.1.1--General. The Video Detection System hardware will typically consist of two (2) major components:

- 1) Video Camera Sensors (color) with zoom lens (one sensor in each direction)
- 2) Video Detection System Processor (inside the sensor for Type 1 system)

643.02.1.2--Functional Requirements for Type 1 Detection System. The VDS shall be capable of monitoring vehicles on a roadway via processing of video images and providing discrete detection of vehicles and functional detection parameters on a per lane basis for each of the following:

- 1) Presence of moving or stopped vehicles (a vehicle that has not moved for a user-definable length of time)
- 2) Traffic volume (absolute number of discrete vehicles per time interval per lane)
- 3) Speed (average lane speed in mph)
- 4) Occupancy (individual lane occupancy measured in percent of time)
- 5) Density (average lane density volume/speed)
- 6) Headway (average time interval between vehicles by lane in seconds)
- 7) Vehicle classification and volumes per lane by user-selectable vehicle lengths (minimum four (4) bins)
- 8) Wrong Way vehicle detection
- 9) Alarms for the following:
- 10) wrong-way vehicles
- 11) speed threshold
- 12) vehicle classifications
- 13) Loop Emulation based on single or dual loops for a minimum of four (4) lanes.
- 14) Provide direct real-time iris and shutter speed control and be equipped with an integrated auto zoom/auto focus lens that can be changed using computer software.
- 15) Shall be fully IP-enabled and addressable from the video detection system processor, with all configuration, detection data, and encoded video stream available on a single Ethernet interface.
- 16) Shall provide MPEG-4 streaming video output.
- 17) Shall provide all data and video communications over the power supply conductors as shown on the plans.

643.02.1.3--System Features. As a minimum, the system shall include the following features:

- 1) Shall be capable of detecting and storing discrete lane data for either approaching or receding vehicles in at least four (4) lanes and two (2) shoulders / emergency lanes.
- 2) When this function is required in the plans, shall provide a Contact Closure Interface to a traffic controller or other device, this interface shall accept eight (8) Contact Closure inputs (usually red and green control signals) and provide sixteen (16) Contact Closure outputs to a traffic signal controller. For a SDLC interface to a NEMA T52 traffic controller, this interface shall display 32 phase colors and emulate up to four (4) bus interface units (BIU).
- 3) Shall include software with the capability to define detectors through interactive graphics by placing lines and/or boxes or polygons defined by a minimum of four (4) points.
- 4) Shall be a tracking based system or a system of detection zones (lines and/or boxes) which may assign logical functions to one detector or a group of detectors to accomplish directionality or classification.
- 5) Shall be capable of programming the expected flow direction of traffic to facilitate alarm generation for vehicles traveling in the wrong direction.
- 6) Shall be capable of operating as a stand-alone unit when communication to the central system is lost, calculating traffic parameters in real-time and storing data in its own nonvolatile memory.

- 7) Shall be capable of compensating for camera movement attributable to temperature effects, wind shifts, pole sway, pole expansion, or vibration of the mount when attached to bridges, sign structures or other structures.
- 8) Shall allow for detection zone calibration for accommodating perspective variations due to varying camera heights and angles.
- 9) Shall provide for day and night operation.
- 10) Shall provide for communications interface to the video detection system processor through a cabinet-mounted interface panel that terminates the power/communications conductors to the processor and provides the Ethernet interface to the processor.

643.02.1.4--Detection Configurations. The VDS shall be programmable for the following detector configurations; at a minimum they shall perform the following functions:

- 1) Count Detector
- 2) Presence Detector
- 3) Speed Detector
- 4) Station Detector
- 5) Speed Alarm
- 6) Lane Detector
- 7) Tunnel Detector

The Speed Detector shall report vehicle speed and vehicle classification based on five (5) user-defined length categories, satisfying the four generalized category requirement recommended by FHWA.

643.02.1.5--VDS Software Requirements. The VDS sensor shall store cumulative traffic statistics, internally in non-volatile memory, for later retrieval and analysis. The VDS sensor shall have at least 5Mb of memory for data storage. Data collection shall not require additional modules or extra software.

The real-time traffic data and color video shall be viewable through a standard web browser using a data collection and management service (DCMS). The DCMS license will be for a 24 month period and start from the date of acceptance of the Final Inspection. The manufacturer shall display the data and streaming video real-time on a custom web-site which can be linked to the Department's internal web-sites, MDOTTraffic.com & GoMDOT.com. The DCMS provider must guarantee 95% uptime. All collected data (except video) shall be archived once a month and two (2) electronic copies sent to the Department. The Department requires the ability to create and print custom data reports in Excel or HTML by accessing the manufacturer website and filtering data using reporting parameters. In addition, the Department requires the capability of having all "raw" data sent directly to a Department owned data collection server.

The VDS shall have the capability of polling any and all video detector sensors through communication interfaces, including but not limited to, fiber, wireless, leased broad-band, and leased point to point T1.

The DCMS Server shall be able to generate details including, but not limited to the following:

- 1) Microsoft Excel, SQL, XML, Jscript database technology
- 2) Microsoft .NET Framework, including support for ASP.NET
- 3) Custom, automated reports, alarms, ftp, and e-mail services.
- 4) Report Manager Graphic User interface (GUI) to customize data distribution and reporting.

643.02.1.6--Detection Requirements. Unless otherwise shown in the plans, the Video Detection System shall detect vehicle passage and presence when the VDS camera assembly is mounted 40 feet or higher above the roadway, when the camera is located adjacent to or over the desired coverage area, and when the distance to the farthest detection zone locations are not greater than 10 times the mounting height of the camera.

Optimum accuracy shall be achieved when the length of the detection area or field of view is not greater than four (4) times the mounting height of the image sensor.

The camera shall not be required to be directly over the roadway to achieve minimum accuracy requirements.

The Video Detection System shall be able to use a single camera to view either approaching and/or receding traffic in the same field of view.

643.02.1.7--Accuracy Requirements and Measurement Methods. The accuracy will be measured under normal weather conditions (i.e., not during rain, snow, fog etc.) when the VDS sensor camera is mounted 40 feet or higher, or as otherwise shown in the plans, above the travel lanes, when the image sensor is adjacent to desired coverage areas, and when the distance to the farthest detection zone is less than four (4) times the mounting height measured in a straight line along the center axis of the field of view.

The Video Detection System shall provide a level of accuracy of less than 5% error rate based on volume counts for the entire field of view compiled over multiple time intervals that contain a minimum of 300 vehicles.

Volume - The volume (count) of vehicles in each lane collected by the video detection system must be within five percent ($\pm 5\%$) of the manually counted volume for that lane. These levels of accuracy shall be provided during both day and night conditions. A minimum of 300 vehicles shall be used as a sample size for the entire field of view for volume counting accuracy checking.

Vehicle Classification - The vehicle classification feature must classify at least 80 % of the vehicles correctly by classifying vehicles into one of four (4) bins (FHWA categories) by vehicle length. This feature will be tested by manually classifying vehicles into cars, light trucks or tractor trailer or larger trucks using an observer (who does the classification) and video tape using the same samples as collected for the volume test. The manually collected classification data will be compared to the data collected by the system for each lane and the percent error will be calculated for the entire field of view.

Stopped Vehicle Detection - The Vehicle Detection System shall be capable of detecting 95% of all vehicles stopped on the shoulders or in lanes and triggering an alarm. Because of the possible dangers to motorists and workers during this test, the test will be completed after operation has been enabled. A vehicle will be sent to the location and stopped on a shoulder in an active detection zone. An inspector or TMC operator will observe to verify

the detection of the stopped vehicle. This test will be performed on all of the video detection system installations up to five (5), or on a random sample of five (5) if the total number of Video Detection System installations is greater than this. If all parameters are met for all locations tested, all that are installed on the project will be considered acceptable. If one (1) or more locations fail, a second set of five (5) locations will be examined. If a failure in the second set is recorded, the Contractor will be required to take remedial action until a pass of five (5) locations is achieved.

Speed - The system shall provide an average vehicle speed measurement within $\pm 10\%$ of actual speeds. These levels of accuracies shall be provided for traffic traveling between 20 and 75 mph. These levels of accuracies shall be provided during both day and night conditions. Personnel participating in and observing these tests will use either radar detectors or probe vehicles to conduct this accuracy demonstration. This test will be performed after the system is in operation as described in the stopped vehicle tests. Failure to achieve accuracy will require remedial/corrective action by the Contractor and repeated testing until accuracy is achieved.

Other Parameters (Occupancy, Flow Rate, Headway, and Density) - If the measurements of speed and volume as described above fall within acceptable specified limits of accuracy, and the system is demonstrated to be able to provide the calculated values for these parameters, no further testing will be required. The formulas/algorithms used for the calculations by the system shall be provided to the Engineer as part of the documentation of the system.

643.02.1.8--Video Camera Sensor. The video camera sensor shall be compatible with the Video Detection System processor and as a minimum meet the following requirements:

- 1) Lens: The video camera sensor will be equipped with a 16X to 22X motor driven variable focal length zoom lens.
- 2) Image Sensor: Minimum resolution of 470H X 350V TV lines.
- 3) The Sensor's picture element shall be 768H pixels X 494V pixels or greater.
- 4) Input power: 115 VAC $\pm 15\%$, 60 Hz $\pm 10\%$ single phase power. Any required power conversion shall be contained within the VDS, the chassis, or facilitated by a power adapter provided.
- 5) Electromagnetic Interference (EMI): The video camera sensor and associated connected equipment will comply with FCC Part 15, Subpart J, Class A device requirements.
- 6) Video camera sensor enclosure: The video camera sensor shall be installed in an enclosure:
 - a. The enclosure shall meet NEMA 250 Type 4 enclosure standards and shall be available un-pressurized or optionally pressurized types.
 - b. If the enclosure is pressurized, it shall be pressurized to at least 5 psi ± 1 psi and a low pressure sensor with an alarm output to the Video Detection System processor and cabinet assembly will be provided.
 - c. Provide a sun shield visor on the front of the enclosure, which is sufficiently adjustable to divert water away from the video camera sensor lens and also to prevent direct sunlight from entering the iris when mounted in its installed position.
 - d. Install the sun shield so that it does not impede operation or performance accuracy of the video camera sensor or require removal of the video camera sensor enclosure for adjustment.

- e. Use an enclosure that allows the video camera sensor horizon to be rotated in the field during installation.
- 7) Weight: The standard video camera sensor will not weigh more than 10 lbs., including the mount, shield and camera. If a pressurized video camera sensor and housing is used, the unit including a standard mount, shield and camera will not weigh more than 13 lbs.
- 8) Mounting: The video camera sensor assembly mounting and hardware shall be included as part of the system.
 - a. The video camera sensor horizon shall be adjustable without removing the camera, mounting bracket and enclosure, or sun shield.
 - b. The video camera sensor assembly shall be capable of sustained wind loading of 90 mph with a 30% gust factor.
- 9) The video camera sensor assembly shall include all cabling, mounts, fasteners, conduit, connectors, etc., to provide power and connectivity to the VDS cabinet equipment for a fully functional system. The connection for the power and video cable shall be the connection type recommended by the manufacturer.

643.02.1.9--Video Detection System Processor. The Video Detection System processor shall meet the following requirements:

- 1) Shall be contained/integrated in the VDS sensor enclosure.
- 2) Shall process and make available for transmission (upload) to the TMC data stored in operator selectable time periods of 10, 20, or 30 seconds and 1, 5, 10, 15, 30, or 60 minutes (default setup by Contractor shall be 1 minute).
- 3) Shall be password protected to prohibit unauthorized changes, if enabled by user. A minimum of ten (10) different users may be authorized with different levels of authority.
- 4) Observation of detection operation only, without ability to edit configurations, may be allowed with no password. The VDS shall record time and date of each password usage.
- 5) Shall provide the data and MPEG-4 encoded video through a communications interface device via an Ethernet version 2.0 IEEE 802.3 compliant 10/100 Base-T Auto Sensing port in real-time.
- 6) The processor shall be IP-addressable using the user datagram protocol/IP or UDP/IP message packet and routing standard.
- 7) A communications address shall be automatically assignable or manually configured to the unit during setup.
- 8) Upon receiving a command with the appropriate address from the TMC central computer, the unit shall respond with the accumulated traffic parameter measurements from the period since the last request.
- 9) Shall operate reliably in a typical roadway aerial mounting and under the following conditions:
 - a. Shall have an operating ambient temperature range: -29°F to 140°F
 - b. Shall have an operating humidity tolerance of: 5% to 95% humidity per NEMA TS 1-1989 (R 1994).
 - c. Vibration: A video camera sensor and enclosure shall be provided that maintains its functional capability and physical integrity when subjected to a vibration of 5 to 30 Hz up to 0.5 gravity applied to each of three mutually perpendicular axes (NEMA TS1- 1989 (R 1994)).
 - d. Shock: The video camera sensor and enclosure shall withstand a minimum 9G shock. Neither permanent physical deformation nor inoperability of the video

- camera sensor and enclosure shall be sustained from this shock level.
- e. Acoustic Noise: A video camera sensor and enclosure shall withstand a 150 dB for 30 minutes continuously, with no reduction in function or accuracy.
- 10) Shall be capable of storing data for an extended period of time.
 - a. All traffic parameter data shall be stored in non-volatile memory within the video detection system processor.
 - b. All traffic parameter data shall be capable of being retrieved using the central computer and by means of an automatic polling client application.
 - c. Upon loss of communications, the system shall automatically store no less than seven (7) days of data in 30 second increments based on the default set-up required. At a minimum, data storage requirements apply to volume, speed and occupancy requirements.
 - 11) Shall be powered by input power: 115 VAC $\pm 15\%$, 60 Hz $\pm 10\%$ single phase power. Any required power conversion shall be contained within the VDS, the chassis, or facilitated by a power adapter provided Total power for a single video camera sensor and the processor shall not exceed 15 watts with the camera heater in operation.
 - 12) Shall have transient protection that meets the requirements of NEMA TS1-1989 (R 1994) and NEMA T52-1992 standards.
 - 13) Shall recover from power interruptions. Momentary interruptions in power to the processor shall not result in loss of function upon restoration of power.
 - 14) In the event of an interruption of power, the equipment shall automatically recover when power is restored. All detection zones, stations, and parameters shall be returned to their last configurations.
 - 15) Each VDS location shall be capable of simultaneously processing data and images from four (4) separate video camera sensor installations for detection and analysis.
 - 16) The system shall be capable of detecting objects in EIA-170 (monochrome) and NTSC (color), or CCIR (monochrome) and PAL (color) video signals.
 - 17) Shall allow still image capture (snapshot) from any of the Video Detection System processor's active video inputs and provide for downloading the image to the central computer for display or storage as a picture file; capture and transmit the still image to the central computer in one (1) minute or less.

643.02.2--Materials Type 2 Vehicle Detection System. The Type 2 Video Detection System shall consist of power supply, video cameras, all necessary video and power cabling with end connectors, mounting brackets, lightning protection as recommended by the manufacturer, video detection processors/extension modules capable of processing the number of camera and phase combination video sources shown on the project plans or in the purchase order. A sufficient number of cameras shall be provided to process vehicle presence, passage and system detection zones as shown on the project plans or listed on the purchase order.

643.02.2.1--Functional Requirements for Type 2 Vehicle Detection System. The Video Detection System configuration shall utilize video processors with one or more video inputs and one (1) video output, responding to specific site applications, camera locations and detection zones shown on the project plans. Video processors or interface modules shall be provided which plug directly into NEMA TS-1 and TS-2 detector racks without adapters. Extension modules which allow detection zones from one camera to be routed to other card slots shall also be provided. The system shall be Ethernet compatible with an RJ4S port.

643.02.2.2--Interface Type 2 Video Detection System. The following interfaces shall be

provided:

- 1) Video inputs that accept RS 170 (NTSC) signals from an external video source. A BNC type interface connector shall be provided and located on the front of the video processing unit.
- 2) A LED indicator to indicate the presence of the video signal. The LED shall illuminate upon valid video synchronization and turn off when the presence of a valid video signal is removed.
- 3) One (1) video output per processor module. The video output shall be RS 170 compliant and shall pass through the input video signal. The video output shall have the capability to show text and graphical overlays to aid in system setup. The overlays shall display real-time actuation of detection zones upon vehicle detection or presence. Control of the overlays and video switching shall also be provided through the serial communications port. The video output interface connector shall be BNC or RCA type. If RCA connector is used, an RCA to BNC adapter shall be provided.
- 4) A serial communications port on the front panel. The serial port shall be compliant with RS-232 or RS-422 electrical interfaces and shall use a DB9 or RJ4S type connector. The serial communications interface shall allow the user to remotely configure the system and/or to extract calculated vehicle/roadway information.
- 5) Interface software. The interface protocol shall support multi-drop or point-to-multipoint communications. Each video detection system shall have the capability to be individually IP addressable either built in or with third party video server units.
- 6) Open collector contact closure outputs meeting NEMA T52 requirements. The open collector output will be used for vehicle detection indicators as well as discrete outputs for alarm conditions.
- 7) LED status indicators on the front panel. The LED's shall illuminate when a contact closure output occurs. Provide one output LED for each contact closure output.
- 8) A mouse compatible port (PS-2 or USB) on the front panel of the video processing unit. The mouse port shall be used as part of the system setup and configuration.

643.02.2.3--Functionality. Detection zones shall be programmed via an on-board menu displayed on a video monitor and a pointing device connected to the video detection processor. The menu shall facilitate placement of detection zones and setting of zone parameters or to view system parameters. The video detection processor shall detect vehicles in real time as they travel across each detection zone. The video detection processor shall have an RS-232 (DB9 or RJ4S) port for communications with an external computer. The video detection processor port shall be multi-drop capable.

It shall be possible to upload and save all configuration data including loop placement and save the file on a computer. It shall be possible to download a configuration file from a computer to the detection device.

The video detection processor shall accept new detection patterns from an external computer through the RS-232 port when the external computer uses the correct communications protocol for downloading detection patterns.

A Windows™ based software designed for local and remote connection shall be provided for video capture, real-time detection indication and detection zone modification capability.

The video detection processor shall send its detection patterns to an external computer through the RS-232 port.

The video detection processor shall default to a safe condition, such as minimum recall, fixed recall or a constant call on each active detection channel, in the event of unacceptable interference with the video signal, low visibility conditions, or power failure.

A user-selected output shall be active during the low-visibility condition that can be used to modify the controller operation if connected to the appropriate controller input modifier(s). The system shall automatically revert to normal detection mode when the low-visibility condition no longer exists.

643.02.2.3.1--Functionality for Span Wire Mounted Type 2 Vehicle Detection System.

The Video Detection Processor (VDP) for the Span Wire Mounted Type 2 Vehicle Detection System shall employ Dynamic Zone Stabilization to provide motion tracking and compensation for swaying camera sensors mounted on dual or single span wires. The VDP shall include software that discriminately detects the presence of vehicles and bicycles in single or multiple lanes using only the video image. The VDP shall compensate for swaying motions by tracking the position of the stop bar for the approaching vehicle or bicycle movement. The VDP shall compensate for low frequency (cable sag) motion due to temperature changes during the day. The VDP shall compensate for moderate frequency motion induced by winds. The VDP shall compensate for up to +/- 5 degrees of tilt from vertical without any adverse detection false calls or dropped calls.

643.02.2.4--Vehicle Detection. A minimum of 24 detection zones per camera input shall be possible, and each detection zone shall be capable of being sized to suit the site and the desired vehicle detection area.

A single detection zone shall be able to replace multiple inductive loops and the detection zones shall be OR'ed as the default or may be AND'ed together to indicate vehicle presence on a single phase of traffic movement.

Placement of detection zones shall be done by using only a pointing device, and a Graphical Interface built into the video detection processor and displayed on a video monitor, to draw the detection zones on the video image from each video camera. Detection zones created in this manner shall be compatible with the PC-based software provided with the system.

The video detection processor's memory shall be non-volatile to prevent data loss during power outages.

When a vehicle is detected crossing a detection zone, the corners or entire zone of the detection zone shall flash/change color on the video overlay display to confirm the detection of the vehicle. It shall be possible to record the operation of the unit in real time with the detection zones operating.

Detection shall be at least 98% accurate in all weather conditions, with slight degradation acceptable under adverse weather conditions (e.g. rain, snow, or fog) which reduce visibility.

The video detection processor shall maintain normal operation of existing detection zones when one (1) zone is being added or modified.

The video detection processor shall output a constant call on any detector channel corresponding to a zone being modified and shall resume normal operation upon completion.

Detection zones shall be directional to reduce false detections from objects traveling in directions other than the desired direction of travel in the detection area.

The video detection processor shall process the video input from each camera using a microprocessor at 30 frames per second at one volt, peak to peak, 75 ohms, or EIA 170 NTSC video standard.

The video detection processor shall output minimum recall, fixed recall or constant call for each enabled detector output channel if a loss of video signal occurs. The recall behavior shall be user selectable for each output. The video detection processor shall output a constant call during the background "learning" period.

Detection zone outputs shall be configurable to allow the selection of presence, pulse, extend, and delay outputs. Timing parameters of pulse extend, and delay outputs shall be user definable between 0.1 to 25.0 seconds in increments of 0.1 seconds.

Up to six (6) detection zones per camera view shall have the capability to count the number of vehicles detected, measure classification and speed. The data values shall be internally stored within the processor module for later retrieval through the RS-232 port. The data collection interval shall be user definable in periods of 5, 15, 30, or 60 minutes or by intersection cycle. Real-time data shall be retrieved from the PC-based software provided with the system.

643.02.2.5--Camera. Cameras shall be completely compatible with the video detection processor and shall be certified by the manufacturer to ensure proper system operation.

The Video Detection System shall produce accurate detector outputs under all roadway lighting conditions, regardless of time of day. The minimum range of scene luminance over which the camera shall produce a useable video image shall be the minimum range from nighttime to daytime, but not less than the range 0.009 to 930 foot-candles.

The camera shall use a color CCD sensing element with resolution of not less than 470 lines horizontal and 400 lines vertical.

The camera shall include mechanisms to compensate for changing of lighting by using an electronic shutter and/or auto-iris lens.

The camera shall include a variable focal length lens with factory preset focus that requires no field adjustment. Zooming of the camera lens to suit the site geometry by means of a portable interface device designed for that purpose. The horizontal field of view shall be adjustable. Camera configuration shall be customized for each approach based on field site conditions and the project plans.

The camera electronics shall include automatic gain control (AGC) to produce a satisfactory image at night.

The camera shall be housed in a weather-tight sealed enclosure. The housing shall be field rotatable to allow proper alignment between the camera and the traveled road surface.

The camera enclosure shall be equipped with a sunshield. The sunshield shall include a provision for water diversion to prevent water from flowing in the camera's field of view.

The camera enclosure shall include a thermostatically controlled heater to assure proper operation of the lens shutter at low temperatures and prevent moisture condensation on the optical faceplate of the enclosure. The heater shall directly heat the glass lens and require less than five (5) watts over the temperature range.

Power consumption of the camera shall be 15 watts or less under all conditions.

The camera enclosure shall be equipped with separate, weather-tight connections for power and setup video cables at the rear of the enclosure. These connections shall allow diagnostic testing and viewing of video at the camera while the camera is installed on a mast arm or pole using a lens adjustment module furnished under this bid item.

The video signal output by the camera shall in accordance with NTSC standards.

All necessary mounting brackets shall be mounted to pole shafts, mast arms, or other structures to mount cameras as indicated on the project plans. Mounting brackets shall result in a fixed-position mounting. Mounting Brackets shall be included at no additional cost.

643.02.2.6--Video Cable. The cable provided shall be as recommended by the manufacturer for optimal video detection performance. The cable shall be either multi-paired jacketed cable or coaxial cable. Coaxial cable can be used between the camera and the video detection processor in the traffic signal controller cabinet and shall be as per manufacturer's specifications. The signal attenuation shall not exceed 0.78 dB per 100 feet at 10 MHz. Nominal outside diameter shall be approximately 0.305 inch. Coaxial cable shall be suitable for installation in conduit and in exposed sunlight environment. 75-ohm BNC plug connectors shall be used at both the camera and cabinet ends. The coaxial cable, BNC connector, and crimping tool recommended by the manufacturer of the video detection system shall be used and installed per the manufacturer's recommended instructions to ensure proper connection.

Multi-paired jacketed cable shall include a minimum of four (4) individually paired No. 19 AWG communication cables with an overall shield. Pairs shall not be individually shielded. Paired cable and power cables may be installed under the same outer jacket.

643.02.2.7--Power Cable. Power cable for 120VAC cameras shall be rated for 90°C, 300 volt, stranded, AWG 16, 3-Conductor cable with a nominal outside diameter of approximately 0.330 inch. Conductor insulation color code shall be black, white, and green. Outside jacket shall be black.

Power cable for 24 Volt or other low voltage cameras shall be the cable recommended by the manufacturer.

Camera power cable shall be suitable for installation in conduit and in exposed sunlight environment, and UL listed.

The power and video cable may be installed under the same outer jacket.

643.02.2.8--Surge Protection. Surge protection devices shall be provide for all new or added video detection devices as recommended by the manufacturer.

Coaxial cable shall be protected with an inline surge suppressor as recommended by the manufacturer or a panel mounted surge suppressor as recommended by the manufacturer or approved equal, installed and grounded per manufacturer's recommendations.

643.02.2.9--Physical and Environmental Specifications. Physical and Environmental Specifications shall be as follows.

Video Detection System Processor: The video detection system processor shall operate reliably in a typical roadside traffic cabinet environment. Internal cabinet equipment and a video detection system processor shall be provided that meets the environmental requirements of NEMA T52-2003 Section 2. If the processor is located in the sensor, it shall meet the same requirements.

Video Camera Sensor: The operating ambient temperature range shall be -30°F to 140°F. Additionally, a heater shall be included to prevent the formation of ice and condensation in cold weather. Do not allow the heater to interfere with the operation of the video camera sensor electronics, or cause interference with the video signal.

Vibration: Vibrations shall meet the requirements of NEMA TS2-2003 section 2.1.9.

Shock: Shock shall meet the requirements of NEMA TS2-2003 section 2.1 .10.

Acoustic Noise: A video camera sensor and enclosure shall be provided that can withstand 150 dB for 30 minutes continuously, with no reduction in function or accuracy.

643.02.3--Materials Type 3 Vehicle and Bicycle Detection System. The Type 3 Video Detection System shall consist of a single integrated camera with video detection processor, a cabinet interface which mounts in a standard detector rack or as a stand-alone shelf mount unit, all necessary video and power cabling with end connectors, mounting brackets, lightning protection as recommended by the manufacturer. A sufficient number of cameras shall be provided to process vehicle presence, passage and system detection zones as shown on the project plans or listed on the purchase order.

643.02.3.1--Functional Requirements for Type 3 Vehicle Detection System. The Video Detection System configuration shall utilize an integrated camera with video detection processor, responding to specific site applications, camera locations and detection zones shown on the project plans. Type 3 Vehicle Detection Systems shall be able to detect vehicles and bicycles in multiple lanes using only the video image.

643.02.3.2--Cabinet Interface. A Cabinet Interface shall be provided that is specifically designed to mount in a standard NEMA TS-1 and TS-2 detector rack without adapters or rewiring, or as a stand-alone shelf mount unit. The Interface shall operate in a temperature range from -31°F to +165°F and a humidity range from 0% to 95% relative humidity. The Cabinet Interface shall be powered by 100v to 240v AC, 50 or 60Hz. The front of the Interface shall include LED detection indications for each channel of detection, One BNC

video output and detector test switches that allow the user to place calls on each channel.

643.02.3.3--Functionality. Detection zones shall be programmed via an on-board menu displayed on a video monitor and a pointing device connected to the Cabinet Interface. The menu shall facilitate placement of detection zones and setting of zone parameters or to view system parameters. The video detection processor shall detect vehicles and bicycles in real time as they travel across each detection zone. The Cabinet Interface shall have an EIA-232 port for communications with an external computer.

It shall be possible to upload and save all configuration data including loop placement and save the file on a computer. It shall be possible to download a configuration file from a computer to the detection device.

The video detection processor shall accept new detection patterns via the Cabinet Interface from an external computer through the EIA-232 port when the external computer uses the correct communications protocol for downloading detection patterns.

A Windows™ based software designed for local and remote connection shall be provided for video capture, real-time detection indication and detection zone modification capability.

The video detection processor shall send its detection patterns via the Cabinet Interface to an external computer through the EIA-232 port.

A Shelf mount version of the Cabinet Interface shall be available to avoid the need of rewiring the detector rack for high voltage input.

The video detection processor shall default to a safe condition, such as a constant on each active detection channel, in the event of unacceptable interference with the video signal, low visibility conditions, or power failure.

The system shall be capable of automatically detecting a low-visibility condition such as fog and respond by placing all defined detection zones in a constant call mode. The system shall automatically revert to normal detection mode when the low-visibility condition no longer exists.

643.02.3.4--Vehicle and Bicycle Detection. Eight (8) detection zones per camera input shall be possible, and each detection zone shall be capable of being sized to suit the site and the desired vehicle detection area.

A single detection zone shall be able to replace multiple inductive loops and the detection zones shall be OR'ed as the default or may be AND'ed together to indicate vehicle presence on a single phase of traffic movement.

Placement of detection zones shall be done by using only a pointing device, and a Graphical Interface built into the video detection processor and displayed on a video monitor, to draw the detection zones on the video image from each video camera. Detection zones created in this manner shall be compatible with the PC-based software provided with the system.

The video detection processor's memory shall be non-volatile to prevent data loss during power outages.

Confirmation of detection shall be provided when a vehicle or bicycle is detected crossing a detection zone.

Detection shall be at least 98% accurate in all weather conditions, with slight degradation acceptable under adverse weather conditions (e.g. rain, snow, or fog) which reduce visibility.

The video detection processor shall maintain normal operation of existing detection zones when one (1) zone is being added or modified.

The video detection processor shall output a constant call on any detector channel corresponding to a zone being modified and shall resume normal operation upon completion.

The video detection processor shall support bicycle type zones where the zone can differentiate between motorized vehicles and bicycles, producing a call for one but not the other. Bicycle zones shall only output when a bicycle is detected. The video detection processor shall provide the ability to assign a separate output channel for bicycle zones to allow traffic controllers to implement special bicycle timing for applications where the traffic controller has separate bicycle detection inputs. Bicycle zones shall have the ability to have extensions assigned to individual bicycle ones for applications where the traffic controller does not have bicycle specific detection inputs.

Up to six (6) detection zones per camera view shall have the capability to count the number of vehicles detected, measure average speed and occupancy by lane. The data values shall be internally stored within the processor module for later retrieval through the EIA-232 port.

Six (6) additional count zones for bicycles shall be provided to accumulate bicycle counts at user specified intervals.

643.02.3.5--Video Detection Processor with integrated Camera. The Video Detection System shall produce accurate detector outputs under all roadway lighting conditions, regardless of time of day. The minimum range of scene luminance over which the camera shall produce a useable video image shall be the minimum range from nighttime to daytime, but not less than the range 0.009 to 930 foot-candles.

The VDP camera shall use a color CCD sensing element with resolution of not less than 700 lines horizontal and 400 lines vertical.

The VDP camera shall include mechanisms to compensate for changing of lighting by using an electronic shutter and/or auto-iris lens.

The VDP camera shall include a variable focal length lens with a minimum of 10x zoom. Zooming of the camera lens to suit the site geometry shall be accomplished by means of a portable interface device designed for that purpose. The horizontal field of view shall be adjustable. Camera configuration shall be customized for each approach based on field site conditions and the project plans.

The VDP camera electronics shall include automatic gain control (AGC) to produce a

satisfactory image at night.

The VDP with integrated camera shall be housed in a weather-tight sealed enclosure. The housing shall be field rotatable to allow proper alignment between the camera and the traveled road surface.

The VDP camera enclosure shall be equipped with a sunshield. The sunshield shall include a provision for water diversion to prevent water from flowing in the camera's field of view.

The VDP camera enclosure shall include a proportionally controlled heater to assure proper operation of the lens shutter at low temperatures and prevent moisture condensation on the optical faceplate of the enclosure.

The VDP camera enclosure shall be equipped with a single weather-tight connector.

643.02.3.6—Video/Power Cable. The Cable used between the VDP and the Cabinet Interface shall be a three (3) twisted pair cable, meeting IMSA 39-2 requirements. The cable shall be a continuous unbroken run from the VDP to the Cabinet Interface. This cable shall be suitable for installation in conduit or overhead with appropriate span wire. Pluggable connectors or terminal blocks should be used at both the VDP and Cabinet Interface ends. The Cable and installation tools shall be approved by the supplier and manufacturer's instructions must be followed to ensure proper connection.

643.02.3.7--Surge Protection. Surge protection devices shall be provide for all new or added video detection devices as recommended by the manufacturer.

643.02.3.8--Physical and Environmental Specifications. Physical and Environmental Specifications shall be as follows.

Cabinet Interface: The video detection system processor shall operate reliably in a typical roadside traffic cabinet environment and shall meet the environmental requirements of NEMA T52-2003 Section 2. The operating ambient temperature range shall be -31°F to 165°F.

Video Detection Processor with integrated Camera Sensor: The operating ambient temperature range shall be -31°F to 165°F. Additionally, a heater shall be included to prevent the formation of ice and condensation in cold weather.

Vibration: Vibrations shall meet the requirements of NEMA TS2-2003 section 2.1.9.

Shock: Shock shall meet the requirements of NEMA TS2-2003 section 2.1 .10.

Acoustic Noise: A video camera sensor and enclosure shall be provided that can withstand 150 dB for 30 minutes continuously, with no reduction in function or accuracy.

643.02.4--Materials Multi-Sensor Vehicle Detection System.

643.02.4.1--General. The Multi-Sensor System shall utilize two (2) different sensors of different technologies, video imaging and radar, to detect and track licensed and unlicensed vehicles at distances up to 600 feet. The sensor system shall fuse vehicle information from the two sensors to provide highly accurate and precise detection for special or advanced

applications.

The Multi-Sensor System shall use a primary detector rack mounted processor to interface with the traffic control cabinet. The module shall process information from both video imaging and radar sensors simultaneously in real-time.

643.02.4.2--System Configurations. The Multi-Sensor Detection System (MSDS) shall consist of up to four (4) video cameras and radar units, detection processors (DP) capable of processing from one (1) to four (4) intersection approaches, output extension modules, surge suppressors, a setup tool and a pointing device.

The proposed MSDS shall be available in various configurations to allow maximum deployment flexibility. Each configuration shall have an identical user interface for system setup and configuration. The communications protocol to each configuration shall be identical and shall be hardware platform independent.

The system shall include software that detects vehicles in multiple lanes. Video imaging detection zones shall be defined using only an on-board video menu and a pointing device to place the zones on a video image. Up to 24 video detection zones per camera view shall be available. Two (2) additional trigger zones for the radar sensor shall be available and be configurable by using the same system setup menu on the DP. A separate computer shall not be required to program the detection zones. A pre-programmed setup tool is required to align and input radar information and set the camera field of view (zoom and focus).

643.02.4.3--Multi-Sensor Detection System Hardware. The MSDS hardware shall consist of the following four (4) elements:

- 1) Video Imaging Camera Sensor
- 2) Radar Sensor
- 3) Sensor Data Combiner
- 4) Detection Processor

643.02.4.3.1--Video Imaging Camera Sensor. The video imaging camera sensor shall meet the following minimum requirements:

- To accommodate deployment flexibility, the MSDS camera sensor shall be compatible with the Data Processor platforms. The MSDS camera sensor shall be supplied by the MSDS manufacturer.
- The advanced camera enclosure shall utilize technology for the heating element of the front glass. The transparent coating shall not impact the visual acuity and shall be close to optically clear.
- Cable terminations at the data combiner for video and power shall not require crimping or special tools.
- The camera sensor shall allow the user to set the focus and field of view via Wi-Fi connectivity.
- The camera shall produce a useable video image of vehicles under all roadway lighting conditions, regardless of time of day. The minimum range of scene luminance over which the camera shall produce a useable video image shall be the minimum range from nighttime to daytime, but not less than the range 1.0 lux to 10,000 lux.

- The camera electronics shall include automatic gain control (AGC) to produce a satisfactory image at night.
- The imager luminance signal to noise ratio (S/N) shall be more than 50 dB with the automatic gain control (AGC) disabled.
- The imager shall employ three (3) dimensional dynamic noise reduction (3D-DNR) to remove unwanted image noise.
- The camera imager shall employ wide dynamic range (WDR) technology to compensate for wide dynamic outdoor lighting conditions. The dynamic range shall be greater than 100 dB.
- The camera shall be digital signal processor (DSP) based and shall use a CCD sensing element and shall output color video with resolution of not less than 550 TV lines.
- The camera sensor shall include an electronic shutter control based upon average scene luminance and shall be equipped with an auto-iris lens that operates in tandem with the electronic shutter. The electronic shutter shall operate between the range of 1/1 to 1/10,000th second.
- The camera sensor shall utilize automatic white balance.
- The camera sensor shall include a variable focal length lens with variable focus that can be adjusted, without opening up the camera housing, to suit the site geometry by means of a portable interface device designed for that purpose and manufactured by the detection system supplier.
- The horizontal field of view shall be adjustable. This camera configuration may be used for the majority of detection approaches in order to minimize the setup time and spares required by the user. The lens shall be a minimum 10x zoom lens with a variable focal length.
- The lens shall also have an auto-focus feature with a manual override to facilitate ease of setup.
- The camera shall incorporate the use of preset positioning that store zoom and focus positioning information. The camera shall have the capability to recall the previously stored preset upon application of power.
- The camera shall be housed in a weather-tight sealed enclosure conforming to IP-67 specifications. The housing shall allow the camera to be rotated to allow proper alignment between the camera and the traveled road surface.
- The camera enclosure shall be equipped with a sunshield. The sunshield shall include a provision for water diversion to prevent water from flowing in the camera's field of view.
- The camera enclosure shall be designed so that the pan, tilt and rotation of the camera assembly can be accomplished independently without affecting the other settings.
- The camera enclosure shall include a proportionally controlled heater design that maximizes heat transfer to the lens. The output power of the heater shall vary with temperature, to assure proper operation of the lens functions at low temperatures and prevent moisture condensation on the optical faceplate of the enclosure.
- The glass face on the front of the enclosure shall have an anti-reflective coating to minimize light and image reflections.
- When mounted outdoors in the enclosure, the camera shall operate in a temperature range from -29°F to +165°F and a humidity range from 0% RH to 100% RH. Measurement of satisfactory video shall be based upon DP system operation.
- The camera sensor shall acquire its power from the sensor data combiner.
- Recommended camera placement height shall be 18 to 33 feet above the roadway,

and over the traveled way on which vehicles are to be detected. For optimum detection the camera should be centered above the traveled roadway. The camera shall view approaching vehicles at a distance not to exceed 350 feet for reliable detection (height to distance ratio of 10:100). Camera placement and field of view (FOV) shall be unobstructed and as noted in the installation documentation provided by the supplier.

- The video signal shall be fully isolated from the camera enclosure and power cabling
- A weather-proof protective cover shall be provided to protect all terminations at the camera.

643.02.4.3.2--Radar Sensor. The radar sensor shall meet the following minimum requirements:

- The radar sensor shall operate in the 24 GHz frequency band.
- The radar detection range shall be 600 feet minimum, $\pm 5\%$.
- The radar sensor shall be able to track up to 20 independent objects simultaneously.
- Object speed detection shall be within a range of zero (0) to 150 mph ± 1.0 mph.
- The radar sensor shall be able to detect vehicles in one (1) to four (4) traffic lanes.
- The radar sensor shall be housed in a weather-tight sealed enclosure conforming to IP-67 specifications. The housing shall allow the radar to be adjusted to allow proper alignment between the sensor and the traveled road surface.
- When mounted outdoors in the enclosure, the radar shall operate in a temperature range from -29°F to $+165^{\circ}\text{F}$ and a humidity range from 0% RH to 100% RH.
- The radar sensor shall communicate with the sensor data combiner.
- The radar sensor shall acquire its power from the sensor data combiner.
- Data and power cables between the radar sensor and sensor data combiner shall be fully isolated from the sensor enclosure.

643.02.4.3.3--Multi-Sensor Assembly. Multi-Sensor Assembly shall meet the following requirements:

- Both camera and radar sensors shall be housed in an overall, single enclosure assembly.
- The maximum power consumption for the Multi-Sensor Assembly shall be less than ten (10) watts typical, 20 watts peak.

643.02.4.3.4--Sensor Data Combiner. The sensor data combiner (if required) shall meet the following minimum requirements:

- A sensor data combiner that combines sensor information from both video and radar sensors shall be employed.
- The sensor data combiner shall supply primary power to each sensor unit.
- The sensor data combiner shall facilitate digital communications between the sensor data combiner and each of the sensor units.
- The sensor data combiner shall get its primary power from an AC power source using industry standard 3-Conductor cabling.
- The sensor data combiner shall communicate with the detection processor using a single coax cable. Both video imaging and radar data shall use the single coax cable.
- The sensor data combiner shall also employ industry standard Wi-Fi connectivity for remote sensor system setup using a mobile programming device such as a

netbook or tablet computer. Video camera and radar sensor shall be able to be configured independently.

- The sensor data signal shall be fully isolated from the mechanical enclosure and power cabling
- Cable terminations at the sensor data combiner shall not require crimping tools.
- The Sensor Data Combiner shall be housed in a weather-tight sealed enclosure conforming to IP-67 specifications.

643.02.4.3.5--Detection Processor. The detection processor shall meet the following minimum requirements:

- Each sensor input shall accept RS170 (NTSC) or CCIR (PAL) signals from an external video source. The interface connector shall be BNC type and shall be located on the front of the processing unit. The sensor input shall have the capability to be terminated into 75-ohms or high impedance (Hi-Z) using dip switches or software control from the user menu. The sensor input shall also facilitate the data from the radar sensor.
- A LED indicator shall be provided to indicate the presence of the sensor signal. The LED shall illuminate upon valid sensor synchronization and turn off when the presence of a valid sensor signal is removed.
- One (1) video output shall be provided. The video output shall be RS170 or CCIR compliant and shall pass through the input video signal. For multi-channel video input configurations, a momentary push-button shall be provided on the front panel to cycle through each input video channel. In the absence of a valid sensor signal, the channel shall be skipped and the next valid sensor signal shall be switched. The real time video output shall have the capability to show text and graphical overlays to aid in system setup. The video output interface connector shall be positive locking BNC type. Friction type (e.g. RCA type) connectors shall not be allowed.
- A communications port shall be provided on the front panel. The communications interface shall allow the user to remotely configure the system and/or to extract calculated vehicle/roadway information. The interface protocol shall be documented or interface software shall be provided. Each MSDS shall have the capability to be addressable. The DP shall support data rates of 1200 bps to 230,400 bps, inclusive.
- Open collector (contact closure) outputs shall be provided. Four (4) open collector outputs shall be provided for the single or dual channel rack-mount configuration. Additionally, the DP shall allow the use of extension modules to provide up to 24 open collector contact closures per camera input. Each open collector output shall be capable of sinking 30 mA at 24 VDC. Open collector outputs will be used for vehicle detection indicators as well as discrete outputs for alarm conditions. The DP outputs shall be compatible with industry standard detector racks assignments.
- Logic inputs such as delay/extend or delay inhibit shall be supported through the appropriate detector rack connector pin or front panel connector in the case of the I/O module. For DPs and extension modules, 4 inputs shall be supported via detector rack interface. The I/O module shall accommodate eight (8) inputs through a 15-pin "D" connector.
- Detection status LEDs shall be provided on the front panel. The LEDs shall illuminate when a contact closure output occurs. The front panel of the DP shall have detector test switches to allow the user to manually place calls on each DP output channel. The test switch shall be able to place either a constant call or a

momentary call depending on the position of the switch.

- A USB mouse port shall be provided on the front panel of the rack mount detection processing unit. The mouse port shall not require special mouse software drivers. The mouse port shall be used as part of system setup and configuration.
- Extension modules (if required) shall be connected to the DP by an 8-wire twisted-pair cable with modular RJ45 connectors. DP and EM communications shall be accommodated by methods using differential signals to reject electrically coupled noise.
- Extension modules (EM) shall be available to eliminate the need of rewiring the detector rack, by enabling the user to plug an extension module into the appropriate slot in the detector rack to provide additional open collector outputs. The extension module shall be available in both two (2) and four (4)-channel configurations. The DP and EM shall be specifically designed to mount in a standard detector rack, using the edge connector to obtain power, provide contact closure outputs and accept logic inputs (e.g. delay/extend). No adapters shall be required to mount the DP or EM in a standard detector rack. Detector rack rewiring shall not be required.
- The DP shall utilize non-volatile memory technology to store on-board firmware and operational data.
- The DP shall enable the loading of modified or enhanced software through the EIA232 or USB port (using a USB thumb drive) and without modifying the DP hardware.
- The DP and EM shall be powered by 12 or 24 volts DC. DP and EM modules shall automatically compensate for either 12 or 24 VDC operation. DP power consumption shall not exceed 7.5 watts. The EM power consumption shall not exceed three (3) watts.
- The DP shall operate satisfactorily in a temperature range from -40°F to +165°F and a humidity range from zero (0) %RH to 95 %RH, non-condensing as set forth in NEMA specifications.
- A video surge suppresser shall be provided for each sensor input. The surge suppresser shall be appropriately grounded to the cabinet ground rod using AWG 14 minimum.

643.02.4.4--System Software. The system software shall meet the following general system functions:

- Detection zones shall be programmed via an on board menu displayed on a video monitor and a pointing device connected to the DP. The menu shall facilitate placement of detection zones and setting of zone parameters or to view system parameters. A separate computer shall not be required for programming detection zones or to view system operation.
- The DP shall store up to three (3) different detection zone patterns in non-volatile memory. The DP can switch to any one of the three (3) different detection patterns within one (1) second of user request via menu selection with the pointing device. Each configuration shall be uniquely labeled and able to be edited by the user for identification. The currently active configuration indicator shall be displayed on the monitor.
- The DP shall detect vehicles in real time as they travel across each detection zone.
- The DP shall accept new detection patterns from an external computer through a communications port when the external computer uses the correct communications protocol for downloading detection patterns. A Windows™ based software

designed for local or remote connection and providing video capture, real-time detection indication and detection zone modification capability shall be provided with the system.

- The DP system shall have the capability to automatically switch to any one of the stored configurations based on the time of day which shall be programmable by the user.
- The DP shall send its detection patterns to an external computer through the communications port when requested when the external computer uses the appropriate communications protocol for uploading detection patterns.
- The DP shall default to a safe condition, such as a constant call on each active detection channel, in the event of unacceptable interference or loss of the sensor signal.
- The system shall be capable of automatically detecting a low-visibility condition such as fog and respond by placing all effected detection zones in a constant call mode. A user-selected alarm output shall be active during the low-visibility condition that can be used to modify the controller operation if connected to the appropriate controller input modifier(s). The system shall automatically revert to normal detection mode when the low-visibility condition no longer exists.
- Up to 24 detection zones per camera input shall be supported and each detection zone can be sized to suit the site and the desired vehicle detection region.
- The DP shall support two (2) independent trigger points for radar outputs for dilemma zone applications.
- The DP shall provide up to 24 open collector output channels per sensor input using one or more extension modules.
- A single detection zone shall be able to replace multiple inductive loops and the detection zones shall be OR'ed as the default or may be AND'ed together to indicate vehicle presence on a single approach of traffic movement.
- Placement of detection zones shall be done by using only a pointing device, and a graphical interface built into the DP and displayed on a video monitor or laptop computer to draw the detection zones on the video image from each video camera.
- When a vehicle is detected within a detection zone, a visual indication of the detection shall activate on the video overlay display to confirm the detection of the vehicle for the zone.
- Detection shall be at least 98% accurate in good weather conditions, with slight degradation possible under adverse weather conditions (e.g. rain, snow, or fog) which reduce visibility. Detection accuracy is dependent upon site geometry, camera placement, camera quality and detection zone location, and these accuracy levels do not include allowances for occlusion or poor video due to camera location or quality.
- The DP shall provide dynamic zone reconfiguration (DZR). DZR enables normal operation of existing detection zones when one zone is being added or modified during the setup process. The new zone configuration shall not go into effect until the configuration is saved by the operator.
- Detection zone setup shall not require site specific information such as latitude and longitude to be entered into the system.
- The DP shall process the video input from each camera at 30 frames per second. Multiple camera processors shall process all video inputs simultaneously.
- The DP shall output a constant call during the background learning period of no more than three (3) minutes.
- Detection zone outputs shall be configurable to allow the selection of presence,

pulse, extend, and delay outputs. Timing parameters of pulse, extend, and delay outputs shall be user definable between 0.1 to 25.0 seconds.

- Up to six (6) video detection zones per sensor input shall have the capability to count the number of vehicles detected. The count value shall be internally stored for later retrieval through the communications port.
- In addition to the count type zone, the DP shall be able to calculate and/or acquire average speed and lane occupancy using both video and radar sensors. These values shall be stored in non-volatile memory for later retrieval.
- The DP shall have an “advance” zone type where detection outputs to the traffic controller are compensated for angular occlusion and distance.
- The user shall have the ability to enable or disable the display of the phase information on the video output.
- The DP shall have the capability to change the characteristics of a detection zone based on external inputs such as signal phase. Each detection zone shall be able to switch from one zone type (i.e. presence, extension, pulse, etc.) to another zone type based on the signal state. For example, a zone may be a “count” zone when the phase is green but change to a “presence” zone type when the phase is not green. Another application would be zone type of “extension” when the signal phase is green and then “delay” when red.
- The DP shall aid the user in drawing additional detection zones by automatically drawing and placing zones at appropriate locations with only a single click of the mouse. When the user wishes to modify the location of a zone, the DP shall allow the user move a single zone, multiple zones or all zones simultaneously.
- On screen zone identifiers shall be modifiable by the user. The user shall be allowed to select channel output assignments, zone type, input status, zone labels or zone numbers to be the identifier.
- For multiple camera input DPs, the user shall have the ability to enable automatic video output switching. The dwell time for each sensor input shall be user programmable.
- For the radar sensor zones the output can be triggered by presence of a vehicle only or by presence of a vehicle above a speed defined by the user.

643.02.4.5--Multi-Sensor Cable. The cable to be used between the Multi-Sensor Assembly and the DP in the traffic cabinet shall be per manufacturer’s specifications. This cable shall be suitable for installation in conduit or overhead with appropriate span wire. BNC plug connectors shall be used where applicable. The cable, BNC connector, and crimping tool shall be approved by the supplier of the MSDS, and the manufacturer's instructions must be followed to ensure proper connection.

643.02.4.6--Power Cable. The power cabling shall be per manufacturer’s specifications. The cabling shall comply with the National Electric Code, as well as local electrical codes.

643.03--Construction Requirements. The Construction and testing requirements for Type 1, Type 2, and Type 3 Video Detection Systems, and Multi-Sensor Detection System are the same.

643.03.1--General Requirements. The Contractor shall perform the following:

- 1) Install all sensors, system processors and associated enclosures and equipment at the locations specified in the plans, in any related notice to bidders, per manufacturer’s

recommendations, or as directed.

- 2) Install all cabinet-mounted equipment in the intersection equipment cabinet or as specified in the plans.
- 3) Cabling from all sensors shall be provided and installed in accordance with the manufacturer's recommendations.
- 4) Make all necessary adjustments and modifications to the total VDS/MSDS prior to requesting inspection for system/device acceptance.
- 5) Mount the sensors as per manufacturer's recommendations or as shown in the plans.
- 6) Mount the sensors so as to view approaching traffic unless otherwise directed.
- 7) Optimize the sensors location and zone of detection as directed by the Engineer, or authorized designee.
- 8) Adjust the sensor zoom lens to match the width of the road/detection area, and minimize lane vehicle occlusion.
- 9) Fasten all other cabinet components, with hex-head or Phillips-head machine screws insulated with nuts (with locking washer or insert) or into tapped and threaded holes. Do not use self-tapping or self-threading fasteners.
- 10) Provide electrical cables for video, communications signaling and power supply between the cabinet and the VDS/MSDS image sensor cameras as recommended by the manufacturer, and as required for a fully functional System.

643.03.2--Contractor Training. Installation of the Video Detection System shall be as recommended by the supplier and performed by a Contractor trained and certified by the supplier. Where time does not reasonably permit training of the installing Contractor, a supplier factory representative shall supervise and assist a Contractor during installation of the Video Detection System.

Installation of the Multi-Sensor Detection system shall be as recommended by the supplier and performed by a Contractor with factory-certified installers and documented in installation materials provided by the supplier. Proof of factory certification shall be provided.

643.03.3--Test Requirements. The Contractor shall conduct a Project Testing Program as required below. All costs associated with the Project Testing Program shall be included in overall contract prices; no separate payment will be made for any testing.

643.03.3.1--General Requirements. The Contractor is responsible for planning, coordinating, conducting and documenting all aspects of the Project Testing Program. The Project Engineer and/or authorized representatives are only responsible for attending and observing each test, and reviewing and approving the Contractor's test results documentation. The Project Engineer and/or authorized representatives reserve the right to attend and observe all tests.

Each test shall fully demonstrate that the equipment being tested is clearly and definitely in full compliance with all project requirements.

Test procedures shall be submitted and approved for each test as part of the project submittals. Test procedures shall include every action necessary to fully demonstrate that the equipment being tested is clearly and definitely in full compliance with all project requirements. Test procedures shall cross-reference to these Technical Specifications or the Project plans. Test procedures shall contain documentation regarding the equipment configurations and programming.

No testing shall be scheduled until approval of all project submittals and approval of the test procedures for the given test.

The Contractor shall provide all ancillary equipment and materials as required in the approved test procedures.

The Contractor shall request in writing the Project Engineer's approval for each test occurrence a minimum of 14 days prior to the requested test date. Test requests shall include the test to be performed and the equipment to be tested. The Project Engineer reserves the right to reschedule test request if needed.

All tests shall be documented in writing by the Contractor in accordance with the test procedure and submitted to the Project Engineer within seven (7) days of the test. Any given test session is considered incomplete until the Project Engineer has approved the documentation for that test session.

All tests deemed by the Project Engineer to be unsatisfactorily completed shall be repeated by the Contractor. In the written request for each test occurrence that is a repeat of a previous test, the Contractor shall summarize the diagnosis and correction of each aspect of the previous test, which was deemed unsatisfactory. The test procedures for a repeated test occurrence shall meet all the requirements of the original test procedures, including review and approval by the Project Engineer and ITS Manager.

The satisfactory completion of any test shall not relieve the Contractor of responsibility to provide a completely acceptable and operating system that meets all requirements of this project.

643.03.3.2--Factory Acceptance Test (FAT). Factory Acceptance Tests shall be conducted at the Manufacturer or Contractor facility or at a facility acceptable to all parties. All equipment to be utilized for this project shall be subject to tests that demonstrate the suitability of the design and compliance with the contract requirements, unless an exception for an equipment item is granted by the Project Engineer. The tests shall be performed on production units identified to be delivered under this contract.

The FAT procedure shall demonstrate all requirements defined in these specifications are met, including, but not limited to: functional/system performance requirements, electrical requirements, data transmission/communication requirements, safety/password requirements, environmental requirements, and interface requirements with other components of the project system.

The Project Engineer reserves the right to waive FATs which are deemed to be unnecessary and reserves the right to witness all FATs that are determined to be critical to the project. At a minimum, the Project Engineer and/or authorized representative will be in attendance at the FAT for the first three (3) units tested. The FAT for the first three (3) units shall be conducted during the same period. The Project Engineer shall be notified a minimum of forty-five (45) calendar days in advance of such tests. Salary and travel expenses of the Project Engineer and authorized representatives will be the responsibility of the Department. In case of equipment or other failures that make a re-test necessary, travel expenses of the Project Engineer and authorized representatives shall be the responsibility of the Contractor. These costs shall be deducted from payment due the Contractor.

The vendor must complete the FAT on all remaining units on their own and submit documentation to the Project Engineer that the FATs were completed. The Project Engineer reserves the right to randomly attend those FAT tests.

No equipment for which a FAT is required shall be shipped to the project site without successful completion of factory acceptance testing as approved by the Project Engineer and the Engineer's approval to ship.

643.03.3.3--Standalone Acceptance Test (SAT). The Contractor shall perform a complete SAT on all equipment and materials associated with the field device site, including but not limited to electrical service, conduit, pull boxes, communication links (fiber, leased copper, wireless), control cables, poles, etc. A SAT shall be conducted at every field device site. Where applicable, a SAT shall be conducted for a fully installed and completed connection to the designated Traffic Management Center (TMC) or central data/video collection site.

The SAT shall demonstrate that all equipment and materials are in full compliance with all project requirements and fully functional as installed and in final configuration. The SAT shall also demonstrate full compliance with all operational and performance requirements of the project. All SATs will include a visual inspection of the cabinet and all construction elements at the site to ensure they are compliant with the specifications.

All SATs will include videos of the approach with detection zones overlaid showing detector activations.

- 1) One (1) hour videos shall be made of each approach and compared to actual detection calls.
- 2) 30 minute videos shall be made starting 15 minutes prior to sunrise and sunset for each approach and compared to actual detection calls.
- 3) All videos shall be date and time stamped.
- 4) Provide all videos to the Engineer with a summary of the results included total calls, missed calls and false calls.
- 5) All test results must meet a 98% accuracy requirement.

The Contractor must demonstrate the accuracy requirements specified in Subsection 643.02.1.7 at selected intersections after a sixty (60) day burn in period for Type 1 and a thirty (30) day burn in period for Type 2, Type 3 and MSDS. The intersections to be tested will be randomly selected by the Project Engineer.

643.03.4--Warranty. The Video Detection System shall be warranted to be free of manufacturer defects in materials and workmanship for a period of one (1) year from the date of final acceptance. Equipment covered by the manufacturer's warranties shall have the registration of that component placed in the Department's name prior to final inspection. The Contractor is responsible for ensuring that the vendors and/or manufacturers supplying the components and providing the equipment warranties recognize the Department as the original purchaser and owner/end user of the components from new. During the warranty period, the supplier shall repair or replace with new or refurbished material, at no additional cost to the State, any product containing a warranty defect, provided the product is returned postage-paid by the Department to the supplier's factory or authorized warranty site. Products repaired or replaced under warranty by the supplier shall be returned prepaid by

the supplier.

The Multi-Sensor Detection System shall be warranted to be free of manufacturer defects in materials and workmanship for a period of three years (3) from the date of final acceptance.

During the warranty period, technical support shall be available from the supplier via telephone within four (4) hours of the time a call is made by the Department, and this support shall be available from factory certified personnel. During the warranty period, updates and corrections to Control Unit Software shall be made available to the Department by the supplier at no additional cost.

643.03.5--MDOT Employee Training. The Contractor shall submit to the Project Engineer for approval a detailed Training Plan including course agendas, detailed description of functions to be demonstrated and a schedule. The Contractor must also submit the Trainer's qualifications to the Project Engineer for approval prior to scheduling any training. The training must include both classroom style training and hands-on training in the field of the maintenance and troubleshooting procedures required for each component. The training should also consist of a hands-on demonstration of all software configuration and functionality where applicable.

The supplier of the detection system shall, at a minimum, provide a 16-hour operations and maintenance training class with suitable documentation for up to eight (8) persons selected by the Department. The operations and maintenance class shall be scheduled at a mutually acceptable time and location.

643.03.6--Maintenance and Technical Support. The supplier shall maintain an adequate inventory of parts to support maintenance and repair of the detection system. Spare parts shall be available for delivery within 30 days of placement of an acceptable order at the supplier's then current pricing and terms of sale of said spare parts.

The suppliers shall maintain an ongoing program of technical support for the detection system. This technical support shall be available via telephone or via personnel sent to the installation site upon placement of an acceptable order at the supplier's then current pricing and terms of sale of said technical support services.

The installation or training support shall be provided by a factory-authorized representative and shall be a minimum IMSA-Level II Certified Traffic Signal Technician.

All product documentation shall be written in the English language.

643.04--Method of Measurement. Video Detection System of the type specified and Video Detection-Data Collection and Reporting Tool License will be measured as a unit per each.

Video Detection Training will be measured as a lump sum after the completion of all training.

Multi-Sensor Detection System of the type specified will be measured as a unit per each

643.05--Basis of Payment. Video Detection System and Video Detection-Data Collection

and Reporting Tool License, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for installation, system integration, documentation, system software, and testing of a complete video detection system site including video camera sensor/processor, the sensor environmental enclosure, all cables between cameras and the cabinet, attachment hardware and brackets, completion of all testing requirements and all work, equipment and appurtenances as required to provide and install a complete video detection system. The price bid shall also include all system documentation including: shop drawings, operations and maintenance manuals, wiring diagrams, block diagrams and other materials necessary to document the operation of the Video Detection System. This price shall be full compensation for all labor, tools, materials, equipment and incidentals necessary to complete the work.

Video Detection Training, measured as prescribed above, will be paid for at the contract unit lump sum price, which price shall be full compensation for all training costs.

Multi-Sensor Detection System, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for installation, system integration, documentation, and testing of a complete Multi-Sensor Detection System site including video imaging camera sensor, radar sensor, sensor data combiner, detection processor, system software, the sensor environment enclosure, all cables between sensors and the cabinet, attachment hardware and brackets, completion of all testing requirements and all work, equipment and appurtenances as required to provide and install a complete Multi-Sensor Detection System. The price bid shall also include all system documentation including: shop drawings, operations and maintenance manuals, wiring diagrams, block diagrams and other materials necessary to document the operation of the multi-sensor detection system. This price shall be full compensation for all labor, tools, materials, equipment and incidentals necessary to complete the work.

Payment will be made under:

643-A: Video Detection System, __ Sensor, Type __	- per each
643-B: Video Detection System, Span Wire Mounted Sensor, Type __	- per each
643-C: Video Detection-Data Collection and Reporting Tool License	- per each
643-D: Video Detection Training	- lump sum
643-E: Multi-Sensor Detection System, __ Sensor	- per each

SECTION 645 - PEDESTRIAN DETECTION ASSEMBLIES

645.01--Description. This work consists of furnishing Pedestrian Detection Assemblies of the type specified and installing them in accordance with these specifications and the details shown on the plans or as directed by the Engineer. Pedestrian Detection Systems are classified in two (2) categories: Standard Pedestrian Pushbutton Detection Systems and Accessible Pedestrian Pushbutton Detection Systems. A Pedestrian Detection System consists of the following principal components: Pushbuttons, Pedestrian Actuation Signs, electronics, wiring, and mounting hardware. The function intended for use with these systems include Pedestrian Detection.

645.02--Materials.

645.02.1--Standard Pedestrian Pushbutton Detector. Pushbuttons shall be raised from or flush with their housings and be a minimum of two (2) inches in the smallest dimension. The Pushbutton shall require no more than five pounds (5 lbs.) of force to activate. The detector shall be weather-tight and tamper resistant. The pushbutton shall be provided complete with suitable mounting hardware for banding, or attaching by other suitable methods, to poles.

645.02.1.1--Housing. The housing shall be a two (2) piece unit consisting of a base housing and a removable cover. The housing shall be cast metal with a brushed aluminum finish and shall be primed and painted black in color. The housing shall be rain-tight, weatherproof, and shall protect users from electrical shock. The housing or adapter shall conform to the shape of a pole and provide a flush, secure fit. Unused openings shall be closed with a weatherproof closure and painted to match the housing. The housing shall be permanently marked with the Manufacturer name or trademark, part number, date of manufacture, and serial number.

645.02.1.2--Pushbutton. The Pushbutton shall include a normally-open, mechanical phenolic enclosed, positive-acting, snap-action switch with signal pole, single throw contacts or Piezo driven solid state switch rated for a minimum of 50 V. The switch, when activated, shall give an audible (i.e., click) or visual indication of actuation. Switch connections inside the housing shall allow wiring and installation without binding. The switch shall have a minimum design life of one (1) million operations at rated load.

645.02.1.3--Electrical Requirements. The cabling, at a minimum, shall be AWG 14, 5-Conductor stranded with 600 V outdoor insulation rating.

645.02.1.4--Control Electronics. Control electronics shall not require more than four (4) wires for each Pushbutton connection, and no more than two (2) wires for each controller pedestrian input. Voltage at the Pushbutton shall not exceed 24 VAC.

645.02.2--Accessible Pedestrian Pushbutton Detector. The Accessible Pedestrian Pushbutton Detector shall be MUTCD, latest edition, compliant and consist of all electronic control equipment, wiring, mounting hardware, pushbuttons, and Pedestrian Actuation Signs designed to provide both a pushbutton with a raised, vibrating tactile arrow on the button as well as a variety of audible indications for differing pedestrian signal functions.

645.02.2.1--Electronic Control Equipment. The Accessible Pedestrian Pushbutton Detector shall include electronic control equipment that is programmable and adjustable using a laptop computer or vendor supplied programmer. Electronic control equipment shall be able to be installed within a traffic controller cabinet or within Pedestrian Signal housing. Electronic control equipment installed within a traffic controller cabinet shall allow the use of up to 16 pushbuttons (four (4) maximum per channel) with a single traffic controller cabinet. The Accessible Pedestrian Pushbutton Detector shall receive timing from WALK and DON'T WALK signals.

645.02.2.1.1--Audible Messages. Audible messages shall be programmable. All audible messages and tones shall emanate from the Accessible Pedestrian Pushbutton housing. The

Accessible Pedestrian Pushbutton Detector shall utilize digital audio technology. The system shall have, at a minimum, three (3) programmable locator tones. The Accessible Pedestrian Pushbutton Detector shall have independent minimum and maximum volume limits for the Locator Tone, “Walk,” and Audible Beaconing features. The “Wait” message shall only annunciate once per actuation.

645.02.2.1.2--Pushbutton Locator Tone. The Accessible Pedestrian Pushbutton Detector shall provide independent ambient sound adjustment for the locator tone feature. The Accessible Pedestrian Pushbutton Detector shall allow the locator tone to be deactivated.

645.02.2.1.3--Vibrating Pushbutton (VPB). The Accessible Pedestrian Pushbutton Detector shall include a Vibrating Pushbutton (VPB). The VPB shall be a single assembly containing an ADA compliant, vibro-tactile, directional arrow button, weatherproof audible speaker and pedestrian actuation sign with optional placard Braille messages. The VPB tactile arrow shall be two (2) inches in length, be field adjustable to two (2) directions, and require no more than five pounds (5 lbs.) of applied force to activate.

645.02.2.1.4--Conflict Monitoring. The Accessible Pedestrian Pushbutton Detector shall monitor the WALK condition for conflict operation. The Accessible Pedestrian Detector system shall disable the WALK functionality if a conflict is detected.

645.02.2.1.5--Cabinet Control Unit (CCU). The Accessible Pedestrian Pushbutton Detector may include a CCU for interfacing and connecting the system. The CCU shall have labeled LED indicators for each channel operation. The CCU shall reset upon loss of internal communication.

645.02.2.2--Inputs and Outputs. All inputs and outputs shall use Mil-Spec Multi-pin connectors.

645.02.2.2.1--Inputs. WALK and DONT WALK inputs shall be optically isolated 80-150 volts AC/DC, five (5) mA max. General purpose inputs shall be optically isolated 10-36 volts AC/DC, ten (10) mA max.

645.02.2.2.2--Outputs. Outputs shall be optically isolated 36 volts AC/DC peak, 300mA solid state fused contact closures. CCUs shall include a normally open relay contact fault output.

645.02.2.3--Communication. The CCU shall include an Ethernet interface. The CCU shall have an integral web server that provides information on audible/tactile pedestrian-pushbutton detector status, access to event logs, and provides for remote configuration of Accessible Pedestrian Pushbutton Detector System options. VPBs shall include an Ethernet, serial, or USB programming interface.

645.02.3--Electrical. All wiring shall meet applicable NEC requirements. The Accessible Pedestrian Pushbutton Detector shall operate using a nominal input voltage of 120 volts alternating current (VAC). If any device requires nominal input voltage of less than 120 VAC, furnish the appropriate voltage converter.

Accessible Pedestrian Pushbutton Detector control electronics that are mounted in a pedestrian signal head shall be able to receive power from the WALK and DONT WALK circuits of the signal head. Control electronics shall not require more than four (4) wires

for each pushbutton connection, and no more than two (2) wires for each controller pedestrian input. Voltage at the Pushbutton shall not exceed 24 VAC.

645.02.4--Mechanical. Equipment shall be permanently marked with manufacturer name or trademark, part number, date of manufacture, and serial number. Self-tapping screws shall not be used on the exterior of the assembly.

All parts shall be made of corrosion-resistant materials. All assembly hardware, including nuts, bolts, external screws and locking washers less than 5/8 inch in diameter, shall be Type 304 or 316 passivated stainless steel. Stainless steel bolts, screws and studs shall meet ASTM F593. Nuts shall meet ASTM F594. All assembly hardware greater than or equal to 5/8 inch in diameter shall be galvanized. Bolts, studs, and threaded rod shall meet ASTM A307. Structural bolts shall meet ASTM A325.

Enclosures shall have a NEMA 4X rating. Pushbutton housings shall be black in color.

645.02.5--Environmental. Ensure equipment performs all required functions during and after being subjected to the environmental testing procedures described in NEMA TS2, Sections 2.2.7, 2.2.8, and 2.2.9.

645.03--Construction Requirements. The installation shall be carried out in conformance with the requirements herein stated and shown on the plans, and shall present a neat and workmanlike appearance.

The Pedestrian Detection Assemblies shall be mounted on the traffic signal or pedestal poles and connected to the detector wiring as indicated on the plans and as required in these specifications. The height of the assemblies shall be based on the final grade of the completed project.

645.04--Method of Measurement. Pedestrian Detection Assemblies of the type specified will be measured as a unit per each.

645.05--Basis of Payment. Pedestrian Detection Assemblies, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing the housing, pushbutton, electronic control equipment, programmed audible messages and tones, mounting attachments, sockets, socket wiring, and all other materials; for installing, mounting, connecting, aligning, testing, equipment, labor, tools, and all incidentals necessary to complete the work.

Payment will be made under:

- | | |
|-------------------------------------------------|------------|
| 645-A: Standard Pedestrian Detection Assembly | - per each |
| 645-B: Accessible Pedestrian Detection Assembly | - per each |

SECTION 646 - LED INTERNALLY ILLUMINATED SIGNS

646.01--Description. This work consist of furnishing and installing illuminated traffic, blank-out or street name signs as shown on the plans and set forth herein.

This specification addresses the minimum requirements for supplying illuminated traffic, street name signs and blank-out signs for use with span wire and mast arm mounted traffic signal systems.

646.02--Materials.

646.02.1--Illuminated Traffic Signs. Illuminated traffic signs shall be LED internally illuminated warning or regulatory signs with a single sided rigid mount.

646.02.1.1--Mechanical Specifications. The outer dimensions of the sign assembly shall be as shown on the plans, or as specified in the MUTCD, with standard nominal heights of 18" to 36".

646.02.1.2--Housing. The long edges of the sign shall be made from corrosive resistant aluminum. The ends caps shall be made from aluminum and shall be affixed to the frame with stainless steel screws. The power supply shall be mounted internally and one (1) end cap shall be removable to enable replacing panels and components.

Both the back panel and the sign face panel shall be securely held inside of the sign's extruded rails.

The sign shall have a front panel that is UV, weather, abrasion and impact resistant. The front panel shall be replaceable so that maintaining agencies have the option to supply sheeting and electrocut film for the sign faces.

All exterior surfaces of the sign assembly shall be powder-coat painted in accordance with Military Standard MIL-C-24712. Finish will meet the requirements of ASTM D3359, ASTM D3363, and ASTM D552

No silicone will be used in the weather resistant seal of the sign. The sign enclosure shall have a weatherproof design that ensures water does not reach internal components, and shall be able to do so in its design, without the use of silicone.

646.02.1.3--Rigid Mount. The sign shall rigid mount directly to the signal mast arm or to a sign mast arm with no moving parts. Sign bracket shall be able to be leveled to accommodate mast arms that are slightly off level. Sign bracket hardware shall mount as per manufacturer's specifications.

The sign will have no holes drilled though the enclosure's back plate for use in a rigid mount mast arm configuration. Adjustable rigid mount hardware shall securely grasp the top and bottom rails of the sign to provide maximum retention of the sign when installed on the mast arm.

The sign shall be supplied with rigid back brace mounting brackets on two (2) positions on the back of the sign. The rigid back brace mounting brackets will be powder-coat painted to an exact match of the sign extrusions and shall be in accordance with Military Standard

MIL-C-24712. The finish shall meet the requirements of ASTM D3359, ASTM D3363, and ASTM D552. Approved brackets as per manufacturer's specifications, shall be used for this installation.

646.02.1.4--Environmental. The sign and power supply shall be field hardened and be able to withstand extreme operating temperatures.

Signs shall be tested and certified for the following environmental conditions:

- Exclusion of Water Test
- Thermal Shock Test
- Salt Spray Test
- Strain Relief Test
- Temperature Test
- Dielectric Voltage - Withstand Test.

Signs shall be UL (Underwriters Laboratories) listed and approved.

646.02.1.5--Structural. The sign shall meet the specifications set forth in the latest edition of the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals. The sign shall meet the wind requirements set forth in the latest edition of the AASHTO Wind Map.

646.02.1.6--Luminance. The entire surface of the sign panel shall be evenly illuminated with a minimum average brightness reading at the letters of a minimum of 500 lux.

646.02.1.7--Light Source. The light source for the sign shall be LEDs. The LEDs shall evenly illuminate a light panel that is the same dimensions of the sign face. The LEDs shall have a minimum projected lifespan of 50,000 hours. The Failure of one (1) LED shall not reduce the light output or cause other LEDs to fail. All LED's shall meet ITE Standards for color and viewing angle and be high in optical power.

646.02.1.8--Energy Requirement. The sign shall be an Energy Star Qualified Product.

646.02.1.9--Quality Assurance. Manufacturer shall be ISO 9001:2000 compliant certified.

646.02.1.10--Electrical Standards. The sign shall be listed and approved to UL Standards by a Nationally Recognized Testing Laboratory.

LED Single Output Switching Power Supply shall be a fully-encapsulated, constant-current design built to withstand 300VAC surge input for five (5) seconds, with inherent short circuit/over current/over voltage protection. The Power Supply shall be a UL 1310 Class 2 power unit, and will be housed in a fully isolated plastic case to prevent water intrusion.

Safety Standards shall meet the following criteria: UL1310 Class 2, CAN/CSA C22.2 No. 223-M91 (for LPC-60-1750 only), IP67 approved; design refer to TUV EN60950-1, EN61347-2-13.

646.02.1.11--Warranty / Guarantee. Sign shall be guaranteed for a minimum of five (5) years.

646.02.2--Illuminated Street Name Signs. Illuminated Street Name Signs shall be LED Internally illuminated signs allowing for single or double sided signs for span wire or rigid mounts.

646.02.2.1--Mechanical Specifications. The outer dimensions of the sign assembly shall be as shown on the plans with standard nominal heights of 18” to 36”, and standard nominal lengths of 48” to 144”.

646.02.2.2--Housing. The sign housing and finish shall meet the requirements of Subsection 646.02.1.2.

646.02.2.3--Mounting. For a single-sided underhang sign, the sign shall be supplied with underhang mounting brackets on two (2) positions on the back of the sign. The mounting bracket shall have a bolt hole pattern to accept manufacturer specified sign hardware. For a double-sided sign, the sign shall be supplied with underhang mounting brackets on two (2) positions on the top of the sign that allows the sign to swing freely. The mounting bracket shall have a bolt hole pattern to accept the manufacturer’s hardware.

646.02.2.4--Environmental Specifications. The sign shall meet the requirements of Subsection 646.02.1.4.

646.02.2.5--Structural. The sign shall meet the requirements of Subsection 646.02.1.5.

646.02.2.6--Luminance. The sign shall meet the requirements of Subsection 646.02.1.6.

646.02.2.7--Light Source. The sign shall meet the requirements of Subsection 646.02.1.7.

646.02.2.8--Energy Requirements. The average power consumption of the sign shall not exceed 3 – 5 Watts per square foot of viewing area. The sign shall be capable of operating at 120 VAC to 277 VAC. The sign shall be an Energy Star Qualified Product.

646.02.2.9--Electrical Standards. The sign shall meet the requirements of Subsection 646.02.1.10.

646.02.2.10--Warranty / Guarantee. The sign shall meet the requirement of Subsection 646.02.1.11.

646.02.3--LED Blank-Out Signs. Blank-Out Signs are an alternative to static warning and regulatory signs to increase visibility, and for creating a safer driving environment. The signs shall conform to Manual on Uniform Traffic Control Devices (MUTCD), latest edition, font and symbol sign standards. In addition enclosures shall meet NEMA 3R standards. The sign shall be capable of displaying one (1) or multiple messages. The messages may be red, amber or bluish/green and be displayed on one (1) side or two (2). The messages shall be formed by single or double rows of LED's.

646.02.3.1--Housing and Mounting. The housing shall be weatherproof and made of 5052-H32 marine-grade aluminum that is 0.125 inch thick.

The finish shall be black powder coat unless otherwise specified in the plans. The finish on the sign housing shall be two (2) coats of exterior enamel applied after surface material is acid-etched and primed with zinc-chromate primer.

All corners and seams of one 1- or 2-way housings shall be heli-arc welded to provide a weatherproof seal around the entire case. Continuous full-length stainless steel hinges shall connect the housing and the extruded aluminum door.

Window dimension shall be between 24" to 60" wide with a maximum weight of 100 pounds.

Door gaskets shall be $\frac{3}{16}$ -inch x 1-inch neoprene to provide a weatherproof seal. Each door shall be fitted with a sun hood of 0.063-inch aluminum. The standard length shall be six inches (6"). Drainage shall be provided by four (4) drain holes at the corners of the housing.

The sign shall rigid mount directly to the signal mast arm or to a sign mast arm with no moving parts. Sign bracket shall be able to be leveled to accommodate mast arms that are slightly off level. The sign shall also be able to mount on span wire.

646.02.3.2--Structural. The sign shall meet the structural specifications provided in Subsection 646.02.2.5.

646.02.3.3--Light Source. All messages shall be clearly legible, attracting attention under any lighting condition. At full intensity, the signal will be highly visible anywhere within a 15 degree cone centered about the optic axis.

All LED's shall have an expected lifetime of a minimum of 50,000 hours. LED Modules shall continue to shall continue to operate if one LED goes out.

All LED's shall meet ITE Standards for color and viewing angle and be high in optical power.

646.02.3.4--Electrical. The sign shall be solid state, with a 95 to 125 VAC input, 12 to 15 VDC output, and >95% power factor. The average power consumption of the sign shall be 35 to 105 Watts, varies per message. Transformers shall be used to reduce the incoming 120 volts AC to the design DC voltage. The transformers shall contain Class A insulation and weatherproofing.

The sign shall be capable of continuous operation over a range in temperatures from -35°F to +165°F.

646.02.3.5--Warranty / Guarantee. All products will be warranted to be free of defects due to material and workmanship for a period of two (2) years.

646.03--Construction Requirements. All signs shall be installed in accordance with the plans and the Manual on Uniform Traffic Control Devices (MUTCD). Signs shall be installed with appropriate mounting brackets and associated hardware to mast arms, signal poles, or span wire as prescribed above.

646.04--Method of Measurement. Illuminated Traffic Sign, Illuminated Street Name Sign, and LED Blank-Out Sign of the type specified will be measured as a unit per each.

646.05--Basis of Payment. Illuminated Traffic Sign, Illuminated Street Name Sign, and LED Blank-Out Sign, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing the sign and mounting hardware and installing the same on the span wire, signal pole or mast arm, and for all equipment, tools, labor, and incidentals necessary to complete the work.

Payment will be made under:

- 646-A: Illuminated Traffic Sign * - each
- 646-B: Illuminated Street Name Sign - each
- 646-C: LED Blank-Out Sign * - each

* Additional information may be indicated

SECTION 647 - REMOVAL OF EXISTING TRAFFIC SIGNAL EQUIPMENT

647.01--Description. This work consists of removing all existing traffic control equipment that will no longer be required.

647.02--Blank.

647.03--Construction Requirements. Existing traffic signals, traffic controllers, span wires, control wires, interconnect cable, etc. will be removed by the Contractor. Existing traffic signal support poles that are no longer required and have no other utilities attached will be removed. The Contractor shall restore areas disturbed by the removal of the existing equipment to the satisfaction of the Engineer.

When salvaged by the State, all removed equipment will be identified by a tag noting its location and date of removal. The Engineer shall be informed of the items removed, their location and date of removal. Removed items will be stored on the project and the Contractor shall notify and coordinate with the State for the return of salvaged traffic signal equipment. Unless otherwise noted in the contract, all loading and hauling of State-salvaged traffic signal equipment will be the responsibility of the State.

647.04--Method of Measurement. Removal of existing traffic signal equipment will be measured as a unit lump sum quantity. Such measurement shall include removal, any required tagging and storing of signal equipment, span wire, interconnect cable, etc.

647.05--Basis of Payment. Removal of existing traffic signal equipment, measured as prescribed above, will be paid for at the contract lump sum price, which price shall be full compensation for removal and disassembly of existing traffic signal equipment, for restoration of areas disturbed by removal and for furnishing all equipment, tools, labor and incidentals necessary to complete the work.

Payment will be made under:

647-A: Removal of Existing Traffic Signal Equipment

- lump sum

SECTION 653 - TRAFFIC AND STREET NAME SIGNS

653.01--Description. This work shall consist of furnishing and installing reflectorized regulatory and warning traffic signs and street name signs as shown on the plans and set forth herein.

This specification addresses the minimum requirements for supplying traffic and street name signs for use with span wire and mast arm mounted traffic signal systems.

653.02--Materials. All materials for traffic and street name signs shall be new and meet the requirements of Section 721 of the Standard Specifications.

653.02.1--Reflective Sheeting. Reflective sheeting for traffic and street name signs shall be Type III or Type VII retroreflective sheeting. The type and color of reflective sheeting shall be indicated on the plans or set forth herein.

653.02.2--Sign Blanks. Sign blanks shall be flat aluminum sign blanks constructed of 5052-H38 aluminum alloy. Blanks shall be 0.100 inches thick, degreased, deburred, etched and alodine. Sizes shall be as indicated in the plans for the specific warning, regulatory or street name sign called for and to accommodate the various legends.

653.02.3--Sign Faces. All sign faces shall consist of sheeting material and their legends applied to aluminum blanks specified herein using a heat vacuum method and/or by silk screening the legends only onto the backings and material. The sheeting shall be applied with legends to one side of each warning, regulatory or street name sign as shown on the plans.

The color of all faces shall consist of a reflectorized yellow, red, green or silver-white background with reflectorized black, red or white legend. The legend shall consist of letters and symbols conforming to the design of warning or regulatory signs as shown in the MUTCD and for street name signs as shown on the plans.

All letter sizes spacing shall be in accordance with FHWA and the manufacturer's recommendations to insure proper legibility with the increased reflectance.

653.03--Construction Requirements. All signs shall be installed in accordance with the plans and the Manual on Uniform Traffic Control Devices (MUTCD). Signs are to be tilted in order to minimize or eliminate specular reflection.

653.03.1--Warning and Regulatory Signs. Warning and regulatory signs shall be installed at locations as noted on the plans with the appropriate mounting bracket and banding material.

653.03.2--Street Name Signs. Street name signs shall be installed at locations as noted on the plans. If installed on mast arms, they shall be attached with at least two mounting brackets and appropriate banding materials.

653.03.3--Washers. Washers, if recommended by the sheeting manufacturer to protect the sign surface from damage by bolts or other fasteners, shall be furnished by the manufacturer at no additional charge.

653.04--Method of Measurement. Traffic sign and street name sign of the type specified will be measured by the square foot, which measurement being inclusive of aluminum sign blank, applied reflective sheeting, mounting brackets and banding materials and begin inclusive of all materials, work and services necessary for a properly constructed sign.

653.05--Basis of Payment. Traffic sign and street name sign, measured as prescribed above, will be paid for at the contract unit price per square foot, which price shall be full compensation for furnishing the sign and mounting hardware and installing the same on the span wire, signal pole or mast arm, and for all equipment, tools, labor and incidentals necessary to complete the work.

Payment will be made under:

653-A: Traffic Sign, Type - per square foot

653-B: Street Name Sign, Type - per square foot

SECTION 656--DYNAMIC MESSAGE SIGN

656.01--Description. This work consists of furnishing, installing and integrating a stationary electronic Dynamic Message Sign (DMS) assembly. The Contractor shall supply a complete operating Light Emitting Diode (LED) sign including the sign housing, sign controller unit (SCU), roadside DMS controller cabinet, all cabling, conduits, electrical service, surge suppression and all hardware associated with a complete installation in accordance with these specifications.

The DMS assemblies will provide MDOT personnel with a means to visually communicate with motorists regarding incidents, accidents, special events, travel times, etc., that may impact travel on the roadway network.

656.02--Materials.

656.02.1--Types of DMS. Each DMS shall be one of the following types:

DMS Type 1 shall be full a color high resolution matrix sign. The display and pixel spacing shall be capable of displaying three lines of text with 21 characters per line such that each character shall each have a nominal height of 18 inches. The pixel pitch shall be 20mm (0.78") or less. The signs housing shall be a walk-in enclosure.

DMS Type 2 shall be a full color high resolution matrix sign. The display and pixel spacing shall be capable of displaying three lines of text with 21 characters per line such that each character shall have a nominal height of 18 inches. The pixel pitch shall be 20mm (0.78") or less. The signs housing shall be either a front access or rear access enclosure. A walk-in enclosure is not required for a Type 2 DMS but is allowed if preferred by the vendor.

DMS Type 3 shall be a full color high resolution matrix sign. The display and pixel spacing shall be capable of displaying two lines of text with 9 characters per line such that each character shall each have a nominal height of 12 inches. The pixel pitch shall be 20mm (0.78”) or less. The signs housing shall be either a front access or rear access enclosure. A walk-in enclosure is not required for a Type 3 DMS but is allowed if preferred by the vendor.

656.02.2--DMS Components. Each DMS shall include the following main components:

- 1) Sign Housing (walk-in or front/rear access).
- 2) LED Modules.
- 3) LED Drivers.
- 4) Power Supplies
- 5) Roadside DMS Cabinet.
- 6) Sign Controller
- 7) Surge Protection Device (SPD)

656.02.3--References. This specification incorporate nonnative references to other standards as listed below. If a conflict exists between the standards referenced and this specification, this specification shall govern.

- 1) NEMA TS-4: NEMA TS4-2004, Hardware Standards for Dynamic Message Signs (DMS) with NTCIP Requirements. NEMA TS-4 requirements that apply to fixed signs locations shall be used.
- 2) NTCIP

656.02.4--Glossary of DMS Terms. The definitions of the terms used within this specification are those terms defined in NEMA TS-4.

656.02.5--Environmental Requirements. Each DMS shall meet all of the performance and testing requirements as outline in Section 2 of NEMA TS-4 standard in addition to the following minimum requirements:

SPD shall be installed at each of the following locations:

- 1) AC power service entrance into the DMS Cabinet before the main cabinet breaker.
- 2) AC power out to the DMS housing after the branch breaker.
- 3) AC power entrance into the DMS Housing before the main housing breaker.

The SPD shall be designed to meet IEEE C62.41 C3 conditions.

A SPD installed for AC power feed at the panel board shall be connected in parallel and meet the following minimum electrical requirements:

- 1) Withstand a peak 100,000-ampere surge current, 50kA L-N, 50kA L-G
- 2) 5000 Category (C3 High) impulses with <10% drift, short-circuit current rating (SCCR) of 200,000 rms symmetrical amperes (UL Listed) .
- 3) UL 1449 200kA SCCR, UL 1283 4th Edition, and Canadian safety standards.
- 4) Temperature range of -40°F to +140°F

A SPD installed for DMS control equipment protection shall be connected in series and meet the following minimum electrical requirements:

- 1) Withstand a peak 50,000-ampere surge current for an 8x20 microsecond wave form
- 2) Maximum continuous operating current of 15 amps at 120 VAC, 60 Hz
- 3) UL 1449 surge rating of 400V or less
- 4) Temperature range of -40°F to +158°F

656.02.6--Mechanical Construction. Each DMS shall meet all of the performance and testing requirements as outlined in Section 3 of NEMA TS-4 standard in addition to the following requirements:

656.02.6.1--Vents and Filters. Each DMS vent and air filters shall meet the following requirements:

- 1) Air filters installed between the intake vent and the fan.
- 2) Air filters are replaceable, industrial grade, and pleated.
- 3) Air filters completely covering the vent opening area.
- 4) Air filters manufactured per ASHRAE Standard 52.2P or Standard 52.1.
- 5) Air filters of fire retardant and water resistant construction, able to withstand temperatures up to 300°F.
- 6) Filter replacement without tools with easy access.

656.02.6.2--Ventilation System. Each DMS shall incorporate a ventilation system meeting the following requirements:

- 1) The electric fans designed for continuous duty.
- 2) Sign housing venting fan(s) having a minimum combined capacity to keep the signs housing internal temperature to a maximum of thirty (30) degrees Fahrenheit above external ambient temperature under the following conditions:
 - a) All pixels on maximum illumination level.
 - b) Maximum solar loading for the State of Mississippi.
 - c) Worse case humidity for the State of Mississippi.
- 3) LED cooling fans to vent the air between the display module and the sign face cover.
- 4) Sufficient LED cooling fans to keep the air surrounding the LEDs to a maximum temperature not exceeding the rated temperature for the LEDs.
- 5) Sign housing ventilation calculations and LED cooling calculations to show sufficient air circulation is provided to meet the herein requirements.
- 6) The fan(s) mounted within the housing.
- 7) The fan(s) down stream from the air filters.
- 8) The sign housing venting fan(s) blowing the air into the sign housing.
- 9) The DMS manufacturer to determine the number, placement, and size of the electric fans to meet the requirements listed in this subsection.
- 10) The fans thermostatically controlled.
- 11) The thermostat having a minimum adjustable range between 77° to 122°F.

656.02.6.3--Sign Face Material. The sign face material shall be replaceable.

656.02.6.4--Sign Housing Construction. The DMS housing shall meet the following requirements:

- 1) Engineer approved sign housing dimensions.
- 2) Sign housing to present a clean, unbroken, neat appearance.
- 3) No visible text or logo on sign housing.
- 4) Angular alignment of the sign housing adjusted in the vertical direction down by three (3) degrees.
- 5) Sign housing constructed of aluminum sheeting to be 5052-H32 and structural members to be 6061-T6, per ASTM Specifications.
- 6) Aluminum sheeting no less than 1/8 inch thick with all seams continuously welded by MIG (metal inert gas) welding or other approved method of similar strength.
- 7) The front of the sign housing having a flat black matte finish.
- 8) All surfaces other than the front of the sign housing having a bare aluminum mill finish.
- 9) Weep holes to allow moisture to escape.
- 10) Sign housing shall having an interior, non-skid walkway where the walkway shall extend the entire length of the sign housing.

656.02.6.5--Access Door. Walk in DMS housing shall include an access door meeting the following requirements:

- 1) Access to the interior of the sign case via a gasketed door.
- 2) Gasketing on all door openings meeting the following requirements:
 - a) Dust-tight.
 - b) Meeting NEMA 3R requirements
 - c) Permanently bonded to the door metal.
 - d) Not sticking to the mating metal surface.
- 3) A gasket top channel to support the top gasket on the door in order to prevent gasket gravitational fatigue.
- 4) When the door is closed and latched, the door shall be locked. The lock shall meet the following requirements:
 - a) Lock and lock support rigidly mounted on the door.
 - b) In the locked position, the bolt throw extends a nominal 0.25-inch into the latch cam area.
 - c) A lid or seal to prevent dust or water entry through the lock opening.
 - d) #2 key type locks matching the master number of the existing signs.
 - e) Two keys with each lock.
 - f) Keys removable in the locked position only.
 - g) Locks having rectangular, spring loaded bolts.
- 5) For DMS installed on an overhead structure with catwalk, the access door located on side of DMS housing that is immediately adjacent to catwalk.
- 6) For DMS installed on a roadside structure, the access door located on the side of the DMS housing that is immediately adjacent to roadside, but NOT directly above the travel lanes, and facing traveled way.

656.02.7--Controller to Sign Interface. Each DMS shall meet all of the performance and testing requirements as outline in Section 4 of NEMA TS-4 standard.

656.02.8--Display Properties. Each DMS shall meet all of the performance and testing requirements as outlined in Section 5 of NEMA TS-4 standard for outdoor sign using light emitting pixels in addition to the following.

DMS pixel shall be manufactured using LEDs. Each pixel shall contain the quantity of discrete LEDs needed to output white colored light at a minimum luminous intensity of 12,400 candelas per square meter when measured using a photometric meter through the DMS front face panel assembly. Each pixel shall be capable of displaying amber colored light with a minimum luminous intensity of 7,440 candelas per square meter when measured using a photometric meter through the DMS front face panel assembly. Each pixel shall consist of a minimum of one (1) independent string of discrete LEDs for each color. All pixels shall contain an equal quantity of LED strings. Pixels shall be replaceable either individually or in groupings. Groupings with three or more pixels shall be permitted only if bench level repairs and replacements to individual pixels are possible. The failure of an LED in one string within a pixel shall not affect the operation of any other string or pixel.

656.02.9--Optical Components. Each DMS shall meet all of the performance and testing requirements as outlined in Section 6 of NEMA TS-4 standard in addition to the following LED requirements. LEDs used to form each pixel shall meet the following minimum requirements.

DMS pixels shall be constructed with discrete LEDs manufactured by Avago Technologies (formerly Agilent Technologies), Toshiba Corporation, or Nichia Corporation, OSRAM, EOI, or a manufacturer submitted and approved in writing by the Department.

LED lenses shall be UV light resistant.

All LEDs shall be water resistant having a nominal viewing cone of 30 degrees with a half-power angle of 15 degrees measured from the longitudinal axis of the LED. Viewing cone tolerances shall be as specified in the LED manufacturer's product specifications and shall not exceed +/- 5 degrees. Using optical enhancing lenses with 15 degrees LED's will not conform to 30 degree half-power viewing cone specification.

Red LEDs shall utilize AlInGaP semiconductor technology and shall emit red light that has a peak wavelength of 615-635 nm.

Green LEDs shall utilize InGaN semiconductor technology and shall emit green light that has a peak wavelength of 520-535 nm.

Blue LEDs shall utilize InGaN semiconductor technology and shall emit blue light that has a peak wavelength of 464-470 nm.

The various LED color and intensity bins shall be distributed evenly throughout the sign and shall be consistent from pixel to pixel.

The LED manufacturer shall assure color uniformity and consistency on the LED display face within 30 degree cone of vision. Inconsistent color shifts of intensity will be cause for rejection.

The LEDs shall be rated by the LED manufacturer to have a minimum lifetime of 100,000 hours of continuous operation while maintaining a minimum of 70% of the original brightness.

656.02.10--DMS Controller Cabinet. Each DMS controller cabinet shall meet all of the performance and testing requirements as outlined in Section 7 of NEMA TS-4 standard.

656.02.11--Electronics and Electrical. Each DMS shall meet all of the performance and testing requirements as outlined in Section 8 of NEMA TS-4 standard in addition to the following requirements:

656.02.11.1--Brightness Controls. The DMS light sensing and dimming control shall meet the following minimum requirements.

- 1) Sixteen (16) user selectable brightness levels
- 2) The controller monitoring ambient light levels through a photo sensor assembly that senses the ambient illumination level using three (3) photodiodes oriented as follows:
 - a) Cell 1 - Monitors the change from "day" to "night".
 - b) Cell 2 - Facing towards oncoming traffic; monitors prevailing ambient light levels in the upstream traffic.
 - c) Cell 3 - Facing passed traffic; monitors prevailing ambient light levels in the downstream traffic.

656.02.11.2--Communication Interfaces. The DMS controller shall support two Central Communication Ports (CCPs). One CCP shall be an Ethernet port, and the second CCP shall be a serial RS232 port.

656.02.11.3--NTCIP Protocol and Command Sets. As a minimum, the DMS hardware and software shall support the following NTCIP objects.

This specification references several standards through their NTCIP designated names and numbers. Each NTCIP Component covered by these project specifications shall implement the most recent version of the standard that is available as of project advertisement date, including any and all prepared Amendments to these standards as of the same date.

Profile Implementation Conformance Specifications (PICS) for each NTCIP standard required shall be submitted for review and approval to the Department.

656.02.11.3.1--Ethernet Interface. Communication interfaces using Ethernet shall conform at a minimum with all mandatory objects of all mandatory Conformance Groups of the following standards:

- 1) 1101 -NTCIP Simple Transportation Management Framework (STMF)
- 2) 1203 -NTCIP Object Definition for Dynamic Message Signs
- 3) 2301 -NTCIP AP-STMF
- 4) 2202 -NTCIP TP-Internet
- 5) 2104 -NTCIP SP-Ethernet

656.02.11.3.2--RS-232 Interface. Communication interfaces using RS-232 shall conform at a minimum with all standards:

- 1) 1101 -NTCIP Simple Transportation Management Framework (STMF)
- 2) 1203 -NTCIP Object Definition for Dynamic Message Signs
- 3) 2301 -NTCIP AP-STMF

- 4) 2201 -NTCIP TP-Transportation Transport Profile
- 5) 2104 -NTCIP SP-PMPP/RS232

656.02.11.3.3--Subnet Level. For each communication interface, the Subnet Level shall meet the following minimum requirements.

NTCIP Components may support additional Subnet Profiles at the manufacturer's option.

At any one time, only one Subnet Profile shall be active on a given communication interface.

The NTCIP Component shall be configurable to allow the field technician to activate the desired Subnet Profile.

656.02.11.3.4--Transport Level. For each communication interface, the Transport Level shall meet the following minimum requirements.

Communication interfaces may support additional Transport Profiles at the manufacturer's option.

Response datagrams shall use the same Transport Profile used in the request.

Each communication interface shall support the receipt of diagrams conforming to any of the identified Transport Profiles at any time.

656.02.11.3.5--Application Level. For each communication interface, the Application Level shall meet the following minimum requirements.

All communication interfaces shall comply with NTCIP 1101 and shall meet the requirements for Conformance Level 1 (NOTE -See Amendment to standard).

Optionally, the NTCIP Component may support Simple Network Management Protocol (SNMP) traps.

A communication interface may support additional Application Profiles at the manufacturer's option.

Responses shall use the same Application Profile used by the request.

Each communication interface shall support the receipt of Application data packets at any time allowed by the subject standards.

656.02.11.3.6--Information Level. All communication interfaces Information level protocol shall meet the following minimum requirements.

All communication interfaces shall provide Full, Standardized Object Range Support of all objects required by these procurement specifications unless otherwise indicated below.

The maximum Response Time for any object or group of objects shall be 200 milliseconds.

All communication interfaces shall implement all mandatory objects of all mandatory Conformance Groups as defined in NTCIP 1203 and their respective Amendments.

Table 1 indicates the modified object requirements for these mandatory objects. Table 2 shows the required minimum support of messages that are to be stored in permanent memory.

The sign shall blank if a command to display a message contains an invalid Message CRC value for the desired message.

Table 3 specifies the support of the required MULTI tags and their ranges.

Interfaces shall also implement all mandatory objects of the following optional conformance groups of NTCIP 1201.

- a) Time Management Conformal Group
- b) Report Conformal Group. Table 4 indicates the modified object requirements.

The following items shall be implemented:

- all objects of the Font Configuration Conformance Group, as defined in NTCIP 1203. Table 5 indicates the modified object requirements for this conformance group.
- all objects of the DMS Configuration Conformance Group, as defined in NTCIP 1203.
- all objects of the Multi Configuration Conformance Group, as defined in NTCIP 1203. Table 6 indicates the modified object requirements for this conformance group.
- all objects of the Multi Error Configuration, as defined in NTCIP 1203.
- all objects of the Illumination/Brightness.
- Sign Status, as defined in NTCIP 1203.
- Status Error, as defined in NTCIP 1203.
- Pixel Error Status, as defined in NTCIP 1203.

Since the display of graphics is currently not defined within the NTCIP Standards or their amendments, the vendor shall propose, and provide detailed documentation (i.e., interface protocol description level), how the specified graphical shapes can be displayed.

The optional objects listed in Table 7 shall be implemented

Table 1: Modified Object Ranges for Mandatory Objects

Object	Reference	Project Requirement
ModuleTableEntry	NTCIP 1201 Clause 2.2.3	Shall contain at least one row with moduleType equal to 3 (software). The moduleMake shall specify the name of the manufacturer, the moduleModel shall specify the manufacturer's name of the component and the modelVersion shall indicate the model version number of the component.
MaxGroupAddresses	NTCIP 1201 Clause 2.7.1	Shall be at least 1
CommunityNamesMax	NTCIP 1201 Clause 2.8.2	Shall be at least 3
DmsNumPermanentMsg	NTCIP 1203 Clause 2.6.1.1.1.1	Shall be at least 1*
DmsMaxChangeableMsg	NTCIP 1203 Clause 2.6.1.1.1.3	Shall be at least 60 supporting at least 3 pages per message.
DmsFreeChangeableMemory	NTCIP 1203 Clause 2.6.1.1.1.4	Shall be at least 20 when no messages are stored.
DmsMessageMultiString	NTCIP 1203 Clause 2.6.1.1.1.8.3	The DMS shall support any valid MULTI string containing any subset of those MULTI tags listed in Table 3.
DmsControlMode	NTCIP 1203 Clause 2.7.1.1.1.1	Shall support at least the following modes: <ul style="list-style-type: none"> ▪ local ▪ external ▪ central ▪ centralOverride

Table 2: Content of Permanent Messages

Perm. Msg. Num.	Section 12 Description
1	Permanent Message #1 shall blank the display (i.e., command the sign to use dmsMessageType 7). It shall have a run-time priority of 50.

Table 3: Required MULTI Tags

Code	Feature
f1	Field 1 - time (12hr)
f2	Field 2 - time (24hr)
f8	Field 8 - day of month
f9	Field 9 - month
f10	Field 10 - 2 digit year
f11	Field 11 - 4 digit year
Fl (and /fl)	flashing text on a line by line basis with flash rates controllable in 0.5 second increments.
Fo	Font
J12	justification - line - left
J13	justification - line - center
J14	justification - line - right
J15	justification - line - full
Jp2	justification - page - top
Jp3	justification - page - middle
Jp4	justification - page - bottom
Mv	moving text
Nl	New line
Np	New page, up to 2 instances in a message (i.e., up to 4 pages/frames in a message counting first page)
Pt	page times controllable in 0.5 second increments.

Table 4: Modified Object Ranges for the Report Conformance Group

Object	Reference	Project Requirement
maxEventLogConfigs	NTCIP 1201 Clause 2.5.1	Shall be at least 50
eventConfigurationMode	NTCIP 1201 Clause 2.4.3.1	The NTCIP Component shall support the following Event Configuration Modes: <ul style="list-style-type: none"> ▪ onChange ▪ greaterThanValue ▪ smallerThanValue
maxEventLogSize	NTCIP 1201 Clause 2.5.3	Shall be at least 200
maxEventClasses	NTCIP 1201 Clause 2.5.5	Shall be at least 16

Table 5: Modified Object Ranges for the Font Configuration Conformance Group

Object	Reference	Project Requirement
numfont	NTCIP 1203 Clause 2.4.1.1.1.1	Shall be at least 12*
maxFontCharacters	NTCIP 1203 Clause 2.4.1.1.1.3	Shall be at least 127**

- * Upon delivery, the first font shall be a standard 18" font. The second font shall be a double- stroke 18" font. The third font shall be a 12" font. The fourth font shall be empty.
- ** Upon delivery, the first three font sets shall be configured in accordance with the ASCII character set for the following characters:
 - a) "A" thru "Z" - All upper case letters.
 - b) "a" thru "z" - All lower case letters.
 - c) "0" thru "9" - All decimal digits.
 - d) Space (i.e., ASCII code 0x20).
 - e) Punctuation marks shown in brackets [. , ! ? - ' ' " " / ()]
 - f) Special characters shown in brackets [# & * + < >]

Table 6: Modified Object Ranges for the MULTI Configuration Conformance Group

Object	Reference	Project Requirement
defaultBackgroundColor	NTCIP 1203 Clause 2.5.1.1.1.1	The DMS shall support the following background colors: <ul style="list-style-type: none"> ▪ black
defaultForegroundColor	NTCIP 1203 Clause 2.5.1.1.1.2	The DMS shall support the following foreground colors: <ul style="list-style-type: none"> ▪ amber
defaultJustificationLine	NTCIP 1203 Clause 2.5.1.1.1.6	The DMS shall support the following line justification: <ul style="list-style-type: none"> ▪ Left ▪ Center ▪ Right ▪ Full
defaultJustificationPage	NTCIP 1203 Clause 2.5.1.1.1.7	The DMS shall support the following forms of page justification: <ul style="list-style-type: none"> ▪ Top ▪ Middle ▪ Bottom
defaultPageOnTime	NTCIP 1203 Clause 2.5.1.1.1.8	The DMS shall support the full range of these objects with step sizes no larger than 0.5 seconds
defaultPageOffTime	NTCIP 1203 Clause 2.5.1.1.1.9	The DMS shall support the full range of these objects with step sizes no larger than 0.5 seconds
defaultCharacterSet	NTCIP 1203 Clause 2.5.1.1.1.10	The DMS shall support the following character sets: <ul style="list-style-type: none"> ▪ eightBit

Table 7: Optional Object Requirements

Object	Reference	Project Requirement
globalSetIDParameter	NTCIP 1201 Clause 2.2.1	
eventConfigLogOID	NTCIP 1201 Clause 2.5.2.7	
eventConfigAction	NTCIP 1201 Clause 2.5.2.8	
eventClassDescription	NTCIP 1201 Clause 2.5.6.4	
defaultFlashOn	NTCIP 1203 Clause 2.5.1.1.1.3	The DMS shall support the full range of these objects with step sizes no larger than 0.5 seconds
defaultFlashOff	NTCIP 1203 Clause 2.5.1.1.1.4	The DMS shall support the full range of these objects with step sizes no larger than 0.5 seconds
dmsSWReset	NTCIP 1203 Clause 2.7.1.1.1.2	
dmsMessageTimeRemaining	NTCIP 1203 Clause 2.7.1.1.1.4	
dmsShortPowerRecoveryMessage	NTCIP 1203 Clause 2.7.1.1.1.8	
dmsLongPowerRecoveryMessage	NTCIP 1203 Clause 2.7.1.1.1.9	
dmsShortPowerLossTime	NTCIP 1203 Clause 2.7.1.1.1.10	
dmsResetMessage	NTCIP 1203 Clause 2.7.1.1.1.11	
DmsCommunicationsLossMessage	NTCIP 1203 Clause 2.7.1.1.1.12	
dmsTimeCommLoss	NTCIP 1203 Clause 2.7.1.1.1.13	
dmsEndDurationMessage	NTCIP 1203 Clause 2.7.1.1.1.15	
dmsMemoryMgmt	NTCIP 1203 Clause 2.7.1.1.1.16	The DMS shall support the following Memory management Modes: <ul style="list-style-type: none"> ▪ normal ▪ clearChangeableMessage ▪ clearVolatileMessages

dmsMultiOtherErrorDescription	NTCIP 1203 Clause 2.7.1.1.1.20	If the vendor implements any vendor-specific MULTI tags, the DMS shall be provided with documentation that includes meaningful error messages within this object whenever one of these tags generates an error.
dmsIllumLightOutputStatus	NTCIP 1203 Clause 2.8.1.1.1.9	
watchdogFailureCount	NTCIP 1203 Clause 2.11.1.1.1.5	
dmsStatDoorOpen	NTCIP 1203 Clause 2.11.1.1.1.6	
fanFailure	NTCIP 1203 Clause 2.11.2.1.1.8	
fanTestActivation	NTCIP 1203 Clause 2.11.2.1.1.9	
tempMinCtrlCabinet	NTCIP 1203 Clause 2.11.4.1.1.1	
tempMaxCtrlCabinet	NTCIP 1203 Clause 2.11.4.1.1.2	
tempMinSignHousing	NTCIP 1203 Clause 2.11.4.1.1.5	
tempMaxSignHousing	NTCIP 1203 Clause 2.11.4.1.1.6	

656.02.11.4--NTCIP Compliance Documentation. Software shall be supplied with full documentation, including a CD-ROM containing ASCII versions of the following Management Information Base (MIB) files in Abstract Syntax Notation 1 (ASN.1) format:

- 1) The relevant version of each official standard Mill Module referenced by the device functionality.
- 2) If the device does not support the full range of any given object within a Standard Mill Module, a manufacturer specific version of the official Standard Mill Module with the supported range indicated in ASN.1 format in the SYNTAX and/or DESCRIPTION fields of the associated OBJECT TYPE macro. The filename of this file shall be identical to the standard MIB Module, except that it will have the extension ".man".

- 3) A MIB Module in ASN.1 format containing any and all manufacturer-specific objects supported by the device with accurate and meaningful DESCRIPTION fields and supported ranges indicated in the SYNTAX field of the OBJECT-TYPE macros.
- 4) A MIB containing any other objects supported by the device.
- 5) Additionally, the manufacturer shall provide a test procedure that demonstrates how the NTCIP compliance of both, the data dictionaries (NTCIP 1201, 1203, and their amendments) and the communications protocols have been tested.
- 6) The manufacturer shall allow the use of any and all of this documentation by any party authorized by the Procuring Agency for systems integration purposes at any time initially or in the future, regardless of what parties are involved in the systems integration effort.

656.02.12--Performance Monitoring. Each DMS shall meet all of the performance and testing requirements as outlined in Section 9 of NEMA TS-4 standard.

656.02.13--Power Requirements. Each DMS shall meet all of the performance and testing requirements as outlined in Section 10 of NEMA TS-4 standard.

656.02.14--Operational Security. The Contractor shall change the manufacturer's default passwords for all levels of access. The passwords for each level of access shall be different. The individual passwords shall be at least eight (8) characters in length, contain both upper and lowercase alphabetic characters (A-Z, a-z), have at least one (1) numerical character (0-9), and have at least one (1) special character (~!@#%&*_()-+=). The passwords shall not 1) spell a word or series of words that can be found in a standard dictionary, 2) spell a word with a number added to the beginning and the end, or 3) be based on any personal information such as user id, family name, pet, birthday, etc. The Contractor shall provide the Project Engineer with a listing of all passwords for each DMS prior to the DMS being placed on the project. If multiple DMSs are used on a project, they shall each have distinct passwords.

656.03--Installation Requirements. All equipment shall be installed according to the manufacturer's recommendations, the plans and as follows.

The Contractor shall provide the Department with a written inventory of items received and the condition in which they were received. Inventory shall be inclusive of make, model, and serial numbers, MAC address, and installation GPS coordinates. All equipment shall be installed according to the manufacturer's recommendations or as directed by the Engineer.

Any new, additional or updated drivers required for the existing ATMS software to communicate and control new DMS installed by the Contractor shall be the responsibility of the Contractor.

656.03.1--Certified Installation. Installation of the DMS shall be performed by the supplier or a Contractor trained and certified by the supplier. If a certified Contractor performs the installation and configuration, a supplier factory representative shall supervise and assist the Contractor during installation and configuration.

656.03.2--Testing. Each DMS shall undergo testing to verify conformance to the following specifications. The Contractor shall conduct a Project Testing Program as

required below. All costs associated with the Project Testing Program shall be included in overall contract prices; no separate payment will be made for any testing.

656.03.2.1--General Requirements. The Contractor is responsible for planning, coordinating, conducting and documenting all aspects of the Project Testing Program. The Project Engineer, ITS Engineer, and/or their designee(s) are only responsible for attending and observing each test, and reviewing and approving the Contractor's test results documentation. The Project Engineer, ITS Engineer, and/or their designee(s) reserve the right to attend and observe all tests. The Contractor is required to perform the DMS Sub-System test and the Conditional Acceptance test with the Department ITS Engineer or designee present.

Each test shall fully demonstrate that the equipment being tested is clearly and definitely in full compliance with all project requirements.

Test procedures shall be submitted and approved for each test as part of the project submittals. Test procedures shall include every action necessary to fully demonstrate that the equipment being tested is clearly and definitively in full compliance with all project requirements. Test procedures shall cross-reference to these specifications or the project plans. Test procedures shall contain documentation regarding the equipment configurations and programming.

No testing shall be scheduled until approval of all project submittals and approval of the test procedures for the given test.

The Contractor shall provide all ancillary equipment and materials as required in the approved test procedures.

The Contractor shall request in writing the Project Engineer's approval for each test occurrence a minimum of 14 days prior to the requested test date. Test requests shall include the test to be performed and the equipment to be tested. The Project Engineer reserves the right to reschedule test request if needed.

All tests shall be documented in writing by the Contractor in accordance with the test procedure and submitted to the Project Engineer within seven (7) days of the test. Any given test session is considered incomplete until the Project Engineer has approved the documentation for that test session.

All tests deemed by the Project Engineer to be unsatisfactorily completed shall be repeated by the Contractor. In the written request for each test occurrence that is a repeat of a previous test, the Contractor shall summarize the diagnosis and correction of each aspect of the previous test. The test procedures for a repeated test occurrence shall meet all the requirements of the original test procedures, including review and approval by the Project Engineer and ITS Engineer.

The satisfactory completion of any test shall not relieve the Contractor of responsibility to provide a completely acceptable and operating system that meets all requirements of this project.

656.03.2.2--DMS Factory Acceptance Test (FAT). The Contractor shall perform FAT on the DMS prior to shipping from the factory. The goal of the DMS FAT is to verify that the DMS meets the requirements of the specifications.

FATs shall be conducted at the Manufacturer or Contractor facility or at a facility acceptable to all parties. All equipment to be utilized for this project shall be subject to tests that demonstrate the suitability of the design and compliance with the contract requirements, unless an exception for an equipment item is granted by the Project Engineer. The tests shall be performed on production units identified to be delivered under this contract.

The FAT procedure shall demonstrate all requirements defined in these specifications are met, including, but not limited to: functional/system performance requirements, electrical requirements, data transmission/communication requirements, safety/password requirements, environmental requirements, and interface requirements with other components of the project system.

The Project Engineer reserves the right to waive FATs which are deemed to be unnecessary and reserves the right to witness all FATs that are determined to be critical to the project. At a minimum, the Project Engineer and/or the Project Engineer's representative will be in attendance at the FAT for the first three (3) units tested. The FAT for the first three (3) units shall be conducted during the same period. The Project Engineer shall be notified a minimum of forty- five (45) calendar days in advance of such tests. Salary and travel expenses of the Project Engineer and the Project Engineer representatives will be the responsibility of the Department. In case of equipment or other failures that make a retest necessary, travel expenses of the Project Engineer and the Project Engineer's representatives shall be the responsibility of the Contractor. This shall include all costs including, but not limited to, airfare, automobile rental, lodging, and per diem. These costs, excluding airfare shall not exceed \$500.00, per representative, per day. These costs shall be deducted from payment due or charged to the withholding account of the Contractor when the project is terminated.

The vendor must complete the FAT on all remaining units on their own and submit documentation to the Project Engineer that the FATs were completed. The Project Engineer reserves the right to randomly attend those FAT tests.

No equipment for which a FAT is required shall be shipped to the project site without successful completion of factory acceptance testing as approved by the Project Engineer and the Engineer's approval to ship.

656.03.2.3--DMS Pre-Installation Test (PIT). The Contractor shall perform PIT on the DMS as they arrive from the factory. The goal of the DMS PIT is to verify that the DMS were not damaged during shipping. The PIT shall test or inspect the following DMS components:

- 1) External or internal visible damage
- 2) DMS display damage
- 3) Verify all pixels are operational
- 4) Verify the ventilation system works
- 5) Verify all equipment is secured
- 6) Verify sign configurations

656.03.2.4--DMS Stand Alone Test (SAT). The Contractor shall perform SAT on the DMS as they arrive from the factory. The goal of the SAT is to verify that the DMS has been properly installed and commissioned according to the manufacturer requirements. The SAT shall include at minimum the following tests and inspections:

- 1) Verify the signs have been attached properly to the structure.
- 2) Verify the sign case and roadside cabinet have been grounded.
- 3) Verify the sign has been properly connected to the power.
- 4) Verify the sign case has no structural damage or deformities.
- 5) Verify all pixels are operational
- 6) Verify local sign control through the serial port
- 7) Verify local sign control through the Ethernet port.

656.03.2.5--DMS Sub-System Test (SST). The Contractor shall perform SST on the DMS to verify that the sign is operational from the TMC. The goal of the SST is to verify that all remote DMS functions and alarms are operational. The Contractor shall coordinate the SST with the Project Engineer and ITS Engineer. The Contractor shall provide a SST plan to the Department ITS Engineer with a copy to the Project Engineer and be approved a minimum of two week in advance of tests being performed.

656.03.2.6--Conditional System Acceptance Test (CSAT). The Contractor shall perform a complete CSAT on all equipment and materials on the project. The Contractor shall not request the CSAT for a phase until the SATs have been satisfactorily completed, all as-built documentation has been submitted and approved, and all other project work has been completed to the satisfaction of the Engineer. Prior to a CSAT, the Contractor shall provide advance notice of and written test results documentation that the Contractor has performed a dry-run of the CSAT, and the Engineer reserves the right to require attendance of a dry-run test session.

The Contractor shall test all project systems simultaneously from the TMC in a manner equivalent to the normal day-to-day operations of the system. The Conditional System Acceptance Test shall demonstrate that all equipment and materials in the network are in full compliance with all project requirements and fully functional as installed and in final configuration, communicating with and being controlled through the control center at the TMC. Upon completion and full approval of the CSAT for all equipment, conditional system acceptance will be given and the Burn-in Period will begin. The Contractor shall coordinate the CSAT with the Project Engineer and ITS Engineer. The Contractor shall provide a CSAT plan to the ITS Engineer with a copy to the Project Engineer and be approved a minimum of thirty (30) calendar days in advance of tests being performed. The CSAT plan shall be inclusive of steps and procedures to be performed and scheduled times to perform test procedures.

656.03.2.7--Burn-In Period. Following the Engineer's written notice of successful completion of the CSAT, the entire newly installed system must operate successfully for a three (3) month burn-in period. During this burn-in period the Contractor shall be responsible for the full maintenance of the newly installed equipment. However, no separate payment will be made for the burn-in period activities and shall be included in the cost of other items. Successful completion of the burn-in period will occur at the end of three complete months of operation without a major system failure attributable to hardware, software or communications components. Each system failure during the burn-in period

will require an additional month of successful operation prior to being eligible for Final Acceptance. (i.e., if there are two system failures during the initial three month period, the burn-in period would be increased to five (5) months.)

Burn-In General Requirements. Determination of a system failure shall be at the sole discretion of the Engineer. System failure is defined as a condition under which the system is unable to function as a whole or in significant part to provide the services as designed. While a single component failure will not constitute a system failure, chronic failure of that component or component type may be sufficient to be considered a system failure. Chronic failure of a component or component type is defined as 3 or more failures for the same component during the burn-in period.

Components are defined as contract items or major material elements in a contract item. For electrical and electronic contract items, components are defined as the complete assembly of materials that makes up the contract item.

Specifically exempted as system failures are failures caused by accident, acts of God, or other external forces that are beyond the control of the Contractor. However, failure of the contractor to respond to the repair request for that failure within 24 hours may be considered a system failure.

The Department will advise the Contractor in writing when it considers that a system failure has occurred or chronic failure exists.

If multiple system and/or chronic failures continue to occur throughout the burn-in period due to a single component type, the Contractor may be required to replace all units of that component type with a different model or manufacturer.

The Contractor shall document all failures and subsequent diagnosis and repair. The repair documentation shall include as a minimum:

- Description of the problem
- Troubleshooting and diagnosis steps
- Repairs made
- List of all equipment and materials changed including serial numbers.
- Update of the equipment inventory where needed.

The Contractor shall provide the repair documentation to the Engineer within two (2) days of completing the repair; failure to provide acceptable documentation as required shall be reason to not approve the repair as complete. The Engineer will provide acceptance or rejection of the repair and documentation within seven (7) days.

The Engineer reserves the right to require, at no additional expense to the State, the presence of a qualified technical representative of the equipment and/or software manufacturers as related to the diagnosis and/or repair of any system failure.

During the burn-in period the Contractor shall perform incidental work such as touching up, cleaning of exposed surfaces, leveling and repair of sites, sodding/grassing and other maintenance work as may be deemed necessary by the Engineer to ensure the effectiveness and neat appearance of the work sites.

During the burn-in period the Engineer shall maintain a “burn-in period punch list” that contains required Contractor actions but that the Engineer does not define as a system failure. Each burn-in period punch list action item shall be completed by the Contractor to the Engineer’s satisfaction within seven (7) days of Contractor notification of the action item.

During the burn-in period the Contractor is required to meet the following response times once notified there is a problem. A response is defined as being on-site to begin diagnosing the problem.

- Monday thru Friday: The Contractor shall respond no later than 9:00 a.m. the following morning after being notified.
- Weekends: If the Contractor is notified on Friday afternoon or during the weekend, the Contractor shall respond by 9:00 a.m. on Monday morning.

During the burn-in period the Contractor shall provide all labor, materials, equipment and replacement parts to completely maintain, troubleshoot and repair all items installed under this contract. No separate payment will be made for any labor, materials, equipment, or replacement parts needed during the burn-in period.

The overall burn-in period will be considered complete upon the successful completion of the burn-in time periods, the Engineer’s acceptance of all repairs and repair documentation, completion of all burn-in period punch list actions and a final inspection as described below.

656.03.2.8--DMS Final Inspection. Upon successful completion of the burn-in period, the project shall be eligible for the DMS final inspection. The DMS final inspection will be conducted provided the burn-in period has demonstrated the entire system is operating successfully. The DMS final inspection shall include but is not limited to;

- monitoring of all system functions at the TMC to demonstrate the overall system is operational
- a field visit to each site to ensure all field components are in their correct final configuration
- verification that all burn-in punch list items have been completed
- verification that all final cleanup requirements have been completed
- approval of final as-built documentation

Prior to conducting the DMS final inspection, the burn-in period shall demonstrate that all requirements defined in the specifications have been met.

The Contractor shall request in writing the Engineer’s approval to start the DMS final inspection a minimum of 14 days prior to the requested start date. The Engineer reserves the right to reschedule the start date if needed. The start date for the DMS final inspection cannot be prior to the successful completion of the overall burn-in period.

An unsuccessful or incomplete DMS final inspection shall require a new DMS final inspection after the Contractor has made the necessary corrections. Up to 14 days shall be allowed for the Engineer to conduct a DMS final inspection.

The Engineer reserves the right to require, at no additional expense to the State, the attendance of a qualified technical representative of the equipment and/or software manufacturers to attend a portion of a DMS final inspection. The presence of the Project Engineer and ITS Engineer or his designee is required during the final inspection.

The Contractor shall be responsible for the full maintenance of all project equipment and materials during the entire time period from the successful completion of the burn-in period until Final System Acceptance is granted.

656.03.2.9--Final System Acceptance. Upon successful completion of the DMS final inspection and all other items of work, the Engineer will conduct a project final inspection in accordance with Subsection 105.20 of the Standard Specifications.

656.03.3--Documentation. DMS documentation shall meet all of the performance and testing requirements as outline in Section 12 of NEMA TS-4 standard.

656.03.4--Warranty. The DMS shall be warranted to be free of manufacturer defects in materials and workmanship for a period of one year from the date of Final Maintenance Release. Equipment covered by the manufacturer's warranties shall have the registration of that component placed in the Department's name prior to Final Inspection. The Contractor is responsible for ensuring that the vendors and/or manufacturers supplying the components and providing the equipment warranties recognize the Department as the original purchaser and owner/end user of the components from the time of installation. During the warranty period, the supplier shall repair or replace with new or refurbished material, at no additional cost to the State, any product containing a warranty defect, provided the product is returned postage-paid by the Department to the supplier's factory or authorized warranty site. Products repaired or replaced under warranty by the supplier shall be returned prepaid by the supplier. During the warranty period, technical support shall be available from the supplier via telephone within four hours of the time a call is made by the Department, and this support shall be available from factory certified personnel. During the warranty period, updates and corrections to control unit software shall be made available to the Department by the supplier at no additional cost.

656.03.5--MDOT Employee Training. As a minimum, the Contractor shall submit to the Project Engineer for approval a detailed Training Plan including course agendas, detailed description of functions to be demonstrated and a schedule. The Contractor must also submit the Trainer's qualifications to the Project Engineer for approval prior to scheduling any training. The training must include both classroom style training and hands-on training in the field of the maintenance and troubleshooting procedures required for each component. The training should also consist of a hands-on demonstration of all software configuration and functionality where applicable.

The supplier of the DMS shall, at a minimum, provide a sixteen-hour operations and maintenance training class with suitable documentation for up to eight (8) persons selected by the Department. This training shall include One (1) day of site device operation, maintenance, and configuration training for up to ten (10) individuals and One (1) day of on-site system training at the TMC for up to ten (10) individuals that is separate from the above training and specifically for software control of the integrated devices. The operations and maintenance class shall be scheduled at a mutually acceptable time and location.

The training shall be approved two (2) week ahead of the scheduled date.

656.03.6--Maintenance and Technical Support. The supplier shall maintain an adequate inventory of parts to support maintenance and repair of the DMS. Spare parts shall be available for delivery within 30 days of placement of an acceptable order at the supplier's then current pricing and terms of sale of said spare parts.

656.04--Method of Measurement. Dynamic Message Sign will be measured per each DMS installation.

656.05--Basis of Payment. Dynamic Message Sign, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing, installing, system integration and testing of the complete dynamic message sign including the sign case, light sources, display apparatus, wiring, controller, roadside DMS cabinet, communications interface, wiring between the sign case and DMS cabinet, structure mounted conduit, fittings, and junction boxes, sign case support connections to the sign support structure, satisfactory completion of testing and training requirements and all labor, tools, materials, equipment, appurtenances, and incidentals necessary to complete the work for a complete and functional DMS including remote and local control of the sign

It shall also include all system documentation including: shop drawings, operations and maintenance manuals, wiring diagrams, block diagrams, and other material necessary to document the operation of the DMS.

This work does not include the sign support structure.

Progress payments for Dynamic message signs shall be paid as follows:

- 1) 80% of the contract unit price upon completion of the installation and all SAT, and
- 2) 20% of the contract unit price upon final system acceptance.

Payment will be made under:

656-A: Dynamic Message Sign * - per each

* Type may be specified

SECTION 660 - ITS EQUIPMENT CABINETS

660.01--Description. The cabinet will provide a protective outdoor housing enclosure in which to install field hardware required for ITS devices. Major elements of the equipment cabinet include the cabinet housing and equipment mounting hardware, interior wiring and termination facilities, power supplies, electrical accessories and field installation. Work also includes making modifications to existing ITS cabinets in accordance with the plans, specials provisions, Notice to Bidders and contract documents.

660.02--Materials.

660.02.1--Blank.

660.02.2--Equipment and Materials. The Contractor shall furnish only new equipment and materials as follows.

Equipment cabinets and integral materials shall be as recommended by the manufacturers for outside plant use and the intended application. This requirement shall include wiring and electrical materials and configurations (including connector pin-outs) that are wholly or partially related to the field device applications (CCTV, RDS, VDS, etc.).

Equipment cabinets shall be furnished, installed, and configured at locations shown in the plans. All equipment and materials shall be furnished and configured for each specific location as shown in the plans.

Electrical systems and components shall be UL-listings.

Unless otherwise specified, wire and cable shall be stranded copper conductors, 75°/90° Celsius wet/dry rated insulation, and sized for the maximum voltage and current in the circuit.

660.02.3--Components Specified As Rail-Mounted. Components specified as rail-mounted shall be compliant as follows.

- 1) DIN EN 50022 (NS35) component rails.
- 2) Component rails shall be the perforated type and of sufficient length as to protrude beyond the mounted components for fastening to cabinet panels as specified herein.
- 3) UL 1059.
- 4) UL 486E.
- 5) NEMA ISC-4.
- 6) Alternate Rail configurations may be submitted to the Engineer for consideration and approval.

660.02.4--Terminal Blocks and Component Terminals. Terminal Blocks and Component Terminals shall be nickel-plated copper, copper alloy or brass.

Terminal blocks shall have voltage and current ratings greater than the ratings of the wires that are terminated, be able to terminate wires from #8 AWG to #1/0 AWG wiring and shall be assembled into housing enclosures such that all exposed surfaces are touch-safe. Conductor fastening screws shall be captive. Terminal block housings shall be colored as follows:

- 1) 120 VAC line/hot: black
- 2) 120 VAC neutral: white
- 3) 24 VDC positive: red
- 4) 24 VDC negative: gray
- 5) RS485 communications: orange
- 6) Ground: green or green/yellow

660.02.5--Door Locks. Door Locks shall be provided for all cabinet doors, keyed to the Department standard #2 key type lock keyed to be operated with a traffic industry conventional # 2 key made from heavy-duty blanks. Two keys shall be provided with each cabinet.

660.02.6--Labels.

660.02.6.1--Cabinet Labels. Labels shall be provided with agency name, device name and ID labels on all cabinets.

Labels shall be flat black lettering on a reflective white background. Lettering shall be a minimum of one inch (1") in height.

Labels shall be manufactured from pre-coated adhesive backed reflective sheeting material meeting the minimum requirements of AASHTO M268 Type 1.

The agency name labels shall be "MDOT ITS" in one continuous adhesive sheet.

The device ID labels shall include the device name as an acronym and a hyphen, and shall be one continuous adhesive sheet. Device name acronyms are "CCTV-", "RDS-", "VDS-" or "DMS-".

The device ID shall be numerals corresponding to the location and shall be installed adjacent to the acronym sheet. Multiple device IDs of the same type shall be on the same line separated with a space. Examples: "CCTV-73", "RDS-219 220", "VDS-303 304".

Labels shall be installed along the top of the cabinet door (front cabinet door on Type B cabinets), with MDOT ITS label at the top and the device ID labels immediately underneath.

660.02.6.2--Voltage Labels. A voltage label shall be provided on all cabinets or enclosures in accordance with the NEC labeling requirements. Voltage labels shall meet the following minimum requirements.

Labels shall be flat black lettering on a reflective yellow background. Lettering shall be a minimum of 1 inch in height.

Labels shall be manufactured from pre-coated adhesive backed reflective sheeting material meeting the minimum requirements of AASHTO M268 Type 1.

Labels shall include the voltages entering the cabinet and shall be one continuous adhesive sheet. Examples are "120VAC" or "24VDC".

Labels shall be installed on all cabinet doors.

660.02.7--Type A Cabinet. All Type A cabinets shall be identical in manufacture and assembly, capable of supporting Radar Detection System units.

A Type A cabinet intended for outdoor use shall be provided with a minimum NEMA 3R rating.

The cabinet enclosure shall be manufactured from 0.125-inch aluminum.

The cabinet shall provide a minimum of one ventilation louver on at least two sides. Any louver opening greater than 3/16 inch in any dimension shall be screened to prevent insect entry.

The cabinet shall be intended for strapped pole-mounting; provide all mounting hardware necessary including ½-inch stainless steel mounting straps.

A Type A cabinet enclosure shall be provided with dimensions of 18 inches (H) x 14 inches (W) x 8 inches (D) with a tolerance of ±0.25 inches.

Cabinet door shall reveal the entire front opening of the cabinet for accessibility. The hinge shall be designed to prevent the door from sagging.

A single-piece 0.125-inch aluminum back panel shall be provided that covers no less than 90% of the cabinet back wall. Back panel shall be affixed to the enclosure with threaded fasteners and shall be removable from the enclosure with hand tools only and without requirement to remove the cabinet door, mounting straps, or any other components other than communications or device wiring.

The cabinet shall be furnished with doorstops, which retain the doors open in a 90 degree and 120 degree positions.

A grounding lug shall be provided on the back panel that is directly bonded to the back panel capable of terminating #6 AWG wire.

660.02.7.1--RDS Communications Wiring. RDS communication wiring shall meet the following.

- 1) Component rail physically and electrically fastened to the cabinet back panel.
- 2) Strain relief brackets for the comm. cable(s) and the RDS unit harness cables.
- 3) Parallel-connection single-stage surge suppressors for the four wire RS-485 data signal for the RDS units with integral or separate terminals for a minimum of three RDS comm. Cables.
- 4) Parallel-connection zero-power dissipation surge suppressor for the 12-24VDC power supply for the RDS units with integral or separate terminals for a minimum of three RDS comm. cables and two RDS unit harness cables.
- 5) Connection/jumper wiring between the surge suppressors and the local/remote communications disconnect module(s) same as conductor size, type, and insulation color in the RDS comm. cable.

660.02.8--Type B Cabinet. All Type B cabinets, except those at solar power locations, shall be uniform in manufacture and assembly, capable of supporting the field equipment as shown on the plans. As a minimum support is required for two RDS units, one Type A, B, D or E network switch, one video encoder, one Type A radio/antenna, RDS comm. cable and fiber drop panel terminations, regardless of the devices shown in the plans at a specific location.

A complete Type B cabinet shall be an assembly consisting of a cabinet housing and electrical subsystems.

A Type B cabinet housing shall be provided that conforms to the standards for a Type 170 336S with approximate exterior dimensions of 46 inches (H) x 24 inches (W) x 23 inches (D), including standard EIA 19-inch rack cabinet cage, as defined in the latest version of the Caltrans Transportation Electrical Equipment Specifications (TEES). The minimum clear vertical inside dimension of the 19-inch rack for equipment mounting shall be 39.5

inches. Standard cabinet accessories for traffic signal operations, such as controller, power distribution assembly, input/output file and termination panels, and the police panel, are not required as part of this cabinet assembly.

660.02.8.1--Hardware. All mounting hardware necessary for base or pole mounting as shown on the plans shall be provided. As a minimum, three (3) 3/4-inch stainless steel mounting straps shall be provided for pole mounted cabinets.

Hooks welded to the inside of each cabinet door shall be provided for hanging a side-opening, opaque, resealable, heavy-duty plastic documentation pouch with metal or hard-plastic reinforced holes for the door hooks. One pouch shall be provided with each cabinet.

A rack-mounted cabinet sliding storage drawer shall be provided in accordance with the following:

- 1) Approximate exterior dimensions 1.75 inches (H) x 16 inches (W) x 14 inches (D).
- 2) Telescoping drawer guides to allow full extension from the rack cage.
- 3) Opening storage compartment lid to access storage space for cabinet documentation and other items.
- 4) Supports a weight of 25 pounds when extended.
- 5) Non-slip plastic laminate surface attached to the compartment lid which covers a minimum of 90% of the surface area of the lid.
- 6) Mounted in the rack cage with the bottom surface approximately 9 inches above the bottom of the rack cage.

Side panels shall be provided within the two sides of the rack cabinet cage, inserted and fastened from the inside of the cage. Side panels shall be fabricated from 0.125-inch 5052 sheet aluminum alloy and sized to the full inside dimensions of the rack cabinet cage. Side panel surfaces for equipment mounting are denoted by cabinet side with the "right" side being the support pole side and by upper or lower as related to the sliding storage drawer. Upper right side panel (support pole side of cabinet, above the drawer) and lower left side panel (opposite side from the support pole, below the drawer) are example side panel surface names.

A 12-inch long DIN rail shall be included for future components mounted in the horizontal and vertical center of the lower left side panel.

660.02.8.2--Electrical Subsystems. Type B cabinet electrical subsystems shall meet the following requirements. Note that the Type B cabinets at solar power locations are not required to meet Subsection 660.03.2 requirements.

- 1) An electrical distribution module comprised of the following DIN rail-mounted components:
 - a. Service entrance terminal block with positions for 120VAC line, neutral, and ground and capable of terminating minimally #6 through #8 AWG wire, located at one end of the mounting rail with an approximately 0.75-inch blank spacer module adjacent to the main cabinet breaker.
- 2) Main cabinet automatic overcurrent 15A circuit breaker that is UL-listed and of the mechanical-magnetic type rated for use from 0°F to 122°F minimum.

- 3) Main cabinet surge suppressor for single-phase 120VAC service entrance, parallel wired with a clamp voltage of approximately 280V and capable of a surge current of at least 20,000 amps.
- 4) Main cabinet filter for power line noise and switching transient suppression, integral to, or separate from and wired to, the main cabinet surge suppressor.
- 5) Electrical distribution terminal block for line and neutral conductors parallel wired to the main cabinet surge suppressor but non-filtered, with a minimum terminating capability of six conductors of #10 to #18 AWG. The terminal block shall be labeled as "ACCY POWER".
- 6) Electrical distribution terminal block for line and neutral conductors for circuits on the load/equipment side of the power line filter, with a minimum terminating capability of six conductors of #10 to #18 AWG. Label the block as "EQUIP POWER".
- 7) Electrical distribution terminal block for grounding and bonding conductors located on the same rail but separate from the service entrance terminal block and connected to the entrance ground with a #6 AWG green insulated wire. The grounding block shall have a minimum terminating capability of two #6 AWG conductors and ten #10 to #18 AWG conductors.
- 8) Ground fault interrupt duplex receptacle (NEMA 5-15R) with 2.5A circuit breaker connected to the ACCY POWER distribution block. Permanently affixed to the receptacle, provide two red, orange or green/yellow labels with minimum 0.25 inch lettering with the legend "300 WATTS MAX." This receptacle is for technician use only and shall not be used to power equipment.
- 9) Include two duplex non-GFCI equipment power receptacles (NEMA 5-15R) connected to the EQUIP POWER distribution block mounted on the upper rear corner of the cabinet upper right side panel. Permanently affixed to the receptacle, two red, orange or green/yellow labels with minimum 0.25-inch lettering with the legend "75 WATTS MAX" permanently affixed to the receptacle.
- 10) Interconnection wiring between all electrical distribution module components and the other systems included in or housed in the Type B cabinet.

660.02.8.3--Lighting Subsystem. A cabinet lighting subsystem shall be provided comprised of the following components:

- 1) One fluorescent lighting fixture, minimum 15-watt, mounted on the inside top front portion of the cabinet, with a cool white lamp with shatter-proof cover and operated by a normal power factor UL listed ballast.
- 2) A resistor-capacitor network noise suppressor installed across the light fixture power terminals.
- 3) Two door-actuated switches installed to turn on the cabinet light when either door is opened.
- 4) Powered from the ACCY POWER distribution block.

660.02.8.4--RDS Communications Subsystem. Where RDS are shown in the plans, DIN rail-mounted components shall have a nominal 24VDC output power supply, capable of user setting between 23 and 28VDC minimum, with minimum 1A output rating and minimum operating temperature range of -13°F to +158°F. Power supply shall provide terminal facilities for a minimum of three sets of #14 AWG conductors (in the RDS comm cable). Maximum size of the power supply shall be 1 inch (W) x 7 inches (H) x 7 inches (D). The power supply shall be connected to the EQUIP POWER distribution block for 120VAC input.

Interconnection wiring shall be provided between the RDS communications subsystem and the Terminal Server.

Surge suppressor for the RS485 data signal, wired between the terminal server and the RDS units shall be provided. The surge suppressor shall protect the 4-wire RS485 data signal with hybrid multi-stage suppression components including gas tube and silicon avalanche diode. The surge suppressor shall have a response time no greater than 1 nanosecond. The surge suppressor shall provide terminal facilities for a minimum of four two-pair cables of #22 AWG conductors.

660.02.8.5--CCTV Subsystem. The requirements listed in Subsection 643.02.2.6 shall be met by installing the required CCTV support equipment in the Type B Cabinet.

660.02.9--Type C Communication Hub Cabinet. A complete Type C cabinet shall be an assembly consisting of a cabinet housing, base and electrical subsystems.

The Type C cabinet shall be an AASHTO/ITE/NEMA ITS Cabinet Standard specification Cabinet Housing #3 with two Cages #1. It shall be equipped with four (4) side mounting panels in the rack cabinet cages. The side mounting panels shall mount from inside the rack cabinet cage only. The side panels shall be fabricated from 5052 sheet aluminum alloy with a minimum thickness of 0.125 inch with minimum dimensions of 50 inches (H) x 21 inches (W). Standard cabinet accessories for traffic signal operations, such as controller, power distribution assembly, input/output file and termination panels, and the police panel, are not required as part of this cabinet assembly.

A minimum of four (4) wiring pass-through holes shall be provided on the inside mounting panels to permit patch cords to pass between the two cabinet sides. Each pass-through hole shall be five (5) inches in diameter and shall be fully grommetted for patch cord protection, with the holes positioned with two (2) in the cabinet front and two (2) in the cabinet rear and aligning horizontally between the two side panels.

660.02.9.1--Hardware. The hardware shall consist of a minimum of 16 plastic-coated or rubber-coated J-hooks or D-rings, minimum 1-inch depth and height, on the inside rails of the rack cabinet cages, to organize patch cords passing between the two cabinet sides. The J-hooks shall be installed in horizontally-aligned pairs on the inside rails, with four (4) pairs in the cabinet front and four (4) pairs in the cabinet rear.

Hooks shall be welded to the inside of the two front cabinet doors for hanging the plastic documentation pouch. Two plastic documentation pouches shall be provided to store the cabinet and equipment documentation. Pouches shall be side-opening, re-sealable, opaque, and of a heavy-duty plastic material. Pouches shall have metal or hard-plastic reinforced holes for hanging from hooks included on the cabinet door. The pouches shall be of the size and strength to easily hold all wiring diagrams, equipment documentation, maintenance logbooks, etc.

Two sliding drawers shall be installed that are aluminum storage compartments mounted in the rack assembly with the approximate following dimensions: 1.75 inches (H) x 16 inches (W) x 14 inches (D). The compartments shall have telescoping drawer guides to allow full extension from the rack assembly. When extended, the storage compartments shall open to provide storage space for cabinet documentation and other miscellaneous

items. Storage compartment shall be of adequate construction to support a weight of 25 pounds when extended. The tops of the storage compartments shall have a non-slip plastic laminate attached which covers a minimum of 90% of the surface area of the top.

660.02.9.2--Electrical Systems. Type C cabinet electrical subsystems shall include an electrical distribution module comprised of the following components:

- 1) Service entrance terminal block with positions for 120VAC line, neutral, and ground and capable of terminating minimally #6 through #8 AWG wire, located at one end of the mounting rail with an approximately 0.75-inch blank spacer module adjacent to the main cabinet breaker.
- 2) Main cabinet automatic overcurrent minimum 30A circuit breaker that is UL-489 and CSA 22.2 approved and plainly marked with trip, frame sizes and ampere rating. All circuit breakers shall be quick-make, quick-break on either automatic or manual operation. Contacts shall be silver alloy and enclosed in an arc-quenching chamber. Overload tripping shall not be influenced by an ambient air temperature range from 0°F to 122°F. Minimum interrupting capacity shall be 5,000 amperes RMS.
- 3) Main cabinet surge suppressor for single-phase 120VAC service entrance, parallel wired with a clamp voltage of approximately 280V and capable of a surge current of at least 20,000 amps.
- 4) Main cabinet filter for power line noise and switching transient suppression, integral to, or separate from and wired to, the main cabinet surge suppressor.
- 5) Electrical distribution terminal block for line and neutral conductors parallel wired to the main cabinet surge suppressor but non-filtered, with a minimum terminating capability of six conductors of #10 to #18 AWG. The terminal block shall be label as "ACCY POWER".
- 6) Electrical distribution terminal block for line and neutral conductors for circuits on the load/equipment side of the power line filter, with a minimum terminating capability of six conductors of #10 to #18 AWG. The block shall be as "EQUIP POWER".
- 7) Electrical distribution terminal block for grounding and bonding conductors located on the same rail but separate from the service entrance terminal block and connected to the entrance ground with a #6 AWG green insulated wire. The grounding block shall have a minimum terminating capability of two #6 AWG conductors and ten #10 to #18 AWG conductors.
- 8) Ground fault interrupt duplex receptacle (NEMA 5-15R) with 2.5A circuit breaker connected to the ACCY POWER distribution block. Two red, orange or green/yellow labels with minimum 0.25-inch lettering with the legend "300 WATTS MAX" permanently affixed to the receptacle. This receptacle is for technician use only and shall not be used to power equipment.
- 9) Two duplex non-GFCI equipment power receptacles (NEMA 5-15R) connected to the EQUIP POWER distribution block mounted on the upper rear corner of the cabinet upper right side panel.

Interconnection wiring shall be installed between all electrical distribution module components and the other systems included in or housed in the Type C cabinet.

Rack mounted power strip outlets shall be connected to the EQUIP POWER distribution block, mounted near the top of the cabinet. The power strip shall incorporate eight (8) NEMA 5-15R receptacles. The power strip receptacle shall face the back of the cabinet

and shall be recessed within the cabinet rack to provide a minimum spacing of three (3) inches between the outlet's face and the cabinet door when the door is closed.

Door open switches shall be provided on four doors and configure the switches so that any single door opening will provide a circuit closure. The assembly of switches shall be wired to a single two-position terminal block, with normally open circuit that closes upon a door opening.

Two cabinet ventilation fans shall be connected to the ACCY POWER distribution block, with a minimum capacity of 200 cubic feet of free air delivery per minute. The fan thermostat shall be set at its lowest limit or 70°F, whichever is greater.

Each of the four cabinet doors shall have an intake and filter as specified in Subsection 6.2.7.1 of the AASHTO/ITE/NEMA ITS Cabinet Standard specification.

660.02.9.3--Lighting Subsystem. The lighting subsystem shall be four (4) fluorescent lighting fixtures mounted inside the top portions of each cabinet side. A cool white lamp, covered and operated by a normal power factor UL listed ballast shall be included with the fixture. A RC network noise suppression filter shall be installed in the light circuit. Door actuated switches shall be installed in the front and rear of each cabinet side, configured to turn on all cabinet lights when any door is opened. The lighting fixtures shall be powered from the ACCY POWER distribution block.

660.03--Construction Requirements.

660.03.1--General. This work shall meet the following general requirements.

Cabinets shall be installed and configured as shown in the plans and according to manufacturer's recommendations, including installations and dimensions given for pole-mounting in relationship to the surrounding grade.

All cabinets shall be bound to the pole grounding lug with minimum #6 AWG stranded copper bare or green-insulated cabinet grounding wire. Alternately on existing poles only, the cabinet grounding wire shall be bound to an existing pole grounding wire with a cast brass or copper alloy threaded compression connector within 4 inches of the existing pole grounding lug.

Electrical service or electronic devices shall not be installed in the cabinet or connected to the cabinet until ground testing for the pole or structure has been successfully completed and accepted, and the cabinet ground connection has been installed.

A cabinet wiring and interface diagram shall be provided and included in the required hanging, side-opening, re-sealable opaque, heavy duty plastic documentation pouch.

660.03.2--Type B and C. Equipment in the Type B and C cabinets shall be installed and configured in accordance with the requirements for that equipment, including RDS units, CCTV, Type A, B, D or E network switches, video encoders, Type A radio/antennas, RDS comm. cables and/or fiber distribution or drop panels.

Electronic devices shall not be installed in the cabinet until electrical service has been installed and activated, and the cabinet ventilation fan is operational.

Network switches and video encoders shall be installed in the top most area of the cabinet rack. The equipment receptacles shall be used for power.

Supporting equipment/electronics for CCTV shall be installed on the lower area of the cabinet upper left side panel. There shall be no physical or access conflict with the network switch and video encoder. The EQUIP POWER distribution block shall be used for the power source.

Fiber drop panels shall be installed in a vertical configuration on the lower rear edge of the cabinet upper right side panel.

660.03.3--Testing. The Contractor shall conduct a Project Testing Program as required below. All costs associated with the Project Testing Program shall be included in overall contract prices; no separate payment will be made for any testing.

The ITS Engineer, Project Engineer and/or their designee(s) shall only be responsible for attending and observing each test, and reviewing and approving the Contractor's test results documentation. The ITS Engineer, Project Engineer and/or their designee(s) reserve the right to attend and observe all tests. The Contractor will be required to perform the Conditional Acceptance test with the the Department ITS Engineer or his designee present.

The Contractor shall conduct a project testing program for all equipment cabinets. The project testing program shall include but is not limited to the specific requirements in this subsection.

All test results shall confirm physical and performance compliance with the specifications.

All test results documentation shall be submitted to the Engineer within seven (7) days of completion of the tests. The Engineer will review test documentation.

660.03.3.1--Standalone Acceptance Test (SAT). A SAT shall be performed on all equipment cabinets on this project after field installation is complete including, but not limited to, all field devices (RDS, CCTV, communications electronics, etc.) to be installed in or connected to that given cabinet.

A SAT for a given equipment cabinet shall only be performed in conjunction with the SAT for all devices installed in or connected to that given cabinet.

A visual inspection shall be made of the installation and the cabinet documentation.

Functional test shall be made of all cabinet equipment, including circuit breaker, receptacles, fan and thermostat, and lights and door switches.

A measurement of DC power supply shall be made when operating under full load.

660.04--Method of Measurement. Equipment Cabinet of the type specified will be measured per each.

Cabinet modifications will be measured per each installation.

660.05--Basis of Payment. Equipment Cabinet and Equipment Cabinet Modifications, measured as prescribed above, will be paid for at the contract unit price per each, which shall be full compensation for all labor, tools, materials, equipment, system integration, testing, system documentation, mounting hardware, foundations, fiber splicing, external conduit entrances including conduit bodies and nipples, electrical service, pole grounding, terminations, and all incidentals necessary to complete the work.

Progress payments for Equipment Cabinets will be paid in accordance with the following:

- 1) 80% of the contract unit price for complete installation of equipment cabinet and all interior components, electrical service feed (activated), interior cabinet components, all conduit entrances, grounding connection, and testing;
- 2) An additional 10% of the contract unit price for completion of Stand Alone Site Test of all field devices housed or connected to the equipment cabinet; and
- 3) Final 10% of the contract unit price upon Final System Acceptance.

Payment will be made under:

- 660-A: Equipment Cabinet, Type ___ - per each
- 660-B: Cabinet Modifications - per each

SECTION 662 – RADIO INTERCONNECT SYSTEM

662.01--Description. This section describes the Wireless Radio Interconnect Systems and specifies the minimum technical requirements for Radio Interconnect System devices furnished, installed, integrated, and tested at locations designated on the plans.

662.02--Materials. The Contractor shall provide a functional wireless system in accordance with any applicable FCC and FAA rules and regulations. The Contractor shall be responsible for supplying all equipment needed for a 100% functional wireless system capable of providing video, data, or both to each of the sites encompassed in the project. The Contractor shall ensure that each site location's wireless link has sufficient bandwidth for all devices to communicate properly across the network. The wireless link shall support the minimum bandwidth requirements with a 99.99% reliability factor. The Contractor shall be responsible for providing all equipment needed to connect to the existing MDOT Wireless Network. All components provided in this project must be 100% compatible with the existing Wireless Network (where applicable) and provide the same features, specifications, bandwidth, and capabilities unless specifically stated otherwise.

The wireless system shall include wireless communications devices that are inclusive of the following types: Signal Control, Broadband Type Short Range, Broadband Type Long Range, Television Broadcast Radio (TVBR) Type Short Range, TVBR Type Long Range. Each Type shall be capable of meeting all requirements as identified in this specification except broadband Type Long Range shall be capable of meeting all performance requirements for line-of-sight (LOS) wireless link distances of 10 miles or greater. Broadband Type Short Range shall be capable of meeting all performance requirements for LOS wireless link distances of up to 10 miles. TVBR Type Long Range shall be capable of meeting all performance requirements for non-line-of-sight (NLOS) wireless link distances of two (2) miles or greater. TVBR Type Short Range shall be capable of

meeting all performance requirements for wireless link distances of up to two (2) miles. The Contractor shall provide all elements necessary to provide a functional system including radios, antennas, coaxial cable and connectors, lightning suppressors, mounting and grounding hardware, and any other equipment, hardware, enclosures and cabling required to make a complete and fully functional system.

662.02.1--General Requirements. Unless specified otherwise in preceding sections, the radio interconnect systems discussed herein shall adhere to the following minimum technical requirements for Radio Interconnect System devices.

All furnished equipment shall be new, environmentally hardened, and capable of optimal operation in all weather conditions as applicable to Mississippi.

The Contractor shall test all radio hardware and required equipment necessary to provide a complete and fully operational system at no additional cost to the Department.

The Contractor shall conduct site evaluation, path analysis, obtain and reserve necessary frequencies, and apply for all required licenses by the FCC. The Contractor shall also meet the requirements for filing with the Federal Aviation Administration for proposed structures, which are based on a number of factors: mounting height, proximity to an airport, location, and frequencies emitted from the structures, etc. as described in CFR Title 14 Part 77.9. The charges and fees incurred while applying for and obtaining licenses are included in the pay items outlined in this specification and will not be paid for separately.

The wireless communication equipment shall be fully interchangeable by radio frequency, radio type and compatible with the existing network to transmit all data from field devices across the Department wireless network to communications towers (where applicable), hubs, and/or nodes to be transmitted to the MDOT ITS Network by way of existing network equipment.

The wireless radio equipment shall be configured for minimal noise and interference as determined by project location and the manufacturer's equipment specifications and include the required channel(s) to communicate with radios of the same type and operating as designed.

The Mean Time Between Failures (MTBF) shall be at least 87,658. If the radio system has not been manufactured long enough to validate the corresponding MTBF then Contractor may present the MTBF from a radio system of similar type for approval by the Department. The Contractor must first request approval by the Department to permit the submittal of MTBF specifications of an approved radio system.

The minimum bandwidth provided per each individual link shall be the cumulative minimum bandwidth of each device type and number of each per device utilizing that link according to the following table of min bandwidth requirements.

Device Type	Min Bandwidth per Device
CCTV PTZ	512 kbps
CCTV Fixed	256 kbps
DMS	128 kbps
Detection	256 kbps

Radio Interconnect System General Equipment requirements are as follows:

- 1) Network Features
 - a. 802.3i 10 Mbps Ethernet.
 - b. 802.3u 100 Mbps Ethernet with auto-negotiation.
 - c. Network topology: Point-to-Point (PTP) and Point-to-Multipoint.
 - d. The RF network latency shall not exceed 15ms between each transmitting and receiving device.
 - e. The wireless radio shall be analogous to a Layer 2 device by operating similar to a switch or bridge device. The wireless radio shall be capable of connecting to the MDOT Network via an RJ-45 port.
 - f. The wireless radios shall be fully interchangeable and compatible with the existing wireless devices operating on the same frequency and of the same type.

- 2) Management
 - a. Local management interface via RS-232, RS-422/485, or RJ45.
 - b. Remote Management, i.e., HTTP, SSH, Telnet, SNMP, TFTP, or CLI.
 - c. Web-based Management (HTML) shall have Web GUI.
 - i. The web-based management shall be password protected management software allowing remote configuration.

- 3) Power Requirements
 - a. The wireless radios may transmit/receive data and receive power via Ethernet cable by PoE. PoE devices adhering to the alternative A/B standards for PoE are recommended. For proprietary PoE devices, the Contractor shall be responsible for ensuring that these devices are not connected to IEEE standard PoE switches or vice versa as this may result in damage to the device and/or switch.
 - b. Output Voltage: voltage and power ratings shall adhere to 802.3af or 802.3at for devices conforming to the IEEE standards.

- 4) Environmental Requirements
 - a. Radio interconnect field equipment shall be fully operational in all-weather conditions occurring in Mississippi.
 - b. Relative humidity 95% non-condensing.
 - c. Weather, Water, & Dust Proof, e.g., IP-66/IP-67.
 - d. Operating temperature shall exceed the range from -35°F to 135°F

662.02.2--Radio Interconnect System, Signal Control. The radio interconnect system, signal control shall provide communications between the master and the local intersections by RF data link. The radio shall operate in the 900 MHz data frequency bands. Each local intersection shall have a transceiver, power supply and an antenna. A transceiver shall be provided at the master location. The Signal Control Radio Interconnect System is not subject to the requirements outlined in Subsection 662.02.1 Radio Interconnect System General Equipment Requirements.

662.02.2.1--Specific Requirements.

662.02.2.2--Antennas. Two (2) antennas will be required at repeater stations, one for each radio. Measures shall be taken to minimize the chance of interference between these antennas. One effective technique for limiting interference shall employ vertical

separation. In this arrangement, one antenna is mounted directly over the other, separated by at least four feet (4'). This takes advantage of the minimal radiation exhibited by most antennas directly above and below their driven elements.

Another interference reduction technique is to cross-polarize the repeater antennas. If one antenna is mounted in the vertical plane and the other in the horizontal plane, an additional 20 dB attenuation can be achieved. The corresponding stations shall use the same antenna orientation when cross-polarization is used.

662.02.2.3--Interface Wiring. A null modem cable shall be required between the Data Interface connectors of the two radios forming a repeater station, allowing radios to exchange data even though they are both configured as DCE (data circuit-terminating equipment) devices.

662.02.3--Radio Interconnect System, Broadband. The radio interconnect system, broadband, shall be a licensed or unlicensed wireless communication device as called out in the plans or directed by the project engineer, capable of transmitting and receiving broadband wireless communication at distances as called out on the plans. The Contractor shall be responsible for determining the most optimal frequency range to furnish radios that will provide wireless links with sufficient bandwidth for all devices to communicate properly across the network. When expanding the wireless link of an existing system, the Contractor shall ensure the frequency of the new equipment is compatible with the existing system. The radio system shall be used to connect ITS device sites and Traffic signal systems to the existing MDOT ITS Network as described in project plans. The broadband wireless communication system shall be furnished with all necessary hardware and software to include radios, repeaters, antennas, cable, surge protection and connectors in accordance with the plans and specifications to establish stable wireless communication channel(s) between two (2) or more LOS/partial LOS devices setup in point-to-point or point-to-multipoint configurations. The broadband radio interconnect requirements shall be as follows:

- 1) The broadband radios furnished and installed shall meet all regulations set forth by the FCC part 15 of the FCC rules.
- 2) Short range broadband radios shall be capable transmitting up to 10 miles.
- 3) Long range broadband radios shall be capable of transmitting at distances exceeding 10 miles.
- 4) The short range and long range broadband radios shall provide reliable communication and sufficient bandwidth (i.e., greater than the cumulative minimum bandwidth of each device that will utilize the link) for all devices utilizing the wireless link(s).
- 5) The Contractor may propose the use of multiband (dual band, tri band, etc.) radios using licensed 4.9 GHz and unlicensed 5.8 GHz and 2.4 GHz bands if bandwidth requirements and path interference warrants the use of such radios, and approved by the Project Engineer.

662.02.4--Radio Interconnect System, Television Broadcast Radio (TVBR). TVBRs are unlicensed radios designed to produce, transmit, and/or receive radio communication signals at select geographical locations. These radios transmit on available channels in the broadcast television frequency band. The TVBRs shall be proposed on project plans and drawings in geographical locations lacking visual line-of-sight transmission between the proposed transmitting and receiving devices. These devices shall provide partial line-of-

sight (LOS) and/or non-line-of-sight (NLOS) radio transmission to establish network communication in areas with obstacles obstructing LOS wireless communication.

The TVBRs operate under the Federal Communications Commission (FCC) approved white space TV band database. Each TVBR shall determine the available TV channels it can operate on before it will be functional for typical usage. The TVBRs retrieve a list of available channels via an Internet connection from the white space TV band database dependent on the TVBRs specific geographic coordinates, which are acquired and saved on the device during configuration. Typically, TVBRs can transmit and receive radio communication on six (6) MHz channels. TV Channels 14-36 and 38-51 are available for TVBRs operating on TV channels in the UHF frequency range (470-698 MHz). Once a TVBR is registered with the white space TV band database and associated with a specified operating channel, the channel is removed from the list of available channels. The Contractor shall be responsible for determining the availability of TV bands in the geographical areas for all TVBRs proposed. The Contractor shall provide a list of available TV channels in the UHF frequency range to the Project Engineer, or approved designee. The Contractor shall not procure, purchase, furnish, or install TVBRs or any related equipment without the consent of the Project Engineer or the approved designee without first receiving confirmation from the Project Engineer or their designee that verification has been made that the specified channels are available in all geographic location(s) for each proposed TVBR site.

662.02.4.1--Specific Requirements. The TVBR, type long range and short range, shall be a capable of LOS, partial LOS, and NLOS wireless radio transmission. Each TVBR and antenna shall be pole mounted or mounted to an approved structure. The antenna shall be mounted in the immediate location of the TVBR to minimize attenuation due to cable length. The TVBR radio interconnect requirements shall be as follows.

- 1) The TVBR's procurement and installation shall meet all regulations set forth by the FCC 47 CFR 15 subpart H – Television Band Devices.
- 2) The TVBR's shall be capable of LOS and NLOS wireless transmission operating on the UHF TV band frequency range (470-698 MHz).
- 3) The Type Long Range TVBR shall be capable of communicating over wireless link distances exceeding two (2) miles. The bandwidth capacity shall exceed 25 Mbps provided LOS transmission and 5 Mbps provided NLOS transmission.
- 4) The Type Short Range TVBR shall be capable of communicating over wireless link distances up to two (2) miles. The bandwidth capacity shall exceed 3 Mbps provided LOS transmission and 1 Mbps for NLOS transmission.
- 5) The TVBR's transmit power shall not exceed 30 dBm for stable RF communication given the minimum distance and bandwidth requirements.
- 6) The RF network latency for Long Range TVBR shall not exceed 5ms between each transmitting and receiving device.
- 7) The MTBF shall be at least 43,829 hours for Type Short Range TVBR and 87,658 for Type Long Range TVBR. If the TVBR system has not been manufactured long enough to validate the corresponding MTBF, the Contractor may present the MTBF from a radio system of similar type for approval by the Department. The Contractor shall first request approval by the Department to permit the submittal of MTBF specifications of an approved radio system.

662.03--Construction Requirements. All equipment shall be installed according to the manufacturer's recommendations, the plans, and as follows.

662.03.1--Installation Services. The Contractor shall prepare a comprehensive Network Design, Wireless Evaluation, and Installation Plan for the wireless network to document how it will be implemented and integrated with the existing system. All required Federal Communications Commission (FCC) and Federal Aviation Administration (FAA) applications and filings shall be prepared by the Contractor on behalf of the Department, including any modifications to existing Department licenses. The Contractor shall submit a copy of the Network Design, Wireless Evaluation, Installation Plan, and copies of any FCC license applications to the MDOT Project Engineer. The Department reserves the right to reject any network designs and installation plans submitted. If rejected, the Contractor will be responsible for submitting revised network design and/or installation plan.

The Contractor shall provide all labor, tools, materials, equipment, and transportation necessary to conduct and complete the Wireless Evaluation. The cost of the wireless evaluation and report shall be included in the contract unit price per the radio interconnect system pay items. The Wireless Evaluation report shall include:

- 1) Line-of-site photographs taken at proposed sites. The photographs shall be taken at antenna height level.
- 2) Identification of any wireless interference, line-of-sight concerns, or any other issues that would hinder the Contractor's ability to deliver a functional wireless link. The Contractor shall present alternative solutions if the throughput or any other requirements cannot be met.
- 3) Planned wireless topology identifying point-to-point and point-to-multipoint radio groups.
- 4) Frequency analysis, through a spectrum analysis at each site, and proposed frequency allocation.
- 5) Radio test results for each communication link, including received signal strength, noise floor, and throughput results recorded using Iperf, or equivalent software.

The Contractor shall provide a written inventory of items received and the condition in which they were received. The inventory shall be inclusive of make, model, and serial numbers, MAC address, and installation GPS coordinates. All equipment shall be installed according to the manufacturer's recommendations or as directed by the Department.

Any new, additional or updated drivers required for the existing ATMS software to communicate and control new radio interconnects installed by Contractor shall be the responsibility of the Contractor.

662.03.2--Testing. The Contractor shall conduct a Project Testing Program as required below. All costs associated with the Project Testing Program shall be included in overall contract prices; no separate payment will be made for any testing.

662.03.2.1--General Requirements. The Project Engineer, ITS Engineer, and/or their designee(s) are only responsible for attending and observing each test, and reviewing and approving the Contractor's test results documentation. The Project Engineer, ITS Engineer, and/or their designee(s) reserve the right to attend and observe all tests. The Contractor shall perform the Standalone Acceptance Test (SAT) with the MDOT Project Engineer, ITS Engineer or his designee present.

Each test shall fully demonstrate that the equipment being tested is clearly and definitely in full compliance with all project requirements.

Test procedures shall be submitted and approved for each test as part of the project submittals. Test procedures shall include every action necessary to fully demonstrate that the equipment being tested is clearly and definitely in full compliance with all project requirements. Test procedures shall cross-reference to these Specifications or the Project plans. Test procedures shall contain documentation regarding the equipment configurations and programming.

No testing shall be scheduled until approval of all project submittals and approval of the test procedures have been granted by the Department.

The Contractor shall provide all ancillary equipment and materials as required in the approved test procedures.

The Contractor shall request in writing the Project Engineer's approval for each test occurrence a minimum of 14 calendar days prior to the requested test date. Test requests shall identify the test to be performed and the equipment to be tested. The Project Engineer reserves the right to reschedule test request if needed.

All tests shall be documented in writing by the Contractor in accordance with the test procedure and submit to the Project Engineer within seven (7) days after the completion of the test. Any given test session is considered incomplete until the Project Engineer has approved the documentation for the given test session.

All tests deemed by the Project Engineer to be unsatisfactory shall be repeated by the Contractor. When the Contractor requests a test occurrence that is a repeat of a previous test, the Contractor shall summarize the diagnosis and correction of each aspect of the previous test that was deemed unsatisfactory. The test procedures for a repeated test occurrence shall meet all the requirements of the original test procedures, including review and approval by the Project Engineer and ITS Manager or his designee.

The satisfactory completion of any test shall not relieve the Contractor of responsibility to provide a completely acceptable and operating system that meets all requirements of this project.

662.03.2.2--Standalone Acceptance Test (SAT). The Contractor shall perform a complete SAT on all equipment and materials associated with the field device site, including but not limited to electrical service, conduit, pull boxes, communication links, control cables, poles, etc. An SAT shall be conducted at every field device site.

The SAT shall demonstrate that all equipment and materials are in full compliance with all project requirements and fully functional as installed and in final configuration. The SAT shall also demonstrate full compliance with all operational and performance requirements of the project. All SATs will include a visual inspection of the cabinet and all construction elements at the site to ensure they are compliant with the specifications.

The SAT at each site for this project shall include testing from both the new device location as well as from the existing equipment location to demonstrate that the video and data is

being transmitted to the existing equipment and that the new equipment is fully operational with the existing equipment.

662.03.2.3--Local Ethernet System Testing. Successful communications shall demonstrate, at minimum, the ability of a wireless transceiver to send video and an error-free data message to the receiving station and processed for viewing and confirmation. A minimum of 30 test transmissions shall be attempted at each test site. If a failure occurs at the locations selected, it will be the responsibility of the Contractor to re-check the test area to determine if a problem exists. When problem(s) occur, it will be the Contractor's responsibility to perform additional tests as required to define the cause of the problem and confirm the final working functionality. If areas of non-performance represent more than the Contractor's predicted link reliability, it will be the Contractor's responsibility to correct such problems at the sole expense of the Contractor. Additional costs associated with the repeated tests will be the sole responsibility of the Contractor.

The Contractor shall prepare and execute a detailed system acceptance test plan, including detailed system acceptance test procedures. The Contractor shall submit a copy of all system acceptance test plans to the MDOT Project Engineer through the standard Department submittal process.

662.03.3--Warranty. The radio interconnect system shall be warranted to be free of manufacturer defects in materials and workmanship for a period of one (1) year from the date of final acceptance. Equipment covered by the manufacturer's warranties shall have the registration of that component placed in the Department's name prior to Final Inspection. The Contractor is responsible for ensuring that the vendors and/or manufacturers supplying the components and providing the equipment warranties recognize the Department as the original purchaser and owner/end user of the components from new. During the warranty period, the supplier shall repair or replace with new or refurbished material, at no additional cost to the State, any product containing a warranty defect, provided the product is returned postage-paid by the Department to the supplier's factory or authorized warranty site. Products repaired or replaced under warranty by the supplier shall be returned prepaid by the supplier.

During the warranty period, technical support shall be available via telephone within four (4) hours of the time a call is made by the Department, and this support shall be available from factory certified personnel. During the warranty period, updates and corrections to control unit software shall be made available to the Department by the supplier at no additional cost.

662.04--Method of Measurement. The radio interconnect system components of the type specified will be measured per each installation.

Partial payments for the radio interconnect system(s) will be measured for payment per each as follows:

- 1) 70% of the contract unit price upon completion of the installation and the standalone acceptance testing of the wireless network;
- 2) An Additional 20% of the contract upon conditional system acceptance; and
- 3) Final 10% of the contract unit price upon final system acceptance.

662.05--Basis of Payment. The radio interconnect system components, measured as

prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing all labor, tools, equipment, connecting, testing, materials inclusive of radio, software, base stations, power supply, antennas, cables and connectors, lightning suppressors, mounting and grounding hardware, enclosures, receivers, and transceivers, system documentation including shop drawings, operations and maintenance manuals, wiring diagrams, and block diagrams, and all incidentals necessary to complete the work.

The installation shall provide an appropriate RF data link that is fully integrated and operational with the existing system.

The price bid for the spare parts shall be measured per each and in accordance to the specifications and requirements.

Payment will be made under:

662-A: Radio Interconnect, Signal Control, Installed in New Controller Cabinet	- per each
662-B: Radio Interconnect, Signal Control, Installed in Existing Controller Cabinet	- per each
662-C: Radio Interconnect, Signal Control Repeater	- per each
662-D: Radio Interconnect, Broadband, *	- per each
662-E: Radio Interconnect, TVBR, *	- per each
662-F: Radio Interconnect, Spare Parts, Furnish Only	- per each

* Type – Long Range or Short Range

SECTION 665 - VIDEO COMMUNICATION EQUIPMENT

665.01--Description. This work consists of the furnishing and installing video communications equipment to support CCTV camera equipment for a fully operational video communications system.

The video communication equipment will transport digitized video signals and data communications for the CCTV camera system over the IP-based Ethernet network utilizing video encoders, video decoders, and video fiber codex.

The Contractor shall supply, install, test and integrate the video equipment as indicated in the contract documents and plans, and as further specified in this section.

665.02--Materials. All proposed encoding and decoding equipment and software shall comply with the following minimum requirements:

665.02.1--General Requirements. All digital Video Encoders (VE) and Video Decoders (VD) shall support the following general requirements.

All VE and VD provided by the Contractor shall be new and shall be from the same manufacturer and be fully compatible and interoperable with each type provided.

All VE and VD types provided by the Contractor shall be fully compatible and interoperable with the network equipment and the MDOT MSTRaffic WEB servers' video streaming format and the Department video wall IP video streaming systems.

Interoperability: The VE shall fully interoperate with the VD (hardware and/or software) as defined in the specifications.

Mean Time Between Failures (MTBF): The VE shall have a minimum MTBF of 20,000 hours.

Latency: The end-to-end system latency between the VE appliance and the VD appliance shall be no more than 300 msec, not including network delays. The VE shall support various frame adjustments to minimize latency.

Remote Control: VE shall be remotely adjustable via a video management system or command set so that a technician can adjust image quality controls for contrast, brightness, hue and color levels.

Decoding: The Contractor shall provide decoders that are capable of auto-detecting the corresponding encoder's streaming parameters such as compression, resolution and bit rate, and appropriately decode the encoded digitized video signal.

Video equipment shall support the NTSC signal format.

665.02.2--Video Encoder/Decoder Requirements. The Video Encoder (VE) and Video Decoder (VD) shall be of the type defined by the Video Compression Technology and the minimum requirements are as follows:

665.02.2.1--Video and Data Requirements. The VE/VD shall meet the following minimum video and data requirements.

The VE /VD shall be capable of decoding or streaming a minimum of the following Video Compression Technology types:

- H.264 (Video Coding Experts Group (VCEG)/Moving Picture Experts Group).
- MPEG -4 (Moving Picture Experts Group).
- MJPEG Motion JPEG (Moving Picture Experts Group).

The VE shall be capable of the following:

- streaming multiple bandwidth and compression types simultaneously per video input channel.
- support streaming multicast and unicast streams simultaneously.
- automatically initiate and stream a multicast stream upon starting without any remote request to join the multicast group.
- support multiple simultaneous Real Time Streaming Protocol (RTSP) requests.

- supply multiple unique and independent video streams with frame rate, bit rate, and image size settings adjustable through an RTSP request.
- support a minimum of two (2) simultaneous unique and independent H.264 video streams with frame rate, bit rate, and image size settings adjustable per video input channel.
- support capturing of snapshot images of the video stream.
- hardware-based network device able to accept a minimum of one analog National Television System Committee (NTSC) video input and encode for transport across IP networks.

VE and VD shall be specifically designed for network operation, and adhere to ISO standards.

VE video encoded streams shall be compatible with the existing video wall server decoders, MSTraffic, and streaming web servers or as approved by the Intelligent Transportation Systems Program Manager.

Support the following minimum encoded resolutions:

- NTSC - Full D1
- CIF/SIF
- QCIF/QSIF

Dynamic bandwidth control: The VE shall provide up to 3 Mbps or greater rates. The data rate shall be defined as the maximum committed bandwidth to be utilized, which includes data bursting.

Bandwidth increments shall be user configurable via the network. The minimum bandwidth setting shall be 56Kbs or less.

VE streams shall be capable of being set to variable or constant bit rates.

The default bandwidth for the VE as furnished shall be set to 2 Mbps when communicating over fiber and 56kbs when communicating otherwise.

The VE shall provide on-board buffered video memory for protection against potential network disruptions.

VE shall be capable of providing JPEG snapshots and transfer image via FTP.

There shall be available standard software decoders that are compatible with the provided hardware VE.

665.02.2.2--Serial Data Interface Requirements. The VE/VD shall meet the following minimum serial data interface requirements.

The VE/VD shall provide bi-directional serial communications over Ethernet 10/100 Base-TX via the following methods:

- VE serial port to VD serial port data stream.

- IP socket to VE/VD serial port by TCP protocol.
- The serial interface shall be transparent to the device (i.e. no additional or special protocols shall be used to communicate between the VE/VD and the CCTV control interface).

Each serial port shall provide full-duplex serial interface and data rates of 115.2 Kbps (minimum).

Serial port(s) shall be software configurable, locally or over the network, to EIA-232/422/485 mode of operation as defined by the EIA for data format, data rate, and data structure (e.g., baud rate, the number of bits, parity, stop bits, flow control, etc.) via the management software provided.

No serial adaptors or interface converters shall be permitted.

Each VE shall use the serial interface port to support PTZ camera control functions.

VE serial port shall provide IP addressing and socket number selection and provide the capability to establish an IP connection directly from an operator workstation to any VE IP address and socket number to transport serial data, independent of whether or not the video stream for that VE is being viewed.

655.02.2.3--Network Requirements. The VE/VD shall meet the following minimum network requirements.

Network connection shall be Ethernet Compliant IEEE 802.3, 802.3u, and 802.3x; 10/100 Mbps or higher, auto sensing full/half-duplex operations.

Each VE shall provide encapsulation of the video streams in a UDP packet for network transmission.

The VE/VD shall connect to a network device (i.e., media converter, Ethernet switch/router, IP wireless device, etc.) via a RJ-45 connector through Category 6 or higher quality stranded patch cords.

All network RJ-45 ports shall be standard EIA/TIA-568-A pin-outs and shall be rated at 10/100Mbps or greater.

All VE and VD provided by the Contractor shall be fully interoperable without customization or the addition of appliances within either the remote or primary communications network. All devices shall be fully interoperable with the backbone communications network.

All VE shall address Static IP Addressing (class A, B, and C).

All VE shall have RTP, UDP, Unicast and IP Multicast (Internet Group Multicast Protocol / IGMP V2) features for digital video transmission.

All VE shall support Real Time Streaming Protocol (RTSP) over RTP.

All VE shall support multiple stream requests.

665.02.2.4--Physical and Environmental Requirements. The VE/VD shall meet the following minimum physical and environmental requirements.

The Video Encoder/Decoder shall have the following ports as a minimum:

- Network: 10/100 Mbps RJ-45 or as directed by the Department.
- Video Connector: BNC
- Serial Data Interface: One (1) minimum RJ-45 port/connector. Serial port may utilize D-sub connectors or thumb screw terminals as approved by the Department.
- In locations where there are more than one video source, and VE with multiple video ports are used, each video input port shall meet all the video and data requirements of Subsection 665.02.2.1 independently.

The video input performance measures shall comply with NTSC and EIA requirements, including the EIA-170 standard, with a nominal composite video of 1 volt peak-to-peak (Vp-p). The equipment shall have an electrical impedance of 75 ohms

The VE at field locations shall operate in outdoor weatherproof field cabinets where the inside cabinet temperature range is -4°F to +158°F, and the relative humidity is between 10% and 90% non-condensing.

VE shall be installed in a field cabinet with protection from moisture and airborne contaminants, blowing rain, wind, blowing sand, blowing dust, humidity, roadside pollutants, vandalism, and theft.

The VE shall be resistant to vibration and shock, and conform to Sections 2.1.9 and 2.1.10, respectively, of the NEMA TS 2 standard.

The VD shall operate in the following minimum environment: Temperature ranging from 32°F to 122°F, and the relative humidity is between 10% and 90% non-condensing.

VE/VD for field site locations shall be PCB conformal coated to provide a level of protection from humidity, contaminants, dust, pollution, etc.

VE/VD shall provide a local status display capability for video, data, network interfaces and power. Status indicators shall be LED.

Cable connections (data/video/power) shall require no tools for installation or removal and be designed with positive locking devices such that they will not vibrate loose.

External markings shall be provided for all connectors and indicators. Replaceable components shall be permanently marked and traceable to the supplied documentation, including schematics and parts list. The external markings shall include the product function name, model number, serial number, and manufacturer's name.

All parts required for a completed video system shall be made of corrosion-resistant materials, such as stainless steel, anodized aluminum, brass, or gold-plated metal.

All individual VE shall be shelf, rack/module, or DIN rail mountable. Other mounting options may be submitted for review and approval by the Engineer.

665.02.2.5--Chassis Based VE and VD. In environmentally controlled locations where more than two (2) encoders or decoders are needed, chassis based encoders and decoders should be supplied and in full compliance with this specification.

VE/VD Chassis shall support a minimum of 12 VE or VD cards.

VE/VD Chassis shall be 7U or less and be 19" rack mountable.

Each VE card shall include a minimum of four (4) encoders per card with a corresponding number of BNC ports per encoder.

Each VD card shall include a minimum of four (4) decoders per card with a corresponding number of BNC ports per decoder.

VE and VD cards shall be fully contained and obtain power from the chassis.

All Contractor provided VE and VD cards shall be compatible with, and of the same make as standalone VE and VD provided by the Contractor

665.02.2.6--On-Screen Display (OSD) Requirements. Where OSD functionality is not supplied by cameras, the minimum on-screen text insertion and display requirements shall be as follows.

VE / VD shall support a static text insertion capability and shall be capable of inserting a minimum of one (1) user configurable text messages of up to 20 characters in length.

VE / VD shall be able to generate a date and time stamp in the video stream and shall be synchronized to a time-server on the network.

VE / VD shall be able to display camera title in the video stream.

VE / VD shall have the option to display or not display the on-screen text.

665.02.2.7--Management Requirements. The minimum management system requirements shall include the following:

- 1) VE/VD manageable through SNMP (v2), HTTP, FTP/TFTP, and/or Telnet/CLI
- 2) The management system to remotely configure and diagnose the VE/VD
- 3) Have capability to reset/reboot and firmware upload via the methods listed above.
- 4) Have the capability to remotely change any of the device configuration settings including bit rates, image resolution and compression settings and serial interface type.
- 5) Provide pre-defined optimized video compression and streaming settings for various bit rates.
- 6) Provide update capability for the firmware in the VE from the central site. Ability to access the serial number, firmware number, IP address and equipment configuration. Have the capability to upload firmware to multiple units automatically.
- 7) Provide ability for remote firmware upgrades.

665.02.2.8--Electrical Requirements. The minimum electrical/power requirements shall include the following.

Power shall have a nominal input voltage of 120 VAC, 60 Hz. ± 3 Hz.

If the device requires operating voltages of less than 120 VAC, the appropriate voltage converter shall be supplied. All voltage conversion devices shall also be temperature hardened as specified herein for location (field or central).

The equipment or its voltage converter shall operate within a voltage range of 90 VAC to 135 VAC.

Power Consumption for a single VE or VD shall not exceed 30 Watts per video device.

The VE/VD shall provide for automatic recovery from an over or under voltage condition when prime power has returned to the tolerance values specified herein. All configuration parameters shall be stored in non-volatile memory and no reprogramming or manual adjustments shall be required upon power recovery.

Plug type transformer/power supplies shall be provided with a fastening device that shall securely attach the unit to the power outlet. No plug-in types will be accepted without a fastening mechanism. All corded transformers shall be mountable with the ability to neatly secure power cords.

Electrical components shall include UL listing.

665.02.3--Fiber Video Codex. Fiber Video Codex will be used where video will be transported in a non IP and/or ETHERNET communication system. This unit will be used when interfacing with current sites or when expanding existing sites or links that require the use of traditional video communication means. All Fiber Video Codex will be completely compatible and of same make and type as with existing Fiber Video Codex in the system unless approved otherwise by the Intelligent Transportation Systems Program Manager.

665.03--Installation Requirements. All video equipment shall be installed according to the manufacturer's recommendations, the plans and as follows.

The Contractor shall furnish and install auxiliary video equipment in support of a communications network that will transport video as specified in this specification.

Materials and associated accessories/adapters shall not be applied contrary to the manufacturer's recommendations and standard practices.

The Contractor shall furnish all tools, equipment, materials, supplies, and manufactured hardware, and shall perform all operations and equipment integration necessary to provide complete, fully operational video equipment as specified herein, within the Plan set, and/or in the contract documents.

The Contractor shall provide the Department with a written inventory of items received and the condition in which they were received. Inventory shall be inclusive of make, model, and serial numbers, MAC address, and installation GPS coordinates. All equipment

shall be installed according to the manufacturer's recommendations or as directed by the Department.

Any new, additional or updated drivers required for the existing ATMS software to communicate and control new video communication equipment installed by Contractor shall be the responsibility of the Contractor.

665.03.1--Testing. The Contractor shall conduct a Project Testing Program as required below. All costs associated with the Project Testing Program shall be included in overall contract prices; no separate payment will be made for any testing.

665.03.1.1--Testing General Requirements. The Contractor shall conduct a project testing program for all VE and VD provided. The project testing program for VE and VD shall include but is not limited to the specific requirements in this subsection.

All test results shall confirm physical and performance compliance with this specification.

Contractor shall submit all test results documentation to the Engineer for review within 14 calendar days of completion of the tests.

All test results shall be reviewed and approved by the Department prior to continuing with further tests and deployment activities. The Contractor is responsible for planning, coordinating, conducting and documenting all aspects of the Project Testing Program. The ITS Engineer, Project Engineer and/or their designee(s) are only responsible for attending and observing each test, and reviewing and approving the Contractor's test results documentation. The ITS Engineer, Project Engineer and/or their designee(s) reserve the right to attend and observe all tests. The Contractor is required to perform the Stand Alone Acceptance Test (SAT) and the Integration Test with the MDOT ITS Engineer or his designee present.

665.03.1.2--Stand Alone Acceptance Test (SAT). The Contractor shall perform a complete SAT on all video equipment and materials associated with the field device site, including but not limited to electrical service, cabling, etc. A SAT shall be conducted at every field device site with video equipment.

The SAT shall demonstrate that all video equipment and materials are in full compliance with all Department project requirements and fully functional as installed and in final configuration. The SAT shall demonstrate full compliance with all operational and performance requirements of the project requirements. All SATs also include a visual inspection of the cabinet and all construction elements at the site to ensure they are compliant with the specifications. The SATs for each site type shall include but are not limited to the following:

- 1) Verify that physical construction has been completed as detailed in the plans.
- 2) Inspect the quality and tightness of ground and surge protector connections.
- 3) Verify proper voltages for all power supplies and related power circuits.
- 4) Connect devices to the power sources.
- 5) Verify all connections, including correct installation of communication and power cables.
- 6) Verify video image is present and free from over-saturation and any other image defect in both color and monochrome mode.

- 7) Verify network connection to the VE through ping and telnet session from a remote PC.
- 8) Verify serial data transmission through the VE serial ports.

665.03.1.3--Integration Test. The Contractor shall be responsible for a Integration Test on all provided video communications equipment with the Departments existing Traffic Management control software and with the existing video wall control. The Contractor shall be responsible to provide equipment that meets all requirements and is compatible with existing systems, TMC software, software drivers, and video wall systems or the Contractor shall provide new or updated software, software drivers, and system upgrades necessary to meet requirements at no additional cost to the State.

The Integration Test shall demonstrate full compliance with all operational and performance requirements of the project requirements including communications and control from the TMC. Integration Test shall include, but are not limited to, the verification of the following:

- 1) VE supports unicast, multicast and network management features.
- 2) Video Switching through existing Traffic Management control software.
- 3) Integration with CCTV video and controls.
- 4) Compatibility with Existing Video Wall display formats.
- 5) Compatibility with MSTraffic web servers.
- 6) RTSP functionality.

665.03.2--Warranty. All warranties and guarantees shall be assigned to the Mississippi Department of Transportation.

The warranty shall be a minimum of one (1) year warranty per VE and VD and all other installed and/or attached appurtenances.

The warranty period begins upon final acceptance of the video subsystem.

During the warranty period, the Contractor shall repair or replace with new or refurbished material, at no additional cost to the State, any product containing a warranty defect, provided the product is returned postage-paid by the Department to the manufacturer's factory or authorized warranty site.

Products repaired or replaced under warranty by the manufacturer shall be returned prepaid by the manufacturer.

During the warranty period, technical support shall be available from the Contractor via telephone within four (4) hours of the time a call is made by the Department, and this support shall be available from factory certified personnel.

During the warranty period, updates and corrections to hardware, software and firmware shall be made available to the Department by the Contractor at no additional cost.

665.03.3--MDOT Employee Training. Minimum training requirements are as follows:

The training shall be approved two (2) week ahead of the scheduled date.

For provided devices that the Department already has the same make and model existing in the system, training shall be:

- One (1) day of on-site device operation, maintenance, and configuration training for up to 10 individuals.
- One (1) day of on-site system training at TMC for up to 10 people, that is separate from above training and specifically for software control of integrated devices.

For provided devices that the Department does not have the same make and model existing in the system, training shall be:

- Three (3) days of on-site device operation, maintenance, and configuration training for up to 10 individuals.
- Three (3) days of on-site system training at TMC for up to 10 people, that is separate from above training and specifically for software control of integrated devices.

665.04--Method of Measurement. Video Encoder, Video Decoder, Video Encoder / Decoder Chassis, Video Encoder Card, Video Decoder Card, and Fiber Video Codex will be measured per each.

665.05--Basis of Payment. Video Encoder, Video Decoder, Video Encoder/Decoder Chassis, Video Encoder Card, Video Decoder Card, and Fiber Video Codex, measured as prescribed above, will be paid for at the contract unit price bid per each, which price shall be full compensation for furnishing, installing, warranties, full operation and configuring the equipment in accordance with applicable Standards, Specifications, and requirements. It shall also include the mounting hardware including any required VE/VD rack and power supplies, Cat-6 patch cords, power cable, user manuals, training, testing, warranties, serial cable as necessary, and any and all labor, tools, materials, equipment and incidentals necessary to complete the work.

Progress payment for Video Communication Equipment may be paid as follows:

- 1) 50% of the contract unit price upon delivery of equipment and approval of any bench and/or pre-installation test results, as prescribed in Project Testing Program;
- 2) An additional 40% of the contract unit price upon approval of Stand Alone Acceptance Test results; and
- 3) Final 10% of the contract unit price upon Final Project Acceptance.

Payment will be made under:

665-A: Video Encoder	- per each
665-B: Video Decoder	- per each
665-C: Video Encoder/Decoder Chassis	- per each
665-D: Video Encoder Card	- per each
665-E: Video Decoder Card	- per each
665-F: Fiber Video Codex	- per each

SECTION 680 -- PORTABLE CONSTRUCTION LIGHTING

680.01--Description. Whenever the Contractor's operations are being conducted at night, the Contractor shall provide artificial lighting as may be necessary to provide for safe and proper construction and inspection of the work. This work shall consist of furnishing, installing, maintaining, moving and removing lighting for nighttime work operations.

680.02--Materials. All lighting equipment will be furnished as required and retained by the Contractor after the work is completed. Material and/or equipment are not required to be new but shall be in good operating condition and in compliance with applicable safety and design codes.

Prior to beginning nighttime operations, the Contractor shall submit a lighting plan showing the type and location of lights proposed for use during night work. It shall clearly show the location of all lights necessary for every aspect of work to be done at night. In addition to the lighting plan, the Contractor shall submit catalog cuts giving the specific brand names, model numbers and ratings of the lighting equipment. The lighting plan shall include power ratings, photometric data, and lighting calculations confirming that the illumination requirements will be met by the layout. Night work shall not begin until the Contractor has submitted the above mentioned lighting plan meeting the requirements set forth in this specification.

The Contractor shall take lighting level measurements in the presence of the Engineer at locations designated by the Engineer to verify compliance with the lighting plan and the specifications. Field light level measurements shall be equal to or exceed required light levels.

680.02.1--Tower Lights. Tower lights shall consist of lighting fixtures mounted on a tower up to thirty (30) feet in height. The tower light fixtures shall be heavy duty flood, area, or roadway style with wide beam spread. The tower shall be sturdy and free-standing without the aid of guy wires or bracing. The power supply shall be of sufficient capacity to operate the light(s) and shall be located for the shortest safe routing of cables to the fixtures.

Tower lights shall be of sufficient wattage and/or quantity to provide an average maintained horizontal luminance in accordance with Subsection 680.02.3.

680.02.2--Machine Lights. All moving equipment used during night time operations shall have a balloon lighting system or equivalent system and a flashing amber light on the equipment. In lieu of a flashing amber light, the Contractor may install four square feet of approved reflective material on the equipment in a location that will be seen by the traveling public. This lighting system shall illuminate the work area in each direction of travel of the equipment. Work area shall be defined as 30 feet in front and 30 feet behind moving equipment. Machine lights shall be heavy duty flood, area, or roadway style with wide beam spread mounted on supports attached to the construction machine at a height of no more than thirteen (13) feet. The power supply shall be of sufficient capacity to operate the light(s) and shall be securely mounted on the machine. Electrical grounding of generators to frames of machines on which they are mounted shall be done in conformance with the National Electrical Code (NEC).

The light fixtures shall be of sufficient wattage and/or quantity to provide an average maintained horizontal luminance in accordance with Subsection 680.02.3.

Machine lights are in addition to conventional automotive type head lights, which are necessary for maneuverability.

680.02.3--Lighting Levels. The submitted lighting plan shall indicate how the Contractor intends to accomplish the lighting of the work area(s). Work areas shall be classified into one (1) of the following categories depending on the type of work to be accomplished:

CATEGORY I - Category I work areas will be lit to five foot-candles (5 fc). This category of work includes general work zone safety and visual tasks with large objects.

CATEGORY II - Category II work areas will be lit to ten foot-candles (10 fc). This category of work includes work around all construction equipment and visual tasks that require greater accuracy such as inspection of paving and resurfacing activities.

CATEGORY III - Category III work areas will be lit to twenty foot-candles (20 fc). This category of work includes activities that require the highest visual efficiency. These tasks present higher levels of visual difficulty and require significant attention from the observer, such as crack and pothole filling, joint sealing, critical connection and maintenance involving electrical connections and moving mechanical parts.

Lighting equipment shall be placed so the uniformity ratio, average maintained to minimum, shall not be greater than 10:1.

680.03--Construction Requirements.

680.03.1--Lighting Systems. Tower lights may be used when the night work is confined to a fairly small area and is essentially a stationary operation.

A balloon lighting system or equivalent system shall be used when the night work is not confined to a small area and is essentially a continuous moving construction operation.

Use of tower lights in lieu of balloon lights will be considered when the number of machines, type of work, or need for inspection justify their use as decided by the Engineer.

The work area where traffic control devices are being set up or repositioned at night shall be illuminated.

If night work requires the use of a flagger, then the flagger must be illuminated by balloon lighting or equivalent system providing ten foot-candles (10 fc).

The illuminated work area shall be large enough so that the movements of all personnel and equipment engaged in the work will be contained in the area.

The Contractor shall provide sufficient fuel, spare lamps, generators, and personnel qualified to operate the lights to assure that they will be maintained in operation during night work.

Existing roadway lights shall not eliminate the requirement for the Contractor to provide

lighting. Consideration may be given to the amount of illumination provided by existing lights in determining the wattage and/or quantity of lights to be provided, if noted in the Contractor's submitted lighting plan.

630.03.2--Glare Control. All lighting shall be designed, installed, and operated to avoid glare interference with roadway traffic or discomfort for residences adjoining the roadway. The Contractor shall locate, aim, and adjust the lights to provide the required level of illuminance and uniformity in the work area without the creation of objectionable glare. The Engineer shall determine when glare exceeds acceptable levels, either for traffic or adjoining residences. The Contractor shall provide shields, visors, or louvers on luminaries as necessary to reduce objectionable levels of glare. Lighting systems should not be aimed higher than 30° from straight down unless the fixture has been specifically designed to prevent glare. In no case shall the main beam of the light be aimed higher than 60° above straight down. The lights should be set as far from traffic as practical and aimed in the direction of, or perpendicular to, the traffic flow.

680.04--Method of Measurement. Portable construction lighting, by tower and/or machine lighting systems, will be measured for payment only when a pay item for portable construction lighting is included in the contract. Otherwise, portable construction lighting will be considered incidental to other contract items and no direct payment will be made.

When a pay item for the portable construction lighting is provided in the contract, measurement will be made at the contract lump sum price. Partial payments for this pay item will be made as follows:

- 1) 50% of the lump sum price on the first monthly estimate after using the lighting system.
- 2) 25% of the lump sum price on the first monthly estimate made after 50% of scheduled night work that requires construction lighting is completed.
- 3) 25% of the lump sum price on the first monthly estimate after the completion of all scheduled night work that requires construction lighting.

680.05--Basis of Payment. Portable Construction Lighting, as measured above, shall be paid for at the contract lump sum price, which price shall be full compensation for furnishing, operating and maintaining everything necessary to provide a portable construction lighting system.

Payment will be made under:

680-A: Portable Construction Lighting

- lump sum

SECTION 681 - ROADWAY LIGHTING SYSTEM

681.01--Description. This work consists of furnishing; installing, testing, erecting, constructing and assembling all materials to ensure a properly operating roadway lighting system in accordance with the plans and specifications.

681.02--General Provisions.

681.02.1--Tests and Inspection. The complete job shall be, during and/or after

construction, subject to the supervision of the Engineer. Inspections and tests shall be conducted by the Engineer or in the presence of the Engineer prior to acceptance of the project and shall consist of the following tests:

- 1) Upon written notice, the Contractor shall furnish two men, one to include the job foreman, and tools to assist and be directed by the Engineer for a period of time required to make such tests and inspections as are requested by the Engineer pertaining to the safety and operation of any devices or system installed.
- 2) Insulation break-down tests with a megohm meter shall be conducted on each and every circuit. Results of the tests shall meet minimum requirements for such tests set up by the latest edition of U.L. Standard 83. All readings shall be made in the Engineer's presence and a written report of same submitted to the Engineer upon completion of these tests.
- 3) The ground resistance of each ground rod and grounding system shall be measured. The resistance and soil conditions at the time the measurements were made shall be recorded and a report shall be submitted to the Engineer for approval. Ground-resistance measurements shall be made in normally dry weather, not less than forty-eight (48) hours after rainfall, and with the ground under test isolated from other grounds. Ground resistance shall also be measured from each piece of equipment to the ground electrode. The ground rods and grounding system shall meet the requirements of the National Electrical Code (NEC). The Contractor shall be required to correct any deficiencies prior to acceptance of the system.
- 4) The Contractor shall be required to demonstrate in the presence of the Engineer, the operation of each and every device installed. This shall include, but not be limited to, all winches, latching devices, photocells and circuit breakers.
- 5) The Contractor may be required to take lighting level measurements in the presence of the Engineer at locations designated by the Engineer to verify compliance with the approved lighting layout submittals. Field light level measurements shall be equal to or exceed light levels on the submittal.

After completion of all tests, the Contractor shall request a semi-final electrical inspection. After this inspection and when all discrepancies have been corrected, the roadway lighting system shall be placed in operation for a satisfactory performance period. Final electrical inspection will not be made until the entire roadway lighting system has operated satisfactorily for a period of not less than fourteen (14) consecutive days, during which period(s) contract time will continue to be evaluated. During each fourteen (14) day performance period, if any failure should occur in any of the mechanical or electrical equipment in the system other than minor readily replaceable components, such as light bulbs, etc., the cause of the failure shall be determined, the necessary replacements made and the system operated satisfactorily for an additional period of not less than fourteen (14) consecutive days.

Upon completion of all work on the project and the satisfactory completion of the fourteen (14) day performance period on the roadway lighting system, the Contractor may request a final inspection of the project. If all items of work, excepting the completion of the Contractor's warranty period on the roadway lighting system, are considered satisfactory and acceptable, the Contractor may be given a partial maintenance release. This partial maintenance release is to relieve the Contractor of responsibility, except as stated in the roadway lighting system material warranty section, from maintenance on all other items of work on the project during the warranty period on the roadway lighting system. If the

minimum 6-month warranty period has expired on the day of final inspection, this partial maintenance release is to relieve the Contractor of responsibility from maintenance on all items of work on the project.

During final inspection or upon completion of the warranty period after the final inspection, the Contractor shall request an inspection of the roadway lighting system. If this work is considered satisfactory and acceptable, the Contractor may be given a full maintenance release.

Payment of the final estimate releasing the remaining retainage will not be made until after final acceptance of the project.

No additional time will be allowed for any additional performance period(s) found to be necessary because of failure(s) during the initial period, or subsequent performance period(s).

Acceptance will be for the entire roadway lighting system, no parts of the system will be accepted separately.

681.02.2--Material Warranty. The following Contractor warranty stipulations are in addition to those covered by Subsection 106.01.2 of the Standard Specifications.

All roadway lighting equipment and related components shall be fully operational at the final inspection of the project.

The Contractor shall warrant and guarantee all roadway lighting equipment and related components for a minimum period of six (6) months. This warranty period begins after the day of partial release from maintenance or at the start of continuous use as referenced in Subsection 681.02.8. Regardless of when the warranty period begins, the Contractor shall warrant and guarantee the roadway lighting equipment and related components (1) at least up to and including the day of final inspection and (2) during the Contractor's warranty period. Final acceptance will not be made until after the warranty period expires.

It is the intent of the preceding paragraph to provide for equipment that performs as intended by the manufacturer. It is the further intent to obtain from the Contractor a level of workmanship that assures the Department of an operational system devoid of Contractor laxities. Failure to perform as indicated shall require the Contractor to replace in kind or repair, the equipment or workmanship in question at no additional cost to the State. All materials and labor cost resulting from the replacement or repair of equipment or correction of poor workmanship shall be borne by the Contractor.

The Contractor shall not be responsible for outages occurring during the warranty period due to vandalism, traffic accidents or any problem not related to materials or workmanship. The Contractor will be required to make the necessary repairs but the cost of such repair shall be borne by the Department.

All manufacturer's standard warranties or guarantees on all electrical and mechanical equipment provided as customary trade practice shall be delivered to the Engineer at the final inspection. All warranties and guarantees shall be made out to the Department.

681.02.3--General Information. Plans are diagrammatic and care shall be exercised to

install all electrical work in a manner that functions in accordance with plans, specifications and manufacturer's recommendations.

Exact location of all equipment shall be determined from dimensions on the plans, manufacturer's shop plans, or as directed by the Engineer.

Conduit runs, cable runs and circuit groupings are indicated diagrammatically with number of conductors shown in each run to clarify the operation and function of the system. The Contractor shall provide the number of conductors and conduits to produce an operative system as specified herein.

All materials shall be new and of equal or superior quality to those specified. All equipment or materials shall conform to the latest requirements and/or additions to the Underwriter's Laboratories, National Electrical Code, or National, State or local agency having jurisdiction.

All materials, devices, equipment, etc. shall be installed, tested, and connected in strict compliance with the manufacturer's recommendations, and, where specified, under the direct supervision of a manufacturer's representative.

All materials, devices, equipment, lighting, etc. shall be installed as required by the plans, specifications and manufacturer's recommendations. The Contractor shall use only experienced labor to do all trenching and jacking.

All equipment and apparatus furnished shall be protected from damage by the Contractor. All items marred or damaged shall be replaced or repaired to the complete satisfaction of the Engineer solely at no additional cost to the State.

Any piece of equipment, switch, device, etc., shown to be mounted on and/or adjacent to any existing equipment, which if installed may impair the proper operation of that equipment, shall be moved by the Contractor as required in order that existing equipment shall function properly. The Engineer shall be notified if any such condition exists.

It shall be the responsibility of the Contractor to provide training in the operation and maintenance of all parts of the roadway lighting system to any person, or persons designated by the Engineer. The training shall consist of a minimum of eight (8) hours of on-site instructions and shall be conducted near the end of completion of all work, but prior to final acceptance of the project.

The Contractor shall furnish the Engineer three (3) bound sets of the manufacturer's publications relating to the installation, operation and maintenance of all component parts of the roadway lighting system. The Contractor shall maintain a complete and accurate set of as-built plans throughout the project. At the final inspection, one (1) set each of full scale and 1/2 scale as-built blueprints shall be furnished to the Engineer.

The Contractor shall submit eight (8) copies of a letter of certification from the high mast manufacturer on manufacturer's letterhead, certifying that all of the lowering devices, poles and luminaires have been installed in accordance with the manufacturer's guidelines.

As referenced in Section 683 regarding high mast lighting assemblies, the following shall be provided from the same manufacturer.

- 1) Poles
- 2) Lowering Devices
- 3) Luminaires
- 4) Anchor Bolts
- 5) Portable Power Unit

The Contractor will be responsible for all power costs including deposits, customer charges, connection cost, etc. associated with roadway lighting system. The Contractor shall provide all electrical power required for construction, tests, satisfactory performance period(s), and usage up to and including the day of the final inspection of the system. Beginning on the day after the final inspection all power and related cost will be paid by the Department. The Department may assume power cost prior to the final inspection if the requirements of Subsection 681.02.8 are met.

All lamps shall be from the same manufacturer.

681.02.4--Corrosion Protection. It is the intent of these specifications to have all joints, connections, etc. completely water and moisture tight.

681.02.5--Coordination of Existing Utilities. It shall be the responsibility of the Contractor to coordinate work near all existing utilities, both overhead and underground, and to verify utility locations with the various utilities companies prior to commencing any work. Failure to do this shall not relieve the Contractor of any responsibility and will not be justification for requesting additional money from the Department due to damage of any of these utility lines.

681.02.6--Removal of Salvaged Material and Debris. It shall be the responsibility of the Contractor to have all salvaged materials, debris, etc. resulting from the Contractor's operations completely removed from the project site continually during construction.

681.02.7--Initial Power Cost. The Contractor will make all application and contacts necessary to obtain power from the local utility company. All costs relating to obtaining, providing and using electrical power during the entire life of the contract will be absorbed by the Contractor, with exception noted in Subsection 681.02.8.

681.02.8--Operation of the System. After the final electrical inspection is completed and all noted deficiencies have been corrected, the system may be placed in operation at the request of the Engineer. This shall be accomplished before the complete removal of any temporary lighting system. When the system is placed into operation at the request of the Engineer, the Department will begin assuming all power costs. The Contractor will submit to the Department original bill(s) received from the Utility Company after the day the Department assumes the power cost. The Department will pay for only the cost of power used during and after that billing period.

The Contractor will continue to warrant and maintain the system up to and including the day of final inspection.

The date the system is placed in operation at the request of the Engineer, shall be considered the commencement of the warranty period, otherwise material warranties will be in accordance with Subsection 681.02.2.

681.03--Codes and Standards. The Contractor shall strictly comply with the latest edition of the National Electrical Code, Federal, State or local codes having jurisdiction and shall notify the Engineer of any conflict between any of these codes and the plans and/or specifications before bid date or correct same at no additional cost to the State.

The following Codes shall be complied with in each and every respect as though fully written herein:

- 1) Latest Edition - National Electrical Code
- 2) Latest Edition - National Electrical Safety Code
- 3) AASHTO Requirements, Latest Edition, thereof

681.04--Basic Materials and Methods. The Contractor shall submit to the Engineer eight (8) copies of submittal data for all electrical materials and equipment proposed for use not later than forty-five (45) days prior to beginning any lighting work.

Refer to Subsection 105.01 of the Standard Specifications for explanation of the Engineer's authority with respect to materials furnished.

Before purchasing any equipment, the following materials shall be submitted to the Engineer for approval: Eight (8) copies of shop plans, computerized lighting layouts, test reports, design calculations showing overall dimensions, bus sizes, bussing diagrams, lug sizes, equipment rating, lighting levels on the roadway and all other pertinent information for the following items:

- 1) Lighting Controller
- 2) Wire and Cable
- 3) Conduit, Fittings and Pull Boxes
- 4) Luminaires
- 5) Wiring devices
- 6) Lamps
- 7) Poles
- 8) Lowering devices
- 9) Portable electric power unit
- 10) Breakaway bases
- 11) Ground Rods
- 12) Safety Switches
- 13) Hardware
- 14) Miscellaneous items as shown on the plans and/or stated herein

The Contractor shall provide manufacturer's in-use history data on the following items:

- 1) Luminaires
- 2) Poles
- 3) Lowering devices
- 4) Lowering devices - power unit

Shop plans for poles and breakaway devices shall include conformance certification that the device meets or exceeds the latest AASHTO standards. Information must also include all bolt torque requirements for anchor bolts and breakaway device bolts.

This data shall include a minimum of two (2) recently completed installations, a minimum of five (5) installations that have been in-place five (5) or more years, and the name and address of the owner of each installation. The data shall be submitted with shop plans.

Reinforcing steel shall comply with Section 711 of the Standard Specifications.

Concrete shall comply with Section 804 of the Standard Specifications.

SECTION 682 - ELECTRICAL DISTRIBUTION SYSTEM

682.01--Description. In addition to the requirements set forth in Section 681, the electrical distribution system generally consists of the secondary electrical service, grounding and bonding system, secondary distribution and secondary power controller.

The secondary electrical service shall be 480 volts, 1 phase, 3-wire, 60 HZ, unless indicated otherwise on the plans. The overhead service entrance shall have five (5) feet of tail-wire extension from the service entrance cap for connection to the Utility Company's overhead transformer service facilities. An underground service entrance shall consist of conduit and wire placed, after coordination with the serving utility, in a manner to connect the secondary power controller with the ground mounted transformer. The system will be metered as per serving utility company's requirements.

Bonding and grounding of all electrical service equipment enclosures and ground terminals shall be as shown on the plans and/or in accordance with Article 250 of the National Electrical Code.

The secondary distribution shall consist of furnishing, installing, erecting and laying electrical branch circuits. All branch circuits shall be buried underground except where shown otherwise on the plans. Branch circuits shall consist of conduit, conductors, connectors, and all hardware necessary to complete the work. Pull boxes and junction boxes may be both underground and/or structure mounted.

The secondary power controller shall consist of a lighting controller for control of roadway lighting, enclosure, conduit with fittings, wire, devices, ground rods, photocell, and miscellaneous hardware. The controller shall have a dead front behind outer doors with only breaker handles, hand-off automatic selector switch and receptacle exposed. All controllers shall be labeled with a phenolic engraved label having 1/4-inch white letters on a black background. Example: "SPC#1".

682.02--Materials.

682.02.1--Secondary Distribution. The materials used in this construction shall meet the requirements of Subsection 723.02.

682.02.2--Secondary Power Controller. The materials used in this construction shall meet the requirements of Subsection 723.03.

682.03--Construction Requirements.

682.03.1--Grounding and Bonding System. Where conduit enters an enclosure, a bonding type bushing shall be used on all conduits with #6 AWG copper bonding conductors bonded to all conduits thence to equipment enclosure or ground bus.

The green equipment grounding terminal of all grounding type equipment shall be bonded to its equipment ground conductor with a properly sized green bonding conductor.

One (1) green equipment grounding conductor shall be pulled into all raceways, sized the same as the branch circuit conductors, or as noted on the plans. This conductor shall be bonded to box ground terminals, pole ground terminal, ground bus of panel, cabinet, enclosures, and/or ground electrodes shown on the plans.

682.03.2--Secondary Distribution. All trenching shall be performed by mechanical means and all sides shall be straight and vertical. Width of trenches shall not exceed eight (8) inches on either side of placed branch circuit conduits. All backfill shall be made with a friable material that has been approved by a visual inspection of the Engineer. The Contractor shall seed trenched areas as directed by the Engineer.

All conduits shall be sized as shown on the plans, or where size is not indicated, the Engineer shall be consulted. All conduits shall be run 2' 0" outside of roadway shoulder lines where practicable. All conduit field bends shall be made in accordance with the National Electrical Code, Article 344 for metallic conduit, or Article 352 for non-metallic conduit. All upturned conduits shall be plugged or ends taped to prevent entrance of debris or moisture. A dry swab shall be pulled through each conduit to remove any debris or moisture before pulling wire.

All flexible conduits shall be liquid tight with proper liquid tight fittings.

Conduit mounts exposed on poles or other supports shall be supported at 5' 0" on center by 2-hole straps.

Only approved lubricants that will not harm the conductor insulation shall be used while pulling wires. Each branch circuit shall be labeled with a permanent pressure-sensitive label with proper numbers and letters for identification.

All connections shall be made in pole bases and controller panels unless otherwise shown on the plans. Splices shall be made using compression type splice connectors. All splices and connections shall be well taped to provide an insulation equal in rating and thickness to the conductor insulation as follows:

- 1st layer - flame retardant, cold and weather resistant vinyl plastic tape.
- 2nd layer - self fusing, rubber-based insulating compound laminated to all weather grade PVC backing, rated up to 600 volts.
- 3rd layer - same as 1st layer.

No splices shall be allowed in pull boxes. All runs shall be continuous from controller to pole and from pole to pole. The Contractor shall be responsible for purchasing continuous lengths of wire to achieve the above.

Approved jacking or boring methods shall be used where a branch circuit must be placed under an existing roadway. Boring operations shall be kept a minimum of two (2) feet

from the edge of shoulder, and care shall be taken not to disturb existing pavement or edge drains. The use of water, which could undermine pavements, shall not be permitted. The jacking or boring site must be returned to its undisturbed state upon completion of the operation. Jacking or boring operations and other incidentals necessary to this operation will be cost of Underground Branch Circuit, Jacked or Bored.

The Contractor may jack, bore, or trench at paved ditches encountered on branch circuit runs. Where paved ditches are trenched, all concrete must be replaced at no additional cost to the Department.

682.03.3—Pull Boxes and Junction Boxes. Pull boxes and junction boxes shall be installed in accordance with the plans. The location of the boxes may be adjusted to accommodate field conditions with the approval of the Engineer. When specified, pads around pull and junction boxes may be required.

682.03.4--Secondary Power Controller. The secondary power control unit shall be installed in accordance with the plans and shall present a neat and workmanlike finished appearance. The Contractor shall cooperate with utility in completion of unit.

682.04--Method of Measurement.

682.04.1--Secondary Distribution. Branch circuits shall be measured by the linear foot. The measurement being computed as follows:

Jacked or Bored - Horizontally along the length of the jacked section of conduit.

Underground - Horizontally along the trench lengths.

Structure mounted branch circuit - horizontally or vertically along the length of the sections of conduit installed.

No extra length will be allowed for risers to lighting assemblies or secondary power controllers. The terminals for measurement of lengths will be considered specifically as the center of lighting assemblies, power controllers, and junction boxes. Payment for branch circuit connectors, tape, etc. shall be included in payment allowed for the total length of branch circuits.

Hardware, fittings, support devices, excavation, sod, backfill, seeding and other incidentals will not be measured for separate payment, but shall be included in the contract unit price per linear foot for branch circuits.

Pull boxes and junction boxes will be measured as a unit quantity per each as detailed on the plans.

682.04.2--Secondary Power Controller. Secondary power controllers complete in place will be measured as unit quantities per each, which shall include all items necessary to complete the installation.

682.05--Basis of Payment.

682.05.1--Secondary Distribution. Branch circuits of the type specified, measured as prescribed above, will be paid for at contract unit price per linear foot, which price shall be full compensation for furnishing, installing, connecting, excavating, trenching, backfilling

and replacement of sod, for hardware, fittings and support devices, for final clean-up, and for all labor, tools, equipment and incidentals necessary to complete the work.

Pull boxes and junction boxes, as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing, installing, and mounting, for hardware, fittings, supports, for final clean up, for labor, tools, equipment and incidentals necessary to complete the work.

682.05.2--Secondary Power Controller. Secondary power controllers, measured as prescribed above, will be paid for at the contract unit price per each, which price shall include all constructing, erecting, installing, testing, connecting, cleaning up and for all materials, equipment, labor and tools necessary to complete the work.

Payment will be made under:

682-A: Underground Branch Circuit, <u>Size, No. of Conductors</u>	- per linear foot
682-B: Underground Branch Circuit, Jacked or Bored, <u>Size, No. of Conductors</u>	- per linear foot
682-C: Structure Mounted Branch Circuit, <u>Size, No. of Conductors</u>	- per linear foot
682-D: <u>Type</u> Pull Box *	- per each
682-E: <u>Type</u> Junction Box *	- per each
682-F: Secondary Power Controller	- per each

* Additional description may be included

SECTION 683 - LIGHTING ASSEMBLIES

683.01--Description. In addition to the requirements set forth in Section 681, lighting assemblies shall consist of high mast lighting assemblies, low mast lighting assemblies, underpass lighting assemblies and portable power units. High mast lighting assemblies shall consist of a pole, lowering device, luminaires, anchor bolts, lamps, and miscellaneous hardware. Low mast lighting assemblies shall consist of pole, arm, luminaire, anchor bolts, breakaway device, lamp, and miscellaneous hardware. Underpass lighting assemblies shall consist of the luminaire, conduit box, lamp, fuses and miscellaneous hardware. The portable power unit shall consist of a heavy-duty industrial type reversible power unit, dry type transformer and hand held control unit. Where called for on the plans, lighting fixtures can be of several different types. When either high pressure sodium or light emitting diode (LED) is specified, they shall meet the requirements as set forth in the following sections. LED luminaires may be used in any lighting assembly.

683.02--Materials.

683.02.1--High Mast Lighting Assembly. The materials used in this construction shall meet the requirements of Subsection 723.04.

683.02.2--Low Mast Lighting Assembly. The materials used in this construction shall meet the requirements of Subsection 723.05.

683.02.3--Underpass Lighting Assembly. The materials used in this construction shall meet the requirements of Subsection 723.06.

683.02.4--Light Emitting Diode (LED) Lighting Fixture. The materials used in this construction shall meet the requirements of Subsection 723.07.

683.02.5--Portable Electric Power Unit. The materials used in this construction shall meet the requirements of Subsection 723.08.

683.03--Construction Requirements.

683.03.1--High Mast Lighting Assemblies.

683.03.1.1--Field Assembly of All Components. The pole section shall be fitted together and supported by blocks. The Contractor shall use the piece marks provided by the manufacturer. The proper joint overlap shall be provided and verified. The sections shall be lashed together by an approved method that will not damage galvanizing during erection. The wiring, lowering device, cables, and all components, except luminaires, shall be installed on the pole before erection, as per manufacturer's guidelines. No field welding is permitted on the pole shaft. Any damaged areas on the pole surface shall be coated with a zinc rich paint before erection.

683.03.1.2--Setting and Aligning Poles. The pole shall be lifted at a point as far above center of gravity as possible. The lifting shall be smooth, continuous and free of abrupt motions. The base shall be placed on pre-leveled nuts and supported by the crane until anchor bolt nuts are tightened. Cables or chains that may damage galvanizing shall not be tied to poles.

Poles shall be plumbed by the method shown on the plans. The plumbing shall be done early in the morning while minimum heat is affecting the pole and while there is no appreciable wind. After the pole is plumb, the anchor bolt nuts shall be tightened and secured against loosening by tightening the nuts until there is an abrading or coining of the base plate under the nut.

The space between the top of the foundation and the bottom of the base plate shall be grouted a maximum of three (3) inches deep, making two (2) drainage openings with 3/4-inch PVC pipe for internal condensate drainage.

683.03.1.3--Cable Installation. Care shall be taken to remove all twisting from hoisting cables before installation and/or operation of the lowering device.

683.03.2--Low Mast Lighting Assemblies.

683.03.2.1--General. All component parts of the low mast lighting assemblies shall be installed as per manufacturer's guidelines and this specification.

683.03.2.2--Setting and Aligning Poles. All wiring, luminaires, and other components shall be installed as per plans before pole erection. Poles shall be lifted into place on the

foundation using pre-leveled nuts for alignment. All poles shall be as nearly plumb as possible.

683.03.2.3--Alignment of Luminaires. Luminaires shall be installed and aligned to provide the proper lighting pattern on the roadway. Pavement overhang shall be one (1) foot for bracket arm type assemblies or as shown on the plans. Post top mounted assemblies shall be properly aimed.

683.03.3--Underpass Lighting Assemblies. All component parts of the underpass luminaire shall be installed as per manufacturer's guidelines and the plans.

683.03.4--Portable Power Unit. The power unit shall be constructed in accordance with Underwriters Laboratories Standards and shall be so listed.

683.04--Method of Measurement. High mast and low mast lighting assembly, of the type specified, will be measured as a unit quantity per each, which measurement shall include the pole, lowering device, luminaires, lamps, pole wiring, conduit, anchor bolts, ground rods and all other items necessary to complete installation.

Underpass lighting assembly, of the type specified, will be measured as a unit quantity per each, which shall include luminaire, lamp, wiring, conduit box, fuse, and mounting hardware.

The portable power unit, complete in place, will be measured as a unit quantity per each, which shall include all items necessary to complete the unit.

683.05--Basis of Payment. High mast and low mast lighting assembly, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing all materials, placing, erecting, installing, connecting, testing, poles, lowering device, luminaires, lamps, breakaways, ground rods, conduits, cable, wiring, all hardware, final cleaning up, equipment, labor, tools, and incidentals necessary for completion of the work.

Underpass lighting assembly, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing all materials, for all construction, installing, connecting, testing, luminaires, lamps, conduit boxes, hardware, wiring, connectors, miscellaneous hardware, tools, labor, equipment and incidentals necessary to complete the work.

Portable electric power unit, measured as prescribed above, complete and accepted, which price shall be full compensation for furnishing all equipment and materials, power unit, transformer, attachment devices, remote control unit, all labor and incidentals necessary to complete the unit.

Payment will be made under:

683-A: Lighting Assembly, High Mast, *, Type - per each

683-B: Lighting Assembly, Low Mast, *, Type - per each

683-C: Lighting Assembly, Underpass, * , Type

- per each

683-D: Portable Electric Power Unit

- per each

* Specify Type of Lighting Fixture

SECTION 684 - POLE FOUNDATIONS

684.01--Description. In addition to the requirements set forth in Section 681, pole foundations shall be cast-in-place reinforced concrete pilings or driven piling of types and sizes detailed on the plans.

684.02--Materials. Concrete for pole foundations shall be Class "B" structural concrete.

All reinforcement steel shall be in accordance with Section 711 of the Standard Specifications. The sizes for the reinforcement shall be as shown on the plans.

Pilings will be in accordance with Section 719 of the Standard Specifications.

684.03--Construction Requirements. Pole foundations shall be constructed as per the details on the plans, this specification and Section 803 of the Standard Specifications. Casings, as required, will be in accordance with Section 803 of the Standard Specifications.

Structure excavation for foundations shall be opened vertically in accordance with Section 801 of the Standard Specifications. All reinforcement, conduits, and anchor bolts shall be set in place before any concrete is poured. Forming, casting, and curing shall be in accordance with Section 601 of the Standard Specifications.

When the depth of a foundation is more than five feet, a tremie will be required during the placement of the concrete. When a tremie is used, it shall be in accordance with the requirements in Subsection 804.03.6.1.

It may be necessary to use slip casing to keep the holes open. Casing will be required in portions of the holes that are not stable. Casings authorized by the Engineer shall be of suitable size and strength to accommodate the drilling equipment and to withstand ground-pressures and removal operations without deformation of the poured shaft. When removed, the casings shall revert to the Contractor for disposal.

684.04--Method of Measurement. Pole foundations of the size specified will be measured by the cubic yard, which measurement shall be the area bounded by the vertical planes of the neat lines of the foundation.

Slip casings will be measured by the linear foot from the ground elevation to the bottom of the strata needing to be cased.

Piling will be measured by the linear foot from the bottom of the pile to the top of the pile.

684.05--Basis of Payment. Pole foundations, measured as prescribed above, will be paid for at the contract unit price per cubic yard, which price shall include full compensation for concrete, structure excavation, and reinforcing steel, for placing, vibrating, curing,

installing, final clean-up, all equipment, labor, tools and incidentals necessary to complete the work.

Slip casings, measured as prescribed above, will be paid for at the contract price per linear foot, which price shall be full compensation for all materials, tools, equipment, labor, and incidentals necessary to complete the work.

Piling, measured as prescribed above, will be paid for at the contract price per linear foot, which price shall be full compensation for all materials, tools, equipment, labor, and incidentals necessary to complete the work.

Payment will be made under:

684-A: Pole Foundations, ___" Diameter	- per cubic yard
684-B: Slip Casings, ___" Diameter	- per linear foot
684-C: Piling	- per linear foot

SECTION 685 - TEMPORARY LIGHTING SYSTEM

685.01--Description. In addition to the requirements set forth in Section 681, a temporary lighting system shall consist of furnishing all materials, installing, erecting, constructing, and assembling same to ensure a properly operating temporary lighting system in accordance with the plans and specifications. The work shall also include all maintenance associated with the completed lighting system, provision of service and electrical power for this system during the duration of the required lighting period, adjustment and relocation during traffic control phases and removal of the system at the completion of the required lighting period.

685.01.1--General. The Contractor shall make provisions with the serving utility company for all construction necessary by the utility for power service. It will be required that initial fees be paid to the utility for installation of wiring, transformers, cutouts, etc., before utility construction can begin.

The Contractor shall be responsible for repairing all malfunctions in the system due to equipment failure, vandalism, accidents, etc., including all parts, labor, equipment and incidentals necessary to maintain the system. The Contractor shall also be responsible for all utility company costs for removal of the service upon completion of the project at no additional costs to the State.

The system shall be in fully operating condition during all hours of darkness for the duration of the required lighting period.

All electrical materials and operations for complete and operative systems shall be as follows and hereinbefore specified.

Lighting systems complete with fixtures, lamps, poles, switches, conduits, and wiring shall be provided.

The Contractor shall provide for power requirements and final electrical connections to all lighting systems, relocations required by traffic control phasing and removal of systems at completion of project.

685.01.2--Secondary Electrical Service. The temporary lighting service shall be 240-Volt, 1-phase, 3-wire, 60-hertz or as noted on the plans.

The Contractor shall pay all costs for electricity required by the lighting system during the duration of the project at no additional cost to the State.

The system shall be metered. Meter base shall be of a type approved by serving utility company. The Contractor shall pay all costs associated with system metering at no additional cost to the State.

685.01.3--Removal of Materials. Upon completion of the project in conjunction with removal of the temporary roadways and traffic control devices, the Contractor shall disconnect and remove the traffic control lighting system. All materials shall be the property of the Contractor.

The Contractor shall also be responsible for all costs incurred by the utility company for removal of utility company services.

685.02--Materials. Materials for temporary lighting systems shall meet the requirements of Subsection 723.09.

685.03--Construction Requirements. All component parts of the temporary traffic control lighting system shall be installed as shown on the plans and required by construction procedures.

685.04--Method of Measurement. Electrical cable of the type specified shall be measured by the linear foot. Measurement shall be computed horizontally from terminal to terminal along the circuits. No extra lengths will be measured for risers to lighting assemblies or any other terminals.

Temporary lighting assembly shall be measured as a unit quantity per each. Measurement shall include fixture, junction box, wiring, pole, ground rod, bracket, lamp and all other items necessary to complete the installation.

Service pole shall be measured per each. Measurement shall include pole, wiring, conduit, supporting devices, ground rod, hardware, safety switch, fuses, utility company service provisions, electrical power and all other items necessary to complete the installation.

685.05--Basis of Payment. Electrical cable, measured as prescribed above, will be paid for at the contract unit price per linear foot, which price shall be full compensation for furnishing, installing, connecting, testing, materials, supporting devices, final clean-up, all labor, equipment, tools, and incidentals necessary to complete the work and for removal of materials upon completion of project.

Temporary lighting assembly, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing all materials, for excavation, back-filling, replacing sod, for all construction, placing, erecting, installing,

connecting, testing, maintaining, junction boxes for poles, brackets, luminaires including lamps and ballast, ground rods, conduits, hardware, cable, for adjustments, replacement of equipment or material which malfunctions, for final cleaning up, for all equipment, labor, tools, and incidentals necessary to complete the work, and for removal of materials upon completion of project.

Service pole, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for furnishing all materials for all construction, placing, erecting, installing, connecting and testing, for utility company up/down costs, electrical power, pole, safety switch, wiring, fuses, conduit, ground rod, supporting devices, all hardware, for adjustments, replacement of defective equipment, for final clean-up, equipment, labor, tools and incidentals necessary to complete the work, and for removal upon completion of the project.

Payment will be made under:

685-A: Underground Electric Cable, <u>Type</u> , <u>AWG #</u> , <u>No. of Conductors</u>	- per linear foot
685-B: Aerially Supported Electric Cable, <u>Type</u> , <u>AWG #</u> , <u>No. of Conductors</u>	- per linear foot
685-C: Temporary Lighting Assembly, <u>Type</u>	- per each
685-D: Service Pole	- per each

SECTION 686 - RELOCATION OF EXISTING LIGHTING ASSEMBLIES

686.01--Description. In additional to the requirements set forth in Section 681, relocation of existing lighting assemblies of the types indicated on the plans shall consist of removing and relocating pole, luminaire, providing new foundation and miscellaneous hardware. Wiring shall be reworked or replaced as directed below and on the plans.

686.02--Materials. Generally, all the materials needed to relocate the lighting assembly(ies) will be existing materials. The lighting assemblies, wire and foundations may be either permanent or temporary. Wiring, ground rods, bolts and other items shall be relocated as per the plans. Additional items necessary for a complete working lighting assembly shall be required whether or not mentioned in these specifications.

686.02.1--Poles. Steel poles are hot-rolled weldable grade steel, galvanized in accordance with ASTM A 123, length as indicated on the plans. Since the anchor bolt layout may vary from pole to pole, the Contractor shall field verify bolt circles of existing lighting assemblies.

Timber poles, used on temporary lighting systems, shall conform to the applicable requirements of Section 685. Voids left by the removal of these poles shall be filled and compacted as directed by the Engineer.

686.02.2--Luminaire. Low mast luminaires are bracket arm mounted type, 250 or 400-watt, high pressure sodium. The Contractor shall verify luminaire lamp wattage that may

be stated on the plans. High mast luminaires are 1000-watt high pressure sodium.

The Contractor will be required to install new 250-watt, 400-watt or 1000-watt clear high pressure sodium lamps as indicated on the plans.

The fixtures shall be cleaned and refurbished before re-installing. Any inoperative ballast shall be replaced. The luminaire is to be in good working order when re-installed.

686.02.3--Pole Foundations. Pole foundations are cast-in-place concrete. The removal of the foundations shall be as detailed in other sections of the specifications.

New foundations shall be cast-in-place as per Section 684 or as per plans.

686.02.4--Anchor Bolts. The Contractor will be required to install new anchor bolts. Anchor bolts shall be galvanized as per ASTM A 123. The minimum yield strength of the anchor bolts shall be 50,000 psi. The new anchor bolts shall be of the same design as the existing bolts.

686.03--Construction Requirements. All component parts of the lighting assemblies shall be removed and relocated as shown on the plans and required by the new construction procedures. When an item is removed it shall be stored in a location approved by the Engineer. All items scheduled to be re-installed shall be safeguarded by the Contractor and shall be fully operational at the end of the project.

686.03.1--Branch Circuit Wiring. All existing wiring in place will be shown on the plans. The Contractor shall verify the type and size. For relocation and maintenance purposes, splicing of permanent wiring will not be permitted. New branch circuit wiring shall be provided as detailed on the plans.

Splices of permanent wiring are permitted in pole bases only. Temporary wiring may be spliced as needed. All wiring shall meet the requirements of the National Electrical Code (NEC).

The re-use of existing conductors and conduit when relocating permanent wiring will not be permitted. New conductors, conduit, boxes, connectors, etc. shall be provided as detailed on the plans. New wiring installation and materials shall be as per specified for underground branch circuit elsewhere in these specifications. Temporary wire may be re-used as long as it meets the requirements of the NEC.

686.03.2--Maintenance of Service. The existing lighting system shall be maintained and kept in operation during the duration of the project. The Contractor shall provide and install any and all materials required to keep the lighting system in operation through the duration of the contract. Existing disconnected underground circuit conductors shall be cut off 24 inches below grade and abandoned.

686.04--Method of Measurement. Relocation of existing lighting assembly will be measured as a unit quantity per each. Relocation of existing wiring will be measured per linear foot.

686.05--Basis of Payment. Relocation of existing lighting assembly, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be

full compensation for furnishing all new materials required, for excavation, backfill, sod replacement, construction, placing, reconnecting, and for testing; for all equipment, tools, labor, final clean up and incidentals necessary for completion of the work.

Relocation of existing wiring, measured as prescribed above, will be paid for at the contract unit price per linear foot, which price shall be full compensation for furnishing all material, for trenching, backfilling, disconnecting, reconnecting, replacing sod, for all construction, testing, installing, conductors, conduit, J-boxes, connectors, miscellaneous materials, for final clean-up, tools, labor, equipment and incidentals necessary for completion of the work.

Payment will be made under:

- 686-A: Relocation of Existing Lighting Assembly - per each
 686-B: Relocation of Existing Wiring - per linear foot

SECTION 699 - CONSTRUCTION STAKES

699.01--Description. This work consists of performing all calculations and other work necessary to establish and/or verify all horizontal and vertical control data; and furnishing, placing and maintaining roadway construction stakes or bridge construction stakes, or both, necessary for the proper prosecution of all features and items of the work under contract. This shall include, but not be limited to, grades and drainage structure locations, lengths, elevations and skews. When the contract includes a pay item for roadway construction stakes as provided herein, any references in other sections of the Standard Specifications to establishment of control points or construction staking "by the Department" shall be construed to mean "by the Contractor".

This work may be performed utilizing Automated Machine Guidance technologies and systems in accordance with the standard specifications and contract documents. Automated Machine Guidance (AMG) is defined as the utilization of positioning technologies such as Global Positioning Systems (GPS), Robotic Total Stations, lasers, and sonic systems to automatically guide and adjust construction equipment according to the intended design requirements. Global Positioning Systems (GPS) shall NOT be used for determining any points above the subgrade line. The Contractor may use any type of AMG system(s) that result in compliance with the contract documents and applicable Standard Specifications.

Automated Machine Guidance (AMG) is not a mandatory requirement. Automated Machine Guidance (AMG), conventional staking, or a combination of both may be used at the Contractor's option for staking on this project.

699.02--Materials. The Contractor shall furnish all personnel, materials, equipment and devices necessary for determining, establishing, setting, checking and maintaining points, lines, grades and layout of the work. All surveying equipment shall be properly adjusted and suited for performing the work required. Traffic control necessary for the proper execution of the work shall be furnished by the Contractor without separate measurement for payment. Stakes shall be of sufficient length, thickness and quality to serve the purpose for which they are being used.

All equipment required to accomplish automated machine guidance shall be provided by the Contractor. The Contractor may use any type of AMG equipment that achieves compliance with the contract documents and applicable Standard Specifications.

The Contractor shall provide the Department with an acceptable portable grade-verification device (Rover) to be used by the Department during the duration of the contract. On large projects with high production rates, the Contractor may be required to provide more than one device. At the end of the contract, the device will be returned to the Contractor. This device shall have the same capabilities as the unit used by the Contractor.

699.03--Construction Requirements.

699.03.1--General. The Department will establish, one time only, secondary control points with elevations at distances not to exceed 1500 feet or that minimum distance necessary to maintain inter-visibility. For bridge work, the Engineer's field control will consist of a stationed baseline reference point near each end of the bridge(s) and one accessible bench mark near each bridge site. For the purpose of determining responsibility for construction stakes, lines and grades, a box bridge will not be considered as a bridge. The Contractor shall verify the accuracy of the control points before proceeding with the layout for construction.

When errors are discovered and control points do not agree with the plans, the Contractor shall promptly notify the Engineer in writing, and explain the problem in detail. The Engineer will advise the Contractor within five (5) working days of any corrective actions that may be deemed necessary.

The Contractor will be responsible for verifying and modifying, as necessary to best fit existing field conditions, lengths, locations, elevations and skew angles of all drainage structures shown on the construction plans. All junction box and inlet locations and heights shall also be verified and modified as necessary to fit existing field conditions. Modifications to the plans shall not be made without the consent of the Project Engineer. The Contractor will not be responsible for determining the size of drainage structures, but should immediately report any suspected error to the Engineer. Heights of fill over drainage structures shall be checked to verify class of pipe, bedding and the appropriate standard and/or modified standard drawing(s) required in the construction with any differences from the plans being reported to the Engineer.

The Contractor shall perform work necessary to verify alignment and plan grades on all roadway intersections and tie-ins. Any discrepancies in grades, alignment, location and or dimension detected by the Contractor shall immediately be brought to the attention of the Project Engineer.

The Contractor shall employ sufficient qualified personnel experienced in highway surveying and layout to complete the work accurately. The Contractor shall also determine and provide all additional grade controls and staking operations necessary to secure a correct layout and construction of the work. All minor variations in layout and grades required to meet field conditions shall be resolved with the Engineer and shall not be considered justification for adjusting contract price or time.

Examples of minor variations in layout and grades are:

- (a) Adjustment of drainage or other structure length, alignment, and flow line elevation.
- (b) The adjustment of grades and alignment at roadway intersections, cross-overs, railroad crossings, interchanges, existing bridges and roadways.
- (c) Adjustment of curve data.

The Contractor will be responsible for calculating and laying out all additional lines, grades, elevations and dimensions necessary to construct the work required in the plans. All grades and other layout data computed by the Contractor shall be recorded and a copy of this data shall be furnished, with sufficient time for checking, to the Engineer before field work is started. The originals of all data shall be furnished to the Engineer on or before final inspection for the Department's permanent file. The Contractor shall also furnish personnel to assist the Engineer in taking tolerance verification checks or other notes to determine whether specified tolerances are met. Any inspection or checking of the Contractor's layout by the Engineer and the approval of all or any part of it will not relieve the Contractor of the responsibility to secure proper dimensions, grades, and elevations of the several parts of the work.

Prior to beginning construction on any structure that references to an existing structure or topographical feature, the Contractor shall check the pertinent location and grades of the existing structures or topographical features to determine whether the location and grade shown on the plans are correct.

The Contractor shall stake centerline control at each station, BOP, EOP, PC, PT, SC, CS, TS, ST, and equations just before field cross sectioning by the Department for both original and final cross sections.

The Contractor shall furnish "as built" finish centerline elevations to the Project Engineer prior to final inspection of the project.

The Contractor shall set stakes and/or flags on the right-of-way line at each station and right-of-way break or as directed by the Engineer before clearing operations are started on any section of roadway.

Regardless of the method used, the Contractor shall meet the surface tolerances addressed in Section 321.

The Contractor shall exercise care in the preservation of stakes and bench marks and shall reset them when they are damaged, lost, displaced or removed. The Contractor shall use competent personnel and suitable equipment for the layout work required and shall provide that it be performed under the supervision of, or directed by, a Registered Professional Engineer or Registered Land Surveyor who is duly registered and entitled to practice as a Professional Engineer or Professional Land Surveyor in the State of Mississippi. The duties performed by said Registrant shall conform to the definitions under the "practice of engineering" and practice of "land surveying" in Mississippi Law and the latest edition of the MDOT Survey Manual. The MDOT Survey Manual can be obtained online at the following address.

<http://sp.mdot.ms.gov/RoadwayDesign/Pages/MDOT-Survey-Manual.aspx>

The Contractor shall not engage the services of any person in the employ of the Department for the performance of any of the work covered by this Section or any person who has been employed by the Department within the past six months except those who have legitimately retired from service with the Department during this period.

All cross sections, measurements, and tickets required for determining pay quantities will be the responsibility of the Department.

The Department reserves the right to check any or all of the Contractor's layout work for accuracy and shall be assisted by the Contractor's personnel in such checking. When errors or discrepancies are found, the Contractor will take measures necessary to correct, at no expense to the State, any construction that has been performed using the improper layout. Any inspection, checking and approval thereof by the Engineer of work for which the Contractor is responsible will not relieve the Contractor of responsibility to secure correct dimensions, grades, elevations, alignments and locations of the work for satisfactory completion of the project and as a condition for final acceptance by the Department.

699.03.2--Conventional Staking. In addition to the requirements set forth in Subsection 699.03.1, the following shall be required when using the conventional staking method.

On grading projects, the Contractor shall set slope stakes at each station and at the beginning and end of spirals and curves. Closer intervals will be required for sharp changes in grades or alignment, widening and certain other geometric details.

The Contractor shall set subgrade blue tops on centerline, break points and at the left and right subgrade shoulder lines at intervals of not more than 100 feet on tangents and intervals of not more than 50 feet in curves. Closer intervals will be required for sharp changes in grades or alignment, widening, or super elevation.

The Contractor shall furnish personnel to assist the Engineer in taking stringline and other notes to determine whether specified tolerances are met.

On paving contracts, the Contractor shall set subgrade, base and paving blue tops. The base and pavement grade stakes shall be set on intervals in accordance with the applicable requirements of Sections 321, 403 and 501.

699.03.3--Automated Machine Guidance. In addition to the requirements set forth in Subsection 699.03.1, the following shall be required when using the automated machine grading method.

699.03.3.1--Automated Machine Guidance Work Plan. The Contractor shall submit a comprehensive written Automated Machine Guidance Work Plan to the Engineer for review at least 30 days prior to use. The Project Engineer will have to concur with the Plan prior to the Contractor performing any AMG work. The submittal of an AMG Work Plan shall be an indication of the Contractor's intention to utilize AMG instead of conventional methods on the project areas and elements stated in the Work Plan. The Engineer shall review the AMG Work Plan to ensure that the requirements of this specification are addressed. The Contractor shall assume total responsibility for the performance of the system utilized in the Work Plan. Any update or alteration of the AMG Work Plan in the course of the work shall be approved and submitted to the Department for determination of conformance with requirements of this specification.

The AMG Work Plan shall describe how the AMG technology will be integrated into other technologies employed on the project. This shall include, but not limited to, the following:

1. A description of the manufacturer, model, and software version of the AMG equipment.
2. Information on the Contractor's experience in the use of AMG system (or Related Technologies) to be used on the project, including formal training and field experience of project staff.
3. A single onsite staff person as the primary contact, and up to one alternate contact person for AMG technology issues.
4. A definition of the project boundaries and scope of work to be accomplished with the AMG system.
5. A description of how the project proposed secondary control(s) is to be established. It shall also include a list and map detailing control points enveloping the site.
6. A description of site calibration procedures including, but not limited to, equipment calibration and the frequency of calibration as well as how the equipment calibration and information will be documented to the Department and the Project Engineer. The documentation shall contain a complete record of when and where the tests were performed and the status of each equipment item tested within or out of the ranges of required tolerances.
7. A description of the Contractor's quality control procedures for checking mechanical calibration and maintenance of equipment. It shall also include the frequency and type of checks to be performed.
8. A description of the method and frequency of field verification checks and the submission schedule of results to the Project Engineer.
9. A description of the Contractor's contingency plan in the event of failure/outage of the AMG system.
10. A schedule of Digital Terrain Models (DTM) intended for use on the project. This shall be submitted to the Engineer for review, feedback, and communication.

699.03.3.2--State's Responsibilities. The District Surveyor will set the primary horizontal and vertical control points in the field for the project as per the latest edition of the Department Survey Manual. The control points shall be in the Mississippi State Plane coordinate system.

The Department will provide an electronic alignment file and primary control file for the project. This file will be based on the appropriate Mississippi State Plane Coordinate Zone either West or East. These files will be created with the computer software applications MicroStation (CADD software) and GEOPAK (civil engineering software). The data files will be provided in the native formats. The Contractor shall perform necessary conversion of the files for their selected grade control equipment, field verify the data for accuracy, and immediately report any errors to the Department.

The Department will provide design data, if available, in an electronic format to the Contractor. These files will be created with the computer software applications MicroStation (CADD software) and GEOPAK (civil engineering software). The data files will be provided in the native formats as specified in the Data Format section of this specification. No guarantee is made to the data accuracy or completeness, or that the data systems used by the Department will be directly compatible with the systems used by the Contractor. Information shown on the plans marked with the seal (official plans as

advertised) shall govern.

The Engineer will perform spot checks as necessary of the Contractor's machine control grading results, surveying calculations, records, field procedures, and actual staking. If the Engineer determines that the work is not being performed in accordance with the Specifications, the Engineer shall order the Contractor to re-construct the work to the requirements of the contract documents at no additional cost to the Department.

699.03.3.3--Contractor's Responsibilities. The Contractor shall provide formal training, as requested, on the use of the AMG Equipment, including Rover, and the Contractor's systems to the Department project personnel prior to the start of construction activities utilizing AMG. This training is for providing the Department project personnel with an understanding of the equipment, software, and electronic data being used by the Contractor.

The Contractor shall use the alignment and control data provided by the Department.

The Contractor shall bear all costs, including but not limited to the cost of actual reconstruction work that may be incurred due to errors in application of Automated Machine Guidance techniques or manipulation of the Department design data in Digital Terrain Models (DTM). The Contractor shall also bear all costs associated with any graphical grading outside the model / typical section, such as tying to existing grades at the beginning or end of a project.

The Contractor shall be responsible for converting the information on the plans and/or electronic data file provided by the Department into a format compatible with the Contractor's AMG system.

The Contractor shall establish secondary control points at locations along the length of the project and outside the project limits and/or where work is performed beyond the project limits as required by the AMG system utilized. The Contractor shall establish this secondary control using survey procedures as outlined in the latest edition of the MDOT Survey Manual. A copy of all new control point information shall be provided to the Engineer prior to construction activities. The Contractor shall be responsible for all errors resulting from their efforts and shall correct deficiencies to the satisfaction of the Engineer and at no additional cost to the State.

The Contractor shall preserve all reference points and monuments that are established by the District Surveyor outside the construction limits. If the Contractor fails to preserve these items, they shall be re-established by the Contractor to their original quality at no additional cost to the State.

The Contractor shall set grade stakes at the top of the finished sub-grade and base course at all hinge points on the typical sections at 1000-foot maximum intervals on mainline, critical points such as, but not limited to, PC's, PT's, beginning and ending super elevation transition sections, middle of the curve, and at least two locations on each of the side roads and ramps, and at the beginning and end of each cross slope transition where Automated Machine Guidance is used. These grade stakes shall be established using conventional survey methods for use by the Engineer to check the accuracy of the construction.

On projects with grading, the Contractor shall set slope stakes and centerline stationing every 500 feet and at the beginning and end of spirals and curves. Closer intervals will be

required for sharp changes in grades or alignment, widening and certain other geometric details.

On projects with paving, the staking requirements addressed in Sections 403 and 501 will not apply. The Contractor shall furnish an acceptable portable grade-verification device(s) (Rover) to verify grade tolerances.

The Contractor will be required to set 20 grade points (hubs) per mile at locations determined by the Engineer for field verification. If tolerances are not met, additional grade points may be required by the Engineer.

The Contractor shall furnish personnel to assist the Engineer in taking tolerance verification checks as necessary to determine whether specified tolerances are met.

The Contractor shall meet the same accuracy requirements as detailed in the Standard Specifications.

The Contractor shall be responsible for implementing the AMG system using the Mississippi State Plane Coordinate System. No localization methods will be accepted.

699.03.3.4--Data Format. It is the Contractor's responsibility to produce the Digital Terrain Model(s) and/or 3D line work needed for AMG. The Department does not produce this data in its design process. The Department does provide CADD files created in the design process to the Contractor. The CADD files provided by the Department are provided in the native software application formats in which they are created with no conversions, and their use in developing 3D data for machine guidance is at the discretion of the Contractor. The CADD files that may be available are listed below. Cross-Sections are one of the items provided but are not necessarily created at critical design locations. Therefore their use in Digital Terrain Models (DTM) for AMG is limited.

1. Project Control - Microstation DGN file and ASCII file
2. Existing Topographic Data - Microstation DGN file(s)
3. Preliminary Surveyed Ground Surface - GeoPak TIN, if available
4. Horizontal and Vertical alignment information - GeoPak GPK file and/or Microstation DGN file(s)
5. 2D Design line work (edge of pavement, shoulder, etc.) - Microstation DGN file(s)
6. Cross sections - Microstation DGN file(s), GeoPak format
7. Superelevation - Microstation DGN file(s), GeoPak format
8. Form Grades - Microstation DGN file(s)
9. Design Drainage - Microstation DGN file(s)

It is expressly understood and agreed that the Department assumes no responsibility in respect to the sufficiency or accuracy of these CADD files. These files are provided for convenience only and the plans constitute the legal document for constructing the project.

699.04--Method of Measurement. Construction stakes will be measured as a lump sum quantity. When Pay Item No. 699-A, Roadway Construction Stakes, is provided in the contract, measurement shall include the staking of all bridges, including detour bridges, which are a part of the contract.

699.04.1--Roadway Construction Stakes. Roadway Construction Stakes will be

measured for payment in accordance with the following schedule:

- (a) When one percent of the original contract amount is earned from all direct pay items, 10 percent of the amount bid for Roadway Construction Stakes will be paid.
- (b) When five percent of the original contract amount is earned from all direct pay items, 25 percent of the amount bid for Roadway Construction Stakes will be paid.
- (c) When 20 percent of the original contract amount is earned from all direct pay items, 50 percent of the amount bid for Roadway Construction Stakes will be paid.
- (d) After the Contractor has earned 50 percent of the original value of all direct pay items, the amount paid will be based on the contract percent complete.

699.04.2--Bridge Construction Stakes. Bridge Construction Stakes will be measured for payment in accordance with the following schedule:

- (a) When one percent of the original contract value of all bridge items is earned, 10 percent of the amount bid for Bridge Construction Stakes will be paid.
- (b) When five percent of the original contract value of all bridge items is earned, 25 percent of the amount bid for Bridge Construction Stakes will be paid.
- (c) When 20 percent of the original contract value of all bridge items is earned, 50 percent of the amount bid for Bridge Construction Stakes will be paid.
- (d) After the Contractor has earned 50 percent of original contract value of all bridge items, the amount paid will be based on the percentage of work completed on all bridge items.

699.05--Basis of Payment. Construction stakes, measured as prescribed above, will be paid for at the contract lump sum price, which shall be full compensation for completing the work.

Payment will be made under:

- | | |
|------------------------------------|------------|
| 699-A: Roadway Construction Stakes | - lump sum |
| 699-B: Bridge Construction Stakes | - lump sum |

DIVISION 700 - MATERIALS AND TESTS

700.01--General. Materials will be inspected and sampled in accordance with current Department SOP pertaining to inspecting and sampling.

Unless otherwise provided, all materials furnished that are to remain in place after final acceptance shall be new and unused before incorporation into the work, except that crushed reclaimed concrete pavement meeting the requirements of Section 703, as amended, may be used to produce aggregate for all asphalt pavements. When allowed by the specifications, Recycled Asphalt Pavement (RAP) may be used in the manufacture of asphalt pavements. Other recycled products approved for use by the Department may be incorporated in the work.

The Contractor shall maintain sufficient approved materials on hand so that delays to the work will not result from the necessary sampling, testing, and evaluation of test results.

Domestic steel, iron and wire products including prestressing cable and strand shall be furnished for incorporation in the work. All manufacturing processes, including application of a coating, for these materials must occur domestically. However, pig iron and processed, pelletized, and reduced iron ore manufactured outside of the United States may be used in the domestic manufacturing process for steel and/or iron products. For the purpose of this specification, the activity of coating is considered a manufacturing process. The material being applied as a coating is not covered under Buy America. Coating includes all processes that protect or enhance the value of the material to which the coating is applied, such as epoxy coatings, galvanizing, painting, etc.

Domestic shall be understood to mean all States of the United States, District of Columbia, Puerto Rico, American Samoa, Guam, the Virgin Islands and any other place subject to the jurisdiction of the United States.

In the case of coatings for the above referenced domestic steel, iron and wire products, it shall be the Contractor's responsibility to forward to the State Materials Engineer a certified statement from those having applied a coating to these materials that the application of the coating occurred domestically.

It shall be the Contractor's responsibility to forward to the State Materials Engineer, with copies to the Project Engineer, such certification from the manufacturer, or at the election of the State Materials Engineer, such certification may be accepted directly from a manufacturer annually, or as otherwise requested by the State Materials Engineer.

700.02--Glossary of Terms and Definitions.

Aggregate - Inert material such as sand, gravel, lightweight aggregates, broken stone, slag, shell, or combinations thereof.

Approved Products List (APL) – The Materials Division maintains a list of approved products that have completed the source approval process and in compliance with these standards.

Argillaceous - Containing or consisting of clay.

Asphaltic Cement - A product of the refining of crude oil to form a residue that is used usually without the addition of more than a small quantity of flux or any liquefying agent of a higher volatile material than the residue itself.

Calcareous Material - A material containing more than 50 percent calcium type material.

Cementitious Material - Portland cement, masonry cement, blended hydraulic cement, and/or pozzolan material used as the bonding agent in hydraulic cement concrete. Cementitious shall mean "as having cementing properties". Supplementary cementitious materials (SCM) also include Class C fly ash, Class F fly ash, silica fume, and ground granulated blast furnace slag (GGBFS).

Clay - The fraction part of a soil finer than 0.002 mm that is more or less plastic when wet.

Compaction - The process of obtaining the density of a soil or material.

Crusher Run - The product of a crushing plant that has not been rescreened or separated into various sizes.

Cutback Asphalt - An asphaltic material obtained from the refining of petroleum by adding to or fluxing the residue from distillation with volatile petroleum fractions to produce a uniform mixture capable of becoming quite fluid at relatively low temperatures.

Fineness Modulus - An empirical factor obtained by adding the total percentages of aggregate retained on the Nos. 100, 50, 30, 16, 8, 4, 3/8", 3/4", 1 1/2", and 3" sieves and dividing the sum by 100.

Frame - The part of the work or materials for which the same quality characteristics are specified, such as a base course, an aggregate stockpile, a hot bituminous pavement course, etc.

Gravel - The granular, pebbly material, usually retained on a No. 8 sieve, resulting from the natural disintegration of rock.

Hydraulic Cement Concrete - A concrete mixture composed of cementitious materials, water, fine aggregate, coarse aggregate, air, and possibly admixture(s) and fibers.

Increment - The smallest unit(s) set aside for the sampling and testing process.

Loess - Wind-blown, yellowish-brown loam having little or no stratification.

Lot - A subdivision of a frame, representing a designated quantity of work or materials, and is the unit of such work or materials which will be accepted or rejected.

Liquid Limit (LL) - The water content, expressed in percentage by weight of the oven-dried soil, at which the soil passes from a plastic to a liquid state when subjected to a standard method of determining liquid limit of soils.

Mechanical Analysis - The determination of the size and grading of soil particles by standard tests.

New Source Approval – The material is required to go through the product approval process and be tested and approved by the Department.

Optimum Moisture - The moisture content necessary to obtain the standard density of a soil.

Overburden - Refers to soil or similar material directly above a deposit of rock, sand, gravel, or select material.

Pea Gravel - That portion of uncrushed gravel passing a 3/8 inch sieve and retained on a No. 8 sieve.

Plastic Limit (PL) - The water content, expressed in percentage by weight of the oven-dried soil, at which a soil passes from a solid or semi-solid state to a plastic state when subjected to a standard method of determining plastic limit of soils.

Plasticity Index (PI) - The range of water content through which the soil remains in a plastic condition. This term is the numerical difference between the liquid limit and plastic limit and is a measure of cohesion.

Portland Cement Concrete - A concrete mixture composed of cementitious materials, portland cement, water, fine aggregate, coarse aggregate, air, and possibly admixture(s).

Sample - The portion taken from a lot and considered to represent the whole or a designated portion of the lot. It may consist of one or more increments or a fractional part of one or more combined increments.

Sand - A fine granular material resulting from the natural or mechanical disintegration of rock. Depending on its use, material may be classed as sand if it passes the 3/8 inch, No. 4 or No. 10 sieve. Sand is synonymous with fine aggregate.

Sand Clay - A mixture of sand and clay often found blended so that their opposite qualities tend to maintain a condition of stability under varying moisture contents.

Screenings - Broken rock, limestone, slag, or other material, including the dust, of a size that will pass a 1/2 inch sieve.

Selected Material - Material from State-furnished or optioned sources, for use in bases, or for other specified use.

Shale - A fissile rock formed by the consolidation of clay, mud, or silt having a finely stratified or laminated structure.

Shrinkage Limit (SL) - The maximum calculated water content of a soil at which a reduction in water content will not cause a decrease in the volume of the soil mass.

Sieves - Sieves for testing purposes conforming to the requirements of the Standard Specifications for Sieves for Testing Purposes of the AASHTO M 92.

Silt - The finer particles of organic or rock substance, ranging in size from 0.074 mm to 0.002 mm.

Slag - The nonmetallic product thrown off from molten ore or metal or other processes and used as fine or coarse aggregate.

Soil - A natural aggregate of mineral grains, with or without organic constituents, which can be separated by gentle mechanical means such as agitation in water.

Spall - A relatively small piece or fragment broken from rock, concrete, or other material.

Specific Gravity - The ratio of the weight of a volume of some substance to the weight of an equal volume of substance, usually water, taken as a standard or unit.

Standard Density (Standard Compaction) - The maximum dry unit weight in pounds per cubic foot obtained by the compactive effort exerted under the applicable test designation as provided in Subsection 700.03.

Sublot - The smallest unit(s) set aside from a lot for the sampling and testing process.

Test Portion - The actual quantity of material tested that may be, in some instances, the whole of the sample or, in other instances, only a quartered or other portion of the sample.

Test Result - The value of the specified characteristic obtained from testing a single test portion.

Test Value - The value determined as being the test result when only one test is required to satisfy a specified condition, or the average of the test results on two or more test portions of a lot, or a designated portion thereof.

Volume Change (VC) - The decrease in volume of the soil mass when the water content is reduced from a given percentage to the shrinkage limit.

Water-Cement Ratio - The ratio of the weight of water used, including free moisture in the aggregate, to the weight of cementitious material.

Other Definitions - Other applicable definitions as prepared by the Special Committee on Nomenclature and adopted by AASHTO.

700.03--Sampling and Testing. Sampling and testing for acceptance and control of materials may be performed at any time prior to incorporation in the work. Sampling and testing for control and acceptance of a work item will be performed progressively as sections of the work item are being constructed or completed, as applicable.

Unless otherwise designated, all tests will be made in accordance with applicable standard methods of AASHTO, ASTM, Federal Specifications, or approved Mississippi Test Methods (MT-_____) in effect on the date of advertisement for bids. Note: It is contemplated that certain methods of testing will be developed by the Department. These will generally consist of minor revisions of AASHTO or ASTM Methods and will be designed to more nearly fit local conditions. Such methods are designated MT-_____. As such methods are developed, approved, and issued, they will be used as standards in field testing or in the Central Laboratory, as designated in the method, on projects advertised subsequent to their approval and issuance.

Material requiring specified tests used by a plant for producing composite material(s) or product(s) to be used in the work will be tested and approved by the Engineer. If such materials, composite materials, or products are stored separately for the exclusive use in the work, the cost of testing will be borne by the Department. If such materials, composite materials or products are not stored separately for the exclusive use in the work, the cost of testing shall be borne as set out in the Department's issued SOP in effect at the time bids are received.

700.04--Determination of Conformity. The determination of conformity with each required measurable characteristic under the intent of Subsection 105.03 will be made in accordance with the following:

All test values or test results used to determine compliance will be rounded off to the nearest decimal point as expressed in the specifications for the particular characteristic under consideration. Fractions beyond the point of rounding amounting to less than 0.50 will be dropped. Similar fractions amounting to more than 0.50 will be rounded off by increasing the last digit within the rounding. Similar fractions amounting to even 0.50 will be rounded toward the specifications by dropping or by increasing the last digit within the rounding, as applicable.

The various frames of materials or work will be divided into lots as specified in the contract or conforming to the Department's SOP for frequency of sampling and testing.

In the case of borderline quality products or a demonstrated trend toward borderline quality products, the Engineer will require the Contractor to improve the quality of the materials or work to more nearly conform to the specifications and may require a suspension of the operations that have resulted in the borderline product or the trend toward borderline quality until such corrective measures have been taken as deemed necessary to produce the contemplated quality products.

All increments of tests for determination of acceptance will be taken by random sampling. However, during or as a result of visual inspection, the Engineer will take increments for testing for progress checks or spot checks at any time and place the Engineer may deem necessary to determine weak spots or other progress information. The results of any such progress or spot checks may be used to determine whether or not additional work or corrective action is considered necessary prior to acceptance testing.

Minimum and maximum requirements in these specifications are set out on the basis that the desirable average test value of the materials or work is appreciably above the minimum requirement or appreciably below the maximum requirement established.

700.05--Material Certifications and Certified Test Reports. All certifications and certified test reports shall meet the requirements set forth herein; however, certification requirements for cement and asphalt are set out separately in the Department's *Materials Division Inspection, Testing, and Certification Manual* and Department SOPs.

700.05.1--Certifications. All certifications shall:

- (a) Have letterhead of the manufacturer, producer, supplier, or fabricator.
- (b) Include the project number.

- (c) Itemized list of materials covered by the certification.
- (d) Contain a material conformance statement that certifies that the materials conform to the specific specification. Example: I/We hereby certify the materials listed herein conform to the requirements of Subsection 714.11 of the Mississippi Standard Specifications for Road and Bridge Construction.
- (e) Certification for all iron, steel and steel wire products must also include a certified statement by the manufacturer that all of the manufacturing processes, excluding those for pig iron and processed, pelletized, and reduced iron ore used in the manufacture of said steel and/or iron products, have occurred domestically.
- (f) Signature of a responsible company official.

700.05.2--Certified Test Reports. All certified test reports shall:

- (a) Have letterhead of the manufacturer, producer, supplier, fabricator, or laboratory.
- (b) Include name and description of material, lot, batch or heat number, etc., as applicable.
- (c) Show results of each required test, and state that the test was run according to the test method specified.
- (d) Test reports for all iron, steel and steel wire products must also include a certified statement by the manufacturer that all of the manufacturing processes, excluding those for pig iron and processed, pelletized, and reduced iron ore used in the manufacture of said steel and/or iron products, have occurred domestically.
- (e) Signature of the responsible laboratory official.

SECTION 701 - HYDRAULIC CEMENT

701.01--General. The following requirements shall be applicable to hydraulic cement:

Only hydraulic cements conforming to Section 701 shall be used. Hydraulic cements shall not be listed or designated as meeting more than one AASHTO or Department type.

Different brands of hydraulic cement, or the same brand of hydraulic cement from different mills, shall not be mixed or used alternately in any one class of construction or structure, without written permission from the Engineer; except that this requirement will not be applicable to hydraulic cement treatment of design soils, or bases.

The Contractor shall provide suitable means for storing and protecting the hydraulic cement against dampness. Hydraulic cement that has, for any reason, become partially set or that contains lumps of caked hydraulic cement will be rejected. Hydraulic cement salvaged from discarded or used bags shall not be used.

The temperature of bulk hydraulic cement shall not be greater than 165°F at the time of incorporation in the mix.

Acceptance of hydraulic cement will be based on the certification program as described in the Department's *Materials Division Inspection, Testing, and Certification Manual* and job control sampling and testing as established by Department SOP.

Retests of hydraulic cement may be made for soundness and expansion within 28 days of test failure and, if the hydraulic cement passes, it may be accepted. Hydraulic cement shall

not be rejected due to failure to meet the fineness requirements if, upon retests after drying at 212°F for one hour, it meets such requirements.

701.02--Portland Cement.

701.02.1--General.

701.02.1.1--Types of Portland Cement. Portland cement shall be either Type I or Type II conforming to AASHTO M85. Type III cement conforming to AASHTO M85 or Type III (MS), as defined by the description below in Table 1, may be used for the production of precast or precast-prestressed concrete members.

701.02.1.2--Alkali Content. All cement types in this Subsection shall meet the Equivalent alkali content requirement for low-alkali cements listed in AASHTO M85, Table 2.

701.02.2--Replacement by Other Cementitious Materials. The allowable replacement of cement by weight is 20-25% for fly ash or 45-50% for ground granulated blast furnace slag (GGBFS). Replacement contents below the minimum tolerance of fly ash or GGBFS may be used, but shall not be given any special considerations, such as the maximum acceptance temperature for portland cement concrete containing pozzolans in Subsection 804.02.13.1.5. Special considerations shall only apply for replacement of cement by fly ash or GGBFS.

701.02.2.1--Portland Cement Concrete Exposed to Soluble Sulfate Conditions or Seawater. When portland cement concrete is exposed to moderate or severe soluble sulfate conditions, or to seawater, cement types and replacement of cement by Class F fly ash, GGBFS, or silica fume shall be as follows in Table 1.

Table 1- Cementitious Materials for Soluble Sulfate Conditions or Seawater

Sulfate Exposure	Water-soluble sulfate (SO ₄) in soil, % by mass	Sulfate (SO ₄) in water, ppm	Cementitious material required
Moderate and Seawater	0.10 - 0.20	150 - 1,500	Type II * cement, or Type I cement with one of the following replacements of cement by weight: 24.5-25% Class F fly ash, or 49.5-50% GGBFS
Severe	0.20 - 2.00	1,500 - 10,000	Type I cement with a replacement by weight of 49.5-50% GGBFS, or Type II cement with one of the following replacements of cement by weight: 24.5-25% Class F fly ash, 49.5-50% GGBFS

- * Type III cement conforming to AASHTO M85 with a maximum 8% tricalcium aluminate (C₃A) may be used in lieu of Type II cement as allowed in Subsection 701.02.1; this cement is given the designation “Type III(MS).”

Class C fly ash shall not be used as a replacement for cement in any of the sulfate exposure conditions listed above.

701.02.2.2--Hydraulic Cement for Soil Stabilization Exposed to Soluble Sulfate Conditions or Seawater. When hydraulic cement for use in soil stabilization is exposed to moderate or severe soluble sulfate conditions, or to seawater, cement types and replacement of cement by Class F fly ash or GGBFS shall meet the requirements of Subsection 701.02.2.1. Silica fume shall not be used to bring the cementitious materials into compliance with the requirements of Table 1.

701.03--Masonry Cement. Masonry cement shall conform to ASTM C 91 and shall only be used in masonry applications.

701.04--Blended Hydraulic Cement.

701.04.1--General.

701.04.1.1--Types of Blended Cement. Blended hydraulic cements shall be of the following types and conform to AASHTO M 240:

- Type IS – Portland blast-furnace slag cement
- Type IP – Portland-pozzolan cement
- Type IL – Portland-limestone cement

Blended cement Types IS, IP, and IL for use in hydraulic cement concrete or soil stabilization exposed to the moderate soluble sulfate condition or exposure to seawater as defined in Table 2 shall meet the sulfate resistance requirement listed in AASHTO M 240, Table 4 and the “(MS)” suffix shall be added to the type designation. Type IL cement may be used for soil cement stabilization.

701.04.1.2--Alkali Content. All blended hydraulic cement shall be made with clinker that would result in cement meeting the requirements of Subsection 701.02.1.2 when used in the production of AASHTO M 85, Type I or Type II cement.

701.04.2--Replacement by Other Cementitious Materials. The allowable replacement of blended cement Type IL by weight is 35% for fly ash or 45-50% for GGBFS. Replacement contents below 20% for fly ash or 45% for GGBFS may be used, but shall not be given any special considerations, such as the maximum acceptance temperature for blended hydraulic cement concrete containing pozzolans in Subsection 804.02.13.1.5. Special considerations shall only apply for replacement of blended cement by fly ash or GGBFS. No additional cementitious materials, such as hydraulic cement, blended hydraulic cement, fly ash, GGBFS, or others, shall be added to or as a replacement for blended cement Types IS and IP.

701.04.2.1--Blended Hydraulic Cement Concrete Exposed to Soluble Sulfate Conditions or Seawater. When blended hydraulic cement concrete is exposed to moderate or severe soluble sulfate conditions, or to seawater, cement types and

replacement of cement by Class F fly ash, GGBFS, or silica fume shall be as follows in Table 2.

Table 2- Cementitious Materials for Soluble Sulfate Conditions or Seawater

Sulfate Exposure	Water-soluble sulfate (SO ₄) in soil, % by mass	Sulfate (SO ₄) in water, ppm	Cementitious material required
Moderate and Seawater	0.10 - 0.20	150 - 1,500	Type IL cement with one of the following replacements of cement by weight: 24.5-35% Class F fly ash, 49.5-50% GGBFS, or 7.5-8% silica fume
Severe	0.20 - 2.00	1,500 - 10,000	Type IL cement with following replacement of cement by weight of 49.5-50% GGBFS

Class C fly ash shall not be used as a replacement for cement in any of the sulfate exposure conditions listed above. Type IS and IP blended cements shall not be used in sulfate conditions.

701.04.2.2--Hydraulic Blended Cement for Soil Stabilization Exposed to Soluble Sulfate Conditions or Seawater. When hydraulic blended cement for use in soil stabilization is exposed to moderate or severe soluble sulfate conditions, or to seawater, cement types and replacement of cement by Class F fly ash or GGBFS shall meet the requirements of Subsection 701.04.2.1. Silica fume may be used to bring the cementitious materials into compliance with the requirements of Table 2.

701.04.3--Exposure to Soluble Sulfate Conditions or Seawater. When blended hydraulic cement for soil stabilization is exposed to moderate soluble sulfate conditions or to seawater, where the moderate soluble sulfate condition is defined in Table 2, the blended cement shall meet the sulfate resistance requirement listed in AASHTO M 240.

When hydraulic cement concrete or blended cement for soil stabilization is exposed to severe soluble sulfate conditions, where the severe soluble sulfate condition is defined in Table 2, Types IP and IS blended cements shall not be used.

SECTION 702 - BITUMINOUS MATERIALS

702.01--General. Bituminous materials shall include asphalt cement, cutback asphalt, or emulsified asphalt and shall meet the requirements of the applicable specifications. The material furnished for any item in any one contract shall be of one brand, type, and grade, unless special permission is obtained otherwise. Materials furnished shall exhibit uniform characteristics.

When more than one grade of material is called for under any item, the Engineer will select the grade to be used.

All sampling and reporting of bituminous materials shall be performed as set out in the

Department's SOPs. All testing shall be performed in accordance with applicable AASHTO methods unless specifically modified by a Mississippi Test Method (MT-_____).

Bituminous material shall not be heated to a temperature that causes injury as evidenced by the formation of carbonized particles.

702.02--Measurement. Volumetric measurement of bituminous materials by the U.S. gallon will be based upon a temperature of 60°F. Corrections to this temperature for asphalt cement, cutback asphalts and emulsified asphalt will be made in accordance with the Temperature Correction Tables set out in the *Material's Division Inspection, Testing, and Certification Manual*.

For purposes of measurement, a U.S. gallon shall be a volume of 231 cubic inches.

When bituminous material is to be paid for by the gallon, the distributor tank(s) or storage tank(s), as applicable, to be used for measurement shall be calibrated by an agency and in a manner approved by the Department. A calibration chart, showing the dimensions and volume per inch of depth, and a measuring gauge, calibrated in inches, shall be furnished to the Engineer. Each tank shall have an identifying serial number on a steel plate welded or riveted to the tank. In the event the Contractor does not have such calibration chart, previously made by an approved agency, the Department will, upon request, perform the calibration and furnish required charts; however, the Contractor will be fully responsible for any delays occasioned by such calibration by the Department.

The measurements shall be taken when the bituminous material is of a uniform temperature and free of air bubbles. In no case shall the total number of gallons of bituminous material allowed for any tank exceed the capacity of the tank as rated by the U.S. Interstate Commerce Commission, the State Tax Commission, or the Department.

702.03--Heating Bituminous Material. Tanks for heating and storage of bituminous materials shall be capable of heating the material to the specified temperature under effective and positive control at all times. The heating system shall provide uniform heating for the entire contents of the tank. The circulating system shall be of adequate size to ensure proper and continuous circulation of the material during the entire operating period. Suitable means shall be provided, either by steamjacketing or other insulation, for maintaining the specified temperature of the bituminous material in the lines, meters, weigh buckets, spray bars, and other containers or flow lines.

Thermometers of approved type and adequate range, calibrated in 5°F increments, shall be located at points readily visible. These thermometers shall be kept clean and in good condition at all times.

Where storage tanks are required, the capacity shall be sufficient for at least one day's run.

The heating of bituminous materials shall be rigidly maintained at the "lowest workable temperature."

702.04--Sampling. Sampling of bituminous materials shall be as set out in AASHTO T 40.

702.05--Petroleum Asphalt Cement. Asphalt cement shall be homogeneous, free of water and shall not foam when heated to a temperature of 175°C.

Except for use in asphalt pavements, asphalt cement of the grade specified shall conform to the requirements of Subsection 702.12, Table I or II.

Bituminous material conforming to AASHTO M 320, Grade PG 58-28 may be used in lieu of petroleum asphalt cement, Grade AC-10.

The bituminous material used in all types of asphalt mixtures shall conform to AASHTO M 320, Performance Grade PG 67-22, as modified in the table below, except that Polyphosphoric Acid (PPA) may be used at low dosage rates as a modifier to enhance the physical properties of a base binder to meet the requirements for Performance Grade PG 67-22. In addition, PPA may be used as a catalyst or mixing agent at low dosage rates in the production of Polymer Modified, Performance Grade PG 76-22.

When PPA is used as a modifier, in no case shall the PPA modifier be used to adjust the physical properties of the binder a full binder grade. For example: the base binder (unmodified) is graded as a PG 64-22 and should only be modified by the addition of PPA to a modified binder grade of PG 67-22.

When petroleum asphalt cement is modified by PPA, the following dosage limits shall be applied.

Grade	Dosage Limit
PG 67-22	0.75% by weight of binder
PG 76-22	0.50% by weight of binder

Specifications For Performance Graded Asphalt Binders Not Addressed By AASHTO M 320		
Grade		
PG 67-22		
Property	Specification	Test Method, AASHTO
Original Binder		
Flash Point Temperature	minimum 230°C	T 48
Rotational Viscosity	maximum 3 Pa•s @ 135°C	T 316
Dynamic Shear, G*/sin δ	minimum 1.00 kPa @ 67°C	T 315
Rolling Thin Film Oven Residue (AASHTO T 240)		
Mass Loss (RTFO)	maximum 1.00 %	T 240
Dynamic Shear, G*/ sin δ	minimum 2.20 kPa @ 67°C	T 315
Pressure Aging Vessel Residue (AASHTO R 28)		
Dynamic Shear, G* sin δ	maximum 5000 kPa @ 26.5°C	T 315
Creep Stiffness, S	maximum 300 MPa @ -12°C	T 313
m-value	minimum 0.300 @ -12°C	T 313

The bituminous material used in polymer modified asphalt mixtures shall conform to

AASHTO M 320, Grade PG 76-22 or PG 82-22. Unless otherwise indicated in the contract, Grade PG 76-22 will be used in polymer modified asphalt mixtures.

Asphalt cement Grade PG 76-22 & PG 82-22 shall be the product resulting from the addition of a polymer modifier to a PG 67-22 or lower grade asphalt cement and not by some other refining technique. The polymer shall meet the requirements of Subsection 702.08.3.

702.06--Cutback Asphalts. Cutback asphalt shall consist of a liquid asphalt produced by the fluxing of an asphaltic base with a suitable distillate. It shall be of uniform consistency, free of water, and shall show no separation or curdling prior to use. In addition, cutback asphalt shall conform to the following requirements:

- Rapid-Curing Cutback Asphalt: AASHTO M 81.
- Medium-Curing Cutback Asphalt: AASHTO M 82.

The standard naphtha solvent shall be used when the spot test is performed.

702.07--Emulsified Asphalt. Emulsified asphalt shall be homogeneous, showing no separation of asphalt, limits for settlement excepted, after thorough mixing, within 30 days after delivery.

Emulsified asphalts that have been subjected to freezing temperatures while in storage shall be retested and acceptance of the material shall be based on the results of such retest.

Emulsified asphalts, of the grade specified, shall conform to the following requirements:

- Emulsified Primes shall conform to the requirements of Subsection 702.12, Table III.
- Anionic and Cationic Emulsion shall conform to the requirements of AASHTO M 140 and AASHTO M 208, respectively, with the following exceptions.

The required tests on residue may be performed on residue obtained by evaporation at 325°F., three hours, 50 grams, after filtering through a No. 50 sieve; however, in the event of the failure of any test performed on this residue, the emulsion shall be distilled and the test repeated on the residue so obtained.

LockDown (LD-7) and CQS-1h shall conform to the requirements of Subsection 702.12, Table V.

702.07.1--Blank.

702.07.2--Blank.

702.07.3--Polymer Modified Cationic Emulsified Asphalt (CRS-2P). Polymer Modified Cationic Emulsified Asphalt shall conform to the requirements of AASHTO M 316.

702.07.4--Ground Tire Rubber Modified Cationic Emulsified Asphalt (CRS-2TR). Ground Tire Rubber (GTR) Modified Cationic Emulsified Asphalt shall conform to the requirements of Subsection 702.12, Table VI. The GTR particle size shall have a 30 Mesh maximum. The metal content in the Ground Tire Rubber shall not exceed 0.01%.

702.08--Asphalt Additives.

702.08.1--Asphalt Antistrip Additives. The antistrip additive shall meet the following properties:

- (a) The bituminous mixture with antistrip additive, when tested in accordance with Mississippi Test Method MT-63, shall yield a minimum Tensile Strength Ratio (TSR) of 85 and must show an increase in indirect tensile strength for a water conditioned specimen. In a visual examination of the interior faces of the water conditioned specimen, the proportion of stripped aggregate particles shall not exceed five percent.
- (b) The rate of application shall be determined for each job-mix formula during the mix design process using Mississippi Test Method MT-63.
- (c) A stripping test, MT-63, will be performed for each job-mix formula at the beginning of plant production and no less than one test per two week's production thereafter. A minimum of one stripping test per day of production according to Mississippi Test Method MT-59 shall also be conducted. Should either the TSR (MT-63) or the boiling water (MT-59) stripping test fail, a new antistrip rate shall be established or other changes made immediately that will result in a mixture that conforms to the specifications; otherwise, production shall be suspended until corrections are made.

The antistrip additive shall not present any difficulties in mixing of the liquid asphalt with the particular aggregates proposed for use.

The liquid asphalt and antistrip agent mixture shall meet the viscosity requirements for the grade of liquid asphalt used in the paving mix.

702.08.2--Silicone. When specified or permitted, silicone with a viscosity of 1,000 centistokes at 77°F shall be added to the asphalt cement at the rate of one ounce per 5,000 gallons.

702.08.3--Polymers. The polymer shall be a Styrene Butadiene Styrene (SBS), a Styrene Butadiene Rubber (SBR) or an equal approved by the Engineer. The polymer shall be thoroughly blended with the asphalt cement at the refinery or terminal prior to shipment to the hot-mix plant. Producers of polymer modified asphalt cement must be listed on the Department's APL of Polymer Modified Asphalt Cement. The producer of the polymer modified asphalt cement shall perform or have performed by an approved laboratory all tests contained in AASHTO M 320 on a lot basis. A lot shall consist of one (1) refinery or terminal storage tank not to exceed 225,000 gallons. The Producer shall furnish two copies of a certified test report (one copy for the Contractor and one copy for the Department Representative) with each shipment. A third copy of the certified test report shall be mailed to the State Materials Engineer. The certified test report shall contain the following:

- (a) Test results showing complete conformance to AASHTO M 320
- (b) Type and percentage of polymer added
- (c) A statement certifying that the transport vehicle was inspected prior to loading and was found to be empty
- (d) A statement certifying that the shipment conforms to Department specifications for the grade of polymer modified asphalt cement specified

(e) A copy of the temperature-viscosity curve attached to the certified test report.

Crumb rubber used as a polymer modifier shall meet the following additional requirements:

Crumb rubber shall be produced by ambient grinding methods. The rubber shall be sufficiently dry so as to be free flowing and to prevent foaming when mixed with asphalt cement. The rubber shall be free of contaminants including fabric, metal, minerals and other non-rubber substances. Up to four percent, by weight of rubber, of talc, such as magnesium silicate or calcium carbonate, may be added to prevent sticking and caking of the particles.

The crumb rubber shall be tested in accordance with AASHTO T 27 with the following exceptions: a 100-gram sample size and up to 25% dusting agent (talc). Rubber balls may also be used to aid in the sieving of finely ground rubber. The resulting rubber gradation shall meet the gradation limits shown herein.

Gradations of Crumb Rubber
Type A

<u>Sieve Size</u>	<u>% Passing</u>
10	--
20	--
30	--
40	100
60	98-100
80	90-100
100	70-90
200	35-60

The specific gravity of the rubber shall be 1.15 ± 0.05 when tested in accordance with ASTM D 297, pycnometer method.

The moisture content shall be determined in accordance with AASHTO T 255, with the exception that the oven temperature shall be $140 \pm 5^\circ\text{F}$ and the weight of the sample shall be 50 grams. The moisture content shall not exceed 0.75% by weight.

No more than 0.01% metal particles shall be detected when thoroughly passing a magnet through a 50-gram sample.

The chemical composition of the crumb rubber shall be determined in accordance with ASTM D 297 and shall meet the following requirements:

Acetone Extract	Maximum 25 percent
Rubber Hydrocarbon Content	40 to 55 percent
Ash Content	Maximum 10 percent
Carbon Black Content	20 to 40 percent
Natural Rubber	16 to 34 percent

Crumb rubber meeting these specifications shall be supplied in moisture resistant packaging such as either disposal bags or other appropriate bulk containers. Each container or bag of crumb rubber shall be labeled with the manufacturer's designation for the rubber and the specific type, maximum nominal size, weight and manufacturer's batch or lot

designation.

The producer of the polymer modified asphalt cement shall furnish the State Materials Engineer one copy of the manufacturer's certified test results covering each shipment of crumb rubber. These reports shall indicate the results of tests required by this specification. The reports shall also include a certification that the material conforms to the specifications, and shall be identified by manufacturer's batch or lot number.

702.09--Blank.

702.10--Blank.

702.11--Application Temperatures. Bituminous materials for the several applications indicated in the specifications shall be applied within the temperature ranges shown in Subsection 702.12, Table IV.

702.12--Tables.

**TABLE I
SPECIFICATIONS FOR ASPHALT CEMENT (PETROLEUM)**

TEST	*AC-5		AC-10		**AC-13		
	Min.	Max.	Min.	Max.	Min.	Max.	
Viscosity @ 140°F, poises	400	600	800	1200			
Viscosity @ 275°F, C _s	175	--	240	--			
Penetration @ 32°F					25		
Penetration @ 77°F, 100g, 5 sec.	140	--	80	--	65	90	
Penetration @ 115°F						325	
Flash Point COC, °F	400	--	425	--	450	--	
Solubility in Trichloroethylene	99.0	--	99.0	--	99.0	--	
Residue from Thin-Film Oven Test:							
Viscosity, 140°F, poises	--	2250	--	4500			
Ductility, 77°F, 5 cm per min., cm.	100	--	100	--	75	--	
% Loss on Heating	--	1.0	--	0.5	--	0.5	
Specific Gravity @ 60°F/60°F					1.00		
Spot Test: Standard Naphtha Solvent		Negative for all Grades***					
Softening Point, °F (R & B)					110		

NOTES: * When cut-back asphalt cement is to be produced as specified in Subsection 702.06, this material shall be the base asphalt.

** This is an asphaltic material used primarily for sealing joints and cracks.

*** If positive, the test must be rerun with a solution of 75% naphtha and 25% xylene.

**TABLE II
SPECIFICATIONS FOR ASPHALT CEMENT (PETROLEUM)**

TEST	AC-20		AC-30		AC-40	
	Min.	Max.	Min.	Max.	Min.	Max.
Viscosity @ 140°F (60°C), poises	1600	2400	2400	3600	3200	--
Viscosity @ 275°F (135°C), C _s	300	--	350	--	350	
Penetration @ 32°F (0°C)						--
Penetration @ 77°F (25°C) 100g, 5 sec.	60	--	50	--	40	--
Penetration @ 115°F (46°C)						
Flash Point COC, °F	450	--	450	--	450	--
Solubility in Trichloroethylene	99.0	--	99.0	--	99.0	--
Residue from Thin-Film Oven Test:						
Viscosity, 140°F (60°C), poises	--	9000	--	13500	--	18000
Ductility, 77°F (25°C), 5 cm / min., cm.	80	--	60	--	40	--
% Loss on Heating	--	0.5	--	0.5	--	0.5
Specific Gravity @ 60°F/60°F						
Spot Test: Standard Naphtha Solvent		Negative for all Grades*				
Softening Point, °F (R & B)						

NOTES: * If positive, the test must be rerun with a solution of 75% naphtha and 25% xylene.

**TABLE III
SPECIFICATION FOR EA-1 PRIME**

Test Requirements	Minimum	Maximum
Furol Viscosity @ 122°F	30	100
Water Content Xylene Distillation, %	3	8
Test on Residue from Distillation		
Ductility @ 77°F, cms.	40	
Solubility in Trichloroethylene, %	97.0	
Asphalt Cement, % of Total Primer	50.0	
Penetration @ 77°F, 100 g., 5 sec.	80	300

SPECIFICATION FOR AE-P PRIME

Test Requirements	Min.	Max.	AASHTO Test Method
25°C SFS Viscosity, sec.	10	50	T-59
5-Day Settlement, %	--	5	T-59
Total Distillate, % weight	--	55	T-59
Oil Distillate, % volume	--	12	T-59
Tests on Residue from Distillation: Distillation to 500°F (AASHTO T-59)			
60°C Float Test, sec.	20	--	T-50
Solubility in TCE, %	97.5	--	T-44

**TABLE IV
WORKING TEMPERATURES FOR BITUMINOUS MATERIALS**

Bituminous Materials	Temperature, °F			
	Spraying		Mixing	
	Min.	Max.	Min.	Max.
Asphalt All Cements	275	350	225	350
Cutback Asphalts RC & MC				
30	80	150	60	105
70	80	150	95	140
250	100	200	135	175
800	195	270	165	205
3000	235	300	200	240

**TABLE V
SPECIFICATION FOR FOG SEAL**

Test Requirements	LD-7		CBC-1h		Test Method
	Min.	Max.	Min.	Max.	
Viscosity, Saybolt Furol, @ 25°C, Sec.	10	100	10	100	AASHTO T 72
Storage Stability Test, 24 hr, %	-	1	-	1	AASHTO T 59
Settlement, 5 day, %	-	5	-	-	AASHTO T 59
Particle Charge	-	-	Positive		AASHTO T 59
Oil Distillate, %	-	1	-	-	AASHTO T 59
Sieve Test, % *	-	0.3	-	0.1	AASHTO T 59
Residue by Distillation, %	40	-	50	-	AASHTO T 59
Test on Residue from Distillation					
Penetration @ 25°C	-	20	-	-	AASHTO T 49
Dynamic Shear, $G^* \sin \delta$ @ 67°C, kPa	1	-	1		AASHTO T 315
Softening Point, °C	65	-	-	-	ASTM D 36
Solubility in trichloroethylene, %	97.5	-	97.5	-	AASHTO T 44
Ductility @ 25°C, cm	-	-	40	-	AASHTO T 51
Original DSR @ 82° ($G^*/\sin \delta$, 10 rad/sec)	1	-	-	-	AASHTO T 111

* The Sieve result is tested for reporting purposes only and may be waived if no application problems are present in the field.

TABLE VI
SPECIFICATION FOR CATIONIC RAPID SETTING
EMULSIFIED ASPHALT (CRS)

Property	AASHTO Test Method	CRS-2TR	
		Min	Max
Viscosity, Saybolt Furol 122°F, sec.	T 72	150	500
Sieve test, %	T 59	–	0.1
Demulsibility, 35 ml of 0.8% sodium dioctyl sulfosuccinate, %	T 59	40	–
Storage stability, 1 day, %	T 59	–	1
Particle charge	T 59	Positive	
Distillation test: 1	T 59		
Residue by distillation, % by weight		65	–
Oil distillate, % by volume of emulsion		–	3
Tests on residue from distillation:			
Modifier Type		Tire Rubber	
Modifier content, wt. % (solids basis)		5.0	–
Penetration, 77°F, 100 g, 5 sec.	T 49	90	150
Solubility in trichloroethylene, %	T 44	98	–
Ductility, 77°F, 5 cm/min., cm	T 51	40	–
Ductility, 39.2°F, 5 cm/min., cm	T 51	–	–
Force Ratio, (f2/f1)			
Elastic Recovery, %			
Force Ratio	T 51		

SECTION 703 - AGGREGATES

703.01--General. All aggregate sources shall be approved by the Department prior to use. All approved aggregate sources will be re-examined periodically for conformance to the quality requirements set herein.

The term "thin or elongated piece" is intended to mean a piece whose length is more than five times its average thickness. Suspected pieces will be chosen from a representative sample, and the length and average thickness will be determined visually.

The term "fractured face" is intended to mean that the approximate area of a fractured face shall not be less than the approximate cross-sectional area at the minor axis of the particle. This area will be visually determined. A piece of aggregate with a small chipped area will not be considered as crushed.

All concrete produced for use in Department work shall be manufactured from aggregates which have been tested and accepted by Department personnel.

703.02--Fine Aggregate for Hydraulic Cement Concrete.

703.02.1--General Requirements. Fine aggregate for hydraulic cement concrete used in construction of culverts, headwalls, retaining walls, steps, or other minor structures shall consist of natural sand or manufactured limestone sand. Fine aggregate used in major construction, such as concrete pavements and bridges, shall be natural sand unless otherwise designated on the plans or in any special provisions. Natural sand, or manufactured limestone sand, shall be composed of clean, hard, durable, and uncoated particles free of deleterious substances and organic impurities. Fine aggregate from more than one source shall not be used alternately, or mixed, without the written consent of the Engineer. Fine aggregates will be added to the APL based on new source approval testing by the Department. Source approval of fine aggregate sources will be based on the following:

- (a) Soundness of aggregate shall meet the requirements set out in Subsection 703.02.2.3.
- (b) Expansion of mortar bars shall not exceed 0.10% in 16 days when tested in accordance with AASHTO T 303. Alternatively to AASHTO T 303, ASTM C 1260 expansion test results shall not exceed 0.10% at 16 days.

A source of sand may be rejected if experience proves that concrete made from the source does not have a satisfactory service record. Unless indicated otherwise, fine aggregate shall meet the requirements hereinafter specified.

703.02.2--Detail Requirements.

703.02.2.1--Deleterious Substances. The quantity of deleterious substances shall not exceed the following limits:

Deleterious Substance	General Use	Bridges and Super Structures
	Maximum Percent (%) by Mass	
Clay Lumps and friable particles	3.0	1.0
Coal and lignite	0.5	None
Material finer than No. 200 sieve	2.0	1.0
Other deleterious substances such as shale, alkali, mica, coated grains, lightweight particles, and soft and flaky particles	2.0	1.0
Total Maximum Accumulative	3.0	2.0

703.02.2.2--Gradation Requirements. Fine aggregate for concrete shall be well graded from coarse to fine and shall conform to the following:

Square Mesh Sieve	Percent Passing by Weight
1/2 inch	100
3/8 inch	97 - 100
No. 4	92 - 100
No. 8	75 - 100
No. 16	45 - 90
No. 30	25 - 70
No. 50	3 - 35
No. 100	0 - 10

The gradation of material from any one source shall be reasonably uniform and not subject to the extreme gradation shown above. The degree of uniformity will be determined by fineness modulus determination from representative samples submitted from the sources the Contractor proposes to use.

When the slip-form method for placement of concrete pavement is used, the fine aggregate gradation requirements will be modified if necessary.

703.02.2.3--Soundness. When subjected to five cycles of soundness tests using magnesium sulfate, AASHTO T 104, the weighted percentage of loss shall not be more than 15.

703.02.2.4--Additional Requirements. Fine aggregate shall also meet the organic impurities and mortar-making properties specified in AASHTO M 6.

703.03--Coarse Aggregate for Hydraulic Cement Concrete.

703.03.1--General Requirements. Coarse aggregate shall consist of gravel, crushed limestone, granite, and Department-approved stone sources unless otherwise designated or permitted on the plans or in any special provisions.

The coarse aggregate shall be hard, durable particles that are thoroughly clean, free from adherent coatings of injurious character, and reasonably free of soft or disintegrated pieces, frozen lumps, vegetable, or other deleterious matter. Coarse aggregate from more than one source shall not be used alternately, or mixed, without the written approval of the Engineer. Coarse aggregates will be added to the APL based on new source approval testing by the Department. Coarse aggregate source approval will be based on the following:

- (a) Soundness of aggregate shall meet the requirements set out in Subsection 703.03.2.3.
- (b) Resistance to abrasion shall meet the requirements set out in Subsection 703.03.2.2.
- (c) Expansion of mortar bars shall not exceed 0.5% in six months, 0.10% in 16 days, or 1.0% in one year when tested in accordance with AASHTO T 303. Alternatively to AASHTO T 303, ASTM C 277 expansion test results shall not exceed 0.05% at 3 months and 0.10% at 6 months. If either of these test results exceed the tolerances, ASTM C 295 should be performed to further evaluate the

aggregate source.

A source of coarse aggregate may be rejected if experience proves that concrete made from the source does not have a satisfactory service record.

703.03.2--Detail Requirements.

703.03.2.1--Deleterious Substances. The quantity of deleterious substances shall not exceed the following limits:

Deleterious Substance	General Use	Bridge Super Structures
	Maximum Percent (%) by Mass	
Coal and lignite	0.5	None
Clay lumps and Friable Particles	2.0	1.0
Material passing the No. 200 sieve:		
Limestone	1.5	1.5
Other Materials	1.0	1.0
Thin or elongated pieces as referenced in Subsection 703.01	15.0	15.0
Soft fragments	3.0	3.0
Sticks	None	None
Other deleterious substances	1.0	1.0
Maximum accumulative mass of shale, coal, lignite, clay lumps, friable particles, free shell, soft fragments, lightweight particles, and other deleterious substances	3.0	2.5

703.03.2.2--Percentage of Wear. The percentage of wear shall not be more than 40, when coarse aggregate is subjected to the test for abrasion of coarse aggregate, AASHTO T 96.

703.03.2.3--Soundness. When subjected to five cycles of soundness test by the use of magnesium sulfate, AASHTO T 104, the weighted percentage of loss shall not be more than 15%.

703.03.2.4--Gradation. Coarse aggregate for cement concrete, of the type designated, shall be well-graded from coarse to fine, and shall conform to the following:

**Table of Sizes and Gradation of Coarse Aggregate
for Hydraulic Cement Concrete**

Square Mesh Sieves	Percent Passing by Weight						
	Size No. 467 ¹	Size No. 57	Size No. 67 ²	Size No. 7	Size No. 78	Size No. 8	Size No. 89
2 inch	100						
1½ inch	95-100	100					
1 inch		80-100	97-100				
¾ inch	35-70		80-100	100	100	100	
½ inch		25-60		90-100	90-100	95 100	100
⅜ inch	10-30		20-55	40-70	40-75	75-100	85 100
No. 4	0-5	0-10	0-10	0-15	5-25	5-30	20-40
No. 8		0-5	0-5	0-5	0-10	0-10	0-10
No. 16					0-5	0-5	0-5

NOTE: ¹ - Size No. 467 is allowed only in concrete pavements Section 501 – Hydraulic Cement Concrete Pavements;

² - This tolerance is not applicable for Class F and Class FX Concrete.

The gradation from any one source shall be reasonably uniform and not subject to the extreme limits of gradation shown in the table.

For the purpose of determining the degree of uniformity, a fineness modulus determination will be made upon representative samples from the sources proposed for use by the Contractor.

703.03.2.5--Lightweight Particles in Coarse Aggregate. Lightweight particles in coarse aggregate typically have an oven dry specific gravity less than 2.00. The lightweight particle and coarse aggregate blend testing requirements are specified in Subsection 804.02.12.5. The lightweight particle and coarse aggregate blend is subjective to increased testing and monitoring with an oven dry specific gravity of less than 2.45. In addition to oven dry specific gravity, visual inspection can identify the presence of excessive lightweight particles. The Engineer may require additional testing based on visual inspection of the aggregate source and/or producer stockpiles.

703.04--Aggregate for Crushed Stone Courses.

703.04.1--Coarse Aggregate. Coarse aggregate, defined as material retained on No. 8 sieve, shall be either crushed limestone, steel slag, granite, concrete, or combination thereof. Crushed concrete is defined as recycled concrete pavement, structural concrete, or other concrete sources that can be crushed to meet the gradation requirements for Size No. 825B as modified below. In no case shall waste from concrete production (wash-out) be used as a crushed stone base.

Individual sources of coarse aggregate shall conform to the following quality requirements:

Percentage of wear shall not exceed 45 when tested in accordance with AASHTO T 96.

The coarse aggregate shall have a minimum dry rodded unit weight of 70 pounds per cubic foot when tested in accordance with AASHTO T 19.

703.04.2--Fine Aggregate. Fine aggregate, defined as material passing the No. 8 sieve, shall be material resulting from the crushing of limestone, steel slag, granite, concrete, or a combination thereof. Fine aggregate, when manufactured, shall be manufactured from material meeting the quality requirements for coarse aggregate, and it shall be free of lumps of clay and friable particles, loam, organic or foreign matter.

Individual sources of fine aggregate shall be non-plastic when tested in accordance with AASHTO T 90.

Fly ash, when used as a portion of the fine aggregate to obtain desired properties of the mixture, shall be from an approved source.

When the fine aggregate is combined with other aggregate fractions in the proper proportion, the resultant mixture shall meet the requirements of the contract.

703.04.3--Gradation. Aggregates for crushed stone shall be well-graded from coarse to fine, and shall conform to the following:

**TABLE OF SIZES AND GRADATION
OF CRUSHED STONE AGGREGATE**

Sieve Size	Percent Passing by Weight		
	Size ¾ inch and Down	Size No. 610	Size No. 825 B
2 inch			100
1 1/2 inch		100	90 - 100
1 inch	100	90 - 100	75 - 100
¾ inch		70 - 100	
½ inch		62 - 90	60 - 85
¾ inch	50 - 85	50 - 80	
No. 4	35 - 65	40 - 65	40 - 70
No. 8			28 - 54
No. 10	25 - 50		
No. 16			19 - 42
No. 40	15 - 30	12 - 26	
No. 50			9 - 32
No. 200	5 - 15	5 - 12	4 - 18

If crushed concrete is used, the crushed material shall meet the gradation requirements of Size No. 825 B with the exception that the percent passing by weight of the No. 200 sieve shall be 2 - 18.

703.05--Blank.

703.06--Aggregates for Asphalt.

703.06.1--Coarse Aggregates. Coarse aggregate, material retained on the No. 8 sieve, shall be either crushed stone, slag, granite, shell, expanded clay, expanded shale, crushed gravel, or a combination thereof. Crushed reclaimed concrete pavement shall also be allowed as a coarse aggregate provided it meets the quality requirements below and the final product produced therefrom meets all other specification requirements.

The percentage of wear shall not exceed 45 when tested in accordance with AASHTO T 96.

When tested in accordance with AASHTO T 19, the dry rodded unit weight of all aggregates except expanded clay and shale shall not be less than 70 pounds per cubic foot.

The coarse aggregate shall be free of any injurious coating that will prohibit the adherence of asphalt to the aggregate particles.

The percentage of loss shall not exceed 20 when tested for soundness using magnesium sulfate in accordance with AASHTO T 104.

Shell shall consist of durable, washed particles of dead clam or dead reef oyster shell, or combination thereof. The shell shall be free of objectionable matter such as sticks, mud, clay lumps, cannery or live shell, or other deleterious matter. Not more than five percent by weight of the dredged material shall pass the No. 200 sieve; any such material shall be dispersed throughout the mass.

703.06.1.2--Fine Aggregates. Fine aggregate, material passing the No. 4 sieve, shall consist of hard, durable particles of naturally disintegrated rock, or material obtained by crushing stone, slag, gravel, reclaimed concrete pavement, or combinations thereof. Fine aggregate produce from crushing reclaimed concrete pavement shall be manufactured from material meeting the quality requirements for coarse aggregate.

Fine aggregate shall be free of lumps of clay and friable particles, loam, organic or foreign matter.

Fine aggregate produced by crushing stone, slag or gravel shall be manufactured from aggregate meeting the quality requirements of coarse aggregate.

Individual sources of fine aggregate shall be non-plastic when tested in accordance with AASHTO T 90.

Natural deposits of fine aggregate shall contain no more than 10 percent by weight passing the No. 200 sieve when tested in accordance with AASHTO T 11.

Individual fine aggregate components shall be of such consistency and dryness that a uniform and even flow from the cold feed will be provided.

703.07--Granular Materials.

703.07.1--General. Granular materials shall be composed of a natural or manufactured mixture of soil binder and sand, soil binder, sand and gravel, stone, slag, or combinations thereof. The mixture shall have satisfactory cementing qualities and shall be homogeneous in character and reasonably free of clay balls, vegetable matter, or other deleterious

substances that cannot be classed as serviceable.

To ensure adequate soil drainage through the shoulders, no material used above the design soil in the construction of shoulders shall have a minus 200 sieve fraction, liquid limit, or plasticity index appreciably exceeding like characteristics in the adjacent base courses.

703.07.1.1--Fine Aggregate (Portion Passing The No. 10 Sieve). The fine aggregate shall be composed of a natural or artificial mixture of soil binder and granular material. The soil binder shall be clay or silt or other materials, or combinations thereof having satisfactory cementing qualities, homogeneous in character, and reasonably free of vegetable matter, clay balls, or other deleterious substances that cannot be classed as serviceable. The granular portion shall be composed of sand, stone, or slag screenings and shall be hard and durable and preferably sharp.

703.07.1.2--Coarse Aggregate (Portion Retained on the No. 10 Sieve). The coarse aggregate shall be composed of gravel, stone, slag, or a combinations thereof, and shall consist of hard, durable particles reasonably free of vegetable matter or other deleterious substances. Materials that break up and weather rapidly when alternately frozen and thawed or wetted and dried shall not be used.

Coarse aggregate, when tested in accordance with AASHTO T 96, shall have a percentage of wear not to exceed 50, except no abrasion testing will be required for aggregates used in shoulder construction.

703.07.2--Gradation. The gradations shown in the following tables are the maxima and minima for all sources, and the gradation from any one source shall be reasonably uniform and not subject to the extreme limits in the tables. It shall be the responsibility of the Contractor to furnish a material that has sufficient silt and clay, within the ranges permitted in the tables, to insure that the material will, when processed as specified, bind together and form a stable course and will, when properly compacted, have the required density.

The gradation of the class specified shall meet the applicable requirements of the following table:

Percentage (by weight) Passing Square Mesh Sieves

Sieve Size	Class									
	1 & 2	3 & 4	5 & 6	7	8	9	10			
3"	100	100	100	100	100	100	100	100	100	100
1 1/2"	85 - 100	85 - 100	85 - 100	100	100	100	100	100	100	100
1"	65 - 100	65 - 100	65 - 100	100	100	100	100	100	100	100
1/2"	35 - 90	35 - 90	35 - 100	100	100	100	100	100	100	100
No. 4	30 - 70	30 - 75	30 - 85	100	100	100	100	100	100	100
No. 10	30 - 50	30 - 57	30 - 65	30 - 100	30 - 100	30 - 100	30 - 100	30 - 100	30 - 100	30 - 100

Note: The minimum percentage passing the No. 10 sieve may be lowered to 25% by the Engineer if proper placement characteristics and stability can be obtained by the coarser gradation.

Material Passing the No. 10 Sieve

Sieve Size	Class									
	1	2	3	4	5	6	7	8	9	10
No. 10	100	100	100	100	100	100	100	100	100	100
No. 40	20 - 80	20 - 90	20 - 90	20 - 90	20 - 100	20 - 100	40 - 80	20 - 85	20 - 100	20 - 100
No. 60	15 - 70	15 - 80	15 - 80	15 - 80	15 - 80	15 - 80	30 - 70	15 - 70	15 - 85	15 - 100
No. 200	8 - 40	6 - 40	8 - 40	6 - 40	8 - 40	6 - 40	10 - 40	8 - 40	6 - 40	8 - 60

Material Passing the No. 40 Sieve shall meet the following:

Group Symbol	LL Max.	PI	
		Min.	Max.
A	25		6
B	25		8
C	30		10
**D	35		15
**E	35	6	15

General Note: Material will be designated in the contract by Class _____, Group _____.

** In the case of Group D material, the range of PI shall be no more than nine in any half-mile section. When Group E material is specified in the contract, that portion to be treated with cement may be less plastic or non-plastic except that the range in PI shall be no more than nine in any half-mile section.

703.07.3--Sampling and Testing. The material shall be sampled and tested as outlined in Subsection 700.03.

703.08--Mechanically Stabilized Courses. Specified aggregates meeting the requirements of Subsection 703.20 when combined with soils or other aggregates as required will be tested for gradation and plasticity of the composite mixture.

In the case of gravel, stone, or slag aggregates or combinations thereof, the composite mixture will be designated in the contract as Type A, Type B, or Type C. In the case of reef shell or clam shell aggregates or combinations thereof, the composite mixture will be designated in the contract as Type D.

The composite mechanically stabilized mixture of the type and group specified in the contract shall meet the following requirements:

Percentage By Weight Passing Square Mesh Sieves

Sieve Size	Type			
	A	B	C	D
3"	100	100	100	
1 1/2"	85-100	85-100	85-100	95-100
1"	65-100	65-100	65-100	
1/2"	35-90	35-90	35-100	
No. 4	30-70	30-75	30-85	
No. 10	30-50	30-57	30-65	
No. 40				55(Max.)

Material passing the No. 40 sieve shall meet the following:

Group Symbol	LL Max.	PI	
		Min.	Max.
A	25		6
B	25		8
C	30		10
**D	35		15
**E	35	6	15

Note: Desired product will be designated in the contract as Type _____, Group _____.

703.09--Blank.

703.10--Blank.

703.11--Blank.

703.12--Blank.

703.13--Aggregate for Cold Mix Asphalt Pavement. The fine and coarse aggregate fractions for the mixture shall be so sized and graded that when combined the resultant mixture will be uniformly graded from coarse to fine and meet the applicable requirements of the gradation table.

703.13.1--Coarse Aggregate. The coarse aggregate shall be crushed slag, crushed limestone, crushed gravel, expanded clay, granite, crushed reef shell or a combination thereof and shall meet the quality requirements of Subsection 703.06.

Crushed processed reef shell shall consist of dead oyster shell, dead clam shell, or combinations thereof. It shall not contain cannery or live shell. The uncrushed shell shall be produced or processed by washing over a screen washer. The mesh of the screen washer shall not be smaller than 1/4 inch. Before crushing, material passing the No. 200 sieve shall not exceed four percent.

703.13.2--Fine Aggregate. Fine aggregate shall meet the quality requirements of Subsection 703.06. When crushed limestone or crushed reef shell is used as the coarse aggregate, at least 60% of the fine aggregate portion of the mixture shall consist of naturally disintegrated rock.

703.13.3--Aggregate for Top Dressing. Material for top dressing shall consist of dry sand, gravel screenings, stone screenings or slag screenings and conform to the following gradation requirements:

<u>Square Mesh Sieve</u>	<u>Percent Passing By Dry Weight)</u>
3/8 inch	100
No. 4	95 (min.)
No. 50	30 (max.)
No. 100	5 (max.)

**GRADATION REQUIREMENTS
COLD BITUMINOUS PAVEMENTS**

Type:	Binder A	Binder B	Binder C	Surface D	Surface E	Surface F	Surface G
Designation:	(Percent Passing by Weight, Aggregate Only)						
Sieve:	(Percent Passing by Weight, Aggregate Only)						
1 1/2 inch	100						
1 1/4 inch	90-100						
1 inch		100	100		100	100	100
3/4 inch	30-60	90-100			90-100		90-100
5/8 inch		40-85	80-100	100		100	
1/2 inch			60-90	90-100		95-100	
3/8 inch			45-75	60-98	10-40	40-70	
No. 4	5-25	10-35	35-60	35-70	5-30	15-50	50-90
No. 10	0-15	5-20	12-30	14-35	1-20	5-30	20-55
No. 40	0-5	0-12	4-20	3-15	0-15	1-20	7-30
No. 80			1-10	0-5	0-5	0-10	2-12
No. 200	0-2	0-6					
% A.C. by Weight of Total Mix	3.5-5.5 Max.2.0	4.0-7.0 Max.2.0	5.0-8.0 Max.2.0	5.0-8.0 Max.2.0	4.5-6.5 Max.2.0	4.5-8.5 Max.2.0	5.8-8.5* Max.2.0
Liquefier**							
Hydrated Lime***	0.5-1.5	0.5-1.5	0.5-1.5	0.5-1.5	0.5-1.5	0.5-1.5	0.5-1.5

* These limits include the natural asphalt recoverable by extraction in natural asphaltic limestone, and aggregate gradation limits include sand added in accordance with Subsection 703.13.2.

** Liquefier shall be commercial grade Naptha or Kerosene.

*** Hydrated lime, for facilitator, shall meet Subsection 714.03.

RANGE OF TOLERANCES

Passing No. 10 and larger Sieves -----	± 10%
Passing Nos. 40 and 80 Sieves -----	± 7%
Passing No. 200 Sieve -----	± 3%
Percent Asphalt Cement -----	± 0.5%
Percent Liquefier -----	± 0.5%

703.14--Aggregate for Chip Seals.

703.14.1--General Requirements. Aggregate for chip seals and liquid seals shall consist of crushed stone, crushed slag, gravel, or expanded clay as specified in the contract.

Only one kind and type of aggregate shall be used on a single course unless otherwise authorized by the Engineer in writing.

703.14.2--Detail Requirements.

703.14.2.1--Gradation. Aggregates shall conform to the gradation requirements contained in the following table:

GRADATION REQUIREMENTS FOR COVER AGGREGATE

Square Mesh Sieve	Coarse Aggregate Cover Material			Seal Aggregate Cover Material		
	Slag, Stone, Granite or Gravel (Crushed or Uncrushed)			Slag, Stone, Granite or Crushed Gravel		
	Size No.	Size No.	Size No.	Size No.	Size No.	Size No.
	5	56	6	7	7	8
Percent Passing Square Opening Sieves						
1 1/2 inch	100	100				
1 inch	90-100	90-100	100		100	
3/4 inch	20-55	40-85	90-100	100	90-100	100
1/2 inch	0-10	10-40	20-55	90-100	40-85	85-100
3/8 inch	0-5	0-15	0-15	40-85	0-15	10-30
No. 4		0-5	0-5	0-15	0-5	0-10
No. 8				0-5		0-5
No.16					0-10	0-5

The size coarse aggregate cover material and the size seal aggregate cover material shall be as specified in the bid schedule of the contract; however, only one kind of aggregate shall be used unless otherwise authorized by the Engineer in writing.

703.14.2.2--All Materials. The quantity of deleterious substances shall not exceed the limits set out in Subsection 703.03.2.1 for general use.

When subjected to five cycles of soundness test for coarse aggregate by use of magnesium sulfate, AASHTO T 104, the weighted percentage of loss shall not be more than 15.

The percentage of wear, when tested for abrasion in accordance with AASHTO T 96, shall not be more than 40%.

703.14.2.3--Crushed Stone. Crushed stone shall consist of clean, tough, durable, uncoated fragments free from an excess of soft or disintegrated pieces.

703.14.2.4--Crushed Slag. Crushed slag shall be air-cooled slag consisting of angular fragments, reasonably uniform in density and quality, and reasonably free of dirt or other objectionable matter. Crushed slag shall have a dry-rodded weight of 70 to 90 pounds per cubic foot when tested in accordance with AASHTO T 19 and shall not contain more than 10 percent by weight of glassy particles. The maximum unit weight is waived for chromium slag.

703.14.2.5--Crushed Gravel. Crushed gravel shall be composed of clean, tough, durable particles of gravel, free from excess dirt or other objectionable matter. At least 85% by weight of the particles retained on the No. 10 sieve shall have one or more fractured faces.

703.14.2.6--Uncrushed Gravel. Uncrushed gravel shall be composed of clean, tough, durable particles free from excess vegetable or other objectionable matter. It shall meet the requirements specified above for all materials as to deleterious substances.

703.14.2.7--Expanded Clay. Expanded clay aggregate shall be the product of a plant approved by the Engineer. It shall conform to the gradation requirements in the preceding table and to requirements of ASTM C 330, with the following exception: The loss by abrasion shall not be more than 40% when subjected to the Los Angeles Abrasion Test, AASHTO T 96.

When used for sealing joints as specified in Section 413, the soundness and abrasion requirements will be waived.

703.15--Blank.

703.16--Mineral Filler. Mineral filler shall consist of shell dust, limestone dust, hydraulic cement, or other calcareous type materials having a high affinity for asphalt. The source of the material shall be approved by the Engineer.

Mineral filler shall meet the following gradation requirements:

Passing the No. 30 sieve, % -----	100
Passing the No. 50 sieve, not less than, %-----	95
Passing the No. 200 sieve, not less than, % -----	65

703.17--Blank.

703.18--Mortar Sand. Sand for mortar shall consist of hard, strong, durable, uncoated

mineral or rock particles, free of injurious amounts of organic or other deleterious substances. It shall not contain, by weight, more than three percent clay or inorganic silt or combination thereof.

Mortar sand shall be uniformly graded from coarse to fine within the following limits:

<u>Sieve Size</u>	<u>% Passing</u>
No. 4	100
No. 8	97-100
No. 50	8-40
No. 100	0-10
No. 200	0-5

Mortar sand shall meet other requirements of AASHTO M 45.

703.19--Lightweight Aggregate for Structural Concrete.

703.19.1--Lightweight Aggregate for Structural Concrete. Lightweight aggregate for structural concrete shall meet the requirements of AASHTO M 195.

703.19.2--Lightweight Aggregate for Internal Curing of Concrete. Lightweight aggregate for internal curing of concrete shall meet the requirements of ASTM C 1761. The lightweight aggregate shall meet the gradation requirements listed in Table 1 for either “9.5 mm to 2.36 mm (3/8 in. to No. 8)” Coarse aggregate, “9.5 mm to 0 (3/8 in. to 0)” Combined fine and coarse aggregate, or “4.75 mm to 0 (No. 4 to 0)” Fine aggregate. The fineness modulus of the lightweight aggregate shall not be less than 2.70.

703.20--Aggregate for Stabilizer.

703.20.1--General Requirements. The material for stabilizer aggregate shall meet the requirements hereinafter specified for each type.

The gradation limits shown below are the maxima and minima for all cases, and a closer control appropriate to the job materials will be required for the specific project. Each type of aggregate shall be uniformly graded from coarse to fine. Skip-graded material will not be acceptable.

703.20.2--Detail Requirements.

703.20.2.1--Gravel, Stone, or Slag Coarse Stabilizer. Gravel or stone shall be composed of hard, tough, durable particles reasonably free of injurious or deleterious substances. The percentage of wear, when tested in accordance with AASHTO T 96, shall not exceed 50%.

Slag shall be air-cooled slag, consisting of angular fragments, reasonably uniform in density and quality, and reasonably free of dirt or other objectionable matter. The weight per cubic foot shall be not less than 85 pounds.

703.20.2.2--Shell. Shell shall consist of durable, washed particles of slaked clam or reef shell or combination thereof. The shell shall be free of objectionable matter such as sticks, mud, clay lumps, or other deleterious matter. Not more than four percent by weight of clay

and sand will be permitted and such material shall be dispersed throughout the mass.

Clam shell shall consist of washed dead clam shell. Reef shell shall consist of washed dead oyster shell and shall not contain cannery or live shell.

703.20.2.3--Medium and Fine Stabilizer. Medium aggregate stabilizer and fine aggregate stabilizer shall consist of sand, stone, shell, and/or slag screenings.

Slag screenings, sand, or stone shall be composed of hard, durable particles reasonably free of injurious amounts of soft or flaky particles, dust lumps, organic, or other deleterious substances. Shell shall comply with the requirements set out in Subsection 703.20.2.2.

703.20.3--Gradation. The gradation of the various types of stabilizer shall be as follows:

PERCENT PASSING BY WEIGHT

Square Mesh Sieves	Shell	Coarse			Medium	Fine
		Size I	Size II Note (1)	Size III Note (3)		
3 inch	90-100			100		
2 1/2 inch				90-100		
2 inch		100				
1 1/2 inch		90-100	100			
1 inch		80-100	97-100			
3/4 inch		55-100	55-100	0-10		
1/2 inch		35-85	35-85	0-5	100	
3/8 inch		12-65	12-65		97-100	
No. 4, Note (2)		0-30	0-30		92-100	
No. 10		0-8	0-8		80-100	100
No. 40				10-40	80-100	
No. 60				0-20	30-100	
No. 100					15-80	
No. 200	0-5	0-4	0-4	0-5	0-30	
PI Material Passing No. 40				6 or less	0	

Note (1): Size II is intended for use in bases in which hydraulic cement is used.

Note (2): Ground shell shall contain at least 97% passing the No. 4 sieve.

Note (3): Size III is intended for use in stabilized construction entrances.

703.20.4--Stabilizer Aggregate, Local Materials. When local materials are designated for use as stabilizer aggregate, their requirements will be shown on the plans or in the special provisions.

703.21--Borrow Excavation. Borrow excavation shall be composed of a natural or manufactured mixture of sand, silt, and clay or combinations of sand, silt, clay, gravel or stone. The material shall have satisfactory cementing qualities, shall be reasonably free of vegetable matter or other deleterious substances that cannot be classed as serviceable, and shall be such that when properly compacted will form a dense mass. When rock or stone is used in the embankment, it shall be so graded and manipulated that the embankment will

contain no appreciable interstices.

Borrow excavation from outside the right-of-way is divided into classes, each class conforming to the requirements set out in the following table:

BORROW EXCAVATION

	CLASS																
	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	B17
Percent Passing (Min.)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	36	8
No. 200 Sieve (Max.)	25	35	10	35	35	100	100	100	100	100	-	-	-	-	-	-	50
Percent Passing (Min.)	-	-	-	-	-	-	-	-	-	-	8	8	8	8	-	-	-
No. 270 Sieve (Max.)	-	-	-	-	-	-	-	-	-	-	100	70	100	100	-	-	-
Percent Silt (Max.)	-	-	-	-	-	-	-	-	-	-	90	50	90	75	-	-	-
Fraction Passing No. 40 Sieve - Liquid Limit (Max.)	-	40	-	45	40	45	40	55	40	55	45	40	55	45	-	40	40
Plasticity Index (Min.)	6	10	np	10	20	25	10	10	20	-	25	20	35	25	35	-	12
% Volume Change (Max.)	-	-	-	-	-	-	-	-	-	-	-	-	10	-	10	11	-
Group Index (Max.)	-	-	-	-	-	-	-	-	-	-	-	-	60	-	50	50	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-

The class of material will be specified in the contract.

When the contract contains a numerical designation after the class number, it shall be understood to indicate the requirement that the material shall have a minimum PI of not less than that indicated by the numerical designation. For example, Class B9-6 requires Class B9 material having a minimum PI of 6; or a Class B9-10 requires Class B9 material having a minimum PI of 10, etc.

When a minimum PI is specified, the maximum plasticity index and the maximum liquid limit, as indicated in the table, will be raised the numerical designation for minimum PI, except that in the case of Class B8, Class B10 and Class B13 the maximum liquid limit shall remain as indicated in the table above.

For the design soil portion of the embankment all of the material shall pass a three-inch sieve. Individual contracts may further restrict the maximum size of material in the top portion of the design soil.

SECTION 704 - AGGREGATE FOR DRAINAGE

704.01--Permeable Material. Permeable material for use in backfilling trenches, under, around, and over underdrains and permeable material for blankets or other subdrainage purposes shall consist of hard, durable, clean sand, gravel, crushed stone, or crushed slag, and shall be free from organic material, clay balls, or other deleterious substances. These materials shall be as designated by Type as set out below.

704.02--Type A Filter Material. Type A filter material shall meet the requirements for Size 7 seal cover aggregate, or Size 7, 57, or 67 coarse aggregate for hydraulic cement concrete, or Size II gravel coarse stabilizer as set out in Section 703. The crushing requirement for gravel seal cover aggregate is not applicable.

704.03--Type B Filter Material. Type B filter material shall be concrete sand conforming to the requirements of Subsection 703.02.

704.04--Type C Filter Material. Type C filter material shall consist of sand, stone, and/or slag screenings composed of hard, durable particles reasonably free of injurious amounts of soft or flaky particles, dust, lumps, organic, or other deleterious substances.

The gradation of the material shall be as follows:

<u>Sieve Size</u>	<u>Percent Passing</u>
1/2 inch	100
No. 4	80 - 100
No. 16	37 - 80
No. 50	5 - 30
No. 100	0 - 10

704.05--Type D Impervious Material. Type D impervious material shall consist of natural soil, soil aggregates, or a blend of natural soil and aggregates. The material shall be reasonably free of sticks, roots and other objectionable matter, shall be classified as

Group A-6 or A-7, and shall conform to the following:

Percent passing No. 10 Sieve -----	80-100
Percent passing the No. 200 Sieve, minimum -----	36
Liquid Limit, maximum -----	50
Plasticity Index-----	12 to 25
pH -----	4.5 to 8.0

704.06--Crushed Stone Drainage Layers. The aggregate shall be crushed limestone, sandstone or granite conforming to the quality requirements of Subsections 703.01 and 703.03. The aggregate shall conform to the gradation set out below.

<u>Sieve Size</u>	<u>% Passing by Weight</u>
1 1/2"	100
1"	95 - 100
1/2"	60 - 82
No. 4	35 - 55
No. 8	5 - 25
No. 16	3 - 11
No. 50	2 - 7

**SECTION 705 - STONE BLANKET PROTECTION
AND FILTER BLANKET MATERIALS**

705.01--Stone Blanket Protection. In addition to meeting the quality requirements of AASHTO M 80, Class E, stone blanket protection shall be in accordance with AASHTO M 43, Size No. 357.

705.02--Stone Filter Blanket. In addition to meeting the quality requirements of AASHTO M 80, Class E, filter blanket material shall conform to the gradation requirements of AASHTO M 43, Size No. 467.

705.03--Sand Filter Blanket. The sand filter blanket shall conform to the gradation requirements of Subsection 703.02 for concrete sand.

705.04--Stone Riprap. Aggregate for loose riprap, stone riprap for foundation protection, or that to be grouted shall consist of field stone, broken concrete, or rough, unhewn quarry stone as nearly rectangular in section as is practicable. The stone shall be dense, free of clay or shale seams, resistant to the action of air and water, and suitable in all other respects for the purpose intended. Quality requirements for rock to be furnished under these specifications will come from a pre-approved source or be visually approved prior to use.

Stones for riprap, of the size specified, shall meet the requirements for size by weight of the mass as specified in the following table:

**PERCENTAGE LARGER THAN
By Weight of the Mass**

Rock Size	Size									
	8 Ton	4 Ton	2 Ton	1 Ton	1/2 Ton	1/4 Ton	500 Pound	300 Pound	200 Pound	100 Pound
8 Ton	50	0								
4 Ton	85	50	0							
2 Ton	--	95	50	0						
1 Ton	--	--	95	50	0					
1/2 Ton	--	--	--	95	50	0	0			
1/4 Ton	--	--	--	--	95	50	0-10			
300 Pound	--	--	--	--	--	--	--	0		
200 Pound	--	--	--	--	--	--	50	--	0	
100 Pound	--	--	--	--	--	--	--	--	--	0
75 Pound	--	--	--	--	--	90	--	--	--	--
60 Pound	--	--	--	--	--	--	--	80	--	--
40 Pound	--	--	--	--	--	--	--	--	80	--
20 Pound	--	--	--	--	--	--	90	90	--	80
10 Pound	--	--	--	--	--	--	--	--	90	--
5 Pound	--	--	--	--	--	--	--	--	--	90

This table sets out minimum requirements for the large stone per size designation. The Contractor shall furnish material well graded with the smaller stones such that a homogeneous blanket of riprap will result with all interstices reasonably well filled with rock.

SECTION 706 - MASONRY UNITS

706.01--Brick.

706.01.1--General. Brick shall have a fine-grained, uniform, and dense structure, and be free of lumps of lime, laminations, cracks, checks, soluble salts, or other defects that may in any way impair the strength, durability, appearance or usefulness of the brick for the purpose intended. Bricks shall emit a clear, metallic ring when struck with a hammer.

706.01.2--Building Brick. Unless otherwise stipulated, building brick shall conform to ASTM C 62, Grade SW.

706.01.3--Sewer and Manhole Brick. Unless otherwise stipulated, brick for sewer and manholes shall conform to ASTM C 32, Grade SM.

706.02--Concrete Brick. Concrete brick shall conform to ASTM C 55, Grade N, Type I.

706.03--Concrete Masonry Blocks. Concrete masonry blocks may be rectangular or segmented and, when specified, shall have ends shaped to provide interlock at vertical joints. The blocks shall conform to the requirements of ASTM C 139; or, for hollow blocks, to ASTM C 90, Grade N, Type I. Dimensions and tolerances shall be as specified.

706.04--Right-of-Way Markers.

706.04.1--General. Concrete right-of-way markers shall be constructed in conformity with the details shown on the plans and shall meet the requirements hereinafter set forth.

When more than 20% of the units in a lot is rejected, the entire lot will be rejected.

706.04.2--Manufacture.

706.04.2.1--Description. The exposed portion of the marker shall present a smooth, uniform surface, free of honeycomb, chips, or other defects. The shape, dimensions, and placement of steel shall be in accordance with details shown on the plans. All letters, figures, or other markings shall be true to type and size shown on the plans, and shall be legible.

706.04.2.2--Materials. The materials used in the manufacture shall conform to the following.

706.04.2.2.1--Cement. The cement used shall meet the requirements of Section 701.

706.04.2.2.2--Aggregates. The aggregates used shall conform to the requirements of Subsections 703.02 and 703.03, except that the requirements for gradation will not apply.

706.04.2.2.3--Reinforcing Steel. Reinforcing steel shall conform to the requirements of Subsection 711.01.

706.04.2.2.4--Proportions. The concrete shall have a minimum cement factor of 1.25.

706.04.2.2.5--Strength Requirements. The strength of the right-of-way markers shall be determined by the beam method. Under the beam method, a completed unit is loaded at the midpoint of an 18-inch span with three-edge bearing; the unit shall develop a strength of not less than 12,000 pounds, total load. Two specimens will be tested for each 200 units, or increment thereof; one to destruction and one to the ultimate load of 12,000 pounds.

SECTION 707 - JOINT MATERIALS

707.01--General. Joint fillers and seals for concrete bridges, concrete pavements or base course, and culvert pipe shall conform to the following applicable subsections.

707.02--Joint Fillers.

707.02.1--Poured Joint Filler.

707.02.1.1 Asphalt Joint Material. Poured asphalt filler shall be blown asphalt, Grade AC-13, conforming to the requirements of Subsection 702.05.

707.02.1.2--Polymerized Emulsified Asphalt Joint Material. Cold applied polymerized-emulsified asphalt joint material shall meet the following requirements when tested in accordance with AASHTO T 59 and as specified below:

	Minimum	Maximum
Tests on Emulsion		
Viscosity, Saybolt Furol @ 122°F, seconds	50	450
Storage Stability, 24 hr., % *	-	1
Classification Test	Pass	
Particle Charge Test	Positive	
Cure Test **	Pass	
Stretch Test ***	Pass	
Distillation:		
Oil distillate by volume of emulsion %	-	2
Residue from distillation, %	65	-
Tests on Residue from Distillation		
Penetration, 77°F, 100 g., 5 seconds	80	150
Ductility, 77°F, cm	40	-
Solubility in Trichloroethylene, %	97.5	-

* Note 1: Upon examination of the test cylinder after standing undisturbed for 24 hours, the surface shall show no white, milky colored substance but shall be a homogeneous brown color throughout.

** Note 2: Cure Test - Pour approximately one milliliter of the emulsion onto a metal surface. Allow to cure at a minimum temperature of 80°F under a bright light for four hours. Outside in the sun may be used as the test site. After the four-hour curing period, the material shall show no tackiness or tendency to stick to the finger when pressed.

*** Note 3: Stretch Test - Pour onto a one-quart friction lid, or similar flat container, enough emulsion to cover the surface. While the emulsion is still brown, embed with thumb pressure several clean, sharp edged rocks of 3/8 to 1/2-inch size. Cure in oven at 100°F for a minimum of eight hours. Remove from oven and allow to cool at room temperature for one hour. Upon lifting a rock from the surface, the asphaltic material must stretch for a distance of three inches before breaking.

707.02.1.3--Concrete Joint Sealer Compound - Hot-Poured Elastic Type. Concrete joint sealer compound, hot-poured elastic type, shall conform to the requirements of ASTM D 6690 for Type I Joint and Crack Sealant.

707.02.1.4--Silicone Sealant. The silicone sealant must be listing on the Department's APL prior to its use. The silicone sealant shall be a single-component low modulus non-acetic acid cure sealant that does not require a primer for bond to concrete. Unless specifically designated otherwise, silicone sealant shall be either the standard non-sag type or the self-leveling type meeting the following requirements:

PHYSICAL REQUIREMENTS

Property	Standard Non-Sag Type	Self- Leveling Type
Shore A Durometer Hardness, 7-day cure @ 73.4 ±3.6°F & 45% to 55% R.H., ASTM D 2240	10 - 25	15 maximum
Elongation, 7-day cure @ 73.4 ±3.6°F & 45% to 55% R.H., ASTM D 412, Method A, Die C, minimum	500%	500%
Tensile Stress @ 150% Elongation, 7-day cure @ 73.4 ±3.6°F & 45% to 55% R.H., ASTM D 412, Method A, Die C	20 - 45 psi	10 - 30 psi
Flow/Sag, ASTM C 639, maximum	0.3 inch	Self-Leveling
Tack-Free Time, 73.4 ±3.6°F & 45% to 55% R.H., ASTM C 679, maximum	90 minutes	180 minutes
Shelf Life from Date of Manufacture, minimum	6 months	6 months

The manufacturer of the joint material shall furnish certified test results of each lot of material furnished to each project. Each lot of the sealant shall be delivered in containers plainly marked with manufacturer's name or trade mark, lot number and date of manufacture.

707.02.1.5--Backer Rod for Use with Hot and Cold Poured Joint Sealer. The backer rod shall be a closed-cell foam rod made from polyethylene, polyolefin or similar type material, and shall conform to ASTM D 5249 with the exception that water absorption shall be determined by ASTM C 1016, Procedure A. The backer rod shall either be a Type I, for use with either hot or cold poured joint sealers, or a Type 3, for use with cold poured joint sealers only. Open-cell foam rods or open-cell foam rods covered with an impermeable sheath or skin shall not be allowed.

The Contractor shall furnish a three linear foot sample of each shipment and three copies of the manufacturer's certification that the backer rod meets the requirements of this specification.

707.02.1.6--Tar. Tar filler shall be produced from suitable gas-house, coke-oven, and/or water-gas tars and shall conform to the following requirements:

	Minimum	Maximum
Float Test at 122°F	75	100
Total Distillate, percent by weight to 572°F	-	25
Water, percent by volume		1
Bitumen soluble in CS ₂ , percent	80	-
Softening Point of Residue (R & B), °F		162
Specific Gravity, 60°F/60°F	1.20	1.28

707.02.2--Preformed Sponge, Rubber, Cork and Closed-Cell Polypropylene Foam Joint Fillers for Concrete Paving and Structural Constructions. Preformed joint filler shall conform to AASHTO M 153 for sponge, rubber, and cork and tested according to AASHTO T 42. The type required will be indicated on the plans.

Closed-cell polypropylene foam shall conform to the requirements in AASHTO M 213 except for the following: the compression test may be less than 340 kPa and closed-cell polypropylene foam shall be tested in accordance with AASHTO T 42.

707.02.3--Wood. Wood board joint filler shall be redwood, cypress, yellow pine, white pine, fir, longleaf pine, Tupelo gum, or other lumber classed as softwood, and shall conform to the following requirements:

- (a) Boards shall be free of knots, except that small pin knots 1/4 inch maximum diameter will be permitted. Boards containing occasional knots of larger size may be used, providing the knots are removed and the holes either filled with properly sized plugs of the same type wood or covered with approved thin metal attached to the board. Occasional medium surface checks not to exceed 1/32 inch width and 10 inch length will be permitted, provided the board is free of defects that will impair its usefulness for the purpose intended.
- (b) Dimensions shall be as shown on the plans, and tolerances of plus or minus 1/16 inch thickness and plus or minus 1/8 inch width will be permitted. For slip-form paving a tolerance of minus 1/4 inch on each end in length will be permitted.
- (c) The oven-dry weight shall not exceed 38 pounds per cubic foot, and the load required to compress the material in an oven-dry condition to 50% of its thickness before test shall not be more than 2500 psi when tested in accordance with AASHTO T 42.
- (d) A sample shall be submitted for each shipment of 1000 linear feet or less. Each sample shall consist of a representative section at least 36 inches long and the full depth of the joint. Testing shall be in accordance with AASHTO T 42, as applicable.
- (e) The joint filler shall be a one-piece board or a lamination of like species of the required thickness, depth and lane width length without joints or splicing except that milled shop finger end joints are permissible.

707.02.4--Preformed Joint Insert Material for Concrete Paving. The preformed joint insert material shall be of such character as not to be deformed or broken by twisting, bending, or other ordinary handling when exposed to atmospheric conditions. Pieces of the joint filler that have been damaged shall be rejected. This material is for use in longitudinal joints. When tested, the joint material for concrete paving will meet the requirements of Subsection 707.02.2 or 707.02.3.

707.02.5--Preformed Elastomeric Compressive Joint Seals for Concrete. The preformed elastic joint shall be a polychloroprene joint sealer of the size and shape shown on the plans, bonded to the concrete with a lubricant adhesive and shall conform to ASTM D 2628.

The lubricant adhesive shall be in accordance with the recommendation of the manufacturer of the joint seals.

The Contractor shall submit the manufacturer's certified test results for each lot of joint seals.

707.03--Blank.

707.04--Rubber Type Gaskets for Joining Conduit. Rubber gaskets for pipe joints and revisions in design of pipe for installation of the gaskets shall conform to the requirements of ASTM C 443. The Contractor shall submit the manufacturer's certified test results for each consignment of material.

707.05--Bituminous Plastic Sealer for Joining Conduit. Bituminous plastic sealer shall be composed of steam-refined petroleum asphalt or refined coal tar which has been dissolved in a suitable solvent and stiffened with an inert mineral filler.

The sealer shall be a smooth uniform mixture, not thickened or livered. It shall show no separation that cannot be easily overcome by stirring. The material shall be of such consistency and properties that it can be readily applied with a trowel, a putty knife, or a caulking gun without pulling or drawing. The material, when applied to pipe surfaces, shall exhibit good adhesive and cohesive properties and shall have only slight shrinkage after curing. The material shall be capable of being exposed to below freezing temperatures without incurring damage. When applied in a layer of 1/16 inch to 1/8 inch thick on a tinned metal panel and cured at room temperature for 24 hours, the bituminous plastic sealer shall set to a tough plastic coating, free of blisters. Additional requirements are:

	Minimum	Maximum
Grease cone penetration, unworked, 150 grams, 25°C, 5 sec., ASTM D 217, mm/10	175	250
Weight, pounds per gallon	9.75	-
Non-volatile, 19 grams, 105°C - 110°C, 24 hrs., %	75	-
Ash, by ignition, %	25	55

707.06--Flexible Plastic Gasket for Joining Conduit. Gasket joint seals shall be produced from blends of refined hydrocarbon resins and plasticizing compounds reinforced with inert mineral filler and shall contain no solvents. The gasket joint sealer shall not depend on oxidizing, evaporating, or chemical action for its adhesive or cohesive strength and shall be supplied in extruded rope form of suitable cross-section and of such size as to fill the joint space when the pipes are laid. The gasket joint sealer shall be protected by a suitable removable two-piece wrapper. The two-piece wrapper shall be so designed that one-half may be removed longitudinally without disturbing the other half.

The material shall be obtained from sources approved by the laboratory, and the approval will be based on results of testing as required herein.

The Department may require the performance test described in AASHTO M 198.

Flexible plastic gasket shall also meet the following requirements:

	Minimum	Maximum	Test Method
Composition			
Bitumen / Petroleum Plastic Content	50	70	ASTM D 4
Ash-Inert Mineral Matter	30	50	AASHTO T 111
Volatile Matter	--	2.0	ASTM D 6
Property			
Specific Gravity at 77°F	1.20	1.35	ASTM D 71
*Ductility at 77°F (cm)	5.0	--	ASTM D 113
*Softening Point	320°F	--	ASTM D 36
*Penetration 77°F, 150 g, 5 sec.	50	120	ASTM D 217

- * Due to the nature of the material, each sample to be tested must be manually kneaded, in lieu of heating and pouring, into the testing containers.

The Contractor shall furnish the Engineer three copies of the manufacturer's certificate, stating that the flexible plastic gasket meets all the requirements of the specifications and has the properties and characteristics herein specified.

707.07--Neoprene Expansion Joints.

707.07.1--General. Neoprene expansion joints shall consist of an integrally molded unit of neoprene and bonded metal components or neoprene extrusions bonded to steel extrusions so arranged as to provide for the expansion and contraction movements of the bridge deck.

707.07.2--Material Requirements. Materials used in the manufacture of the expansion joints shall meet the following requirements:

Neoprene shall meet the requirements of AASHTO M 297.

Steel plates bonded in the joints and steel extrusions shall conform to the requirements of ASTM A 36.

Aluminum plates used in the manufacture of the expansion joints shall conform to the requirements of ASTM B 209, Alloy 6061-T6.

Anchor bolts or studs shall be of a weldable alloy if arc welding is used, and shall conform to the strength requirements of ASTM A 307, Grade A Low Carbon Steel Fasteners.

707.07.3--Certification of Materials. The Contractor shall furnish the Engineer three copies of the manufacturer's certificate, stating that the expansion joint and each component material meets all the requirements of the specifications and have the properties and characteristics herein specified.

SECTION 708 - NON-METAL STRUCTURES AND CATTLEPASSES

708.01--General. The structures covered in these specifications are for use as pipe

culverts, precast box culverts, cattlepasses, sidedrains, sewers, underdrains, and downspouts.

708.02--Concrete Pipe. Unless otherwise specified, pipe and tile shall conform to the requirements hereinafter set forth. When more than 20% of the pipe in a lot is rejected, the entire lot of pipe will be rejected.

When elliptical reinforcing is used, lift holes shall be cast in the top and "Top" or "Bottom" shall be clearly inscribed or stenciled on the inside of the pipe to indicate the proper position when laid. When it is found that the position for laying is not marked, or is marked improperly, the entire lot of such pipe will be rejected.

When rubber gasket joints are permitted or specified, the pipe joints shall be so constructed as to accommodate this type of jointing.

708.02.1--Materials for Use in Concrete Pipe.

708.02.1.1--Cement. Portland cement Types I, II or III, or blended hydraulic cement, shall conform to the requirements set out in Section 701.

708.02.1.2--Fly Ash. Fly ash conforming to the requirements of Subsection 714.05 may be used to replace hydraulic cement on a one to one replacement rate but not to exceed 25% by weight of the hydraulic cement.

708.02.1.3--Fine Aggregate. Fine aggregate shall consist of natural sand and shall conform to the requirements set out in Subsection 703.02, except that the requirements for gradation are not applicable.

708.02.1.4--Coarse Aggregate. Coarse aggregate shall consist of gravel or crushed limestone conforming to the requirements of Subsection 703.03, except that the requirements for gradation are not applicable.

708.02.1.5--Water. The water shall conform to the requirements set out in Subsection 714.01.2.

708.02.1.6--Reinforcement. Reinforcement shall consist of wire conforming to the applicable requirements of Subsection 711.02.

708.02.2--Manufacture - General. Circular pipe of 54-inch diameter and smaller shall be machine made. Other pipe may be either machine made or wet cast.

All sizes of concrete pipe may be furnished with either bell and spigot or tongue and groove, provided that the minimum thickness of concrete on the groove end is at least 1¼ inches. This measurement for thickness will be made at a point 3/8 inch from the outer end of the groove.

When no particular length is specified, the pipe shall be manufactured in standard lengths of at least 2½ feet and not more than eight feet.

The pipe shall be constructed in such a manner and of such design that the joint will meet the same requirements for strength stipulated for the pipe.

708.02.3--Exceptions to AASHTO Standard Specifications.

708.02.3.1--Liquid Membrane Curing Compound. Liquid membrane curing compound will not be permitted.

708.02.3.2--Marking. Required markings shall be placed on the inside wall of the pipe. Machine made pipe shall be marked in accordance with one of the following methods: 1) the pipe shall be inscribed on the outside of the pipe and stenciled on the inside of the pipe, or 2) the pipe shall be inscribed on the inside of the pipe only. All other pipe may be stenciled. The specification designation for reinforced pipe may be excluded from the required markings.

708.02.3.3--Basis of Acceptance. All pipe will be tested under Option I, three-edge bearing test, or Option II, cylinder test, as set forth in Department SOP.

Pipe having a diameter of 30 inches or less will be tested under Option I.

Pipe larger than 30 inches in diameter will be tested under Option I or II. The pipe producer shall advise the Testing Engineer in writing of the option chosen for testing of the pipe. The option chosen will remain in effect until rescinded in writing.

Flared end sections and cattlepasses will be tested under Option II unless otherwise authorized by the Testing Engineer.

The specified D-load and compressive strength shall be considered as minimum and allowable failures will not apply.

Normally, neither the absorption test nor the ultimate load will be required.

708.02.3.4--Rejection. All pipes shall be subject to rejection for nonconformance to the specifications. Individual sections of pipe may be rejected for one or more of the following:

- (a) Visible fractures or cracks, except for a single end crack that does not exceed the depth of the joint.
- (b) Defects that indicate imperfect proportioning, mixing, and molding.
- (c) Surface defects indicating honey-combed or open texture.
- (d) Damaged or cracked ends that prevent a satisfactory joint.
- (e) Defects indicating incorrect positioning of reinforcing steel.

708.02.3.5--Repairs. Repairs will not be permitted in the barrel of the pipe. Repairs may be made on the ends, tongue and groove or bell and spigot, with an approved commercial concrete patching compound used according to manufacturer's recommendations and properly cured.

708.02.3.6--Tongue and Groove. The thickness of the tongue shall not vary more than 1/4 inch or five percent of the wall thickness, whichever is greater, when measured at the outer edge. The thickness of the groove shall not vary more than 1/4 inch or five percent of the wall thickness, whichever is greater, when measured at a point 3/8 inch from the outer end of the groove. The depth of the groove shall not vary more than 1/4 inch from the length of the tongue.

708.02.3.7--Lift Holes. Lift holes may be formed, punched, or drilled in plastic concrete. Lift holes may be placed in cured pipe only by drilling with a diamond core-drill bit.

708.02.4--Non-reinforced Concrete Pipe. In addition to the applicable requirements of Subsection 708.02, non-reinforced concrete pipe shall meet the requirements of AASHTO M 86 for the class specified. Testing shall be in accordance with AASHTO T 280.

708.02.5--Reinforced Concrete Pipe. All reinforced concrete pipe except Class V pipe with diameters of 54 inches and larger shall meet the requirements of AASHTO M 170 as modified by Subsection 708.02.

Class V pipe with diameters of 54 inches and larger shall meet the requirements of AASHTO M 170 or M 242 as modified by Subsection 708.02 and herein.

Circular reinforced concrete pipe with S-stirrup reinforcement shall be in accordance with Figure 1 and the following requirements.

The wall thickness, amount of circular reinforcement, S-stirrup system and concrete strength shall comply with those set out in Table 1 herein. The spacing center to center of adjacent inner rings of circumferential reinforcement in a cage shall not exceed 4 inches for pipe up to and including pipe having a 4-inch wall thickness nor exceed 5½ inches for 54 inch pipe and 6 inches for all other pipe sizes.

Each line of S-stirrups shall have a continuous S shape extending longitudinally from end to end of the pipe. They shall extend from the inner cage toward the outer surface of the pipe for a distance not less than the minimum amplitude. S-stirrups shall pass around and be in contact with each inside circumferential member of the inner cage. Each line of S-stirrups shall lie essentially in a plane passing through the longitudinal axis of the pipe.

Where more than one length of stirrup material is used per line, a lap around one circumferential member of the inner cage shall be made. The ends of "S" shaped stirrups at splices shall include an outer bend. Not more than three lengths of S material may be used in a line, and the minimum length of a section of S-stirrups shall be 30 inches.

All designs in Table 1 are accepted designs with noted 0.01 inch crack and ultimate D-load.

Additional Markings. After the capital letter "D" designating the D-load, the design wall thickness shall be shown in inches expressed as a decimal. Pipe with "S" stirrups shall have the symbol S. Pipe requiring axis orientation without lift holes, i.e. stirrup pipe or quadrant reinforced pipe, shall have the center line of the crown of the pipe marked inside and outside with the symbol TB. Pipe with quadrant steel shall be marked with the symbol Q. Pipe with deformed wire reinforcement required in the design shall have the symbol DF.

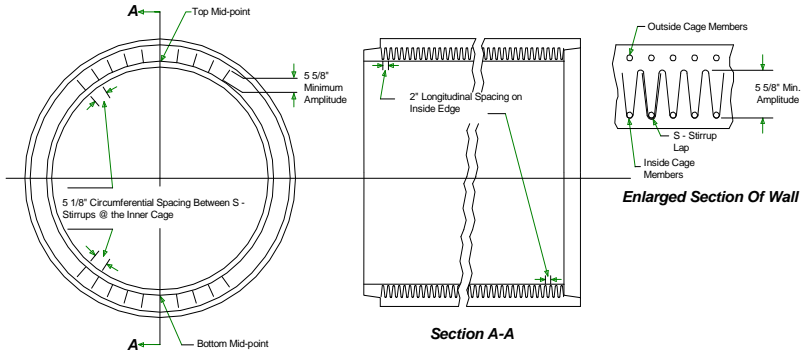


Figure 1

Illustrative Example of S-Stirrup Support System for 0.01-inch Crack D-load
 3,000 102-inch Diameter Pipe, Minimum Area Per Support 0.053 Square Inch.,
 11 Lines Spaced @ 5 1/8 inches. For Other Classes and Sizes, See Table.

TABLE 1
 0.01 Inch Crack D-Load 3,000
 Ultimate Strength D-Load 3,750

Internal Diameter of Pipe	Wall Thick-ness	Circular Reinforcement in Circular Pipe		"S" Stirrups				
		Inner Cage	Outer Cage	Minimum Area Per Support Element	Number of Lines*	Longitudinal Spacing	Circumferential Spacing on Inner Cage	Minimum Amplitude** of Stirrups,
inches	inches	square inches per foot of pipe	square inches per foot of pipe	square inches		inches	inches	inches
Concrete Strength 5,000 Psi								
54	5½	0.64	0.48	0.029	15	2	2 1/8	2 5/8
60	6	0.70	0.53	0.029	14	2	2 5/8	3 1/8
66	6½	0.79	0.59	0.029	13	2	3 1/8	3 5/8
72	7	0.87	0.66	0.029	12	2	3 5/8	4 1/8
78	7½	0.92	0.69	0.031	11	2	4 1/8	4 5/8
84	8	0.99	0.74	0.034	11	2	4 5/8	5 1/8
90	8	1.13	0.85	0.041	11	2	4 5/8	5 1/8
96	8½	1.20	0.90	0.045	11	2	5 1/8	5 5/8
102	8½	1.34	1.00	0.053	11	2	5 1/8	5 5/8
108	9	1.51	1.13	0.063	11	2	5 5/8	6 1/8
114	9½	1.51	1.13	0.064	11	2	6 1/8	6 5/8
120	10	1.62	1.21	0.068	11	2	6 1/2	7 1/8
126	10½	1.73	1.30	0.072	11	2	6 7/8	7 5/8
132	11	1.84	1.38	0.076	11	2	7 1/4	8 1/8
144	12	2.09	1.57	0.085	11	2	8	9 1/8

* Number of lines in the table indicates the number of longitudinal lines required in each top and bottom portion of the pipe. The area of each support element in a pipe is 2 times the cross-sectional area of the "S" stirrups wire used. There shall be an equal number of these lines of "S" stirrups on either side of the mid-point of both the top and bottom of the pipe. See Fig. 1.

** The amplitude is the overall width of the line of stirrups.

708.03--Concrete Cattlepasses. Concrete cattlepasses shall conform to the plans, the applicable requirements of Subsection 708.02, and the following:

- (a) The requirements as to manufacture, materials, and curing shall conform to the requirements of AASHTO M 170.
- (b) The compressive strength of the concrete shall be at least 4,000 psi at 28 days.

708.04--Reinforced Concrete Flared-End Section. Reinforced concrete flared-end sections shall conform to the plans, the applicable requirements of Subsection 708.02 and the following:

- (a) The requirements as to manufacturer, materials, and curing shall be the same as for the connecting pipe.
- (b) The compressive strength of the concrete shall be at least 3,000 psi at 28 days.

708.05--Perforated Concrete Pipe. Perforated concrete pipe shall conform to the requirements of Subsection 708.02.4 and AASHTO M 175.

708.06--Concrete Drain Tile. Standard drain tile or extra quality drain tile shall conform to the applicable requirements of AASHTO M 178.

708.07--Porous Concrete Pipe for Underdrains. Porous concrete pipe for underdrains shall conform to the requirements of AASHTO M 176.

708.08--Blank.

708.09--Blank.

708.10--Blank.

708.11--Blank.

708.12--Blank.

708.13--Blank.

708.14--Reinforced Concrete Arch Pipe. Reinforced concrete arch pipe shall meet the requirements of AASHTO M 206. Horizontal elliptical pipe may be furnished in lieu of arch pipe.

708.15--Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe. This pipe shall conform to the requirements of AASHTO M 207.

708.16--Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets. The joints shall conform to the requirements of AASHTO M 198.

708.17--Corrugated Plastic Pipe Culverts.

708.17.1--Corrugated Polyethylene Pipe Culverts. Corrugated polyethylene pipe shall

conform to the requirements of AASHTO M 294, Type S and/or SP, as applicable, and shall have soil tight joints, unless otherwise specified.

The Contractor shall furnish to the Engineer three copies of the manufacturer's certified test reports and certification covering each shipment of pipe stating the amount furnished and that the pipe, fittings, couplings, etc. comply with the requirements of the specifications.

708.17.1.1--Inspection and Final Acceptance of Corrugated Polyethylene Pipe Culverts. Approximately 50% of the installed length of corrugated polyethylene pipe shall be inspected for excess deflection no sooner than 30 days after the embankment material over the pipe is placed to the required subgrade elevation or the maximum required fill height. The inspection shall be performed using either electronic deflectometers, calibrated television or video cameras, or a “go, no-go” mandrel that has an effective diameter of 95% of the nominal inside diameter of the pipe.

Pipe found to have deflection values greater than 5% shall be removed and replaced at no cost to the State.

708.17.2--Corrugated Poly (Vinyl Chloride) (PVC) Pipe Culverts. Corrugated poly (vinyl chloride) (PVC) pipe shall conform to the requirements of AASHTO M 304 and shall have soil tight joints, unless otherwise specified. Non-perforated PVC pipe used in underdrains shall either be manufactured with an ultra-violet light inhibitor or be fully coated with an ultra-violet light inhibitor.

708.17.2.1--Inspection and Final Acceptance of Poly (Vinyl Chloride) (PVC) Pipe Culverts. Approximately 50% of the installed length of PVC pipe shall be inspected for excess deflection no sooner than 30 days after the embankment material over the pipe is placed to the required subgrade elevation or the maximum required fill height. The inspection shall be performed using electronic deflectometers, calibrated television or video cameras, or a “go, no-go” mandrel that has an effective diameter of 95% of the nominal inside diameter of the pipe.

Pipe found to have deflection values greater than 5% shall be removed and replaced at no cost to the State.

708.18--Sewer Pipe Used for Underdrains.

708.18.1--General. Pipe less than four inches in diameter shall conform to commercial grade PVC water pipe.

Perforations, when required, shall be circular and conform to the requirements of AASHTO M 278.

In lieu of the pipe listed in this subsection, pipe meeting the requirements of Subsection 708.19 may also be used for plastic underdrain pipe.

708.18.2--Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe. This pipe and fittings used for underdrains shall meet the requirements of ASTM D 2751 for the pipe SDR number specified.

708.18.3--Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe. This pipe and fittings used for underdrains shall meet the requirements of ASTM D 3034 for the pipe SDR number specified. Non-perforated PVC pipe shall either be manufactured with an ultra-violet light inhibitor or be fully coated with an ultra-violet light inhibitor.

708.18.4--Poly (Vinyl Chloride) (PVC) Corrugated Sewer Pipe. This pipe shall conform to the following requirements.

- (a) For pipe sizes less than or equal to six inches (<6"), the pipe shall be Class PS46 meeting the requirements of AASHTO M 278.
- (b) For pipe sizes greater than six inches (> 6"), the pipe shall meet the requirements of AASHTO M 304.
- (c) Non-perforated PVC pipe shall either be manufactured with an ultra-violet light inhibitor or be fully coated with an ultra-violet light inhibitor.

708.19--Corrugated Polyethylene Pipe. This pipe shall be high density polyethylene pipe or drainage tubing meeting the requirements of AASHTO M 294, Type S or SP, or AASHTO M 252, Type S or Type SP, as applicable.

708.20--Perforated Semicircular Plastic Pipe for Underdrains.

708.20.1--General. Semicircular plastic subdrain pipe is intended for direct burial and shall be extruded from thermoplastic materials as specified below. Unless otherwise specified, the pipe shall be supplied in 20-foot lengths. The pipe shall have an expanded bell on one end for direct coupling, or separate couplings shall be supplied. The pipe sections shall be joined by a friction fit.

The pipe fittings, including straight couplings, end caps, tees, right laterals, left laterals, 45° elbows, and 90° elbows, shall be molded from thermoplastic materials as specified below. Fabricated fittings shall be made of the same material as the pipe sections.

708.20.2--Pipe Sections and Fabricated Fittings. The pipe sections and fabricated fittings shall be made from virgin poly vinyl chloride (PVC). PVC resins shall conform to ASTM D 1784, Class 12454-B. Virgin resin is defined as resin that contains not more than 10 percent regrind material and has not previously been used to make another product.

708.20.3--Molded Fittings. Molded fittings shall be made from virgin high density polyethylene (HDPE) conforming to ASTM D 1248, Type III, Class B, Category 3, with the addition of a minimum of 0.25% carbon black.

708.20.4--Workmanship. The plastic pipe and fittings shall be homogeneous throughout and free of visible surface flaking, chips or cracks. The semicircular trough interior shall be smooth and free from obstructions. The products shall be as uniform as commercially practicable in respect to color, opacity, density and other physical properties.

708.20.5--Dimensions. The minimum wall thickness of the pipe at any point shall be 0.125 inch, protective lip excluded. Sufficient additional wall thickness shall be supplied at perforated areas to maintain an effective wall strength equal to 0.125 inch thick non-perforated wall. The protective lip shall extend a minimum of 0.500 inch from the pipe at an angle of approximately 30°. The nominal inside radius of the semicircular trough shall be 2 5/16 inch, providing a minimum cross-sectional flow area of 8.3 square inch below

the water entry level. Total water intake area shall be 3.5 square inch per linear foot. All measurements shall be taken at $72 \pm 5^\circ\text{F}$.

708.20.6--Load Deformation. At a deflection of 0.2 inch, the minimum pipe stiffness, $F\Delta y$, shall be 100 psi when tested in accordance with ASTM D 2412, except that specimens shall be conditioned a minimum of 12 hours at approximately 72°F .

708.20.7--Impact Resistance. Impact resistance of the plastic pipe and fittings shall be as follows when tested in accordance with ASTM D 2444, except that specimens for routine inspection shall be conditioned for a minimum of one hour at approximately 72°F or two hours at approximately 32°F .

Using a 20-pound Tup B, the plastic pipe and fittings shall be capable of withstanding 125 foot-pounds at 72°F and 62 foot-pounds at 32°F .

708.20.8--Hydrocarbon Resistance. The plastic pipe and fittings shall meet the load deformation requirements specified above after being immersed for seven days in normal heptane as specified in ASTM D 543.

708.20.9--Product Marking. Each section of pipe and each fitting shall be clearly marked on the exterior surface to show the manufacturer's name or trademark and the material from which it is made, PVC or HDPE. Product marking shall be permanent and legible in characters at least $3/8$ inch high.

708.20.10--Packing and Storage. All pipe sections and fittings shall be so stored prior to shipment that they do not warp, deteriorate or suffer dimensional distortion.

All pipe sections shall be banded or palletized so as to protect them during shipment, handling and subsequent storage. Fittings shall be banded together or packed in suitable containers.

708.21--Blank.

708.22--Precast Concrete Box Culvert.

708.22.1--General. Precast concrete box culverts shall conform to the design and dimensions shown on the plans, and the materials and manufacture of box sections shall meet the requirements of AASHTO M 259 or M 273, as applicable, with the following exceptions:

- (a) Cement shall meet the requirements of Section 701.
- (b) Aggregates shall meet the requirements of Subsections 703.02 and 703.03, except that gradation will not apply.
- (c) Admixtures and blends may be used with the approval of the Engineer.
- (d) Reinforcement shall meet the requirements of Subsection 711.02.3.
- (e) Water shall meet the requirements of Subsection 714.01.
- (f) Each line of box section should be manufactured by one producer's plant.
- (g) The slab and wall thickness shall not vary from the design dimensions by more than five percent or $3/16$ inch, whichever is greater.
- (h) The depth of cover and amount of steel may, at the discretion of the Testing

Engineer, be checked by an electro-magnetic device.

- (i) The permissible variation in diameter of any wire in finished fabric shall conform to the tolerances prescribed for the wire before fabrication by AASHTO M 32.
- (j) Box sections may be repaired, if necessary, because of occasional imperfections in manufacture or handling damage and will be acceptable if, in the opinion of the Engineer, the repairs are sound, properly finished and cured, and the repaired box section conforms to the specifications. These repairs will be allowed in the ends and on joints, only. No repairs will be allowed in the barrel of the box section.

708.23--Special Sections. Any special section, not otherwise specified, shall be of the same wall thickness, size, and type as the pipe to which it is joined and shall conform to the applicable requirements for the particular type of pipe as set forth therein.

Elbows, tees, wyes, or other such special sections shall, unless otherwise specified, have a minimum length for each projection sufficient to properly join the section to the joining elements of the completed structure.

Other details shall be as shown on the plans.

SECTION 709 - METAL PIPE

709.01--Cast Iron Culvert Pipe. Cast iron culvert pipe shall conform to ASTM A 716, for the wall thicknesses set out in the Tables, or as specified on the plans.

709.02--Corrugated Metal Culvert Pipe and Pipe Arches. All corrugated metal pipe and arches covered in these specifications shall conform to AASHTO M 36, except the minimum gauge thickness shall be as shown on the plans or in the contract; however, corrugated metal pipe manufactured from sheets thicker than that specified will be acceptable when approved by the Engineer. The internal diameter of corrugated metal pipe will be determined by inside measurement between the crests of the corrugations. Corrugations greater than 3" x 1" will not be allowed in arch pipe.

709.02.1--Aluminized Corrugated Metal Culvert Pipe and Pipe Arches. All aluminized metal pipe and arches shall be manufactured from Type 2 corrugated metal pipe and arches in accordance with the requirements of Subsection 709.02.

709.03--Bituminous Coated Corrugated Metal Pipe and Pipe Arches.

709.03.1--Materials. Bituminous coated corrugated metal pipe and arches shall conform to the requirements of AASHTO M 190 and be completely coated inside and out with an asphalt cement that meets the performance requirements hereinafter.

The pipe shall be coated uniformly to a minimum thickness of 0.05 inch, measured on the crest of the corrugations. The asphalt cement used shall be at least 99.5% soluble in carbon disulfide.

709.03.2--Performance Requirements. The asphalt cement shall adhere to the metal tenaciously, shall not chip off in handling, and shall protect the pipe from deterioration as evidenced by successfully withstanding the following tests:

709.03.2.1--Stability Test. Parallel lines shall be drawn along the valleys of the corrugations of a representative sample of coated pipe and the specimen placed on end in a constant-temperature oven with the parallel lines in a horizontal position.

The temperature of the specimen shall be maintained at a temperature of $150\pm 2^{\circ}\text{F}$ for a period of four hours. At the end of this time, no part of any line shall have dropped more than 1/4 inch.

709.03.2.2--Imperviousness Test. The asphalt cement shall be impervious to liquids as indicated by the following tests: 25 to 50 milliliters of a 25% water solution of sulfuric acid and of a 25% water solution of sodium hydroxide shall be placed in separate corrugations for a period of 48 hours, during which time no loosening or separation of the bituminous material from the metal shall have taken place.

709.04--Bituminous Coated Paved Invert Corrugated Metal Pipe and Arches. Bituminous coated corrugated metal pipe and arches with paved invert shall conform to the requirements of Subsection 709.03. In addition, bituminous material shall be applied in such a manner that a smooth pavement will result in the invert (bottom of pipe when installed) for 1/4 of the circumference of circular pipe and 40% of the circumference of pipe arches. The pavement, except where the upper edges intersect the corrugations, shall have a minimum thickness of 1/8 inch above the crest of the corrugations.

709.05--Polymer Coated Corrugated Metal Pipe and Pipe Arches. Polymer coated corrugated metal pipe and arches shall conform to the requirements of AASHTO M 245, except the minimum gauge thickness shall be as shown on the plans or in the contract; however, corrugated metal pipe manufactured from sheets thicker than that specified will be acceptable when approved by the Engineer. The internal diameter of corrugated metal pipe will be determined by inside measurement between the crests of the corrugations. Corrugations greater than 3" x 1" will not be allowed in arch pipe. The polymer precoated sheet shall be Type B with a minimum coating thickness of 0.010 inches or 0.25 millimeters on both surfaces.

709.06--Corrugated Metal Pipe for Underdrains. Corrugated metal pipe shall conform to AASHTO M 36, Type III. Type I pipe that has been perforated to permit the in-flow or out-flow of water may be used in lieu of Type III pipe.

709.06.1--Aluminized Corrugated Metal Culvert Pipe for Underdrains. All aluminized corrugated metal pipe for underdrains shall be manufactured from Type 2 corrugated metal pipe and arches in accordance with the requirements of AASHTO M 36, Type III. Manufacturer must repair any damaged coating caused from perforating the pipe.

709.07--Bituminous Coated Corrugated Metal Pipe for Underdrains. Bituminous coated corrugated metal pipe shall conform to the requirements of AASHTO M 190, Type A with a bituminous coating applied in accordance with the requirements of Subsection 709.03. Manufacturer must repair any damaged coating caused from perforating the pipe.

709.08--Polymer Coated Corrugated Metal Pipe for Underdrains. The metal pipe for underdrains shall conform to the requirements of AASHTO M 245, Type III and the polymer coating shall conform to the requirements of Subsection 709.05. Type I pipe that has been perforated to permit the in-flow or out-flow of water may be used in lieu of Type III pipe. Manufacturer must repair any damaged coating caused from perforating the pipe.

709.09--Corrugated Aluminum Alloy Culvert Pipe and Arches. Corrugated aluminum culvert pipe and arches shall conform to the requirements of AASHTO M 196, Type IA. Minimum thickness of sheets shall be as indicated on the plans or in the special provisions.

709.10--Corrugated Aluminum Alloy Pipe for Underdrains. Corrugated aluminum pipe underdrains shall conform to the requirements of AASHTO M 196, Type III. Type I pipe that has been perforated to permit the in-flow or out-flow of water may be used in lieu of Type III pipe.

709.11--Bituminous Coated Corrugated Aluminum Alloy Culvert Pipe and Arches. Bituminous coated aluminum culvert pipe and arches shall conform to AASHTO M 196, Type IA, and in addition shall be coated inside and out as specified in Subsection 709.03. Manufacturer must repair any damaged coating caused from perforating the pipe.

709.12--Bituminous Coated Paved Invert Corrugated Aluminum Alloy Culvert Pipe and Arches. Bituminous coated corrugated aluminum culvert pipe and arches with paved invert shall conform in every respect to the requirements of Subsection 709.09 and, in addition, to the requirements of Subsection 709.04 for paved invert.

709.13--Bituminous Coated Corrugated Aluminum Alloy Pipe for Underdrains. This pipe shall conform to AASHTO M 196, Type III, and shall be coated with bituminous material conforming to AASHTO M 190, type coating as specified. Manufacturer must repair any damaged coating caused from perforating the pipe.

709.14--Structural Plate for Pipe, Pipe Arches, and Arches. These conduits and bolts and nuts for connecting plates shall conform to AASHTO M 167.

709.15--Full Bituminous Coated Structural Plate Pipe, Pipe Arches, and Arches. These conduits shall conform to AASHTO M 167 and shall be coated with bituminous material conforming to AASHTO M 190, type coating as specified.

709.16--Aluminum Alloy Structural Plate for Pipe, Pipe Arches, and Arches. These conduits and the bolts and nuts for connecting plates shall conform to AASHTO M 219.

709.17--Full Bituminous Coated Aluminum Alloy Structural Plate Pipe, Pipe Arches and Arches. These conduits shall conform to AASHTO M 219 and shall be coated with bituminous material conforming to AASHTO M 190, type coating as specified.

709.18--Special Sections. Any special sections, such as elbows, flared end sections, branch connections, or other specified appurtenances shall be of the same base metal, size, type, fabrication, coating, invert, and other applicable requirements as for the particular type of pipe to which it is joined.

Each elbow shall be not less than the following length:

<u>Diameter</u>	<u>Angle - Up to and Including</u>	<u>Minimum Overall Length</u>
6-inch to 48-inch	22½°	24 inches
54-inch to 84-inch	22½°	48 inches
6-inch to 36-inch	45°	24 inches
42-inch to 84-inch	45°	48 inches
6-inch to 24-inch	60°	24 inches
30-inch to 60-inch	60°	48 inches
66-inch to 84-inch	60°	72 inches
6-inch to 15-inch	90°	24 inches
18-inch to 36-inch	90°	48 inches
42-inch to 60-inch	90°	72 inches
66-inch to 84-inch	90°	96 inches

Other details shall be as shown on the plans.

All three-piece corrugated metal end sections shall have 12 gauge minimum thickness sides and 10 gauge minimum thickness center panels. Width of center panels shall be greater than 20 percent of the pipe periphery. Multiple panel bodies shall have lap seams tightly joined by three-eighths inch diameter galvanized rivets or bolts. For 60-inch thru 84-inch sizes, reinforced edges shall be supplemented with galvanized stiffener angles. The angles shall be two inches by two inches by one-quarter inch for 60-inch thru 72-inch diameters and two and one-half inches by two and one-half inches by one-quarter inch for 78-inch and 84-inch diameters. The angles shall be attached by three-eighths inch diameter galvanized nuts and bolts. For the 79-inch by 49-inch and 85-inch by 54-inch sizes, reinforced edges shall be supplemented by galvanized stiffener angles that are two inches by two inches by one-quarter inch. Angle reinforcement shall be placed under the center panel seams on the 79-inch by 49-inch and 85-inch by 54-inch sizes. A toe plate of the same materials as the end section shall be furnished and installed on each end section, unless deemed by the Engineer to be unnecessary for the particular location.

709.19--Steel Pipe and Steel Pipe Encasements. Steel pipe shall conform to the design and dimensions shown on the plans, and materials shall meet the requirements hereinafter specified.

Steel pipe with a nominal diameter of less than six inches shall meet the requirements of ASTM A 53, Type E or F, Grade A, Black, Schedule 40.

Steel pipe with nominal diameter of six inches or more shall meet the requirements of ASTM A 139, Grade A unless otherwise specified, Welded, Black, for the wall thicknesses set out in the Tables, or as specified on the plans.

Steel pipe with a nominal diameter greater than 24 inches shall be as specified on the plans.

Unless otherwise indicated on the plans, steel pipe ends shall be factory beveled for welding. The Contractor shall furnish the State Materials Engineer the original and three copies of the Mill Certificate of Compliance for all materials furnished.

SECTION 710 - PAINT

710.01--General. All paint materials, including vehicle, pigment, paste, driers, thinners, and mixed paint shall conform to the requirements of these specifications unless otherwise stipulated. Paint shall be furnished ready-mixed or in paste or powder form, as may be specified, and shall be of the type and color shown on the plans or as otherwise indicated. All paints for incorporation in the work shall be manufactured in the United States. Any paint that has caked, hardened or otherwise deteriorated shall not be used.

710.01.1--Sampling and Testing. Sampling and testing of paint shall be in accordance with the appropriate method in Federal Test Method No. 141, ASTM and/or Mississippi Test Method.

Sampling at the option of the Department will be performed at the point of manufacture or at a designated point of delivery. When the paint is sampled at the point of manufacture, the Department representative shall be given full access to the manufacturing process.

The Central Laboratory may utilize x-ray analysis, gas chromatography, infrared, or ultra violet spectral analysis of the paint or its components to determine whether specified ingredients were used. Paint found not to be in compliance with the approved formula shall not be used.

710.01.2--Containers and Marking. Paint shall be shipped in sturdy leak proof containers. The size of the containers shall be at the option of the Contractor unless specified otherwise in the contract.

Each container or label thereon shall be marked as follows:

- Net weight in pounds
- Net volume in U. S. gallons
- Color
- Code number
- Batch number
- Name and percentage of each component
- Name and address of manufacturer
- Date of manufacture

In addition, each container and labeling thereon shall meet the requirements of State and Federal Regulations for transporting the paint.

710.02--Mixed Paints. Unless otherwise specified, paint shall be delivered completely mixed and ready for use without further additions or alterations. Paint shall be of a uniform consistency and when applied shall dry to a hard tough film without running, streaking or sagging.

All paints and components thereof shall conform to the applicable subsection as contained herein.

Mixed paint in storage shall not be exposed to temperatures less than 32°F, or such higher temperature as recommended by the paint manufacturer. Paint exposed to temperatures lower than specified will be subject to rejection or retesting.

710.02.1--Aluminum Paint. This paint shall be aluminum alkyd paint as specified by the Steel Structures Painting Council Paint Specifications SSPC 101-64T. Paint that is to be stored for periods longer than six months shall be a two component system. Two-component paints shall be prepared by mixing two pounds of aluminum paste with one gallon of vehicle.

Type I Leafing Aluminum Paint shall always be used as the finish or top coat. Intermediate coats shall be alternate coats of Type II Non-Leafing Aluminum Paint and Type I Leafing Aluminum Paint.

710.02.2--Fast Drying Acrylic Waterborne Traffic Paint. This specification covers fast drying acrylic waterborne, ready-mixed white and yellow traffic paints, Codes FDWBTW and FDWBTY.

710.02.2.1--Composition of Formulation. The composition of the paint shall be left to the discretion of the manufacturer as long as the finished product is composed of 100% acrylic emulsion or one listed on the Department's APL, and meets the requirements of this specification and of any applicable Federal, State or Local regulations for products of this type.

The paint shall contain no lead, chromium, cadmium or barium. The organic yellow shall be pigment yellow C.I. #75 or #65. Rutile titanium dioxide shall be used in the yellow paint, FDWBTY.

710.02.2.1.1--Percent Pigment. The percent pigment by weight shall be not less than 45% or more than 55%.

710.02.2.1.2--Total Non-Volatile. The paint shall have not less than 73% total non-volatiles by weight.

710.02.2.1.3--Non-Volatile Vehicle. The non-volatile portion of the vehicle shall be composed of a 100% acrylic polymer or one listed on the Department's APL, and shall not be less than 44% by weight.

710.02.2.1.4--Organic Matter. The volatile content of the paint shall contain less than 150 grams of volatile organic matter per liter of total non-volatile paint material.

710.02.2.1.5--Solids Volume. The volume of solids shall be not less than 58%.

710.02.2.1.6--Weight per Gallon. The paint shall weigh a minimum of 12.0 pounds per gallon and the weight of the production batches shall not vary more than ± 0.2 pound per gallon from the weight of the qualification samples.

710.02.2.2--No Tracking Time. The paint shall dry to a no tracking condition under traffic in ninety (90) seconds maximum when applied at 15 ± 1 mil. wet film thickness and 110 to 140°F, and from three (3) to ten (10) minutes when applied at ambient temperature with six (6) pounds per gallon of Class A, Standard, glass beads or with twelve (12) pounds per gallon of Class B, High-Visibility, glass beads.

710.02.2.3--Viscosity. The consistency of the paint shall be not less than 75 nor more than

95 Krebs Units (KU) at 77°F when tested in accordance with Federal Test Method Standard No. 141.

710.02.2.4--Flexibility. The paint shall show no cracking or flaking when tested in accordance with Federal Specification TT-P-1952.

710.02.2.5--Dry Opacity. The minimum contrast ratio shall be 0.96 when drawn with a 0.005 Bird applicator.

710.02.2.6--Daylight Reflectance. The daylight directional reflectance shall not be less than 85% for white paint and not less than 54% for yellow paint, relative to magnesium oxide, when tested in accordance with Federal Test Method No. 141.

710.02.2.7--Abrasion Resistance. No less than 180 liters of sand shall be required for removal of the paint film when tested in accordance with Federal Specification TT-P-1952.

710.02.2.8--Glass Bead Adhesion. The test for bead adhesion shall be conducted in accordance with the Abrasion Resistance Test with the exception that the test be modified to require glass beads to be uniformly applied on the paint by gravity flow at the rate of six (6) pounds per gallon for Class A, Standard, beads and 12 pounds per gallon for Class B, High-Visibility, beads. No less than 145 gallons of sand shall be required for the removal of the beaded film. The application of the glass beads is to be a separate operation, but applied at the same time as the paint.

710.02.2.9--Bleeding. The paint shall have a minimum bleeding ratio of 0.97 when tested in accordance with Federal Specification TT-P-1952. The asphalt saturated felt shall conform to Federal Specification HH-R-590.

710.02.2.10--Scrub Resistance. The paint shall pass 300 cycles minimum when tested in accordance with ASTM D 2486.

710.02.2.11--Freeze-thaw-Stability. The paint shall show no coagulation or change in consistency greater than five (5) Krebs Units, or a decrease in scrub resistance of greater than 10% when tested in accordance with Federal Specification TT-P-1952.

710.02.2.12--Dilution Test. The paint shall be capable of dilution with water at all levels without curdling or precipitation such that the wet paint can be readily cleaned up with water only.

710.02.2.13--Storage Stability. After 30 days storage in a three-quarters filled, closed container, the paint shall show no caking that cannot be readily remixed to a smooth, homogeneous state, no skinning, livering, curdling, or hard settling. The viscosity shall not change more than five (5) Krebs Units from the viscosity of the original sample.

710.02.2.14--Acceptance Procedure. The traffic paint must be obtained from a manufacturer on the Department's APL for traffic paint manufacturers. Acceptance will be based on results of tests performed by the Central Laboratory on random samples obtained from delivered batches. Certification, sampling and acceptance shall be in accordance with the requirements of the Department's *Materials Division Inspection, Testing, and Certification Manual* and the Department's SOPs.

710.03--Inorganic Zinc Rich System.

710.03.1--Inorganic Zinc Primer. The shop coat or prime coat shall be a self-curing multiple component inorganic zinc rich primer conforming to the requirements of AASHTO M 300, Type I or Type II. The inorganic zinc rich primer, as applied, shall meet State and Federal regulations on Volatile Organic Compounds (VOC).

The inorganic zinc primer shall be formulated so as to produce a distinct contrast in color with the blast cleaned metal surface and the intermediate field coat to be applied thereon.

The inorganic zinc primer must be one from the Department's APL.

The paint manufacturer's technical representative who is certified by the National Association of Corrosion Engineers (NACE) shall be present at the beginning of coating operations as needed to provide technical expertise in the application of the coating. This technical expertise shall be provided without additional cost to the Department. The fabricator is responsible for arranging for the presence of the manufacturer's technical representative.

710.03.2--Epoxy Mastic Field Touch-Up Paint. Inorganic zinc primer coat that has been damaged during storage, handling, transporting and/or erection shall be repaired using epoxy mastic touch-up paint prior to finish coating. Epoxy mastic touch-up paint shall be manufactured or recommended by the supplier of the inorganic zinc primer, shall be as listed on the Department's APL and, as applied, shall be VOC compliant with State and Federal Regulations.

The epoxy mastic touch-up paint shall conform to the same formulation as originally approved by the Department. Determination of conformance to the originally approved formulation will be based on physical tests and infrared spectrum. The results of these tests shall be in agreement with the results obtained on the originally approved formulation.

710.03.3--Acrylic Latex Intermediate and Top Coats, Field Coats. The acrylic latex field coats shall be manufactured by the supplier of the inorganic zinc primer coat, shall be as listed on the Department's APL and, as applied, shall be VOC compliant with State and Federal regulations. The acrylic latex paint shall conform to the same formulation as originally approved by the Department.

Determination of conformance to the originally approved formulation will be based on physical tests and infrared spectrum of the vehicle component. The infrared spectrum, 2.5 to 15 microns, of the vehicle component shall agree with the infrared spectrum of the vehicle component of the originally approved paints in both peak position and relative intensity of the peaks.

The color of the acrylic latex intermediate coat shall be white in color. The color of the acrylic latex top coat shall be light gray in color.

At the Engineer's request, the paint manufacturer's technical representative who is certified by the National Association of Corrosion Engineers shall be present at the job site at the beginning of each separate coating operation as needed to provide technical expertise in the application of the field coats. This technical expertise shall be provided without additional cost to the Department. The Contractor shall be responsible for arranging for

the presence of the manufacturer's technical representative.

710.03.4--Mixing of Paint. All paint shall be mixed in accordance with the paint manufacturer's printed instructions.

710.03.5--Packaging and Marking. Multiple component paints shall be furnished in premeasured packages so as to form one unit of mixed paint when mixed with the vehicle in its container.

The containers for all paints shall be coated as necessary to prevent attack by the paint. Each container shall bear a label with the following information shown thereon: name and address of manufacturer, trade mark or trade name, kind of paint, date of manufacture and lot number, mixing instructions and equipment clean-up instructions. The VOC content shall be stated either on the label, product data sheet, or Material Safety Data Sheet.

710.03.6--Acceptance Procedure. Prior to use, the Contractor must furnish the Engineer a certificate from the manufacturer, covering each lot of paint in the shipment, attesting that the paint in the shipment conforms to the same formula as that originally approved by the Department.

Final acceptance of the paint will be based on results of tests performed by the Central Laboratory on samples obtained by the Department's representative prior to or after delivery. The use of any lot of paint prior to its final acceptance shall be prohibited.

710.04--Epoxy Mastic System. The coating system shall consist of a modified epoxy mastic prime coat with a uniform dry film thickness of not less than five nor more than eight mils and a vinyl finish coat of not less than three nor more than five mils.

710.04.1--Prime Coat. The prime coat shall be a two-component epoxy mastic designed as a one-coat high-build complete protective coating system with excellent adhesion to rusted steel and old coating systems after such surfaces have been cleaned as specified.

710.04.1.1--Pigment. The silica and metallic aluminum pigment shall include rust inhibitors and adhesion reinforcers / promoters. The aluminum factor shall contain both leafing and non-leafing types.

710.04.1.2--Vehicle. The vehicle shall be a modified epoxy-polyimide resin formulated to have suitable insensitivity to moisture and shall contain special wetting agents to ensure adequate adhesion.

710.04.1.3--Mixed Paint. The mixed paint shall conform to the following requirements:

- (a) The catalyzed epoxy shall contain $92\pm 2\%$ solids by weight when tested in accordance with ASTM D 1644, modified to a drying time of 72 hours at 100°F.
- (b) Total solids by volume shall be a minimum of 90%.
- (c) The coating shall air cure to a hard, tough film within five days at a temperature of 75°F. It shall be dry to the touch in 24 hours at 75°F.
- (d) The usable pot life of the mixed paint shall be not less than four hours at 75°F and two hours at 90°F.
- (e) It shall exhibit good compatibility with inorganic zinc primers.
- (f) The color shall contrast with the steel and the finish coat.

- (g) The catalyzed mixture, after thinning 20% by volume with specified thinner, shall be suitable for spraying in one coat to a 10 mil wet thickness without exhibiting runs or sags.
- (h) The coating shall be suitable for application with both conventional and airless spray equipment.

710.04.1.4--Packaged Qualities. The paint shall be supplied as a two-package material with a one-to-one mixing ratio and shall be well ground and not caked, skinned or badly settled in the container. Usable shelf life shall be not less than 12 months.

710.04.1.5--Flexibility Test. A five mil dry film thickness of paint shall be applied to one side of a 4-inch x 30-inch x 1/8-inch steel panel that has been cleaned in accordance with Steel Structures Painting Council SSPC-SP-5, Commercial Blast Cleaning. After the coating has been cured for two weeks at 75°F, it shall show no signs of cracking or loss of adhesion after the panel is uniformly bent 180 degrees (coated side out) around an eight-inch diameter pin.

710.04.1.6--Resistance Tests. A 3-inch by 5-inch by 1/8-inch test panel meeting the requirements of ASTM D 609 shall be prepared by blast cleaning in accordance with SSPC-SP-6, Commercial Blast Cleaning. After cleaning, the panels shall be exposed to the weather for 30 days to allow uniform rusting. The panels shall then be hand-cleaned with a wire brush in accordance with SSPC-SP-2.

The modified epoxy mastic paint shall be spray applied in one coat to the prepared panels with a uniform dry film thickness of six mils. Curing shall be in accordance with manufacturer's recommendations.

Each test shall be performed on one or more panels, and the paint will be unacceptable if it fails one or more of the following tests:

- (a) Salt Water Resistance. One or more panels shall be scribed with an X of at least two-inch legs down to the base metal and immersed in 5% sodium chloride at 75 ±5°F. The panel(s) shall be examined after 7, 14 and 30 days and shall show neither rusting, blistering, nor softening of the coating beyond 1/16 inch from the scribe mark. The solution shall be changed after each examining period.
- (b) Weathering Resistance. One or more panels shall be tested in accordance with ASTM G 23, Type D. The panel(s) shall be placed on test at the beginning of the wet cycle. After 1,000 hours continuous exposure, the coating shall show neither rusting, blistering, nor loss of bond.
- (c) Salt Fog Resistance. One or more panels shall be scribed with an X of at least two-inch legs down to the base metal. The panel(s) shall then be tested in accordance with ASTM B 117. After 1,000 hours continuous exposure, the coating shall show neither loss of bond, rusting nor blistering beyond 1/16 inch from the scribe mark.

710.04.2--Vinyl Finish Coat, Field Coat. The vinyl finish coat shall be manufactured by the supplier of the prime coat. The vehicle shall consist essentially of vinyl chloride-acetate copolymer resin dissolved in aromatic or ketone and aromatic solvents. The vinyl coat shall display compatibility with, and adhesion to, the cured primer film when applied in accordance with the manufacturer's printed instructions.

710.04.2.1--Composition. The vinyl finish coat shall be gray in color and supplied in a single package at a consistency ready for use. It shall be well ground and not caked, livered, skinned or badly settled in the container.

The vinyl finish coat shall contain not less than 29% pigment and 19% vehicle for a total of no less than 48% solids by weight. The weight per gallon shall be 9.6 ± 0.5 pounds at 77°F. The grind minimum shall be four. Any extender pigments shall be barytes.

The vinyl finish coat shall air dry at temperatures of 70°F or above to a hard tough film within four hours, entirely by evaporation of solvents. It shall be dry-to-touch in 25 minutes at 70°F.

710.04.3--Packaging. Two-component paint shall be packaged so that one unit of pigment can be mixed with the vehicle in its container. The containers for all paints shall be coated as necessary to prevent attack by the paint.

Each container shall be plainly marked with the net weight in pounds, net volume in U. S. gallons, color, code number, batch number(s), the name and address of the manufacturer and the date of manufacture. Each container, or label thereon, shall bear a true statement of the name and percentage of each component or constituent, both solid and liquid. Any package not so marked will be unacceptable.

Each shipment of paint shall be accompanied by complete written instruction and precautions for use, either on the container label or in a separate document.

710.04.4--Acceptance Procedure. Before each shipment is used, the Contractor must furnish the Engineer a certificate from the manufacturer attesting that the commercial product furnished conforms to the same formula as that previously approved.

Final acceptance will be based on results of tests performed on samples obtained by the Department prior to or after delivery. Batches of paint found not to be of the approved formulation will be rejected.

710.05--Primer for Miscellaneous Metals. The primer shall be a commercial product formulated primarily for industrial use, to combine weather durability, resistance to mildly corrosive exposures, with good film build and ease of application with all generally used methods.

710.06--Fast Dry Solvent Traffic Paint. Fast dry solvent traffic paints intended for use under this specification shall include products that are single packaged and ready mixed. Upon curing, these materials shall produce an adherent, reflective pavement marking capable of resisting deformation by traffic. The manufacturer shall have the option of formulating the material according to their specifications. However, the requirements delineated in this specification, Section 619 and Section 710 shall apply regardless of the formulation used. The material shall be free from all skins, dirt and foreign objects.

710.06.1--Composition.

710.06.1.1--Percent Pigment. The percent pigment by weight shall be not less than 51% or more than 58% when tested in accordance with ASTM D 3723.

710.06.1.2--Viscosity. The consistency of the paint shall be not less than 75 nor more than 95 Krebs Units (KU) when tested in accordance with ASTM D 562.

710.06.1.3--Weight per Gallon. The paint shall weigh a minimum 11.8 pounds per gallon and the weight of the production batches shall not vary more than ± 0.5 pounds per gallon from the weight of the qualification samples when tested in accordance with ASTM D 1475.

710.06.1.4--Total Solids. The percent of total solids shall not be less than 70% by weight when tested in accordance with ASTM D 2369.

710.06.1.5--Dry Time (No pick-up). The paint shall dry to a no tracking condition in a maximum of 10 minutes.

710.06.1.6--Volatile Organic Content. The volatile organic content (VOC) shall contain a maximum of 1.25 pounds of volatile organic matter per gallon of total non-volatile paint material when tested in accordance with ASTM D 3960.

710.06.1.7--Bleeding. The paint shall have a minimum bleeding ratio of 0.95 when tested in accordance with Federal Specification TT-P-115D.

710.06.1.8--Color. The initial daytime chromaticity for yellow materials shall fall within the box created by the following coordinates:

Initial Daytime Chromaticity Coordinates (Corner Points)

	1	2	3	4
x	0.53	0.51	0.455	0.472
y	0.456	0.485	0.444	0.4

The initial daytime chromaticity of white materials shall fall within the box created by the following coordinates:

Initial Daytime Chromaticity Coordinates (Corner Points)

	1	2	3	4
x	0.355	0.305	0.285	0.355
y	0.355	0.305	0.325	0.375

710.06.2--Environmental Requirements. All yellow materials using lead chromate pigments shall meet the criteria of non-hazardous waste as defined by 40 CFR 261.24 when tested in accordance with EPA Test Method 1311, Toxicity Characteristics Leaching Procedures (TCLP). The striping and marking material, upon preparation and installation, shall not exude fumes that are toxic, or detrimental to persons or property. All material using lead free pigments shall NOT contain either lead or other Resource Conservation and Recovery Act (RCCA) materials in excess of the standard defined by EPA Method 3050 and 6010.

710.06.3--Acceptance Procedures. Acceptance of all fast dry solvent based traffic paint will be based on the Manufacturer's Certification and Certified Test Results. The Contractor shall furnish the Engineer with three copies of the manufacturer's certification

stating that each lot of material in a shipment complies with the requirements of the contract. In addition, the Contractor shall provide Certified Test Reports for all tests required by this specification. The test results shall be representative of the material contained with the shipment.

710.07--High Build Water Borne Traffic Paint. The high build traffic paint shall be quick dry water-borne traffic paint to be applied on asphalt or concrete pavements. The paint must perform properly when preheated to 110° to 130°F and accept glass beads so that the spheres are imbedded to a depth of 50 percent of their diameter.

All paint materials, including vehicle, pigment, paste, driers, thinners, and mixed paint shall conform to the requirements of these specifications unless otherwise stipulated. Paint shall be furnished ready-mixed or in paste or powder form, as may be specified, and shall be of the type and color shown on the plans or as otherwise indicated. All paints for incorporation in the work shall be manufactured in the United States. Any paint that has caked, hardened or otherwise deteriorated shall not be used.

710.07.1--Sampling and Testing. Sampling and testing of paint shall be in accordance with the appropriate method in Federal Test Method No. 141, ASTM and/or Mississippi Test Method.

Sampling at the option of the Department will be performed at the point of manufacture or at a designated point of delivery. When the paint is sampled at the point of manufacture, the Department representative shall be given full access to the manufacturing process.

The Central Laboratory may utilize x-ray analysis, gas chromatography, infrared, or ultra violet spectral analysis of the paint or its components to determine whether specified ingredients were used. Paint found not to be in compliance with the approved formula shall not be used.

A sample may be taken by the Department at random from the initial shipment of each batch received by the Contractor and forwarded to the Central Laboratory and tested for compliance with all requirements of this specification. If the test results fail, another sample will be taken from the same batch number and re-tested. Unacceptable test results shall be cause to reject the entire batch of traffic paint.

710.07.2--Containers and Marking. Paint shall be shipped in sturdy leak proof containers. The size of the containers shall be at the option of the Contractor unless specified otherwise in the contract.

Each container or label thereon shall be marked as follows:

- Net weight in pounds
- Net volume in U. S. gallons
- Color
- Code number
- Batch number
- Name and percentage of each component
- Name and address of manufacturer
- Date of manufacture

In addition, each container and labeling thereon shall meet the requirements of State and Federal Regulations for transporting the paint.

710.07.3--High Build Paint. This material shall be a rapid setting waterborne compound suitable for use with hot application equipment. The material shall meet the requirements of Table 1. The paint emulsion shall be one listed on the Department's APL. White paint shall contain a minimum of 1.0 pound per gallon of titanium dioxide conforming to ASTM D 476 and the yellow paint shall be Hansa Yellow (11-2400). The paint shall be tested by analytical infrared (IR) spectroscopy.

**Table 1
Water Borne Traffic Paint Physical Properties**

Property	Requirements		Test Method
	Min	Max	
PH	9.9		ASTM E 70
Viscosity, at 25°C Krebs Unit	80	95	ASTM D 562
Drying Time Minutes	--	10	ASTM D 711
Percent Pigment *	55	62	ASTM 3723
Total Solids,%	73	79	ASTM D 2369
Weight Per Gallon, lbs./gal			ASTM D 1475
White	13.7		
Yellow	13.1		
Daylight Reflectance, %			ASTM E 1349
White	Not less than 84%, relative to magnesium oxide	--	Federal Test Method No. 141
Yellow	Not less than 54%, relative to magnesium oxide	--	Federal Test Method No. 141
Color	Pass		ASTM D 6628
Pigment Composition	Pass		See above
IR	Pass		See above

* No theoretical empirical factor shall be applied in determining the pigment percent of the paint. Percent pigment will not be calculated by adding back the burned off organic constituents of the pigment.

Color -- Yellow shall conform to requirements of the Table 2 listed below when tested in accordance with ASTM E 1349.

Table 2
Water Borne Traffic Paint Color Specification Limits (Daytime)

Color	1		2		3		4	
	x	y	x	y	x	y	x	y
Yellow	0.500	0.428	0.470	0.456	0.500	0.483	0.530	0.456

The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 Standard Colorimetric System measured with Standard Illuminant D65.

710.07.4--Glass Beads. Glass beads shall meet the requirements of Subsection 720.01 for Class 'B' High Visibility beads.

SECTION 711 - REINFORCEMENT AND WIRE ROPE

711.01--Deformed and Plain Carbon-Steel Bars for Concrete Reinforcing and Wire Rope - General. All reinforcement used in concrete construction, unless otherwise specified in the plans, shall conform to the provisions and requirements hereinafter set out. When incorporated into the work, reinforcement shall be reasonably free of dirt, paint, oil, grease, loose-thick rust, or other foreign substances and, when deemed necessary, shall be cleaned to the satisfaction of the Engineer. Tight-thin rust or powdering rust shall not be cause to require cleaning. Reinforcement that has rusted sufficiently to cause it to fail to meet specified physical properties or prestressing strands displaying pits visible to the naked eye shall be rejected.

711.02--Deformed and Plain Carbon-Steel Bars for Concrete Reinforcing.

711.02.1-- Deformed and Plain Carbon-Steel Bars for Concrete. Cut lengths and coils of reinforcing steel rebar shall conform to the requirements of AASHTO M 31. Concrete reinforcing shall meet or exceed Grade 60 in AASHTO M 31.

Bars shall be fabricated as indicated on the plans; shall be cold-bent, unless otherwise permitted, to the shapes shown on the plans or as directed; and shall be bent prior to being wholly or partially embedded in concrete.

Unless otherwise authorized or provided on the plans, bends or hooks shall not be fabricated to a smaller diameter than that indicated for the bend test.

Rail steel bars shall be bent to the specified shapes at the mill or fabricating plant.

711.02.2--Welded Deformed Steel Bar Mats for Concrete. Welded deformed steel bar mats for concrete pavement reinforcement shall meet or exceed Grade 60 billet steel according to AASHTO M 31 and shall conform to the requirements of AASHTO M 54.

711.02.3--Steel Welded and Non-Welded Wire Reinforcement, Plain and Deformed, for Concrete. Welded or non-welded concrete reinforcing wire, plain or deformed or a combination thereof, shall meet the following.

711.02.3.1--Plain Steel Wire. Plain steel wire shall conform to the requirements of

AASHTO M 55.

711.02.3.2--Deformed, Welded Steel Wire. Deformed, welded steel wire shall conform to the requirements of AASHTO M 221.

711.02.3.3--Deformed Steel Wire. Deformed steel wire shall conform to the requirements of AASHTO M 225.

711.02.4--Dowel Bars and Marginal Bars. Unless otherwise indicated, dowel bars used to span transverse joints and marginal bars shall be plain round bars. The bars shall meet or exceed, AASHTO M 31, Grade 60.

Before installation, each dowel bar shall be painted with one coat of industrial grade zinc base primer, epoxy or other approved rust inhibitive primers.

One half of each dowel bar shall be greased with a heavy grease equivalent to 600W or cup grease to prevent bonding with concrete. The greased end is to be inserted into the dowel bar sleeve described in the following paragraph.

Sleeves for dowel bars shall be metal or plastic of an approved design, mortar-tight, of sufficient strength to prevent collapse, and at least two inches in length. A suitable stop shall be provided in the sleeve to permit movement of the dowel bar within the sleeve of not less than the thickness of the expansion filler used.

Dowel bars shall be free from burring or other deformations restricting slippage in the concrete.

711.02.5--Tie Bars. Unless otherwise indicated, tie bars used to span longitudinal joints shall be deformed bars, billet steel, meeting the requirements set forth in Subsection 711.02.1.

711.02.6--Cold-Drawn Steel Wire. Cold-drawn steel wire shall conform to the requirements of AASHTO M 32.

711.02.7--Supports for Bar Reinforcement. Metal bar supports shall be fabricated from stainless steel wire conforming to ASTM A 493, 16% chromium minimum, or cold-drawn wire with a minimum of 1/2 inch of the height of the leg above the form surface protected by one of the following:

- (a) Plastic coating conforming to CRSI Standards;
- (b) Galvanized, conforming to AASHTO M 232, Class D;
- (c) Stainless steel conforming to ASTM A 493, 16% chromium minimum;
- (d) Other protective coating as approved by the Engineer; or
- (e) Other supports as approved by the Engineer may be used.

711.02.8--Epoxy Coated Bar Reinforcement. All reinforcement bars required to be epoxy coated shall conform to the requirements of ASTM A 775. The Contractor shall furnish written certification that the coated reinforcing bars were cleaned, coated and tested in accordance with the specifications and ASTM A 775.

711.02.9--Corrosion Resistant Reinforcement. Corrosion Resistant Reinforcement (CRR) bars shall conform to the requirements of ASTM A 1035 CS, Grade 100 deformed bars.

711.02.10--Blank.

711.02.11--Stainless Steel Reinforcement. When indicated or specified, hot rolled deformed stainless steel reinforcement bars shall be in accordance with ASTM A 955, Grade 60 meeting one of the following UNS Designations: S24100, S30400, S31653, or S31803.

711.03--Reinforcement for Prestressed Concrete.

711.03.1--Pretensioning Reinforcing.

711.03.1.1--Steel Strand, Uncoated Seven-Wire for Concrete Reinforcement. Steel uncoated seven-wire used in pretensioned and post-tensioned prestress concrete construction shall conform to the requirements of AASHTO M 203.

711.03.1.2--Uncoated Stress-Relieved Steel Wire for Prestressed Concrete. Uncoated stress-relieved round, high carbon steel wire for prestressed linear concrete construction shall conform to the requirements of AASHTO M 204.

711.03.2--Posttensioning Reinforcing.

711.03.2.1--Bars. Bars for posttensioning shall be of high tensile strength steel. They shall be equipped with wedge-type anchorages that will develop the minimum specified ultimate bar stress on the nominal bar area.

The minimum physical properties of the bar steel and the stress-strain curve determined by static tensile tests, shall conform to the following:

Stress at 0.3% elongation, psi	-----	75,000
Stress at 0.7% elongation, psi	-----	130,000
Ultimate stress, psi	-----	145,000
Elongation in 20 diameters, %	-----	4
Modulus of elasticity, psi	-----	25,000,000

The diameter tolerance of the bar steel shall be from -0.010 to +0.02375 inch.

711.03.2.2--Parallel Wire Assemblies. Wire assemblies for post-tensioning shall consist of parallel wires of the number and size shown on the plans. Wires shall conform to the requirements of AASHTO M 204.

711.03.3--Anchorages for Post-Tensioned Tendons.

711.03.3.1--For Bars. Wedge-type anchorages shall be used for bars. The wedge device shall develop the minimum ultimate strength specified for the nominal bar area.

Wedge anchorages shall bear against anchor plates fabricated of hot-rolled steel having

physical characteristics not less than that specified for No. 104 of American Iron and Steel Institute (AISI) Specifications.

711.03.3.2--For Parallel Wire Assemblies. Wedge or direct-bearing type anchorage shall be used, generally. The anchorage device shall be capable of developing the ultimate strength of the total number of wires anchored. Conical type anchorages shall be embedded within the ends of the concrete members unless otherwise specified. Anchorages shall generally bear against grids of reinforcing steel of approved type.

711.03.3.3--Alternate Anchorage Types. Alternate anchorage types conforming to the general physical requirements for wedge or direct-bearing type anchorages will be permitted. All anchorage types shall develop the specified ultimate strength of the reinforcing tendons, or the allowable stress of the tendon will be based on the anchorage strength.

As a specific exception, threaded anchorages not on upset or oversize reinforcing ends will not be considered for approval.

Any alternate type anchorage, before being considered, will be required to show evidence of being capable of withstanding at least 3,000,000 cycles of twice the maximum live load stress variation.

711.03.4--Tests for Prestressing Reinforcing. The Engineer shall be furnished with three certified copies of test results for all tests specified below. These tests shall be performed by the manufacturer or a recognized commercial laboratory at no additional cost to the State. The Engineer or Engineer's representative shall have the privilege of witnessing any or all tests.

711.03.4.1--Strand. The physical characteristics of strand shall be determined in accordance with AASHTO M 203.

711.03.4.2--Bars.

711.03.4.2.1--Proof Test. During manufacture, each bar shall be proof tested to a minimum stress of 130,000 psi.

711.03.4.2.2--Static Test. From each mill heat, one static test shall be made on an assembled bar and anchorage to determine the physical properties of the steel and the assembly. Such physical properties shall conform to the minimum physical properties hereinbefore specified.

711.03.4.3--Wires and Wire Anchorages. One static test shall have been made from each five coils received, except that at least one static test shall have been made for each shipment. For each 500 anchorages received, or fraction thereof, one anchorage assembly shall have been tested statically to destruction.

711.04--Synthetic Structural Fiber. The synthetic structural fibers shall be approved for listing in the Department's APL prior to use. The synthetic structural fibers shall be added to the concrete and mixed in accordance with the manufacturer's recommended methods.

711.04.1--Material Properties. The fibers shall meet the requirements of ASTM C 1116, Section 4.1.3. The fibers shall be made of polypropylene, polypropylene/polyethylene blend, nylon, or polyvinyl alcohol (PVA).

711.04.2--Minimum Dosage Rate. The dosage rate shall be such that the average residual strength ratio ($R_{150,3.0}$) of fiber reinforced concrete beams is a minimum of 20.0 percent when the beams are tested in accordance with ASTM C 1609.

The fiber manufacturer shall have the fibers tested by an acceptable, independent laboratory acceptable to the Department and approved and in good standing with a Cement and Concrete Reference Laboratory (CCRL), or AASHTO accredited laboratory and approved to perform AASHTO T 22, T 97, and R 39.

The laboratory shall test the fibers following the requirements of ASTM C 1609 in a minimum of three (3) test specimens cast from the same batch of concrete, molded in 6 x 6 x 20-inch standard beam molds meeting the requirements of AASHTO T 23. The beams shall be tested on an 18-inch span. The tests for $R_{150,3.0}$ shall be performed when the average compressive strength of concrete used to cast the beams is between 3500 and 4500 psi. The tests for compressive strength shall follow the requirements of AASHTO T 22. The average compressive strength shall be determined from a minimum of three (3) compressive strength cylinders.

The value for $R_{150,3.0}$ shall be determined using the following equation:

$$R_{150,3.0} = \frac{f_{150,3.0}}{f_1} \times 100$$

The residual flexural strength ($f_{150,3.0}$) shall be determined using the following equation:

$$f_{150,3.0} = \frac{P_{150,3.0} \times L}{b \times d^2}$$

where:

$f_{150,3.0}$ is the residual flexural strength at the midspan deflection of $L/150$, (psi),

$P_{150,3.0}$ is the residual load capacity at the midspan deflection of $L/150$, (lbf),

L is the span, (in),

b is the width of the specimen at the fracture, (in), and

d is the depth of the specimen at the fracture, (in).

For a 6 x 6 x 20-inch beam, the $P_{150,3.0}$ shall be measured at a midspan deflection of 0.12 inch.

Additionally, $R_{150,3.0}$, $f_{150,3.0}$, and $P_{150,3.0}$ may also be referred to as R_{150}^{150} , f_{150}^{150} , and P_{150}^{150} respectively.

At the dosage rate required to achieve the minimum $R_{150,3.0}$, the mixture shall both be workable and the fibers shall not form clumps.

The manufacturer shall submit to the State Materials Engineer certified test reports from the independent laboratory showing the test results of each test specimen.

711.04.3--Job Control Requirements. The synthetic structural fibers shall be one from the Department's APL.

At the required dosage rate, the mixture shall be workable and the fibers shall not form clumps to the satisfaction of the Engineer. If the mixture is determined by the Engineer to not be workable or have clumps of fibers, the mixture may be rejected.

SECTION 712 - FENCE AND GUARDRAIL

712.01-- General. Each of the several items included under this section shall be of the design, shape, size, and dimensions shown on the plans or set out in these specifications. The connections with all intersecting fences, bridges, and culvert headwalls shall be as shown on the plans.

712.02--Barbed Wire. Barbed wire shall conform to the requirements of AASHTO M 280. In the coastal counties of Hancock, Harrison, and Jackson, Coating Type Z Class 3, Coating Type ZA Class 80, or Coating Type A shall be furnished. Coating Type Z Class 1, Coating Type ZA Class 40, or Coating Type A or superior corrosion resistant coating system shall be furnished for all other areas of the State.

712.03--Metallic-Coated, Steel Woven Wire Fence Fabric. Woven wire fencing shall conform to the requirements of AASHTO M 279. In the coastal counties of Hancock, Harrison, and Jackson, Coating Type Z Class 3, Coating Type ZA Class 80, or Coating Type A shall be furnished. Coating Type Z Class 1, Coating Type ZA Class 40, or Coating Type A or superior corrosion resistant coating system shall be furnished for all other areas of the State.

712.04--Chain Link Fence. Details will be shown on the plans or in the special provisions. Chain link fence shall conform to the requirements of AASHTO M 181 and have hardware designed to support fabric in a vertical, taut position. This specification covers fences and gates that comprise of chain link fence fabric, posts, rails, tie wire, tension wire, bands, bards, rods, fittings and other hardware.

The Contractor shall furnish the Engineer with manufacturer's or fabricator's test results and other data certifying that materials furnished for construction of all types of chain link fence comply with the requirements set out in these specifications. The Engineer reserves the right to retest all materials.

712.04.1--Fabric. In the coastal counties of Hancock, Harrison, and Jackson, Type I Class D or Type II, Type III, and Type IV fabrics that provide a superior corrosion resistance coating systems to Type I Class D shall be furnished. Type I Class C or Type II, Type III, and Type IV fabrics that provide a superior corrosion resistance coating systems to Type I Class C shall be furnished for all other areas of the State.

712.04.2--Tie Wire. Tie wire shall be of the same material as the fencing wire being used, shall be of good commercial quality, and shall meet the requirements of AASHTO M 181. In the coastal counties of Hancock, Harrison, and Jackson, Type I Class 3 or Type II, Type III, and Type IV tie wire that provide a superior corrosion resistance coating systems to Type 2 Class 3 shall be furnished. Type I Class 1 or Type II, Type III, and Type IV tie wire that provide a superior corrosion resistance coating systems to Type I Class 2 shall be furnished for all other areas of the State. Aluminum-coated tie wire shall meet AASHTO M 181 Section 25 – Mass of Coating (Tension Wire).

712.04.3--Tension Wire. Tension wire shall be of the same material as the fencing wire being used, shall be of good commercial quality, and shall meet the requirements of AASHTO M 181. In the coastal counties of Hancock, Harrison, and Jackson, Type I Class 3 or Type II, Type III, and Type IV tension wires that provide a superior corrosion resistance coating systems to Type 2 Class 3 shall be furnished. Type I Class 1 or Type II, Type III, and Type IV tension wires that provide a superior corrosion resistance coating systems to Type I Class 2 shall be furnished for all other areas of the State. Aluminum-coated tension wire shall meet AASHTO M 181 Section 25 – Mass of Coating (Tension Wire).

712.04.4--Metal Posts, Rails, Tie Wire, Tension Wire, Bands, Barbs, Rods, Fittings And Other Hardware. Details for these items will be shown on the plans or in the special provisions. These other components of fence system shall conform to the requirements of AASHTO M 181 and ASTM F 1083 and/or ASTM F 1043. This includes round steel post, method of manufacture, pipe size and weight, pipe strength, protective coatings, steel tee post, steel H-beam post, and gate frames. Protective corrosion resistance coating systems shall meet AASHTO M 181 Grade 2.

712.04.5--Steel Fence Post and Assemblies, Hot-Wrought. Steel tee posts, tee, channel or U, Y-Bar, H-Post and angle shapes shall meet the requirements of AASHTO M 281, galvanized in accordance with the requirements of AASHTO M 111, unless otherwise specified in the contract. Acceptance of the steel posts shall be by certification from the manufacturer, producer, supplier, or fabricator, as applicable.

712.04.6--Aluminum-Alloy Posts and Assemblies. Round aluminum-alloy posts shall meet the requirements of ASTM B 241, Alloy 6061, T6. Aluminum-Alloy H-Beam posts shall meet the requirements of ASTM B 221, Alloy 6061, T6.

712.04.7--Formed Steel Section Posts. Formed steel section posts, "C" sections, shall be formed from sheet steel conforming to ASTM A 1011, Grade 45, and shall be galvanized in accordance with ASTM A 123.

712.05--Fence Posts and Braces. Temporary silt fence post shall be accepted by certification based on manufacturer's requirements based on industry standards for road construction.

712.05.1--Treated Timber Posts and Braces.

712.05.1.1--General. All wood posts and braces shall be Southern Pine and shall be furnished in the sizes shown on the plans or as otherwise specified.

Insofar as practicable, each charge shall consist of pieces approximately equal in size,

moisture, and sapwood content into which approximately equal quantities of preservative can be injected. Each layer of material shall be separated at each end, and at the center when necessary, by strips at least 3/8 inch in thickness.

All wood posts and braces shall be treated in accordance with American Wood Protection Association (AWPA) Standard Specifications for Highway Construction, except the type of preservative shall conform to Subsection 718.04. Only one type of preservative shall be used for the treatment of materials for any one class of construction on a project, unless otherwise specified.

Posts and braces will not be accepted for use unless they have been inspected by an authorized representative of the Department and found to be satisfactory both before and after treatment. Inspection prior to treatment may be waived by the State Materials Engineer when the preservative will be pentachlorophenol or chromated copper arsenate.

Inspection for conformance to these specifications will be conducted in accordance with Department SOP. Borer cores for determining the amount of preservative retained and the penetration of preservative will be obtained in accordance with Standard M2. The test method for determining the amount of preservative retained will be either as specified in AWPA or Mississippi Test Methods. All borings shall be taken at the center of the narrow side of the piece. Test holes shall be plugged with treated plugs. If 20% or more of the borings from a charge of treated material fail to meet the penetration requirements, the entire charge shall be rejected and subject to retreatment. If upon retreatment, the material meets the penetration requirements it will be accepted provided all other characteristics conform to the specifications. Only one retreatment will be permitted, and any apparent damage due to retreatment shall be cause for rejection.

The Department shall be notified sufficiently in advance of treating the material so that an inspector may be furnished at the plant to inspect the material and the treatment of same. All materials and processes used in the manufacture of the materials shall be subject to inspection. The plant shall be equipped with the necessary gauges, thermometers, appliances, and facilities to enable the inspector to determine the conditions at all stages of the treatment and to satisfy the inspector that the requirements of the specifications are fulfilled. The manufacturer shall also provide the apparatus and chemicals necessary for making tests at the plant as required by the Department. All equipment, apparatus, etc., shall be maintained in proper and satisfactory condition for use at all times.

712.05.1.2--Round Posts. Unless otherwise indicated, wood line posts shall be round, shall be cut from sound and solid trees, and shall be free from short or reverse bends in more than one plane. A straight line from center of tip to center of butt shall not deviate outside the post. Posts shall be free of ring shake, season cracks more than 1/4 inch wide, splits in the end, and unsound knots. Sound knots will be permitted provided the width of the knot does not exceed 1/3 the diameter of the post at the point where it occurs. Groups of knots or any combination of defects impairing the strength more than the maximum size knot will not be permitted. The posts shall show not less than three annual rings per inch, and not less than 30% of summer wood.

The size of round posts will be specified in even inches of diameter at the top (smaller) end and shall not vary more than 1/2 inch from the specified diameter - i.e., nominal four-inch posts may vary between 3 1/2 inches and 4 1/2 inches, and nominal six-inch posts may vary between 5 1/2 inches and 6 1/2 inches. This diameter shall be determined from the

circumference after peeling. In the case of ovate (not true round) posts, the maximum diameter shall not be more than 20 percent greater than the minimum diameter, direct measure. The maximum allowable increase of diameter at the butt shall be at the rate of 1½ inches in 10 feet. A tolerance of ±2 inches will be allowed in the specified length.

Prior to treatment, round posts shall be machine peeled for their full length, with all bark and inner skin removed and all knots or projections trimmed flush with the surface of the surrounding wood. The ends shall be sawed square. Treatment shall be in accordance with AWP Standard C14.

712.05.1.3--Sawed Posts. Sawed fence posts shall conform to the shape and nominal dimensions shown on the plans. They shall be No. 1 or better, graded in accordance with American Lumber Standards. Treatment will be in accordance with AWP Standard Specifications for Highway Construction.

712.05.1.4--Sawed Braces. Sawed braces shall conform to the shape and nominal dimensions shown on the plans. They shall be No. 1 or better, graded in accordance with American Lumber Standards. Treatment will be in accordance with AWP Standard Specifications for Highway Construction.

712.05.2--Blank.

712.05.3--Concrete Posts.

712.05.3.1--Manufacture. Concrete posts shall be manufactured in accordance with the details shown on the plans and shall conform to the requirements hereinafter set forth. Posts shall receive a Class 1 finish as noted in Subsection 804.03.19. Where indicated on the plans, holes and bolts shall be accurately cast in the members at the time of pouring. Posts shall be cured at least seven days.

712.05.3.2--Materials. The materials used in the manufacture shall conform to the following:

- (a) Cement shall meet the requirements of Section 701.
- (b) Aggregates shall meet the requirements of Subsections 703.02 and 703.03, except that the requirements for gradation are not applicable.
- (c) Reinforcing steel shall meet the requirements of Section 711.
- (d) The concrete shall have a minimum cement factor of 1.25, or five bags of cement to a cubic yard of concrete.

712.05.3.3--Strength Requirements. The strength of concrete posts shall be determined by the beam method. When loaded at the midpoint of an 18-inch span with three edge bearing, the unit shall develop at least 6,000 pounds total load for a four-inch by four-inch post, or 12,000 pounds total load for a six-inch by six-inch post.

Two specimens will be tested for each 200 posts - one to destruction and one to the ultimate load specified above.

712.06--Guard and Guardrail Posts.

712.06.1--General. Unless otherwise specified, guard posts may be wood, steel, or

concrete, and guardrail posts may be either wood or steel. All guard and guardrail posts materials shall conform to the dimensions and requirements as shown on the plans or as set out in these specifications.

712.06.2--Treated Wood Posts. Treated wood posts shall conform to the size and dimensions as shown on the plans and as hereinafter specified.

712.06.2.1--Square Posts. All square posts shall be inspected in accordance with Section 718 except that the posts may be rough and shall be within $\pm 3/8$ " of the dimensions shown on the plans. Treatment will be in accordance with AWPAs Standard Specifications for Highway Construction.

712.06.2.2--Round Posts. All round posts shall be inspected and treated in conformity with Subsection 712.05.1 and shall be of the shape and dimensions as shown on the plans.

712.06.3--Concrete Posts. Concrete posts shall conform to the requirements of Subsection 712.05.3.

712.06.4--Steel Posts. Steel posts shall be of the section and length as shown on the plans and shall conform to the requirements of ASTM A 36.

The posts shall be galvanized or shop-painted as specified.

712.06.5--Treated Wood Blocks for Use with Metal Guardrail Posts. Treated wood blocks for use with metal guardrail posts shall be within $\pm 3/8$ -inch of the size and dimensions shown on the plans, except that a minus tolerance shall not be allowed for the slotted width in which the metal post must fit. Preservative treatment shall be in accordance with AWPAs Standard Specifications for Highway Construction.

The blocks must be obtained from approved manufacturers listed on Department's APL for suppliers of treated wood products. The manufacturer's approval will be based on their Quality Control Program for material certification. The manufacturer shall employ a certified material grader and treatment inspector who will be responsible for grading and inspecting the treated material. The inspector's certification shall be from an approved industrial organization such as AWPAs, SPIB or American Lumber Standard. The manufacturer's certification shall be based on satisfactory grading, dimensional measurements, and treatment results. The manufacturer shall provide the Contractor two copies of their material certification and treatment report for each charge of material delivered. Also, a copy of these documents shall be mailed to the State Materials Engineer for all blocks shipped for use on Department projects.

The manufacturer shall brand each block with the following information:

- (1) manufacturer's logo or initials (XYZ)
- (2) manufacturer's plant location
- (3) species of wood (SYP)
- (4) treatment type (CCA-C)
- (5) minimum preservative retention by assay (0.50)

The Contractor, prior to installation of the blocks, shall furnish a copy of the manufacturer's certification and treatment report covering the blocks to be installed to the

Department's representative.

The Project Engineer, or the Project Engineer's designated representative, will inspect each block prior to installation for proper dimensions, identification and damage or other deficiency prior to permitting installation of the blocks. The Project Engineer will notify the State Materials Engineer when blocks are delivered to the project and report any deficiencies found. The State Materials Engineer will, at the State Materials Engineer's discretion, dispatch an inspector to the project for inspecting and boring the blocks for an assay test. Final acceptance of the blocks will be based on satisfactory field inspection and satisfactory test results when field sampling is performed.

712.07--Metal Rail. Metal rail for guardrail shall conform to the requirements of AASHTO M 180 and as specified on the plans.

712.08--Timber Rail. Timber rail shall conform to the requirements of Section 718 and as specified on the plans.

712.09--Guardrail Hardware. Guardrail hardware such as bolts, nuts and washers shall conform to the requirements of ASTM A 307 except specified bolts, as shown on the plans, shall meet the requirements of ASTM A 325 or AASHTO M 164. Galvanizing may be hot-dipped or by a mechanical method all in accordance with ASTM A 153, except for method of coating.

712.10--Box Beam Rail. Steel beam rail elements shall conform to the requirements of ASTM A 500 or ASTM A 501 and shall be galvanized after fabrication in accordance with AASHTO M 111. When corrosion resistant steel rail elements are specified, rail elements shall be made of steel meeting the dimensional and mechanical requirements of ASTM A 500 or ASTM A 501, shall have an atmospheric corrosion resistance approximately two times that of carbon structural steel with copper, and shall not be painted or galvanized. Posts shall conform to Subsection 712.06 and hardware to Subsection 712.09.

712.11--Guardrail Cable and Anchorage. Cable shall meet the requirements of AASHTO M 30 for Type II wire rope.

The anchor rod shall be fabricated of steel conforming to the requirements of ASTM A 36. The eye may be drop forged or formed with a full penetration weld and shall develop 100 percent of the rod strength.

The swaged fitting and stud assembly shall be of steel conforming to the requirements of ASTM A 576, Grade 1035 and shall be annealed and suitable for cold swaging. The fitting shall be galvanized in accordance with ASTM A 123 before swaging. The studs shall conform to the requirements of ASTM A 449 and shall be galvanized as set forth for guardrail hardware. The swaged fitting, stud and nut shall develop the breaking strength of the wire rope. Three certified copies of the manufacturer's certificate attesting to the strength of the swage fittings shall be furnished to the State Materials Engineer.

712.12--Gates.

712.12.1--Slatted Aluminum Gates. Slatted aluminum gates shall be of the design and dimensions as shown on the plans. Members, parts, and accessories shall be formed of an aluminum alloy having a high resistance to corrosion. Minimum nominal thickness of

members shall be 0.051 inch for horizontals and 0.040 inch for diagonals and verticals.

Aluminum gates shall be tightly riveted construction and after erection shall not show any sag or warp. The gates shall be equipped with satisfactory hinge supports and latch or aluminum chain with steel snap.

712.12.2--Galvanized Ferrous Metal Gates. Galvanized ferrous metal gates shall be of the design and dimensions as shown on the plans. The gates shall be fabricated from 24-gauge or heavier metal with rigid construction, and after erection the gates shall not show any sag or warp. Steel sheets used in fabricating gates shall be hot dip galvanized in accordance with ASTM A 653, G 60 Coating Designation.

712.12.3--Aluminum-Zinc Alloy Coated Metal Gates. Aluminum-zinc alloy metal gates shall be of the design and dimensions as shown on the plans. The gates shall be fabricated from 24-gauge or heavier metal with rigid construction, and after erection the gates shall not show any sag or warp. Steel sheets used in fabricating gates shall be coated with an aluminum-zinc alloy by the hot-dip process. The coating shall have a nominal chemical composition of 55.0% aluminum, 43.4% zinc and 1.6% silicon. The chemical analysis of the coating shall agree with the nominal composition within $\pm 3\%$ for aluminum and zinc, and within $\pm 0.5\%$ for silicon. The minimum weight of coating shall be 0.5 ounce per square foot total both sides when tested in accordance with AASHTO T 65.

712.12.4--Aluminum Coated Metal Gates. Aluminum coated metal gates shall be of the design and dimensions as shown on the plans. The gates shall be fabricated from 24-gauge or heavier metal with rigid construction, and after erection shall not show any sag or warp. Steel sheets used in fabricating gates shall be coated with aluminum by the hot-dip process. The coating shall meet the chemical requirements of AASHTO M 274. The minimum weight of coating shall be 0.4 ounce per square foot total on both sides when tested in accordance with AASHTO T 213.

712.12.5--Fabric Filled Gates. The gate frame shall be constructed from pipe meeting the requirements of ASTM F 1083, Schedule 40, and to the design and dimensions as shown on the plans. All connections shall be welded and watertight. The entire frame shall be hot dip galvanized after welding.

712.12.6--Acceptance Procedure. The Contractor shall furnish the Engineer three copies of the manufacturer's certification attesting that the gates furnished comply with the requirements of the contract.

712.13--Blank.

712.14--Blank.

712.15--Staples. Unless otherwise specified, staples shall be made of 9-gauge galvanized steel wire and shall be of the shape and size shown on the plans. The galvanizing shall be commercial quality uniformly applied zinc coating.

712.16--Other Tie Wire, Fence Post, Metal Posts, Rails, Tension Wire, Bands, Barbs, Rods, Fittings and Other Hardware. Unless otherwise specified, these products shall meet the requirements of Subsection 712.04.

SECTION 713 - CONCRETE CURING MATERIALS AND ADMIXTURES

713.01--Curing Materials. Concrete curing agents, including water and earth, shall be free of any ingredients that may damage or be detrimental to the concrete. Such agents, unless otherwise specified, shall conform to the requirements hereinafter set forth.

713.01.1--Burlap Cloth. Burlap to be used for curing concrete shall conform to the requirements of AASHTO M182.

Class 3 burlap shall be used by placing one or two layers as required. The substitution of other classes may be made, provided their combined weight will equal or exceed the weight required.

713.01.2--Liquid Membrane Compound. Membrane-forming compound for curing concrete shall conform to the requirements of ASTM C 309.

Unless otherwise specified, only Type 2, White Pigmented, will be permitted for use.

Type 1-D compound may be used on bridge rails, median barriers, and other structures requiring a spray finish. When Type 1-D compound is used, it will be the responsibility of the Contractor to assure that the compound has dissipated from the structure prior to applying the spray finish and that the spray finish adheres soundly to the structure.

The use of liquid membrane for curing concrete surfaces that require a rubbed finish or faces of construction joints will not be permitted.

713.01.3--Polyethylene Sheeting. White polyethylene sheeting shall conform to the requirements of ASTM C 171 for white opaque polyethylene film.

713.02--Admixtures for Concrete. Air-entraining admixtures used in hydraulic cement concrete shall comply with AASHTO M 154. Set-retarding, and/or water-reducing admixtures shall comply with AASHTO M 194. Water-reducing admixture shall meet the minimum requirements for Type A. Set-retarding admixtures shall meet the minimum requirements for Type D. Admixtures providing a specific performance characteristic(s) other than those of water reduction or set retardation shall meet the minimum requirements for Type S. For admixtures meeting the requirements for Type S, the manufacturer shall provide data to substantiate the specific performance characteristic(s) to the satisfaction of the State Materials Engineer.

In order to obtain approval of an admixture, certified test reports, made by an acceptable independent laboratory approved and in good standing with the Cement and Concrete Reference Laboratory (CCRL) or AASHTO accredited laboratory, which show that the admixture meets all the requirements of the applicable AASHTO Standard Specification, shall be furnished to the State Materials Engineer.

The Department reserves the right to sample, for check tests, any shipment or lot of admixture delivered to a project.

The Department reserves the right to require tests of the material to be furnished, using the specific cement and aggregates proposed for use on the project, as suggested in AASHTO

M 154 and outlined in AASHTO M 194.

After an admixture has been approved, the Contractor shall submit to the State Materials Engineer, with each new lot of material shipped, a certification from the manufacturer in accordance with the requirements of Subsection 700.05.1 stating that the material is of the same composition as originally approved and has not been changed or altered in any way. The requirement in Subsection 700.05.1(b) is not required on the certification from the manufacturer.

Failure to maintain compliance with any requirement of these specifications shall be cause for rejection of any previously approved source or brand of admixture.

Admixtures shall only be used in accordance with the manufacturer's recommended dosage range as set forth in the manufacturer's approval request correspondence. When an admixture is used in hydraulic cement concrete, it shall be the responsibility of the Contractor to produce satisfactory results.

713.02.1--Source Approval. In order to obtain approval of an admixture, the Producer/Suppliers shall submit to the State Materials Engineer the following for review: certified test reports, made by an acceptable independent laboratory regularly inspected by and approved and in good standing with the Cement and Concrete Reference Laboratory (CCRL) or AASHTO accredited laboratory, which show that the admixture meets all the requirements of the applicable AASHTO or Department Specification for the specific type and the dosage range for the specific type of admixture.

713.02.2--Specific Requirements. Admixtures containing chlorides will not be permitted.

713.02.3--Acceptance. The Department reserves the right to sample, for check tests, any shipment or lot of admixture delivered to a project.

The Department reserves the right to require tests of the material to be furnished, using the specific cement and aggregates proposed for use on the project, as suggested in AASHTO M 154 and outlined in AASHTO M 194.

Failure to maintain compliance with any requirement of these specifications shall be cause for rejection of any previously approved source or brand of admixture.

With each new lot of material shipped the Contractor shall submit to the State Materials Engineer, a notarized certification from the manufacturer that show the material complies with the requirements of the applicable AASHTO or Department Specification.

When an admixture is used, it shall be the responsibility of the Contractor to produce satisfactory results.

713.02.4--Waterproofing Admixture. This product is used as a waterproofing admixture for cast in place concrete bridge decks and bridge deck topping.

The Contractor shall submit to the State Materials Engineer the manufacturer's product data and installation methods for each type of the products required to demonstrate the product complies with specifications.

The materials shall be installed in accordance with manufacturer's instructions.

The waterproofing admixture shall be one listed on the Departments APL.

Any retardation of set that occurs will depend upon the concrete mix design and the dosage rate of the admixture.

SECTION 714 - MISCELLANEOUS MATERIALS

714.01--Water.

714.01.1--General. All water used shall be free from injurious quantities of oil, acid, alkali, or vegetable matter; shall be reasonably clear; and shall not be brackish. If at any time water from source becomes of unsatisfactory quality or of insufficient quantity, the Contractor shall provide satisfactory water from some other source. Where the source of water is relatively shallow, the Engineer may require the intake to be enclosed so as to exclude silt, mud, grass, or other foreign materials.

Requirements for impurities set out in these specifications are general maximums that may be used as a basis for acceptance. However, if the preliminary analysis indicates that any of the specified limits for acidity or alkalinity, organic solids, or inorganic solids are exceeded, the water may be further tested as provided in Subsection 714.01.6 to determine its suitability for the purpose intended.

714.01.2--Water for Use in Concrete. Water used in mixing of concrete, mortar, and grout shall be as set out above. In addition, the water shall not contain impurities in excess of the following limits:

Acidity or alkalinity, calculated in terms of calcium carbonate, % -----	0.05
Total organic solids, % -----	0.05
Total inorganic solids, % -----	0.05

The tests for organic solids and inorganic solids may be waived by the State Materials Engineer on water samples from ponds, lakes, streams, rivers, and ditches in all except the following counties: Pearl River, Stone, George, Hancock, Harrison, and Jackson Counties.

714.01.3--Water for Use in Chemically Stabilized Base. Water used in the construction of bases that contain cement, lime, or other chemical additive shall be as set out in Subsection 714.01.1 and, in addition, shall not contain impurities in excess of the following limits:

Acidity or alkalinity, calculated in terms of calcium carbonate, % -----	0.05
Total organic solids, % -----	0.05
Total inorganic solids, % -----	0.20

The tests for organic solids and inorganic solids may be waived by the State Materials Engineer on water samples from ponds, lakes, streams, rivers, and ditches in all except the following counties: Pearl River, Stone, George, Hancock, Harrison, and Jackson Counties.

714.01.4--Water for Use in Granular Base. Water for use in granular bases may be

brackish.

714.01.5--Water for Use in the Planting and Establishment of Vegetation. Water used for planting and establishment of vegetation shall meet the requirements of Subsection 714.01.1 as related to injurious quantities of oil, acid, or alkali and shall not be brackish.

714.01.6--Tests. As applicable, a routine analysis of the sample of water submitted will be made. If the routine analysis indicates that any of the specified limits for acidity or alkalinity, organic solids, or inorganic solids are exceeded, the water may be further tested by either or both of the following methods as determined by the State Materials Engineer:

1. A chemical analysis to determine the nature of the specified characteristics for which minimum values are established.
2. Strength and Time-of-Set Test. Results of additional tests may be considered satisfactory if:
 - (a) the solids are found to be not detrimental to the materials with which the water is used;
 - (b) the alkali carbonates and bicarbonates do not exceed 0.1% by weight of water when the combination of carbonates and bicarbonates is calculated to sodium carbonate, Na_2CO_3 ;
 - (c) the 28-day strength of mortar made with the water is not less than 90% of that made with distilled water; and
 - (d) the time of set is not less than 45 minutes.

In general, water will be approved if it complies with the applicable requirements of the Standard Specifications, or if the results of additional tests as provided above are determined by the State Materials Engineer to be satisfactory.

No formal tests of water used for granular base, or embankment construction, or in connection with the planting and establishment of vegetation will be made unless the Engineer questions the quality of the water.

714.02--Calcium Chloride. Calcium chloride shall conform to the requirements of AASHTO M 144. Calcium chloride shall not be used in concrete that will be prestressed, nor shall it be used in other concrete unless specifically approved by the Engineer.

714.03--Lime.

714.03.1--General. Lime shall be stored and handled in closed, weather-proof containers until used. If local storage is provided, lime shall be used only from approved storage facilities and shall meet the requirements of the contract at the time of use.

714.03.2--Hydrated Lime. Hydrated lime for use in mortar shall conform to the requirements of ASTM C 207, Type N.

Hydrated lime for soil stabilization shall conform to the following requirements:

Calcium and magnesium oxides, nonvolatile basis, %, minimum -----	90
Carbon dioxide, %, maximum -----	7
Moisture loss, 2 hours @ 120°C, maximum -----	3

Gradation of Residue:

Retained on No. 30 sieve, %, maximum -----	2.5
Retained on No. 200 sieve, %, maximum -----	15

714.03.3--Quick Lime.

714.03.3.1--Granular or Pelletized Quick Lime. Granular or pelletized quick lime for soil stabilization shall be a commercial granular or pelletized quick lime and shall conform to the following requirements prior to slaking:

Calcium and magnesium oxides, nonvolatile basis, %, minimum -----	90
Carbon dioxide, %, maximum -----	7
Gradation, percent passing by weight:	
¾-inch sieve -----	100
No. 4 sieve -----	0-30

The Contractor shall furnish certified test reports with each shipment of quick lime attesting to the purity of the lime and that the lime meets the requirements of the specifications; however, the material shall be subject to inspection, test, or rejection by the Engineer at any time.

714.03.3.2--Dry Quick Lime. Dry quick lime used for soil stabilization by the dry application method shall be a commercial quick lime and shall conform to the following requirements after two minutes on a Ro-tap shaker:

<u>Sieve</u>	<u>Percent Passing By Weight</u>
No. 10	100
No. 20	90 - 100
No. 100	0 - 20
No. 200	0 - 5

Dry quick lime shall meet the slaking standards as defined in ASTM C 110, and shall reach maximum heat rise in no more than six (6) minutes.

The Contractor shall furnish certified test reports with each shipment of quick lime attesting to the purity of the lime and that the lime meets the requirements of the specifications; however, the material shall be subject to inspection, test, or rejection by the Engineer at any time.

714.03.4--Bag Lime. When bag lime is used, the bag shall bear the weight certified by the manufacturer. Bags varying more than five percent from the certified weight will be rejected, and the average weight of bags in any shipment determined by weighing 50 bags taken at random shall not be less than the certified weight. Bag lime shall conform to the requirements of hydrated or quick lime as applicable.

714.03.5--Limestone Dust. The source of the material shall be approved by the Engineer and meet the following gradation requirements:

<u>Sieve</u>	<u>Percent Passing</u>
No. 30	95 - 100
No. 200	20 - 100

714.04--Sodium Chloride. Sodium chloride shall conform to the requirements of AASHTO M 143.

714.05--Fly Ash.

714.05.1--General. The fly ash source must be approved for listing in the Department's APL prior to use. The acceptance of fly ash shall be based on certified test reports, certification of shipment from the supplier, and tests performed on samples obtained after delivery in accordance with the Department's Materials Division Inspection, Testing, and Certification Manual and Department SOP.

Different classes of fly ash or different sources of the same class shall not be mixed or used in the construction of a structure or unit of a structure without written permission from the Engineer.

The Contractor shall provide suitable means for storing and protecting the fly ash from dampness. Separate storage silos, bins, or containers shall be provided for fly ash. Fly ash that has become partially set or contains lumps of caked fly ash shall not be used.

The temperature of the bulk fly ash shall not be greater than 165°F at the time of incorporation into the work.

All classes of fly ash shall meet the supplementary option chemical requirement for available alkalis listed in AASHTO M 295, Table 2. Class F fly ash shall have a calcium oxide (CaO) content of less than 8.0%. Class C fly ash shall have a CaO content of greater than or equal to 8.0%.

The replacement of hydraulic cement with fly ash shall be in accordance with the applicable replacement content specified in Subsection 701.02.2 and 701.04.2.

In addition to these requirements, fly ash shall meet the following specific requirements for the intended use.

714.05.2--Fly Ash for Use in Concrete. When used with hydraulic cement in the production of concrete or grout, the fly ash shall meet the requirements of AASHTO M 295, Class C or F, except the loss on ignition shall not exceed 6.0 percent.

No additional cementitious materials, such as blended hydraulic cement, GGBFS, metakaolin, or others, shall be added to or as a replacement for hydraulic cement when used with fly ash. Type IL may be permitted in accordance with Subsection 701.04.

714.05.3--Fly Ash for Soil Stabilization. When used with hydrated lime in soil stabilization, the class of fly ash shall be as specified in the contract. The fly ash, when mixed with hydrated lime and soil or soil-aggregate, shall produce the minimum design characteristics for the course to be stabilized. The fly ash shall meet the requirements of AASHTO M 295 for the class specified, except the loss on ignition shall not exceed 10.0 percent.

714.06--Ground Granulated Blast Furnace Slag.

714.06.1--General. The ground granulated blast furnace slag (GGBFS) source must be approved for listing in the Department's APL prior to use. The acceptance of GGBFS shall be based on certified test reports, certification of shipment from the supplier, and tests performed on samples obtained after delivery in accordance with the Department's *Materials Division Inspection, Testing, and Certification Manual* and Department SOP.

The Contractor shall provide suitable means for storing and protecting the GGBFS against dampness and contamination. Separate storage silos, bins, or containers shall be provided for GGBFS. GGBFS that is partially set, caked or contains lumps shall not be used.

The State Materials Engineer shall be notified in writing of the nature, amount and identity of any processing or other additions made to the GGBFS during production.

GGBFS from different mills shall not be mixed or used alternately in any one class of construction or structure without written permission from the Engineer; except that this requirement will not be applicable to cement treatment of design soils or bases.

No additional cementitious materials, such as blended hydraulic cement, fly ash, metakaolin, or others, shall be added to or as a replacement for hydraulic cement when used with GGBFS in the production of concrete. The replacement of hydraulic cement with GGBFS shall be in accordance with the applicable replacement content specified in Subsection 701.02.2.

714.06.2--Specific Requirements. GGBFS shall meet the requirements of AASHTO M 302, Grade 100 or 120. GGBFS shall contain no chlorides.

714.07--Stabilizing Fibers.

714.07.1--General. Stabilizing fibers shall be used in Stone Matrix Asphalt (SMA) mixtures and other mixtures, as necessary, for draindown reduction. Fibers shall be added at a minimum dosage rate of 0.30 percent for both cellulose and mineral fibers by weight of total mix. The produced mixture containing the fibers shall exhibit a draindown of 0.30 percent or less when tested in accordance with Mississippi Test Method MT-82.

Either cellulose or mineral fibers may be used. A pelletized fiber comprised of either cellulose or mineral fiber may also be used.

714.07.2--Cellulose Fibers. Cellulose fibers shall conform to the following properties.

Property	Specification Requirement
Fiber Length	0.25 inch maximum
Sieve Analysis	
a. Alpine Air Jet Sieve Method Passing No. 100 sieve	60 – 80 percent
b. Mesh Screen Sieve Method Passing No. 20 sieve Passing No. 40 sieve Passing No. 100 sieve	75 – 95 percent 55 – 75 percent 20 – 40 percent
Ash Content	18.0 ± 5 percent
PH	7.5 ± 1.0
Oil Absorption	5.0 ± 1.0
Moisture Content	5.0 percent maximum

714.07.3--Mineral Fibers. Mineral fibers shall conform to the following properties.

Property	Specification Requirement
Average Fiber Length	0.25 inch maximum
Average Fiber Thickness	0.0002 inch maximum
Shot Content (ASTM C612)	
Passing the No. 60 sieve	85 – 95 percent
Passing the No. 230 sieve	60 – 80 percent

714.07.4--Pelletized Fibers.

Pelletized fibers shall conform to the properties provided in Subsection 714.07.2 or 714.07.3.

714.08--Frames, Grates, Covers, and Ladder Rungs. Metal units shall conform to the plan dimensions and to the applicable requirements in Sections 716 or 717.

Galvanizing, where specified for these units, shall conform to the requirements of AASHTO M 111, unless otherwise designated.

714.09--Additional Cementitious Materials.

714.09.1--Blank.

714.09.2--Silica Fume.

714.09.2.1--General. Silica fume shall only be used as a supplementary cementitious material in hydraulic cement concrete for compliance with the requirements for cementitious materials exposed to soluble sulfate conditions. Silica fume from different sources shall not be mixed or used alternately in any one class of construction or structure without written permission from the Engineer. No additional cementitious materials, such as blended hydraulic cement, performance hydraulic cement, fly ash, GGBFS, or others, shall be added to or as a replacement for hydraulic cement when used with silica fume in the production of concrete.

The State Materials Engineer shall be notified in writing of the nature, amount and identity of any processing, or other additions made to the silica fume during production.

714.09.2.2--Source Approval. The approval of each silica fume source shall be on a case by case basis as determined by the State Materials Engineer. In order to obtain approval of a silica fume source, the Producer/Suppliers shall submit to the State Materials Engineer the following for review: certified test reports, made by an acceptable, independent laboratory regularly inspected by the Cement and Concrete Reference Laboratory (CCRL) or AASHTO accredited laboratory, that show that the silica fume meets all the requirements of AASHTO M307, Table 3, including the Sulfate resistance expansion, listed in the table for Optional Physical Requirements, and other requirements listed herein.

In order to demonstrate effectiveness in contributing to sulfate resistance, the test data shall include results of silica fume from the proposed source tested in accordance with ASTM C 1012. There shall be two sets of test specimens per the following:

- (a) One set of test specimens shall be prepared using a Type I hydraulic cement meeting the requirements of AASHTO M85 with a tricalcium aluminate (C_3A) content of more than 8.0%,
- (b) One set of test specimens shall be prepared using a Type II hydraulic cement meeting the requirements of AASHTO M85.
- (c) The proposed silica fume shall be incorporated at the rate of 8% cement replacement in each set of test specimens and shall meet the following acceptance criteria for source approval:
 - (i) The requirement for acceptance of the test sample using Type I hydraulic cement is an expansion of 0.10% or less at the end of six months.
 - (ii) The requirement for acceptance of the test sample using Type II hydraulic cement is an expansion of 0.05% or less at the end of six months.

714.09.2.3--Storage. The Contractor shall provide suitable means for storing and protecting the silica fume against dampness and contamination. Silica fume that is partially set, caked, or contains lumps shall not be used.

714.09.2.4--Acceptance. With each new lot of material shipped, the Contractor shall submit to the State Materials Engineer a certified test report from the manufacturer showing that the material meets the Chemical and Physical Requirements of AASHTO M307.

The Department reserves the right to sample, for check tests, any shipment or lot of silica fume delivered to a project.

714.10--Elastomeric Bearings.

714.10.1--General. This work shall consist of furnishing and installing elastomeric bearings in accordance with the plans and these specifications. All required testing and furnishing of sample bearings is considered to be part of the covered work. Shop drawings shall be approved by the Engineer prior to beginning of fabrication or production of bearings.

Elastomeric bearings, as herein defined, shall include plain or non-reinforced pads

consisting of elastomer only, and reinforced or laminated bearings consisting of elastomer reinforced with steel laminates.

All elastomeric bearings shall be furnished to the dimensions indicated on the plans. They shall be composed of the specified elastomer type, grade and hardness or shear modulus, shall be adequate for the specified design load, shall be tested at the appropriate level, and shall satisfy any special requirements as shown on the plans.

714.10.2--Elastomer. The raw elastomer shall be virgin polychloroprene (Neoprene), Grade 3 as referenced in AASHTO M 251.

Elastomer for plain or non-reinforced bearings shall be 70-Durometer, adequate for 800 pounds per square inch design compression stress, and shall be tested to Level I as hereinafter described.

Unless otherwise shown on the plans, elastomer for laminated or reinforced bearings shall be 50-Durometer, adequate for 1,000 pounds per square inch design compression stress, and shall be tested to Level I as hereinafter described.

An elastomer of higher grade number may be substituted for the specified grade.

The elastomer compound shall also meet the minimum requirements of Table I except as otherwise specified by the Engineer. When test specimens are cut from the finished product, a 10 percent variation in physical properties shall be permitted. All material tests shall be carried out at $73 \pm 4^{\circ}\text{F}$ unless otherwise specified.

TABLE I

Material Property	ASTM Designation	Test Requirements	Polychloroprene			Units
			50 Duro	60 Duro	70 Duro	
Physical Properties	D 2240	Hardness	50 ±5	60 ±5	70 ±5	Shore A Pts.
	D 412	Minimum tensile strength	2250	2250	2250	psi
		Minimum ultimate elongation	400	350	300	%
Heat Resistance at specified temperature	D 573	Specified temperature of the test for 22 hours	212	212	212	°F
		Aging time	70	70	70	Hours
		Maximum change in durometer hardness	+15	+15	+15	Shore A Pts.
		Maximum change in tensile strength	-15	-15	-15	%
Compression Set at specified temperature	D 395 Method B	Maximum change in ultimate elongation	-40	-40	-40	%
		Specified temperature of test degrees	212	212	212	°F
		Maximum permissible set	35	35	35	%
Ozone Resistance	D 1149	Partial pressure of ozone during test	50	50	50	mPa
		Duration of test	100	100	100	Hours
		Tested at 20% strain 100 ±2°F mounting procedure D518, Procedure A	no cracks	no cracks	no cracks	

(Continued on next page)

TABLE I - (Continued)

Material Property	ASTM Designation	Test Requirements	Polychloroprene			Units
			50 Duro	60 Duro	70 Duro	
Low Temperature	D 2137 Method A	Low temperature Brittleness Test required for Grade 3 and 5 only at -13°F for Grade 3 and -40°F for Grade 5	no failure	no failure	no failure	
	D 1415 or D 2240	Low temperature stiffness required for Grades 2, 3 and 5 only. Conditioned for 22 hours at 14°F for Grade 2, 13°F for Grade 3 and -40°F for Grade 5. Maximum change in hardness	+15	+15	+15	Shore A Pts.
	D 1229	Maximum low temperature compression set required for Grades 2, 3 and 5 only when tested at 25% compression for: 22 hours at 32°F for Grade 2, 7 days at 14°F for Grade 3, 14 days at each of 14°F and -13°F for Grade 5.	65	65	65	%

714.10.3--Steel Laminates. Steel laminates used for reinforcement shall be made from rolled mild steel conforming to ASTM A 36 or A 1011, unless otherwise specified by the Engineer. The laminates shall have a minimum nominal thickness of 16-gauge. Holes in plates for manufacturing purposes shall be considered in design.

714.10.4--Bonding Adhesive. The vulcanized bond between the elastomer and steel laminates shall have a minimum peel strength of 40 pounds per inch. The peel strength shall be performed in accordance with ASTM D 429, Method B.

714.10.5--Fabrication.

714.10.5.1--General. Plain pads shall be cast as a single unit in individual molds under heat and pressure except leveling pads 3/8 inch or less in thickness may be sheared. Bearings with steel laminates shall be cast as a unit in a mold and bonded and vulcanized under heat and pressure. The molds shall have standard shop practice mold finish. The internal steel laminates shall be sandblasted and cleaned of all surface coating rust and mill scale before bonding, shall be free of sharp edges and burrs, and shall have a minimum edge cover of 1/8 inch.

Flash tolerance, finish, and appearance shall meet the requirement of the latest edition of the Rubber Handbook as published by the Rubber Manufacturers Association, Inc., RMA F3 and T.063 for molded bearings and RMA F2 for extruded bearings.

714.10.5.2--Tolerances. Plain pads and laminated bearings shall be built to the design dimensions and these specifications with the following tolerances:

- | | |
|--------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|
| (a) Overall Vertical Dimensions | |
| Design Thickness 1¼ inches or less | -0, +1/8" |
| Design Thickness >¼ inches | -0, +1/4" |
| (b) Overall Horizontal Dimensions | |
| 36 inches and less | -0, +1/4" |
| over 36 inches | -0, +1/2" |
| (c) Thickness of Individual Layers of Elastomer | |
| Laminated Bearings Only at any point within the bearing | ±20% of design value but no more than ±1/8" |
| (d) Variation from a Plane Parallel to the Theoretical Surface as determined by Measurements at the edge of the bearings | |
| Top | slope relative to the bottom of no more than 0.005 radians |
| Sides | 1/4" |
| (e) Position of Exposed Connection Members | 1/8" |
| (f) Edge cover of Embedded Laminates or Connection Members | -0, +1/8" |
| (g) Size of Holes, Slot or Inserts | ±1/8" |
| (h) Position of Holes, Slots, or Inserts | ±1/8" |

714.10.6--Acceptance Procedure. The acceptance criteria shall be at two levels. Level I acceptance shall be applied to all elastomeric bearings. Level II acceptance criteria shall be applied as required on the plans or contract documents. Level II criteria shall also be

used to resolve differences over the acceptance of bearings to which only Level I tests have been applied.

Level I criteria require that bearing pads be manufactured according to this specification and any additional requirements specified on the plans. The manufacturer shall proof load each steel reinforced bearing with a compressive load of 1500 pounds per square inch. If bulging patterns imply laminate placement that does not satisfy design criteria and manufacturing tolerances or if bulging suggests poor laminate bond, the bearing shall be rejected. If there are three (3) separate surface cracks greater than 0.08-inch wide and 0.08-inch deep, the bearing shall be rejected.

A copy of the proof loading results for each lot of steel reinforced bearings shall be furnished the Bridge Engineer prior to shipment of the bearings.

The Department reserves the right to require that proof loading be done in the presence of and witnessed by a representative of the Department. Whether a Department representative was present to witness the proof loading or not, the manufacturer's certification concerning compliance with the requirements of the contract shall attest to acceptable proof loading.

Level I criteria require that the elastomer satisfy the minimum properties of Table I. Level I criteria also include bond test for laminated bearings as referenced in ASTM D 429, Method B.

Level II certification requires that all Level I conditions be satisfied, except that individual conditions may be waived by the Engineer if Level II certification is used as an arbitration of disputes. Additionally, shear modulus and compressive stiffness shall be determined in accordance with ASTM D 4014. The shear modulus shall fall within the range of values specified in Table II. Compressive stiffness tests shall be performed on the complete bearing. The compressive stiffness shall vary by no more than ± 10 percent from the median value of all bearings.

TABLE II

HARDNESS (SHORE A)	50	60	70
Shear Modulus at 73°F, psi	85 - 100	120 - 155	160 - 200

The Contractor shall furnish to the Engineer three copies of the manufacturer's certified test reports and certification that each lot in a shipment complies with the requirements of the contract.

714.10.7--Marking. Each reinforced bearing shall be marked in indelible ink or flexible paint. The marking shall consist of the order number, lot number, bearing identification number, and elastomer type and grade number. Unless otherwise specified in the contract documents, the marking shall be on a face that is visible after the erection of the bridge.

714.10.8--Sampling. A lot for plain bearings shall be the manufacturer's lot. Each designated thickness of laminated bearings used on a project shall constitute a lot. Unless otherwise specified on the plans or in the contract documents, sampling shall be at the rate of one bearing per lot. The supplier shall produce sufficient extra bearing pads to accommodate this sampling. Bearing pads from within a lot shall be selected at random by a representative of the Department as samples for inspection and testing.

714.11--Hydraulic Cement Mortar, Grout and Concrete Patching Compounds.

714.11.1--General. The ingredients for hydraulic cement mortar and grout shall conform to the following subsections:

Portland Cement	701.02
Masonry Cement	701.03
Water	714.01.2
Fine aggregate unless otherwise designated	703.02 or 703.18
Calcium chloride	714.02
Hydrated lime	714.03.2
Fly Ash	714.05
Limestone Dust	714.03.5

714.11.2--Grout for Pressure Grouting. Grout for pressure grouting shall consist of a mixture of hydraulic cement, water, calcium chloride, fly ash and/or limestone dust and fine sand in the proportions set forth in Section 512.

Fine sand shall meet the following requirements:

<u>Square Mesh Sieve</u>	<u>Percent Passing by Weight</u>
No. 10	100
No. 60	40 - 90
No. 200	0 - 50
Percent Silt	0 - 25
Percent Clay	0 - 12
Percent Organic Material	0 - 3
Plasticity Index	N.P.

714.11.3--Grout for Posttensioned Members. Grout for posttensioned members shall consist of a mixture of the following:

- 1 part hydraulic cement, Type 1
- 1/4 part fly ash
- 3/4 part washed sand, all passing No. 16 sieve, not more than five percent retained on No. 30
- Four to six gallons of water per bag of cement

A plasticizing admixture, subject to approval by the Engineer, shall be used in accordance with the manufacturer's recommendations.

The grout shall be mixed in a mechanical mixer and shall be agitated until placed.

Members shall not be moved before the grout has set, which ordinarily requires a minimum of 24 hours at 80°F or higher.

714.11.4--Blank.

714.11.5--Masonry Mortar. Masonry mortar shall consist of masonry cement mixed in accordance with the formula shown on the bag or shall consist of one part hydraulic cement, three parts mortar sand, and sufficient water to make a mortar of such consistency that it

can be easily handled and spread with a trowel. The addition of hydrated lime will be permitted in the proportion of 1/10 part by volume of the cement.

Fine aggregate meeting the requirements of Subsection 703.02 may be used for mortar to be used in other than masonry work.

Unless an approved mortar mixing machine is used, the sand and mortar mix, or cement and lime, shall be mixed dry in a tight box until the mixture assumes a uniform color, after which water shall be added as the mixing continues until the mortar attains the proper consistency.

Mortar shall be used within 45 minutes after its preparation. Retempering of mortar will not be permitted.

714.11.6--Rapid Setting Cementitious Patching Compounds for Concrete Repair.

Rapid setting concrete patching compounds must be approved for listing in the Department's APL prior to use. Upon approval, a product must be recertified every four (4) years to remain on the APL. Each product shall be pre-measured and packaged dry by the manufacturer. All liquid solutions included by the manufacturer as components of the packaged material shall be packaged in a watertight container. The manufacturer may include aggregates in the packaged material or recommend the addition of Contractor furnished aggregates.

The type, size and quantity of aggregates, if any, to be added at the job site shall be in accordance with the manufacturer's recommendations and shall meet the requirements of Subsection 703.02 for fine aggregate and Subsection 703.03 for coarse aggregate. Required mixing water to be added at the job site shall meet the requirements of Subsection 714.01.2.

Only those bonding agents, if any, recommended by the manufacturer of the grout or patching compounds may be used for increasing the bond to old concrete or mortar surfaces.

Patching compounds containing soluble chlorides will not be permitted when in contact with steel.

Site preparation, proportioning of materials, mixing, placing and curing shall be performed in accordance with the manufacturer's recommendation for the specific type of application, and the Contractor shall furnish a copy of these recommendations to the Engineer.

Rapid setting cementitious concrete patching compounds, including components to be added at the job site, shall conform to the following physical requirements:

- (a) Non-shrink cementitious grouts shall not be permitted for use.
- (b) Compressive strength shall equal or exceed 3000 psi in 24 hours in accordance with ASTM C 928 for Type R2 concrete or mortar.
- (c) Bond strength shall equal or exceed 1000 psi in 24 hours in accordance with ASTM C 928 for Type R2 concrete or mortar.
- (d) The material shall have a maximum length change of $\pm 0.15\%$ in accordance with ASTM C 928 for Type R2 concrete or mortar.

The Contractor shall furnish to the Engineer three copies of the manufacturer's certified test report(s) showing results of all required tests and a certification that the material meets the specifications when mixed and placed in accordance with the manufacturer's instructions. When the mixture is to be placed in contact with steel, the certification shall further state that the packaged material contains no chlorides. Certified test report(s) and the certification shall be furnished for each lot in a shipment.

The proportioning of materials must be approved by the State Materials Engineer and any subsequent change in proportioning must also be approved. A sample of each component shall be submitted to the Engineer along with the quantity or percentage of each to be blended. At least 45 days must be allowed for initial approval.

The proportioning of materials for subsequent lots may be approved by the State Materials Engineer upon receipt of certification from the manufacturer that the new lot of material is the same composition as that originally approved by the Department and that the material has not been changed or altered in any way.

714.11.7--Commercial Grout for Anchoring Doweled Tie Bars in Concrete. Approved Non-"Fast Set" Epoxy anchor systems may be used for the repair of concrete pavements that do not involve permanent sustained tension applications or overhead applications. Approved epoxy anchors for concrete pavement repair shall be one listed on the Department's APL.

714.11.7.1--Epoxy Grout Anchor System. Epoxy grout shall consist of one part liquid epoxy to a maximum of four parts clean dry silica sand by volume. The epoxy shall be a two-component epoxy-resin bonding system for application to hydraulic cement concrete. The silica sand shall be bagged general purpose blast cleaning sand. The grout shall be placed with equipment that dispenses the grout evenly around the bar and completely fills the hole. Tamping the material in the hole by hand will not be satisfactory.

714.11.7.2--Non-Expanding Chemical Anchor System. Chemical anchor system shall consist of a premeasured unit containing polymeric or epoxy type resin and a hardener and may also include quartz sand aggregate. The resin and hardener shall be isolated from each other by a physical-chemical barrier or may be contained in separate premeasured units.

714.11.7.3--Installation. Unless otherwise specified, installation and hole sizes shall be in accordance with the manufacturer's recommendations.

714.11.7.4--Acceptance Procedure. The anchor system must be one from the Department's APL. Prior to use, the Contractor shall furnish the Engineer three copies of the manufacturer's certification for each shipment stating that the material furnished is of the same composition as that originally approved by the Department and that the material has not been changed or altered in any way. Upon approval, a product must be recertified every four (4) years to remain on the APL.

Each day an in-place tension test shall be performed at random on a tie bar with a maximum curing time of two hours. If the test fails to meet the total load required to stress the bar to 50,000 psi, three additional tests shall be made at random. If any of the additional tests fail, all bars installed on that day shall be tested and any bar that fails shall be replaced. The Contractor shall furnish the testing device that shall include a certified calibration chart. No separate measurement for payment will be made for the testing device.

714.11.8--Epoxy Joint Repair System.

714.11.8.1--General. When the epoxy system is from the Department's current APL, the Contractor shall furnish the Engineer three copies of the manufacturer's certification, for each shipment, stating that the epoxy and all components is the same composition as that originally approved by the Department and that the material has not been changed or altered in any way. Upon approval, a product must be recertified every four (4) years to remain on the APL.

If the materials proposed for use are not from the Department's current list of approved materials, a sample of the epoxy and all components required for the epoxy mortar mix shall be submitted to the Engineer for evaluation and approval at least 30 calendar days prior to placement. Subsequent approval of each shipment may be by manufacturer's certification as set out above.

A representative of the epoxy manufacturer must be present for sufficient time to assure that the Contractor is properly schooled in the use of the epoxy materials.

714.11.8.2--Epoxy Resin. The material shall meet the requirements of ASTM C 881, Type I, Grade 2, Class C.

714.11.8.3--Silica Sand. The material shall be bagged general purpose blast cleaning sand.

714.11.8.4--Epoxy Mortar Mix. The mortar mix shall consist of one part liquid epoxy to 3.5 parts clean dry sand by volume.

714.11.8.5--Mixing and Curing. Mixing of all epoxy materials shall be accomplished with a mechanical mixer. A trial batch of mortar, approximately one cubic foot, will be mixed and used for joint repair. From this batch, the pot life and subsequent amount of material to be mixed will be determined.

714.12--Sprayed Finish for Concrete Surfaces. The spray material shall be an approved commercial product designed specifically for a sprayed finish and when applied to the concrete specimens at a rate of one gallon per 50 square feet shall conform to the following requirements.

714.12.1--Freeze-Thaw Test. Cast and cure three concrete specimens, not less than 4" x 6" x 6". Fourteen days moist curing with a drying period in room air at 60° to 80°F for 24 hours before coating with spray finish is required. Caution shall be taken to ensure that there is no excessive oil on specimen forms. Sides of specimens, brush permitted, shall be coated as herein set out and cured at room temperature for 48 hours, after which the following steps shall be taken:

- (a) Immerse in water at room temperature, 60° to 80°F for three hours;
- (b) Remove and place in cold storage at -15°F for one hour;
- (c) Remove and thaw at room temperature, 60° to 80°F, for one hour;
- (d) Repeat (b) and (c) for 50 cycles.

At the end of the 50 cycle Freeze/Thaw Test, the specimens shall show no visible defects.

714.12.2--Accelerated Weathering. Material shall be subjected to a 5000 hour exposure test in accordance with ASTM G 151. Testing shall be performed in conjunction with either ASTM G 153, Carbon Arc Light Apparatus, or ASTM G 155, Xenon Arc Light Apparatus. Test Exposure Conditions shall be as specified in Table X1.1, Cycle 1 in ASTM G 153, or Table X3.1, Cycle 1 in ASTM G 155. At the end of the exposure test, the exposed sample must not show any chipping, flaking or peeling.

714.12.3--Fungus Growth Resistance. Material to be used shall pass a fungus resistance test as described by ASTM D 3273 with a minimum incubation period of 21 days where no growth shall have been indicated after the test.

714.12.4--Color. Unless otherwise specified or directed by the Bridge Engineer, the color of the finish shall be that deemed by the Engineer to be as close as practicable to the color of a rubbed concrete finish.

714.12.5--Testing and Certification. All testing shall be performed by a qualified commercial testing laboratory acceptable to the Engineer.

Before any part of a shipment is applied on the project, the Contractor shall furnish the Engineer with a certificate from the manufacturer attesting that the commercial product furnished conforms to the same formula as that previously subjected to the specified tests, and approved. Copies of the current test reports shall be attached to the certificate.

No test report for tests made more than four years prior to shipment to the project will be accepted.

714.13--Geotextiles.

714.13.1--General. Unless specified otherwise, the geotextile may be woven or non-woven. The fibers used in the manufacture of the geotextiles and the threads used in joining geotextiles by sewing, shall consist of long-chain synthetic polymers, composed of at least 95% by weight polyolefins, polyesters, or polyamides. They shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including selvages. The geotextile shall be mildew resistant and inert to biological degradation and naturally encountered chemicals, alkalines and acids. Geotextile not protected from sunlight after installation shall contain stabilizers and/or inhibitors to make it resistant to deterioration from direct sunlight, ultraviolet rays, and heat.

The edges of the geotextile shall be selvaged or finished in such a manner to prevent the outer yarn of filaments from raveling. The geotextile shall be free of defects or flaws that affect the required physical properties. Unless otherwise specified in Subsection 714.13, the geotextile fabric shall meet the requirements and conform to the applications in AASHTO M 288.

Geotextile for silt fence shall be manufactured in widths of not less than three feet, and geotextile for other applications shall be manufactured in widths of not less than six feet. Sheets of geotextile may be sewn or bonded together at the factory or other approved locations, but deviation from the physical requirements will not be permitted.

Acceptance testing will be conducted with geotextile samples from each lot shipped to the project, as per Subsection 714.13.10.

714.13.2--Geotextile for Silt Fence. The geotextile shall conform to the physical requirements of Type I or II as shown in Table I. Unless a specific type is specified in the plans or contract documents, the Contractor may select Type I or II. Silt fence will be accepted by certification. Unless otherwise specified in Subsection 714.13, the geotextile for silt fence shall meet the requirements and conform to the applications in AASHTO M 288.

714.13.2.1--Woven Wire Backing. Woven wire backing for reinforcing silt fence shall be at least 32 inches high and have no less than six horizontal wires. Vertical wires shall be spaced no more than 12 inches apart. The top and bottom wire shall be 10-gauge or larger. All other wire shall be no smaller than 12½-gauge. Woven wire backing may also be accepted by Subsection 712.03.

714.13.2.2--Posts. Wood or steel posts may be used. Wood posts shall have a minimum diameter of three inches and length of five feet and shall be straight enough to provide a fence without noticeable misalignment. Steel tee posts shall be five feet long, approximately 1 3/8" wide, 1 3/8" deep, and 1/8" thick with a nominal weight of 1.33 pounds per foot prior to fabrication. The posts shall have projections, notches or holes for fastening the wire backing or geotextile to the posts.

714.13.2.3--Staples. Staples shall be made of 9-gauge wire with a minimum length of one inch after bending.

714.13.3--Geotextile for Subsurface Drainage. Unless otherwise specified, the geotextile shall conform to the physical requirements of Type III as shown in Table I.

714.13.3.1--Geotextile for Edge Drains. The geotextile shall conform to the physical requirements of Type V as shown in Table I, except the AOS for the woven geotextile shall have a range of 0.15 mm to 0.43 mm.

714.13.4--Geotextile Underseal. The geotextile shall be non-woven polyester or polypropylene, that is satisfactory for use with asphalt cements. Unless otherwise specified, the geotextile shall conform to the physical requirements of Type IV in Table I.

714.13.5--Geotextile for Use Under Riprap. Unless otherwise specified, the geotextile shall conform to the physical requirements of Type V in Table I. The requirements for grab tensile, puncture, and trapezoidal tear strengths may be reduced 50 percent when the geotextile is cushioned from rock placement by a 6-inch minimum layer of sand.

714.13.6--Geotextile Stabilization. The geotextile shall meet the physical requirements as shown in Table I for the Type specified in the plans or contract documents.

714.13.7--Securing Pins. Steel pins used for anchoring the geotextile shall be three-sixteenth inch (3/16") in diameter, minimum length of 15 inches, pointed at one end and fabricated with a head for retaining a steel washer. A minimum one and one-half inch (1½") washer shall be installed on each pin.

714.13.8--Identification. Each roll of geotextile or container shall be visibly labeled with the name of the manufacturer, type of geotextile or trade name, lot number, and quantity of material.

714.13.9--Shipment and Storage. During shipment and storage, the geotextile shall be protected from direct sunlight, ultraviolet rays, temperatures greater than 140°F, mud, dirt, dust, and debris. The geotextile shall be wrapped and maintained in a heavy-duty protective covering, including ends of roll.

714.13.10--Certification, Acceptance Sampling and Testing. The Contractor shall furnish to the Engineer three copies of the manufacturer's certification that each lot in a shipment complies with the requirements of the contract. Certification of geotextile for silt fence shall include a material conformance statement, as per Subsection 700.05.1, that the geotextile meets or exceeds the minimum average roll values specified in Table 1 and II. All geotextile, steel pins, washers, fence posts, woven wire and wire staples are subject to approval by the Engineer upon delivery to the work site.

Acceptance testing shall be completed prior to incorporating in the work. Acceptance of geotextile to be used in the work will be based on the results of tests performed by the Department on verification samples submitted from the project. The Engineer will select one roll at random, from each lot in a shipment, for sampling. A sample extending full width of the randomly selected roll and containing at least five square yards of geotextile will be obtained and submitted by the Engineer. The sample shall be provided at no additional cost to the State. The geotextile shall meet the requirements of Table 1 in Subsection 714.13.11. Unless otherwise specified in Table 1 in Subsection 714.13.11, the geotextile fabric shall meet the requirements and conform to the applications in AASHTO M 288.

714.13.11--Table.

Table 1 - Geotextiles

Type Designation	I ¹	II ¹	III	IV	V		VI		VII		VIII	IX
					Sediment Control	Drainage	Paving	Separation & Drainage	Separation, Stabilization & Reinforcement			
Physical Property ²						Woven	Non-Woven	Woven	Non-Woven			Test Method
Grab Strength (lb)	50	90	110	90	200	280	180	450	280	-----	-----	ASTM D 4632
Elongation (%)	----	50% max @ 45 lb	20% min	50% min @ break	50% min	50% max	50% Min	50% max	50% Min	-----	-----	ASTM D 4632
Seam Strength (lb)	----	----	70	----	180	240	160	400	240	-----	-----	ASTM D 4632
Puncture Strength (lb)	----	----	40	----	80	110	75	180	115	-----	-----	ASTM D 6241
Trapezoidal Tear (lb)	----	----	40	----	80	100	70	150	100	-----	-----	ASTM D 4533
Asphalt Retention (gal/yd ²)	----	----	----	0.2	----	----	----	----	----	-----	-----	ASTM D 6140
Permittivity (sec ⁻¹) min	0.05	0.05	0.05	----	0.2	0.2	0.2	0.2	0.2	-----	-----	ASTM D 4491
AOS Woven (mm) max	0.60	0.60	0.6	----	0.6	0.43	----	0.43	----	-----	-----	ASTM D 4751
AOS Non-Woven (mm) max	0.84	0.84	0.43	----	0.43	----	0.43	----	0.43	-----	-----	
Tensile Strength after UV (% Retained)	70% @ 500 hr	70% @ 500 hr	50% @ 500 hr	----	50% @ 500 hr	50% @ 500 hr	50% @ 500 hr	50% @ 500 hr	50% @ 500 hr	-----	-----	ASTM D 4355
Melting Point °(F)	----	----	----	325	----	----	----	----	----	-----	-----	ASTM D 276
Minimum Ultimate Tensile Strength ³ (lb/in)	----	----	----	----	----	----	----	----	----	660	2000	ASTM D 4595

Notes: 1 - All property values, with the exception of apparent opening size (AOS), represent minimum average roll values in the weakest principal direction. Values for AOS represent the maximum average roll values, 2 - Values not identified in this table should meet manufacturer certification for the use and application, 3- Machine direction

714.14--Geotextile for Moisture Barrier.

714.14.1--General. The geotextile for moisture barrier shall consist of sheeting, coated geotextile or a geotextile-sheeting laminate constructed exclusively of man-made materials. Sheeting shall be of single-layered construction. Coated geotextile shall be made of woven or non-woven polyester, polyethylene or polypropylene. The geotextile shall be furnished precoated on one or both sides or impregnated so as to make the geotextile impermeable to water or moisture. Geotextile-sheeting laminate shall consist of geotextile fused or heat-sealed to sheeting so as to form an integral geotextile membrane.

The geotextile shall be able to withstand normal handling and placement at material temperatures from 20°F to 145°F without endangering the serviceability of the material in the intended application. If the geotextile evidences de-lamination, such de-lamination may serve as grounds for rejection. The geotextile shall be mildew, abrasion, and puncture resistant and suitable for long term burial in the presence of water and/or moisture in the intended construction application. It shall be packaged in rolls of the length and width specified on the plans or directed by the Engineer.

714.14.2--Physical Requirements. The geotextile shall meet the following additional requirements when sampled and tested in accordance with the methods specified.

<u>Test</u>	<u>Requirements</u>	<u>Method</u>
Original Physical Properties		
Geotextile weight, ounces per square yard, air-dried tension-free sample.	6.5 minimum	Texas Test Method Tex-616-J "Testing Construction Fabrics"
Water permeability expressed as weight of water in ounces per square yard. Geotextile is subjected to the equivalent of a ten foot column of water for a period of two hours. Moisture passing through the geotextile is determined by weight gain of desiccant.	0.6 maximum	Tex-616-J
Abrasion Resistance expressed as weight of water in ounces per square yard. After prescribed sandblast the geotextile shall meet the requirement for water permeability.	0.6 maximum	Texas Test Method Tex-851-B "METHOD FOR EVALUATING THE ABRASION RESISTANCE OF PAVEMENT MARKING MATERIALS" modified as follows: six-inch sample distance, 40 psig regulated blast pressure and one kilogram of blast medium with a blast time of two minutes plus or minus 15 seconds per one kilogram of blast medium.
Load characteristics at break or 100% elongation, whichever occurs first. Material shall meet specified minimum in both machine direction and cross-machine direction. Test values to be expressed in pounds.	150 minimum	ASTM D 5034, Grab Test G with 1-inch x2-inch jaws and constant time to break rate of extension of 20 plus or minus three seconds, as specified.
Apparent elongation at break or rupture, expressed in percent.	20% minimum	See Grab Test G above
Tear strength determined by the tongue, single rip, method on specimens prepared from "as-received" samples. Specimens are to be tested at a cross-head speed of twelve plus or minus 0.5 inches/minute. Test results are to be calculated by the "average of five highest peaks" method. Both the average of five specimens cut with the longer dimension parallel to the machine direction and the average of five specimens cut in the cross-machine direction shall meet the specified minimum expressed in pounds.	15 minimum	ASTM D 751

714.14.3--Packaging Requirements. The geotextile shall be packaged in rolls of the length and width specified on the plans or directed by the Engineer. The material shall be uniformly wound onto suitable cylindrical forms or cores to aid in handling and unrolling. Each roll shall be packaged individually in a suitable sheath, wrapper or container to protect from ultraviolet light and moisture damage during normal storage and handling.

714.14.4--Identification. Each roll of geotextile or container shall be visibly labeled with the name of the manufacturer, type of geomembrane or trade name, date, lot number and length, width and quantity of material.

714.14.5--Sampling. A sample of five square yards of the geotextile shall be furnished to the State from each shipment for verification testing. The samples shall be provided at no cost to the State.

714.14.6--Certification. The Contractor shall furnish to the Engineer three copies of the manufacturer's certified test report(s) showing results of all required tests and certification that the material meets the specifications. Certification shall be furnished for each lot in a shipment.

714.15--Geogrids.

714.15.1--General. A geogrid is defined as a geosynthetic formed by a regular network of integrally connected elements with apertures greater than 0.25 inch to allow interlocking with surrounding soil, rock, earth and other surrounding materials to function primarily as reinforcement.

The geogrid shall be creep tested in accordance with ASTM D 5262. The long term design load that shall be reported for design use, shall be that load at which no more than 10% strain occurs over a 100-year design life of the geogrid, as calculated from tests run on representative samples for no less than 10,000 hours. The long term design load shall be reported unfactored, as the AASHTO strength reduction - Durability and Installation, and safety factors - will be considered by the Department's Geotechnical Branch on a site specific design basis.

The geogrid shall meet the physical requirements of Table II for the type shown on the plans and shall be selected from the Department's APL.

The geogrid shall be mildew resistant and inert to biological degradation and naturally encountered chemicals, alkalis and acids. The geogrid shall contain stabilizers and/or inhibitors, or a resistance finish or covering to make it resistant to deterioration from direct sunlight, ultraviolet rays, and heat.

Unless specified in this subsection, the geosynthetics used may be approved by the Materials Division and tested to meet the requirements of Table II. Materials Division may approve materials alternatively tested according to ASTM D 4759.

714.15.2--Marking, Shipment and Storage. Each roll or container of geogrid shall be visibly labeled with the name of the manufacturer, trade name of the product, lot number, and quantity of material. In addition, each roll or container shall be clearly tagged to show the type designation that corresponds to that required by the plans. During shipment and storage the geogrid shall be protected from direct sunlight, and temperatures above 120°F

or below 0°F. The geogrid shall either be wrapped and maintained in a heavy duty protective covering or stored in a safe enclosed area to protect from damage during prolonged storage.

714.15.3--Manufacturer's Certification. The Contractor shall furnish the Engineer three copies of the manufacturer's certified test reports indicating that the geogrid furnished conforms to the requirements of the specifications and is of the same composition as that originally approved by the Department.

714.15.4--Acceptance Sampling and Testing. Final acceptance of each shipment will be based upon results of tests performed by the Department on verification samples submitted from the project, as compared to the manufacturer's certified test reports. The Engineer will select one roll or container at random from each shipment for sampling. A sample extending full width of the randomly selected roll or container and being at least five (5) square yards in area will be obtained and submitted by the Engineer. The sample from each shipment shall be provided at no cost to the State.

**TABLE II
GEOGRIDS**

MINIMUM AVERAGE ROLL VALUE

Physical Properties	Type Designation						Test Method
	I	II	III	IV	V	VI	
Long Term Design Load, pounds per foot, Machine Direction	250	500	750	1500	2500	3500	ASTM D-5262
Minimum Ultimate Tensile Strength, pounds per foot, Machine Direction	500	1000	1500	3000	5000	7000	ASTM D-4595
Open Area, percent	70	70	50	50	50	50	Direct Measurement

SECTION 715 - ROADSIDE DEVELOPMENT MATERIALS

715.01--Topsoil.

715.01.1--General. Topsoil shall be a well-graded soil of good uniform workable quality, free of debris, refuse, or foreign material and reasonably free of hard clods, gravel, concrete, sticks, or other undesirable material harmful to plant life.

715.01.2--Material to be Obtained from the Right-of-Way. Topsoil for slope treatment shall meet the general requirements as stated above and shall have a pH value of not less than 4.5 nor more than 8.0.

715.01.3--Material to be Furnished by the Contractor. Topsoil for slope treatment shall meet the general requirements of Subsection 715.01.1, shall have a pH value of not less than 4.5 nor more than 8.0, and shall be classified as a Group A-4 or A-6 soil with a minimum PI of 6.0 as specified by AASHTO M 145.

Topsoil for plant holes or pits shall be a rich, well-graded, well-drained soil of good uniform quality. The organic content, unless otherwise specified, shall not be less than three percent nor more than 20% as determined by ignition test on oven-dried samples. The pH value of the topsoil shall not be less than 4.5 nor more than 8.0. The Contractor may elect to mix or blend the materials for plant holes or pits so as to ensure a homogenous mixture complying with the specific requirements of these specifications. No extra compensation will be allowed for the blending or mixing of materials.

715.01.4--Sampling and Testing. Sampling and testing of topsoil shall be as set out in Subsection 700.03.

715.02--Fertilizers.

715.02.1--General. Fertilizers shall comply with the fertilizer laws of the State of Mississippi.

715.02.2--Commercial, Combination or Manufactured, Fertilizer. Combination or manufactured fertilizer shall be "standard commercial products" and shall contain not less than the percentages by weight of the ingredients set out in Table A, except for agricultural limestone, which shall meet the requirements of Subsection 715.02.2.1.

TABLE A
TYPES OF FERTILIZERS

	Combination									Ureaform		
	*10	18	6	15	12	8	0	13	Super Phosphate		Ammonium Nitrate	Urea
	10	46	8	10	24	24	20	13				
	10	0	8	10	12	24	20	13				
Chemical Components												
Nitrogen	*10	18	6	15	12	8	0	13		33	45	
Phosphorous P ₂ O ₅	10	46	8	10	24	24	20	13	20			
Potash K ₂ O	10	0	8	10	12	24	20	13				60

* Ureaform (38-0-0) -- This fertilizer shall contain a minimum of 38% total nitrogen, 27% of which shall be insoluble nitrogen derived from ureaform. The final mixture shall have a minimum activity index (AI) of 50% as determined by the appropriate AOAC procedure.

* Ureaform (10-10-10) -- This fertilizer shall contain a minimum of 10% total nitrogen, 35% of which shall be insoluble nitrogen derived from ureaform. The final mixture shall have a minimum activity index (AI) of 40% as determined by appropriate AOAC procedure.

715.02.2.1--Agricultural Limestone. Agricultural limestone shall be either a hard-rock limestone material or a marl or chalk agricultural liming material as addressed in the latest amendment to the Mississippi Agricultural Liming Material Act of 1993, published by the MDAC

715.02.2.1.1--Screening Requirements. Marl or chalk lining material shall not have less than 90% of the material passing the No. 10 sieve.

715.02.2.1.2--Calcium Carbonate Equivalent. Marl or chalk liming material shall not have less than 70% calcium and magnesium carbonate calculated as calcium carbonate equivalent when expressed on a dry weight basis.

715.02.2.1.3--Neutralizing Values. Hard-rock limestone material shall have a minimum Relative Neutralizing Value (RNV) of 63.0%, which is determined as follows.

$$\% \text{ RNV} = \text{CCE} \times (\% \text{ passing \#10 mesh} + \% \text{ passing \#50 mesh}) / 2$$

Where: CCE = Calcium Carbonate Equivalent

715.02.3--Sampling and Testing. Sampling and testing of agricultural limestone shall be in accordance with Subsection 700.03. Labels on containers or attached thereto showing the guaranteed analysis of other fertilizers will be prima facie evidence as to conformity with the specified requirements.

715.03--Seed.

715.03.1--General. All seeds shall comply with the seed law of the State of Mississippi and the current regulations duly promulgated thereunder. The seed shall be delivered in bags with certified tags or labels attached to each bag showing the seed name, kind, variety, percent of germination and purity of the seed, and the percent of obnoxious weeds and inert matter.

715.03.2--Germination and Purity Requirements. The requirements for germination and purity shall be as set out in Table B:

**TABLE B
Germination and Purity Requirements**

Name (Kind)	Name (Variety)	Percent Germination	Percent Purity
GRASSES			
Bermudagrass	Common	85	95
Bahiagrass	Pensacola or Wilmington	85	85
Tall Fescue	Kentucky 31	80	95
Lovegrass	Weeping	80	97
Carpetgrass	-----	80	85
Millet	Browntop	85	98
Oats	-----	90	98
Rye Grain	-----	80	98
Centipede	-----	80	85
Rye Grass	Annual	80	98
Wheat	-----	80	98
LEGUMES			
Crimson Clover	Dixie, Chief, Tibbee, or Autauga	85	98
Annual Lespedeza	Kobe, Summit, or Climax	80	98
Sericea Lespedeza	Common, Interstate or Serala	80	98
Lespedeza	Vergata	90	98
Vetch	Hairy	85	95

715.03.3--Sampling and Testing. Except as provided in Subsection 214.02, the certified analysis shown on the seed bags will be used to determine the purity, obnoxious seeds, and inert matter as to conformance with the above requirements. Seeds from bags not identified by certified analysis or from bags with certified analysis indicating the seeds do not meet contract requirements shall not be used.

All seeds will be sampled and tested for percent germination, and the Department reserves the right to sample and test seeds for any required characteristic when deemed appropriate to do so as a check on the quality of the seeds, in which case the results of such tests shall be the basis for acceptance, rejection, or adjustment under the provisions of the contract.

Seeds to be tested by the Department will be sampled under the supervision of the District Materials Engineer. The seeds sampled by Department personnel will be sampled by means of a probe through the seed bags that are stored in accordance with Subsection 214.02.

The procedures for sampling, testing, acceptance, rejection, or adjustment will be in accordance with Subsection 214.02 supplemented by Department SOP.

715.03.4--Leguminous Inoculants. Approved legume seeds shall be treated with leguminous inoculant under the supervision of the Engineer. The inoculants for treating leguminous seeds shall be standard, pure culture of nitrogen fixing bacteria. The seed shall be treated at the rate specified and according to the directions shown on the container of the inoculants and before the expiration date for use of the inoculant as also shown on the container.

715.04--Water. Water used in planting and establishment of vegetation shall comply with the applicable requirements of Subsection 714.01.

715.05--Vegetative Materials for Mulch. The vegetative materials for mulch shall be classed as follows:

Type I - Approved baled straw of wheat, oat, rye grain, or rice or broomsage or Bahia grass with seed heads that has reached maturity prior to cutting.

Type II - Approved baled hay produced from Bermuda, Bahia, Fescue, Dallis Grass, any of the Lespedezas, or combinations thereof.

All of the above materials shall have been properly cured prior to baling and shall be reasonably free from Johnson Grass and other noxious grasses and weeds. Vegetative material shall be reasonably bright in color, dry, and shall not be musty, moldy, or of otherwise low quality. Vegetative material that is wet or that has been baled green, not cured properly, shall not be used.

Unless otherwise permitted in writing by the Engineer, Type I shall be furnished and used. The Engineer may permit the use of Type II when the Contractor has furnished satisfactory evidence in writing that Type I material is not available.

715.06--Blank.

715.07--Mulch for Woody Plant Materials. The mulch materials shall conform to the

following.

715.07.1--Tree Bark Mulch. The mulch shall be a standard manufactured product of ground, shredded, or broken particles from the bark of trees and shall be reasonably free of weed seeds, harmful bacteria, or disease spores and substances toxic to plant growth. The mulch particles shall be of the following type(s), as specified in the contract.

Type I - Commonly known as extra coarse. Particle size shall be approximately one inch to 2 1/2".

Type II - Commonly known as coarse. Particle size shall be approximately 1/2 inch to one inch.

Type III - Commonly known as medium. Particle size shall be approximately 1/4 inch to 1/2 inch.

Type IV - Commonly known as fine. Particle size shall be approximately 1/8 inch to 1/4 inch.

Type V - Commonly used for the surface mulching plant holes and plant pits. Mulch shall be shredded cedar, cypress, pine, or hardwood bark strip (pole peelings), commercial type, with no pieces larger than 1½ inches across the surface. Once or twice hammered material is not acceptable for Tree Bark Mulch, Type V. The Contractor shall submit samples of all mulches to the Engineer and receive approval prior to delivery to site.

All tree bark mulch shall be handled so as to ensure proper protection against contamination at all times. The mulch shall be delivered to the job in unbroken bags or bales with a manufacturer's label or tag on each container. Labels or tags on the containers shall show the physical analysis of the contents, the size of the particles, and the volume. Labels on containers or attached thereto showing the guaranteed analysis and volume will be prima facie evidence of the materials meeting the above requirements. All mulch will, however, be subject to approval by the Engineer as to quality and quantity.

715.07.2--Aggregate Mulch. Aggregate used as mulch shall be crushed or uncrushed gravel Size 5 or Size 56 meeting the gradation requirements of Subsection 703.14 for coarse aggregate cover material.

715.07.3--Straw. Straw material for mulch shall be classed as follows.

Class I - Approved baled wheat, oat, rice or rye straw. The materials shall have been cured properly prior to baling and shall be reasonably free from obnoxious grasses and weeds. The straw material shall be reasonably bright in color, dry and shall not be musty, moldy, or of otherwise low quality.

Class II - Approved baled pine needles that is reasonably free of twigs, branches, and obnoxious grasses and weeds. The material shall be dry and shall not be musty, moldy, or of otherwise low quality.

All straw mulch shall be inspected and approved by the Engineer prior to its use.

715.08--Fertilizer for Woody Plant Material. The fertilizer material for woody plants shall conform to the following requirements:

715.08.1--Fertilizer Packet. The fertilizer packet shall consist of an approved manufactured sealed polyethylene-paper laminated perforated packet containing one, two, or four ounces of water soluble fertilizer with a minimum guaranteed analysis of 16-8-16, 16% Nitrogen, 8% Phosphoric Acid, 16% Potash.

715.08.2--Fertilizer Tablet. The fertilizer tablet shall consist of an approved tightly compressed slow-release tablet 5, 10 or 21 gram size containing a minimum guaranteed analysis of 20-10-5, 20% Nitrogen, 10% Phosphoric Acid, 5% Potash.

715.08.3--Guaranteed Analysis. Labels on containers or attached thereto showing the guaranteed analysis will be prima facie evidence of the fertilizer materials meeting the specified requirements. All fertilizer packets and tablets will, however, be inspected and approved by the Engineer or, at the Engineer’s discretion, may be sampled and tested.

715.09--Ditch Liner Material. All ditch liner materials shall be new and free of rips or tears.

715.09.1--Jute Mesh. Jute mesh shall be of uniform, plain weave with warp and weft yarns of approximately the same size. The physical requirements shall be:

- Length 50 yards per roll, minimum
- Width 48 inches, plus or minus one inch
- Warp ends 78 per width, minimum
- Weft yarns 41 per yard, minimum

The weight of cloth shall average 1.22 pounds per linear yard with a tolerance of plus 10% or minus 5%.

715.09.2--Excelsior Blanket. The excelsior blanket shall consist of a machine-produced mat of interlocking wood excelsior with uniform thickness and the fiber evenly distributed over the entire area of the blanket. A fabric net of extruded plastic shall be applied to one side of the excelsior wood mat to hold the wood fibers in place.

The blankets shall be supplied in a protective covering and shall not be exposed to moisture prior to placing. The blankets shall meet the following physical requirements:

- Interlocking Wood Fibers . 0.020" x 0.04" (±25%), 50% must be 3½ inches or longer
- Fabric Net 1½" x 3½" maximum mesh size
- Width 36-inch minimum

715.09.3--Erosion Control Blanket. The erosion control blanket shall consist of a machine-produced mat whose primary component is clean, weed-free straw from cereal grain crops. The straw must be evenly distributed throughout the mat. The top side of the blanket shall be covered with a photodegradable plastic mesh having 3/4" x 3/4" maximum openings, which shall be substantially adhered to the straw by a knitting process using degradable thread. The blanket shall be supplied in a protective covering and shall meet the following requirements:

Straw *	0.50 pounds per square yards, minimum dry weight
Netting	Photodegradable plastic
Width	48-inch minimum

* Coconut fiber may be used to replace a portion or all of the straw.

715.09.4--Erosion Control Fabric. The erosion control fabric shall consist of a flexible knitted construction of high strength degradable yarn with uniform openings interwoven with strips of biodegradable paper and shall conform to the following requirements:

Width	48-inch minimum
Weight	0.2 pounds per square yard, approximate

715.09.5--Wire Staples. The staples for securing the ditch liner material in place shall be a double prong "U" configuration made from 11-gauge or heavier steel wire with an approximate length of six inches after bending.

715.09.6--Roving.

715.09.6.1--Polypropylene Roving. This material shall be formed from continuous strands of fibrillated polypropylene yarn, collected into a rove. Fibrillation is defined as a net-like physical structure of the yarn created by splitting the yarn in a precise pattern during manufacture.

The polypropylene shall contain a sufficient amount of UV inhibitors so as to retain 70 percent of its strength after 500 hours of exposure in a Weatherometer.

The fibrillated polypropylene roving shall have the following detailed requirements:

<u>Property</u>	<u>Limits</u>	<u>Test Method</u>
Strands / Rove	20-30	End Count
Yards per Pound of Rove	410-620	ASTM D 1907
Package Weight, pounds	18 minimum	Scale
Color	Black	

715.09.6.2--Fiberglass Roving. The material shall be formed from continuous fibers drawn from molten glass, coated with a chromecomplex sizing compound, collected into strands, and lightly bound together into a rove.

The fiberglass roving material shall meet the following detailed requirements:

<u>Property</u>	<u>Limits</u>	<u>Test Method</u>
Yield, yards per pound	170 - 300	ASTM D 578
Fiber Diameter, inch	0.00035 - 0.00055	ASTM D 578
Strands / Rove	50 - 70	End Count
Package Weight, pounds	25-50	Scale

715.09.7--Certification. The Contractor shall furnish the Engineer with three copies of the manufacturer's certification for each shipment of ditch liner material stating the amount

furnished and that the material complies with the requirements of the specifications and also forward three copies of the manufacturer's or distributor's certification showing the wire size for each shipment of staples.

The certifications by the manufacturer or distributor will be prima-facie evidence that the materials meet the specified requirements. All ditch liner material and staples will, however, be subject to approval by the Engineer.

SECTION 716 - MISCELLANEOUS METALS

716.01--General. All miscellaneous metals shall be as shown on the plans or in the special provisions, and shall conform to the requirements as set out in this subsection, unless otherwise specified.

Unless waived by the Engineer, the Contractor shall furnish the State Materials Engineer three copies of certified test reports from an approved testing laboratory covering all material described in this section.

716.02--Steel Castings.

716.02.1--Carbon Steel Castings. Carbon steel castings shall conform to AASHTO M 103. Grade 70-36 shall be furnished unless otherwise specified.

716.02.2--Chromium Alloy-Steel Castings. Chromium alloy-steel castings shall conform to ASTM A 743. Grade CA-15 shall be furnished unless otherwise specified.

716.03--Steel Forgings. Steel forgings shall conform to AASHTO M 102. Class C forgings shall be furnished unless otherwise specified.

716.04--Gray Iron Castings. Gray iron castings shall conform to AASHTO M 105. Class 30B shall be furnished unless otherwise specified. For testing purposes a lot size shall be defined as the lesser of either a total of 35,000 pounds or one week's production for the Department. The test bar shall be made from a melt of iron used in production of units for the Department. The test bar length shall be a minimum of 16 inches.

716.05--Malleable Castings. Malleable castings shall conform to ASTM A 47. Grade No. 35018 shall be furnished unless otherwise specified.

716.06--Bronze Castings and Bearings. Bronze castings and bearings shall conform to AASHTO M 107. Alloy UNS No. C91100 shall be furnished unless otherwise shown on the plans.

716.07--Copper Bearings and Sheet Copper.

716.07.1--Rolled Copper-Alloy Bearings and Expansion Plates. Rolled copper-alloy bearings and expansion plates shall conform to ASTM B 100. Alloy UNS No. C51000 shall be furnished unless otherwise specified.

716.07.2--Sheet Copper. Sheet copper shall meet the requirements of AASHTO M 138 including the embrittlement test. The Copper No. shall be as designated on the plans.

716.08--Self-Lubricating Bearing Plates. Self-lubricating bearing plates shall be an article of standard production by an established manufacturer of such equipment. They shall be provided with trepanned or drilled recesses, not grooves, which shall be filled with a lubricating compound capable of withstanding the atmospheric elements and consisting of graphite and metallic substances with a lubricating binder. This compound shall be pressed into the recesses by hydraulic presses so as to form dense nonplastic lubricating inserts. The lubricating area shall comprise not less than 25% nor more than 35% of the total bearing area. Contractor shall furnish additional lubricating material in stick form. Just prior to erecting the members that rest on the bronze plates, the Contractor shall thoroughly rub the steel bearing plates that rest on the bronze with the lubricant. These surfaces shall be unpainted and shall be cleaned with a steel brush immediately before the lubricant is applied.

The bearing plates shall be made of (1) rolled bronze conforming to the requirements of Subsection 716.07.1, or (2) cast bronze conforming to requirements of Subsection 716.06, Alloy UNS No. C91100 or No. C90500, except that a maximum lead content of 2.5% is allowable.

The coefficient of friction shall not exceed 0.10 when subjected to design loading and also when subjected to twice the design loading.

Contact surfaces shall be finished in the direction of motion in accordance with the requirements of ANSI B46 1-55 No. 125. All machined surfaces shall be flat within 0.0005 inch per inch of length and width. In mating curved surfaces of steel and bronze, the concave surfaces may have a plus tolerance of 0.01 inch and the convex surfaces may have a minus tolerance of 0.01 inch.

The Contractor shall furnish the manufacturer's shop drawings showing pattern and size of recesses.

716.09--Babbitt. Babbitt shall conform to ASTM B 23. The alloy number shall be as designated on the plans.

716.10--Lead Plates, Pipes, Etc. Lead used for plates, pipes, etc. shall conform to ASTM B 29, Grade: Pure Lead.

716.11--Galvanized Pipe. Galvanized pipe for water, gas, etc. shall conform to ASTM A 53.

716.12--Rolled Zinc. Rolled zinc shall conform to ASTM B 69. The type shall be as designated on the plans.

716.13--Blank.

716.14--Bar Grates.

716.14.1--Material Requirements. Plain round steel bars and strap bars shall conform to the following requirements:

B-9 Grates and Bar Grates AASHTO M 270, Grade 36

MI, GI, & SS-3 Grates AASHTO M270, Grade 50W, or ASTM A 588, Grade 50W

716.14.2--Fabrication and Finish. All bar grates shall be constructed in accordance with these specifications and in conformity with the detailed plans.

Holes shall be punched or drilled in the strap bars to accommodate the round bars. The junctions of all round bars and/or strap bars shall be welded. The completed bar grate shall exhibit good workmanship.

After fabrication, the bar grate shall be coated with an approved commercial quality coating designed for coating steel castings and fabricated units. The State Materials Engineer shall approve the coating material prior to application.

SECTION 717 - STRUCTURAL STEEL

717.01--Structural Steel.

717.01.1--General. Steel shall be furnished according to the specifications in this section. Unless otherwise specified, structural carbon steel shall be furnished. Steels other than those required herein may be specified on the plans. When steel is used in welded construction, the welding procedure shall be suitable for the steel and the intended service.

717.01.2--Requirements for Structural Steel. Structural steel shall meet the applicable AASHTO and ASTM Standards, which shall include the Supplementary Bend Test Requirement and the following Charpy V-Notch Requirements for minimum service temperature 0°F and above:

ASTM DESIGNATION	THICKNESS & FABRICATION	MINIMUM CHARPY V-NOTCH ENERGY @ TEMPERATURE
A 36	Up to 4"	15 ft. lb. @ 70°F
*A 588	Up to 4" Mechanically Fastened	15 ft. lb. @ 70°F
*A 588	Up to 2" Welded	15 ft. lb. @ 70°F
*A 588	Over 2" to 4" Welded	20 ft. lb. @ 70°F
*A 572	Up to 4" Mechanically Fastened	15 ft. lb. @ 70°F
*A 572	Up to 2" Welded	15 ft. lb. @ 70°F
*A 572	Over 2" to 4" Welded	20 ft. lb. @ 70°F
A 514	Up to 4" Mechanically Fastened	25 ft. lb. @ 30°F
A 514	Up to 2½" Welded	25 ft. lb. @ 30°F
A 514	Over 2½" to 4" Welded	35 ft. lb. @ 30°F
A 852	Up to 4" Mechanically Fastened	20 ft. lb. @ 50°F
A 852	Up to 2½" Welded	20 ft. lb. @ 50°F
A 852	Over 2½" to 4" Welded	25 ft. lb. @ 50°F

* If the yield strength of the material exceeds 65 ksi, the temperature for the CVN value for acceptability will be reduced 15°F for each increment or fraction thereof of 10 ksi above 65 ksi.

The procedure for sampling and testing shall be in accordance with ASTM A 673. The

(H) Frequency of Heat Testing shall be used for all the steel specifications except ASTM A 514 which shall be in accordance with the (P) Frequency of Piece Testing.

If ASTM A 517 steel is used in lieu of A 514, the sampling and testing requirements shall be the same as the A 514 of equal thickness.

717.01.3--Structural Carbon Steel. Structural carbon steel for bolted and welded construction shall be in accordance with ASTM A 36.

717.01.4--Eyebars. Steel for eyebars shall be a weldable grade. These grades include structural steel conforming to:

- (a) Structural Carbon Steel ASTM A 36.
- (b) High-Strength Low-Alloy Structural Steel with 50,000 psi, minimum yield point to four inches (4") thick, ASTM A 588 with supplementary requirements for Charpy V-Notch mandatory.

717.01.5--High Strength Low-Alloy Structural Steel. High-Strength Low-Alloy Structural Steel shall conform to:

- (a) High-Strength Low-Alloy Columbium-Vanadium Steels of Structural Quality, ASTM A 572.
- (b) High-Strength Low-Alloy Structural Steel with 50,000 psi, minimum yield point to four inches (4") thick, ASTM A 588.

717.01.6--High Strength Low-Alloy Structural Steel for Welding. High-Strength Low-Alloy Structural Steel for welding shall conform to:

- (a) High-Strength Low-Alloy Columbium-Vanadium Steels of Structural Quality, ASTM A 572, Grade 50.
- (b) High-Strength Low-Alloy Structural Steel with 50,000 psi, minimum yield point to four inches (4") thick, ASTM A 588.

717.01.7--High-Strength Structural Steel for Bolted Construction. High-Strength Structural Steel for bolted construction shall conform to:

- (a) High-Strength Low-Alloy Columbium-Vanadium Steels of Structural Quality, ASTM A 572, Grade 50.
- (b) High-Strength Low-Alloy Structural Steel with 50,000 psi, minimum yield point to four inches (4") thick, ASTM A 588.

717.01.8--High-Yield-Strength, Quenched, and Tempered Alloy Steel Plate. High-Yield-Strength, Quenched and Tempered Alloy Steel Plate shall conform to:

- (a) High-Yield-Strength, Quenched, and Tempered Alloy Steel Plate, suitable for welding, ASTM A 514.
- (b) High-Strength Alloy Steel Plates, Quenched and Tempered for pressure vessels, ASTM A 517.

717.01.9--Weathering Structural Steel. Where indicated on the plans, material designated as A709, Grade HPS70W shall be high-strength, low-alloy, quenched and

tempered structural steel plate meeting the requirements of ASTM A709 including the supplemental requirement S83 for Non-Fracture Critical material. The Contractor is advised that quenched and tempered steel plates are limited to a fifty (50) feet maximum delivery length from United States mills.

Non-quenched and tempered Thermo-Mechanical Controlled Processed (TMCP) HPS70W material may be directly substituted for material up to two (2) inches, provided that the chemistry of the TMCP plate is identical to Quenched and Tempered HPS70W and that the TMCP plate meets the minimum mechanical properties for Quenched and Tempered HPS70W steel listed below.

MINIMUM MATERIAL PROPERTIES

Type	High Strength, Low-Alloy, Quenched and Tempered Steel
ASTM Designation	A709, Grade HPS70W
Thickness	To 4"
Tensile Strength, Fu	85-110 ksi
Minimum Yield Strength, Fy	70 ksi

The A709 HPS70W material shall meet the longitudinal Charpy V-notch requirements of Zone 1 for Non-Fracture Critical material.

All other steel shall meet the requirements of ASTM A709 Grade 50W. All field connections shall be made using ASTM A325, Type 3 High Strength bolts. Nuts shall be heavy hex and shall conform to the requirements of ASTM A563, Grade DH3. Washers shall conform to the requirements of ASTM F436, Type 3.

717.01.10--Acceptance Procedure. Structural Steel shall be accepted on the basis of manufacturer's certified test reports. The Contractor shall furnish the Engineer with three copies of the certified test reports.

717.02--Fasteners. Fasteners for structural steel joints shall conform to the ASTM specifications with revisions, as specified herein.

717.02.1--Plain Finish Fasteners.

717.02.1.1--Bolts. Ungalvanized bolts shall meet the requirements of ASTM A 325 or ASTM A 490, as specified on the plans.

717.02.1.2--Heavy Hex Nuts. Ungalvanized nuts shall meet the requirements of ASTM A 194, Grade 2H, or A 563, Grade DH, as specified on the plans.

717.02.1.3--Hardened Washers. Ungalvanized washers shall meet the requirements of ASTM F 436.

717.02.2--Galvanized Fasteners.

717.02.2.1--Galvanized Bolts. Bolts shall meet the requirements of ASTM A 325, Type 1. Galvanizing shall be in accordance with ASTM A 153, Class C, or ASTM B 695, Class

50. Thickness of zinc coating shall be measured on the wrench flats or top of bolt head.

717.02.2.2--Galvanized Nuts. Nuts shall meet the requirements of ASTM A 563, Grade DH. Galvanizing shall be in accordance with ASTM A 153, Class C, or ASTM B 695, Class 50. Thickness of zinc coating shall be measured on the wrench flats.

717.02.2.3--Galvanized Washers. Washers shall meet the requirements of ASTM F 436. Galvanizing shall be in accordance with ASTM A 153, Class C, or ASTM B 695, Class 50.

717.02.2.4--Direct Tension Indicators. Direct tension indicators shall meet the requirements of ASTM F 959 and galvanized in accordance with ASTM B 695, Class 50. Visual indicating paint rupturing DTIs may be permitted if approved by Materials Division.

717.02.3--Revisions to ASTM Specifications.

717.02.3.1--ASTM A 325. Hardness for bolt diameters 1/2-inch to 1-inch inclusive shall have a minimum Rockwell C Hardness Number of 24 and a maximum Rockwell C Hardness Number of 33.

717.02.3.2--ASTM A 563. Nuts that are to be galvanized shall be tapped oversize the minimum amount required for proper assembly. The amount of overtap in the nut shall be such that the nut will assemble freely on the bolt in the coated condition and shall meet the rotational-capacity test set out in Subsection 717.02.3.4.

The overtapping requirements of ASTM A 563, Subsection 7.4, shall be considered maximum values instead of minimum, as currently shown.

Galvanized nuts shall be lubricated with a lubricant containing a dye of any color that contrasts with the color of the galvanizing.

717.02.3.3--ASTM F 606.

717.02.3.3.1--Bolts. Proof load tests shall be performed in accordance with Method 1, Length Measurement. Minimum frequency of tests shall be as specified in ASTM A 325 for "Production Lot Method."

Wedge tests on full size bolts are required. If bolts are to be galvanized, the tests shall be performed after galvanizing. Minimum frequency of tests shall be as specified in ASTM A 325, "Production Lot Method."

717.02.3.3.2--Nuts. Proof load tests shall be performed in accordance with ASTM: F 606, Subsection 4.2. If nuts are to be galvanized, tests shall be performed after galvanizing, overtapping and lubricating.

717.02.3.3.3--Washers. If galvanized washers are supplied, hardness testing shall be performed after galvanizing. The coating shall be removed prior to taking hardness measurements.

717.02.3.4--Rotational-Capacity Testing of Assemblies. Rotational-capacity tests are required and shall be performed on all black or galvanized bolt, nut and washer assemblies

by the manufacturer or distributor prior to shipping. Tests on galvanized bolts and hardware shall be performed after galvanizing. Washers are required as part of the test even though they may not be required as part of the installation procedure. Except as modified herein, the rotational-capacity test shall be performed in accordance with the requirements of ASTM A 325.

The following shall apply:

- (a) Each combination of bolt production lot, nut lot and washer lot shall be tested as an assembly. Where washers are not required by the installation procedures, they need not be included in the lot identification.
- (b) A rotational-capacity lot number shall be assigned to each combination of lots tested.
- (c) The minimum frequency of testing shall be two assemblies per rotational-capacity lot.
- (d) The bolt, nut and washer assembly shall be assembled in a Skidmore-Wilhelm Calibrator or an acceptable equivalent device. For short bolts that are too short to be assembled in the Skidmore-Wilhelm Calibrator see (h) below.
- (e) The minimum rotation, from a snug tight condition (10% of the specified proof load), shall be:
 240°, 2/3 turn, for bolt lengths < 4 diameters
 360°, 1 turn, for bolt lengths ≥ 4 diameters and < 8 diameters
 480°, 1 1/3 turn, for bolt lengths ≥ 8 diameters
- (f) The tension reached at the above rotation shall be equal to or greater than 1.15 times the required installation tension. The installation tension and the tension for the turn test are shown below:

Diameter, inches	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
Required Installation Tension, kips	12	19	28	39	51	56	71	85	103
Turn Test Tension, kips	14	22	32	45	59	64	82	98	118

- (g) After the required installation tension listed above has been exceeded, one reading of tension and torque shall be taken and recorded. The torque value shall conform to the following:

$$\text{Torque} \leq 0.25 \text{ PD}$$

Where:

- Torque = measured torque, foot-pounds
- P = measured bolt tension, pounds
- D = bolt diameter, feet

- (h) Bolts that are too short to test in Skidmore-Wilhelm Calibrator may be tested in a steel joint. The tension requirement of (f) above need not apply. The maximum torque requirement of (g) above shall be computed using a value of P equal to the turn test tension shown in the table in (f) above.

717.02.4--Reporting. The results of all tests, including zinc coating thickness, required herein and in the appropriate ASTM specifications shall be recorded on the appropriate document. The location where tests are performed and the date of tests shall be reported

on the appropriate document. The manufacturer or distributor that performs the test shall certify that the results recorded are accurate. The manufacturer shall certify that the steel and the assembly components are domestic products.

717.02.5--Documentation.

717.02.5.1--Mill Test Report(s) (MTR). MTR shall be furnished for all mill steel used in the manufacture of the bolts, nuts, and washers. MTR shall indicate the place where the material was melted and manufactured.

717.02.5.2--Manufacturer Certified Test Report(s) (MCTR). The manufacturer of the bolts, nuts, and washers shall furnish the Department three copies of test reports (MCTR) for the items furnished. Each MCTR shall have the appropriate MTR attached. Each MCTR shall contain the information required in Subsection 717.02.4.

The manufacturer performing the rotational-capacity test shall include on the MCTR the following:

- (a) The lot number of each of the items tested.
- (b) The rotational-capacity lot number as required in paragraph (b) of Subsection 717.02.3.4.
- (c) The results of the tests required in Subsection 717.02.3.4.
- (d) The pertinent information required in Subsection 717.02.4.
- (e) A statement that MCTR for the items are in conformance with this specification and the appropriate ASTM specifications.
- (f) The location where the bolt assembly components were manufactured.

717.02.5.3--Distributor Certified Test Report(s) (DCTR). The following shall be applicable for DCTR:

- (a) The DCTR shall include MCTR for the various bolt assembly components.
- (b) The rotational-capacity test may be performed by a distributor in lieu of a manufacturer and reported on the DCTR.
- (c) The DCTR shall show the results of the tests required in Subsection 717.02.3.4.
- (d) The DCTR shall also show the pertinent information required in Subsection 717.02.4.
- (e) The DCTR shall show the rotational-capacity lot number as required in paragraph (b) of Subsection 717.02.3.4.
- (f) The DCTR shall certify that the MCTR are in conformance with this specification and the appropriate ASTM specifications.

717.02.6--Shipping. Bolts, nuts and washers, where required, from each rotational-capacity lot shall be shipped in the same container. If there is only one production lot number for each size of nut and washer, the nuts and washers may be shipped in separate containers. Each container shall be permanently marked with the rotational-capacity lot number such that identification will be possible at any stage prior to installation.

Three copies of the appropriate MTR, MCTR or DCTR shall be furnished to the Department.

717.02.7--Final Acceptance. Final acceptance of high strength bolts, nuts, washers and

direct tension indicators will be based on tests performed on samples obtained from the project by the Department. Tests will be performed in accordance with the procedures set out in these specifications. A lot shall be defined as each shipment to a project from the manufacturer's lot number and of the same size and length. The integrity of each lot shall be maintained until tests are completed by the Department.

Each lot of bolts, shall be sampled as follows:

<u>Lot Size</u>	<u>Sample Size</u>
150 or less	2
151 to 280	4
281 to 500	6
501 to 1,200	10
1,201 to 3,200	16
3,201 to 10,000	26
10,001 and over	40

Note: One-half of the sampled bolts will be used for tensile testing and the other one-half will be tested for coating and/or hardness.

Each lot of nuts or washers shall be sampled as follows:

<u>Lot Size</u>	<u>Sample Size</u>
800 or less	1
801 to 8,000	2
8,001 to 22,000	3
22,001 and over	5

Note: The sample size shall be doubled when galvanized nuts or washers are specified or used.

Each lot of direct tension indicators shall be sampled as follows:

<u>Lot Size</u>	<u>Sample Size</u>
35,000 or less	16
35,001 to 250,000	26
250,001 and over	32

Direct tension indicators shall be tested in accordance with ASTM F 959. One-half of the samples will be tested in compression and the remaining one-half will be tested for coating.

717.03--Copper Bearing Steels. When copper bearing steel is specified, the steel shall contain not less than 0.2 percent copper.

717.04--Welded Stud Shear Connectors. Shear connector studs shall conform to the requirements of Cold Finished Carbon Steel Bars and Shafting, ASTM A 108, Cold-Drawn Bars, Grades 1015, 1018, or 1020, either semi or fully killed. If flux retaining caps are used, the steel for the caps shall be of a low carbon grade suitable for welding and shall comply with Cold-Rolled Carbon Steel Strip, ASTM A 109.

Tensile properties as determined by tests of bar stock after drawing or of finished studs

shall conform to the following requirements:

Tensile Strength, minimum	60,000
Yield Strength*, minimum	50,000
Elongation, minimum	20% in 2 inches
Reduction of area, minimum	50%

* As determined by a 0.2 percent offset method.

Tensile properties shall be determined in accordance with the applicable sections of ASTM A 370, Mechanical Testing of Steel Products. Tensile tests of finished studs shall be made on studs welded to test plates. If fracture occurs outside of the middle half of the gage length, the test shall be repeated.

Finished studs shall be uniform quality and condition, free from injurious laps, fins, seams, cracks, twists, bends, or other injurious defects. Finish shall be as produced by cold drawing, cold rolling, or machining.

The manufacturer shall certify that the studs as delivered are in accordance with the material requirements of this section. Certified copies of in-plant quality control test reports shall be furnished to the Engineer upon request.

The Engineer may select, at the Contractor's expense, studs of each type and size used under the contract, as necessary for checking the requirements of this section.

717.05--Steel Grid Flooring.

717.05.1--Steel. All steel shall conform to the Specification for Structural Steel of the ASTM A 36, ASTM A 572, Grade 50, or ASTM A 588. Unless the material is galvanized, it shall have a copper content of 0.2 percent.

717.06--Pins and Rollers. Steel for pins and rollers shall conform to the designations listed in Tables I and II below.

Pins and rollers shall be accurately turned to the dimensions shown on the drawings and shall be straight, smooth, and free from flaws. Pins and rollers more than nine inches in diameter shall be forged rollers and annealed. Pins and rollers nine inches or less in diameter may be either forged and annealed or cold-finished carbon-steel shafting.

In pins larger than nine inches in diameter, a hole not less than two inches in diameter shall be bored full length along the axis after the forging has been allowed to cool to a temperature below the critical range, under suitable conditions to prevent injury by too rapid cooling, and before being annealed.

Table I

Minimum Material Properties Structural Steel		
Type	Structural Carbon Steel	High Yield Strength Quenched and Tempered Alloy and Low Alloy Steel
Designation ASTM	A 36	A 514/A 517
Thickness of Plates	Up to and including 8 inches	Over 2½ inches up to and including 4 inches
Minimum Tensile Strength, Fu	58,000	100,000
Minimum Yield Point or Minimum Yield Strength, Fy	36,000	90,000
	Up to and including 4 inches	Up to and including 4 inches
	A 572, Grade 50	A 588
	65,000	70,000
	50,000	50,000

Table II

Minimum Material Properties Pins and Rollers		
Expansion rollers shall be not less than 4 inches in diameter		
ASTM Designation	A 108	A 668 *
Grade or Class	Grades 1016 to 1030 inclusive	Class F
Size Limitations	4 inches or less in diameter	Up to 10 inches in diameter
Minimum Yield, Point, psi, Fy	36,000	50,000
	37,500	50,000
	Up to 20 inches in diameter	Up to 20 inches in diameter
	Class D	Class G

* May substitute rolled material of the same properties.

SECTION 718 - TIMBER AND DIMENSION LUMBER

718.01--Timber and Dimension Lumber. General. All timber and dimension lumber shall be Southern pine and shall conform in all respects to applicable requirements of AASHTO M 168. Inspection for conformance to these specifications will be conducted in accordance with Department SOP.

Timber and dimension lumber shall be furnished in the sizes shown on the plans or as specified. Unless otherwise specified, timber and dimension lumber shall be No. 1, or better, graded according to the latest American Lumber Standards.

Only one type of preservative shall be used for the treatment of materials for any one class of construction on a project, unless otherwise specified.

Where timber and dimensional lumber is to be used in non-highway construction or use, such as decking, handrails in walking trails, or in any manner where general public exposure by touch is possible, the treatment requirements will be as per project plans and/or approved by the State Materials Engineer.

718.02--Untreated Timber and Dimension Lumber. Untreated timber and dimension lumber shall comply with the requirements set out in Subsection 718.01.

718.03--Treated Timber and Dimension Lumber. Timber and dimension lumber to be treated shall meet the requirements herein specified and shall be treated by a pressure method to the minimum required retainage of preservative as specified on the plans or elsewhere in the specifications. Treated timber or dimensional lumber will not be accepted for use unless it has been inspected by an authorized representative of the Department and found to be satisfactory both before and after treatment. Inspection prior to treatment may be waived by the Testing Engineer when the preservative will be pentachlorophenol or chromated copper arsenate.

718.03.1--Seasoning. Seasoning timber, dimension lumber, piles and poles to be treated with preservatives shall conform to the requirements of AWPA.

718.03.2--Treatment.

718.03.2.1--General. Insofar as practicable, each charge shall consist of pieces approximately equal in size, moisture, and sapwood content into which approximately equal quantities of preservative can be injected. Each layer of material shall be separated at each end, and at the center when necessary, by strips at least 3/8 inch in thickness. Caps, stringers, and other large timbers shall be separated by strips of at least 1/2-inch thickness.

All timber and lumber shall be treated in accordance with AWPA treating practices unless otherwise specified herein.

Unless otherwise directed, the type and minimum quantity of preservative shall be in accordance with TABLES 1, 2 or 3.

Any treated timber or lumber to be painted shall be treated in accordance with Subsection 718.04.3, Type B solvent, or Subsection 718.04.4.

Brackish water, as listed in TABLES 1, 2 or 3, shall mean salt waters, bordering land, and waters adjacent thereto that are subject to tidal flow.

718.03.2.2--Penetration. Unless otherwise specified, treated timber and lumber shall show a 100 percent sapwood penetration or a minimum penetration of four inches.

The test method for determining the amount of preservative retained will be either as specified in AWWA or Mississippi Test Methods. The borer cores shall be obtained in accordance with AWWA Standard M2 and shall be taken from pieces having a sapwood depth at least equal to the sampling zone specified as follows:

- (a) Round Units, piling and poles, shall be in accordance with AWWA requirements.
- (b) Structural members less than four inches shall be from zero to one and one half inches from the surface.
- (c) All other structural members shall be from zero to two inches from the surface.

718.03.2.3--Inspection. The Department shall be notified sufficiently in advance of treating the material so that an inspector may be furnished at the plant to inspect the material and the treatment of same. All materials and processes used in the manufacture of the material shall be subject to inspection. The plant shall be equipped with the necessary gauges, thermometers, appliances, and facilities to enable the inspector to determine the conditions at all stages of the treatment and to satisfy the inspector that the requirements of the specifications are fulfilled. The manufacturer shall also provide the apparatus and chemicals necessary for making tests at the plant as required by the Department. All equipment, apparatus, etc., shall be maintained in proper and satisfactory condition for use at all times.

Tests for penetration of preservative shall be made with an increment borer. Test holes shall be plugged with treated plugs. All borings shall be taken at the center of the narrow side of the piece. Sufficient borings shall be taken to ensure that the specified penetration has been obtained, with a minimum of 20 borings required for each charge of materials.

If 20% or more of the borings from a charge of treated material fail to meet the penetration requirements, the entire charge shall be rejected and subject to retreatment. If upon retreatment, the material meets the penetration requirements, it will be accepted. Only one retreatment will be permitted, and any apparent damage due to retreatment shall be cause for rejection.

718.03.3--Handling Treated Material. Any bruising or rough handling will be cause for rejection.

718.03.4--Storage of Treated Material. All material treated for stock shall be stacked as compactly as possible on a well-drained surface. Material shall be supported on sills spaced as necessary, not to exceed 10 foot intervals and shall have at least one foot of air space beneath the stacks.

All materials treated with CCA for use in buildings and applications where painting is required shall be dried after treatment. The treated wood shall be kiln dried by American Lumber Standards, or air dried for a period of at least 21 days before shipment.

718.04--Preservative. The preservatives shall meet the applicable requirements of AWWA, and the water content in an oil preservative shall not exceed 3.0% unless otherwise approved by the Engineer; but in no case shall it exceed 5.0%.

718.04.1--Blank.

718.04.2--Blank.

718.04.3--Pentachlorophenol. The pentachlorophenol shall meet the requirements of AWWA P-8. The test methods shall be either AWWA or Mississippi Test Methods.

The hydrocarbon solvent used in the pentachlorophenol solution shall meet the requirements of AWWA P-9, Type A or B. When painting is required, Type B solvent shall be used. Type A solvent shall be used for all other treatment unless otherwise specified.

Minimum Treatment Rates for Pentachlorophenol Preservative

Material	Coastal Areas and Brackish Water	Other Locations
	Retention pounds / cubic foot	Retention pounds / cubic foot
Lumber	(1)	0.80
Piling	Penta Not Permitted	0.80
Poles	0.60	0.60
Material to be Painted	(2)	(2)

Notes: (1) Pentachlorophenol not permitted for lumber that will be in contact with brackish water. Lumber in the Coastal Area that is not in contact with brackish water may be treated as specified for "Other Locations".

(2) Treated at the rate specified above using AWWA P-9, Type B Solvent.

718.04.4--Chromated Copper Arsenate (CCA). The solution shall contain a sufficient concentration of the water-born preservative to produce the minimum specified retention. The preservative shall meet the requirements of AWWA P-5, CCA Type B or C. The test methods shall be either AWWA or Mississippi Test Methods.

Minimum Treatment Rate For Chromated Copper Arsenate Preservative

Material	Coastal Areas and Brackish Water	Other Locations
	Retention pounds / cubic foot	Retention pounds / cubic foot
Lumber (1)	2.50	0.80
Piling	2.50	0.80
Poles	0.60	0.60

Notes: (1) Lumber in the Coastal Area that is not in contact with brackish water may be treated as specified for "Other Locations".

SECTION 719 - PILES

719.01--General. Piles shall be untreated timber, treated timber, precast concrete, cast-in-

place concrete, or steel piles, as specified and in addition to the general requirements of these specifications and the plans, shall conform to the specific requirements hereinafter set forth, unless otherwise stipulated.

719.02--Timber Piles. All piles shall conform to the requirements of ASTM D 25, except as hereinafter specified. Inspection for conformance to these specifications will be conducted in accordance with Department SOP.

The circumference and diameters of piling shall be in conformity with Table I.

719.02.1--Untreated Timber Piles. Untreated timber piles may be any species that satisfactorily withstand driving. They shall be reasonably clean-peeled.

719.02.2--Treated Timber Piles. Treated timber piles shall be Southern Pine preferably cut during the winter season. Treated timber piles shall be inspected and treated in accordance with the requirements set forth in Section 718.

**TABLE I
CIRCUMFERENCES AND DIAMETERS OF TIMBER PILES**

Length Feet	Three Feet From Butt				At Tip	
	Minimum		Maximum		Minimum	
	Circum- ference	Approx. Diameter	Circum- ference	Approx. Diameter	Circum- ference	Approx. Diameter
	inches	inches	inches	inches	inches	inches
Under 40	38	12	63	20	25	8
40 to 50*	38	12	63	20	22	7
51 to 70*	41	13	63	20	22	7
70 to 90*	41	13	63	20	19	6
Over 90	44	14	63	20	19	6
* inclusive						

719.03--Concrete Piles. Concrete piles, both prestressed and cast-in-place, shall be constructed in conformity with the plans and in accordance with these specifications. Additional requirements for prestressed piles are set out in Section 803.

All concrete materials and their preparation and placing shall be in accordance with the requirements of the class of concrete specified and in accordance with Section 803.

Reinforcing steel shall conform to the requirements of Section 711.

719.04--Steel Piles. The material in rolled steel piles shall be standard structural grade steel of the section number, size, and weight per linear foot indicated on the plans. The steel shall conform to the requirements of ASTM A 572, Grade 50.

The Contractor shall furnish the State Materials Engineer three certified copies of the mill test reports containing the true chemical and physical analyses of the material.

719.05--Steel Sheet Piling. Steel sheet piling shall conform to the requirements of ASTM

A 328.

The Contractor shall furnish the State Materials Engineer with three certified copies of the mill test reports containing the true chemical and physical analyses of the material.

719.06--Steel Pipe Piling. Steel pipe piles shall conform to the requirements of ASTM A252, Grade 3 and shall be either (1) seamless, (2) butt-welded: Electric Resistance Weld (ERW) or Double Submerged Arc Weld (DSAW), or (3) spiralweld pipe. Lap welded seams are not acceptable. The steel shall be a Prequalified Base Metal from the American Welding Society (AWS) D1. 1 Structural Welded Code-Steel. Prior to fabrication, the Contractor shall furnish the State Materials Engineer three certified copies of steel producer's certificates in accordance with ASTM A252.

Steel pipe piles shall be uniform sections of the outside diameter and wall thickness shown on the plans. Steel pipe piles shall resist the earth pressure and retain their original form free from harmful distortions after they and adjacent piles have been driven.

All welding of steel pipe piles, including attachment of pile tips, shall be done by certified welders and shall comply with the governing specifications designated in Subsection 810.02.2.

Two coats of two-part, manufacturer applied, epoxy coal tar coating shall be applied to the outside of all permanent steel pipe piling prior to driving. The limits of application of the coating along the length of the piles shall be as shown on the plans. The epoxy coal tar coating shall conform to the requirements of US Corps of Engineers Specification C-200 and shall be one of the products listed in the plans, or an approved equal. The color shall be black. All steel pipe pile surfaces to receive the epoxy coal tar coating shall be cleaned in accordance with Subsection 814.03.7. Any shop applied epoxy coal tar coating damaged during handling or transport shall be repaired in accordance with the manufacturer's recommendations.

Concrete used to plug the driven steel pipe piles shall conform to the requirements of Section 804 for Class "AA" concrete, unless otherwise noted.

SECTION 720 - PAVEMENT MARKING MATERIALS

720.01--Glass Beads. The beads shall be transparent, clean, colorless glass, smooth and spherically shaped, free from milkiness, pits, or excessive air bubbles and conform to the specific requirements for the class designated. The glass beads shall contain no more than 200 ppm (mg/kg) total concentration for lead, arsenic, or antimony. The manufacturer shall furnish the Engineer with a certified test report indicating that the glass beads meet the above requirement. Unless otherwise specified, Class A glass beads shall be furnished.

720.01.1--Class A. The Class A, Standard, beads shall be Type 1, non-flotation with a moisture resistant coating conforming to the requirements of AASHTO M 247.

720.01.2--Class B. The Class B, High-Visibility, beads shall be non-flotation, embedment coated and conform to the following specific requirements.

720.01.2.1--Gradation. The beads shall meet the gradation requirements of Table 1.

Table 1

U.S. Standard <u>Sieve No.</u>	<u>% Retained</u>
12	0
14	0-5
16	5-20
18	40-80
20	10-40
25	0-5
Pan	0-2

720.01.2.2--Roundness. The beads shall have a minimum of 80 percent rounds per screen for the two (2) highest sieve quantities. The remaining sieve fractions shall be no less than 75 percent rounds.

720.01.2.3--Angular Particles. The beads shall have no more than three (3) percent angular particles per screen.

720.01.2.4--Refractive Index. The beads shall have a refractive index of 1.50 to 1.52.

720.01.3--Packaging and Marking. The beads shall be packaged in 50 or 55-pound moisture proofed bags. Each bag shall be stamped with the following information: name and address of manufacturer, shipping point, trademark or name, the wording "glass beads", class, weight, lot number and the month and year of manufacture.

720.01.4--Acceptance Procedures. The manufacturer shall furnish three copies of the certified test report(s) to the Central Laboratory showing results of all required tests and certification that the material meets the specifications. Acceptance sampling and testing of glass beads will be in accordance with Department S.O.P. No. TMD-40-02-00-000.

720.02--Thermoplastic Pavement Markings. The thermoplastic material shall be lead free and conform to AASHTO M 249, except the glass beads shall be moisture resistant coated.

The manufacturer/producers of the thermoplastic compound, glass beads, epoxy resin, and primer/sealer shall furnish three copies of certified test reports to the Engineer showing results of all tests specified therein and shall further certify that the materials meet all requirements. In addition, the certification for the thermoplastic material shall state that the material is lead free.

720.03--Raised Pavement Markers.

720.03.1--General. Raised pavement markers, including high performance raised pavement markers, shall be listed on the Department's APL.

720.03.2--Type of Markers. Pavement and jiggle markers shall conform to one or more of the following types:

Type A	Non-Reflective White Jiggle Markers
Class 1	Acrylonitrile-Butadiene-Styrene Polymer Markers
Class 2	Ceramic Markers
Type AY	Non-Reflective Yellow Jiggle Markers
Class 1	Acrylonitrile-Butadiene-Styrene Polymer Markers
Class 2	Ceramic Markers
Type B	2-Way Clear Reflective Markers
Type C	Red-Clear Reflective Markers
Type D	2-Way Yellow Reflective Markers
Type E	One-Way Clear Reflective Markers
Type F	One-Way Yellow Reflective Markers
Type G	Yellow-Clear Reflective Markers
Type H	Chip Seal Clear Reflective Markers
Type I	Chip Seal Yellow Reflective Markers

High performance raised pavement markers shall be available in Types B through G.

720.03.3--Acceptance Procedures.

720.03.3.1--Marker Type A. The Contractor shall furnish the Engineer three copies of the manufacturer's certified test reports covering all pavement markers shipped to the project. The certified test report shall show the test results on each part of each section contained in Mississippi Test Method MT-17 and shall state that the markers represented by the test results comply with the specifications contained herein in all respects.

The pavement markers will be tentatively accepted on the basis of the manufacturer's certified test reports. Final acceptance shall be based on check samples as set out in Subsection 720.03.4.

720.03.3.2--Marker Type B through G. The Contractor shall furnish the Engineer three copies of the manufacturer's certification covering all pavement markers shipped to the project. The certification shall state that the raised pavement markers meet the applicable requirements of ASTM D 4280.

The pavement markers will be tentatively accepted on the basis of the manufacturer's certification. The Department reserves the right to obtain check samples as deemed necessary for determining compliance with this specification.

720.03.3.3--Marker Type H and I. Prior to use, the Contractor shall furnish the Engineer three copies of a certification for each shipment stating that the material furnished is of the same composition as that originally approved by the Department and that the material has not been changed or altered in any way. The Department will obtain check samples as deemed necessary for determining compliance with this specification.

720.03.4--Sampling, Tolerances, and Packaging. Pavement markers shall conform to sampling, tolerance, and packaging requirements as follows:

- (a) For Marker Type A, H and I, ten (10) markers of each type and class, selected at random, will constitute a representative sample for each lot regardless of lot size.

- (b) For Marker Type B through G, check sampling, when performed, shall require ten (10) markers of each type, selected at random, to constitute a representative sample for each lot regardless of lot size.
- (c) A resample of any marker type will consist of twice as many markers as originally sampled.

720.03.4.1--Blank.

720.03.4.2--Tolerances.

720.03.4.2.1--Tolerances For Marker Type A, H & I. At least 90% of the original sampling of each lot of markers shall pass all tests with the following exceptions:

- (a) When less than 90% but more than 70% pass all tests, a resample of that lot will be allowed at the request of the Contractor.
- (b) When less than 70% of the markers from the original sample comply with the requirements, the lot represented by the samples will be rejected and no resample will be allowed.
- (c) Tolerances for resamples shall be in the same ratio as specified above.

At least two of three specimens, randomly selected for strength, water absorption, and autoclave, as well as the averages of the three, must pass the stated requirements. Otherwise, three additional markers selected at random shall be tested, and if the same conditions for passing are not met for these additional three markers, the lot will be rejected.

720.03.4.2.2--Tolerances For Marker Type B through G. At least 90% of the check sampling of each lot of markers shall pass the strength test required in the Physical Properties Section of ASTM D 4280 with the following exceptions:

- (a) When less than 90% but more than 70% pass the test, a resample of that lot will be allowed at the request of the Contractor.
- (b) When less than 70% of the markers from the check sample comply with the requirements, the lot represented by the samples will be rejected and no resample will be allowed.
- (c) Tolerances for resamples shall be in the same ratio as specified above.

720.03.4.3--Packaging. Shipments shall be made in containers acceptable to common carriers and packaged in such a manner as to ensure delivery in perfect condition. All damaged shipments shall be replaced by the Contractor.

Each package shall be clearly marked as to the name of the manufacturer, type, quantity enclosed, lot number, and date of manufacture.

720.03.5--Non-Reflective Pavement Markers. Non-reflective jiggle markers shall be either Class 1 or Class 2. Markers shall be approved products as listed on the Department's APL for jiggle bar markers.

720.03.5.1--Class 1 Markers. Class 1 non-reflective jiggle markers shall consist of an acrylonitrile-butadiene-styrene polymer or other approved material, and shall be 4 inches wide x 6 inches long. Infrared curves of materials used in markers shall match approved

curves on file at the Central Laboratory.

Class 1 markers shall conform to the following requirements when tested in accordance with Mississippi Test Method: MT-17.

<u>Property</u>	<u>Requirement</u>
Heat Resistance	No change in shape or appearance
Impact Resistance	No break, chip or crack
Load Resistance	No break, chip, crack or permanent deformation

720.03.5.2--Class 2 Markers. Class 2 non-reflective jiggle markers shall consist of a heat-fired, vitreous, ceramic base, and a heat-fired, opaque, glazed surface to produce the properties required in these specifications. The bottom of the marker shall not be glazed. The markers shall be produced from any suitable combination of intimately mixed clays, shales, talcs, flints, feldspars, or other inorganic material that will meet the properties herein required. The markers shall be thoroughly and evenly matured and free from defects which affect appearance or serviceability.

Non-reflective markers shall conform to the following finish and testing requirements:

- (a) The top surface of the marker shall be in reasonably close conformity with the configuration shown on the plans.
- (b) All edges shall be rounded and any change in curvature shall be gradual.
- (c) The top and sides shall be smooth and free of mold marks, pits, indentations, air bubbles, or other objectionable marks or discolorations.
- (d) The base of all markers shall be flat. The deviation from a flat surface shall not exceed 0.05 inch and shall be free from gloss glaze or substances that may reduce its bond to the adhesive.

All tests shall be performed in accordance with Mississippi Test Method: MT-17, which will be on file in the Materials Division.

<u>Test</u>	<u>Requirement</u>
Glaze thickness	0.005 inch minimum
Moh Hardness	6 minimum
Directional reflectance, Type A, white markers only	
Glazed Surface	75 minimum
Body of Marker	70 minimum
Yellowness Index, Type A, white markers only	
Glazed Surface	0.07 maximum
Body of Marker	0.12 maximum
Color, Type AY, yellow markers only,	
FHWA Highway Yellow Color Tolerance Chart	PR Color # 1
Autoclave	Glaze shall not spall, craze, or peel
Compressive Loading	750 pounds, minimum
Water Absorption	2.0% maximum

720.03.6--Reflective Pavement Markers. Reflective pavement markers shall be listed on the Department's APL and shall meet the applicable requirements of ASTM D 4280.

720.03.7--Adhesive for Pavement Markers.

720.03.7.1--General Requirements. The adhesive shall be an asphaltic or thermoplastic material suitable for bonding pavement markers to hydraulic cement concrete pavement, hot bituminous pavement and chip-sealed surfaces when the road surface and marker temperatures are in the range of 50°F to 160°F. The composition of the adhesive must be such that its properties will not deteriorate when heated to and applied at temperatures up to 425°F using either air or oil-jacketed melters.

720.03.7.2--Specific Requirements. In addition to the specific requirements set forth herein, the adhesive shall be listed on the Department's APL prior to its use.

720.03.7.3--Packaging and Labeling. The adhesive shall be packaged in self-releasing cardboard containers that will stack properly. The label shall show the manufacturer, quantity, and lot or batch number. "Adhesive for Pavement Markers" or "Adhesive for Traffic Markers" shall be printed in bold lettering on the label.

720.03.7.4--Sampling. A minimum of 10 pounds of adhesive per lot or batch received shall be submitted to the State Materials Engineer for compliance testing. This may be submitted in the form of an adhesive testing package from each batch or material obtained from a package shipped to the project.

720.03.7.5--Manufacturer's Certified Test Report. The adhesive will be tentatively accepted by a manufacturer's certified test report. The certified test report shall show the test results and shall state that the adhesive represented by the test results meets all the requirements of the contract and has the properties and characteristics as herein specified. It shall be the Contractor's responsibility to furnish three copies of the manufacturer's test report to the Engineer for each batch of adhesive shipped to the project.

720.03.7.6--Bituminous Adhesive, Standard Type. The asphaltic material and mineral filler shall comply with the following requirements:

(a) Adhesive Properties:

	<u>Minimum</u>	<u>Maximum</u>	<u>Test Method</u>
Softening Point, °F	200	-	ASTM: D 36
Penetration @ 77°F	10	20	ASTM: D 5
Flow, inch	-	0.2	MT-73
Heat Stability Flow, inch	-	0.2	MT-73
Viscosity, 400°F, Poises	-	75	MT-73
Flash Point, C.O.C., °F	550	-	ASTM: D 92

(b) Asphalt properties determined on the filler-free material derived from the extraction and Abson recovery process as explained in Mississippi Test Method MT-73.

	<u>Minimum</u>	<u>Maximum</u>	<u>Test Method</u>
Penetration, 100 g, 5 sec, 77°F	25	-	ASTM: D 5
Viscosity, 275°F, Poises	12	-	ASTM: D 2171
Viscosity Ratio, 275°F	-	2.2	MT-73

(c) Filler properties determined using the filler separation technique described in Mississippi Test Method MT-73.

	<u>Minimum</u>	<u>Maximum</u>	<u>Test Method</u>
Filler Content, percent by weight	50	75	MT-73
Filler Fineness, percent passing:			
Sieve No. 100	100	-	MT-73
Sieve No. 200	90	-	MT-73
Sieve No. 325	75	-	MT-73

720.03.7.7--Flexible Adhesive. The hot applied flexible pavement marker adhesive shall be a hot melt thermoplastic material capable of bonding the marker without excessive marker movement at hot summer temperatures and remain flexible at winter temperatures. The adhesive shall comply with the following physical requirements when melted in accordance with ASTM D 3407 and poured into suitable test molds:

<u>Test</u>	<u>Result</u>	<u>Test Method</u>
Penetration, 77°F	25 max.	ASTM D 5
Softening point	200°F min.	ASTM D 36
Brookfield viscosity, 400°F	10,000 cp max.	ASTM D 3236
Ductility @ 77°F, 5 cm/min	15 cm min.	ASTM D 113
Ductility @ 39.2°F, 1 cm/min	5 cm min.	ASTM D 113
Asphalt Compatibility	Pass	ASTM D 5329
Flexibility	Pass at 20°F	Per Subsection 720.03.7.8

720.03.7.8--Test Procedure for Flexibility. The following procedures shall be followed for flexibility.

Sample Preparation - One-eighth inch thick steel shims are used to enclose an opening that is one-inch wide and four-inches long on a sheet of release paper or a release treated metal plate. The heated adhesive is poured into the opening until it is slightly overfilled. After one hour of cooling the excess adhesive is trimmed flush with the shims using a hot knife and then the sample is removed from the shims.

Conditioning - The trimmed samples are placed in a freezer maintained at $20 \pm 2^\circ\text{F}$ for a minimum of four hours.

Testing - The conditioned samples are removed from the freezer and immediately bent over a one-inch diameter mandrel through an arc of 90 degrees in 10 seconds at a uniform rate of nine degrees per second. A passing result is one in which no cracking occurs in the test sample. At least two of the three specimens tested must meet the flexibility requirement at 20°F for a passing result.

720.04--Cold Plastic Pavement Markings.

720.04.1--General. The prefabricated markings described shall consist of white or yellow pigmented plastic films with reflective glass spheres uniformly distributed throughout their entire cross-sectional area, and be capable of being affixed to bituminous or hydraulic cement concrete pavements by either a pressure sensitive precoated adhesive or a liquid contact cement. The markings shall be provided complete in a form that will facilitate rapid application and protect the markings in shipment and storage. The manufacturer shall identify proper solvents and/or adhesives to be applied at the time of application, all equipment necessary for proper application, and recommendations for application that will assure an effective performance life.

Prefabricated legends and symbols shall conform to the applicable shapes and sizes as outlined in the current "Manual on Uniform Traffic Control Devices."

Cold plastic pavement markings shall be listed on the Department's APL. Prior to use, the Contractor shall furnish the Engineer three copies of the manufacturer's certification for each shipment stating that the material furnished is of the same composition as that originally approved by the Department and that the material has not been changed or altered in any way.

720.04.2--Requirements. Unless otherwise indicated on the plans, the material shall be 60 mil retroreflective pliant polymer film.

720.04.2.1--Composition. The retroreflective pliant polymer pavement marking film shall consist of a mixture of high quality polymeric materials, pigments, 1.5 index glass beads uniformly distributed throughout its cross sectional area and a reflective layer of beads bonded to the top surface. The film shall be composed of the following materials:

<u>Material</u>	<u>Minimum Percent by Weight</u>
Resins & Plasticizers	20
Pigments	30
Graded Glass Beads	33

This film shall be capable of being fabricated into pavement markings of specified thickness and dimensions and of being adhered to asphaltic and/or hydraulic cement concrete by means of a pressure sensitive precoated adhesive, or a liquid contact cement applied at the time of installation.

720.04.2.2--Conformability and Resealing. The retroreflective pliant polymer pavement marking film shall be capable of conforming to pavement contours, breaks, faults, etc. through the action of traffic at normal pavement temperatures. The film shall have resealing characteristics that allows it to be capable of fusing with itself and previously applied marking film of the same composition under normal conditions of use.

The film shall show patchability when tested as follows:

- (a) Cut two 1-inch x 3-inch pieces of the pliant polymer and mark the reflective side of one of the pieces with a pencil to delineate a 1-inch x 1-inch area at the end of the piece.
- (b) Wet the surface of the area delineated with a cloth soaked in contact cement or a mixture of MEK and toluene for one minute, keeping the surface wet. At the end of one minute, scrape the beads and binder off the sample and wipe the residual binder from the area. Let the sample dry for at least one minute.
- (c) Remove the liner from the back of the second piece of film and place the backside on top of the cleaned area on the first piece. The sample, while held together, should now form one piece four inches long by one inch wide with the 1-inch x 1-inch overlap patch in the center.
- (d) Place the patched sample on a hard surface under 1,000 grams per square inch, the area of the overlap splice, maintained at 140°F for two hours.
- (e) Remove the sample from the heat and allow to cool to 70°F, room temperature.
- (f) Pull the sample in opposite directions to place a shear strain on the patched area. The two pieces shall not separate without tearing.

720.04.2.3--Tensile Strength. The film shall have a minimum tensile strength of 40 pounds per square inch of cross section when tested according to ASTM D 638. A 6-inch x 1-inch x 0.06-inch sample shall be tested at a temperature between 70°F and 80°F using a jaw speed of 12 inches per minute.

720.04.2.4--Elongation. The film shall have a minimum elongation of 75% at break when tested according to ASTM D 638 using a jaw speed of 12 inches per minute.

720.04.2.5--Plastic Pull Test. A test specimen made the same size as in Subsection 720.04.2.3 shall support a dead weight of four pounds for not less than five minutes at a temperature between 70°F and 80°F.

720.04.2.6--Pigmentation. The pigments shall be selected and blended to provide a marking film that is white or yellow conforming to standard highway colors through the expected life of the film.

720.04.2.7--Glass Beads. The glass beads shall be colorless and have a minimum index of refraction of 1.50 when tested using the liquid oil immersion method. The size and quality of the beads will be such that performance requirements for the retroreflective pliant polymer film shall be met.

Bead adhesion shall be such that beads are not easily removed when film surface is scratched firmly with thumbnail.

The film shall have glass bead retention qualities such that when a 2-inch x 6-inch sample is bent over a 1/2-inch diameter mandrel, with the 2-inch dimension perpendicular to the mandrel axis, microscopic examination of the area on the mandrel shall show no more than 10% of the beads with entrapment by the binder of less than 40%.

720.04.2.8--Skid Resistance. The surface of the retroreflective pliant polymer film shall provide a minimum skid resistance value of 35 BPN when tested according to ASTM E 303.

720.04.2.9--Reflective Intensity. The photometric quantity to be measured shall be specific luminance and shall be expressed as millicandelas per square foot per foot-candle. The minimum initial reflective values shall be 250 for white and 200 for yellow as measured in accordance with Mississippi Test Method MT-70.

720.04.2.10--Reflectivity Retention. The following tests shall be employed to measure reflectivity retention:

- (a) **Taber Abraser Simulation Test.** Using a taber abraser with an H-18 wheel and a 125-gram load, the sample shall be inspected at 200 cycles, under a microscope, to observe the extent and type of bead failure. No more than 15% of the beads shall be lost due to pop-out and the predominant mode of failure shall be "wear down" of the beads.
- (b) **Qualitative Tests.** Bead bond strengths shall be judged under a microscope with a magnification of at least 5X. The beads shall be difficult to remove, and when removed, beads shall show a portion of the polymeric bead bond retained with the beads rather than clean removal from the sockets.

720.04.2.11--Thickness. Unless otherwise indicated on the plans, the retroreflective pliant polymer film, without adhesive, shall be supplied in a standard thickness of 0.06 inch.

720.04.2.12--Effective Performance Life. The film, when applied according to the recommendations of the manufacturer, shall provide a neat, durable marking that will not flow or distort due to temperature if the pavement surface remains stable. Although reflectivity is reduced by wear, the pliant polymer shall provide a cushioned, resilient substrate that reduces bead crushing and loss. The film shall be weather resistant and, through normal traffic wear, shall show no appreciable fading, lifting or shrinkage throughout the useful life of the marking, and shall show no significant tearing, roll back, or other signs of poor adhesion.

720.04.3--Manufacturer's Certification. The Contractor shall furnish the Engineer three copies of the manufacturer's certification stating that each lot in a shipment complies with the requirements of the contract.

720.04.4--Acceptance Sampling and Testing. Final acceptance of each lot will be based on results of tests performed by the Department on verification samples submitted from each lot shipped to the project. The Engineer will select one sample at random from each lot in the shipment for testing. A sample extending full width of the randomly selected sample and five linear feet in length will be obtained and submitted by the Engineer. The sample from each shipment shall be provided at no cost to the State.

720.05--Preformed Pavement Markings for Construction Zones.

720.05.1--General. In addition to the specific material requirements set forth herein, pavement marking materials must have been approved for listing in the Department's APL prior to their use.

The preformed markings shall consist of retroreflective materials on a conformable backing. The pigments shall be selected and blended to provide pavement markings that conform to standard highway colors.

The size, quality, and refractive index of the glass beads shall be such that the performance requirements for the markings will be met. The bead adhesion shall be such that beads are not easily removed when the material surface is scratched with a thumbnail.

The markings shall be precoated with a pressure sensitive adhesive capable of adhering to asphalt and hydraulic cement concrete pavement in accordance with the manufacturer's instructions without the use of heat, solvents or other additional adhesives. The markings and/or adhesive shall not require any curing time after application.

The markings shall be provided in specified widths and shapes. Preformed words and symbols shall conform to the applicable shapes and sizes as outlined in the current "Manual on Uniform Traffic Control Devices for Streets and Highways," or as modified.

The materials shall be packaged in accordance with accepted commercial standards and when stored indoors in a cool dry place, shall be suitable for use one year after date of purchase.

720.05.2--Classification of Markings. Retroreflective preformed pavement markings

shall be of the types described below and as specified on the plans or in the contract documents.

720.05.2.1--Type 1. The markings shall consist of a mixture of high quality polymeric materials, pigments and glass beads with a reflective layer of beads bonded to the top surface. A non-metallic medium coated with a pressure sensitive adhesive shall be incorporated to facilitate removal. The adhesive shall be of a type that is completely removed with the pavement marking or colorless so as not to leave a color mark on the pavement.

Reflectance. The markings shall meet or exceed the initial reflectance values when measured in accordance with the testing procedures of ASTM D 4592.

INITIAL REFLECTANCE VALUES

	<u>White</u>		<u>Yellow</u>	
	86°		86°	
Entrance Angle				
Observation Angles	0.2°	0.5°	0.2°	0.5°
SL (mcd/ft ² /fc)	1770	1270	1310	820

The photometric quantity to be measured shall be specific luminance (SL) and shall be expressed in millicandelas per square foot per foot-candle. The test distance shall be 50 feet, and the sample size shall be a 2.0 x 2.5-foot rectangle. The angular aperture of both the photoreceptor and light projector shall be six minutes of arc. The reference center shall be the geometric center of the sample, and the reference axis shall be taken perpendicular to the test sample.

The quantity SL (specific luminance) treats the retroreflector as a surface source rather than a point source whose projected area is visible as an area at the observation position. The quantity SL related to the way the effective retroreflective surface is focused on the retina of the human eye and to the visual effect thereby produced. It is recommended for describing the performance of highway signs and striping, or large vehicular markings that are commonly viewed as discernable surface areas.

720.05.2.2--Type 2. The pavement markings shall consist of retroreflective materials on a conformable metallic backing, precoated with a colorless, pressure sensitive adhesive that does not leave a color mark on the pavement or of a type that is substantially removed with the pavement marking.

Reflectance. The markings shall meet or exceed the initial reflectance values when measured in accordance with the testing procedures of ASTM D 4592.

INITIAL REFLECTANCE VALUES

	<u>White</u>		<u>Yellow</u>	
	86°		86°	
Entrance Angle				
Observation Angles	0.2°	0.5°	0.2°	0.5°
SL (mcd/ft ² /fc)	1360	760	820	510

The sample size, test procedure and measurement of test values shall be as prescribed for Type 1 in Subsection 720.05.2.1.

720.05.3--Certificates of Compliance. The Contractor shall furnish the Engineer three

copies of certifications from the manufacturer for each lot of pavement markings stating that the material meets the requirements of the contract.

720.06--Preformed Permanent Foil Tape. Preformed foil tape shall be one from the Department's APL. Prior to use, the Contractor shall furnish the Engineer three copies of a certification for each shipment stating that the material is of the same composition as that originally approved by the Department and that the material has not been changed or altered in any way.

720.07--High Performance Cold Plastic Pavement Markings.

720.07.1--General. The preformed high performance pavement markings shall consist of white or yellow films with ceramic beads incorporated to provide immediate and continuing retroreflection.

Preformed high performance cold plastic pavement markings shall be listed on the Department's APL for Preformed High Performance Profile Cold Plastic Pavement Marking Tape. Prior to use, the Contractor shall furnish the Engineer three copies of the manufacturer's certification for each shipment stating that the material furnished is of the same composition as that originally approved by the Department and that the material has not been changed or altered in any way.

The preformed pavement markings shall be capable of being adhered to the pavement by a pre-coated pressure sensitive adhesive. A primer may be used to precondition the pavement surface. When a primer is specified by the manufacturer, it shall be installed as recommended by the manufacturer at no additional cost to the State. The preformed pavement markings shall conform to pavement contours by the action of traffic. After application, the markings shall be immediately ready for traffic. A representative of the manufacturer shall be present to identify proper solvents and/or primers, where necessary, to be applied at the time of application, to identify all equipment necessary for proper application, and to make recommendations for application that will assure effective product performance.

720.07.2--Classification. The preformed pavement markings shall be highly durable retroreflective pliant polymer materials designed for longitudinal markings subjected to high traffic volumes.

720.07.3--Requirements.

720.07.3.1--Composition. The retroreflective pliant polymer pavement marking film shall consist of a mixture of high quality polymeric materials, pigments and glass beads distributed throughout its base cross-sectional area, with a reflective layer of ceramic beads bonded to a durable polyurethane top surface. The surface shall have approximately 50 ±15% of the surface area raised and presenting a near vertical face angle of 0° to 60° to traffic from any direction. The channels between the raised areas shall be substantially free of exposed beads or particles.

720.07.3.2--Retroreflectance. The white and yellow markings shall have the following initial minimum retroreflectance values as measured in accordance with the testing procedures of ASTM D 4061. The photometric quantity to be measured shall be coefficient of retroreflected luminance (R_L), and shall be expressed as millicandelas per square foot

per foot-candle (mcd/ft²/fc).

INITIAL MINIMUM RETROREFLECTANCE VALUES

	White		Yellow	
	86.0°	86.5°*	86.0°	86.5°*
Entrance Angle	86.0°	86.5°*	86.0°	86.5°*
Observation Angle	0.2°	1.0°	0.2°	1.0°
Retroreflected Luminance, R _L (mcd/ft ² /fc)	1100	700	800	500

* These retroreflectance values are based on dark room photometric readings per ASTM D 4061. The Ecolux™ Retroreflectometer measurement geometry is an 86.5° entrance angle and a 1.0° observation angle.

720.07.3.3--Glass Beads. The size and quality of the beads shall be such that the performance requirements for the retroreflective pliant polymer shall be met.

720.07.3.3.1--Index of Refraction. All ceramic beads bonded to the polyurethane coated patterned surface of the material shall have a minimum index of refraction of 1.70 when tested using the liquid oil immersion method. The glass beads mixed into the pliant polymer shall have a minimum index of refraction of 1.5 when tested by the liquid oil immersion method.

TESTING PROCEDURE FOR REFRACTIVE INDEX OF BEADS BY LIQUID IMMERSION

EQUIPMENT REQUIRED:

- Microscope, minimum 100X magnification
- Light Source - preferably sodium light or other monochromatic source, but not absolutely essential
- Refractive Index Liquids*
- Microscope Slide and Slide Cover
- Mortar and Pestle

* Available from R.P. Cargille Laboratories, Inc., Cedar Grove, NJ

PROCEDURE:

- Using the mortar and pestle, crush a few representative beads and place a few of these crushed particles on a microscope slide.
- Place a drop of a refractive index liquid, with an index as close to that of the glass as can be estimated, on the crushed bead particles.
- Cover the slide with a microscope slide cover and view the crushed particles by transmitted light normal to the slide surface by illumination from the bottom.
- Adjust the microscope mirror to allow a minimum light intensity for viewing. This is important when sodium light is not used.
- Bring a relatively flat and transparent particle into focus.
- By slightly raising and lowering the microscope tube, look for one or both of the following:
 - Becke Line - This light line will appear to move either into the particle or away from it. In general, when the microscope tube is raised, the line will move toward the material of higher refractive index. When the microscope tube is lowered, the line will move toward the material of lower index.
 - Variation in Particle Brightness - When raising the microscope tube from sharp focus, the particle will appear to get brighter or darker than the

surrounding field. If it becomes brighter, the glass has a higher refractive index than the liquid. If it becomes darker, the glass has a lower refractive index than the liquid. In both cases, the opposite will be true when the microscope tube is lowered.

- g) This test can be used to confirm that the beads are above or below a specified index. It can also be used to give an accurate determination of the index, ± 0.001 . This is done by using several refractive index liquids until a match or near match of indices occurs. The index of the glass will equal that of the liquid when no Becke line and no variation in bead brightness can be observed.

720.07.3.3.2--Acid Resistance. The beads shall show resistance to corrosion of their surface after exposure to a 1% solution by weight of sulfuric acid. The 1% acid solution shall be made by adding 5.7 mL of concentrated acid into 1000 mL of distilled water. **CAUTION:** Always add the concentrated acid into the water, not the reverse. The test shall be performed as follows:

Take a 1" x 2" sample, adhere it to the bottom of a glass tray and place just enough acid solution to completely immerse the sample. Cover the tray with a piece of glass to prevent evaporation and allow the sample to be exposed for 24 hours under these conditions. Then decant the acid solution, but do not rinse, touch, or otherwise disturb the bead surfaces, and dry the sample while adhered to the glass tray in a 150°F oven for approximately 15 minutes.

Microscopic examination at 20X shall show no more than 15% of the beads having a formation of a very distinct opaque white, corroded, layer on their entire surface.

720.07.3.4--Color. The preformed pavement markings shall consist of white and yellow films with pigments selected and blended to conform to standard highway colors.

720.07.3.5--Skid Resistance. The patterned surface of the retroreflective pliant polymer shall provide an initial average skid resistance value of 45 BPN when tested according to ASTM E 303, except values will be taken at downweb and at a 45 degree angle from downweb. These two values will then be averaged to find the skid resistance of the patterned surface.

720.07.3.6--Patchability. The pavement marking material shall be capable of use for patching worn areas of the same type in accordance with manufacturer's instructions.

720.07.3.7--Thickness. The patterned material, without adhesive, shall have a minimum caliper of 0.065 inch at the thickest portion of the patterned cross-section and a minimum caliper of 0.020 inch at the thinnest portion of the cross-section.

720.07.4--Effective Performance Life. The film, when applied according to the recommendations of the manufacturer, shall provide a neat, durable marking that will not flow or distort due to temperature if the pavement surface remains stable. The film shall be weather resistant and, through normal traffic wear, shall show no appreciable fading, lifting or shrinkage throughout the useful life of the marking, and shall show no significant tearing, roll back, or other signs of poor adhesion.

720.07.5--Manufacturer's Certification. The Contractor shall furnish the Engineer three copies of the manufacturer's certification stating that each lot in a shipment complies with

the requirements of the contract.

720.07.6--Acceptance Sampling and Testing. Final acceptance of each lot will be based on results of tests performed by the Department on verification samples submitted from each lot shipped to the project. The Engineer will select one sample at random from each lot in the shipment for testing. A sample extending full width of the randomly selected sample and five linear feet in length will be obtained and submitted by the Engineer. The sample from each shipment shall be provided at no cost to the State.

720.07.7--Warranty. All manufacturer's standard warranties and guarantees on high performance cold plastic pavement marking material, which are provided as customary trade practice, shall be delivered to the Engineer at the final inspection. All warranties and guarantees shall be made out to the Department.

SECTION 721 - MATERIALS FOR SIGNING

721.01--General. All materials included in this section will be conditionally accepted on the basis of the manufacturer's certification of compliance, as specified in Subsection 106.04, except those materials normally tested by the Department; i.e. concrete, reinforcing steel, timber posts, etc. The State Materials Engineer shall be furnished the original and three copies of the manufacturer's certification. The Department reserves the right to test or have tested by a commercial laboratory any material that has been conditionally accepted by certification.

721.02--Ferrous Materials.

721.02.1--General. All welds shall be mechanically cleaned before galvanizing. All ferrous metal except reinforcing steel, and sheet steel unless otherwise specified, shall be zinc-coated, galvanized, by the hot dip method in accordance with AASHTO M 111 after all fabrication has been completed.

721.02.2--Structural Steel for Sign Supports. Structural steel used in sign support structures shall be of standard shape. Structural steel pipe per ASTM A 53 shall be manufactured by the open-hearth or basic oxygen process.

721.02.2.1--Ground Mounted Sign Supports. Posts shall be provided with "break-away" mountings as shown on the plans using the following materials:

- (a) Structural steel beams for posts per AASHTO M 160.
- (b) Steel plates for steel beam posts per AASHTO M 160.
- (c) Standard round posts shall be welded and seamless steel pipe for posts per ASTM A 53, Type E or S, Grade B, or steel structural tubing per ASTM A 501.
- (d) U-Section and Square Tube posts for supplementary directional signs per Subsection 721.02.3 "Steel Posts for Small and Medium Supplementary Directional Signs" modified as shown on the plans.
- (e) Structural steel shapes, bars, and plates used for bracing, framing and other accessories, including base plates for steel posts, per ASTM A 36.
- (f) High strength bolts, nuts, and washers for post bases and for fuse plates per Subsections 717.01.7 and 810.02.21 modified as shown on the plans.

721.02.2.2--Overhead Sign Supports. Materials approved for use in the construction of overhead sign supports include the following:

- (a) Welded and seamless steel pipe per ASTM A 53, Type E or S, Grade B or Type F.
- (b) Steel structural tubing per ASTM A 501.
- (c) Structural shapes, plates, and bars per ASTM A 36.
- (d) Castings for post base and truss flange per AASHTO M 106, Grade 35018.
- (e) Castings for post caps and chord caps per AASHTO M 105, Class 25 S.
- (f) High strength bolts, nuts, and washers for chord connections per Subsections 717.01.7 and 810.02.21.
- (g) Anchor bolts per ASTM A 307, Grade A.

721.02.3--Steel Posts for Small and Medium Supplementary Directional Signs. Steel posts for small size signs shall be U-section Posts. Steel posts for medium size signs shall be Square Tube posts.

The U-section posts, also referred to as “bendaway” posts, are normally U-section channels of such size and design that when hit by a moving vehicle will easily bend away from the vehicle without seriously damaging it. U-section posts shall be fabricated to acceptable shape and design to provide the Moment of Inertia and Section Modulus for the requirements of the designated post size shown on the plan details. The post shall meet the requirements of ASTM A 499, Grade 60, or a comparable new billet steel meeting the requirements of ASTM A 572, Grade 60.

Square tube posts will not easily bend away when hit by a moving vehicle. Unless otherwise noted on plan details, square tube posts will require a “breakaway” feature to be incorporated with the post. The material and design of the breakaway feature shall be shown by the plan details. Square tube posts shall be fabricated from standard beam shapes of the size, shape, and weight shown on the plans. The material shall conform to the requirements of ASTM A 53, Grade B, Schedule 40 or better with no pressure test required.

All materials furnished for use shall be new, unless otherwise specified by plan details or provisions of the contract.

721.02.3.1--Material. U-section posts shall be of high carbon rail steel ASTM A 499.

Standard square tube posts shall be of high carbon rail steel ASTM A1011, Grade 50 steel with average minimum yield strength after cold forming of 60,000 psi. Breakaway features constructed of steel shall have all elements galvanized, unless otherwise provided by the plan details.

721.02.3.2--Workmanship. All posts shall be straight with no bending, warping, splits, or breaks.

Square tube posts shall meet AASHTO M111. Square tube posts shall be corner welded, scarfed after welding, then zinc coated after scarfing. All surfaces of the square tube posts must be coated with a chromate conversion coating and a clear organic polymer topcoat. Both the interior and exterior surfaces of the square tube posts must be galvanized.

721.02.3.3--Cross-Section. U-section posts shall be as shown on the plans. The bends in

the cross-section of the post must be sharp and well defined, and the radius of the bend shall not be greater than $1^{13}/_{32}$ of an inch.

Square tube posts shall have a 2½-inch outer sleeve. When required, the inner sleeve shall be 2 $^{3}/_{16}$ -inch. The material shall be 10 gauge steel.

721.02.3.4--Weight. The weight of the U-section post per linear foot without ground plates shall be 2.0 pounds for 7-foot to 9-foot lengths, and 3.0 pounds for 11-foot to 14-foot lengths with a tolerance of three and one-half percent (3½%), or as shown on the plans.

The weight of the square tube posts per linear foot without ground plates or inner sleeve shall be a minimum of 4.0 pounds per foot for 10 gauge posts, or as shown on the plans. The weight of the inner sleeve for square tube posts per linear foot without ground plates shall be a minimum of 3.4 pounds per foot for 10 gauge posts, or as shown on the plans.

721.02.3.5--Punching. U-Section posts shall be punched on the center line of the web while hot. Posts of 7-foot to 14-foot lengths shall have $^{3}/_{8}$ -inch holes one inch apart on centers starting one inch from the top of the posts and extending the full length of the post.

Square posts shall be punched on the center line of each of the four sides while hot. Square Tube Posts of 8-foot to 20-foot lengths shall have $^{7}/_{16}$ -inch holes spaced one inch apart on centers starting one inch from the top of the posts and extending the full length of the post on each of the four sides of the post.

721.02.3.6--Blank.

721.02.3.7--Pointing. The posts shall not be pointed.

721.02.3.8--Caps. All standard post shapes whose design will have a tendency to collect water shall be provided with an approved type of tight fitting post cap fabricated of material compatible with that of the post.

721.02.4--Reinforcing Steel. Reinforcing steel shall conform to Section 711 and shall be placed in accordance with Section 602.

721.02.5--Bolts, Nuts, Washers, Screws, and other Hardware. Except as otherwise specified, all bolts, nuts, washers, sheet metal screws, and machine screws shall be coated by the zinc chromate process. The zinc chromate process shall be in accordance with the requirements of ASTM B633. Bolts shall have a 1/2-inch head and shall meet the requirements of ASTM A307, Grade A. Nuts shall be self-locking and shall meet the requirements of ASTM A563. Flat washers shall be installed between the sign support and the self-locking nut and shall meet the requirements of ANSI B27.2. Sheet metal screws shall meet the requirements of ANSI B18.6.4. Machine screws shall meet the requirements of ANSI B18.6.3. Vinyl spacers shall be installed between the bolt head and the sign face and shall meet the following maximum dimensions: 7/8-inch outside diameter by 3/8-inch inside diameter by 1/16-inch thickness.

Post clips used with extruded panel signs shall be cast aluminum per ASTM B 108, Alloy No. 356.0-T6 or extruded aluminum per ASTM B 221, Alloy 6063-T6. Unless otherwise specified, all bolts, sheet metal screws, and machine screws used in assembling signs, frames, and post braces, including post clips and panel bolts, shall be in accordance with

ASTM A 307, Grade A.

721.03--Aluminum. All aluminum shall be free from corrosion, white rust, water stains, dirt, and grease. Fabrication shall be accomplished in a uniform and workmanlike manner. All fabrication, including cutting and punching of holes, shall be completed prior to metal treatment. Sign blanks shall be cut to size and shape and shall be free of buckles, warps, dents, cockles, burrs, and defects resulting from fabrication. The surface of all sign blanks shall be flat.

All blanks not having corner radii shall have square 90° corners to facilitate sign fabrication.

All blanks requiring holes shall have “MDOT” debossed on the blank in a location so as not to be covered by the post when erected. The debossed letters shall be not less than 3/8 inch high and shall be approximately 0.006 inch deep so as not to be visible on the other side of the blank.

721.03.1--Sheet Aluminum. Sheet aluminum or blanks shall meet the requirements of ASTM B 209, Alloy 6061-T6 or 5052-H38. Gauge, dimension, punching and corner radii shall be in accordance with the plans.

721.03.2--Extruded Signs. Extruded sign panels and extruded post clips shall meet the requirements of ASTM B 221, Alloy 6063-T6. Sections and dimensions shall be as shown on the plans. The panel shall be of the butt type, designed to withstand a wind pressure of 50 pounds per square foot. All panels shall be flat and straight within commercial tolerances as established by the aluminum industry. Extruded sign sections shall be subject to approval by the Engineer. Extruded sign sections shall be provided with slotted bolt holes. Post clips shall be designed for the sign panel section with which it is used.

721.04--Concrete. Unless otherwise specified, concrete shall be Class B. Composition, manufacture, and placement shall be in accordance with Section 601.

721.05--Colors and Paint. All colors for signs shall match FHWA specifications for standard highway sign colors.

Aluminum paint shall conform to Subsection 710.02.1.

Transparent and black opaque process colors used in silk screening shall be the same or equal to that recommended by the manufacturer of the retroreflective sheeting, and shall match FHWA Specifications for standard highway sign colors. Toning of certain colors for adjustment in hue shall be accomplished in accordance with the recommendations of the manufacturer of the process paste.

721.06--Reflective Sheeting.

721.06.1--General. Retroreflective sheeting materials shall comply with all applicable requirements of ASTM D 4956, except as specifically modified herein, and shall be listed on the Department's APL.

Reflective sheeting shall be one of the following types:

- (a) Type III. A high-intensity retroreflective sheeting. This shall be an unmetallized microprismatic retroreflective material. This sheeting shall have a protected, pre-coated, pressure-sensitive adhesive backing.
- (b) Type V. A super high-intensity retroreflective sheeting for delineators. This shall be a metalized microprismatic retroreflective material. This sheeting shall have a protected, pre-coated, pressure-sensitive adhesive backing.
- (c) Type VIII. A super high-intensity retroreflective sheeting. This shall be an unmetallized microprismatic retroreflective material. This sheeting shall have a protected, pre-coated, pressure sensitive adhesive backing.
- (d) Type IX. A very high intensity retroreflective sheeting. This shall be an unmetallized, microprismatic retroreflective material. This sheeting shall have a protected, pre-coated, pressure sensitive, adhesive backing.
- (e) Type XI. A very-high intensity retroreflective sheeting. This shall be an unmetallized, cube-corner retroreflective material. This sheeting shall have a protected, pre-coated, pressure sensitive, adhesive backing.

All other retroreflective sheeting shall be as shown in the plans.

721.06.2--Performance Requirements. The retroreflective sheeting shall have the minimum brightness values at 0.2° and 0.5° observation angle, in addition 1.0° for Type IX and XI sheeting, expressed as average candelas per foot-candle per square foot of material, as shown in the tables in this subsection.

Sheetings and inks processed and applied in accordance with the manufacturer's recommendations, shall perform effectively for the number of years stated below. Sheeting will be considered unsatisfactory if it has deteriorated due to natural causes to the extent that: (1) the sign is ineffective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions or (2) the coefficient of retroreflection is less than the minimum specified for that sheeting during the periods listed below. For screen printed transparent colored areas on white sheeting, the coefficients of retroreflection shall not be less than 70% of the values for the corresponding color in the table in this subsection.

<u>Type III</u>	Retain 80% of initial values listed in Table 1 through 7 years Retain 70% of initial values listed in Table 1 between 7 & 10 years
<u>Type V</u>	Retain 80% of initial values listed in Table 2 through 7 years Retain 70% of initial values listed in Table 2 between 7 & 10 years
<u>Type VIII</u>	Retain 85% of initial values listed in Table 3 through 7 years Retain 80% of initial values listed in Table 3 between 7 & 10 years Retain 50% of initial values listed in Table 3 through 3 years for Fluorescent Orange Retain 80% of initial values listed in Table 3 through 7 years for Fluorescent Yellow/Green & Fluorescent Yellow
<u>Type IX</u>	Retain 80% of initial values listed in Table 4 through 7 years Retain 70% of initial values listed in Table 4 between 7 & 10 years Retain 70% of initial values listed in Table 4 for 7 years for Fluorescent Yellow/Green & Fluorescent Yellow Retain 50% of initial values listed in Table 4 for 3 years for Fluorescent Orange
<u>Type XI</u>	Retain 85% of initial values listed in Table 5 through 7 years Retain 80% of initial values listed in Table 5 between 7 & 12 years

Retain 80% of initial values listed in Table 5 for 7 years for Fluorescent Yellow/Green & Fluorescent Yellow
 Retain 50% of initial values listed in Table 5 for 3 years for Fluorescent Orange

MINIMUM COEFFICIENTS OF RETROREFLECTION
 Candela per foot candle per square foot (cd/ftc/ft²)
 Per ASTM Designation: E 810

TABLE 1
Type III Sheeting

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown
0.2°	-4°	250	170	100	45	45	20	12
0.2°	+30°	150	100	60	25	25	11	8.5
0.5°	-4°	95	62	30	15	15	7.5	5.0
0.5°	+30°	65	45	25	10	10	5.0	3.5

TABLE 2

Type V Sheeting

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue
0.2°	-4°	700	470	280	120	120	56
0.2°	+30°	400	270	160	72	72	32
0.5°	-4°	160	110	64	28	28	13
0.5°	+30°	75	51	30	13	13	6.0

MINIMUM COEFFICIENTS OF RETROREFLECTION
 Candela per foot candle per square foot (cd/ftc/ft²)
 Per ASTM Designation: E 810

TABLE 3
Type VIII Sheeting

Observation Angle	Entrance Angle	White	Yellow	Green	Red	Blue	Brown	Fluorescent Orange	Fluorescent Yellow/Green	Fluorescent Yellow
0.2°	-4°	700	525	70	105	32	21	210	560	420
0.2°	+30°	325	245	33	49	15	10	95	260	200
0.5°	-4°	250	190	25	38	11	7.5	75	200	150
0.5°	+30°	115	86	12	17	5	3.5	35	92	69

TABLE 4
Type IX Sheeting

Observation Angle	Entrance Angle	White	Yellow	Green	Red	Blue	Fluorescent Yellow / Green	Fluorescent Yellow
0.2°	-4.0°	380	285	38	76	17	300	230
0.2°	+30.0°	215	162	22	43	10	170	130
0.5°	-4.0°	240	180	24	48	11	190	145
0.5°	+30.0°	135	100	14	27	6.0	110	81
1.0°	-4.0°	80	60	8	16	3.6	64	48
1.0°	+30.0°	45	34	4.5	9	2.0	36	27

MINIMUM COEFFICIENTS OF RETROREFLECTION
 Candela per foot candle per square foot (cd/ft/ft²)
 Per ASTM Designation: E 810

TABLE 5
Type XI Sheeting

Observation Angle	Entrance Angle	White	Yellow	Green	Red	Blue	Brown	Fluorescent Yellow / Green	Fluorescent Yellow
0.2°	-4.0°	580	435	58	87	26	17	460	350
0.2°	+30.0°	220	165	22	33	10	7	180	130
0.5°	-4.0°	420	315	42	63	19	13	340	250
0.5°	+30.0°	150	110	15	23	7	5	120	90
1.0°	-4.0°	120	90	12	18	5	4	96	72
1.0°	+30.0°	45	34	5	7	2	1	36	27

721.06.3--Certification. The Contractor shall require the supplier to furnish certifications to the Engineer showing conformance to these requirements. Manufacturer's warranties or guarantees provided as customary trade practice shall be furnished to the Project Engineer.

721.06.4--Color. Reflective sheeting shall meet the color requirements of ASTM D 4956. See Table 6 below for color specifications for fluorescent yellow green, fluorescent orange, and fluorescent yellow sheeting.

**TABLE 6
Color Specification Limits for New Sheeting - Daytime**

Color	Chromaticity Coordinate 1		Chromaticity Coordinate 2		Chromaticity Coordinate 3		Chromaticity Coordinate 4		Total Luminance Factor Limit Y_T Min.
	x	y	x	y	x	y	x	y	
Fluorescent Yellow Green	0.387	0.610	0.369	0.546	0.428	0.496	0.460	0.540	60%
Fluorescent Orange	0.583	0.416	0.535	0.400	0.595	0.351	0.645	0.355	20%
Fluorescent Yellow	0.479	0.520	0.446	0.483	0.512	0.421	0.557	0.442	40%

721.06.5--Adhesive. The retroreflective sheeting shall include a pre-coated pressure sensitive adhesive, as referenced in ASTM D 4956, Class 1, applied without the necessity of additional adhesive coats on the retroreflective sheeting or application surface.

The Class 1 adhesive shall be a pressure sensitive adhesive of the aggressive tack type requiring no heat solvent or other preparation for adhesion to smooth clean surfaces.

The protective liner attached to the adhesive shall be removed by peeling without soaking in water or other solutions and shall be easily removed after accelerated storage for four hours at 160°F under a weight of 2.5 pounds per square inch.

721.06.6--Additional Contract Requirements. This Subsection is applicable only when the sheeting material is being purchased for use in the Department's Sign Shop. In addition to the above requirements, the requirements of this subsection must also be met.

721.06.6.1--Sheeting Manufacturer's Replacement Obligation. Where it can be shown that retroreflective traffic signs with Type III, Type VII, Type VIII, or Type IX sheeting supplied and used according to the sheeting manufacturer's recommendations have not met the performance requirements, the sheeting manufacturer shall replace the sheeting required to restore the sign surface to its original effectiveness during the entire 10 years. In addition, during the first seven (7) years the manufacturer of Type III, Type VII, Type VIII, or Type IX sheeting shall cover the cost of restoring the sign surface to its original effectiveness at no cost to the Department for materials and labor for both sign manufacture and installation.

721.06.6.2--Technical Assistance Requirements.

Instruction and Training. The manufacturer supplying the retroreflective sheeting shall provide the services of a qualified technician for instruction and training at the sign manufacturing facility, at no additional cost to the State. This instruction shall be provided bi-annually or when requested, and shall include but not be limited to training films, material application, equipment operation, silk screening techniques, packaging, storage, and other proven sign shop practices as they apply to the retroreflective sheeting supplied

by the manufacturer, and to assure that the resulting signs can comply with the applicable specifications.

Technical Service. The sheeting manufacturer shall, without additional cost to the Department, provide the sign shop with competent technical service and product information including service on screen printing problems with the inks furnished by the manufacturer.

Equipment. The manufacturer supplying the retroreflective sheeting shall provide technical assistance for the recommended sheeting application equipment and certify that trained personnel shall be available on 72-hour notice to render such service necessary to adjust ink consistency or otherwise modify the application of silk screen equipment to accommodate use of manufacturer's sheeting. "Service" is understood to mean the capability of calibration and trouble shooting, as well as the training and retaining of personnel as required.

721.07--Delineators. Delineators shall consist of encapsulated lens reflective sheeting of the specified colors applied to sheet metal with mechanical equipment in a manner specified by the sheeting manufacturer. The sheet metal shall be the same as that used for small sheet signs as required under Subsection 721.03.1.

721.07.1--Flexible Posts. Flexible posts for delineators shall be composed of high impact fiberglass reinforced composite, engineering blended plastic or thermosetting polymers that are reasonably unaffected by long term U.V. exposure.

Flexible posts for delineators must be one from the Department's APL. Prior to use, the Contractor shall furnish the Engineer three copies of the manufacturer's certification for each shipment stating that the material furnished is of the same composition as that originally approved by the Department and that the material has not been changed or altered in any way.

721.07.1.1--Performance Testing for Flexible Posts.

721.07.1.1.1--Impact Resistance. The post must be self-erecting after withstanding 10 vehicle impacts at temperatures of 0°F or above without complete loss of serviceability. The impacts shall be made at an impact angle of $25 \pm 5^\circ$ with a sedan at 35 mph.

721.07.1.1.2--Heat Resistance. A post shall be conditioned a minimum of two hours in an oven at $115^\circ \pm 3^\circ\text{F}$. The conditioned post shall be capable of straightening itself within 10 seconds when bent 90° at or near the midpoint for each of four bends. The test on each post shall be completed within two minutes after removal from the oven. The post shall be bent in the direction to form a 90° angle on the convex side of the post.

721.07.1.1.3--Cold Resistance. A post shall be conditioned a minimum of two hours at $-5^\circ \pm 3^\circ\text{F}$ in an environmentally controlled test chamber. Testing shall be performed in the environmental chamber. The conditioned post shall not be adversely affected when bent at or near the midpoint to a 90° angle formed on the convex side of the post. The post shall return to its original shape within 60 seconds for each of four separate bends.

721.07.1.1.4--Color Fastness. The post materials shall be exposed for 1000 hours in a Weatherometer per ASTM G 26 with no significant yellowing or darkening.

721.07.1.2--Acceptance Procedure. Flexible posts for delineators must be one from the Department's APL. Prior to use, the Contractor shall furnish the Engineer three copies of the manufacturer's certification for each shipment stating that the material furnished is of the same composition as that originally approved by the Department and that the material has not been changed or altered in any way.

721.08--Blank.

721.09--Timber Sign Posts. The posts shall conform to the requirements set forth in Subsection 712.05.1.3, except that the preservative shall conform to Subsections 718.04.3 or 718.04.4.

721.10--Direct Applied Copy. Direct applied copy to be provided on guide directional signs, ground mounted or overhead shall be directly applied to the sign face. Direct applied copy shall include letters, numerals, symbols and borders. The designs for capital and lower case shall be as required by the plans. All type of copy other than caps and lower case shall be as required by the plans. All type faces/fonts shall conform to the recommendations contained in standards published by the FHWA. All direct applied copy shall be attached to the sign face by means of pressure sensitive adhesive meeting the requirements of Subsection 721.06.5--Adhesive. Direct applied copy shall consist of retroreflective sheeting of the color shown in the plans meeting the requirements of Subsection 721.06--Reflective Sheeting.

All signs shall be delivered to the site of their erection in one piece with all bolts, rivets, moldings, extrusions, copy, and other required appurtenances thereto attached, complete and ready to be mounted to the sign support structure. Any required supplemental or temporary supports required for stability during transport shall be firmly attached but easily removed prior to erection.

SECTION 722 - MATERIALS FOR TRAFFIC SIGNAL INSTALLATION

722.01--General. Acceptance of all material in this Section is subject to Subsections 106.01 and 106.04.

722.02--Poles. These specifications are for steel, concrete and wood poles for use as signal equipment supports, and other support structures as required.

722.02.1--Taper. All steel and concrete poles shall have a constant taper from bottom to top and may be round or polyhedral.

722.02.2--Type Mountings. The type mounting shall be steel, concrete, or wood as indicated on the plans. Steel or concrete poles shall have either precast butts for direct mounting in the earth or attached base mounts for mounting on concrete foundations or on break-away bases.

Wood poles shall be mounted directly in the earth.

722.02.3--Design Strength Requirements. Unless specified otherwise in the plans, poles shall meet the requirements of the AASHTO *Standard Specifications for Structural*

Supports for Highway Signs, Luminaires, and Traffic Signals, current edition with all interim supplements. All components of the assemblies shall be designed to the following:

- Importance Factor: 1.0; 50 year mean recurrence interval
- Basic Wind Speed (3 second gust): As shown for project county in the following table
- Minimum Gust Effect Factor: 1.14
- Fatigue Category: II
- Ice Loading: As shown for project county in the following table
- Natural Wind Gust Pressure Loads: Included
- Truck Induced Gust Pressure Loads: Not included
- Galloping: Not included

County No.	County	Basic Wind Speed (MPH)	Ice Loading Required (3 psf)
1	Adams	100	No
2	Alcorn	90	Yes
3	Amite	100	No
4	Attala	90	Yes
5	Benton	90	Yes
6	Bolivar	90	Yes
7	Calhoun	90	Yes
8	Carroll	90	Yes
9	Chickasaw	90	Yes
10	Choctaw	90	Yes
11	Claiborne	90	No
12	Clarke	100	No
13	Clay	90	Yes
14	Coahoma	90	Yes
15	Copiah	90	No
16	Covington	110	No
17	DeSoto	90	Yes
18	Forrest	120	No
19	Franklin	100	No
20	George	130	No
21	Greene	120	No
22	Grenada	90	Yes
23	Hancock	140	No
24	Harrison	140	No
25	Hinds	90	No
26	Holmes	90	Yes
27	Humphreys	90	Yes
28	Issaquena	90	No
29	Itawamba	90	Yes
30	Jackson	140	No
31	Jasper	100	No
32	Jefferson	90	No
33	Jefferson Davis	110	No

34	Jones	110	No
35	Kemper	90	No
36	Lafayette	90	Yes
37	Lamar	120	No
38	Lauderdale	90	No
39	Lawrence	100	No
40	Leake	90	No
41	Lee	90	Yes
42	Leflore	90	Yes
43	Lincoln	100	No
44	Lowndes	90	Yes
45	Madison	90	No
46	Marion	110	No
47	Marshall	90	Yes
48	Monroe	90	Yes
49	Montgomery	90	Yes
50	Neshoba	90	No
51	Newton	90	No
52	Noxubee	90	Yes
53	Oktibbeha	90	Yes
54	Panola	90	Yes
55	Pearl River	130	No
56	Perry	120	No
57	Pike	110	No
58	Pontotoc	90	Yes
59	Prentiss	90	Yes
60	Quitman	90	Yes
61	Rankin	90	No
62	Scott	90	No
63	Sharkey	90	No
64	Simpson	100	No
65	Smith	100	No
66	Stone	130	No
67	Sunflower	90	Yes
68	Tallahatchie	90	Yes
69	Tate	90	Yes
70	Tippah	90	Yes
71	Tishomingo	90	Yes
72	Tunica	90	Yes
73	Union	90	Yes
74	Walthall	110	No
75	Warren	90	No
76	Washington	90	Yes
77	Wayne	110	No
78	Webster	90	Yes
79	Wilkinson	100	No
80	Winston	90	Yes
81	Yalobusha	90	Yes
82	Yazoo	90	No

722.02.3.1--Design Submittal Data. The Contractor shall submit for approval by the Engineer, the complete design calculations and design data used that verifies the support structure is designed to meet the minimum requirements of the plans and specifications. The design submittal data shall also include drawing details that identify each support structure component and associated ASTM standard. Fabrication specifications and installation specifications shall also be provided. The Contractor shall provide five (5) printed copies of the submittal data to the Engineer. The Contractor may alternately provide electronic submittal data if preapproved by the Engineer.

722.02.3.2--Anchor Bolts. The foundation anchor bolts shall have the strength requirements as specified in Subsections 722.02.3 and Section 634. Foundation anchor bolts shall be galvanized through hot-dip processing in accordance with ASTM A153 for the full length of the threaded section plus an additional six inches of the foundation anchor bolts beyond the threaded section.

722.02.4--Traffic Signal and Equipment Support Poles. Type V, VI, and VII shall be welded or seamless 4-inch inner diameter steel pipe conforming to ASTM A53 with 36 ksi minimum yield strength and shall be galvanized in accordance with ASTM A123.

722.02.5--Mast Arms for Traffic Signal and Equipment Poles. Pole and arm shafts shall be fabricated from coil or one (1) piece of single ply plate steel. Pole and arm shafts that are round in cross section shall conform to ASTM A595 Grade A (55 ksi yield). Pole and arm shafts that are multi-sided tubular shaped shall conform to ASTM A570 or ASTM A572 Grade 55. Structural steel shapes shall comply with ASTM A572 Grade 55.

Pole and arm shafts shall be made without circumferential weld splices and shall have a linear taper of 0.14 inches per foot of shaft height. Circumferential welds will only be allowed joining the shaft to the pole and arm base. The submerged arc process shall be used to continuously weld pole shafts and arm shafts along their entire length.

Anchor base plates must meet the minimum requirements of ASTM A36 or ASTM A709 Grade 36 or ASTM A572 Grade 50. Flange plate shall telescope the large end of the arm and be welded by two (2) continuous arc welds, one (1) being on the outside of the plate, adjacent to the shaft, and the other one (1) on the inside at the end of the tubular cross section. A tapped flange plate supporting the mast arm shall be welded to the pole near the top and supported side plate tangent to the pole and gusset plates both top and bottom. The tapped flange plate must be sufficient to develop the full capacity of the connecting bolts. Arm and shaft flange plates must be at least as thick as the arm connecting bolts are in diameter. All steel components shall be galvanized in accordance with ASTM A123. All provided hardware shall be galvanized steel or stainless steel and conform to requirements of Subsection 722.11. Approved removable bolt covers and caps shall be provided and attached to the shaft with self-threading stainless steel hex head screws.

722.02.6--Concrete Poles.

722.02.6.1--General. Concrete poles shall be spun cast, prestressed and of the sizes specified on the plans. These poles shall be of the type intended for direct burial, with the hole backfilled with concrete as shown on the plans.

Poles shall be precast, machine made in steel forms by the centrifugal process to produce dense concrete members of the dimensions and design shown on the plans, and in accordance with these specifications. The shaft shall be tapered or circular in cross section with a smooth outer finish.

722.02.6.2--Aggregate. All aggregate shall be graded from 3/8-inch to No. 100 sieve, with not more than ten percent (10%) passing the No. 100 sieve. Characteristics of aggregates, other than gradation, shall comply with the requirements of Section 703.

722.02.6.3--Cement. Hydraulic cement used in the manufacture of poles shall conform to the requirements of Section 701.

722.02.6.4--Water-Cement Ratio. Water used shall conform to the requirements of Subsection 714.01.2. The water-cement ratio shall be in the proportion required to produce concrete with a minimum compressive strength of 3,500 psi, in 24 hours after curing. Test data shall be furnished to the Engineer, when requested.

722.02.6.5--Reinforcement. Prestressed concrete poles shall meet the requirements of Sections 602, 711 and 804. Poles shall be reinforced with high tensile prestressing steel having an ultimate strength of at least 240,000 psi, prestressed to at least 60 percent and not more than 70 percent of ultimate strength.

722.02.6.6--Method of Manufacture. Poles shall be cast in metal forms true to design, including integral butts when specified.

Concrete shall be mixed not less than five (5) minutes, and shall be placed in one (1) continuous operation. When filled, the mold shall be rotated at high speed to insure a dense concrete by centrifugal force and provide a cable raceway of not less than 1¾ inches in diameter, extending throughout the length of the pole. The finished poles shall have smooth surfaces.

Following the casting operation, the concrete shall be cured with low temperature steam.

722.02.6.7--Precast Butt. When specified on plans, an integral butt foundation shall be cast with the pole in the spinning process. The pole shall be provided with a minimum of 2½-inch x 6-inch handhole with approved cover, located 18 inches above ground line. A minimum of 9-inch x 2½-inch cable entrance shall be provided 18 inches below ground line.

722.02.7--Wood Poles. Each pole provided shall be Southern Yellow Pine that is cut, stored, seasoned, and manufactured in accordance with specification ANSI 05, for Southern Yellow Pine poles having a fiber stress of 8,000 psi. The poles shall be inspected and treated in accordance with the requirements of Section 718.

Each pole shall be Class II or Class III with the length of each pole as shown on the plans. The circumference dimensions of each pole shall be as determined by the ANSI classification.

Each pole shall be marked at a point approximately twelve (12) feet above the butt-end with manufacturer name and location, wood species treatment type and date of treatment,

pole class and length. Pole class and length shall be stamped or tagged on both the top and butt end or each pole.

722.03--Electric Cable. Electric cables shall be high-grade insulated conductors of premium quality material and workmanship manufactured in accordance with the accepted industry standards, suitable for use in trays, ducts, conduit, aerial installs, and direct burial applications. It shall be accessible to the Engineer for inspection at all reasonable times. In lieu of such inspection, the Engineer may require that three (3) certified copies of factory tests be furnished.

The materials used for electrical conductors, insulation, jacket armoring and covering shall meet the requirements herein and as indicated on the plans.

Material for backfilling cable trenches shall be as shown on the plans.

Cable shall be of the following types with number of conductors and conductor size as indicated on the plans.

Signal Cable. Signal cable shall be polyethylene insulated, polyethylene jacketed cable, rated at 600 volts meeting the requirements of IMSA Specification No. 20-1, and with integral messenger cable meeting the requirements of IMSA Specification No. 20-3.

Power Cable. Power cables shall be three (3)-Conductor cables or as noted in the plans, rated at 600 volts meeting the requirements of IMSA Specification No. 20-1. Engineer may approve alternate cable at their discretion.

Luminaire Power Cable. Luminaire power cables shall be two (2) or three (3)-Conductor cables, as indicated on the plans, rated at 600 volts meeting the requirements of IMSA Specification No. 20-1. Engineer may approve alternate cable at their discretion.

Tracer Cable and Warning Tape. Tracer cable shall be Type THWN, annealed copper, insulated with high-heat and moisture resistant PVC, jacketed with abrasion, moisture, gasoline, and oil resistant Nylon, or UL-listed equivalent. The cable shall be AWG #10 with 19 strands and a 20-mil insulation thickness. It shall be suitable for operations at 600 volts as specified in the National Electric Code (NEC).

The warning tape shall be a non-detectable commercial warning tape approved by the Engineer.

Loop Detector Wire. Loop detector cable shall meet Subsection 640.02.2.1 specifications.

Loop Detector Lead-In Cable. Loop detector lead-in cable shall meet Subsection 640.02.2.2 specifications.

Category 6 Cable. Category 6 (Cat6) cable shall be outdoor and industrial rated, shielded, and shall be suitable for underground use. Cable shall have a AWG 24 integrated electrostatic discharge drain wire. Cable shall conform to the global cabling, ISO/IEC 11801 standards. The cable standard provides performance of up to 250 MHz and is suitable for 10BASE-T, 100BASE-TX (Fast Ethernet), 1000BASE-T/1000BASE-TX (Gigabit Ethernet), and 10GBASE-T (10-Gigabit Ethernet). Cable shall be UL Copper

pairs and shall be AWG 24 solid copper and have solid polyolefin insulation. Cable shall have an inner jacket of linear low density. Cable shielding shall be aluminum foil bonded to polyester film to provide 100% shield coverage. The cable shall have a linear low density polyethylene outer jacket rated for sunlight resistance, oil resistance, and a maximum operating voltage of 300 V RMS.

Communication Cable. Communication cables shall be paired polyethylene insulated, polyethylene jacketed cable with electrical shielding rated at 300 volts. Communication cables installed underground in conduit shall meet the requirements of IMSA Specification No. 40-2. Communication cables that are aerial cables with messenger support strands shall meet the requirements of IMSA Specification No. 40-4.

722.04--Galvanized Stranded Steel Cable. Galvanized steel strand cable used as messenger, tether and guy cable shall be Utilities Grade manufactured with seven (7) wires per strand. All cables shall meet the requirements of ASTM A475, Class B, Standard Specification for Zinc-Coated Steel Wire Strand.

The base metal used in manufacturing cables shall be steel of such quality and purity that, when drawn and coated, the finished strand and the individual wires shall be of uniform quality. Strands shall have a left lay with uniform tension and the finished wire shall be capable of being wrapped in a close helix without cracking or delaminating the zinc coating. Joints shall be either the brazed or electric butt welded.

The following cable sizes shall be used as indicated:

- Messenger Cable - 3/8-inch diameter
- Tether Cable - 3/8-inch diameter
- Guy Cable - 3/16-inch diameter

Brackets and/or other devices for aerial support shall be in accordance with details shown on the plans or approved by the Engineer.

722.05--Traffic Signal Conduit.

722.05.1--General. The Traffic Conduit shall be of the following types and indicated in the plans.

722.05.2--Type I Rigid Galvanized Steel. Type I conduit shall be made of rigid galvanized steel meeting the requirements of American Standards Association (ASA) Specifications C 80.1 and Underwriters Laboratory (UL) UL6. The weight of zinc coating shall be no less than 0.5 ounce per square foot of coated surface in accordance with AASHTO T65.

722.05.3--Type II Rigid Copper Nickel, Steel Alloy, Hot Dip Galvanized. Type II conduit shall be made of rigid copper nickel, steel alloy, hot dip galvanized containing 1.6 to 2.2 percent nickel and 0.75 to 1.25 percent copper conforming to American Standard Association (ASA) Specification C 80.1 and Federal Specification WW-C-581E. The weight of zinc coating shall be no less than 0.5 ounce per square foot of coated surface in accordance with AASHTO T65.

722.05.4--Type III or Type IV Rigid Non-Metallic Conduit. Type III and IV conduits shall be made of rigid polyvinyl-chloride (PVC) meeting ASTM D 1785, as well as National Electric Manufacturers Association (NEMA) Publication and Underwriters Laboratory UL 651.

722.05.5--Flexible Conduit. Flexible conduit shall be a smooth wall, high density polyethylene (HDPE) conduit designed to be used for cable. Unless otherwise approved by the Engineer, the conduit shall meet the requirements of ASTM Designations: D 2447, D 3035, D 3485, D 2239 and NEMA TC7.

722.05.6--Poly Vinyl Chloride (PVC) Coated Conduit. In addition to the above requirements for Type I conduit, PVC coated conduit shall meet the requirements of UL 6 and NEMA RN1. The conduit shall be coated on the exterior by a 40-mil thick coating of PVC and on the interior by a 2-mil thick coating of urethane. All fittings for PVC coated conduit shall meet the requirements of UL 514B and NEMA RN1 and have the same coating type and thickness.

722.05.7--Roll Pipe Conduit.

722.05.7.1--General. Roll pipe conduit, or duct, shall be manufactured from virgin high density polyethylene (HDPE) materials. The ducts shall be supplied with smooth walls and available in a variety of colors. The duct shall be capable of being coiled or reeled in continuous lengths, transported, stored outdoors and subsequently uncoiled for installation without affecting its properties or performance.

722.05.7.2--Environmental Performance. The duct shall perform in underground and above-ground installations in an ambient temperature range of -30°F to +130°F without degradation of material properties. The duct specified for aerial installation shall be ultraviolet light-resistant. The duct shall be capable of being bent to a minimum supported radius of 10 diameters.

722.05.7.3--Workmanship. The duct shall be free of visible cracks, holes or other physical defects that would degrade its performance. It shall be as uniform as practicable in respect to overall dimensions, color, density, thickness, etc.

722.05.7.4--Color. The duct for exposed areas shall be carbon black. All other colors shall have a UV light stabilizer that will protect the duct for a minimum of 12 months in direct sunlight.

722.05.7.5--Markings. The duct shall have a durable identification showing the name or trademark of the manufacturer, duct size, date and reference code; i.e. 2-inch IPS SCH-80. Length intervals of one foot shall be marked along the duct. Duct specifically intended for electrical cable should have "CAUTION – HIGH VOLTAGE" printed at regular intervals.

722.05.7.6--Plugging Ends. The open ends of each length of reeled duct shall be sealed by plastic caps or with duct seal compound to prevent the entrance of dirt and moisture.

722.05.7.7--Dimensions. The dimensions of the duct shall be as per ASTM D 3035. Wall thickness shall be identified by Standard Diameter Ratio (SDR) designation. The manufacturer should advise the wall thickness required for a particular installation and/or conditions.

722.05.7.8--Pre-lubricated Duct and Pull Rope. The duct shall be factory pre-lubricated to provide a permanent low friction surface. Factory installed low-friction surface or pre-lubricated rope or tape should be provided to lower pulling tensions.

722.05.7.9--Couplings. Couplings should be available to quickly connect the duct and should be air and liquid-tight.

722.05.7.10--Reels. The duct should be provided on lightweight metal reels in maximum lengths possible with no joints or splices allowed. Reel configurations may be paralleled or compartmentalized to meet specific duct bank installation needs. Lift forks shall never be allowed to contact duct during loading or unloading from trucks.

722.05.7.11--Corrosion. The duct shall be resistant to most harsh chemicals and/or protected against degradation due to oxidation or general corrosion.

722.05.7.12--Installation. The duct shall be capable of being direct buried by plowing or trenching with no special consideration to using selective backfill. The duct shall also be capable of being encased in concrete and pulled through a drilled hole.

722.05.7.13--Tests on Finished Duct. Lab tests certifications required for finished products shall include, but are not limited to, the following:

- ASTM D 3035, Polyethylene Plastic Pipe Based on Controlled Outside Diameter
- ASTM D 1238, Melt Flow Rates of Thermoplastics by Extrusion Plastometer
- ASTM D 1599, Resistance to Short-Time Hydraulic Failure Pressure of Plastic Pipe

722.06--Pull Boxes.

722.06.1--Pull Box Enclosures, Grade-Level. Pull box enclosures and covers shall be made of either precast Class “B” concrete or composite material using matched surface tooling and shall conform to all test provisions of the latest version of ANSI/SCTE 77 - *Specification for Enclosure Integrity*.

722.06.2--Surface Mounted Pull Box. Surface mounted junction boxes shall be cast iron, inside flanged and gasket for a NEMA 4 rating. Boxes shall be of size and characteristics as indicated on the plans.

722.07--Circuit Breakers. Circuit breakers shall be a fixed mount, instantaneous magnetic trip-only type, fully enclosed in a molded case of insulating material rated according to the UL 489 Standard. The current carrying parts, mechanisms and trip devices shall be completely contained within the molded case of insulating material.

Each AC circuit breaker used shall interrupt the specified amperage at various voltages. Each circuit breaker shall be independently removable from the enclosure for inspection or replacement. The ON and OFF positions on each circuit breaker shall be clearly labeled. The operating handle shall be trip-free so that contact cannot be prevented from tripping by holding the operating handle in the ON position.

The circuit breakers maximum rating should always be in excess of the utilization equipment rating to provide for a short-time overload capability. The short circuit current shall be rated at the breaker's maximum voltage (ANSI) or voltage class (IEC). The continuous current rating shall be at the rated voltage for ANSI breakers or the normal current on IEC breakers.

Circuit breakers shall be such that their current rating and the instantaneous trip point and the continuous current rating are unaffected by ambient temperature variations. The instantaneous trip point shall be no greater than eight (8) times the continuous current unit rating. Circuit breakers shall have built in arc flash boundary protection and quick break when tripping automatically.

722.08--Terminal Blocks. Each field wiring terminal block shall be a heavy-duty or industrial rated UL and NEMA Class 600 volt, direct mount barrier type device. Terminal blocks shall be constructed of a single piece molded phenolic base with a twelve (12) double point, corrosion resistant, strap screw configuration. Terminal screws shall be binding head type, no smaller than size 10-32 with no less than 9/16 inch center to center spacing. Terminal block slots shall fit spade lug type terminating devices. Waterproof labeling strips shall be provided on all terminal blocks.

All current carrying parts of the terminal blocks shall be insulated from the fixture with integral plugs or strips to provide an insulating value in excess of the line-to-ground flashover voltage. If the Contractor elects to use sectionalized terminal blocks, each section shall be provided with an integral barrier on each side.

722.09--Grounding and Ground Rods. Ground rods used shall be copper clad, steel rods of the diameter and length shown on the plans. Ground rods shall conform to the requirements of UL-467. Grounding rod couplers shall be UL approved, made from bronze, stainless steel or copper clad with a solid center providing 100 percent conductivity.

Single ground rods shall be driven vertically until the top of the rod is at least 12 inches below the finished ground.

Bare solid conductor copper wire, AWG 6 shall be used for grounding conductor and bonding jumpers unless otherwise stated in the plans. Bare solid conductor copper wire shall meet the requirements of ASTM B2.

The grounding conductor shall be continuous and shall be connected to a common ground system between all supporting poles and structures, to each transformer, to each sign support assembly, to each gate, and to each grounding conductor in a multi-conductor cable assembly. Additional grounding rods electrodes (up to four (4) rods) shall be installed to obtain a maximum value of five (5) ohms to ground.

Bolted grounding connections of solder-less type made of the high strength electrical bronze with silicon bronze clamping bolts and hardware may be used; designed such that, bolts, nuts, lock washers and similar hardware that might nick or otherwise damage the ground wire will not directly contact the ground wire. Grounding splices shall not be insulated.

Exothermic welded ground connections shall be use where specified.

722.10-- Expansion Fittings. Expansion fitting shall be made from exterior and interior zinc galvanized, ductile iron, fixed and expansion jointed by rigid steel conduit sleeves. The fitting may be constructed such that disassembly is not required for installation. The fixed head may be integral with the sleeve, forming a one (1) piece body of galvanized malleable iron. Tin copper braid jumpers shall be provided.

722.11--Miscellaneous Hardware. All bolts, nuts, washers and other hardware shall be galvanized steel, stainless steel, or aluminum unless otherwise specified on the plans. Steel hardware that is galvanized shall be coated through hot-dip process in accordance with ASTM A153.

722.12--Surge Suppressors. This section describes the minimum requirements for surge suppressors including surge suppressors for electrical power and data cabling.

Transient Voltage Surge Suppressor (TVSS). The Contractor shall provide TVSS on all electrical service points and the input side of all transformers.

The Contractor shall install TVSS as follows:

- (a) The placement of equipment and wiring within an outside enclosure shall be arranged so that the surge suppressors are located near the conductor's point of entry.
- (b) Surge suppressor shall be located as far as possible from electronic equipment.
- (c) TVSS shall be mounted on the underside of riser and ground-mounted demarcation point breaker panel enclosures and on the underside of transformers.
- (d) The surge suppressors grounding conductor shall be free from sharp bends.

All electrical interconnects shall be protected from transient over-voltages (surges) including lightning and external electromagnetic fields coming into the cabinet. All cables shall be protected from a surge coming in on the ground and load side of the cabinet. The surge protection requirements include:

- (a) Surge suppressors shall be furnished for all non-dielectric cable and conductors (video, data/signal and device/assembly power) between the equipment and the equipment cabinet.
- (b) The surge suppressors shall have leads that are kept to a minimum length as recommended by the surge device manufacturer.
- (c) All surge suppressor devices shall be designed and selected to meet the temperature and humidity requirements expected in this type of outdoor application. Surge suppressors including variable temperature components (i.e., PTCs) shall not impede signals at any elevated temperatures.
- (d) All surge suppressors shall be UL listed (UL 1449 3rd Edition, UL 497, 497A, 497B,) and bonded to the same single-point ground point. Any DIN rail mounted SPDs shall be grounded via conductor and shall not rely solely upon the DIN rail's mechanical connection as a grounding point.
- (e) Any directional SPDs shall be clearly marked as "Protected Side" and "Unprotected Side" and installed such that the Protected Side faces the equipment and the Unprotected Side faces the conductors coming into the cabinet.
- (f) Low Voltage/Signal Cable Surge protectors for data/signal/control cable shall meet/provide the following functionality:

- (i) Peak Surge Current: 10,000-amperes for an 8x20 microsecond waveform.
 - (ii) Shall be rated for the appropriate voltage.
 - (iii) Response Time: one (1) nanosecond or less.
 - (iv) Life Expectancy: capable of surviving at a minimum of 25 occurrences at 2,000 amperes.
 - (v) Surge suppressor shall be self-resetting.
- (g) Power surge protectors for power from equipment cabinet power distribution to the System shall meet/provide the following functionality:
- (i) Frequency: DC to 10MHz.
 - (ii) Clamping Voltage: < 30VAC (rms) or 42VDC.
 - (iii) Insertion Loss: < 0.2dB
 - (iv) Input/Output Impedance: 75 ohms, typical.
 - (v) Peak Surge Current: 3,000-amperes.
 - (vi) Response Time: 1 nanosecond or less.
 - (vii) Surge suppressor shall be self-resetting.
- (h) Coaxial cable surge protectors are used from acceptance by the Engineer, the Coaxial Cable Surge suppressors for coaxial cable shall meet/provide the following functionality:
- (i) Attenuation: 0.3dB @ 10 MHz, typical.
 - (ii) Input/Output Impedance: 75 ohms nominal.
 - (iii) Operating Voltage of the surge protector shall match characteristics of the ITS device/assembly.
 - (iv) Peak Surge Current: 5,000-amperes for an 8x20 microsecond waveform.
 - (v) Response Time: 1 nanosecond or less.
 - (vi) Surge suppressor shall be self-resetting.
 - (vii) Coaxial SPDs shall be installed in a manner that prevents ground loops and resulting signal deterioration. This is usually caused where the cable has different references to ground at either end and connecting SPDs at both ends that have only Pin to Shield protection completes a ground loop circuit through the Shield. SPDs having Pin to Shield protection, and separate Shield to Ground protection are acceptable to eliminate ground loops.

722.13--Electrical Service Equipment.

722.13.1--Meter Base. Meter bases shall be NEMA Type 3R with a minimum rating of 100 amps and shall meet the requirements of the local utility. The meter base shall be provided with ampere rating of meter sockets based on sockets being wired with insulated wire rated at least 167°F.

Meter bases shall be four (4) terminal, 600 volt, single phase, three (3) wire furnished with the following:

- (a) Line, load and neutral terminals accepting #8 to 2/0 AWG copper/aluminum wire,
- (b) Ringed or ringless type, with or without bypass,
- (c) Made of galvanized steel,
- (d) Listed as meeting UL Standard UL-414, and
- (e) Overhead or underground service entrance as specified.

Ensure meter bases have electrostatically applied dry powder paint finish, light gray in color, with a minimum thickness of 2.4 mils.

A 1-inch watertight hub for threaded rigid conduit shall be furnished with meter base.

722.13.2--Disconnect. External electrical service disconnects shall be furnished with a single pole 50-amp inverse time circuit breaker with at least 10,000 RMS symmetrical amperes short circuit current rating in a lockable NEMA 3R enclosure. Disconnects shall be listed as meeting UL Standard UL-489 and marked as being suitable for use as service equipment.

The disconnect enclosure shall be fabricated from galvanized steel and electrostatically apply dry powder paint finish, light gray in color, to yield a minimum thickness of 2.4 mils. Ground bus and neutral bus shall be provided with at least four (4) terminals with minimum wire capacity range of number 14 through number 4.

722.13.3--Ground Mounted – Pedestal – Service Panel. The pedestal shall be of NEMA Type 3R rainproof construction and shall be UL Listed as “Enclosed Industrial Control Equipment” (UL 508A). External construction shall comply with UL50 requirements and shall be of G90 galvanized steel with light green #14672 Federal Specification 595 polyurethane industrial grade powder paint.

Hinges shall be stainless steel and of the continuous piano hinge type.

The pedestal mounting bolts shall not be externally accessible. The pedestal shall be able to be embedded in concrete or use anchor bolts for mounting on concrete base. Either pedestal mounting base or anchor bolt kit shall be required for installation.

The service pedestal shall have three separate isolated sections for metering equipment, utility termination and customer equipment.

The metering section shall be pad-lockable and sealable and have a hinged swing hood with an integral hinged polycarbonate sealable window for access to demand meters. Meter socket type shall meet the requirements of the serving utility.

The utility termination section shall be pad-lockable and sealable and shall have a stainless steel handle provided on a lift-off cover. Sufficient clearance shall be provided for a 4-inch diameter conduit for utility cables entrance. Utility landing lugs shall be UL listed and shall accommodate #6 – 350 kcmil conductors.

The customer compartment door shall be hinged on the left hand side. A stainless pad-lockable hasp shall be provided to secure customer compartment. A door keeper shall be provided to keep the door in an open position. A print pocket shall be provided on the inside of the door in a weatherproof sleeve. Required UL labeling shall be located on the inside of the customer door. Distribution and control equipment shall be behind an internal dead-front door with a quarter-turn securing latch and shall be hinged to open more than 90 degrees. The dead-front door shall be hinged on the same side as the customer section door. All distribution and control equipment shall be factory wired using 600 volt wire sized to NEC and UL requirements.

The service pedestal shall be rated for operation at 10K minimum (AIC) amps interrupting capacity. The provided documentation shall list circuit breaker combinations and those to be used for de-rated operation for series ratings. Circuit breakers shall be permanently labeled with engraved name plates.

The serving utility shall be consulted for requirements before ordering or installing equipment.

722.14--Signal Heads.

722.14.1--Traffic Signal Heads. Traffic signal heads shall consist of all component materials necessary to form heads as specified on the plans and shall be complete with attachments for pole mounting, span wire mounting or mast arm mounting, as indicated, and for tie-ins to the feeder cable.

These signal heads shall meet the requirements of the latest ITE standards for Adjustable Face Vehicle Traffic Control Signal Heads, the National Electrical Code and the MUTCD, where applicable.

No splicing of electric cables will be allowed exterior to the signal head. Quick disconnect hangers will be required where electric cables are too large to enter and leave the normal wire entrance fitting. However, in any signal installation, if one (1) signal head requires quick disconnect hangers, then all heads on that installation shall be furnished with quick disconnect hangers.

722.14.1.1--Housing.

722.14.1.1.1--Materials. Each housing shall be made of one of the following materials:

- a) Cast from aluminum alloy. Material for die cast housings shall be aluminum alloy S-12A, S-12B, SC-84A, SC-84B, or SG-100B, conforming to the specifications in ASTM B 85, or the latest revision thereof. Material for permanent mold castings shall be aluminum alloy S-5A or CS-72A conforming to the requirements of and as listed in ASTM B 108.
- b) Polycarbonate resin material. Material for this type housing shall be fabricated from corrosion resistant U.V. stabilized polycarbonate resin material. The moldings shall be a minimum of 0.090 inch thick and be ribbed for additional strength at point of high stress. Additional thickness shall be provided as necessary to eliminate light transmission through the housing, door, visor, or back plate. The housing of each section shall be a one-piece, corrosion resistant, molding with integral sides, top and bottom, free of voids, cracks, inclusions, or blow holes.

722.14.1.1.2--Features. Each housing shall be furnished with provisions for mounting of a back plate. The top and bottom of the housing shall have an opening two inches (2") in diameter to accommodate standard 1½-inch pipe, with no other opening in the top or bottom of the housing. Individual signal sections shall be fastened together, one above the other into a complete signal face, by means of plated nuts, bolts and washers in such a manner that any section may be rotated about a vertical axis and positioned at an angle with respect to any adjacent section. The opening hub shall have 72 circumferential serrations to secure each section in its orientation, adjustable in five (5) degree increments, and prevent its inadvertent rotation. A minimum 6-position labeled barrier terminal block shall be provided in each signal face for the purpose of field connections. The barrier terminal shall be installed in the circular yellow or yellow arrow section of each signal face. If the face has both of these sections, the terminal block shall be installed in the circular yellow section. There shall be provisions for the attachment of a 3/16-inch tether

line to the bottom of each span wire mounted signal head. A pinnacle shall be provided to close all 1½-inch holes in each housing that will not otherwise be sealed from the weather when installed with the specified mounting hardware.

722.14.1.2--Door. Each door shall be made of a material that is one of the above materials and that is compatible with the material of the housing, except that doors for plastic housings shall be plastic. The outer face of the door shall have four (4) holes equally spaced about the circumference of the lens opening to accommodate the secure mounting of the signal head tunnel visor. The visor shall fit flush against the door and no light shall leak between the door and the visor. Two (2) stainless steel hinge pins shall attach the door to the housing, one (1) in the upper left corner and one (1) in the lower left corner of the door. Two (2) stainless steel wing screws, one (1) in the upper right corner and one (1) in the lower right corner of the door, shall be used for opening the door and closing it tight against the housing. The wing screws shall be installed through the door with keepers to prevent their accidental removal or falling out. The removal of the hinge pins and the operation of the wing screws shall not require the use of tools.

722.14.1.3--Optical System. The optical system shall consist of LED signal modules that shall be sealed units comprised of an outer lens, an optical lens, a printed circuit board for LEDs and entirely enclosed power supply, a back cover and a gasket.

The assembly and manufacturing process for the LED signal modules shall be designed to assure all internal LED and electronic components are adequately supported to withstand mechanical shock and vibration from high winds and other sources as per MIL-STD-883.

The LED signal module shall be rated for use in the ambient operating temperature range of -40°F to +165°F.

The LED signal module lens shall be UV stabilized and shall have a uniform incandescent, non-pixelated appearance.

The light distribution of each LED shall be maximized by an internal beam controlling optical faceted lens designed and patented to meet the 44 points measurement of the VTCSH standard, Part 2. The outer cover made of ultraviolet stabilized polycarbonate shall be convex with a smooth outer surface and be an integral part of the module.

The chip in the ultra-bright 1/5-inch LEDs shall be made using AlInGaP for red and amber, and InGaN technology for the green, and be rated for 100,000 hours of continuous operation by the LED manufacturer.

Enclosures containing either the power supply or electronic components of the signal module shall be made of UL94VO flame retardant materials.

The measured chromaticity coordinates of LED signal modules shall conform to the chromaticity requirements of Section 8.04 and Figure 1 of the VTCSH standard. The LED manufacturers indicate the following X-Y coordinates for their respective LEDs. The X value for red LEDs varies from 0.690 to 0.708 and the Y value varies from 0.292 to 0.306. The value X for amber LEDs varies from 0.554 to 0.575 and the Y value varies from 0.424 to 0.445. The X value for the green LEDs varies from 0.1090 to 0.1138 and the Y value varies from 0.5673 to 0.5830.

All wiring and terminal blocks shall meet the requirements of Section 13.02 of the VTCSH standard. Two (2) secured, color-coded, three feet (3') long, 600 V, 20 AWG minimum, jacketed wires, conforming to the National Electrical Code, rated for service at +221°F, shall be provided for electrical connection.

The module shall operate on a 60 Hz AC line voltage ranging from 80 volts rms to 135 volts rms with less than ten percent (10%) light intensity variation. Nominal rated voltage for all measurements shall be 120 ± 3 volts rms. The circuitry shall prevent flickering over this voltage range.

The individual LEDs shall be wired so that a catastrophic failure of one (1) LED will result in the loss of only that one (1) LED, and not the entire string of LEDs or the entire module.

The power supply must permit the regulation of the current supplied to the LEDs to maintain a constant current.

The LED signal and associated on-board circuitry must meet Federal Communications Commission (FCC) Title 47, Sub-Part B, Section 15 regulations concerning the emission of electronic noise.

The LED signal module shall provide a power factor of 0.90 or greater at 77°F and at the nominal operating voltage.

Total harmonic distortion (THD), current and voltage, induced into an AC power line by a signal module shall not exceed twenty percent (20%), over the operating voltage range specified in Section 14 and within the ambient temperature range specified in Section 4.

The signal module on-board circuitry shall include voltage surge protection to withstand high-repetition noise transients and low-repetition high-energy transients as stated in Section 2.1.6, NEMA Standard TS-2, 1992.

The LED signal module shall operate from a 60 ± 3 Hz ac line power over a voltage range from 80 VAC rms to 135 VAC rms. The current draw shall be sufficient to ensure compatibility and proper triggering and operation of load current switches and conflict monitors in signal controller units the procuring traffic authority customer has in use. Load switches shall be compatible with NEMA TS-1 or later, or Model 170-1989 or later.

All LED signal modules shall be energized for a minimum of 24 hours, at 100 percent on-time duty cycle, in an ambient temperature of 140°F.

Each socket shall be provided with one (1) black lead from the socket and one (1) white lead from the shell. Terminal blocks shall be a 6-position, 12-block, terminal barrier strip placed in the top or red section of all traffic signal heads. Terminal blocks shall be secured on both ends

The manufacturer shall warranty the LED module for a minimum of five (5) years. The LED modules shall be replaced if the module fails to function as intended due to workmanship or material defects or if the module exhibits luminous intensities less than the minimum specified values within the first five (5) years from the date of delivery.

722.14.1.4--Visors. Each signal door shall be fitted with a tunnel visor. Eight-inch signals shall have visors a minimum of seven (7) inches long, 12-inch signals shall have visors a minimum of nine and one half (9 ½) inches long. The outside of the visor shall be black or federal yellow as directed by Engineer. The inside of the visor shall be flat black. The visors shall be attached to the door at four (4) equally spaced locations with four (4) placed screws or four (4) bayonet type self-locking tabs integrally formed with the visor. Visors for polycarbonate signal heads shall be made of a corrosion resistant polycarbonate resin at least 0.100 inch thick. Visors for metal signal heads shall be made from 0.064-inch minimum thickness aluminum alloy sheet.

722.14.1.5--Back Plate. Each signal head assembly shall be equipped with a back plate with a minimum width of five (5) inches with radius corners. Steel rivets shall be provided for mounting to the signal housing. All back plates shall be fabricated from a one (1) piece vacuum formed corrosion resistant, flat polycarbonate resin material at least 0.125 inch thick or 0.064-inch minimum thickness aluminum alloy sheet.

Where specified in the plans, a 2-inch retroreflective yellow tape shall border the back plates.

722.14.1.6--Lenses. Traffic signal lenses shall be circular, red, yellow, or green in color, and 8-inch or 12-inch nominal diameter, as shown on the plans. No legend shall be permitted. Arrow lenses shall be circular, 12 inches in diameter, green or yellow in color, and be opaque except for the arrow legend. The lenses shall conform to all the applicable sections of the latest edition of ITE's Standard on Adjustable Face Vehicular Traffic Control Signal Heads.

722.14.1.7--Mounting Hardware. Span wire suspension fitting with cable entrance shall be a one-piece malleable iron casting, minimum wall thickness of 3/16 inch, and free of flash and voids. The cable entrance shall have a plastic bushing with a minimum inside diameter of one and one-quarter inches (1¼"). The suspension fitting shall provide six (6) separate, clevis pin positions for balancing the signal assembly. The thickness of the solid casting in this suspension area shall be a minimum of 5/8 inch. A hex head threaded malleable iron lock nipple shall be provided for attaching the signal head to the bottom of the suspension fitting for one face signals or to the top bracket of multiface signal brackets. The mounting hardware for each signal face shall include a nylon, serrated, 72-tooth lock ring with full locking pins and a circular neoprene gasket for weather sealing.

Span wire suspension clamp assembly, consisting of a galvanized, malleable iron span wire clevis saddle, 5/8-inch diameter plated steel clevis pin with cotter key, two (2) ½-inch plated steel "U" bolts with nuts and washers, no "J" bolts are permitted, and a galvanized malleable iron cable locking bar, all fitted for 3/8-inch guy span. Galvanizing is to meet ASTM A 153.

Brackets shall consist of a malleable iron center outlet body, schedule 40 pipe, elbows, serrated fittings, and other hardware as required to provide a multi-face signal head assembly with internal wiring raceways to each face as specified.

Mounting brackets for mast arms shall conform to Subsection 722.11.

722.14.1.8--Color, Finish and Painting. Polycarbonate resin hardware shall have color impregnated throughout the material. The finish shall be smooth and unflawed. All metal

hardware, except those specified as galvanized, plated, or stainless steel shall be painted with a primer coat and a finish coat of the best quality oven baked enamel. Lenses, reflectors, gaskets and polycarbonate parts shall not be painted. The following signal head parts shall be colored either black or federal yellow as directed by Engineer: Vehicle Head; Housing; Door; Tunnel Visor; Back Plate; and Pole Bracket.

722.14.2--Traffic Signal Heads - Optically Programmed. Optically programmed traffic signal heads shall, in addition to the requirements prescribed in Subsection 722.14.1, be so constructed, programmed, and operable, as to limit the visibility of the indication exclusively to the area where it is desirable that the indication be seen. This is to be accomplished with a built-in High Resolution Optical System designed for the purpose and can be accomplished by an arrangement of hoods, louver, or other external means as directed by the plans or Engineer.

722.14.3--Pedestrian Signal Heads. Pedestrian signal heads shall consist of all component materials necessary to form heads as specified in the plans and shall be complete with attachments for pole or post mounting. Heads shall conform to the applicable parts of the MUTCD.

Single section pedestrian heads shall be constructed of die cast aluminum. The housing shall be painted black or federal yellow as directed by the plans or Engineer. The housing and door shall be designed such that when properly assembled, they shall provide a waterproof and dustproof enclosure. All screws, bolts, hinge pins and other necessary fasteners shall be stainless steel. Prior to assembly, the housing and door frame shall be painted with one (1) coat of primer and two (2) coats of enamel. Color shall be black or federal yellow as directed by the plans or Engineer.

An "egg crate" or "Z" crate type visor constructed of 0.030-inch minimum thickness and 100% impregnated black polycarbonate strips shall be provided with the signal head. The visor assembly shall be at least 1½ inches deep and shall be bordered by a 0.040-inch minimum aluminum frame.

The design, manufacture and testing of lenses shall conform to the parts concerning "Traffic Signal Lenses" as set forth in "A Standard for Adjustable Face Traffic Control Signal Heads" as published by the Institute of Transportation Engineers. Individual letters of the legend shall be 4½ inches high. The LED signal module lens shall be UV stabilized and shall have a uniform incandescent, non-pixelated appearance

All pedestrian signal heads shall be "Countdown Type" and meet the requirements of the MUTCD. All pedestrian signal heads shall be LED modules fully compliant to the latest adopted version as listed, at time of bid, ITE PTCSI Part-2: LED Pedestrian Traffic Signal Modules. Additionally, prior to bid award, the manufacturer shall submit to purchaser, reports from ETL/Intertek that certify full compliance of LED signal modules, to these specifications. Evidence of full compliance to all required testing methods, procedures and sections as outlined in the above ITE document Attachment 2, "Design Qualification Testing Flow Chart" shall be included without any exceptions, changes or omissions. The manufacturer shall also submit a data sheet showing the exact catalog number of the items submitted on the bid and the Independent Lab report must show full qualification of this catalog number. Combination hand/person pedestrian signal modules shall incorporate separate power supplies for the hand and the person icons.

The manufacturer shall warranty the LED module for a minimum of five (5) years. The LED modules shall be replaced if the module fails to function as intended due to workmanship or material defects or if the module exhibits luminous intensities less than the minimum specified values within the first five (5) years from the date of delivery.

722.14.4--Pedestrian Signal Heads - Optically Programmed. Optically programmed pedestrian signal heads shall, in addition to the requirements prescribed in Subsection 722.14.3, be constructed, programmed, and operable as to limit the visibility of the indication exclusively to the area where it is desirable that the indication be seen.

This shall be accomplished with a built-in High Resolution Optical System designed for the purpose and is not to be accomplished by an arrangement of hoods, louvers or other external means.

722.14.5--Turn-Signal Sign. The turn-signal signs, as indicated on the plans, shall conform to the applicable requirements of Section 631.

722.14.6--Tether Cable. Tether cable attached to the bottom of the signal head shall conform to the requirements of Subsection 722.04 and shall be the size shown on the plans. Tether cable clamps shall be designed such that the clamp will break away without damage to the signal head when the tether cable is hit by a vehicle.

722.14.7--Back Plate. Back plates shall be required on all new traffic signal heads. Back plates shall be one-piece vacuum formed construction and meet the requirements of Subsection 722.14.1.5.

722.14.8--Audible Pedestrian Signals. All pedestrian signals shall provide audible pedestrian indications. Audible pedestrian signals shall provide a "Cuckoo" output (north/south) with a duration 0.6 seconds $\pm 20\%$, Frequency 1,100 Hz $\pm 20\%$, and Frequency Deviation +120 Hz $\pm 20\%$ and "Peep-Peep" output (east/west) with a duration 0.2 seconds $\pm 20\%$, Frequency 2,800 Hz $\pm 20\%$, Frequency Deviation -800 Hz $\pm 20\%$.

The audible pedestrian signal shall operate at 115 Volts AC ($\pm 22\%$) at 60Hz, 3 Watts. The output shall be 90dB @ 1 watt/1 meter.

The audible pedestrian signal shall operate within a humidity range of 5% to 95% relative humidity within a temperature range of -35°F to +165°F.

Prior to assembly, the audible pedestrian signal shall be painted with one (1) coat of primer and two (2) coats of enamel. Color shall be black or federal yellow as directed by the plans or the Engineer.

SECTION 723 - MATERIALS FOR ROADWAY LIGHTING INSTALLATION

723.01--General. Acceptance of all material in this Section is subject to Subsections 106.01 and 106.04 entitled "Source of Supply and Quality Requirements" and "Certification of Compliance," respectively.

723.02--Secondary Distribution.

723.02.1--Raceways, Conduit and Fittings. All branch circuits shall be in Schedule 40 polyvinyl chloride (PVC) or high-density polyethylene (HDPE) conduit unless specifically shown or noted otherwise on the plans, or stated otherwise in these specifications. Conduit exposed on service poles and within five (5) feet of any pole foundation or terminating point shall be galvanized rigid (GRC) heavy wall conduit.

Under roadways, or where conduit is jacked or bored, use Schedule 80 PVC or HDPE conduit.

When transitioning between differing types of conduit, the correct coupling must be used; i.e. GRC to PVC, PVC to HDPE, etc. These couplings shall be approved prior to their use on the project.

In outdoor structure mounted exposed locations, except as noted on the plans, galvanized or sherardized rigid steel conduit shall be used.

At underground entrance or exit locations, all rigid metal conduits in contact with earth shall be polyvinyl, polyethylene, or asphalt paint coated with three (3) coats, unless shown otherwise on the plans.

723.02.2--Conductors. Conductors shall be standard annealed copper rated 600 volts with mechanical strength, insulation, and current carrying capacity adequate for the particular conditions under which they are used and in accordance with the following schedule:

- (a) In all locations, types "THW" or "THWN" shall be used unless indicated otherwise on the plans and/or in the specifications.
- (b) In unwired fixtures where required by National Electrical Code (NEC), approved heat resistant wire shall be used. This wire shall be sized for current, voltage, and temperature at which fixture operates and in accordance with the latest edition of the NEC.
- (c) All conductors entering the self-contained ballast compartment of gaseous vapor discharge fixtures shall be rated 600 volts, silicone rubber, fixture wire, #10 AWG, stranded copper conductor, silicone rubber insulation, glass braid, rated conductor temperature of 200°C.

Wire sized #8 AWG and larger consisting of the stranded type shall have Class B stranding. Wire sized #10 AWG and smaller shall be of the solid type.

The minimum wire size allowed on any project, with exceptions as noted on the plans or as stated in the specifications, will be #12 AWG.

723.02.3--Pull Boxes and Junction Boxes. Pull boxes shall be of the types specified on the plans. The number and location of pull boxes shall comply with the requirements of the NEC. Pull boxes shall be used to limit the strain while pulling conductors and splices will not be allowed.

Junction boxes shall be of the type specified on the plans. Splices will be allowed in junction boxes. Junction boxes shall comply with the applicable requirements of the NEC. All items required by codes, such as grounds, ground rods, etc., shall be supplied and installed as part of the box and will be included as part of the cost of the box.

Ground mounted boxes shall have tops that are reinforced and rated H-20 for vehicular traffic. Tops shall have the word "LIGHTING" molded, etched, or made a permanent part of the box top.

Where shown on the plans a concrete collar or pad shall be constructed around the box. The dimensions of the concrete shall be specified in the plans. When the box falls on a slope it, and the pad, will be constructed to conform to the contours of the slope. Site grading and other items will be included in the cost of the box.

723.03--Secondary Power Controller.

723.03.1--Lighting Controller. The lighting controller shall be factory assembled and contain the following items: one contactor, one hand-off-automatic selector switch, fused control circuit transformer, lightning arrester, branch circuit breakers, a NEMA 3R enclosure, one photoelectric control and a main breaker. Details and schedules are shown on the plans. All breakers shall be labeled as to circuit served with a phenolic engraved label having 1/4-inch white letters on a black background.

723.03.1.1--Contactor. The contactor shall have a continuously rated 120-volt coil that is encapsulated. The contactor shall switch a load at 480 volts and shall have a minimum of 2 poles rated as per the plans. Auxiliary arcing contacts are not permitted. Power contacts shall be totally enclosed and of silver-cadmium-oxide. The contactor shall be in accordance with U.L. 508 and NEMA ICS 2, and rated for 600 volts maximum.

723.03.1.2--Main Breaker. The main breaker shall be a molded case circuit breaker rated at the amperage shown on the plans. Interrupting ratings shall be 22,000 amperes R.M.S. symmetrical. The breaker shall have an over-center trip-free toggle type operating mechanism with quick-make, quick-break action and the switch is "ON" "OFF." The breaker handle shall assume a center position when tripped, with a provision for mechanically tripping the breaker built into the cover. The breaker shall be calibrated for operation at 40°C.

723.03.1.3--Hand-Off-Automatic Selector Switch. The H-O-A switch shall be a heavy duty, three position, maintained contact selector switch with ratings as follows:

7200 VA make
720 VA break
120 - 600 V.A.C.

723.03.1.4--Control Transformer. Control transformer shall have a 480 volt primary and 120 volt secondary, with a fused secondary. The volt-ampere rating shall be a minimum of 500 VA above contactor requirements for other loads.

723.03.1.5--Lightning Arrester. Arrester shall be a low impulse spark over and high discharge - current capacity type.

723.03.1.6--Branch Circuit Breakers. Branch circuit breakers shall be molded case breakers, U.L. listed and shall meet NEMA Standard No. ABI-1975, and Federal Specification No. W-C-375B/GEN. The amperage ratings shall be as scheduled on the plans. Interrupting ratings shall be 22,000 amps RMS symmetrical.

Breakers shall have over-center, trip-free, toggle-type operating mechanisms with quick-make, quick-break action and positive handle indication. All 2-pole breakers shall be common trip. Each breaker shall have a permanent trip unit containing individual thermal and magnetic trip elements in each pole. Circuit breaker handles shall assume a center position when tripped, with a provision for mechanically tripping the breaker built into the cover. Breakers shall be calibrated for operation in an ambient temperature of 40°C.

Breaker lugs shall be removable U.L. listed for copper only, and U.L. listed for installation of mechanical screw type lugs.

723.03.1.7--Copper Busing. Busing shall be copper with tin plating. Rating shall be 100 ampere or 200 ampere as scheduled on the plans.

723.03.1.8--Enclosure. The enclosure shall be NEMA 3R of minimum #14 gauge steel with a hinged door. One (1) hasp with padlock and a minimum of two (2) bolts to secure top and bottom of door shall be provided. Three (3) sets of keys shall be provided with each padlock.

723.03.2--Conduit. All conduit and fittings shall be rigid galvanized steel, sized as per the plans or NEC.

723.03.3--Ground Rods. All ground rods shall be copper-coated steel 3/4-in by 10 feet installed as shown on the plans. Ground wire connections shall be with exothermic welds.

723.03.4--Photocells. Photocell shall have a dust and watertight housing, and shall be rated for 120 volt operation. Contacts shall be rated at 1800 V.A. A time delay of a minimum of 15 seconds shall be built-in to prevent false switching. Turn-on shall be at approximately 1 to 3 foot-candles. Turn-off shall be at 1.5 to 9 foot-candles. Operational temperature range shall be -50 to +60°C. Failsafe protection is required in the closed position.

Mounting shall be as per the plans. Built-in surge protection shall provide a margin of protection of 60°C spark over -1500 V RMS. Impulse spark over voltage discharge is 10,000 amperes, 1½ x 40 M.S. wave at 2000 volts.

Where required on the plans that a photocell control Federal Aviation Administration (FAA) obstruction lights that photocell shall meet current FAA requirements.

723.03.5--Miscellaneous Hardware. All miscellaneous hardware shall be galvanized per ASTM A123.

Care shall be taken to reduce corrosion as much as possible. After drilling or cutting of parts or any operation that may damage anti-corrosion paint or coatings, the Contractor shall clean and apply anti-corrosion paint or coating. This shall be done at no additional cost to the Department.

723.03.6--Service Poles. Service poles shall be Southern Yellow Pine meeting the requirements of the latest edition of ANSI-05.1, "American National Standard for Wood Poles - Specifications and Dimensions," for Southern pine poles having a fiber stress of 8,000 psi. The poles shall be free of all defects such as holes, splits, sap rot, etc. Maximum deviation from straight poles shall be 1/2 inch for each six foot of length from surface of

ground to top of pole when a string is stretched along its bow. Poles shall be approximately thirty (30) feet in length.

All poles shall be inspected and treated in accordance with applicable requirements of the American Wood Protection Association (AWPA) and shall conform to Subsection 718.03 of the Standard Specifications.

723.03.7--Wiring. Wiring shall be copper conductors with THWN or THW type insulation. All wiring shall be tie wrapped and neatly trained in the enclosure.

723.04--High Mast Lighting Assembly.

723.04.1--Pole. The pole shall consist of sections of round or multi-sided tapered steel tubes that telescope together. Minimum yield strength after fabrication shall be 55,000 psi. Designed wind velocity shall be in accordance with the 2013 AASHTO Standard Specifications for Structural Supports for High Signs, Luminaires and Traffic Signals to support the number and type luminaires and lowering device required on the different assembly types. Design wind velocities shall be as follows:

140 MPH ---Hancock, Harrison & Jackson Counties

130 MPH ---Pearl River, Stone, & George Counties

120 MPH ---Lamar, Forrest, Perry & Greene Counties

110 MPH ---Pike, Walthall, Marion, Jefferson Davis, Covington, Jones & Wayne Counties

100 MPH ---Wilkinson, Amite, Adams, Franklin, Lincoln, Lawrence, Simpson, Smith, Jasper & Clarke Counties

90 MPH ---All counties north of and including Jefferson, Copiah, Rankin, Scott, Newton, & Lauderdale

Ice Loading shall be considered in the design for structures in all counties above and including Washington, Humphreys, Holmes, Attala, Winston, & Noxubee.

The gust factor shall be a minimum of 1.14. Recommended design life shall be 50 years. For fatigue design high mast poles will be designed as fatigue category II.

The pole shall be of ASTM A 572 or A 595, Grade 60 steel, hot dipped galvanized in accordance with ASTM A 123.

All factory welds shall be in accordance with ANSI/AWS Structural Welding Code D1.1 sections 1-8, and AASHTO requirements.

The pole shall have a minimum 10-inch wide by 20-in high oval handhole. The opening shall be reinforced to replace the equivalent strength lost by the hole. A hinged and gasketed handhole cover shall be provided, secured by four (4) stainless steel bolts, with three (3) hinges having stainless steel hinge pins. The cover shall be lockable with a hasp and a padlock provided and installed on each cover. The padlocks shall be keyed the same as the controller enclosures.

723.04.2--Lowering Device.

723.04.2.1--General. The lowering device shall be capable of lowering the luminaires to approximately five (5) feet from ground level for maintenance purposes. The lowering device shall consist of the following assemblies:

- a. Head frame assembly
- b. Luminaire mounting ring assembly
- c. Winch assembly
- d. Hoisting cable assembly

723.04.2.2--Head Frame Assembly. The head frame assembly shall be galvanized steel with a weather tight spun aluminum cover. A roller or pulley assembly shall be provided for power cord travel.

Three (3) positive latches shall be provided to support the luminaire ring when the lowering device is not in operation. Reflecting flags, visible from the ground, shall indicate the locking and unlocking of each of the latches. All moving parts of the latches shall be serviceable from the ground. Moving parts shall not be impaired by formation of ice. Latches shall be cast aluminum alloy conforming to ASTM B 221 or A 36 steel. Latch pins shall be ASTM A 276 stainless steel.

723.04.2.3--Luminaire Mounting Ring Assembly. The ring assembly shall be hot dipped galvanized steel channel, typically 6-inch by 2-inch, 7-gauge, with the proper number of 2-inch galvanized steel pipe luminaire mounting arms. The ring assembly shall be prewired with type ST distribution wiring, insulation rated at minimum 105°C. A cast aluminum or stainless steel, hinged cover, weather tight junction box shall be provided with a prewired 600-volt terminal block and a weatherproof twist lock power inlet, for testing of luminaires at ground level. This box shall be aligned with the access handhole cover.

The ring assembly shall be equipped with roller contact spring loaded guide arms to stabilize the ring on the pole while lowering device is in operation.

723.04.2.4--Winch Assembly. The winch shall be rated for 1500 pounds with a worm gear reduction minimum 30 to 1 ratio, and an integral friction drag brake to prevent free spooling. The winch shall be rated for intermittent motor operation or for hand crank operation. The 1/4-inch stainless steel hoisting cable shall be prewound on the winch. The winch drum shall be secured at both ends to prevent tilting.

723.04.2.5--Hoisting Cable Assembly. The hoisting cable shall be a minimum of 1/4-inch, 7 x 19 stainless steel. The three (3) suspension cables shall be a minimum of 3/16-inch stainless steel. The cable terminator shall be hot dipped galvanized.

Power cable shall be Type SO and of a length and size as shown on the plans.

723.04.3--Luminaire.

723.04.3.1--General. The luminaire shall be of the type and size as shown on the plans, normally an enclosed ventilated type with a one piece spun specular aluminum reflector, finished with an alzak or equivalent process. The reflector shall be encased in a spun and sealed aluminum cover or ribbed to provide additional structural integrity.

723.04.3.2--Ballast. The ballast shall be enclosed in a cast aluminum weather tight housing. Connections shall be made through a quick disconnect plug. The ballast shall be fused with inline fuses sized as per manufacturer's recommendations. The ballast shall be copper wound.

Electrical characteristics shall closely conform to the following:

Ballast Type	Lead
Primary Voltage	480V
Secondary Voltage (open circuit)	400V
Power Factor	over 90%
Input Watts	1100
Wattage Regulation	±12% at 10% line volt variation
Minimum Ambient Starting Temperature	20°F
Operating Line Current	2.35A

723.04.3.3--Mounting. The mounting shall be with an adjustable slipfitter for a 2-inch pipe bracket.

723.04.3.4--Lamp Socket. The lamp socket shall be heavy-duty, nickel-plated, porcelain enclosed with an integral lamp gripper and a lamp clamp of insulated stainless steel.

723.04.3.5--Photometrics. The luminaire shall provide an Illuminating Engineering Society (IES) Type V semi-cutoff distribution or as shown on the plans and shall have an output efficiency of 60% bare lamp lumens.

The lamp arc tube shall be optically shielded above 52° from the nadir. The maximum beam candle power for each 1000 lumens shall be a maximum of 200 at 80° vertical

Test reports with illumination data for each type distribution shall be provided with luminaire submittals. These reports must be certified, or conducted by an independent testing laboratory.

723.04.4--Anchor Bolts. Anchor bolts shall be steel in accordance with ASTM F 1554, Grade 105. Minimum yield strength shall be 105,000 psi. Galvanizing shall be in accordance with ASTM A 153. Anchor bolts shall be of the sizes and number recommended and provided by the pole manufacturer.

Each pole shall have a bolt layout template provided by the pole manufacturer for proper bolt installation. The Contractor shall align the template properly for correct handhole orientation.

723.04.5--Lamps. Lamps for high mast luminaires shall be universal burning 1000-watt high pressure sodium. The lamp shall be mogul base and T-18 bulb designation. The lamp shall meet or exceed the following criteria:

Mean Lumens	126,000
Initial Lumens	140,000
Rated Average Life at 10 hr/start, hours	24,000

723.04.6--Miscellaneous. Ground rods shall be 3/4-inch by ten (10) feet, copper coated steel. Lightning rods, cable, bolts and other items making up the high mast lighting assembly shall be provided as per the plans and manufacturer's recommendations. All incidental items necessary for a complete working system shall be provided whether or not mentioned in these specifications.

723.05--Low Mast Lighting Assembly.

723.05.1--Poles. Poles shall be formed from a single sheet of hot rolled weldable grade steel, galvanized in accordance with ASTM A 123. Unless otherwise specified in the plans, the poles shall be forty (40) feet in length.

Unless otherwise noted on the plans, poles shall be made from steel meeting the requirements of ASTM A 572 Grade 55, or A 595 Grade A. Minimum yield strength shall be 48,000 psi after fabrication. Designed wind velocity shall be in accordance with the 2013 AASHTO Standard Specifications for Structural Supports for High Signs, Luminaires and Traffic Signals to support the number and type luminaires and lowering device required on the different assembly types. Design wind velocities shall be as follows:

140 MPH -----Hancock, Harrison & Jackson Counties

130 MPH -----Pearl River, Stone, & George Counties

120 MPH -----Lamar, Forrest, Perry & Greene Counties

110 MPH -----Pike, Walthall, Marion, Jefferson Davis, Covington, Jones & Wayne Counties

100 MPH -----Wilkinson, Amite, Adams, Franklin, Lincoln, Lawrence, Simpson, Smith, Jasper & Clarke Counties

90 MPH-----All counties north of and including Jefferson, Copiah, Rankin, Scott, Newton, & Lauderdale

Ice Loading shall be considered in all counties above and including Washington, Humphreys, Holmes, Attala, Winston, & Noxubee.

The gust factor shall be a minimum of 1.14. Recommended design life for poles shorter than 50 feet shall be 25 years. For fatigue design low mast poles is not required.

Poles shall have a mast arm as required and specified on the plans for luminaire mast arm mounting. Post top mounted luminaires will require a tenon mount.

Poles shall have a constant taper of 0.14 inch nominal per foot.

All poles shall be equipped with a breakaway device that conforms to the latest AASHTO and FHWA requirements that have been approved by same. The Contractor shall submit a manufacturer's certification with the pole shop plans stating that the device meets, or exceeds, these standards.

Bridge-mounted poles shall be equipped with standard anchor bases for mounting on bridge brackets.

Poles shall have a 4-inch by 6½-inch handhole with bolted cover.

Arm lengths shall be as specified on the plans.

723.05.2--Luminaire. Low mast luminaires shall be post top mounted or mast arm mounted with 150-watt, 250-watt or 400 watt high pressure sodium lamps or as required on the plans.

The housing shall be die cast aluminum, joined with a lower housing by a stainless steel hinge, and provided with a trigger latch. The finish shall be gray baked-on enamel.

The reflector shall be polished anodic surface aluminum. The refractor shall be prismatic borosilicate glass. Photometrics shall conform to IES Type III, medium, semi-cutoff or as shown on the plans. Seals and gaskets shall be provided to prevent the entry of contaminants.

The ballast shall be prewired and closely conform to the following criteria:

	<u>400-watt</u>	<u>250-watt</u>	<u>150-watt</u>
Primary Voltage	480 V	480 V	480 V
Operating Current	1.0 A	0.63 A	0.42 A
Secondary Voltage, open circuit	215 V	222 V	128 V
Input Watts	458 W	295 W	188 W
Power Factor	Over 95%	Over 95%	Over 95%

Lamp Wattage Regulation @ ±10% Line Voltage Variation +10%
 Minimum Ambient Starting Temperature -20°F

The ballast shall also have a quick disconnect. The slipfitter shall accept 1¼ to 2-inch outer diameter arms. Maximum projected area shall be 1.5 square feet.

723.05.3--Anchor Bolts. Anchor bolts shall be made of steel in accordance with ASTM F 1554, Grade 55. Anchor bolts shall be galvanized as per ASTM A 123. Minimum yield strength shall be 50,000 psi and "L" shaped. Anchor bolts shall be provided for each pole with two (2) hex nuts and washers per bolt. A bolt layout template shall be provided by the manufacturer for proper bolt installation. The number of anchor bolts and design yield strength shall be as recommended by the manufacturer.

723.05.4--Lamps. Lamps shall be clear 150-watt, 250-watt or 400-watt high pressure sodium type that operate in any position. The lamps shall conform to the following:

	<u>150-watt</u>	<u>250-watt</u>	<u>400-watt</u>
Mean Lumens	14,000	27,500	45,000
Initial Lumens	16,000	24,750	50,000
Average Rated Life, hours	24,000	24,000	24,000

723.05.5--Miscellaneous. Wiring, ground rods, bolts and other items shall be provided as per the plans and manufacturer's recommendations. All items necessary for a complete working lighting assembly shall be provided whether or not mentioned in these specifications. Ground rods shall be 3/4-inch by ten (10) feet copper coated steel.

723.06--Underpass Lighting Assembly.

723.06.1--Housing. The lens shall be injection molded, U.V. stabilized polycarbonate. The reflector shall consist of a hydroformed specular alzak main reflector with parabolic and cylindrical surfaces. The unit shall produce a lighting pattern with a sharp cutoff at 86° above nadir.

Photometrics shall be IES, Type III, or as shown on the plans.

723.06.2--Ballast. The ballast shall be a high power factor type CWAA for -30°C starting and for a 150-watt, high pressure sodium lamp at 480 volts with double fusing.

723.06.3--Conduit Box. The conduit box shall consist of cast aluminum housing with gasketing, bolted to a flat aluminum plate.

723.06.4--Finish. The finish shall be a gray polyester powder coating that has been electrostatically applied and oven cured.

723.07--Light Emitting Diode (LED) Luminaires. LED luminaires shall meet the following general requirements and any special requirements noted on the plans.

723.07.1--Housing. The luminaire housing shall be a low-profile, die-cast aluminum housing, grey powder-coat finish, minimum 3-mil thickness. The housing shall have wide angular channels that allow for natural removal of dirt and debris. The housing shall have a hinged door with tool-less entry. Luminaire weight and projected area must be within design loading limits as shown on the plans. The housing shall be UL 8750 and UL 1598 compliant, vibration tested to 3G per ANSI C136.31. The housing must be NRTL listed for wet locations.

723.07.2--Optical Requirements. The luminaire shall have a completely sealed optical system for the luminaire housing and shall have an International Electrotechnical Commission (IEC) International Protection marking (IP) code of 66 or greater. The luminaire shall have a light distribution pattern at the road surface that has an evenly dispersed appearance and shall provide the Illuminating Engineering Society (IES) pattern as identified on the plans.

723.07.3--Mounting. The luminaire shall have provisions for a 2-bolt slip fitter type mounting on nominal 2-inch (2 3/8" OD) pipe (arm) brackets. The mounting shall have a clamping assembly with two (2) bolts for securing the assembly to the light pole. There shall be an area on the top of the housing to allow for a level to be used for proper orientation of the luminaire. For a vertical (tenon) bracket, it shall have provisions for a 2-inch (2 3/8" OD) vertical tenon. It shall attach to the tenon with set screws.

723.07.4--Labeling Marking. Permanent labels must be placed inside the luminaire indicating NRTL listing. The luminaire shall have an external label per ANSI C136.15. The luminaire shall have an internal label per ANSI C136.22. An internal label or marking with date code of when fixture was manufactured shall be provided.

723.07.5--Electrical. The luminaire shall be rated for operating at ambient temperature between -40 and +40°C. The luminaire shall use Class I LED drivers and the drivers shall have a minimum power factor of 90%. The luminaire shall have a terminal block for connecting pole wiring to the luminaire. The power supply and other components shall

have a quick disconnect wiring harness for ease of maintenance. Drivers and other electrical components must be NRTL listed for wet locations.

723.07.6--Documentation. The following documentation must be available upon request or submitted for approval:

- Luminaire specification sheet
- LED driver specification sheet
- LM-79 Luminaire photometric report. The vendor must submit LM-79 in-situ test data to confirm thermal operating temperatures of the luminaire
- LM-80 Lumen maintenance report
- TM-21 calculations
- Backlight, Uplight, Glare (BUG) rating of the luminaire
- Computer generated point by point photometric analysis
- Written product warranty
- Independent test lab IES photometric reports including: IES electronic file, IES chromaticity data from an LED Lighting Facts approved testing laboratory
- Instructions for installation and maintenance.

723.07.7--Chromaticity. The luminaire shall meet the following Chromaticity requirements:

- The standard color for the LED Luminaire shall be white.
- The colors shall conform to the following color regions based on the 1931 CIE chromaticity diagram.
- Nominal Correlated Color Temperature (CCT) = 4000K \pm 500K.
- The luminaire shall have a minimum Color Rendering Index (CRI) of 70.
- Chromaticity as stated above must be confirmed by an Independent test lab or shown on the LM-79 test report.

723.07.8--Surge Protection. The luminaire shall have a surge protection device (SPD), in addition to driver's internal protection, to withstand repetitive noise transients from utility line switching, nearby lightning strikes, and other interference.

Documentation shall be provided that shows the following:

- The SPD will protect the luminaire from common mode transient peak voltages up to 10 kV (minimum) and transient peak currents up to 5 kA (minimum).
- The SPD conforms to UL 1449, 3rd Edition, and has been tested in accordance with ANSI/IEEE C62.41.2 Scenario I Location Category C with modified test levels of 10kV/5kA Combination Wave for Line-Ground, Line-Neutral and Neutral-Ground.
- The SPD is listed or recognized by a NRTL to UL 1449, 3rd Edition.
- The SPD component in series with the line will stop current to the fixture in the event of SPD failure.

723.07.9--Rating. The fixture shall be rated for a minimum lamp efficiency of 70% lumen output at 75,000 hours @ 25°C.

723.07.10--Warranty. The entire luminaire assembly, including material, finish, workmanship, power supply, LED modules and lumen maintenance, shall have a minimum

of 5-year warranty from the date of installation. The fixture shall be determined to be defective if greater than 10% of the LEDs fail. A finish warranty shall include deterioration such as blistering, cracking, peeling, fading, or corrosion defects for a period of five (5) years.

723.08--Portable Electric Power Unit.

723.08.1--General. The unit shall drive the winch through a torque limiter coupling to prevent excessive force on the system. A back-up shear pin shall be provided set for fifty six (56) pounds maximum. The unit used by the Contractor during construction will not be accepted. The power unit provided to the Department shall be new and unused except for testing to assure proper operation.

723.08.2--Housing. The housing shall be of cast aluminum.

723.08.3--Motor. The motor shall be heavy duty with high temperature windings. The rotor shall be dynamically balanced to assure vibration free operation. The motor shall operate at 120 volts AC, 60 hertz, with the proper horsepower to operate the lowering device recommended by the manufacturer.

723.08.4--Portable Transformer. The transformer shall be rated 480 volts primary and 120 volts secondary, rated KVA shall be 1.5 times necessary for the operation of the lowering device. The primary shall have a male weatherproof receptacle for acceptance of the pole power cord plug. The secondary shall have a weatherproof duplex receptacle, one (1) for connection of the power unit, and one (1) for other tools.

723.08.5--Remote Control Unit. The remote control unit shall have twenty (20) feet of remote cord, with a FORWARD, OFF, REVERSE switch. The switch operation shall be maintained contact type. Momentary contact spring load operation is not acceptable.

723.09--Temporary Lighting System.

723.09.1--Instructions. All exposed conduit shall be rigid galvanized steel. RTV silicon shall be used on all male threads. All final connections to light fixtures shall be through liquid-tight flexible conduits with weathertight connectors.

723.09.2--Conductors. All aerial conductors shall be triplex cable with an ACSR messenger. The conductor shall be aluminum with seven (7) strands. The messenger shall be the same size as the conductor with 6 to 1 stranding. The insulation shall be cross linked polyethylene, Type "XHHW-2" or "XLP."

Conduit installed conductors shall be type "THW" with standard annealed copper rated 600 volts.

Direct buried underground feeder or branch circuit shall be Type "UF."

All splices and connections shall be made in accessible boxes, switches, or at weatherheads.

Pressure type connectors shall be used. The connectors shall be well taped, rated for copper or aluminum

723.09.3--Lighting Assembly Requirements. All lighting assemblies shall be as shown on the plans. Fixtures shall be completely prewired with an integral photocell.

723.09.4--Lamps. Lamps shall be 250 or 400-watt clear high pressure sodium meeting or exceeding the following criteria:

Lamp Life at 10 hours per start, hours	24,000
Mean Lumens for 250-watt	27,000
for 400 watt.....	50,000
Burning Position.....	Operate in any position

723.09.5--Miscellaneous Material. Miscellaneous materials shall be furnished as shown on the plans, and as specified.

723.09.6--Timber Utility Poles. Timber utility poles shall be Southern Yellow Pine meeting the requirements of the latest edition of ANSI-05.1, "American National Standard for Wood Poles - Specifications and Dimensions," for Southern Pine poles having a fiber stress of 8,000 psi. The poles shall be free of all defects such as holes, splits, sap rot, etc. Maximum deviation from straight poles shall be 1/2" for each six (6) foot of length from surface of ground to top of pole when a string is stretched along its bow.

All poles shall be inspected and treated in accordance with applicable requirements of the American Wood Protection Association (AWPA) and shall conform to Subsection 718.03 of the Standard Specifications.

723.09.7--Hardware. All hardware shall be approved for the use and location as shown on plans.

723.09.8--Safety Switch. All safety switches shall be General Duty 2-pole, 600-Volt, fused, with fuses sized as required, and in a NEMA 3R enclosure with a lock.

723.09.9--Junction Boxes. All junction boxes shall be cast aluminum. Locations of junction boxes will be as shown on plans.

DIVISION 800 - BRIDGES AND STRUCTURES**SECTION 801 - EXCAVATION AND FILL**

801.01--Description. Foundation excavation shall include the removal of all material, of whatever nature, necessary for the construction of foundations and substructures of structures in accordance with the plans or as directed by the Engineer. When shown as a pay item, it shall include the furnishing of all necessary equipment and the construction of all cribs, cofferdams, dewatering, etc. necessary for execution of the work. It shall also include the subsequent removal of cofferdams and cribs and the placement of all necessary backfill as hereinafter specified. It shall also include the disposal of excavated material that is not required for backfill or other specified usage, in a manner and in locations that will not affect the carrying capacity of the channel or other drainage or be unsightly.

Unless a greater area is necessary for construction, the bridge site shall be the area defined in Subsection 101.02. Clearing and grubbing shall be in accordance with the provisions of Subsection 201.04.

All substructures, where practicable, shall be constructed in open excavation, and where necessary, the excavation shall be shored, braced, or protected by cofferdams in accordance with approved methods. When footings can be placed in the dry without the use of cribs or cofferdams, backforms may be omitted with the approval of the Engineer and the entire excavation filled with concrete to the top of the footing. The additional concrete required shall be placed at the expense of the Contractor.

801.02--Materials. Unless designated otherwise, all material used for backfill shall meet the requirements of Subsection 203.03.8.6.

801.03--Construction Requirements.

801.03.1--Preservation of Channel. Unless otherwise specified, no excavation shall be made outside of cribs, cofferdams, or sheet piling, and the natural stream bed adjacent to the structure shall not be disturbed without permission of the Engineer. If any excavation or dredging is made at the site of the structure before cribs or cofferdams are in place, the Contractor shall, without extra compensation and after the foundation base is in place, backfill all such excavation to the original ground surface or river bed with material satisfactory to the Engineer. Material deposited within the stream area from foundation or other excavation or from the filling of cofferdams shall be removed and the stream area freed from obstruction thereby.

801.03.2--Depth of Footings. The elevations shown on the plans for bottoms of footings shall be considered as approximate, and the Engineer may order in writing changes in dimensions or elevations necessary for a satisfactory foundation.

801.03.3--Preparation of Foundations for Footings. All rock or other hard foundation material shall be cut to a firm surface, either level, stepped, or roughened as may be directed by the Engineer, and then cleaned of all loose material. All seams shall be cleaned out and filled with concrete, mortar, or grout.

When masonry is to rest on an excavated surface other than rock, special care shall be taken not to disturb the bottom of the excavation, and the final removal of the foundation material to grade shall not be made until just before the masonry is to be placed.

Excavation and preparation of foundations for footings for box bridges shall be in accordance with the provisions of Section 206.

801.03.4--Cofferdams and Cribs.

801.03.4.1--General. Cofferdams and cribs shall be safely designed and constructed to adequate depths and heights, and be made as water-tight as is necessary for the proper performance of the work to be done inside them. In general, the interior dimensions of cofferdams and cribs shall be sufficient to permit construction of forms and the inspection of their exteriors and to permit pumping outside of the forms. Cofferdams or cribs which tilt or move laterally during the process of sinking shall be righted, reset, or enlarged so as to provide the necessary clearance. All corrective work shall be at the expense of the Contractor.

When conditions are encountered that, in the opinion of the Engineer, make it impracticable to dewater the foundation, the Engineer may require the construction of a concrete seal of the dimensions necessary. The foundation shall then be pumped out and the balance of the masonry placed in the dry. When weighted cribs are employed, and the weight is utilized to partially overcome the hydrostatic pressure acting against the bottom of the foundation seal, special anchorage such as dowels or keys shall be provided to transfer the entire weight of the crib into the foundation seal. During the placing of a foundation seal, the water elevation inside the cofferdam shall be controlled to prevent any flow through the seal, and if the cofferdam is to remain in place, it shall be vented or ported at low water level.

801.03.4.2--Protection of Concrete. Cofferdams or cribs shall be constructed so as to protect green concrete against damage from a sudden rising of the stream and to prevent damage to the foundation by erosion. Timber or bracing that will extend into the substructure masonry shall not be left in cofferdams without written permission from the Engineer.

801.03.4.3--Drawings Required. The Contractor shall submit to the Engineer four copies of structural design analysis and detail drawings that show the proposed method of constructing the cofferdam. These drawings shall include the types and sizes of sheeting, wales, bracing, and struts, the connections therefore, and the proposed method of installing, sealing, dewatering, cut-off and/or removal. The cofferdam analysis and details shall be prepared by and bear the seal of a Registered Professional Engineer experienced in cofferdam design.

The Registered Professional Engineer shall certify that the actual material and material fabrication used for cofferdam construction are capable of supporting the loads.

When submitting drawings and design analysis, the Contractor shall list the bent numbers on which the construction of cofferdams is proposed.

801.03.4.4--Removal. Unless otherwise provided, cofferdams or cribs with all sheeting and bracing shall be removed after the completion of the substructure. Care shall be taken not to disturb or otherwise injure the finished masonry.

801.03.5--Pumping. Pumping from the interior of a foundation enclosure shall be done so as to preclude the possibility of movement of water through fresh concrete. There shall be no pumping during the placing of concrete or for a period of at least 24 hours thereafter, unless it can be done from a suitable sump separated from the concrete work by a water-tight wall or other effective means.

Pumping to dewater a sealed cofferdam shall not commence until the seal has set sufficiently to withstand the hydrostatic pressure.

801.03.6--Inspection. After each excavation is completed, the Contractor shall notify the Engineer, and no masonry shall be placed until the Engineer has approved the depth of the excavation and the character of the foundation material.

801.03.7--Backfill. Backfill of solid structures may commence upon removal of forms. Backfill of wall structures shall be in accordance with Subsection 601.03.6.3.

Adequate provision shall be made for thorough drainage of all backfilling. French drains shall be placed at weep holes as specified.

All excavated space not occupied by the permanent structure shall be backfilled to the surface of the surrounding ground or to the typical section indicated on the plans. All backfill shall be thoroughly compacted and sufficient allowance shall be made for settlement.

Where it provides drainage, bearing strength, or lateral support to the permanent construction, all backfilling shall be performed in accordance with the provisions of Subsection 203.03.8.6. In general, the top surface of backfilled area shall be neatly graded to the section indicated on the plans or established.

801.03.8--Approach Embankment. When approach embankments are required, they shall be constructed and will be paid for in accordance with Section 203.

801.04--Method of Measurement. Foundation excavation, satisfactorily performed, will be measured by the cubic yard in the original position with dimensions determined as follows:

- (a) Bottom - the elevation of the bottom of the footing, seal, or web wall as applicable.
- (b) Top - the elevation of the original ground or graded section, whichever is lower.
- (c) Sides - vertical planes no more than 18 inches outside the outer edges shown on the plans, or directed, for the footing, seal and web wall.

The measurement will not include water or other liquids, but will include mud, muck, and other similar semi-solids.

Extra depth excavation, required by the Engineer to establish the elevation of the footing or seal below the elevation shown on the plans, will be measured in cubic yards in its original position. This volume will be determined by multiplying the area of the excavation, as determined above, by the distance the footing or seal is lowered. This volume will be divided into the applicable increments indicated in Subsection 801.05.

When the material yielded from foundation excavation is insufficient, or is determined to be unsuitable, for backfill material, required backfill material ordered by the Engineer will be included in the measurement for the applicable item of excavation under Section 203. Other materials shown on the plans or ordered and used as backfill materials will be measured in accordance with the provisions governing the material specified.

Unless otherwise specified, haul of foundation excavation and materials for backfill will not be measured for separate payment.

When shown as a pay item, cofferdams will be measured as a lump sum quantity. This lump sum quantity includes all cofferdams necessary for footing construction.

Measurement for progress estimates will be based on the number of cofferdams completed as compared to the total number listed by the Contractor in accordance with Subsection 801.03.4.3.

801.05--Basis of Payment. Foundation excavation, measured to the elevation of the bottom of the footing or seal as shown on the plans, will be paid for at the contract unit price per cubic yard.

Extra depth excavation, required below the footing or seal elevation shown on the plans, will be paid for per cubic yard in accordance with the following schedule:

<u>Established Elevation of the Footing Below the Elevation Shown on the Plans</u>	<u>Payment Percent of Contract Price</u>
0.00 to 1.99 feet	100%
2.00 to 3.99 feet	120%
4.00 to 5.99 feet	150%
6.00 to 7.99 feet	165%
8.00 to 9.99 feet	195%
10.00 feet or more	230%

Selected backfill material, shown on the plans or ordered by the Engineer, to be obtained from sources other than from foundation excavation will be paid for at the contract unit price for the material specified and used.

All necessary cofferdams or cribs will be paid for at the contract lump sum price.

The prices thus paid shall be full compensation for completing the work.

All work required under this section for which no pay items are included in the proposal will not be measured for separate payment. Compensation for this work shall be considered as included in the prices and payment for bid items.

Payment will be made under:

801-A: Foundation Excavation - per cubic yard

801-B: Cofferdams - lump sum

SECTION 802 - SHEET PILING

802.01--Description. This work consists of furnishing and installing permanent sheet piling as shown on the plan, or ordered by the Engineer to be left in place as part of the finished structure. Except where indicated as a pay item in the plans, no compensation will be allowed for furnishing and installing temporary sheet piling and appurtenances. Temporary sheet piling will ONLY be paid for when a pay item is included in the plans.

802.02--Materials.

802.02.1--Concrete Sheet Piles. Concrete sheet piles shall be in accordance with the detailed design. The requirements governing their manufacture and installation shall conform, in general, to those governing concrete bearing piles.

802.02.2--Steel Sheet Piles. Steel sheet piles shall conform to the requirements of Subsection 719.05 and shall be of the type and weight designated. The piles, when in place in the completed structure, shall be practically water-tight at the joints. Painting of steel sheet piles shall conform to Section 814.

802.03--Construction Requirements. Construction requirements for sheet piling shall conform to the applicable requirements of Section 803.

Temporary sheet piling shall be a steel sheet pile retaining wall constructed as indicated on the plans. Painting of the sheet piling will not be required. The sheet piling shall be removed upon completion of the work and the area shall be restored as directed by the Engineer.

802.04--Method of Measurement. Permanent sheet piling will be measured by the square foot, on the basis of the piles driven as approved by the Engineer. Cut-offs will be deducted from the measurement. Unless shown as a pay item, no measurement for extra compensation will be made for such temporary sheet piling required for foundations and in conjunction with bridge excavation not designated for payment.

Temporary steel sheet piling will be measured by the square foot, on the basis of the piles driven as approved by the Engineer. Temporary steel sheet piling will only be measured for payment when a pay item is included in the plans.

802.05--Basis of Payment. Permanent and temporary sheet piling, measured as prescribed above, will be paid for by the square foot, which price shall be full compensation for completing the work.

Payment will be made under:

802-A: Permanent Steel Sheet Piling - per square foot

802-B: Permanent Concrete Sheet Piling	- per square foot
802-C: Temporary Steel Sheet Piling	- per square foot

SECTION 803 - DEEP FOUNDATIONS

803.01--General.

803.01.1--Description. This work consists of furnishing and installing deep foundations in accordance with these specifications and in reasonable conformance with the lines, elevations, and spacings shown on the plans. It shall also consist of furnishing all required labor, tools, and equipment to determine the bearing value of the deep foundation by static load testing, by dynamic load testing, and/or by driving of the specified test piles.

803.01.2--Order Lists for Deep Foundations. Lengths found in the plans are estimated lengths for bid purposes. Unless otherwise specified or authorized in writing by the Bridge Engineer, all permanent deep foundations shall be installed within the prescribed tolerances specified herein and to the depths and/or lengths indicated on the itemized Order List furnished by the Engineer. The Order List shall be furnished after bearing has been verified either through static load testing, dynamic load testing, and/or driving of the specified test piles.

The Contractor shall furnish or install driven piles and/or drilled shafts in accordance with an itemized list furnished by the Engineer. The Order List will show the required length of the piles or drilled shafts for each bridge bent or footing.

803.02--Materials. All materials shall conform to the applicable requirements set forth in Sections 710, 711, 719, 804, and 814.

Driven piles shall conform to all applicable requirements set forth in Section 719 and the plans. Paint for steel piles or steel shells shall conform to the applicable requirements of Sections 710 and 814.

Drilled shaft concrete shall conform to the requirements of Section 804 for Class "DS" concrete. All reinforcing steel shall conform to the requirements of Section 711 of the Specifications.

803.03--Construction Requirement. This work shall consist of furnishing all labor, materials, equipment and services necessary to install driven piles of the prescribed type in accordance with these specifications and in conformance with the lines, elevations, and spacings shown on the plans.

This work shall also consist of furnishing all labor, materials, equipment and services necessary to perform all operations to complete the drilled shaft installations in accordance with these specifications and with the details and dimensions shown on the plans. Drilled shafts shall consist of reinforced or non-reinforced concrete with or without concrete bell footings.

803.03.1--Driven Piles.

803.03.1.1--General. Unless otherwise specified or authorized by the Bridge Engineer, all permanent production piles shall be driven in a continuous operation, to the full lengths indicated on the itemized order list furnished by the Bridge Engineer.

803.03.1.2--Accuracy of Installation. Driven piles in trestle bents shall be driven to within a tolerance of 1/4 inch per foot from the vertical or from the batter shown on the plans. Piles to be incorporated into a cap or footing shall not be out of the position shown on the plans by more than six inches. In all cases, piles shall be driven so that they will not be excessively stressed to place them in the proper location in the cap or footing. Excessive manipulation of the piles will not be permitted, and the Contractor shall re-drive or use other satisfactory methods to avoid such manipulations. No shimming on tops of piles will be permitted.

803.03.1.3--Extensions, Build-ups and Splices. If determined by the Engineer to be necessary, production piles that are extended below cut-off shall be extended, built-up, or spliced in accordance with the plans to the extent established by the Bridge Engineer. Extensions or build-ups will not be measured for payment as such, but will be included in the total length of piling in the finished structure.

803.03.1.4--Cut-Offs. If it is determined by the Engineer that the pile has reached practical refusal above pile cut-off elevation but below the prescribed minimum tip elevation shown in the plans then the Contractor will be allowed to cut off the pile at the cut-off elevation.

803.03.1.5--Driven Pile Types. Driven piles shall be of the type listed below unless otherwise specified in the plans.

803.03.1.5.1--Concrete Piles. Concrete piles shall be the size and shape specified. Reinforcement, unless otherwise designated, shall have a clear distance of at least two inches from the face of the pile. When the piles are for use in salt water or alkali soils this clear distance shall be at least three inches.

803.03.1.5.2--Steel Piles. Full-length steel piles shall be used unless splicing is approved in writing by the Bridge Engineer. When permitted, splicing shall be in accordance with the notes and details shown on the plans.

803.03.1.5.3--Timber Piles. Specified timber piles or timber piles used for temporary construction shall meet the requirements set forth in Section 820.

803.03.1.5.4--Special Piles. Piles not of the type specified above, but called for in the plans or additional specifications shall meet the general requirements contained therein.

803.03.1.5.5--Steel Pipe Piling. When permitted, steel pipe pile splices shall be made by a certified welder in accordance with AWS D1.1 or as approved by the Engineer. Either shielded arc or submerged arc welding should be used when splicing steel pipe piles. Any damaged portion of the pile top shall be cut off before splicing. Unless otherwise indicated by the plans, the pipe pile ends may be flame cut. The Contractor shall take care to align the sections prior to splicing so that the axis of the pile is straight. Splices of steel pipe piles shall form a watertight joint and shall not extend beyond the pipe pile OD.

Pipe pile splices within the epoxy coated section require removal and re-application of the specified epoxy coating at the weld location.

803.03.1.6--Preparation for Driving.

803.03.1.6.1--Excavation. When a pile cap is located below the ground line, piles shall not be driven until the required excavation is completed. All material forced up between the piles shall be removed to the correct elevation at the Contractor's expense before concrete for the foundation is placed.

803.03.1.6.2--Pile Cushions. Suitable cushioning material shall be used between the driving helmet and the top of the pile. This is especially critical for concrete piles. The Contractor should submit the type material, cross-sectional area, and total thickness of the pile cushion to the Engineer for approval on the completed *Pile Driving Equipment Data Form*. The pile cushion shall be approved with the pile driving system and is subject to satisfactory field performance.

803.03.1.7--Method of Installation and Driving System.

803.03.1.7.1--General. The pile driving system is defined as all equipment necessary to install the specified piles to the required minimum tip elevations specified in the plans. The pile driving system shall include the pile hammer, hammer leads, followers, water jets, drilling equipment for pre-formed pile holes, and templates, if necessary.

803.03.1.7.2--Submittal of Pile Driving System Data. The Contractor shall submit to the Engineer all technical specifications and operating instructions relating to the pile driving system that is to be used to drive the piling. The Contractor shall also submit a completed *Pile and Driving Equipment Data Form* to the Engineer at the pre-construction conference or no later than 14 days prior to the anticipated driving date. The Contractor will not be allowed to install any piling until the driving system has been approved in writing by the Engineer. The Department will use the submitted information to perform wave equation analysis and prepare a summary report of the wave equation results. The wave equation analysis and other data shall be used to assess the ability of the proposed systems to install the piles to the desired penetration depth within the AASHTO standards for driving stresses.

The Engineer will notify the Contractor of any additional information required and/or changes that may be necessary to meet the project requirements. Any parts of the driving system that are unacceptable will be rejected and the Contractor will submit changes. Review of these changes will be completed within seven (7) days and the Contractor notified of their acceptance or rejection. Approval of the proposed driving system by the Engineer for driving of test piles shall be based upon the wave equation analysis indicating that the proposed driving system is acceptable.

All production piles shall be driven with the hammer bearing the same Serial Number submitted on the *Pile and Driving Equipment Data Form* and used to drive the test piles. In the event multiple hammers of differing type are used on the same bridge, the Contractor shall submit to the Engineer for approval a completed *Pile and Driving Equipment Data Form* for each hammer and specify the bridge bents in which each hammer will be used. This will allow the Department the opportunity to develop appropriate driving and acceptance criteria specific to each hammer.

A different pile driving system, modifications to the existing system, or different pile installation procedures shall be proposed by the Contractor if the pile installation stresses predicted by the wave equation analysis or calculated by the Pile Driving Analyzer (PDA) are not within the AASHTO values. All approvals are conditional and subject to trial and satisfactory performance in the field. Unless otherwise permitted by the Bridge Engineer in writing, test piles and permanent piles shall be driven with the approved driving system.

803.03.1.7.3--Pile Hammers. Piles may be driven with an approved single-acting or double-acting pile hammer in combination with water jets or pre-formed pile holes. The pile driving system shall be constructed so as to afford freedom of movement of the pile hammer and to drive the piles to the required depth within the tolerances specified without undue injury to the piles.

The pile hammer shall be in good working condition and produce the energy required to install piles to the depth or penetration required in the plans. Single or double-acting Steam/Air, Diesel/Internal Combustion, or Hydraulic hammers may be submitted for review and approval.

In no case shall a gravity or drop hammer be used to drive concrete or steel piles supporting the permanent bridge structure. A drop hammer may be used to install timber or steel piles for temporary construction, but in no case shall a gravity or drop hammer be used to drive concrete piles.

803.03.1.7.3.1--Pipe Pile Hammers.

803.03.1.7.3.1.1--Impact Hammers. Piles may be driven with an approved single-acting or double-acting pile hammer, as recommended on the plans, in combination with water jets or pre-formed pile holes. The pile driving system shall be constructed so as to afford freedom of movement of the pile hammer and to drive the piles to the required depth within the tolerances specified without undue injury to the piles.

The pile hammer shall be in good working condition and produce the energy required to install piles to the depth or penetration required in the plans. Single or double-acting Steam/Air, Diesel/Internal Combustion, or Hydraulic hammers may be submitted for review and approval.

In no case shall a gravity or drop hammer be used to drive concrete or steel piles supporting the permanent bridge structure. A drop hammer may be used to install timber or steel piles for temporary construction, but in no case shall a gravity or drop hammer be used to drive concrete piles.

803.03.1.7.3.1.2--Vibratory Hammers. Vibratory hammers in good working condition may be used to advance steel pipe piles to within twenty feet (20') of minimum tip elevation of production pile for PDA Test Piles and five feet (5') of minimum pile tip elevation for permanent piles. Vibratory hammers shall be attached centrally to the pile head. Under no circumstances can vibratory hammers be used to advance steel pipe piles for the last five feet (5') of pile length. The Contractor may have the option to use a vibratory hammer to drive the steel pipe pile within five feet (5') of minimum pile tip elevation for permanent piles.

803.03.1.7.4--Driving Appurtenances.

803.03.1.7.4.1--Pile Hammer Leads. Either fixed leads or swinging leads may be used. Swinging leads shall be used in combination with rigid templates approved by the Engineer. Battered piles shall be driven in inclined leads or multiple rigid templates capable of holding the pile in the proper position during driving.

803.03.1.7.4.2--Pile Cushions. Suitable cushioning material shall be used between the driving cap and the top of the pile. The cushion material shall protect the pile top during driving and shall be constructed such that the hammer energy is uniformly distributed to the pile top. The pile cushion shall be changed prior to driving each pile. In addition, if the cushion material becomes highly compressed, or chars or burns during the driving operations or damage occurs at the pile top, it shall be replaced. The type of material and dimensions of the pile cushion shall be included in the appropriate place on the *Pile and Driving Equipment Data Form*.

803.03.1.7.4.3--Water Jets. Water jets may be used in conjunction with the pile hammer to install piles to the required depth or penetration called for in the plans. The use of water jets, where the stability of embankments or other improvements would be endangered, will not be permitted. When water jets are used, the number of jets and the volume and pressure of water shall be sufficient to adequately facilitate driving without undue damage to the pile or the soil adjacent to or below the pile. Unless otherwise specified, water jets shall not be used within five feet of the final tip elevation of the pile. In addition, it shall be the Contractor's responsibility to withdraw the water jets sufficiently above the five foot requirement to obtain the specified bearing at the required cut off elevation.

In the event a jetted pile fails to obtain the specified bearing at the required penetration and a determination is made by the Engineer that the Contractor has failed to properly control the jetting operation, the Contractor should submit detailed corrective measures for founding the pile to the Engineer for approval. Any required corrective measures to the pile due to the Contractor's operation shall be performed at no additional cost to the State.

803.03.1.7.4.4--Followers. Followers are considered to be part of the Driving System and should be included for approval with the *Pile and Driving Equipment Data Form*. Included with the submittal should be a dimensioned sketch of the follower. Also, the type(s) of materials that the follower is made of and the weight of the follower should be included as well as cushion information.

803.03.1.7.4.5--Pre-formed Pile Holes. The Bridge Engineer will make all determinations as to the necessity for pre-formed pile holes and the size and maximum depth of each hole required or permitted.

If it is determined from the Geotechnical Investigation or from the site survey that pre-formed pile holes are necessary, a pay item and estimated quantities will be included on the plans, and the Bridge Engineer will furnish the Contractor with an itemized list showing the location, size and bottom elevation of each hole.

If the plans do not specify pre-formed pile holes and the Bridge Engineer, with the concurrence of the Construction Engineer, determines during construction that subsurface conditions are encountered that necessitate pre-formed pile holes, at certain locations, an

adjustment in the contract unit price for furnishing and driving piling at these locations may be made under the provisions of Subsection 104.02.

If in the judgment of the Engineer pre-formed pile holes are not required and the Contractor desires to use them, the Contractor may be permitted to do so under conditions prescribed by the Bridge Engineer and at no additional cost to the State.

For pipe piling, the indicator pile and the first production steel pipe test pile shall be driven without a pre-formed hole. Based on the results, the Director of Structures, State Bridge Engineer, will make all determinations as to the necessity for pre-formed holes on all subsequent steel pipe test piles and steel pipe production piles. If it is determined that preformed holes are necessary, the Director of Structures, State Bridge Engineer, will furnish the Contractor with an itemized list showing the location, size, and bottom elevation of each hole.

If in the judgment of the Director of Structures, State Bridge Engineer, pre-formed holes for pipe piling are not required and the Contractor desires to use them, the Contractor may be permitted to do so under conditions prescribed by the Director of Structures, State Bridge Engineer, and at no additional cost to the State.

803.03.1.7.4.6--Additional Equipment. When a minimum penetration is indicated on the plans and is not obtained by the use of an approved hammer, the Contractor shall submit to the Engineer for approval a completed *Pile and Driving Equipment Data* Form for a heavier hammer or resort to jetting at no additional cost to the State.

803.03.1.8--Defective Piles. Prior to driving, piles shall not be subjected to handling that causes damage either through bending, crushing or spalling of concrete, or deformation of the steel. All piles damaged because of internal defects or by improper driving, driven out of the proper location or driven below the specified elevation shall be corrected at the Contractor's expense by one of the following methods approved by the Engineer for the pile in question:

- (a) The pile shall be withdrawn and replaced by a new and, if necessary, a longer pile.
- (b) A second pile shall be driven adjacent to the defective or low pile.
- (c) The pile shall be spliced or built up or a sufficient portion of the footing shall be extended to properly embed the pile. All piles pushed up by the driving of adjacent piles or by any other cause shall be driven down to grade.

803.03.1.9--Determination of Bearing Value of Piling.

803.03.1.9.1--General. The ability of the pile to transfer load to the ground will be determined to the satisfaction of the Bridge Engineer. Such determination will be made by the Department's Geotechnical Engineer and Foundation Engineer from a subsurface investigation conducted by the Department's Geotechnical Branch of Materials Division and test piles that are driven out-of-position or driven to be incorporated in the structure as permanent piles.

803.03.1.9.2--Determination of Bearing Value by Pile Hammer Formulas. When load testing, either static or dynamic, is not called for in the plans, the safe bearing values will be determined by the following formulas or as directed by the Engineer.

$$P = \frac{2WH}{S + 0.2} \quad \text{for single-acting steam/air hammers and open cylinder diesel hammers}$$

$$P = \frac{2H(W+Ap)}{S+0.1} \quad \text{for double-acting steam hammers}$$

Where

- P = safe bearing value in pounds
- W = weight, in pounds, of striking parts of hammer
- H = height of fall in feet
- A = area of piston in square inches
- p = steam/air pressure in pounds per square inch at the hammer
- S = the average penetration in 10 blows for gravity hammers and the last 10 to 20 blows for steam/air hammers.

These formulas are applicable for the following conditions only:

- (a) The hammer has a free fall.
- (b) The pile head is not crushed.
- (c) The penetration is reasonably quick and uniform.
- (d) There is no appreciable bounce after the blow.
- (e) A follower is not used.

Where there is appreciable bounce of the hammer, twice the height of the bounce shall be deducted from "H" to determine its value in the formula.

When water jets are used, the bearing value shall be determined by the above formulas from the results of driving after the jets have been withdrawn, or a static or dynamic load test has been conducted.

Formulas for pile hammers not covered herein must be approved by the Bridge Engineer.

803.03.1.9.3--Determination of Bearing Value by PDA Monitoring (Dynamic Load Testing).

803.03.1.9.3.1--Description. This work consists of furnishing all labor, materials, equipment and services necessary to perform all operations to complete the determination of bearing value of piling by Department forces using a PDA and associated equipment. The dynamic load testing measurements will be performed in accordance with the plans and the guidelines given herein.

803.03.1.9.3.2--Scope and Sequence of Construction. The dynamic measurements will be performed on the piles as detailed below for the purpose of obtaining ultimate pile bearing capacity, pile driving stresses, pile integrity, and the pile driving system efficiency. Unless otherwise directed in the plans, the sequence of construction outlined below shall

not be deviated from unless an alternate sequence of construction is approved in writing by the Engineer.

- (a) When called for in the plans, Load Testing With Special Instrumentation and/or Conventional Static Load Testing will be performed on piles as detailed. Piles to be load tested shall be driven in the location shown in the plans with PDA monitoring under initial drive and have restrikes performed.
- (b) When called for in the plans, PDA Test Piles will be driven with PDA monitoring under initial drive and have restrikes performed as detailed below. The test piles will be used as production piles and be incorporated into the bridge structure.
- (c) The Engineer may require PDA monitoring to be performed on any production piles during initial drive or require PDA restrikes.

803.03.1.9.3.3--PDA Monitored Driving and/or Restrike of Piling.

803.03.1.9.3.3.1--General. When called for in the plans or the Engineer, a PDA and instrumentation will be used to obtain dynamic measurements during pile driving and pile restrikes. The analysis of the monitoring will be the responsibility of the Department. The Contractor shall give notice to the State Geotechnical Engineer at least 14 calendar days before the scheduled date of driving piles to be monitored. The Contractor shall confirm the driving date three (3) calendar days prior to the scheduled driving date.

803.03.1.9.3.3.2--Contractor Requirements. The Contractor shall be responsible for furnishing the following:

- (a) A power supply providing at least 1800 watts of 115-volt AC power with a frequency of 60 Hz at the driving site.
- (b) Prepare the driving site.
- (c) Supply the labor necessary for attaching the dynamic monitoring instrumentation to the piles. The Contractor shall make one of their personnel available to place the transducers on the piles after the piles have been placed in the leads.
- (d) Drive the piles as directed by the Engineer.

The Contractor shall make the piles available prior to driving for drilling and tapping of holes that are necessary for attachment of instrumentation. The expected delay for attaching the instruments to the pile will be approximately one (1) hour. The Contractor shall use reasonable care when working with piles when instruments are installed and shall replace any damaged equipment caused by Contractor error at no additional cost to the State.

803.03.1.9.3.3.3--Driving Requirements. Piles to be used in the determination of pile bearing by PDA monitoring shall be driven with PDA instrumentation attached to the pile and shall have a PDA monitored 1-day and 7-day restrike performed after the initial pile driving. The Engineer may modify the waiting periods that are required before the restrikes are performed. When a static load test is to be performed, the 7-day restrike should be eliminated and a PDA monitored restrike done within 24 hours of completion of the static load test. When deemed necessary by the Engineer, permanent piles may have PDA monitored restrikes performed to confirm or supplement design requirements.

Restrikes shall be performed with a warm hammer operating at normal efficiency. A warm hammer is defined as a hammer that has applied a minimum of 20 blows to another pile or a dummy block immediately before being used in a restrike. The restrike shall consist of striking the pile for 50 blows or until the pile penetrates an additional three inches, whichever occurs first. In the event the pile movement is less than one inch after 15 blows during the restrike, the restrike may be terminated.

803.03.1.9.4--Determination of Bearing Value by Static Load Testing. When called for in the plans or directed by the Engineer, static load testing will be conducted to determine the ultimate bearing capacity of piles. Depending upon the conditions encountered in the field, the Bridge Engineer may increase or decrease the number of static load tests required.

803.03.1.9.4.1--Load Testing of Piling With Special Instrumentation.

803.03.1.9.4.1.1--General. When called for in the plans, out-of-position test piles shall be driven with special instrumentation attached for the purpose of conducting a load test as directed by the plans. A waiting period of seven (7) calendar days shall be observed beginning after the out-of-position test pile is driven. After the waiting period, the pile shall be load tested to failure as directed by the plans. The Contractor will be responsible for furnishing all materials, equipment, labor, and incidentals necessary for conducting the load test. The Contractor shall subcontract and supply all instrumentation, conducting, and reporting of the load test to the company supplying the instrumentation, with the cost included in the contract unit price. Reaction systems and extra pile installations as required in the plans shall be absorbed in the cost for the load test on the pile.

803.03.1.9.4.1.2--Materials. When called for in the plans, instrumentation shall be supplied to meet the requirements set forth in the plans. Instrumentation required in the plans is subject to prior approval by the State Geotechnical Engineer. Additional equipment that may be required are as follows.

- (a) Materials sufficient to construct a stable reference beam system for monitoring deflection of the pile during testing, supported at a minimum distance of three (3) diameters from the center of the pile to prevent disturbance of the reference system.
- (b) Materials sufficient to construct a protected work area including provisions such as a tent or shed for protection from inclement weather for the load test equipment. The work area shall be of size and type required by the Engineer.
- (c) In the case of an out-of-position pile, the pile shall be removed or broken-off such that the remaining pile is at least two (2) feet below the ground or mud line.

Materials supplied, that do not become a part of the finished structure, shall be removed from the job site.

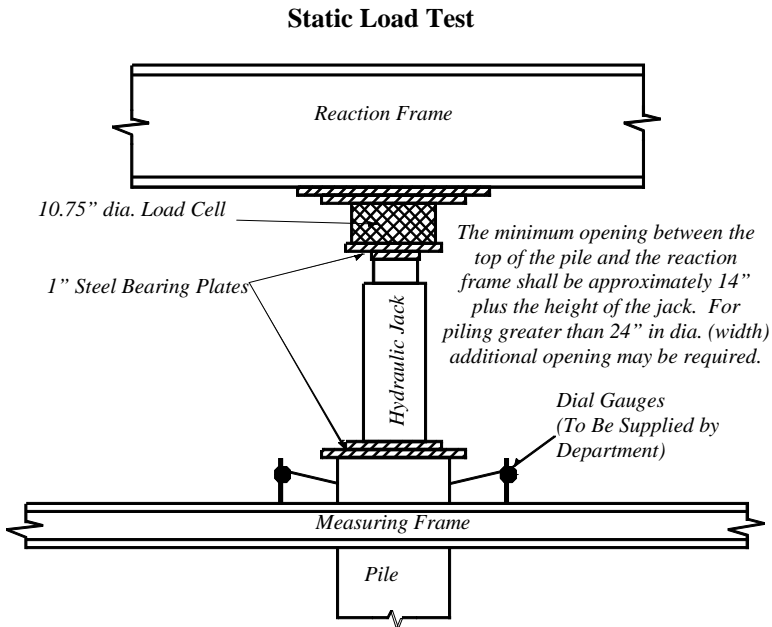
803.03.1.9.4.2--Conventional Static Load Testing of Piling.

803.03.1.9.4.2.1--General. When called for in the plans or directed by the Engineer, the pile to be load tested shall be installed as indicated in the plans to the specified tip elevation or as directed by the Engineer. Once the pile is in place, a static load test will be conducted to determine the ultimate bearing capacity of the pile. A waiting period of seven (7) calendar days shall be observed beginning after all the reaction piles have been driven but prior to static load testing.

803.03.1.9.4.2.2--Contractor Requirements. The Contractor shall be responsible for furnishing the following:

- (a) A reaction load frame capable of resisting a total load of at least five (5) times the design load called for in the plans. The frame shall consist of a beam or girder that will carry the above load while sustaining only minor deflections in the reaction system. The beam or girder shall be attached to a system of anchor piles. The anchor piles shall not be closer to the test pile than five times the diameter (width) of the pile to be tested. See Figure 1 for additional reaction load frame requirements.
- (b) A hydraulic jack that has been calibrated for the full range of anticipated loads in accordance with AASHTO T 67 (ASTM E 4) at least once. The maximum anticipated load shall be assumed to be five (5) times the design load called for in the plans. The pressure gauge shall be calibrated within one year preceding the time of use and whenever there is a reason to doubt the accuracy of the results. The Contractor shall furnish a certificate of calibration for the hydraulic jack at the time of static load testing.
- (c) A measuring frame or reference beam for measuring the movement of the pile during testing. Two dial gauges, supplied by the Department, will be attached to the pile as indicated on Figure 1. Each dial gauge shall be actuated by its stem or by a stem attachment resting on the measuring frame. The supports for the measuring frame shall be placed the maximum practical distance from the test pile and the anchor piles for the reaction load frame. In no case should the measuring frame be affected by movement of the test pile or the anchor piles.
- (d) In the case of an out-of-position pile, the pile shall be removed or broken-off such that the remaining pile is at least two (2) feet below the ground or mud line.

803.03.1.9.4.2.3--Methods and Equipment. Personnel from the Department's Geotechnical Branch will assist in the setup and will be responsible for the running of the test. The Department will be responsible for providing the load cell, dial gauges and associated equipment. The static load test will be performed using ASTM D 1143, quick test methods. A waiting period of seven (7) calendar days shall be observed beginning after all the reaction piles have been driven but prior to static load testing.

**Figure 1**

803.03.1.10--Pile Acceptance. The safe allowable load for each type, size, and length of pile will be determined by the Bridge Engineer. Acceptance criteria for permanent production piles will be supplied by the Bridge Engineer with the final order list.

803.03.1.11--Test Piles. When required in the plans, the Contractor shall furnish and install test piles of the sizes, types, and lengths at the locations shown on the plans. The number of test piles may be increased or decreased by the Bridge Engineer as field conditions warrant. If determined by the Engineer to be necessary, test piles shall be extended, built-up, or spliced and in the case of steel piles driven further if deemed necessary, to the depths established by the Bridge Engineer. Similarly, the Contractor may be required to drive test piles below cut-off and extended as necessary.

803.03.1.12--Protection of Existing Structures. When the plans require piling to be driven within close proximity to existing structures, utilities, or recently placed concrete, the Contractor shall take all reasonable precautions to prevent damage to such structures. This shall include newly constructed bridge components. If not otherwise provided for in the plans, the Contractor shall be solely responsible for taking measures to prevent damage to existing structures resulting from pile driving operations. These measures shall include, but are not limited to, monitoring and controlling the vibrations resulting from pile driving activities. Driving of piling within 30 feet of recently placed concrete will not be permitted unless the concrete in that structure has attained a compressive strength of 2500 psi, as determined by cylinder tests, or maturity meter probe when maturity meter readings indicate that the required concrete strength is achieved. Test samples shall be prepared and tested by the Department from material representative of the recently constructed structure

and cured in conditions similar to the structure. Based upon observations, the Engineer may adjust this distance accordingly.

803.03.2--Drilled Shafts.

803.03.2.1--Submittals.

803.03.2.1.1--Qualification of Contractor. The person(s) or firm directing the work described in this specification shall be knowledgeable of drilled shaft installation procedures and shall have installed drilled shafts of both diameter and length similar to those shown in the plans in accordance with the following minimum experience requirements:

- (a) A drilled shaft Contractor shall have a minimum of three (3) years of drilled shaft installation experience prior to the bid date for this project; or
- (b) A Contractor without prior drilled shaft experience shall employ a superintendent with a minimum of fifteen years of drilled shaft experience prior to the bid date of this project.

A Contractor with limited drilled shaft installation experience may use a combination of their experience and the superintendent's experience, with each five years of experience of the superintendent counting as equivalent to one year's experience of the Contractor. A signed statement listing the applicable work experience of the drilled shaft Contractor shall be submitted to the Engineer at the Preconstruction Conference, or no later than 45 calendar days prior to drilled shaft construction.

At the Preconstruction Conference, or no later than 45 calendar days prior to beginning drilled shaft construction, the Contractor shall furnish the Engineer evidence of the following:

- (a) A signed statement from the drilled shaft superintendent responsible for the drilled shaft installation that the project site has been visited, and that all the subsurface information has been inspected. This information includes the soil profiles and/or boring logs furnished in the plans, soil samples and rock cores, and the Geotechnical Investigation. All the above information may be obtained from the Geotechnical Branch of Materials Division.
- (b) A signed statement from the drilled shaft Contractor detailing their ability to complete a project of this type. This shall be supported by a list containing a detailed description of at least three (3) projects completed in the last three (3) years on which the drilled shaft Contractor and/or superintendent has installed or supervised installation of drilled shafts similar in size to those shown in the plans, and utilized excavation methods similar to those anticipated for this project. This list of projects shall contain names and phone numbers of the project owner's representatives who can verify the drilled shaft Contractor's participation on the project, and the names of the superintendents who were in charge of the drilled shaft operations.
- (c) Name and experience records of the drilled shaft superintendent and driller who will perform the required work.

The Engineer will evaluate the evidence of qualifications submitted for conformance with these specifications. Should the information submitted be incomplete or not conform to

the project specifications, the information will be rejected and the Contractor shall submit changes for reevaluation.

If the Contractor wishes to replace the drilled shaft superintendent or the driller during the life of the project, the name and experience record of the replacement superintendent or driller shall be submitted to the Engineer for approval.

803.03.2.1.2--Drilled Shaft Installation Plan. At the Preconstruction Conference, or no later than 45 calendar days before drilled shaft construction begins, the Contractor shall submit to the Engineer an installation plan for review. This plan shall provide information on the following:

- (a) A copy of the proposed drilled shaft concrete mix design as submitted with the Contractor's Concrete Quality Control Plan. Construction of the trial shaft(s) will not commence until the drilled shaft concrete mix design has been approved in accordance with Section 804, Concrete for Bridges and Structures.
- (b) List and size of proposed equipment including cranes, drill rigs, augers, bits, bailing buckets, digging buckets, final cleaning equipment, slurry tanks, desanding equipment, slurry pumps, tremies, pump lines, concrete pumps, casings, etc.
- (c) Details of the method of exploration including the equipment, if required.
- (d) Details of the sequence of construction operations and sequence of shaft construction within bents or shaft groups.
- (e) Details of shaft excavation method(s).
- (f) Details of slurry type and usage, including proposed methods to mix, circulate and desand slurry when slurry is required.
- (g) Details of proposed methods to clean the drilled shaft excavation upon reaching the minimum required tip elevation.
- (h) Details of reinforcement placement including the method of support while aligning the cage for placement into the drilled shaft excavation and the centering devices to be used to center the cage and assure minimum outside clear space shown in the plans.
- (i) Details of concrete placement including proposed operational procedures for concrete tremie or pump, including initial placement, raising during placement, and overfilling of the shaft concrete, and the ability of the concrete supplier to provide a continuous pour for the anticipated volumes.
- (j) Details of casing installation and removal, when required.
- (k) Details of any required load tests including equipment and recent calibrations for any jacks supplied by the Contractor.

The Engineer will evaluate the Contractor's *Drilled Shaft Installation Plan* for conformance with the plans and specifications, after which the Engineer will notify the Contractor within 14 calendar days of any additional information and/or changes that may be required. Any part of the plan that is unacceptable will be rejected and the Contractor shall submit changes for reevaluation.

All approvals given by the Engineer shall be subject to trial and satisfactory field performance, and shall not relieve the Contractor of the responsibility to satisfactorily complete the work as detailed on the plans and in the specifications.

803.03.2.2--Trial Shaft Construction. The Contractor shall demonstrate the adequacy of the methods and equipment during construction of an out of position trial shaft. This trial shaft shall be positioned as far as practical from the production shafts, in the position shown on the plans or as directed by the Engineer, and shall be drilled to the minimum tip elevation as required on the plans. When shown on the plans, the reaming of bells at specified trial shafts will be required to establish the feasibility of bellings in a specific soil strata. Failure to demonstrate the adequacy of the Contractor's methods and equipment to construct the trial shaft shall be cause for the Engineer to require alterations in equipment and/or method by the Contractor, to eliminate unsatisfactory results. Backfilling of unsuccessful excavations and any additional trial shafts required to demonstrate the adequacy of altered methods of construction or equipment shall be performed by the Contractor at no additional cost to the State. Once the Contractor has completed the excavation for the trial shaft to the satisfaction of the Engineer, the Contractor shall set the reinforcement and pour the concrete to finish construction of the trial shaft. This shall be demonstration that the entire plan for drilled shaft construction is satisfactory. Failure to successfully construct the trial shaft shall be cause for rejection of the trial shaft, and shall be reason for the Engineer to require alterations necessary to eliminate unsatisfactory results. Additional trial shafts necessary to demonstrate correction of deficiencies shall be at the Contractor's expense.

If differing soil conditions require two (2) or more methods for construction of production shafts, said methods shall be demonstrated by trial shaft prior to construction of any production shaft.

After the successful trial shaft has been completed, the Contractor shall submit in writing for review the successful methods and equipment used. This submittal, once reviewed, will serve as the approved method of construction for all the production shafts covered by that successful trial shaft. Once approval has been given to construct production shafts, no changes will be permitted in the methods, equipment, drilled shaft superintendent, or driller from those used during the construction of the trial shaft without written approval of the Engineer.

Trial shafts shall be cut off two (2) feet below finish grade or two (2) feet below the mud line and left in place. The portions of the shafts cut off and removed shall remain the property of the Contractor. The disturbed areas in the vicinity of the trial shaft shall be restored as nearly as practical to their original condition.

803.03.2.3--Construction Methods and Equipment.

803.03.2.3.1--General.

803.03.2.3.1.1--Protection of Existing Structures. When the plans require drilled shaft excavations within close proximity to existing structures or utilities, the Contractor shall take all reasonable precautions to prevent damage to such structures. This shall include newly constructed shafts. If not otherwise provided for in the plans, the Contractor shall be solely responsible for evaluating the need for, design of, and providing all reasonable precautionary features to prevent damage. These measures shall include, but are not limited to, selecting construction methods and procedures that will prevent caving of the shaft excavation, and monitoring and controlling the vibrations from construction activities, including the driving of casings, driving of sheeting, or from blasting, when permitted. Advancing an uncased drilled shaft excavation or the use of a vibratory hammer

to install casings within three times the diameter of a newly constructed shaft will not be permitted unless the concrete in that shaft has attained a compressive strength of 2500 psi, as determined by cylinder tests, or maturity meter probe when maturity meter readings indicate that the required concrete strength is achieved. Test samples shall be prepared and tested by the Department from material representative of the upper mass of the newly constructed shaft and cured in conditions similar to the drilled shaft. Based upon observations, the Engineer may adjust this distance accordingly. During shaft construction, the Contractor shall take into account and make provisions for vibrations caused by activities other than the Contractor's, such as adjacent traffic.

If a maturity meter probe is used, it shall be located in the upper portion of the drilled shaft concrete. Procedures for using the maturity meter and developing the strength/maturity relationship shall follow the requirements of AASHTO T 325 and ASTM C 1074 specifications. Technicians using the maturity meter or calculating strength/maturity graphs shall be required to have at least two hours of training prior to using the maturity equipment. The training shall be approved by the Department.

Such structures shall be monitored for settlement in an approved manner, recording elevations to 0.01 foot. The number and location of monitoring points shall be as approved by the Engineer. Elevations shall be taken before construction begins, during the driving of any required casings, and during excavation as directed by the Engineer.

When shown on the plans, or as directed by the Engineer, the Contractor shall monitor and record vibration levels during the driving of casings, sheeting, or during blasting operations. Vibration monitoring equipment shall be capable of detecting particle velocities of 0.1 inch/second or less.

At any time the Contractor detects settlement of 0.03 foot, vibration levels reaching 1.5 inches per second, or damage to the structure, the Contractor shall immediately stop the source of vibrations, backfill the excavation, and contact the Engineer for instructions.

803.03.2.3.1.2--Construction Sequence for Site Preparation. Excavation to the plan footing elevation, if required, shall be completed before shaft construction begins. Any disturbance to the footing area caused by shaft installation shall be repaired by the Contractor prior to the footing pour.

When drilled shafts are to be installed in conjunction with embankment placement, the Contractor shall construct the drilled shafts after placement of the embankment material.

803.03.2.3.1.3--General Methods and Equipment. The Contractor shall perform the excavations required for the shafts and bell footings, through whatever materials encountered to the dimensions and elevations shown on the plans, or otherwise required by the specifications, at no additional cost to the State. The Contractor's methods and equipment shall be suited for the intended purpose and the materials encountered.

Drilled shafts shall be constructed by the dry method, wet method, casing method, or permanent casing method, as necessary to produce a sound, durable, concrete foundation free of defects. The permanent casing method shall be used only when required by the plans or authorized by the Engineer. When the plans describe a particular method of construction, this method shall be used unless otherwise permitted by the Engineer. The Engineer may permit an alternate method than designated on the plans, only after

successful construction of an out of position trial shaft. When the plans do not describe a particular method, the Contractor shall utilize a method on the basis of its suitability to the site conditions. Blasting shall only be permitted if specifically stated on the plans or approved by the Engineer.

Once approval is given to construct production shafts, no changes will be permitted in the methods or equipment from those used in constructing the accepted trial shaft without written approval of the Engineer.

803.03.2.3.2--Dry Construction Method. The dry construction method shall be used only at sites where the groundwater level and soil conditions are suitable to permit construction of the shaft in a relatively dry excavation, and where the sides and bottom of the shaft may be visually inspected by the Engineer prior to placing the concrete. The dry method consists of drilling the shaft excavation, placing the reinforcing cage, and concreting the shaft in a relatively dry excavation.

The dry construction method shall be used only when the trial shaft excavation demonstrates that: concrete can be placed with less than three (3) inches of accumulated water in the bottom of the shaft; the sides and bottom of the hole remain stable without caving, sloughing, or swelling over a two-hour period immediately following completion of the excavation; and any loose material and excess water can be satisfactorily removed prior to inspection and prior to concrete placement.

803.03.2.3.3--Wet Construction Method. The wet construction method shall be used at all sites where it is impractical to provide a dry excavation for placement of the shaft concrete.

The wet construction method consists of drilling the shaft excavation below the water table, keeping the shaft filled with water or mineral slurry, desanding or cleaning the slurry, final cleaning of the excavation by means of a bailing bucket, air lift, submersible pump or other approved devices, and placing the rebar cage and the shaft concrete, with a tremie or concrete pump beginning at the shaft bottom, which displaces the water or slurry as the shaft is concreted. Temporary surface casings shall be provided to aid shaft alignment and position and to prevent sloughing of the top of the shaft, except when the Contractor demonstrates to the satisfaction of the Engineer that the surface casing is not required.

Where drilled shafts are located in open water areas, the shafts shall be constructed by the wet method using casings extending from above the water elevation into the ground to protect the shaft concrete from water action during placement and curing of the concrete. The casing shall be installed in a manner that will produce a positive seal at the bottom of the casing so that there is no intrusion or extrusion of water or other materials into or from the shaft excavation. Casings for this application may include multiple casings, temporary casings, and/or designed permanent casings.

The wet construction method may be used in combination with the dry method and temporary or permanent casing methods.

803.03.2.3.4--Casing Construction Method. The casing construction method may be used at sites when the dry or wet construction methods are inadequate to prevent hole caving or excessive deformation of the hole. In this method, the casing may be either

placed in a predrilled hole if no caving, swelling, or yielding occurs, or advanced through the ground by twisting, driving, or vibration before being cleaned out.

When a formation is reached that is nearly impervious, a casing shall be placed in the hole and seated in the nearly impervious formation. Drilling may proceed as with the dry method to the projected depth. If seepage occurs at this point, temporary casing may be advanced further to create the dry condition. In the event seepage conditions prevent use of the dry method, excavation shall be completed using wet methods. The placement of the concrete shall proceed as with the wet or dry method, except that the casing shall be withdrawn after the concrete is placed.

When caving soils occur near the ground surface and/or if the top of the concrete for the drilled shaft is below the ground surface, the Contractor shall set a suitable temporary removable surface casing. The minimum surface casing length shall be the length required to prevent caving of the surface soils and to aid in maintaining shaft position and alignment. Predrilling with slurry and/or overreaming to the outside diameter of the casing may be acceptable if required to install the surface casing at some sites.

Where drilling is through materials having a tendency to cave, the drilling shall be advanced by drilling in a mineral slurry. In the event that a caving layer or layers are encountered that cannot be controlled by slurry, the Contractor shall install temporary removable casing through such caving layer or layers. Overreaming to the outside diameter of the casing may be required. However, the final dimensions of the drilled shaft shall not be altered to accommodate these construction practices unless approved by the Engineer. The Contractor shall take whatever steps that are required to prevent caving during shaft excavation including installation of deeper casings. If the Contractor elects to remove a casing and replace it with a longer casing through caving soils, the Contractor shall adequately stabilize the excavation with slurry or backfill the excavation. Other approved methods that will control the size of the excavation and protect the integrity of the foundation soils may be used to excavate through caving layers.

803.03.2.3.5--Permanent Casing Method. The permanent casing method shall be used when required by the plans. In this method, a casing is driven to the prescribed depth before excavation begins. If full penetration cannot be attained, the Contractor may excavate material from inside the casing and the casing may be driven again until reaching the desired penetration. In some cases overreaming to the outside diameter of the casing may be required before driving the casing.

The casing shall be cut off at the prescribed elevation upon reaching the proper construction sequence, and the remainder of the casing is left in place.

803.03.2.3.6--Excavation and Drilling Equipment. The excavation and drilling equipment shall have adequate capacity including power, torque, and down thrust to excavate a hole of both the maximum diameter and to a depth 20 percent greater than the longest shaft shown on the plans.

The excavation and overreaming tools shall be of adequate design, size, and strength to perform the work shown on the plans or described herein. When the material encountered cannot be drilled using conventional earth augers with soil or rock teeth, drill buckets, and/or underreaming tools, the Contractor shall provide special drilling equipment including but not limited to: rock core barrels, rock tools, air tools, blasting materials, and

other equipment as necessary to construct the shaft excavation to size and the depth required. Approval of the Engineer is required before excavation by blasting is permitted.

Sidewall overreaming shall be required when the sidewall of the hole is determined by the Engineer to have either softened due to excavation methods or delays in excavation completion, swelled due to delays in concreting, or degraded because of slurry cake build-up. Overreaming thickness shall be a minimum of one-half inch (1/2") and a maximum of three inches (3") beyond the shaft radius. Overreaming may be accomplished with a grooving tool, overreaming bucket, or other approved equipment. The thickness and elevation of sidewall overreaming shall be as directed by the Engineer. The Contractor shall bear all costs associated with both sidewall overreaming and additional shaft concrete placement.

803.03.2.3.7--Excavations.

803.03.2.3.7.1--General. Shaft excavations shall be made at locations and to the top of shaft elevations, estimated bottom of shaft elevations, shaft geometry and dimensions shown in the plans. The Contractor shall extend drilled shaft tip elevations when the Geotechnical Engineer determines that the material encountered during excavation is unsuitable and/or differs from that anticipated in the design of the drilled shaft.

The Contractor shall maintain a drilling log during shaft excavation. The log shall contain information such as: the description and approximate top and bottom elevation of each soil or rock strata, seepage or groundwater, and remarks. Three (3) copies of the final Contractor's log shall be furnished to the Engineer with a copy to the Geotechnical Engineer at the time the drilled shaft is completed and accepted.

When shown on the plans, bells shall be excavated to form the height and bearing area of the size and shape shown. The bell shall be excavated by mechanical methods. Any drilled shaft concrete over the theoretical amount required to fill any excavations for the bells and shafts dimensioned on the plans shall be furnished at no additional cost to the State.

The Contractor shall not permit workmen to enter a shaft excavation for any reason unless (a) both a suitable size casing has been installed and the water level has been lowered and stabilized below the level to be occupied, and (b) adequate safety equipment and procedures have been provided to workmen entering the excavation. The Contractor is responsible for complying with all State and Federal safety regulations.

803.03.2.3.7.2--Obstructions. Surface and subsurface obstructions at drilled shaft locations shall be removed by the Contractor. Such obstructions may include man-made materials such as old concrete foundations and natural materials such as boulders. Special procedures and/or tools shall be employed by the Contractor after the hole cannot be advanced using conventional augers fitted with soil or rock teeth, drilling buckets and/or underreaming tools. Such special procedures/tools may include, but are not limited to, chisels, boulder breakers, core barrels, air tools, hand excavation, temporary casing, and increasing the diameter of the hole. Blasting shall not be permitted unless specifically approved in writing by the Engineer.

Drilling tools that are lost in the excavation shall be promptly removed by the Contractor at no cost to the State. All costs due to lost tool removal shall be borne by the Contractor

including, but not limited to, costs associated with hole degradation due to removal operations or the time the hole remains open.

803.03.2.3.7.3--Exploration. When directed by the Engineer, the Contractor shall take soil samples or rock cores to determine the character of the material directly below the completed shaft excavation. The soil samples shall be extracted with a standard penetration test split spoon sampler or undisturbed sample (Shelby) tube. Rock cores, if required, shall be cut with an approved double or triple tube core barrel to a minimum of five (5) feet below the bottom of the drilled shaft excavation at the time the shaft excavation is approximately complete. Rock core, undisturbed tube, and/or standard penetration test samples shall be measured, visually identified, and described on the Contractor's log. The samples shall be placed in suitable containers, identified by shaft location, elevation, and project number, and delivered with the Contractor's field log to the Engineer within 24 hours after the exploration is completed. The Engineer will inspect the samples or cores and determine the final depth of required excavation based on the evaluation of the material.

803.03.2.3.7.4--Excavation Completion. Concrete placement must begin within two (2) hours of completion of shaft excavation. If the drilled shafts are five (5) feet in diameter or larger and in excess of sixty (60) feet in length, the elapsed time from completion of the drilled shaft excavation until beginning of concrete placement may extend past two hours provided the excavation remains stable and the extended time is demonstrated on the trial shaft. Completion of shaft excavation is defined as the time at which the specified tip elevation is initially achieved. Before concrete placement begins, bottom cleaning operations, any necessary slurry desanding, and placement of the reinforcing steel must be completed. These operations are included in the two hour time limit.

If it becomes apparent, as the excavation of the shaft is nearing completion, that it will not be feasible or possible to place concrete within the specified limit, the Contractor shall halt excavation operations a minimum of five (5) feet above the specified tip elevation. In the event that the wet construction method is being used, the slurry should be desanded at this point so that the remaining excavation will not cause the slurry to be too heavily contaminated and delay concrete placement due to final desanding operations.

In no case shall any excavation within the bearing zone(s) be allowed to remain open and idle for more than 24 hours. The bearing zone(s) are those soil strata located below the scour line, in the case of hydraulic structures, or five feet (5') below the ground line, whichever is greatest in depth. In no instance shall any uncased excavation, except for trial shafts, be allowed to remain open and idle for more than 24 hours. For partially completed excavations that stand idle for more than six (6) hours but less than 24 hours, sidewall overreaming may still be required by the Engineer.

If completion of shaft excavation has been achieved and concrete placement has not begun within the specified limit, the Contractor shall backfill and/or stabilize the excavation. The Engineer shall then direct the Contractor as to the additional shaft excavation that will be required to produce a sound drilled shaft due to shaft wall and bottom degradation. The cost of the additional excavation, concrete, reinforcing steel, and other incidentals will be borne by the Contractor at no additional cost to the State.

803.03.2.3.7.5--Casings.

803.03.2.3.7.5.1--General. Casings shall be steel, smooth, clean, watertight, and of ample strength to withstand both handling and driving stresses and the pressure of both concrete and the surrounding earth materials. The outside diameter of casing shall not be less than the specified size of the shaft. No extra compensation will be allowed for concrete required to fill an oversized casing or oversized excavations. All casings, except permanent casing, shall be removed from the shaft excavation. Any length of permanent casing installed below the shaft cutoff elevations shall remain in place.

When the shaft is to extend above the ground or through a body of water, the portion exposed above the ground or through a body of water may be formed with removable casing, except when permanent casing is specified. Removable casing shall be stripped from the shaft in a manner that will not damage the concrete. Casings can be removed when (a) the concrete is cured for a full 72 hours; (b) the shaft concrete is not exposed to salt water or moving water for seven (7) days; and (c) the concrete reaches a compressive strength of at least 2500 psi as determined from concrete cylinder tests prepared and tested by the Department. The concrete cylinders will be prepared from material representative of the upper 10% mass of the newly constructed shaft and cured in conditions similar to the drilled shaft.

803.03.2.3.7.5.2--Temporary Casing. All subsurface casing shall be considered temporary unless specifically shown as permanent in the contract documents. All temporary casing shall be removed. Telescoping, predrilling with slurry, and/or overreaming to beyond the outside diameter of the casing may be required to install the casing. When temporary casing larger than called for on the plans is used for telescoping or overreaming, no additional compensation will be made.

If the Contractor elects to remove a casing and substitute a longer or larger diameter casing through caving soils, the excavation shall be either stabilized with slurry or backfilled before the new casing is installed, as directed in Subsection 803.03.2.3.4. Other methods, as approved by the Engineer, may be used to control the stability of the excavation and protect the integrity of the foundation soils.

When temporary casings that are to be removed become fouled or bound in the shaft excavation and cannot be practically removed, and concreting has not yet begun, the Engineer may direct that the shaft excavation be drilled deeper to compensate for the loss of capacity due to the presence of the casing. No additional compensation will be paid for the casing left in the excavation. No additional length of shaft will be paid for beyond the current depth of excavation or the plan tip elevation of the production shaft, whichever is lower.

Temporary casings that become bound or fouled during concreting of the shaft and that cannot be practically removed before the concrete begins to set up, shall constitute a defect in the drilled shaft. When the Engineer, in writing, notifies the Contractor of a defective shaft, the Contractor shall be responsible for improving such defective shafts to the satisfaction of the Engineer. Improvements may consist of, but are not limited to, removing the shaft concrete and extending the shaft deeper to compensate for loss of frictional capacity in the cased zone, providing straddle shafts to compensate for capacity loss, proof load testing or providing replacement shafts. All corrective measures, including redesign of footings or drilled shaft caps, shall be performed to the satisfaction of the Engineer by the Contractor without either additional compensation or extension of Contract Time. No

compensation will be paid for casing remaining in place. Any redesigns submitted must be approved in writing by the Bridge Engineer.

Temporary casing extraction shall be slow and uniform, pulling along the axis of the shaft. The elevation of the concrete in the casing shall be maintained high enough to displace the drilling slurry between the outside of the casing and the edge of the hole as the casing is removed. Temporary casings shall be removed while the concrete remains workable. No temporary casings will be removed if the concrete slump is less than four (4) inches. Should this condition occur, the shaft will be considered defective, and corrections to the situation shall be as described above.

Special casing systems may be used in open water areas, when approved and must be designed to permit removal after the concrete has hardened. Special casings shall be designed so that no damage occurs to the drilled shaft concrete during their removal. Any defects either cosmetic or structural that are apparent after removal of the casing or are due to the removal of the casing shall be repaired to the satisfaction of the Engineer at no additional cost to the State.

In the event that permanent casing is not specified in the plans, and the Contractor elects to use a temporary casing and leave it in place, it shall be cut off at a maximum of 12 inches above the low water elevation as shown on the plans, or painted. Written approval from the Engineer is required in this event, and payment for the temporary casing left in place will be at the contract bid price for temporary casing.

803.03.2.3.7.5.3--Permanent Casings. Permanent casing shall be used when shown on the plans. The casing shall be continuous between top and bottom elevations prescribed on the plans or as directed by the Engineer. Exterior surfaces of permanent casing shall be painted in accordance with the plans unless otherwise noted. After installation is complete, the permanent casing shall be cut off at the prescribed elevation and the shaft completed.

In general, permanent casing shall not be placed in an overreamed shaft hole.

803.03.2.3.8--Slurry. Mineral slurries shall be employed when slurry is used in the drilling process, unless other drilling fluids are approved in writing by the Engineer. The slurry shall have both a mineral grain size that will remain in suspension and sufficient viscosity and gel characteristics to transport excavated material to a suitable screening system. The percentage and specific gravity of the material used to make the suspension shall be sufficient to maintain the stability of the excavation and to allow proper concrete placement. During construction, the level of the slurry shall be maintained at a height sufficient to prevent caving of the hole. In the event there is a sudden, significant loss of slurry within the drilled shaft excavation, the construction of the drilled shaft shall be stopped until a method to stop slurry loss or an alternate construction procedure has been approved by the Engineer.

Mineral slurry shall be premixed thoroughly with clean, fresh water, and an adequate time (as prescribed by the mineral manufacturer) shall be allotted for hydration, prior to introduction into the shaft excavation. Slurry tanks of adequate capacity will be required for slurry circulation, storage, and treatment. No excavated slurry pits will be allowed in lieu of slurry tanks, without the written permission of the Engineer. Desanding equipment shall be provided by the Contractor as necessary to control slurry sand content to less than two percent (2%) by volume at any point in the borehole. Desanding will not be required

for setting sign posts or lighting mast foundations unless shown on the plans. The Contractor shall take all steps necessary to prevent the slurry from "setting up" in the shaft. Such methods may include, but are not limited to: agitation, circulation, and/or adjusting the properties of the slurry. Disposal of all slurry shall be performed offsite in suitable areas by the Contractor, and subject to all environmental regulations pertaining to slurry disposal.

Control tests using suitable apparatus shall be carried out on the mineral slurry mixture by a qualified individual or qualified professional testing laboratory approved by the Engineer. Tests to be conducted will be density, sand content, viscosity, and pH. The acceptable range of values for those physical properties is as follows:

MINERAL SLURRY
Sodium Montmorillonite (Commercial Bentonite)
Acceptable Range of Values

Property Units	At Time of Slurry Introduction	In Hole at Time of Concreting	Test Method
Density, pcf	64.3** - 69.1**	64.3** - 75.0**	Density Balance
Viscosity, seconds/quart	28 - 45	28 - 45	Marsh Cone
pH	8 - 11	8 - 11	pH paper pH meter

**Increase by 2 pcf in salt water

- Notes:**
- a. Tests should be performed when the slurry temperature is above 40 degrees Fahrenheit.
 - b. If desanding is required, sand content shall not exceed two percent (2%) by volume at any point in the borehole as determined by the American Petroleum Institute sand content test.

The limits in the above table may be adjusted when field conditions warrant, as successfully demonstrated on the trial shaft or as directed by the Engineer. All changes must be approved in writing by the Engineer before continued use.

Tests to determine density, viscosity, and pH value shall be performed during the shaft excavation to establish a consistent working pattern. A minimum of four (4) sets of tests shall be made during the first eight (8) hours of slurry use. When the results show consistent behavior, the testing frequency may be decreased to one set every four (4) hours of slurry use.

The Contractor shall insure that heavily contaminated slurry suspension, that could impair the free flow of concrete, has not accumulated in the bottom of the shaft. Prior to placing concrete in any shaft excavation, the Contractor shall take slurry samples using a sampling tool approved by the Engineer or similar to that shown in Figure 2. Slurry samples shall be extracted from the base of the shaft and at intervals not exceeding 10 feet up the shaft,

until two consecutive samples produce acceptable values for density, viscosity, pH, and sand content.

When any slurry samples are found to be unacceptable, the Contractor shall take whatever action is necessary to bring the mineral slurry within specification requirements. Concrete shall not be poured until resampling and testing produce acceptable results.

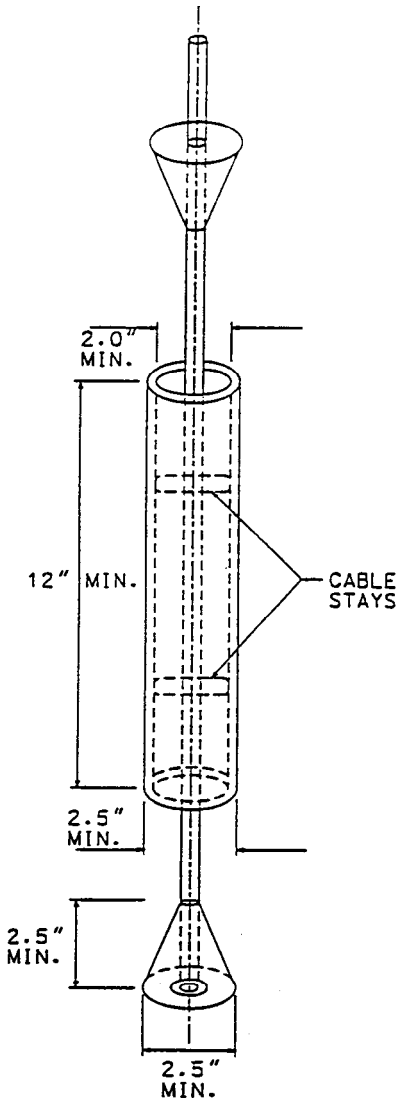
Reports of all tests required above, signed by an authorized representative of the Contractor, shall be furnished to the Engineer at the completion of each drilled shaft. Representatives of the Department may perform comparison tests as determined necessary during mineral slurry operations.

During construction, the level of mineral slurry in the shaft excavation shall be maintained at a level not less than four (4) feet above the highest expected piezometric pressure head along the depth of the shaft. If at any time the slurry construction method fails to produce the desired final results, the Contractor shall discontinue this method and propose an alternate method for approval by the Engineer.

Drilling tools should contain vents to stabilize hydrostatic pressure above and below the tool during extraction. The rate of tool extraction should not cause any noticeable turbulence in the hole.

In locations where saline or chemically contaminated groundwater exists, the slurry should be adjusted with appropriate chemical additives, or developed with a mineral material not affected by such conditions.

803.03.2.4--Excavation Inspection. The Contractor shall provide equipment for checking the dimensions and alignment of each drilled shaft excavation. The dimensions and alignment shall be determined by the Contractor in the presence of the Engineer or the Engineer's inspector. Final shaft depths shall be measured with a weighted tape or other approved methods after final cleaning. Unless otherwise stated on the plans, a minimum of 50 percent of the base of each shaft shall have less than 1/2 inch of sediment at the time of placement of the concrete. Shaft cleanliness will be determined by the Engineer, by visual inspection for dry shafts, or other methods deemed appropriate to the Engineer for wet shafts. In addition, for dry excavations, the maximum depth of water shall not exceed three (3) inches prior to concrete pour.

SLURRY SAMPLER

The sampler consists of three components:

1. Cable with weighted cone-shaped stopper.
2. Cylindrical sampler center stayed for alignment.
3. Top stopper with hole drilled through the center.

SAMPLING PROCEDURE

1. Lower cable with stopper to desired sampling elevation.
2. Slide cable through aligning guides of sampler.
3. Let sampler drop down the cable and seat onto bottom cone-shaped stopper.
4. Slide cable through hole in top stopper and let drop to seat on top of sampler.
5. Withdraw entire assembly from shaft.
6. Sample may be emptied into separate container and used as necessary to perform required testing.

Figure 2

803.03.2.5--Construction Tolerances. The following construction tolerances apply to drilled shafts unless otherwise stated in the contract documents:

- (a) The drilled shaft shall be within three (3) inches of plan position in the horizontal plane at the plan elevation for the top of the shaft.
- (b) The vertical alignment of a vertical shaft excavation shall not vary from the plan alignment by more than 1/4 inch per foot of depth.
- (c) After all the concrete is placed, the top of the reinforcing steel cage shall be not more than three (3) inches below plan elevation.
- (d) All casing diameters shown on the plans refer to O.D. (outside diameter) dimensions. The dimensions of casings are subject to American Pipe Institute tolerances applicable to regular steel pipe. When approved, the Contractor may elect to provide a casing larger in diameter than shown on the plans.
- (e) Bells shall be excavated to the plan bearing area and height shown on the plans as a minimum. The actual diameter of the bells shall not exceed three (3) times the specified shaft diameter. All other plan dimensions shown for the bells may be varied, when approved, to accommodate the Contractor's equipment.
- (f) Top elevation of the shaft shall have a tolerance of plus one (1) inch or minus three (3) inches from the plan top of shaft elevation.
- (g) Excavation equipment and methods shall be designed so that the completed shaft excavation will have a planar bottom. The cutting edges of excavation equipment shall be normal to the vertical axis of the equipment within a tolerance of $\pm 3/8$ inch per foot of shaft diameter.

Drilled shaft excavations and completed shafts not constructed within the required tolerances are unacceptable. The Contractor shall be responsible for correcting all unacceptable shaft excavations and completed shafts to the satisfaction of the Engineer. Materials and work necessary, including engineering analysis and redesign, to complete corrections for out of tolerance drilled shaft excavations shall be furnished without either cost to the State or an extension of the completion dates of the project. Any redesign shall be performed by a professional engineer, registered in the State of Mississippi and engaged by the Contractor. Redesign drawings and computations prepared by the Contractor's engineer shall be signed and sealed.

Out of tolerance shaft holes shall be backfilled in an approved manner, when directed by the Engineer, until the redesign is complete and approved.

803.03.2.6--Reinforcing Steel Construction and Placement. The reinforcing steel cage, consisting of longitudinal bars, ties, cage stiffener bars, spacers, centralizers, and other necessary appurtenances, shall be completely assembled and placed as a unit immediately after the shaft excavation is inspected and accepted, and prior to concrete placement. Details of reinforcing steel will be as shown in the plans.

The reinforcing steel in the shaft shall be double-wire tied at all junctions and supported so that the reinforcing steel will remain within allowable tolerances given in Subsection 803.03.2.5. Stiff tie wire may be required for long reinforcing steel cages. Free-rolling concrete centralizers or other approved noncorrosive rolling centralizer devices shall be used at sufficient intervals. The centralizers shall be attached to the reinforcing steel cage near the bottom, and at intervals not exceeding 10 feet up the shaft for shaft lengths less than 60 feet, and intervals not exceeding seven (7) feet for shaft lengths greater than 60

feet, to ensure concentric spacing for the entire cage length. Centralizers shall be constructed of approved material equal in quality and durability to the concrete specified for the shaft. The centralizers shall be of adequate dimension to insure a minimum five (5) inch annular space between the outside of the reinforcing cage and the side of the excavated hole. Approved cylindrical feet (bottom supports) shall be provided to ensure that the bottom of the cage is maintained the proper distance above the base.

The elevation of the top of the steel cage shall be checked before and after the concrete is placed. If the rebar cage is not maintained within the specified tolerances, corrections shall be made by the Contractor to the satisfaction of the Engineer. No additional shafts shall be constructed until the Contractor has modified the rebar cage support in a manner satisfactory to the Engineer.

If the bottom of the excavated shaft elevation is lower than the bottom of the shaft elevation shown on the plans, all reinforcement required in the upper portion of the shaft shall be achieved by splicing the additional length at the bottom of the cage, to avoid congestion in the upper portion of the shaft.

803.03.2.7--Concrete Placement.

803.03.2.7.1--General. Drilled Shaft concrete shall meet the requirements in Section 804.

Concrete placement during cold weather shall be allowed when ambient air conditions are at or expected to drop below 40°F, but protection of the fresh concrete shall be in accordance with the provisions stated in Sections 804 and 501. The Contractor shall assume all responsibility for protection of fresh concrete in cold weather.

Concrete shall be placed as soon as possible after reinforcing steel placement. Concrete placement shall be continuous from the bottom to the top elevation of the shaft. Concrete placement shall continue after the shaft excavation is full until good quality concrete is evident at the top of the shaft. Concrete shall be placed either through a tremie, concrete pump or free fall. Free fall placement shall require prior written approval of the Engineer and shall be restricted for use in dry excavations only.

For tremied or pumped concrete, the elapsed time from the beginning of concrete placement in the shaft to the completion of the placement shall not exceed four (4) hours, except as noted below. Retarders and/or water reducers in the concrete mixture shall be adjusted as approved for the conditions encountered on the project, so that the concrete remains in a workable plastic state throughout the four-hour placement limit. A workable plastic state is defined as a minimum slump of four inches (4") existing everywhere within the concrete shaft after placement has been completed. Prior to concrete placement, the Contractor shall provide test results meeting the requirements of Subsection 804.02.10 and a slump loss test per the requirements in Subsection 804.02.10.3.1. The Contractor may request a longer placement time, provided a concrete mixture is supplied that will maintain a slump of four inches (4") or greater over the longer placement time, as demonstrated by slump loss tests.

In the event that free-fall concrete placement is approved and used, the 4-inch slump in four hours requirement will be waived.

The Contractor shall place the concrete within the approved time and temperature limitations determined by the trial mix demonstration.

Before the casing is withdrawn, the fresh concrete shall be at such a level that the fluid trapped behind the casing is displaced upward. As the casing is withdrawn, care shall be exercised to maintain the level of concrete within the casing so that the fluid trapped behind the casing is displaced upward out of the shaft excavation without mixing with or displacing the shaft concrete.

803.03.2.7.2--Tremies. Tremies used for concrete placement in either wet or dry excavations shall consist of a tube of sufficient length, weight, and diameter to discharge concrete at the shaft base elevation. The tremie shall not contain aluminum parts that will have contact with the concrete. The tremie inside diameter shall be at least six (6) times the maximum size of aggregate used in the concrete mix but shall not be less than 10 inches. The inside and outside surfaces of the tremie shall be clean and smooth to permit both flow of concrete and unimpeded withdrawal during concreting. The wall thickness of the tremie shall be adequate to prevent crimping or sharp bends that restrict concrete placement.

The tremie used for wet excavation concrete placement shall be watertight. Underwater placement shall not begin until the tremie is placed at the bottom of the excavation. Valves, bottom plates, or plugs may be used only if concrete discharge can begin within one tremie diameter of the base. Plugs and plates shall either be removed from the excavation or be of a material, approved by the Engineer, that will not cause a defect in the shaft if not removed. The discharge end of the tremie shall be constructed to permit the free radial flow of concrete during placement operations. The tremie discharge end shall remain at the excavation bottom as long as possible, and thereafter be immersed at least two shaft diameters but not less than 10 feet in concrete at all times after starting the flow of concrete. The flow of concrete shall be continuous. The concrete in the tremie shall be maintained at a positive pressure differential at all times to prevent water or slurry intrusion into the shaft concrete.

If, at any time during the concrete pour in a wet excavation, the tremie line orifice is removed from the fluid concrete column and discharges concrete above the rising concrete level, the shaft shall be considered defective. In such case, the Contractor shall remove the reinforcing cage and concrete, complete all necessary sidewall removal directed by the Engineer and repour the shaft. All costs of replacement of defective shafts shall be the responsibility of the Contractor.

803.03.2.7.3--Pumping Concrete. Concrete pumps and lines may be used for concrete placement in either wet or dry excavations. All pump lines shall have a minimum 5-inch diameter and be constructed with watertight joints. The use of aluminum pipe as a conveyance for the concrete will not be permitted. Concrete placement shall not begin until the pump line discharge orifice is at the bottom of the excavation.

For wet excavations, a plug or similar device shall be used to separate the concrete from the fluid in the hole until pumping begins. The plug shall either be removed from the excavation or be of a material, approved by the Engineer, that will not cause a defect in the shaft if not removed.

The discharge orifice shall remain at least two shaft diameters but not less than 10 feet below the surface of the fluid concrete at all times after starting the flow of concrete. When lifting the pump line during concreting, the Contractor shall temporarily reduce the line pressure until the orifice has been repositioned at a higher level in the excavation.

If, at any time during the concrete pour, the pump line orifice is removed from the fluid concrete column and discharges concrete above the rising level, the shaft shall be considered defective. In such case, the Contractor shall remove the reinforcing cage and concrete, complete all necessary sidewall removal directed by the Engineer and re-pour the shaft. All costs of replacement of defective shafts shall be the responsibility of the Contractor.

803.03.2.7.4--Free Fall Method. Placement of concrete by the free fall method will be permitted only when approved in writing by the Engineer. Approval of concrete placement by the free fall method shall be contingent upon the following conditions:

- (a) The clear opening inside the reinforcing cage is not less than 24 inches in diameter.
- (b) The dry construction method is used in constructing the drilled shafts.
- (c) The height of free fall placement shall not exceed 75 feet.
- (d) Concrete shall fall directly to the placement location without contacting either the reinforcing cage or shaft walls.
- (e) A hopper shall be used at the top of the shaft to center and direct free fall placement.
- (f) The Engineer will observe the falling of the concrete within the shaft. The Contractor shall reduce the rate of concrete placement or reduce the height of free fall as directed by the Engineer when the concrete strikes the reinforcing cage or shaft sidewalls, when there is excessive spatter from the impact of the falling concrete, or when concrete placement causes the shaft excavation to cave or slough.
- (g) When in the opinion of the Engineer, placement cannot be satisfactorily accomplished by the free fall method, the Contractor shall change to either the tremie or pumping method to accomplish the pour.

803.03.2.8--Drilled Shaft Load Tests. The methods required for the load testing of drilled shafts shall be Static and/or Static with Special Instrumentation. Load testing of drilled shafts shall be completed before construction of any production drilled shafts, and the results used by the Bridge Engineer to determine the drilled shaft lengths given on the order list. The method, number, and locations of load tests shall be as shown on the plans or as designated by the Engineer.

After completion of any load test, the order list providing the final production lengths will be provided within two weeks of receiving the load test results. The production shaft lengths provided by the Bridge Engineer may differ from the individual shaft lengths shown on the plans. Requests for adjustment to the contract due to changes in shaft lengths shall be subject to the provisions of Subsection 104.02.1. Before any consideration will be given for an adjustment to the contract, it must be determined that a significant change in the character of the work has occurred.

803.03.2.8.1--Static Load Tests. Static load testing shall not begin until the concrete has attained a compressive strength of 3000 psi as determined from cylinder tests, or maturity meter probe in accordance with Subsection 803.03.2.3.1.1. If a maturity meter probe is used, it shall be located in the last concrete placed. During the curing time, no other

construction or operations that will induce excessive vibration levels, as previously discussed, shall be performed.

Static axial load tests shall be performed by personnel of the Department's Geotechnical Branch assisted by the Contractor's personnel using the procedures as described in ASTM D 1143, quick test method. No weighted platforms to totally supply the axial load are allowed.

The Contractor shall be responsible for furnishing the following:

- (a) A reaction frame capable of resisting a total load of at least four (4) times the design load of the test shaft shall be provided. The frame shall consist of a beam(s) or girder(s) that will carry the required load while sustaining only minor deflections in the reaction system. The beam or girder shall be attached to a system of anchor shafts or piles. The anchor piles shall not be closer than three (3) diameters measured from the center of the test shaft.
- (b) A hydraulic jack that has been calibrated for the full range of anticipated loads in accordance with AASHTO T 67 (ASTM E 4) at least once shall be provided. The maximum anticipated load shall be assumed to be four (4) times the design load for the test shaft. The pressure gauge shall be calibrated within one year preceding time of use. The Contractor shall furnish a certificate of calibration for the hydraulic jack at the time of load testing.
- (c) A measuring frame or reference beam for measuring the movement of the test shaft during testing shall be provided. Two dial gauges, supplied by the Department, will be attached to the test shaft during testing to monitor downward movement. Each dial gauge will be actuated by its stem or by a stem attachment resting on the measuring frame. The supports for the measuring frame shall be placed the maximum practical distance from the test pile and the anchor shafts or piles. In no case shall the measuring frame be affected by movement of the test shaft or the anchor shafts or piles.

The Geotechnical Branch will furnish the load cell, gages, any needed details of the shaft gage locations and personnel to run the test. The Geotechnical Branch shall also be responsible for reviewing and submitting the results to the Bridge Engineer. The Contractor shall submit a detailed plan for any jacks and load frame to the Engineer for evaluation. This plan should include the following:

- (a) Size and type of the reaction beam or beams.
- (b) Size, type, number, and length of reaction piles or shafts.
- (c) Type and capacity of any jacks and their most recent calibration documents.
- (d) A plan sheet shop drawing showing plan and profile of load frame details. Details should reflect how the reaction beam will be connected to the reaction piles or shafts. A detail showing how the jack, load cell (6" height, 11" diameter, supplied by the Department), and bearing plates are to be arranged between the shaft top and the bottom of the reaction beam.
- (e) Details of a protected work area, including provisions for protection from inclement weather, such as tent or shed, for the testing equipment, of a size and type required by the Engineer.

After the completion of testing, the test shafts and any anchor shafts shall be cut off at an elevation two (2) feet below the finished ground surface. The portion of the shafts cut off and removed shall remain the property of the Contractor.

803.03.2.8.2--Load Testing of Drilled Shafts With Special Instrumentation.

803.03.2.8.2.1--General. When designated on the plans, a dedicated test shaft shall be constructed as detailed in the plans with instrumentation and hydraulic jack(s) cast in the concrete of the drilled shaft. The Contractor will be required to furnish all materials, equipment, labor, and incidentals necessary for conducting the load test and reporting the results. The Contractor shall subcontract the instrumenting, conducting, and reporting of the load test to the company supplying the instrumentation with the cost included in the contract unit price for test shaft.

No reaction systems and extra drilled shaft installations such as anchor shafts are required for conducting the load test. The load test is a non-destructive test, and if the test shaft designated on the plans is a production shaft, it shall be left in a condition suitable for use as a production shaft in the finished structure.

803.03.2.8.2.2--Materials. When called for in the plans, instrumentation shall be supplied to meet the requirements set forth in the plans. Instrumentation required in the plans is subject to prior approval by the State Geotechnical Engineer. Additional equipment that may be required is as follows:

- (a) Materials sufficient to construct a stable reference beam system for monitoring deflection of the shaft during testing, supported at a minimum distance of three (3) diameters from the center of the shaft to prevent disturbance of the reference system.
- (b) Materials sufficient to construct a protected work area, including provisions such as a tent or shed for protection from inclement weather for the load test equipment, of size and type required by the Engineer.

Materials supplied that do not become a part of a finished structure shall be removed from the job site at the conclusion of the load test.

803.03.2.8.2.3--Equipment. The Contractor shall supply any additional equipment required to install the testing instrumentation, conduct the load test, and remove the load test apparatus. If the test shaft is to become a production shaft at the conclusion of the test, the Contractor shall restore the shaft to a condition suitable for use in the finished structure. This equipment includes, but is not limited to:

- (a) Electric power and welding equipment, as required, to assemble the test equipment, instrumentation, and prepare the work area.
- (b) A suitable pressurized gas source consisting either of an approved air compressor or of compressed nitrogen, i.e. four 230 cubic-foot cylinders of nitrogen per load test.
- (c) Equipment and operators for handling the instrumentation and reinforcing cage, if required, during the installation of the test shaft and during the test. This shall include, but is not limited to, a crane or other lifting device, manual labor, and hand tools.

- (d) Equipment and labor sufficient to erect the protected work area and monitoring reference beam system, to be constructed to the requirements of the Engineer and instrumentation supplier.
- (e) Approved small piston type power grout pump with experienced operator, for grouting the cell upon completion of the test if required. Successful demonstration that the grout pumping system works as intended will be required before placing the instrumentation in the test shaft hole.
- (f) Approved small power mortar mixer with suitable mortar box to discharge grout, if required, with an experienced operator.
- (g) Screen with an approximately 1/4-inch mesh to screen grout prior to placement in the grout pump to prevent clogging of the grout pump or the piping.
- (h) Suitable operating and reference level platforms, as required by the Engineer and/or instrumentation supplier, for testing over water or in otherwise unstable foundation conditions.

803.03.2.8.2.4--Procedure. The test shaft shall be constructed by the shaft construction technique approved by the Engineer after trial shaft construction. The test shaft shall then be constructed in accordance with the plans and at the direction of the Engineer.

The instrumentation shall be assembled and made ready for installation under the direction of the instrumentation supplier, in a suitable area that is adjacent to the test shaft. When a reinforcing cage is required for the test shaft, the instrumentation shall be placed as directed in the plans.

When the test shaft excavation has been completed and accepted by the Engineer, the Contractor shall then install the instrumentation and, if required, the reinforcing cage assembly in the test shaft under the direction of the Engineer. The Contractor shall use the utmost care in handling the reinforcing cage and test equipment assembly so as not to damage the instrumentation during installation.

After the installation of the instrumentation, the test shaft shall be concreted in the manner approved from the trial shaft construction. Load testing shall not begin until the concrete has attained a compressive strength of 3000 psi as determined from cylinder tests. During the curing period, no other construction or operations that will induce excessive vibration levels shall be performed.

After completion of the load test, and at the direction of the Engineer, the Contractor shall remove any items, including equipment and material that are not to be a part of the finished structure.

The Contractor shall supply the Engineer with six (6) copies of the final load test report.

803.04--Method of Measurement.

803.04.1--Test Piles. Test piles will be measured per each complete-in-place. Piles measured as test piles will not be included in the measurement of pay footage for permanent piles.

Test piles constructed in accordance with the lengths indicated on the plans and that are required to be extended or built up will be measured as a percentage, calculated by dividing

the sum of the plan length plus the length of the ordered extension or build-up, by the plan length. Splices required for the extension(s) will not be measured for payment.

No measurement for payment will be made for cut-off of a test pile.

803.04.2--Conventional Static Pile Load Tests. Conventional static pile load tests will be measured by the actual number of static load tests conducted on either a test pile or permanent production pile in accordance with these specifications.

In the event a pile is reloaded in accordance with these specifications, the reloading will be measured for payment as 50 percent of a separate conventional static pile load test.

803.04.3--Pile Shoes. Pile shoes of approved design, ordered and used, will be measured and paid as set out in Subsection 803.05.3.

803.04.4--Piling. Piling, exclusive of those measured as test piles, will be measured by the linear foot for each class and size of piling, furnished and installed in accordance with the lengths shown on the plans or as approved by the Department's Bridge Engineer. Cut-offs for each individual pile will be measured and deducted as set forth in Subsection 803.04.5.

Pile lengths in excess of those shown on the plans or approved by the Bridge Engineer will not be measured for payment unless such additional lengths below cut-off are approved in writing by the Bridge Engineer for incorporation in the structure.

803.04.5--Cut-Off. The summation of all cut-offs shall be deducted at 40 percent to determine the length for payment of in-place permanent piling.

The summation of all cut-offs for pile lengths in excess of those shown on the plans or approved by the Bridge Engineer will be deducted at 100 percent to determine the length for payment of in-place permanent piling.

An allowance will be made for prestressed concrete piling cut-offs in accordance with the provisions of Subsection 803.05.5. Cut-offs shall be measured for payment per each for each pile requiring cut-off.

All piling cut-offs shall become the property of and shall be disposed of by the Contractor.

803.04.6--Extensions or Build-Ups. Extensions or build-ups will not be measured for payment as such, but will be included in the length of piling remaining in the finished structure. In determining the amount to be included in piling footage, no allowance will be made for cut-offs necessary to accomplish the extensions or build-ups.

803.04.7--Falsework and Defective Piles. No allowance will be made for furnishing or driving of falsework piles, for piles driven out of place, for defective piles, or for piles damaged by handling or driving.

803.04.8--Splices. Splices necessary for extensions or build-ups on bearing piles will be measured by the linear foot. For prestressed concrete piles, the number of linear feet will be determined by allowing seven linear feet of piling for each splice. For other piles, the number of linear feet will be determined by allowing four linear feet of piling for each

splice. The total number of linear feet of piling to be paid for shall be determined by adding seven feet or four feet, as applicable, to the net length of piling for each splice in place in the finished structure.

No measurement or payment will be made for splices except those made at the direction and under the supervision of the Engineer.

803.04.9--Pre-formed Pile Holes. Pre-formed pile holes, when included as a pay item on the plans, will be measured by the linear foot. For trestle type bents, the footage for each hole will be determined by subtracting the elevation of the bottom of the hole shown on the itemized list from the elevation of the natural ground at the pile site or from the elevation of the excavated section, whichever is lower. For foundations and end bents, the footage will be determined by subtracting the elevation of the bottom of the hole as shown on the itemized list from the elevation of the bottom of the footing or the bottom of the end bent caps, as applicable.

803.04.10--PDA Test Piles and Special Instrumentation Load Test. PDA test piles and special instrumentation load test will be measured per each, which shall include a static load test with special instrumentation. Piles paid for as PDA test piles, special instrumentation load test, will not be included in the measurement of pay lengths for permanent piles.

Completion of this pay item shall include the 1-day restrike after the initial pile driving, the special instrumentation load test, and the restrike within 24 hours after the static load test and the individual components will not be considered separately. Any additional restrike required by the Engineer on this type test pile will be paid for as a PDA Restrike.

803.04.11--PDA Test Piles and Conventional Load Test. PDA test piles and conventional load test, will be measured per each, which shall include a static load test. Piles paid for as PDA test piles and conventional load test will not be included in the measurement of pay lengths for permanent piles.

Completion of this pay item shall include the 1-day restrike after the initial pile driving, the conventional static load test, and the restrike within 24 hours after the static load test and the individual components will not be considered separately. Any additional restrike required by the Engineer on this type test pile will be paid for as a PDA Restrike.

803.04.12--PDA Test Pile. PDA test pile will be measured per each. Piles paid for as PDA test piles will not be included in the measurement of pay lengths for permanent piles.

Completion of this pay item shall include the 1-day and 7-day restrike after initial driving and individual components will not be considered separately. Any additional restrike required by the Engineer on this type test pile will be paid for as a PDA restrike.

803.04.13--Pile Restrike. Pile restrike will be measured per each pile restrike actually performed on permanent piles or test piles as directed by the Engineer. The pile restrike will be conducted as directed by the Engineer for bearing determination and may be conducted either with or without PDA monitoring.

803.04.14--Drilled Shaft. Drilled shaft will be measured per linear foot. Measurement shall be the authorized length in feet of the completed concrete drilled shaft, including

bells, of the diameter and containing the reinforcement shown on the plans. The length shall be determined as the difference between the plan top of shaft elevation and the final bottom of shaft elevation.

803.04.15--Test Shaft. Test shaft of the specified diameter will be measured per each.

803.04.16--Trial Shaft. Trial shaft of the specified diameter will be measured per linear foot.

803.04.17--Exploration. Exploration will be measured per linear foot of soil samples and/or rock cores of the diameter and length required and authorized by the Engineer.

803.04.18--Casing. Casing shall be measured per linear foot. Such measurement shall be full compensation for furnishing, placing, and removing when required, the casing in the shaft excavation.

803.05--Basis of Payment.

803.05.1--Test Piles. Test piles, measured as prescribed above, will be paid for at the contract unit price per each.

803.05.2--Conventional Static Pile Load Tests. Conventional static pile load tests, measured as prescribed above, will be paid for at the contract unit price per each.

803.05.3--Pile Shoes. If not covered by a contract item or otherwise required by the plans, metal shoes ordered by the Engineer will be paid for at double the invoice cost of the shoe. The cost of placing the pile shoes and driving piling with these additional requirements will not be paid for directly, and the cost thereof shall be considered incidental to the respective pile driving pay item.

803.05.4--Piling. Piling of the type specified will be paid for at the contract unit price per linear foot.

All costs for providing and placing pile driving tips and epoxy coal tar coating on steel pipe piling will not be paid for directly, and the cost thereof shall be considered incidental to the respective pile driving pay item.

803.05.5--Cut-Offs. When permanent prestressed concrete piles are required to be cut off and the cut-offs are not necessitated by damage to the pile or as a result of a pile furnished in a length greater than that established by the pile list on the plans or furnished by the Bridge Engineer, the Contractor will be paid \$60.00 per each pile cut-off for sizes smaller than 20 inches and \$80.00 per each pile cut-off for sizes 20 inches and larger.

803.05.6--Extensions or Build-Ups. Extensions or Build-ups will not be paid for directly, but will be included in payment for piling. No payment will be made for extensions or build-ups for test piles.

803.05.7--Blank.

803.05.8--Splices. Splices, measured as prescribed above, will be paid for at the contract unit price per linear foot for the particular type pile splices.

803.05.9--Pre-formed Pile Holes. Pre-formed pile holes of the sizes specified will be paid for at the contract unit price per linear foot.

803.05.10--PDA Test Piles and Special Instrumentation Load Test. PDA test piles and special instrumentation load test, measured as prescribed above, will be paid for at the contract unit price per each.

803.05.11--PDA Test Piles and Conventional Load Test. PDA test piles and conventional load test, measured as prescribed above, will be paid for at the contract unit price per each.

803.05.12--PDA Test Piles. PDA test piles, measured as prescribed above, will be paid for at the contract unit price per each.

All costs for providing and placing pile driving tips on steel pipe piling will not be paid for directly, and the cost thereof shall be considered incidental to the respective pile driving pay item.

803.05.13--Pile Restrike. Pile restrikes, measured as prescribed above, will be paid for at the contract unit price per each.

803.05.14--Drilled Shafts. Drilled shafts of the type specified, measured as prescribed above, will be paid for at the contract unit price per linear foot, which price shall include the cost of concrete, reinforcing steel, and all labor, materials including mineral slurry, equipment, and incidentals necessary to complete the drilled shaft.

803.05.15--Test Shafts. Test shafts of the type specified, measured as prescribed above, will be paid for at the contract unit price per each, which price shall be full compensation for excavating the test shaft through whatever materials are encountered to the bottom of the shaft elevation shown on the plans or as authorized by the Engineer, concrete, reinforcement, required casings, special instrumentation load cell if required, conducting and reporting load test results, restoring the site as required, and all other expenses to complete the work.

803.05.16--Trial Shaft. Trial shafts of the type specified, measured as prescribed above, will be paid for at the contract unit price per linear foot, which price shall be full compensation for excavating the trial shaft through whatever materials are encountered to the bottom of the shaft elevation shown on the plans or as authorized by the Engineer, concrete, reinforcement, required casings, special instrumentation if required, conducting and reporting load test results, restoring the site as required, and all other expenses to complete the work.

803.05.17--Exploration. Exploration, measured as prescribed above, will be paid for at the contract unit price per linear foot, which price shall be full compensation for drilling, extracting, packaging and classifying the samples or cores, delivering them to the Department, furnishing concrete to fill the core hole, and all other expenses necessary to complete the work.

803.05.18--Casings. Casings, measured as prescribed above, will be paid for at the contract price per linear foot, which price shall be full compensation for furnishing, placing, and removing (when required) the casing in the shaft excavation.

The prices thus paid shall be full compensation for all materials, tools, equipment, labor, and incidentals required to complete work.

Payment will be made under:

803-A: Test Pile *	- per each
803-B: Conventional Static Pile Load Test	- per each
803-C: ___” Prestressed Concrete Piling	- per linear foot
803-D: ___ Steel Piling	-per linear foot
803-E: Concrete Piling Cut-off, <u>Size</u>	- per each
803-F: ___” Pre-formed Pile Hole	- per linear foot
803-G: PDA Test Pile and Special Instrumentation Load Test	- per each
803-H: PDA Test Pile and Conventional Load Test	- per each
803-I: PDA Test Pile	- per each
803-J: Pile Restrike	- per each
803-K: Drilled Shaft, ___” Diameter	- per linear foot
803-L: Test Shaft, ___” Diameter	- per each
803-M: Trial Shaft, ___” Diameter	- per linear foot
803-N: Exploration	- per linear foot
803-O: <u>**</u> Casing, ___” Diameter	- per linear foot
803-P: ___” Steel Pipe piling, Wall Thickness ___”	- per linear foot

* Indicate Size and Type

** Temporary or Permanent

SECTION 804 - CONCRETE BRIDGES AND STRUCTURES

804.01--Description. This work consists of constructing concrete bridges and structures in accordance with these specifications and in reasonably close conformity with the dimensions, designs, lines, and grades indicated on the plans or established.

Construction of box bridges shall be in accordance with Sections 601 and 602.

804.02--Materials.

804.02.1--General. Concrete produced and controlled from this specification shall be accepted upon proper certification of concrete production through an approved quality control program and verification by job site acceptance criteria. The Contractor shall develop and implement a quality control program that shall be used to maintain the required properties of concrete. For projects with 1000 cubic yards and more, quality control and acceptance shall be achieved through statistical evaluation of test results. For projects of more than 200 but less than 1000 cubic yards, quality control and acceptance shall be achieved by individual test results. For projects less than or equal to 200 cubic yards, refer to the requirements of TMD-20-05-00-000 “Sampling and Testing of Small Quantities of Miscellaneous Materials” for mixture design and testing requirements.

The materials for concrete bridges and structures, when sampled and tested in accordance with Subsection 700.03, shall meet the requirements of the following Subsections:

Cement	701.01 and 701.02
Blended Cement	701.01 and 701.04
Admixtures	713.02
Fly Ash	714.05
Ground Granulated Blast Furnace Slag (GGBFS)	714.06
Silica Fume	714.09.2
Water	714.01.1 and 714.01.2
Fine Aggregate	703.02
Coarse Aggregate	703.03
Lightweight Aggregate	703.19
Curing Materials	713.01
Joint Materials	707.01, 707.02, and 707.07
Structural Steel Joints and Bearing Devices	717.01
Bearing Pads	714.10
Wire Rope or Wire Cable for Prestressed Concrete	711.01 and 711.03
Sprayed Finish for Concrete Surface	714.12
Reinforcing Steel	711.02

804.02.2--Use, Care, and Handling. The use, care, and handling of materials shall conform to the applicable requirements of Subsection 501.03.10 and the specific requirements of Subsections 804.02.4 and 804.02.5. Unless otherwise authorized, only fine aggregate or coarse aggregate of one type and from the same source shall be used in the construction of any one unit of a structure. Should the Contractor, with written permission of the Engineer, elect to substitute high early strength cement for cement of the type specified, the Contractor will not receive additional compensation for the substitution.

804.02.3--Non-Quality Control / Quality Assurance Concrete. The following concrete items will not be accepted based on the Quality Control / Quality Assurance (QC/QA) requirements. The acceptance of these concrete items will be based on sampling and testing at the project site by Department personnel. The Contractor is required to submit mix designs to accomplish this work in accordance with Section 804 and perform normal Quality Control functions at the concrete plant. Acceptance will be in accordance with the requirements of Section 601, Structural Concrete, and TMD-20-04-00-000. At the

discretion of the Engineer, the Contractor may request that the concrete be accepted based on QC/QA requirements.

<u>Section</u>	<u>Description</u>
221	Paved Ditches
601	Minor Structures - manholes, inlets, catch basins, junction boxes, pipe headwalls, and pipe collars.
605	Edge Drain and Underdrain Outlet Pads
606	Guardrail Anchors
607	Fence Post Footings
608	Sidewalks
609	Curb and Gutter
614	Driveways
616	Median and Island Pavement
630	Sign Footings, except Overhead Sign Supports
815	Slope Paving

804.02.4--Care and Storage of Concrete Aggregates. The handling and storage of aggregates shall be such as to prevent segregation or contamination with foreign materials. The Engineer may require that aggregates be stored on separate platforms at satisfactory locations.

If specified, coarse aggregates shall be separated into two or more sizes in order to secure greater uniformity of the concrete mixture. Different sizes of aggregate shall be stored in separate stock piles sufficiently removed from each other to prevent the material at the edges of the piles from becoming intermixed.

804.02.5--Storage of Cementitious Materials. All cementitious materials shall be stored in suitable weather-proof buildings or bins. These buildings or bins shall be placed in locations approved by the Engineer. Provision for storage shall be ample, and the shipments of cementitious materials as received shall be stored separately or other provisions made to the satisfaction of the Engineer for easy access for the identification, inspection, and sampling of each shipment as deemed desirable. Stored cementitious materials shall meet the test requirements at any time after storage when a retest is ordered by the Engineer.

On small jobs, open storage consisting of a raised platform and ample waterproof covering may be permitted by written authorization from the Engineer.

When specified, the Contractor shall keep accurate records of deliveries of cementitious materials and of their use in the work. Copies of these records shall be supplied in the form required by the Engineer.

804.02.6--Classification and Uses of Concrete. When a specific class of concrete is not specified on the plans or in the contract documents, the structure or parts thereof shall be constructed with the class of concrete as directed by the Engineer.

The classes and their uses are as follows:

- 1) Class AA - Concrete for bridge construction and concrete exposed to seawater.
- 2) Class B - General use, heavily reinforced sections, cast-in-place concrete piles, and conventional concrete piles.

- 3) Class BD - Concrete for bridge decks
- 4) Class C - Massive sections or lightly reinforced sections.
- 5) Class D - Massive unreinforced sections and riprap.
- 6) Class F - Concrete for prestressed members.
- 7) Class FX - Extra strength concrete for prestressed members, as shown on plans.
- 8) Class S - For all seal concrete deposited under water.
- 9) Class DS - Drilled Shaft

804.02.7--Blank.

804.02.8--Laboratory Accreditation. The Contractor shall be responsible for furnishing the laboratory used to perform concrete quality control tests. The laboratory may be the Contractor's facility, the concrete producer's facility, or a certified independent testing laboratory.

Only laboratories certified by the Department are qualified to perform material testing. Certification by AASHTO Accreditation Program (AAP) will be acceptable if the laboratory is listed in the latest AAP publication and maintains accreditation to completion of concrete work.

The Contractor's laboratory designated for quality control testing shall have equipment necessary to test aggregates and concrete for the test methods listed in Table 1.

Table 1

AASHTO: R 39	Making and Curing Concrete Test Specimens in the Laboratory
AASHTO: R 60	Sampling Freshly Mixed Concrete
AASHTO: T 2	Sampling Aggregates
AASHTO: T 19	Bulk Density ("Unit Weight") and Voids in Aggregates
AASHTO: T 22	Compressive Strength of Cylindrical Concrete Specimens
AASHTO: T 23	Making and Curing Concrete Test Specimens in the Field
AASHTO: T 27	Sieve Analysis of Fine and Coarse Aggregates
AASHTO: T 84	Specific Gravity and Absorption of Fine Aggregate
AASHTO: T 85	Specific Gravity and Absorption of Coarse Aggregate
AASHTO: T 119	Slump of Hydraulic Cement Concrete
AASHTO: T 121	Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
AASHTO: T 152	Air Content of Freshly Mixed Concrete by Pressure Method *
AASHTO: T 196	Air Content of Freshly Mixed Concrete by the Volumetric Method *
AASHTO: T 231	Capping Cylindrical Concrete Specimens
AASHTO: T 248	Reducing Field Samples of Aggregate to Testing Size
AASHTO: T 255	Total Evaporable Moisture Content of Aggregate by Drying
AASHTO: T 325	Standard Method of Test for Estimating the Strength of Concrete in Transportation Construction by Maturity Tests **
AASHTO: T 309	Temperature of Freshly Mixed Portland Cement Concrete
ASTM: C 1074	Standard Practice for Estimating Concrete Strength by the Maturity Method **

- * Equipment necessary for either pressure or volumetric air content.
- ** Equipment necessary for estimating concrete strength following the maturity method.

Testing equipment shall be inspected by the Department or through the AASHTO Accreditation Program. Testing equipment calibration files shall be made available upon request by the Department.

804.02.9--Testing Personnel. Technicians testing hydraulic cement concrete, for either acceptance or production control purposes, shall be certified by an accepted certification program. Recertification is required for each Class after five years. Certification requirements are listed in Table 2.

Table 2

Concrete Technician's Tasks	Test Method Required	Certification Required**
Sampling or Testing of Plastic Concrete	AASHTO R 60, T 23, T 119, T 121, T 152, T 196, and T 309	MDOT Class I certification
Compressive Strength Testing of Concrete Cylinders	AASHTO T 22 and T 231	MDOT Concrete Strength Testing Technician certification
Sampling of Aggregates	AASHTO T 2	Work under the supervision of a MDOT Class II certified technician
Testing of Aggregates	AASHTO T 19, T 27, T 84, T 85, T 248, and T 255	MDOT Class II certification
Proportioning of Concrete Mixtures*	AASHTO M 157 and R 39	MDOT Class III certification
Interpretation and Application of Maturity Meter Readings	AASHTO T 325 and ASTM C 1074	Two hours maturity method training

- * Technicians making concrete test specimens for meeting the requirements of Subsection 804.02.10.1.2 shall be MDOT Class I certified and under the direct supervision of an MDOT Class III certified technician.
- ** MDOT Class I certification encompasses the same test procedures and specifications as ACI Concrete Field Testing Technician-Grade I. MDOT Class II certification encompasses the same test procedures and specifications as ACI Aggregate Testing Technician-Level 1. MDOT Concrete Strength Testing Technician encompasses the same test procedures and specifications as ACI Concrete Strength Testing certification.

Specific requirements for each level of certification are in the latest edition of the Department's *Concrete Field Manual*. Current MDOT Class I, MDOT Class II, and/or MDOT Class III certifications shall be acceptable until those certifications expire. Upon expiration of a current certification, recertification with the certifications listed in Table 2

shall be required. Technicians performing either specific gravity testing of aggregates or compressive strength tests shall be required to either:

- (a) have the required MDOT certification listed in Table 2, or
- (b) have a current MDOT Class III certification or work under the direct supervision of current MDOT Class III technician, and have demonstrated the specific gravity and/or compressive strength test during the inspection of laboratory equipment by the Materials Division, Concrete Section.

804.02.10--Hydraulic Cement Concrete Mixture Design. At least 10 working days prior to production of concrete, the Contractor shall submit to the Engineer proposed concrete mixture designs complying with the Department's *Concrete Field Manual*. Materials shall be from approved sources meeting the requirements of the Standard Specifications. Proportions for the mixture designs shall be for the class concrete required by the plans and shall meet the requirements of the "Master Proportion Table for Structural Concrete Design" listed in Table 3. The concrete producer shall assign a permanent unique mixture number to each mixture design. Each mixture design shall be field verified as required in Subsection 804.02.10.3. Acceptable field verification data shall be required for final approval of a mixture design.

All concrete mixture designs will be reviewed by the Materials Division prior to use. Concrete mixture designs disapproved will be returned to the Contractor with a statement explaining the disapproval.

If the Contractor chooses to cure the concrete in accordance with the requirements listed under **Length of Time Defined by Development of Compressive Strength** in Subsection 804.03.17, the compressive strength/maturity relationship shall be developed for the mixture design for a minimum of 28 days following the requirements of Subsection 804.03.15. The compressive strength/maturity relationship information shall be submitted with the mixture design information.

Table 3
MASTER PROPORTION TABLE FOR STRUCTURAL CONCRETE DESIGN

Class	Application	Coarse Aggregate Size No.	Maximum w/cm Ratio	Specified Compressive Strength (f'_c) psi	Maximum Permitted Slump, or Slump Flow inches ³	Nominal Total Air Content (%)	Maximum Static Segregation (%)
AA	General and Structural	57 or 67	0.45	4000	3 [-1.5] 4-8 [-2.5]	4.5±1.5	N/A
B	Minor Structures	57 or 67	0.50	3500	4-8 [-2.5]	4.5±1.5	N/A
BD	Bridge Deck ¹	57 or 67	0.43-0.45	4000	5 [-2.5]	4.5±1.5 6.5±1.5	N/A
C	Massive sections	57 or 67	0.55	3000	4-8 [-2.5]	4.5±1.5	N/A
D	Massive unreinforced sections	57 or 67	0.70	2000	4-8 [-2.5]	4.5±1.5	N/A
F ²	Prestressed members	67	0.40	5000	3 [-1.5] 4-8 [-2.5]	See note ²	NA
F ²	Prestressed members SCC	67	0.40	5000	28 [-4]	See note ²	15
FX ²	Extra strength for prestressed members	67	As per mixture design	As shown on plans	3 [-1.5] 4-8 [-2.5]	See note ²	NA
FX ²	Extra strength for prestressed members	67	As per mixture design	As shown on plans	28 [-4]	See note ²	15
S	Seal concrete deposited under water	57 or 67	0.45	3000	8 [-2.5]	4.5±1.5	N/A
DS ²	Drilled shaft	67	0.45	4000	8±1	See note ²	N/A
DS ²	Drilled shaft SCC	67	0.45	4000	24 [-6]	See note ²	15

¹ For Class BD concrete for bridge decks, the water/cementitious material ratio range shall be 0.43-0.45 and the maximum cementitious material content shall be 550 pounds per cubic yard.

Also, an approved synthetic structural fiber meeting the requirements of Subsection 711.04 shall be incorporated into the mixture at 1.25 times the approved dosage rate. For each additional pound of fibers per cubic yard added in excess of the requirement stated above, an additional inch of slump will be allowed up to a maximum permitted slump of eight (8) inches.

- ² Entrained air is not required for Class F, FX, and DS concrete unless exposed to seawater. For concrete not exposed to seawater, the total air content shall not exceed 6.0%. For concrete exposed to seawater, the nominal total air content shall be 4.5%.

Note: Brackets [#] indicate minus slump tolerances.

- ³ The design slump selected by the Contractor for the mix design approval is the maximum slump permitted.

Lightweight aggregate (LWA) meeting the requirements of Subsection 703.19.2 may also be used as a partial replacement for fine aggregate. The replacement limits of hydraulic cement by weight by other cementitious materials (such as fly ash, GGBFS, silica fume, or others) shall be in accordance with the values in Subsection 701.02. Other hydraulic cements may be used in accordance with the specifications listed in Section 701

At least one water-reducing admixture or water-reducing/set-retarding admixture shall be used in all classes of concrete in accordance with the manufacturer's recommended dosage range. Admixtures providing a specific performance characteristic other than those of water reduction or set retardation may be used in accordance with the manufacturer's recommended dosage range. Accelerating admixtures shall not be used unless approved by the State Materials Engineer. Any combinations of admixtures shall be approved by the Engineer before their use.

804.02.10.1--Proportioning of Hydraulic Cement Concrete Mixture Design.

Proportioning of hydraulic cement concrete shall be based on an existing mixture of which the producer has field experience and documentation or based on a recently batched laboratory mixture tested according to the required specifications.

804.02.10.1.1--Proportioning on the Basis of Previous Field Experience of Trial Mixtures. Where a concrete production facility has a record, based on at least 10 consecutive strength tests from at least 10 different batches within the past 12 months from a mixture not previously used on Department projects, the standard deviation shall be calculated. The record of tests from which the standard deviation is calculated shall:

- (a) Represent similar materials and conditions to those expected. Changes in materials and proportions within the test record shall not have been more closely restricted than those for the proposed work.
- (b) Represent concrete produced to meet a specified strength.
- (c) Consist of 10 consecutive tests, average of two cylinders per test, tested at 28 days. For concrete categorized as a self-consolidating concrete (SCC) mixture, the test data for the plastic concrete shall include the slump flow data, instead of the slump data, and at least one test to determine the static segregation. For all mixture designs, for each of these tests on the plastic concrete the test data shall meet the acceptance criteria of Subsection 804.02.13.1.

The standard deviation, s , shall be calculated as:

$$s = \left[\sum (X_i - \bar{X})^2 \div (N - 1) \right]^{1/2}$$

where:

X_i = the strength result of an individual test

\bar{X} = the average of individual tests in the series

N = number of tests in the series

When the concrete production facility does not have a record of tests for calculation of standard deviation, as required in the above formula, the requirements of Subsection 804.02.10.1.2 shall govern.

The required average compressive strength (f'_{cr}) used as the basis for selection of concrete proportions shall conform to the inequality listed below, while using a standard deviation, s , calculated as shown above.

$$\bar{X} \geq f'_{cr}$$

where:

$$f'_{cr} = f'_c + 1.43s$$

where:

f'_c = specified compressive strength of concrete, psi

f'_{cr} = required average compressive strength of concrete, psi

s = standard deviation, psi

1.43 represents the Lower Quality Index necessary to assure that 93% of compressive strength tests are above f'_c .

804.02.10.1.2--Proportioning on the Basis of Laboratory Trial Mixtures. When an acceptable record of field test results is not available, concrete proportions shall be established based on laboratory trial mixtures meeting the following restrictions:

- (a) The combination of materials shall be those intended for use in the proposed work.
- (b) Trial mixtures having proportions and consistencies suitable for the proposed work shall be made using the ACI 211.1 as a guide to proportion the mixture design.
- (c) Trial mixtures shall be designed to produce a slump within $\pm 3/4$ inch of the design slump allowed, and for air-entrained concrete, ± 0.5 percent of the maximum permitted air content in Table 3. The temperature of freshly mixed concrete in trial mixtures shall be reported.
- (d) For each proposed mixture, at least three compressive test cylinders shall be made and cured in accordance with AASHTO R 39. Each change of water-cement ratio shall be considered a new mixture. The cylinders shall be tested for strength in accordance with AASHTO T 22 and shall be tested at 28 days.

- (e) The required average strength of laboratory trial mixes shall exceed f'_c by 1200 psi for concrete mixture designs less than 5000 psi and by 1400 psi for concrete mixture designs of 5000 psi or more.
- (f) The laboratory trial batch mixtures shall have been made within the previous 12 months before being submitted for approval and shall not have been previously used on Department projects.
- (g) For concrete categorized as a SCC mixture, the mixture shall be designed to produce a slump flow within ± 2 inches of the maximum permitted and a maximum static segregation of 15.0 percent. The concrete shall not be rodded or vibrated during casting the test specimens.
- (h) For concrete categorized as a SCC mixture, test specimens shall be made in accordance with the above listed specifications with the exception that the concrete shall not be rodded or vibrated during casting the test specimens.

804.02.10.2--Documentation of Average Strength. Documentation that the proposed concrete proportions will produce an average strength equal to or greater than the required average shall consist of the strength test records from field tests or results from laboratory trial mixtures.

804.02.10.3--Field Verification of Concrete Mixture Design. Concrete mixture designs will only be tentatively reviewed pending field verification submission and are not approved for payment by the Department until field verification is submitted. The requirements for yield, slump, or total air content shall be successfully met within the first three (3) production days. Mixture designs may be transferred to other projects without additional field verification testing if the mixture design is less than twelve (12) months old, once the mixture design has passed the field verification process. All concrete mixtures will have a complete field verification performed and submitted to the Department's Materials Division every 12 months.

The Contractor's Certified Quality Control Technicians shall test each concrete mixture design upon the first placement of the mix. Aggregates and concrete tests during the first placement shall be as follows.

Aggregates

Bulk Specific Gravity
Moisture
Gradation

Concrete

Water Content
Slump or Slump Flow
Air Content
Unit Weight
Yield
Static Segregation

For all Classes of concrete, the mixture shall be verified to yield within 2.0% of the correct volume when all the mix water is added to the batch. For concrete categorized as a SCC mixture, the mixture shall produce a slump flow within minus four inches (4") of the maximum permitted and a static segregation less than 15.0%.

For all Classes of concrete other than DS, F, and FX, the mixture shall produce a slump within a minus 1½-inch tolerance of the design for mixtures with a design slump of three inches (3") or less or within a minus 2½-inch tolerance of the design for mixtures with a design slump of greater than three inches (3"), and producing a total air content tolerance within the maximum allowable air content in Table 3.

For Class DS, the slump range shall be 8 inches \pm 1 inch. For Class DS exposed to seawater, the total air content shall be within the tolerance of the maximum allowable air content in Table 3. For Class DS not exposed to seawater the total air content shall be within the requirements in Table 3.

For Classes F and FX, the slump shall be within a minus 1½-inch tolerance of the design for mixtures with a design slump of three inches (3") or less or within a minus 2½-inch tolerance of the design for mixtures with a design slump of greater than three inches (3"). For Classes F and FX exposed to seawater, the total air content shall be within the tolerance of the maximum allowable air content in Table 3. For Classes F and FX not exposed to seawater the total air content shall be within the requirements in Table 3.

The mixture shall be adjusted and retested, if necessary, on subsequent placements until the above mentioned properties are met.

If the requirements for yield, slump, or total air content are not met within the first three (3) production days, subsequent field verification testing shall not be permitted on Department projects, and the mixture design shall not be used until the requirements listed above are met. Any mixture design adjustments, changes in the mixture proportions, are to be made by a Class III Certified Technician representing the Contractor. After the mixture design has been verified and adjustments made, verification test results will be reviewed by the Engineer.

804.02.10.3.1--Slump Loss of Class DS Concrete Mixture Designs. Prior to concrete placement, the Contractor shall provide test results of a slump loss test using approved methods to demonstrate that the mixture meets the four hour requirement in Subsection 803.03.2.7.1. The Contractor shall notify the Department 48 hours prior to performing the slump loss test. These tests shall be conducted successfully by an approved testing laboratory during the installation of the trial shaft, with personnel from the Department present. As an alternative, the slump loss test can be performed prior to the installation of the trial shaft. The slump loss test shall be conducted at temperatures and conditions similar to those expected at the job site at the time of the installation of the trial shaft. The sample for the slump loss test shall be from a minimum batch size of four (4) cubic yards of concrete. If the temperature between a successful slump loss test and the installation of the production shaft exceeds 10°F above the concrete temperature, another successful slump loss test shall be performed on the first truckload of concrete as part of the installation of the trial shaft. The requirement to limit the time between the previous slump loss test and an installation of the trial shaft also applies to Class DS concrete mixture designs being transferred from another project. During any shaft installation a slump loss test shall be conducted by the Contractor at the direction of the Engineer from the concrete at the site for verification of slump loss requirements using a sample from a minimum batch size of four cubic yards of concrete. For concrete categorized as a SCC mixture, the Class DS SCC mixture shall not require a slump loss test.

804.02.10.4--Adjustments of Mixtures. The mixture design may be adjusted by the Class III Certified Technician representing the Contractor in accordance with the allowable revisions listed in paragraph 5.7 of the Department's *Concrete Field Manual*. Written notification shall be submitted to the Engineer a minimum of seven (7) days prior to any source or brand of material change, aggregate size change, allowable material type change, or decrease in any cementitious material content. Any adjustments of the concrete mixture

design shall necessitate repeat of field verification procedure as described in Subsection 804.02.10.3.1 and approval by the Engineer.

804.02.11--Concrete Batch Plants. The concrete batch plant shall meet the requirements of the National Ready Mixed Concrete Association *Quality Control Manual, Section 3, Plant Certification Checklist* as outlined in the latest edition of the Department's *Concrete Field Manual*. The Contractor shall submit a copy of the approved checklist along with proof of calibration of batching equipment, i.e., scales, water meter, and admixture dispenser, to the Engineer 30 days prior to the production of concrete.

For projects with 1000 cubic yards and more, the concrete batch plant shall meet the requirements for an automatic system capable of recording batch weights. It shall also have automatic moisture compensation for the fine aggregate. For projects of more than 200 but less than 1000 cubic yards the plant can be equipped for manual batching with a fine aggregate moisture meter visible to the plant operator.

The concrete batch plant shall have available adequate facilities to cool concrete during hot weather.

Mixer trucks to be used on the project are to be listed in the checklist and shall meet the requirements of the checklist.

804.02.12--Contractor's Quality Control. The Contractor shall provide and maintain a quality control program that will provide assurance that all materials and products submitted to the Department for acceptance will conform to the contract requirements, whether manufactured or processed by the Contractor or procured from suppliers, subcontractors, or vendors.

The Contractor's Quality Control program shall implement the minimum quality control requirements shown in Table 4, "CONTRACTOR'S MINIMUM REQUIREMENTS FOR QUALITY CONTROL". The quality control activities shown in the table are considered to be normal activities necessary to control the production and placing of a given product or material at an acceptable quality level. To facilitate the Department's activities, all completed gradation samples shall be retained for a maximum of sixty (60) days by the Contractor until further disposition is designated by the Department.

The Contractor shall perform, or have performed, the tests required to substantiate product conformance to contract document requirements and shall also perform, or have performed, all tests otherwise required.

The Contractor's Quality Control program shall encompass the requirements of AASHTO M 157 into concrete production and control, equipment requirements, testing, and batch ticket information. The requirement of AASHTO M 157, Section 11.7 shall be followed except, on arrival to the job site, a maximum of 1½ gallons per cubic yard shall be allowed to be added. Water shall not be added at a later time. Job site adjustment of a batch using chemical admixtures or the mechanical adjustment of a batch may be performed by the Contractor if the requirements of Subsection 804.02.12.1.1 have been satisfactorily addressed in the Quality Control Plan. If either the maximum permitted slump is exceeded or the total air content is not within the required range after all adjustments are made at the job site, the concrete shall be rejected.

The Contractor's quality control tests shall be documented and shall be available for review by the Engineer throughout the life of the contract.

As set out in these specifications, quality control sampling and testing performed by the Contractor will be used by the Department for determination of acceptability of the concrete.

The Contractor shall maintain standard equipment and qualified personnel as required to assure conformance to contract requirements.

804.02.12.1--Quality Control Plan. The Contractor shall prepare a Quality Control Plan that identifies the personnel responsible for the Contractor's quality control including the company official who will act as liaison with Department personnel. The Quality Control Plan shall be submitted in writing to the Engineer for approval 30 days prior to the production of concrete.

The class(es) of concrete involved will be listed separately. If an existing mixture design(s) is to be used, the mixture design number(s) as previously approved shall be listed.

It is intended that sampling and testing be in accordance with standard methods and procedures, and that measuring and testing equipment be standard and properly calibrated. If alternative sampling methods and procedures and alternative inspection equipment are to be used, they shall be detailed in the Quality Control Plan.

804.02.12.1.1--Elements of Plan. The Plan shall address all elements that affect the quality of the structural concrete including, but not limited to, the following items:

- (a) Stockpile Management
- (b) Procedures for Corrective Actions for Non Compliance of Specifications
- (c) Procedure for Controlling Concrete Temperatures
- (d) Job Site Batch Adjustments by Addition of Chemical Admixtures:
 - (1) The Plan shall address whether the Contractor intends to adjust either the slump and/or total air content of a batch on the job site by adding chemical admixture(s) to a batch. The Contractor shall include the names of the personnel designated to perform this batch adjustment, the equipment used to add the chemical admixture(s), and the procedure by which the batch adjustment will be accomplished. Only the Contractor's designated personnel shall adjust a batch. Only calibrated dispensing equipment shall be used to add chemical admixture(s) to a batch. Only the procedure described in this section of the Plan shall be utilized.
 - (2) If either the maximum permitted slump is exceeded or the total air content is not within the required range after all adjustments are made at the job site, the concrete shall be rejected.
 - (3) If the Contractor elects to utilize Job Site Batch Adjustments by Addition of Chemical Admixture within Item 2, Procedures for Corrective Actions for Non Compliance of Specifications, to adjust batches that do not meet the minimum specification requirements for slump and/or total air content, no more than three batches on any one project shall be allowed to be adjusted regardless of the number of mixtures associated with the project.
- (e) Construction of Concrete Bridge Decks, including the following:

- (1) the description of the equipment used for placing concrete on the bridge deck in accordance with Subsection 804.03.6 and, as applicable, Subsections 804.03.7 and 804.03.8 including any accessories added to the pump to ensure the entrained air in the concrete mixture remains entrained during pumping and depositing of the concrete mixture;
 - (2) the description of and the number of pieces of equipment used to consolidate the concrete in accordance with Subsection 804.03.6.2;
 - (3) the description of the equipment used to finish the bridge deck in accordance with Subsection 804.03.19.7;
 - (4) the plan for ensuring a continuous rate of finishing the bridge deck without delaying the application of curing materials within the time specified in Subsection 804.03.17, including ensuring a continuous supply of concrete throughout the placement with an adequate quantity of concrete to complete the deck and filling diaphragms and end walls in advance of deck placement;
 - (5) the plan for applying the curing materials within the time specified in Subsection 804.03.17;
 - (6) the description of the powered fogging equipment in accordance with Subsection 804.03.17;
 - (7) a sample of the documentation used as the daily inspection report for ensuring maintenance of the continuous wet curing in accordance with Subsection 804.03.17, as required;
 - (8) the description of the equipment used to apply the liquid membrane, including but not limited to, the nozzles, pumping/pressurization equipment, and liquid membrane tanks, in accordance with Subsection 804.03.17;
 - (9) the method for determining the rate of applied liquid membrane meets the application rate requirements in accordance with Subsection 804.03.17; and
 - (10) a sample of the documentation used for the application rate verification of the liquid membrane in accordance with Subsection 804.03.17.
- (f) Mechanical Adjustment of Trucks

804.02.12.2--Personnel Requirements. The Contractor's Designated Certified Technician shall perform and use quality control tests and other quality control practices to assure that delivered materials and proportioning meet the requirements of the mixture design including temperature, slump, air content, and strength and shall periodically inspect all equipment used in transporting, proportioning, and mixing.

The Contractor's Designated Technician shall periodically inspect all equipment used placing, consolidating, finishing, and curing to assure it is operating properly and that placement, consolidation, finishing, and curing conform to the mixture design and other contract requirements.

804.02.12.3--Documentation. The Contractor shall maintain adequate records of all inspections and tests. The records shall indicate the nature and number of observations made, the number and type of deficiencies found, date and time of samples taken, the quantities approved and rejected, and the nature of corrective action taken as appropriate. The Contractor's documentation procedures will be subject to approval of the Department prior to the start of the work and to compliance checks during the progress of the work.

All conforming and non-conforming results shall be kept complete and shall be available at all times to the Department during the performance of the work. Forms shall be on a

computer-acceptable medium. Batch tickets and gradation data shall be documented in accordance with Department requirements.

Batch tickets shall contain all the information in AASHTO M157, Section 16, including the additional information in Subsection 16.2 with the following exception: the information listed in paragraphs 16.2.7 and 16.2.8 is not required. All material added to a batch by both the batch plant or added manually shall be documented on the ticket. Batch tickets shall also contain the concrete producer's permanent unique mixture number assigned to the concrete mixture design. Copies shall be submitted to the Department as the work progresses.

Test data for concrete, including gradation, shall be charted in accordance with the applicable requirements.

The Contractor may use additional control charts as deemed appropriate. It is normally expected that testing and charting will be completed within 24 hours after sampling.

All records documenting the Contractor's quality control tests shall become the property of the Department upon completion of the work.

804.02.12.4--Corrective Action. The Contractor shall take prompt action to correct conditions that have resulted, or could result, in the submission to the Department of materials and products that do not conform to the requirements of the contract documents. All corrective actions shall be documented.

804.02.12.5--Non-Conforming Materials. The Contractor shall establish and maintain an effective and positive system for controlling non-conforming material, including procedures for its identification, isolation and disposition. Reclaiming or reworking of non-conforming materials shall be in accordance with procedures acceptable to the Department.

All non-conforming materials and products shall be positively identified to prevent use, shipment, and intermingling with conforming materials and products. Holding areas, mutually agreeable to the Department and the Contractor, shall be provided by the Contractor.

TABLE 4
CONTRACTOR'S MINIMUM REQUIREMENTS FOR QUALITY CONTROL

Hydraulic Cement Concrete		
Control Requirement	Frequency	AASHTO/ASTM
A. PLANT AND TRUCKS		
1. Mixer Blades	Monthly	
2. Scales		
a. Tared	Daily	
b. Calibrate	Every 6 months	
c. Check Calibration	Weekly	
3. Gauges & Meters - Plant & Truck		
a. Calibrate	Every 6 months	
b. Check Calibration	Weekly	
4. Admixture Dispenser		
a. Calibrate	Every 6 months	
b. Check Operation & Calibration	Daily	
B. AGGREGATES		
1. Sampling		T 2
2. Fine Aggregate		
a. Gradation / FM	250 yd ³ concrete	T 27
b. Moisture	Check meter against test results weekly	T 255
	2500 yd ³ concrete	
c. Specific Gravity / Absorption		T 84
3. Coarse Aggregates		
a. Gradation	250 yd ³ concrete	T 27
b. Moisture	Minimum of once daily or more as needed to control production. Check meter against test results weekly.	T 255
c. Specific Gravity / Absorption	250 yd ³ Concrete if the coarse aggregate oven dry specific gravity is less than 2.450, or 2500 yd ³ Concrete if the coarse aggregate oven dry specific gravity is greater than or equal to 2.450	T 85
C. PLASTIC CONCRETE		
1. Sampling		R 60
2. Air Content	First load then one per 50 yd ³	T 152* or T 196*
3. Slump or Flow*	First load then one per 50 yd ³	T 119* or C 1611*
4. Static Segregation*	2500 yd ³ Concrete	C 1610*
5. Compressive Strength	A minimum of one set (three cylinders) for each 100 yd ³ inclusive and one set for each additional 100 yd ³ or fraction thereof for each class concrete delivered and placed on a calendar day from a single supplier. A test shall be the average of three cylinders.	T 22*, T 23*, T 231
6. Yield	Each 400 yd ³ Concrete	T 121*
7. Temperature	With each sample	T 309

Note: For concrete categorized as a SCC mixture, the following requirements shall apply:

- (a) Substitute the appropriate AASHTO for references to other ASTM Designations listed in ASTM C1610 and C1611.
- (b) Test specimens shall be made in accordance with the above listed specifications with the exception that the concrete shall not be rodded or vibrated during casting the test specimens.

- (c) The slump flow test shall only be performed on SCC mixtures in accordance with ASTM C1611. For these mixtures AASHTO T119 is not required. For the slump flow test, the filling procedure used shall be Procedure B. Additionally, for each slump flow test, determine the T50 and VSI values in accordance with the information in Appendix X1 of ASTM C1611. There are no acceptance criteria for the T50 or VSI determinations.
- (d) The static segregation test shall only be performed on SCC mixtures.

804.02.13--Quality Assurance Sampling and Testing. Quality Assurance (QA) inspection and testing will be provided by the Department to assure that the Contractor’s Quality Control (QC) testing meets the requirements of these specifications.

Acceptance of the material is based on the inspection of the construction, monitoring of the Contractor's QC program, QC and QA test results per Subsection 804.02.13.1, and the comparison of the QA test results with the QC test results. The Department may use the results of the Contractor’s QC tests as a part of the acceptance procedures instead of the results of QA tests, provided:

- (a) The Department's inspection and monitoring activities indicate that the Contractor is following the approved QC program and, respectively,
- (b) For aggregates, the results from the Contractor's QC and the Department’s QA testing of aggregate gradations compare by both meeting the aggregate type’s gradation requirements;
- (c) For concrete, the Contractor's QC and Department’s QA testing of concrete compressive strengths compare when using the data comparison computer program with an alpha value of 0.01 for projects with 1000 cubic yards and more; or, strength comparisons are within 990 psi for projects of more than 200 but less than 1000 cubic yards.

The minimum frequency for QA testing of aggregate and plastic concrete by the Department will follow the frequencies listed in Table 5, Below.

**TABLE 5
DEPARTMENT’S MINIMUM REQUIREMENTS
FOR QUALITY ASSURANCE**

Quality Assurance Tests	Frequency	AASHTO/ASTM
A. AGGREGATES		
1. Sampling		T 2
2. Fine Aggregate Gradation and FM	250 yd ³ concrete	T 27
3. Coarse Aggregates Gradation	250 yd ³ concrete	T 27
4. Coarse Aggregate a. Specific gravity / Absorption	250 yd ³ Concrete if the coarse aggregate oven dry specific gravity is less than 2.450, or 2500 yd ³ Concrete if the coarse aggregate oven dry specific gravity is greater than or equal to 2.450	

B. PLASTIC CONCRETE		
1. Sampling		R 60
2. Air Content	Every 100 yd ³	T 152* or T 196*
3. Slump or Slump Flow*	Every 100 yd ³	T 119 or C 1611*
4. Compressive Strength	One set (three cylinders) for every 100 yd ³ inclusive. A test shall be the average of three cylinders.	T 22*, T 23*, T 231
5. Temperature	With each sample	T 309

Note: * For concrete categorized as a SCC mixture, the following requirements shall apply:

- (a) Substitute the appropriate AASHTO for references to other ASTM listed in ASTM C1611.
- (b) Test specimens shall be made in accordance with the above listed specifications with the exception that the concrete shall not be rodded or vibrated during casting the test specimens.
- (c) The slump flow test shall only be performed on SCC mixtures in accordance with ASTM C1611. For these mixtures AASHTO T119 is not required. For the slump flow test, the filling procedure used shall be Procedure B.

Periodic inspection by the Department of the Contractor's QC testing and production will continue through the duration of the project. Weekly reviews will be made of the Contractor's QC records and charts.

For aggregates, comparison of data of the Contractor's QC aggregate gradation test results to those of the Department's QA aggregate gradation test results will be made weekly during concrete production periods according to Department SOPs. When it is determined that the Contractor's QC test results of aggregate gradations are comparative to that of the Department's QA test results, then the Department will use the Contractor's QC results as a basis for acceptance of the aggregates and the Department's QA testing frequency of aggregates may be reduced to a frequency of no less than three QA tests to every 10 QC tests. If the Contractor's QC aggregate gradation test results fail to compare to those of the Department's QA aggregate gradation test results, Department testing for aggregate gradations will revert to the frequency shown in Table 5 for aggregates until the Contractor's and Department's aggregate gradation test data compare.

For concrete compressive strength, comparison of data of the Contractor's QC compressive strength test results to those of the Department's QA compressive strength test results will be made monthly during concrete production periods according to Department's *Concrete Field Manual*. When it is determined that the Contractor's QC test results of concrete compressive strengths are comparative to that of the Department's QA test results, then the Department will use the Contractor's QC results as a basis for acceptance of the concrete and the Department's QA testing frequency of concrete compressive strengths may be reduced to a frequency of no less than three QA tests to every 10 QC tests. If the Contractor's QC compressive strength test results fail to compare to those of the Department's QA compressive strength test results, Department testing will revert to the frequency shown in Table 5 for plastic concrete until the Contractor's and Department's compressive strength test data compare.

804.02.13.1--Job Control Testing.

804.02.13.1.1--Sampling. Sampling of concrete mixture shall be performed in accordance with the latest edition of the Department's *Concrete Field Manual*.

804.02.13.1.2--Slump. Slump of plastic concrete shall meet the requirements of Table 3. A check test shall be made on another portion of the sample before rejection of any load.

804.02.13.1.3--Air. Total air content of concrete shall be within the specified range for the class of concrete listed in Table 3. A check test shall be made on another portion of the sample before rejection of any load.

804.02.13.1.4--Yield. If the yield of the concrete mix design is more than plus or minus three percent ($\pm 3\%$) of the designed volume, the mix shall be adjusted by a Class III Certified Technician representing the Contractor to yield the correct volume plus or minus three percent ($\pm 3\%$). If batching of the proportions of the mixture design varies outside the batching tolerance range of the originally approved proportions by more than the tolerances allowed in Subsection 804.02.12, the new proportions shall be field verified per Subsection 804.02.10.3.

804.02.13.1.5--Temperature. Cold weather concreting shall follow the requirements of Subsection 804.03.16.1. Hot weather concreting shall follow the requirements of Subsection 804.03.16.2. Concrete with a temperature more than the maximum allowable temperature shall be rejected and not used in Department work.

The maximum acceptance temperature for Class DS concrete mixtures is 95°F.

The maximum acceptance temperature of Class C concrete mixtures is 100°F for mixtures meeting the cement replacement requirements of Subsection 701.02.2. For Class C concrete mixtures that do not meet the cement replacement requirements of Subsection 701.02.2, the maximum acceptance temperature is 95°F.

The maximum acceptance temperature for all other concrete mixtures meeting the cement replacement requirements of Subsection 701.02.2 is 95°F. The maximum acceptance temperature for all other concrete mixtures that do not meet the cement replacement requirements of Subsection 701.02.2 is 90°F.

804.02.13.1.6--Compressive Strength. Standard cured concrete compressive strength tests shall conform to the specified strength (f'_c) listed in the specifications. Concrete represented by compressive strength test below the specified strength (f'_c) may be removed and replaced by the Contractor. If the Contractor elects not to remove the material, it will be evaluated by the Department as to the adequacy for the use intended. All concrete evaluated as unsatisfactory for the intended use shall be removed and replaced by the Contractor at no additional cost to the Department. For concrete allowed to remain in place, reduction in payment will be as follows:

Projects with 1000 Cubic Yards and More. When the evaluation indicates that the work may remain in place, a statistical analysis will be made of the QC and QA concrete test results. If this statistical analysis indicates that at least 93% of the material would be expected to have a compressive strength equal to or greater than the specified strength (f'_c) and 99.87% of the material would be expected to have a compressive strength of at least one standard deviation above the allowable design stress (f_c), the work will be accepted. If the statistical analysis indicates that either of the two criteria is not met, the Engineer

will provide for an adjustment in pay as follows for the material represented by the test result.

Total Pay on Material in Question = Unit Price - (Unit Price x % Reduction)

$$\% \text{ Reduction} = \frac{(f'_c - X)}{f'_c - (f_c + s)} \times 100 \times M$$

where:

- f'_c = Specified 28-day compressive strength, psi
- X = Individual compressive strength below f'_c , psi
- s = standard deviation, psi*
- f_c = allowable design stress, psi
- M = pay reduction multiplier, per the *Concrete Field Manual*, paragraph 7.3

* Standard deviation used in the above reduction of pay formula shall be calculated from the applicable preceding compressive strengths test results plus the individual compressive strength below f'_c . If below f'_c strengths occur during the project's first ten compressive strength tests, the standard deviation shall be calculated from the first ten compressive strength tests results.

Projects of More Than 200 but Less Than 1000 Cubic Yards. When the evaluation indicates that the work may remain in place, a percent reduction in pay will be assessed based on a comparison of the deficient 28-day test result to the specified strength. The Engineer will provide for an adjustment in pay as follows for the material represented by the test result.

Total Pay on Material in Question = Unit Price - (Unit Price x % Reduction)

$$\% \text{ Reduction} = \frac{(f'_c - X)}{f'_c} \times 100 \times M$$

where:

- f'_c = Specified 28-day compressive strength, psi
- X = Individual compressive strength below f'_c , psi
- M = pay reduction multiplier, per the *Concrete Field Manual*, paragraph 7.3

804.02.13.1.7--Static Segregation. For concrete categorized as a SCC mixture, the static segregation of the plastic concrete shall meet the requirements of Subsection 804.02.10.1.2. If the static segregation of the concrete mix design exceeds this requirement, the mix shall be adjusted by a Class III Certified Technician representing the Contractor to ensure a static segregation less than the maximum allowable. If batching of the proportions of the mixture design varies outside the batching tolerance range of the originally approved proportions by more than the tolerances allowed in Subsection 804.02.12.1, the new proportions shall be field verified per Subsection 804.02.10.3.

804.02.14--Dispute Resolution. Disputes over variations between the Contractor's QC test results and the Department's QA test results shall be resolved at the lowest possible

level using the latest edition of the Department's *Concrete Field Manual*. When there are significant discrepancies between the QC test results and the QA test results, the Contractor's QC Manager, the Project Engineer, and/or the District Materials Engineer shall look for differences in the procedures, and correct the inappropriate procedure before requesting a third party resolution.

If the dispute cannot be resolved at the project or District level, the Department's Materials Division will serve as a third party to resolve the dispute. The Materials Division's decision shall be binding.

The Contractor shall be responsible for the cost associated with the third party resolution if the final decision is such that the Department's QA test results were correct. Likewise, the Department will be responsible for the cost when the final decision is such that the Contractor's QC test results were correct.

804.03--Construction Requirements.

804.03.1--Measurement of Materials.

804.03.1.1--General. The accuracy for measuring materials shall be in accordance with AASHTO M 157.

804.03.1.2--Measurement by Weighing. Except when otherwise specified or authorized, the materials shall be measured by weighing. The apparatus provided for weighing materials shall be suitably designed and constructed for this purpose. Cementitious materials and aggregates shall be weighed separately. Cement in standard bags need not be weighed, but bulk cement and other cementitious materials shall be weighed. The mixing water shall be measured by volume or by weight. All measuring devices shall be subject to approval.

804.03.2--Blank.

804.03.3--Blank.

804.03.4--Hand Mixing. Hand mixing of concrete will not be allowed.

804.03.5--Delivery. The plant supplying concrete shall have sufficient capacity and transporting apparatus to ensure continuous delivery at the rate required. The rate of delivery shall be such as to provide for the proper continuity in handling, placing, and furnishing of the concrete. The rate shall be such that the interval between batches shall not exceed 20 minutes. The methods of delivering and handling the concrete shall be that which will facilitate placing with minimum re-handling and without damage to the structure or the concrete.

804.03.6--Handling and Placing Concrete.

804.03.6.1--General. Prior to placing concrete, all reinforcement shall have been accurately placed in the position shown on the plans and fastened as set out in Section 805. All sawdust, chips, and other construction debris and extraneous matter shall have been removed from the interior of the forms. Temporary struts, braces, and stays holding the forms in correct shape and alignment shall be removed when the concrete placing has

reached an elevation rendering their service unnecessary. These temporary members shall be entirely removed from the forms and shall not be buried in the concrete.

No concrete shall be placed until the forms and reinforcement have been inspected.

Except as provided for truck mixers and truck agitators, concrete shall be placed in the forms within 30 minutes after the time that the cement is first added to the mixture.

Concrete shall be placed so as to avoid segregation of materials and displacement of reinforcement. The use of troughs, chutes, and pipes over 25 feet in length for gravity conveyance of concrete to the forms will not be permitted except when authorized by the Engineer and subject to the production of quality concrete.

Only approved mechanical conveyors will be permitted.

Open troughs and chutes shall be metal or metal lined. The use of aluminum pipes, chutes, or other devices made of aluminum that come into direct contact with the concrete shall not be used. Where steep slopes are required, the chutes shall be equipped with baffles or be in short sections that change the direction of movement.

All chutes, troughs, and pipes shall be kept clean and free from coatings of hardened concrete by thoroughly flushing with water after each run. Water used for flushing shall be discharged clear of the structure.

When placing operations involve dropping the concrete more than five feet, it shall be deposited through sheet metal or other approved pipes to prevent segregation and unnecessary splashing. The pipes shall be made in sections to permit discharging and raising as the placement progresses. A non-jointed pipe may be used if sufficient openings of the proper size are provided to allow for the flow of the concrete into the shaft. As far as practicable, the pipes shall be kept full of concrete during placing, and their ends shall be kept buried in the newly placed concrete.

Except as herein provided, concrete shall be placed in horizontal layers not more than 12 inches thick. When, with the Engineer's approval, less than the complete length of a layer is placed in one operation, it shall be terminated in a vertical bulkhead. Each layer shall be placed and compacted before the preceding layer has taken its initial set and shall be compacted so as to avoid the formation of a construction joint with the preceding layer.

If the Department determines that there is an excessive number of projections, swells, ridges, depressions, waves, voids, holes, honeycombs, or other defects in the completed structure, removal of the entire structure may be required as set out in Subsection 105.12.

804.03.6.2--Consolidation. Immediately after depositing the concrete mixture, the concrete mixture shall be thoroughly consolidated by the use of approved mechanical vibrators and suitable spading tools. Only concrete mixture that has not achieved initial set shall be consolidated. Hand spading alone will be permitted on small structural members such as railing, small culvert headwalls, and as necessary to ensure smooth surfaces and dense concrete along form surfaces, in corners, and in locations impossible to reach with vibrators. When hand spading is used for consolidation, a sufficient number of workmen with spading tools shall be provided. For hand spading, flush a thin layer of

mortar to all the surfaces and thoroughly and satisfactorily consolidate the concrete. SCC concrete shall not be consolidated by vibration.

The Contractor shall conduct operations of depositing and consolidating the concrete mixture such that the operation produces concrete that is uniformly smooth and dense, having no honeycombing or pockets of segregated aggregate.

Movement of personnel through the consolidated concrete shall not be permitted. If it is determined that it is necessary to step into previously consolidated concrete, the concrete in the stepped into area shall be consolidated again.

804.03.6.2.1--Requirements for Vibrators. Mechanical vibrators shall be subject to the following:

- (a) To verify compliance with these requirements, the Contractor shall provide the Engineer with a copy of the manufacturer's specifications for each type and brand of vibrator used on the project.
- (b) The Contractor shall provide a sufficient number of personnel with vibrators to properly consolidate each batch immediately after the concrete is placed in the forms. The Contractor shall provide at least one stand-by vibrator and required power source.
- (c) Concrete that has been consolidated shall not be walked in or through. If it is determined it is necessary to step into previously consolidated concrete, the concrete in the stepped into area shall be consolidated again.
- (d) Internal vibrators shall be of the spud or tube type, meeting the following characteristics and performance:
 - (1) The diameter of the head of the vibrator shall be 1¼ to 2½ inches.
 - (2) The frequency of vibration shall be 8000 to 12000 vibrations per minute (Hz) while operating in the concrete.
 - (3) The average amplitude shall be 0.025 to 0.05 inch while operating in air.
 - (4) The minimum radius of influence shall be seven (7) inches.
 - (5) The length of the vibrator head shall be nearly equal to the depth of the layer of concrete placed.
- (e) When the reinforcing steel is coated with epoxy, internal vibrators with heads of rubber or other resilient material shall be used. Rubber covers securely fastened over steel heads shall be acceptable.
- (f) For consolidation of concrete used in concrete bridge decks, the following additional requirements shall apply:
 - (1) Only internal vibration shall be used.
 - (2) Internal vibrators shall all be of the same type and size.
 - (3) The configuration of the internal vibrators shall meet the requirements of Subsection 804.03.6.2.3.

804.03.6.2.2--Operation of Internal Vibration. Mechanical vibrators used for internal vibration shall be operated as follows:

- (a) Vibrators shall not be dragged or moved laterally through the concrete to transport concrete. Vibrators shall not be used in such a manner that the concrete segregates or forms pockets of grout. Vibrators shall not be applied directly or through the reinforcement to sections or layers of concrete that have taken initial set.

- (b) Vibrators shall only be inserted into the concrete while operating and at the point of placement to consolidate the concrete for such a length of time that there is a general cessation in the escape of large entrapped air bubbles at the surface.
- (c) Vibrators shall be inserted slowly into the concrete and allowed to penetrate into the concrete under their own weight.
- (d) Vibrators shall be inserted into the concrete while they are in a vertical position with enough flexibility to work themselves around the reinforcing steel.
- (e) The head of the vibrator shall be completely submerged in the concrete for a time of consolidation between 3 and 15 seconds prior to removal, unless otherwise defined by the Engineer.
- (f) For consolidation of two or more layers of concrete, the vibrator shall be inserted into the bottom most layer at least six (6) inches. The vibrator shall be manipulated in a series of up-and-down motions to knit the layers together.
- (g) Vibrators shall be removed slowly from the concrete after the consolidation has been accomplished. However, once the head of the vibrator has become only partially immersed in the concrete, vibrators shall be removed rapidly.
- (h) The insertions of the vibrators shall be systematically spaced such that the entire surface of the concrete comes under the influence of the vibrator during consolidation. This includes areas around the reinforcing steel, imbedded fixtures, the corners and angles of forms, and any irregular areas. The distance between insertions shall not exceed 1.5 times the radius of influence such that the area visibly affected by the vibrator overlaps the adjacent, just-vibrated area.
- (i) For additional information, refer to ACI 309-07, Chapter 7, Sections 7.1 through 7.3

804.03.6.2.3--Method of Consolidation. The Contractor will accomplish consolidation by internal vibration using vibrators mounted on a mechanical device or an orchestrated effort utilizing personnel. Regardless of the chosen method, the method shall be included in the QCP in accordance with Subsection 804.02.12.1 and shall only receive tentative approval until the method is demonstrated as effectively meeting the requirements of Subsection 804.03.6.2.

804.03.6.3--Discontinuance of Placing. When placing is temporarily discontinued, the concrete, after becoming firm enough to retain its form, shall be cleaned of laitance and other objectionable material to a sufficient depth to expose sound concrete. To avoid visible joints insofar as possible upon exposed faces, the top surface of the concrete adjacent to the forms shall be smoothed with a trowel. Where a "feather edge" might be produced at a construction joint, such as in the sloped top surface of a wing wall, an inset form work shall be used in the preceding layer to produce a blocked out portion that will provide an edge thickness of at least six inches (6") in the succeeding layer. Work shall not be discontinued within 18 inches of the top of any face unless provision has been made for a coping less than 18 inches thick. In this case, and if permitted by the Engineer, the construction joint may be made at the underside of the coping.

Immediately following the discontinuance of placing concrete, all accumulations of mortar splashed on the reinforcement and the surface of forms shall be removed. Dried mortar chips and dust shall not be puddled into the unset concrete. If the accumulations are not removed prior to the concrete becoming set, care shall be exercised not to break or injure the concrete-steel bond at and near the surface of the concrete while cleaning the reinforcement. After initial set the forms shall not be jarred, and no strain shall be placed on the ends of projecting reinforcement until the concrete has sufficiently set to ensure against any damage by such jarring or strain.

804.03.6.4--Placing Bridge Concrete. The method and sequence of placing concrete shall conform to the provisions and requirements set forth for the particular type of construction.

804.03.6.4.1--Foundations and Substructures. Concrete seals shall be placed in accordance with Subsection 804.03.9. All other concrete for foundations shall be poured in the dry unless otherwise stipulated or authorization is given in writing by the Engineer to do otherwise. Concrete shall not be placed in foundations until the foundation area has been inspected and approved.

Unless otherwise specified, the placement of concrete in the substructure shall be in accordance with the general requirements of Subsection 804.03.6.

Unless otherwise directed, concrete in columns shall be placed in one continuous operation, and shall be allowed to set at least 12 hours before the caps are placed.

804.03.6.4.2--Superstructure. For simple spans, concrete shall preferably be deposited by beginning at the center of the span and working toward the ends. For continuous spans, concrete shall be deposited as shown on the plans. Concrete in girders shall be uniformly deposited for the full length of the girder and brought up evenly in horizontal layers. Concrete in areas below the bridge deck but which is deposited at the same time as concrete for the bridge deck like a diaphragm, shall be placed and consolidated sufficiently ahead of placing the concrete for the bridge deck such that the placing, consolidating, finishing, and curing of concrete for the bridge deck shall not be impeded or slowed.

Unless otherwise permitted by the Engineer, concrete shall not be placed in the superstructure until the column forms have been stripped sufficiently to determine the character of the concrete in the columns. Unless otherwise permitted by the Engineer, the load of the superstructure shall not be placed on pile bents until the caps have been in place at least seven (7) days and shall not be placed on other types of bents until the bents have been in place at least 14 days.

In placing concrete around steel shapes, it shall be placed on one side of the shape until it flushes up over the bottom flange of the shape on the opposite side, after which it shall be placed on both sides to completion.

Concrete in girder haunches less than three feet (3') in height shall be placed at the same time as that in the girder stem. Whenever a haunch or fillet has a height of three feet (3') or more at the abutment or columns, the haunch and the girder shall be poured in three successive stages: (a) up to the lower side of the haunch; (2) to the lower side of the girder; and (3) to completion.

Except when intermediate construction joints are specified, concrete in slab, T-beam, or deck-girder spans shall be placed in one continuous operation for each span.

The floors and girders of through-girder superstructures shall be placed in one continuous operation unless otherwise specified, in which case special shear anchorage shall be provided to ensure monolithic action between girder and floor.

Concrete in box girders shall be placed as shown on the plans.

Concrete shall not be chuted directly into the forms of the span and shall be placed continuously with sufficient speed to be monolithic and to allow for finishing before initial set.

804.03.6.4.3--Bridge Deck. When using the Transverse Method in accordance with Subsection 804.03.19.7.3, the period of time between concrete placement and completion of the final curing shall be kept to a minimum, as directed by the Engineer.

804.03.7--Pneumatic Placing. Pneumatic placing of concrete will be permitted only if specified in the contract or if authorized by the Engineer. The equipment shall be so arranged that no vibrations result that might damage freshly placed concrete.

Where concrete is conveyed and placed by pneumatic means, the equipment shall be suitable in kind and adequate in capacity for the work. The machine shall be located as close as practicable to the place of deposit. The position of the discharge end of the line shall not be more than 10 feet from the point of deposit. The discharge lines shall be horizontal or inclined upwards from the machine. At the conclusion of placement the entire equipment shall be thoroughly cleaned.

804.03.8--Pumping Concrete. Placement of concrete by pumping will be permitted only if specified in the contract or if authorized in writing by the Engineer. If used, the equipment shall be arranged so that no vibrations result that might damage freshly placed concrete.

Where concrete mixture is conveyed and placed by mechanically applied pressure (pumping), the equipment shall be suitable in kind and adequate in capacity for the work. The Contractor shall select concrete mixture proportions such that the concrete mixture is pumpable and placeable with the selected equipment.

The pumping equipment shall be thoroughly cleaned prior to concrete placement. Excess form release agent shall be removed from the concrete pump hopper. The Contractor shall prime the pump at no additional cost to the Department by pumping and discarding enough concrete mixture to produce a uniform mixture exiting the pump. At least 0.25 cubic yard of concrete mixture shall be pumped and discarded to prime the pump. Only concrete mixture shall be added directly into the concrete pump hopper after placement has commenced. If anything other than concrete mixture is added to the concrete pump hopper, all concrete mixture in the concrete pump hopper and pump line shall be discarded and the pump re-primed at no additional cost to the Department.

The discharge end of the pump shall be of such a configuration that the concrete does not move in the pump line under its own weight. The intent of this requirement is to ensure that entrained air in the concrete mixture remains entrained during pumping and depositing the concrete mixture. This shall be accomplished with one or both of the following:

- (a) a minimum 10-foot flexible hose attached to the discharge end of a steel reducer having a minimum length of three (3) feet and a minimum reduction in area of 20% which is attached to the discharge end of the pump line, or
- (b) a flexible reducing hose to the discharge end of the pump line with a minimum reduction in area of 20% over a minimum 10-foot hose length.

Regardless of the configuration chosen, the Contractor shall ensure that the concrete is pumped and does not free-fall more than five (5) feet within the entire length of pump line and after discharge from the end of pump line.

The Contractor shall not have any type of metal elbow, metal pipe, or other metal fitting within five (5) feet of any person during discharge of concrete mixture.

Boom pumps shall have a current Concrete Pump Manufacturers Association's ASME/ANSI B30.27 certification. Equipment added to the boom and pump line shall meet the pump manufacturer's specifications and shall not exceed the manufacturer's maximum recommended weight limit for equipment added to the boom and pump line.

The operation of the pump shall be such that a continuous stream of concrete without air pockets is produced. When pumping is completed, the concrete remaining in the pipe line, if it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients. After this operation, the entire equipment shall be thoroughly cleaned.

The use of aluminum pipe as a conveyance for the concrete will not be permitted.

804.03.9--Depositing Concrete Under Water. Concrete shall not be deposited in water except with the approval of the Engineer.

Concrete deposited under water shall be Class S.

Concrete deposited under water shall be carefully placed in a compact mass in its final position by means of a tremie, a bottom dump bucket, or other approved method and shall not be disturbed after being deposited. Special care shall be exercised to maintain still water at the point of deposit. No concrete shall be placed in running water and all form work designed to retain concrete under water shall be water-tight. The consistency of the concrete shall be carefully regulated, and special care shall be exercised to prevent segregation of materials.

Concrete seals shall be placed continuously from start to finish, and the surface of the concrete shall be kept as nearly horizontal as practicable at all times. To ensure thorough bonding, each succeeding layer of a seal shall be placed before the preceding layer has taken initial set.

When a tremie is used, it shall consist of a tube having a diameter of at least 10 inches and constructed in sections having flanged couplings fitted with gaskets. The means of supporting the tremie shall be such as to permit the free movement of the discharge over the entire top surface of the work and to permit it to be lowered rapidly when necessary to choke off or retard the flow of concrete. The discharge end shall be closed at the start of the work so as to prevent water entering the tube and shall be entirely sealed. The tremie tube shall be kept full to the bottom of the hopper. When a batch is dumped into the hopper, the flow of concrete shall be induced by slightly raising the discharge end, always keeping it in the deposited concrete. The flow is then stopped by lowering the tremie. The flow shall be continuous until the work is completed.

Depositing of concrete by the drop bottom bucket method shall conform to the following:

- (a) The top of the bucket shall be open.
- (b) The bottom doors shall open freely downward and outward when tripped.
- (c) The bucket shall be completely filled and slowly lowered to avoid backwash. It shall not be dumped until it rests on the surface upon which the concrete is to be deposited and when discharged shall be withdrawn slowly until well above the concrete.

Dewatering may proceed when the concrete seal is sufficiently hard and strong. As a general rule, this time will be 48 hours for concrete made with high-early-strength cement and three days for concrete made with other types of cement. All laitance and other unsatisfactory material shall be removed from the exposed surface by scraping, chipping, or other means that will not injure the surface of the concrete.

804.03.10--Construction Joints.

804.03.10.1--General. Unless otherwise approved by the Engineer, construction joints shall be made only where located on the plans or shown in the pouring schedule. If not detailed on the plans, or in the case of emergency, construction joints shall be placed as directed by the Engineer. Shear keys or inclined reinforcement shall be used where necessary to transmit shear or to bond the two sections together.

For continuous spans, bridge deck concrete shall be deposited as shown on the plans. Deviation from the pouring schedule shown in the plans is not permitted.

804.03.10.2--Bonding. Before depositing new concrete on or against concrete that has hardened, the forms shall be retightened. The surface of the hardened concrete shall be roughened as required by the Engineer and in a manner that will not leave loosened particles of aggregate or damaged concrete at the surface. It shall be thoroughly cleaned of foreign matter and laitance and saturated with water. When directed by the Engineer, the cleaned and saturated surfaces, including vertical and inclined surfaces, shall first be thoroughly covered with a coating of mortar or neat cement grout against which the new concrete shall be placed before the grout has attained its initial set.

The placing of concrete shall be carried continuously from joint to joint. The face edges of all joints that are exposed to view shall be carefully finished, true to line and elevation.

In order to bond successive courses suitable depressed or raised keys of the designated size shall be constructed. Raised keys shall be monolithic with the concrete of the lower course.

804.03.11--Concrete Exposed to Seawater. Unless otherwise specifically provided, concrete for structures exposed to seawater shall be Class AA concrete as referenced in Subsection 804.02.10. The clear distance from the face of the concrete to the nearest face of reinforcing steel shall be at least four inches. The mixing time and the water content shall be carefully controlled and regulated so as to produce concrete of maximum impermeability. The concrete shall be thoroughly compacted, and stone pockets shall be avoided. No construction joints shall be formed between the levels of extreme low water and extreme high water as determined by the Engineer. Between these levels, seawater shall not come in direct contact with the new concrete until at least 30 days have elapsed. The surface concrete as left by the forms shall be left undisturbed.

804.03.12--Blank.

804.03.13--Falsework. The Contractor shall submit to the Engineer four copies of structural design analysis and detail drawings that show the method of falsework or centering. These designs and detail plans shall be prepared and bear the seal of a Registered Professional Engineer with experience in falsework design.

Falsework plans shall include falsework elevations together with all other dimensions and details that are considered necessary for the construction. Other pertinent data needed is size and spacing of all falsework members and minimum bearing requirements for false piles.

Upon completion of falsework erection, the Registered Professional Engineer shall certify that the erected falsework is capable of supporting the load for construction.

Falsework piling shall be spaced and driven so that the bearing value of each pile is sufficient to support the load that will be imposed upon it. The bearing value of the piles should be calculated according to the appropriate formula given in Section 803.

For designing falsework and centering, a weight of 150 pounds per cubic foot shall be assumed for green concrete. All falsework shall be designed and constructed to provide the necessary rigidity and to support the loads without appreciable settlement or deformation. The Contractor may be required to employ screw jacks or hardwood wedges to take up slight settlement in the falsework either before or during the placing of concrete. An allowance shall be made for anticipated compressibility of falsework and for the placement of shims, wedges, or jacks to produce the permanent structural camber shown on the plans. If during construction, any weakness develops and the falsework shows any undue settlement or distortion, the work shall be stopped, the part of the structure affected removed, and the falsework strengthened before work is resumed. Falsework that cannot be founded on a satisfactory footing shall be supported on piling, which shall be spaced, driven, and removed, as referenced in Subsection 804.03.15, in a manner approved by the Engineer.

All structures built across a public street or highway on which maintenance of traffic is required, shall have falsework so arranged that a vertical clearance of at least 12' 6" is provided. Unless otherwise specified, a horizontal clearance of at least the width of the traveled way shall be provided at all times. If the vertical clearance is less than 13' 6" or the horizontal clearance is less than the full crown width of the roadway, the Contractor shall install and maintain appropriate safety devices, clearance signs and warning lights, and shall notify the Engineer sufficiently in advance of restricting the clearance for the Engineer to advise both the Traffic Engineering and the Maintenance Divisions. All traffic control and safety devices shall be in accordance with the MUTCD.

804.03.14--Forms.

804.03.14.1--General. Forms shall be wood, metal, or other material approved by the Engineer. All forms shall be built mortar-tight and sufficiently rigid to prevent distortion due to pressure of the concrete and other loads incident to the construction operations. Forms shall be constructed and maintained so as to prevent warping and the opening of joints due to shrinkage. The forms shall be substantial and unyielding and shall be so designed that the finished concrete will conform to the proper dimensions and contours.

The design of the forms shall take into account the effect of vibration of concrete as it is placed.

Minimum requirements for slab overhang forms shall be 3/4-inch plywood supported on 2-inch x 6-inch S4S wood timbers placed flatwise on 16-inch centers.

Adjustable brackets for support of slab overhang forms shall be spaced at a maximum distance of 3' 0" center to center unless specifically approved otherwise. Grade points for forms shall coincide with the location of the adjustable form brackets.

Forms for surfaces exposed to view shall be of uniform thickness with a smooth inside surface of an approved type. Joints in forms for exposed surfaces shall be closely fitted to eliminate fins, stone pockets, or other variations in the surface of the concrete that would mar a smooth and uniform texture.

Forms shall be filleted at all sharp corners and shall be given a bevel or draft in the case of all projections, such as girders and copings, to ensure easy removal.

Metal ties or anchorages within the forms shall be so constructed as to permit their removal, without injury to the concrete, to a depth of at least the reinforcing steel clearance shown on the plans. In case ordinary wire ties are permitted, all wires, upon removal of the forms, shall be cut back at least 1/4 inch from the face of the concrete with chisels or nippers. Nippers shall be used for green concrete. All fittings for metal ties shall be designed so that upon their removal the cavities that are left will be the smallest practicable size. The cavities shall be filled with cement mortar and the surface left sound, smooth, even, and uniform in color.

Forms shall be set and maintained to the lines designated until the concrete is sufficiently cured for form removal. Forms shall remain in place for periods determined as hereinafter specified. If forms are deemed to be unsatisfactory in any way, either before or during the placing of concrete, the Engineer will order the work stopped until the defects have been corrected.

The shape, strength, rigidity, water-tightness, and surface smoothness of reused forms shall be maintained at all times. Warped or bulged lumber shall be resized before being reused. Forms that are unsatisfactory in any respect shall not be reused.

Access to the lower portions of forms for narrow walls and columns shall be provided for cleaning out extraneous material immediately before placing the concrete.

All forms shall be treated with an approved oil or saturated with water immediately before placing the concrete. For rail members or other members with exposed faces, the forms shall be treated only with an approved oil to prevent the adherence of concrete. Any material that will adhere to or discolor the concrete shall not be used.

When metal forms are used they shall be kept free from rust, grease, or other foreign matter that will discolor the concrete. They shall be of sufficient thickness and so connected that they will remain true to shape and line, and shall conform in all respects as herein prescribed for mortar tightness, filleted corners, beveled projections, etc. They shall be constructed so as to ensure easy removal without injury to concrete. All inside bolt and rivet heads shall be countersunk.

All chamfer strips shall be dressed, straight, and of uniform width and shall be maintained as such at all times.

804.03.14.2--Stay-In-Place Metal Forms. Stay-in-place (SIP) metal forms are corrugated metal sheets permanently installed between the supporting superstructure members. After the concrete has cured, these forms shall remain in place as permanent, non-structural members of the bridge.

Pay quantities for deck concrete will be computed from the dimensions shown in the contract plans with no allowance for changes in deflection and /or changes in dimensions necessary to accommodate the SIP metal forms.

There will be no direct payment for the cost of the forms and form supports, or any material, tools, equipment, or labor incidental thereto, but the cost shall be considered absorbed in the contract unit price for concrete.

Before fabricating any material, three (3) complete sets of SIP metal form shop drawings and design calculations, bearing the Design Engineer's seal, shall be submitted to the Director of Structures, State Bridge Engineer, through the Engineer, for review. The Contractor's SIP metal form Design Engineer shall be a Mississippi Registered Professional Engineer who is knowledgeable in the field of structural design.

In no case shall additional dead load produced by the use of SIP metal forms overstress any bridge component. Design calculations shall indicate any additional dead load from SIP metal form self-weight, form support hangers, concrete in flutes, concrete due to form deflection, etc., that are not included in the plans. The additional dead loads shall be clearly labeled and tabulated on the shop drawings. Bridge Division will evaluate the additional load for overstress of the bridge components. In the event that the additional dead load produces an overstress in any bridge component, Bridge Division will reject the Contractor's design. Deflection and loads produced by deflection of the SIP metal forms shall be considered and indicated in the design calculations.

The cambers and deflections provided in the plans do not consider the effects of SIP metal forms. The Contractor's Engineer shall take into account the weight of the forms and any additional dead load when developing the "Bridge Superstructure Construction Plan".

For the purpose of reducing any additional dead load produced by the SIP metal forms, the flutes of SIP metal forms may be filled with polystyrene foam. When polystyrene foam is used to fill the forms, the form flutes shall be filled completely. No portion of the polystyrene foam shall extend beyond the limits of the flutes. The Contractor shall ensure that the polystyrene foam remains in its required position within flutes during the entire concrete placement process. The Contractor shall not use reinforcing steel supports or other accessories in such a manner as to cause damage to the polystyrene foam. All damaged polystyrene foam shall be replaced to the satisfaction of the Engineer. All welding of formwork shall be completed prior to placement of polystyrene foam.

For bridges not located in horizontal curves, the Contractor may reduce the additional dead load by matching the flute spacing with the transverse steel spacing of the bottom layer. The bottom longitudinal layer of steel shall have one (1) inch of minimum concrete cover measured from the bottom of the reinforcing to the top of the flute. The Contractor will

not be allowed to vary the reinforcing steel spacing or size from the plans for the purpose of matching flute spacing.

804.03.14.2.1--Materials. SIP metal forms and supports shall meet the requirements of ASTM A653 having a coating designation G165. Form materials that are less than 0.03-inch uncoated thickness shall not be allowed.

804.03.14.2.2--Certification. The Contractor shall provide written certification from the manufacturer stating that the product meets the requirements of this specification to the Engineer along with the delivery of the coated forms to the job site.

804.03.14.2.3--Polystyrene Foam. The polystyrene foam shall be comprised of expanded polystyrene manufactured from virgin resin of sufficient density to support the weight of concrete without deformation. The polystyrene foam shall be extruded to match the geometry of the flutes and provide a snug fit. The polystyrene foam shall have a density of not less than 0.8 pounds per cubic foot. The polystyrene foam shall have water absorption of less than 2.6% when tested according to ASTM C272. The Contractor shall provide written certification from the manufacturer stating the polystyrene foam product meets the requirements of this specification to the Engineer along with the delivery of the coated forms to the job site.

804.03.14.2.4--Design. The design of the SIP metal forms shall meet the following criteria.

- (a) The maximum self-weight of the stay in place metal forms, plus the weight of the concrete or expanded polystyrene required to fill the form flutes (where used), shall not exceed 20 psf.
- (b) The forms shall be designed on the basis of dead load of form, reinforcement, and plastic concrete plus 50 pounds per square foot for construction loads. The design shall use a unit working stress in the steel sheet of not more than 0.725 of the specified minimum yield strength of the material furnished, but not to exceed 36,000 psi.
- (c) Deflection under the weight of the forms, reinforcement, and plastic concrete shall not exceed 1/180 of the form span or 1/2 inch, whichever is less, for form spans of 10 feet or less, or 1/240 of the form span or 3/4 inch, whichever is less, for form spans greater than 10 feet.
- (d) The design span of the form shall equal the clear span of the form plus two (2) inches. The span shall be measure parallel to the form flutes.
- (e) Physical design properties shall be computed in accordance with requirements of the AISI Specifications for the Design of Cold Formed Steel Structural Members, latest published edition.
- (f) The design concrete cover required by the plans shall be maintained for all reinforcement.
- (g) The plan dimensions of both layers of primary deck reinforcement from the top surface of the concrete deck shall be maintained.
- (h) The SIP metal form shall not be considered as lateral bracing for compression flanges of supporting structural members.
- (i) SIP metal forms shall not be used under closure pours or in bays where longitudinal slab construction joints are located. SIP metal forms shall not be used under cantilevered slabs such as the overhang outside of fascia members.
- (j) Forms shall be secured to the supporting members by means other than welding directly to the member. Welding to the top flanges of steel stringers and/or girders

shall not be allowed. Alternate installation procedures shall be submitted addressing this condition.

804.03.14.2.5--Construction. SIP metal form sheets shall not rest directly on the top of the stringer of floor beam flanges. Sheets shall be fastened securely to form supports, and maintain a minimum bearing length of one (1) inch at each end for metal forms. Form supports shall be placed in direct contact with the flange of the stringer or floor beam. All attachments for coated metal forms shall be made by bolts, clips, screws, or other approved means.

804.03.14.2.6--Form Galvanizing Repairs. Where forms or their installation are unsatisfactory in the opinion of the Engineer, either before or during placement of the concrete, the Contractor shall correct the defects before proceeding with the construction work. The cost of such corrective work shall be at the sole expense of the Contractor. Minor heat discoloration in areas of welds shall not be touched up.

804.03.14.2.7--Concrete. The Contractor shall ensure concrete placement does not damage the SIP metal forms. Approved pouring sequences shall be used. The completed SIP metal form system shall be sufficiently tight to prevent leakage of mortar or concrete. The concrete shall be consolidated to avoid honeycomb and voids, especially at construction joints, expansion joints, valleys, and ends of form sheets. Calcium chloride or any other admixture containing chloride salts shall not be used in the concrete.

804.03.14.2.8--Inspection. The Engineer will observe the Contractor's method of construction during all phases of the construction of the bridge deck slab, including the installation of the SIP metal form system, location and fastening of the reinforcement, composition of concrete items, mixing procedures, concrete placement, and vibration, and finishing of the bridge deck. Should the Engineer determine that the procedures used during the placement of the concrete warrant inspection of the underside of the deck, at least one section of the metal forms shall be removed in each span for this purpose. This shall be done as soon after placing the concrete as practical in order to provide visual evidence that the concrete mix and the procedures are obtaining the desired results. An additional section shall be removed in any span if the Engineer determines that there has been any change in the concrete mix or in the procedures warranting additional inspection.

If, in the Engineer's judgment, inspection is needed to check for defects in the bottom of the deck or to verify soundness, the SIP metal forms shall be sounded with a hammer after the deck concrete has been in place a minimum of two days. If sounding discloses areas of doubtful soundness to the Engineer, the SIP metal forms shall be removed from such areas for visual inspection after the concrete has attained adequate strength. The SIP metal bridge deck forms shall be removed at no expense to the State.

At locations where sections of the metal forms have been removed, the Engineer will not require the Contractor to replace the metal forms. The adjacent metal forms and supports shall be repaired to present a neat appearance and to ensure their satisfactory retention. As soon as the form is removed, the Engineer will examine the concrete surfaces for cavities, honeycombing, and other defects. If irregularities are found and the Engineer determines that these irregularities do not justify rejection of the work, the concrete shall be repaired as directed by the Engineer. If the Engineer determines that the concrete where the form is removed is unsatisfactory, additional metal forms as necessary shall be removed to inspect and repair the slab, and the Contractor's method of construction shall be modified

as required to obtain satisfactory concrete in the slab. All unsatisfactory concrete shall be removed and replaced as directed at no expense to the State.

If the method of construction and the results of the inspections as outlined above indicate that sound concrete has been obtained throughout the slabs, the amount of sounding and form removal may be reduced when approved by the Engineer.

The Contractor shall provide a safe and convenient means of conducting the inspection.

804.03.15--Removal of Falsework, Forms, and Housing. In the determination of the time for the removal of falsework, forms and housing and the discontinuance of heating, consideration shall be given to the location and character of the structure, the weather and other conditions influencing the setting of the concrete, and the materials used in the mix. No forms or supports shall be removed prior to approval by the Engineer. During cold weather, removal of housing and the discontinuance of heating shall be in accordance with Subsection 804.03.16.1.

Concrete in the last pour of a continuous superstructure shall have attained a compressive strength of 2,400 psi, as determined by cylinder tests or maturity meter probe, prior to striking any falsework. It is important that falsework be removed as evenly as possible to prevent excessive deflection stresses in the spans.

At the Contractor's option and with the approval of the Engineer, the time for removal of forms may be determined by cylinder tests, in accordance with the requirements listed in Table 6, in which case the Contractor shall furnish facilities for testing the cylinders. The facilities shall include an approved concrete testing machine of sufficient capacity and calibrated by an acceptable commercial laboratory. Tests shall be conducted in the presence of a Department representative to witness and record strengths obtained on each break or performed by a Department certified technician in an approved testing laboratory.

The cylinders shall be cured under conditions that are not more favorable than those existing for the portions of the structure that they represent.

Table 6
Minimum Compressive Strength Requirements for Form Removal

Forms:

Columns	1000 psi
Side of Beams	1000 psi
Walls not under pressure	1000 psi
Floor Slabs, overhead	2000 psi
Floor Slabs, between beams	2000 psi
Slab Spans	2400 psi
Other Parts	1000 psi

Centering:

Under Beams	2400 psi
Under Bent Caps	2000 psi

Limitation for Placing Beams on:

Pile Bents, pile under beam	2000 psi
Frame Bents, two or more columns	2200 psi
Frame Bents, single column	2400 psi

For bridges, non-SIP metal forms for bridge deck slabs overhead and bridge deck slabs between beams shall be removed with the approval of the Engineer, between two weeks and four weeks after the removal of the wet burlap applied in accordance with Subsection 804.03.17.1, or the application of liquid membrane applied in accordance with Subsection 804.03.17.2.

In lieu of using concrete strength cylinders to determine when falsework, forms, and housings can be removed, an approved maturity meter may be used to determine concrete strengths by inserting probes into concrete placed in a structure. The minimum number of maturity meter probes required for each structural component shall be in accordance with Table 7. Falsework, forms, and housings may be removed when maturity meter readings indicate that the required concrete strength is achieved. Procedures for using the maturity meter and developing the strength/maturity relationship shall follow the requirements of AASHTO T 325 and ASTM C 1074 specifications. Technicians using the maturity meter or calculating strength/maturity graphs shall be required to have at least two hours of training prior to using the maturity equipment.

**Table 7
Requirements for use of Maturity Meter Probes**

Structure Component	Quantity of Concrete	No. of Probes
Slabs, beams, walls, & miscellaneous items	0 - 30 yd ³	2
	> 30 to 60 yd ³	3
	> 60 to 90 yd ³	4
	> 90 yd ³	5
Footings, Columns & Caps	0 - 13 yd ³	2
	> 13 yd ³	3
Pavement, Pavement Overlays	1200 yd ²	2
Pavement Repairs	Per repair or 900 yd ² , whichever is smaller	2

Methods of form removal likely to cause overstressing of the concrete shall not be used. Forms and supports shall be removed in a manner that will permit the concrete to uniformly and gradually take the stresses due to its own weight. Centers shall be gradually and uniformly lowered in a manner that will avoid injurious stresses in any part of the structure.

As soon as concrete for railings, ornamental work, parapets and vertical faces that require a rubbed finish has attained a safe strength, the forms shall be carefully removed without marring the surfaces and corners, the required finishing performed, and the required curing continued.

Prior to final inspection of the work, the Contractor shall remove all falsework, forms, excavated material or other material placed in the stream channel during construction. Falsework piles may be cut or broken off at least one foot below the mudline or ground line unless the plans specifically indicate that they are to be pulled and completely removed from the channel.

804.03.16--Cold or Hot Weather Concreting.

804.03.16.1--Cold Weather Concreting. In cold weather, the temperature of the concrete when delivered to the job site shall conform to the temperature limitations of “Temperature Limitations on Concrete when Delivered to Job Site” listed in Table 8 below. Cold weather is defined as three consecutive days when there is a probability that the daily average of the highest and lowest ambient temperatures is expected to be less than 40°F. This three-day forecast shall be based on the latest information available from the National Weather Service.

When the Contractor proposes to place concrete during seasons when there is a probability of ambient temperatures lower than 40°F, the Contractor shall have available on the project the approved facilities necessary to enclose uncured concrete and to keep the temperature of the air inside the enclosure within the ranges and for the minimum periods specified herein.

When there are indications of temperatures of less than 40°F during the first four days after placement of the concrete, the concrete shall be protected from cold temperatures by maintaining a temperature between 50°F and 100°F for at least four days after placement and between 40°F and 100°F for at least three additional days. The Contractor shall use such heating equipment such as stoves, salamanders, or steam equipment as deemed necessary to protect the concrete. When dry heat is used, means of maintaining atmospheric moisture shall be provided.

At the option of the Contractor with the approval of the Engineer, when concrete is placed during cold weather and there is a probability of ambient temperatures lower than 40°F, an approved maturity meter may be used to determine concrete strengths by inserting probes into concrete placed in a structure. The minimum number of maturity meter probes required for each structural component shall be in accordance with Table 7. An approved insulating blanketing material shall be used to protect the work when ambient temperatures are less than 40°F and shall remain in place until the required concrete strength in Table 6 is achieved. Procedures for using the maturity meter and developing the strength/maturity relationship shall follow the requirements of AASHTO T 325 and ASTM C 1074 specifications. Technicians using the maturity meter or calculating strength/maturity graphs shall be required to have at least two hours of training prior to using the maturity equipment.

One or more of the aggregates and/or mixing water may be heated. The aggregates may be heated by steam, dry heat, or by placing in the mixing water that has been heated. Frozen aggregates shall not be used. When either aggregates or water are heated above 100°F, the aggregates and water shall be combined first in the mixer before the cement is added to avoid flash set. Cement shall not be mixed with water or with a mixture of water and aggregate having a temperature greater than 100°F.

The use of salt or other chemical admixtures in lieu of heating will not be permitted.

Before placing concrete, all ice or frost shall be removed from the forms and reinforcement.

In the case of concrete placed directly on or in the ground, such as for footings or bottom slabs, protection and curing during cold weather may be provided as set for concrete pavement under Subsection 501.03.20.3.

The Contractor shall assume all risk and added cost connected with the placing and protecting of concrete during cold weather. Permission given by the Engineer to place concrete during such time will in no way relieve the Contractor of responsibility for satisfactory results. Should it be determined at any time that the concrete placed under such conditions is unsatisfactory, it shall be removed and replaced with satisfactory concrete by the Contractor without extra compensation.

**TABLE 8
COLD WEATHER TEMPERATURE LIMITATIONS ON CONCRETE
WHEN DELIVERED TO JOB SITE**

Section thickness in the least dimension inches	Jobsite Acceptance Temperature Range °F
Less than 12	55 to 75
12 to 36	50 to 70
36 to 72	45 to 65
Greater than 72	40 to 60

804.03.16.2--Hot Weather Concreting. The manufacture, placement, and protection of concrete during hot weather requires special attention to ensure that uniform slump ranges and satisfactory placement qualities are maintained, that surface cracking is held to a minimum, and that design strengths are produced.

For bridge decks when the ambient temperature is above 90°F, the forms, reinforcing steel, steel beam flanges, and other surfaces which will come in contact with the concrete shall be cooled to below 90°F by means of a water spray or other approved methods. Additionally, when the atmospheric temperature is predicted to be 90°F or above based on the latest information available from the National Weather Service any time during the day of placement or day after placement, the time of placement shall not begin until 5:00 p.m. on the day of placement and shall be completed by 6:00 a.m. the following day.

804.03.17--Curing Concrete. Curing is defined as all actions taken to ensure the moisture and temperature conditions of freshly placed concrete exist so the concrete may develop strength and result in a long lasting, durable, structural member. Curing shall take place from the time of placement until the developed strength is such that the concrete is not damaged by rapid drying or temperature gradients. The Contractor shall use the guidance in ACI 308R-01 to:

- (a) cure the concrete in such a manner as to prevent premature moisture loss from the concrete,
- (b) supply additional moisture to the concrete as required in order to ensure sufficient moisture within the concrete, and
- (c) maintain a concrete temperature beneficial to the concrete.

Curing in accordance with the requirements of Subsection 804.03.17.1 or Subsection 804.03.17.2 shall be established within 20 minutes after finishing, except as noted for

bridge decks. Finishing is considered to be complete when the pan drag, burlap drag, or other finishing methods are complete.

The required method of curing for bridge deck concrete is dependent on the method of strike-off, the type of formwork used, and whether or not lightweight aggregate (LWA) is used for internal curing. The required method of curing for each alternative is as follows:

- (a) When removable forms are used, the bridge deck concrete may be cured in accordance with Subsection 804.03.17.1 - Water With Waterproof Cover or Subsection 804.03.17.2 - Liquid Membrane.
- (b) When stay-in-place (SIP) metal forms are used in conjunction with the Transverse Method of strike-off, the bridge deck concrete shall be cured in accordance with Subsection 804.03.17.1 - Water With Waterproof Cover. See Subsections 804.03.14.2 - Stay-In-Place Metal Forms and 804.03.19.7.3 - Transverse Method.
- (c) When the Longitudinal Method or the Transverse Method of strike-off is used for repairs to bridge decks or bridge widening, the bridge deck concrete may be cured in accordance with Subsection 804.03.17.1 - Water With Waterproof Cover or Subsection 804.03.17.2 - Liquid Membrane. Additionally, the time in which the curing is applied to the bridge deck surface may be increased to 30 minutes after finishing due to the nature of the work.

When the bridge deck concrete contains LWA meeting the requirements of Subsection 703.19.2 and the mixture contains an internal curing water content of 8.0 pounds or greater per 100 pounds of total cementitious materials, the bridge deck concrete may be cured in accordance with Subsection 804.03.17.1 - Water With Waterproof Cover or Subsection 804.03.17.2 - Liquid Membrane.

The length of time for curing shall be maintained on the bridge deck surface in accordance with either of the following:

(a) Prescribed Length of Time:

- 1. Curing following the requirements of Subsection 804.03.17.1 - Water With Waterproof Cover shall continue uninterrupted for at least 17 days. This includes a 10-day period in which the concrete is kept wet continually through the use of wet burlap, soaker hoses, and white polyethylene sheets. Immediately following is a 7-day period in which a single layer of liquid membrane is applied to allow the concrete to dry slowly. For bridge decks, construction traffic may utilize the deck during the 7-day drying period, but the Contractor is required to immediately reapply liquid membrane to any marred surfaces.
- 2. Curing following the requirements of Subsection 804.03.17.2 - Liquid Membrane shall continue uninterrupted for at least 10 days.

(b) Length of Time Defined by Development of Compressive Strength:

Curing following the application requirements of Subsection 804.03.17.1 or Subsection 804.03.17.2 shall continue uninterrupted for concrete within an individual pour until the compressive strength of the concrete exceeds 75% of the 28-day compressive strength submitted as the Basis of Proportioning per Subsection 804.02.10.1.

If cured following the requirements of Subsection 804.03.17.1 - Water With Waterproof Cover, once the concrete achieves 75% of the 28-day compressive the polyethylene sheeting and wet burlap may be removed and a single layer of liquid membrane applied. For bridge decks, construction traffic may utilize the deck during the 7-day drying period but the Contractor is required to immediately reapply liquid membrane to any marred surfaces.

804.03.17.1--Water with Waterproof Cover. All burlap shall be completely saturated and wet prior to placing it on the concrete. The burlap shall have been fully soaked in water for a minimum of 12 hours prior to placement on the concrete.

For bridge decks, the Contractor shall apply one (1) layer of saturated burlap within 20 minutes of the initial strike-off for bridges without a skew and 25 minutes of the initial strike-off for bridges with a skew. For all other concrete, the Contractor shall apply one (1) layer of saturated burlap within 20 minutes of completing finishing.

For bridge decks, following the first layer of burlap, the Contractor shall apply a second layer of saturated burlap within five (5) minutes of applying the first layer.

The applied burlap shall completely cover all exposed concrete surfaces. In areas where the burlap may not be directly applied due to the concrete surface, for example, in areas where reinforcing steel protrudes thru the concrete surface, like in the areas of a bridge deck where the bridge railing will be constructed at a later time, the saturated burlap shall be draped over the steel. The concrete surface shall not be allowed to dry after strike-off or at any time during the curing period.

The Contractor shall maintain the burlap in a fully wet condition using powered fogging equipment capable of producing a fog spray of atomized droplets of water until the concrete has gained sufficient strength to allow foot traffic without the foot traffic marring the surface of the concrete. Burlap shall not be maintained in the fully wet condition using equipment that does not produce a fog spray of atomized droplets of water or by use of manually pressurized sprayers.

For bridge decks, once the concrete has gained sufficient strength to allow foot traffic that does not mar the surface of the concrete, soaker hoses shall be placed on the burlap. The soaker hoses shall then be supplied with running water continuously to maintain continuous saturation of all burlap and the entire concrete surface.

If there is a delay in the placement of the first layer of saturated burlap outside the time limit, the struck-off and finished concrete shall be kept wet by use of the powered fogging equipment used to keep the burlap wet.

White polyethylene sheets shall be placed on top of the wet burlap and, as applicable, soaker hoses, covering the entire concrete surface as soon as practical and not more than 12 hours after the placement of the concrete. White polyethylene sheets of the widest practical width shall be used, overlapping adjacent sheets a minimum of six inches (6") and tightly sealed with an adhesive like pressure sensitive tape, mastic, glue, or other approved methods to form a complete waterproof cover of the entire concrete surface. White polyethylene sheets that overlap a minimum of two feet (2') may be held in place using means other than an adhesive. The white polyethylene sheets shall be secured so that wind will not displace them. The

Contractor shall immediately repair the broken or damaged portions or replace sections that have lost their waterproof qualities.

If burlap and/or white polyethylene sheets are temporarily removed for any reason during the curing period, the Contractor shall keep the entire exposed area continuously wet. The saturated burlap and white polyethylene sheets shall be replaced, resuming the specified curing conditions, as soon as possible.

The Contractor shall inspect the bridge deck surface once every eight (8) hours for the entirety of the curing period, so that all areas remain wet for the entire curing period and all curing requirements are satisfied and document the inspection in accordance with Subsection 804.03.17.1.1.

At the end of the curing period, one coating of liquid membrane shall be applied following the requirements of Subsection 804.03.17.1.2. The purpose of the coating of liquid membrane is to allow for slow drying of the concrete. The application of liquid membrane to any area shall be complete within 30 minutes of the beginning of removal of the white polyethylene sheets, soaker hoses, and burlap from this area.

804.03.17.1.1--Documentation for Bridge Decks. The Contractor shall provide the Engineer with a daily inspection report that includes:

- (a) documentation that identifies any deficiencies found (including location of deficiency);
- (b) documentation of corrective measures taken;
- (c) a statement of certification that all areas are wet and all curing material is in place on the entire bridge deck;
- (d) documentation showing the time and date of all inspections and the inspector's signature; and
- (e) documentation of any temporary removal of curing materials including location, date and time, length of time curing was removed, and means taken to ensure exposed area was kept continuously wet.

804.03.17.1.2--Liquid Membrane. At the end of the 14-day wet curing period the wet burlap and polyethylene sheets shall be removed and within 30 minutes, the Contractor shall apply white liquid membrane to the deck. The liquid membrane shall be thoroughly mixed within the time recommended by the liquid membrane producer but no more than an hour before use. If the use of liquid membrane results in a streaked or blotched appearance, the method shall be stopped and water curing applied until the cause of defective appearance is corrected.

The liquid membrane shall be applied when no free water remains on the surface but while the surface is still wet. The liquid membrane shall be applied according to the manufacturer's instructions with a minimum spreading rate per coat of one (1) gallon per 200 square feet of concrete surface. If the concrete is dry or becomes dry, the Contractor shall thoroughly wet it with water applied as a fog spray by means of approved equipment.

The application of liquid membrane shall be accomplished by the use of power applied spray equipment using nozzles and other equipment recommended by the liquid membrane producer. Manually pressurized or manual pump-up type sprayers shall not be used to apply the first application of liquid membrane.

As a visual guide, the color of concrete covered with the required amount of liquid membrane should be indistinguishable from a sheet of commercially available standard “letter” size white copier paper placed on top of it when viewed from a distance of about five feet (5’) away horizontally if standing on the same grade as the concrete. The appearance of the concrete does not supersede applying the minimum spreading rate.

The coating shall be protected against marring for at least seven (7) days after the application of the curing compound. The coating on bridge decks shall receive extra attention and may require additional protection as required by the Engineer. All membrane marred or otherwise disturbed shall be given an additional coating. Manually pressurized or manual pump-up type sprayers may be used for giving marred areas the required additional application of liquid membrane. Should the surface coating be subjected repeatedly to injury, the Engineer may require that the water curing method be applied at once.

The 7-day period during which the liquid membrane is applied and protected shall not be reduced even if the period of wet curing is extended past the required 14 days.

804.03.17.1.2.1--Liquid Membrane Documentation. The Contractor shall make available to the Engineer an application rate verification method and any information necessary during application of the liquid membrane to verify that the rate of application meets the prescribed rate for the various surfaces of the concrete, including, but not limited to, the top surface of the bridge deck and exposed sides of the bridge deck after any forms are removed. The Contractor shall submit this application verification method to the Engineer in accordance with Subsection 804.02.12.1.1.

One method of verifying the rate of application is as follows:

- (a) Determine the volume of liquid membrane in the container. For a container with a uniform cross-sectional area, for example a 55-gallon drum, determine the area of the cross-section. Determine the height of the surface of the liquid membrane from the bottom of the container. This may be accomplished by inserting a sufficiently long, clean dip-stick parallel with the axis of the container into the liquid membrane until the inserted end of the dip-stick contacts the bottom of the container. On removing the dip-stick, measure the length from the end that was inserted to the point on the dip-stick where the liquid membrane ceases to coat the dip-stick. Multiply the area of the cross-section by the height of the level of liquid membrane, maintaining consistent units, to determine the volume.
- (b) Perform step 1 prior to beginning application of the liquid membrane to establish the initial volume.
- (c) During the period of application, perform step 1 each 100 square feet of bridge deck.
- (d) In order to meet the required application rate of one (1) gallon per 200 square feet, the amount in the container shall be at least 0.5 gallon less than the previous volume in the previous 100 square feet. Other changes in volume may apply depending on the manufacturer’s recommended application rate.
- (e) Additional applications to an area shall be applied until the required rate is satisfied. Areas that are not visually satisfactory to the Engineer shall have additional liquid membrane applied as directed by the Engineer.

The amount of liquid membrane applied shall be determined each day using the application verification method. This information shall be submitted to the Engineer within 24 hours of applying the liquid membrane.

804.03.17.2--Liquid Membrane Method. All surfaces on which curing is to be by liquid membrane shall be given the required surface finish prior to the application of liquid membrane. Concrete surfaces cured by liquid membrane shall receive two applications of white liquid membrane. Neither application shall be made from a position supported by or in contact with the freshly placed concrete. Both applications shall be applied perpendicularly to the surface of the concrete.

When using liquid membrane, the liquid membrane shall be thoroughly mixed within the time recommended by the liquid membrane producer but no more than an hour before use. If the use of liquid membrane results in a streaked or blotched appearance, the method shall be stopped and water curing applied until the cause of defective appearance is corrected.

The application of liquid membrane shall be accomplished by the use of power applied spray equipment using nozzles and other equipment recommended by the liquid membrane producer. Manually pressurized or manual pump-up type sprayers shall not be used to apply the first two applications of liquid membrane.

The liquid membrane shall be applied when no free water remains on the surface but while the surface is still wet. The liquid membrane shall be applied according to the manufacturer's instructions with a minimum spreading rate per coat of one (1) gallon per 200 square feet of concrete surface. If the concrete is dry or becomes dry, the Contractor shall thoroughly wet it with water applied as a fog spray by means of approved equipment.

The first application of the liquid membrane shall be made as the work progresses. For bridge decks, the first application shall be completed in each area of the deck, including the area in which the bridge railing will be later constructed, within 20 minutes of initial strike-off for bridges with no skew and within 25 minutes of initial strike-off for bridges with skew. For all other concrete, the first application of the liquid membrane shall be completed within 20 minutes of finishing.

The second application shall be applied within 30 minutes after the first application. The liquid membrane shall be uniformly applied to all exposed concrete surfaces.

As a visual guide, the color of concrete covered with the required amount of liquid membrane should be indistinguishable from a sheet of commercially available standard "letter" size white copier paper placed on top of it when viewed from a distance of about five feet (5') away horizontally if standing on the same grade as the concrete. The appearance of the concrete does not supersede applying the minimum spreading rate.

The Contractor shall make available to the Engineer an application rate verification in accordance with Subsection 804.03.17.1.2.1.

The coating shall be protected against marring for at least 10 days after the application of the curing compound. The coating on bridge decks shall receive extra attention and may require additional protection as required by the Engineer. All membrane marred or otherwise disturbed shall be given an additional coating. Manually pressurized or manual pump-up type sprayers may be used for giving marred areas the required additional

application of liquid membrane. Should the surface coating be subjected repeatedly to injury, the Engineer may require that the water curing method be applied at once.

After the specified time for curing, but prior to constructing the bridge railing, all liquid membrane shall be removed from both the exposed surfaces of the reinforcing steel and the concrete surfaces on which bridge rail will be constructed. This removal of liquid membrane may be accomplished by high pressure washing or other methods approved by the Engineer.

804.03.18--Expansion and Fixed Joints, Bearings, Anchor Bolts, Plates, Castings, Pipes, Drains, Conduits, Etc. All joints shall be constructed according to details shown on the plans. The edges of the concrete at open or filled joints shall be chamfered or edged as indicated on the plans.

804.03.18.1--Open Joints. Open joints shall be placed in the locations shown on the plans and shall be constructed by the insertion and subsequent removal of a wood strip, metal plate, or other approved material. The insertion and removal of the template shall be accomplished without chipping or breaking the corners of the concrete. Reinforcement shall not extend across an open joint unless so specified on the plans.

804.03.18.2--Filled Joints. Poured expansion joints and joints to be sealed with premolded materials shall be constructed similar to open joints. When premolded types are specified, the filler shall be placed in correct position as the concrete on one side of the joint is placed. When the form is removed, the concrete on the other side shall be placed. Adequate water stops of metal, rubber, or plastic shall be carefully placed as shown on the plans.

804.03.18.3--Premolded and Preformed Joint Seals. When preformed elastomeric compressive joint seals are specified, the previously formed and cured open joint shall be thoroughly cleaned of all foreign matter, the required adhesive uniformly applied, and the seal installed in accordance with the recommendations of the manufacturer of the seal.

When premolded filler is used for the joints in the roadway slab, the tops shall be adequately sealed with poured joint filler in accordance with details on the plans. Premolded filler shall be permanently fastened to an adjacent concrete surface by appropriate use of copper wire, copper nails, or galvanized nails.

804.03.18.4--Steel Joints. The plates, angles, or other structural shapes shall be accurately shaped at the shop to conform to the section of the concrete floor. Fabrication and painting shall conform to the specifications covering those items. When called for on the plans or in the special provisions, the material shall be galvanized in lieu of painting. Care shall be taken to ensure that the surface in the finished plane is true and free of warping. Positive methods shall be employed in placing the joints to keep them in correct position during the placing of the concrete. The opening at expansion joints shall be that designated on the plans at normal temperature, and care shall be taken to avoid impairment of the clearance in any manner.

804.03.18.5--Water Stops. Adequate water stops of metal, rubber, or plastic shall be placed as shown on the plans. Where movement at the joint is provided for, the water stops shall be of a type permitting movement without injury. They shall be spliced, welded, or soldered to form continuous watertight joints.

804.03.18.6--Bearing Devices. Bearing plates, rockers, and other bearing devices shall be constructed according to details shown on the plans. Unless otherwise specified or set in plastic concrete, they shall be set in grout to ensure uniform bearing. Structural steel and painting shall conform to the requirements of Sections 810 and 814. When specified, the material shall be galvanized in lieu of painting. The rockers or other expansion bearing devices shall be set, considering the temperature at the time of erection, so that the required position of the device is provided.

At all points of bearing contact, concrete members shall be separated from underlying members by dimensioned bearing pads or by methods and/or materials specified on the plans.

When not otherwise specifically provided, contact areas between concrete super-structures and substructures shall be separated by three layers of No. 15, Type I, roofing felt.

804.03.18.7--Friction Joints. Metal friction joints shall consist of plates as indicated on the plans and shall be securely anchored in correct position. All sliding surfaces shall be thoroughly coated with an approved graphite grease. Movement shall not be impeded by the concrete in which the plates are embedded.

804.03.18.8--Placing Anchor Bolts, Plates, Castings, Grillage, Conduits, Etc. All anchor bolts, plates, castings, grillage, conduits, etc. indicated on the plans to be placed in or on the concrete shall be placed, set, or embedded as indicated or as directed. These items of the construction shall be set in hydraulic cement mortar as referenced in Subsection 714.11.5, except that anchor bolts may, as permitted by the Engineer, be built into the masonry, set in drilled holes, or placed as the concrete is being constructed by inserting encasing pipe or oiled wooden forms of sufficient size to allow for adjustment of the bolts. After removal of the pipe or forms, the space around the bolts shall be filled with hydraulic cement mortar completely filling the holes. The bolt shall be set accurately and perpendicular to the plane of the seat.

Anchor bolts to be set in the masonry prior to the erection of the superstructure shall be carefully set to proper location and elevation with a template or by other suitable means.

When bed plates are set in mortar, no superstructure or other load shall be placed thereon until this mortar has been allowed to set for a period of at least 96 hours, subject to the restrictions for cold weather concreting in Subsection 804.03.16.1. The mortar shall be kept well moistened during this period.

Weep hole drains shall be installed in abutments and retaining walls, and roadway drains or scuppers shall be installed in the roadway slabs in accordance with the details shown on the plans.

Where backfill is to be made at weep holes or openings in the structure, sand or stone chimneys or French drains shall be constructed as specified and shall extend through the portion of the backfill to be drained. Except as otherwise provided, the sand, stone, or slag used in this construction shall meet the requirements of Subsection 704.04.

804.03.19--Finishing Concrete Surfaces.

804.03.19.1--Classes of Finishes. Surface finishes of exposed concrete surfaces shall be classified as follows:

- Class 1 - Ordinary Surface Finish
- Class 2 - Rubbed or spray Finish
- Class 3 - Tooled Finish
- Class 4 - Sand-Blast Finish
- Class 5 - Wirebrush or Scrubbed Finish
- Class 6 - Floated Surface Finish

804.03.19.2--Class 1, Ordinary Surface Finish. Immediately following the removal of forms, all fins and irregular projections shall be removed from all surfaces except from those that are not to be exposed or not to be waterproofed. On all surfaces, the cavities produced by form ties and all other holes, honeycomb spots, broken corners or edges, and other defects shall be thoroughly cleaned, and after having been kept saturated with water for at least three hours, shall be carefully pointed and trued with a mortar of cement and fine aggregate mixed in the proportions used in the class of the concrete being finished. Mortar used in pointing shall be not more than one hour old. The mortar patches shall be cured as specified under Subsection 804.03.17. All construction and expansion joints shall be left carefully tooled and free of mortar and concrete. The joint filler shall be left exposed for its full length with clean and true edges.

The resulting surfaces shall be true and uniform. All surfaces that cannot be repaired to the satisfaction of the Engineer shall be given a Class 2 rubbed finish.

804.03.19.3--Class 2, Rubbed or Spray Finish.

804.03.19.3.1--Rubbed Finish. After removal of forms, the Class 1 finish shall be completed and the rubbing of concrete shall be started as soon as its condition will permit. Immediately before starting this work, the concrete shall be kept thoroughly saturated with water for at least three hours. Surfaces shall be rubbed with a medium course Carborundum stone using a small amount of mortar on its face. The mortar shall be composed of cement and sand mixed in the proportions used in the concrete being finished. Rubbing shall be continued until all form marks, projections, and irregularities have been removed, all voids are filled, and a uniform surface has been obtained. The paste produced by this rubbing shall be left in place at this time.

After all concrete above the surface being treated has been cast, the final finish shall be obtained by rubbing with a fine Carborundum stone and water. This rubbing shall continue until the entire surface is of a smooth texture and uniform color.

After the final rubbing is completed and the surface has dried, it shall be rubbed with burlap to remove loose powder and objectionable marks.

804.03.19.3.2--Spray Finish. Prior to the spray finish, the concrete shall be given a Class 1 finish in accordance with Subsection 804.03.19.2, supplemented if necessary with a grout meeting the requirements of Subsection 714.11 with fine aggregate modified to require 100 percent passing the No. 16 Sieve.

Grout shall be applied with burlap pads or float sponges. As soon as the grout has dried, the surface shall be brushed to remove all loose grout and the surface left smooth and free

of air holes. Surfaces to be sprayed shall be free of efflorescence, flaking coatings, dirt, oil, and other foreign substances. Prior to application of the spray finish, the surfaces shall be free of moisture, as determined by sight and touch, and in a condition consistent with the manufacturer's published recommendations.

The spray finish material shall meet the requirements of Subsection 714.12 and shall be listed on the Approved Sources of Materials. The spray finish shall be applied with heavy duty spray equipment capable of maintaining a constant pressure as necessary for proper application. The material shall be applied as recommended by the manufacturer except the rate of application shall not be less than one gallon per 50 square feet of surface area without prior written approval of the Engineer.

The completed finish shall be tightly bonded to the structure and present a uniform appearance and texture equal to or better than a rubbed finish. If necessary, additional coats shall be sprayed to produce the desired surface texture and uniformity. Upon failure to adhere positively to the structure without chipping or cracking or to attain the desired surface appearance, the coatings shall be completely removed and the surface given a rubbed finish in accordance with Subsection 804.03.19.3.1, or other approved methods shall be used to obtain the desired surface finish to the satisfaction of the Engineer without additional cost to the State.

804.03.19.4--Classes 3, 4, and 5 Finishes. If required, specifications for these finishes will be contained in the special provisions.

804.03.19.5--Class 6, Floated Surface Finish. After the concrete has been deposited in place, it shall be consolidated and the surface shall be struck off by means of a strike board and floated with a wooden or cork float. An edging tool shall be used on edges and expansion joints. The surface shall not vary more than 1/8 inch under a 10-foot straightedge. The surface shall have a granular or matte texture that will not be slick when wet.

804.03.19.6--Required Finishes for Various Surfaces.

804.03.19.6.1--General. Unless otherwise specified, the top surface of sidewalks, the top horizontal surfaces of footings, and the top slabs of box bridges, box culverts, or other structures shall be given a Class 6 finish. All formed concrete surfaces shall be given a Class 1 finish, except on surfaces that are completely enclosed, such as the inside surfaces of cells of box girders, the removal of fins and form marks and the rubbing of mortared surfaces to a uniform color will not be required.

In reference to finishing, exposed surfaces are surfaces or faces that may be seen after all backfill has been placed. Exposed surfaces requiring a Class 2 finish shall be finished at least one foot below the ground line or the low water elevation, whichever is higher.

The Class 2 finish shall be made upon a Class 1 finish. After the removal of forms, the Class 1 finish shall be completed and the rubbing of concrete shall be started as soon as the condition of the concrete will permit.

Bridge floors shall be finished in accordance with Subsection 804.03.19.7.

804.03.19.6.2--Finishing Formed Concrete Surfaces of Box Bridges, Box Culverts, Pipe Headwalls, and Minor Structures. The exposed surfaces of wing walls and parapets of box bridges and box culverts to be used as vehicular or pedestrian underpasses shall be given a Class 2 finish. Exposed surfaces of other box culverts or box bridges, pipe culvert headwalls, and other minor structures shall be given a Class 1 finish unless otherwise indicated on the plans.

The exposed surfaces of retaining walls including copings and parapets shall receive a Class 2 finish.

804.03.19.6.3--Finishing Formed Concrete Surface of Bridges. All exposed formed concrete bridge surfaces shall have a Class 1 or 2 finish as set forth in this subsection unless designated otherwise on the plans.

Bridges with designated surfaces for Class 2 finish are classified as follows:

- Group A - Bridges over highways, roads and streets.
- Group B - Bridges over waterways and railroads.
- Group BB - Twin or adjacent bridges of Group B category.

When a Group B or BB bridge also spans a highway, road or street, exposed concrete surfaces shall be finished in accordance with Group A requirements.

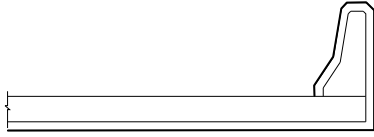
(A) Superstructures. Concrete surfaces to be given a Class 2 finish shall be the exposed surfaces of wings and rails and other exposed surfaces indicated by a double line in Figures 804-1, 804-2, and 804-3.

When a Group B or BB also spans a highway, road or street, the superstructure of spans over and extending one span in each direction beyond the lower level highway, road or street shall be given a Class 2 finish as shown for Group A.

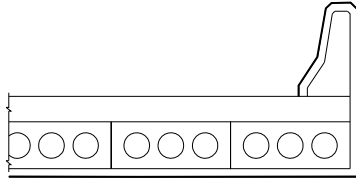
(B) Substructures. Concrete surfaces to be given a Class 2 finish are as follows:

Group A. Exposed surfaces of abutments, end bents, end bent posts, wing walls, railing, retaining walls, parapets, copings, piers, columns, piles, caps, struts or walls between columns or piles, encasement of steel piles, arch rings and spandrel walls.

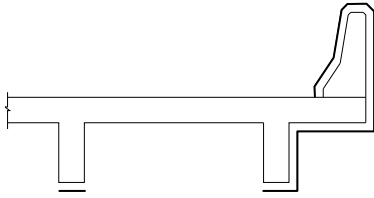
Group B and BB. Exposed surfaces of abutments, wing walls, end bent posts, railing, retaining walls, parapets and copings.



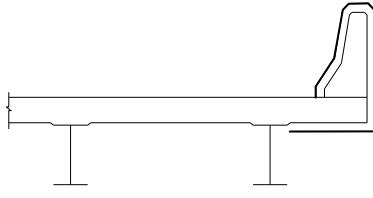
CONCRETE SLAB SPAN & HOLLOW SLAB SPAN



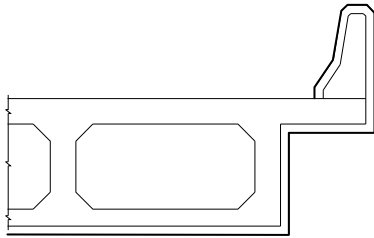
PRECAST HOLLOW SLAB SPAN



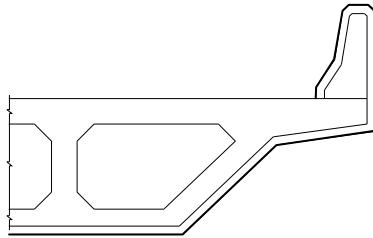
CONCRETE GIRDER SPAN



STEEL BEAM SPAN

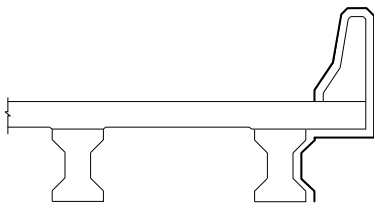


Vertical Face

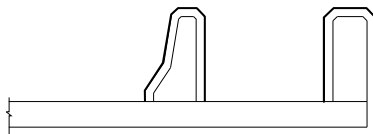


Slope Face

CONCRETE BOX GIRDER SPAN



PRESTRESSED CONCRETE BEAM SPANS



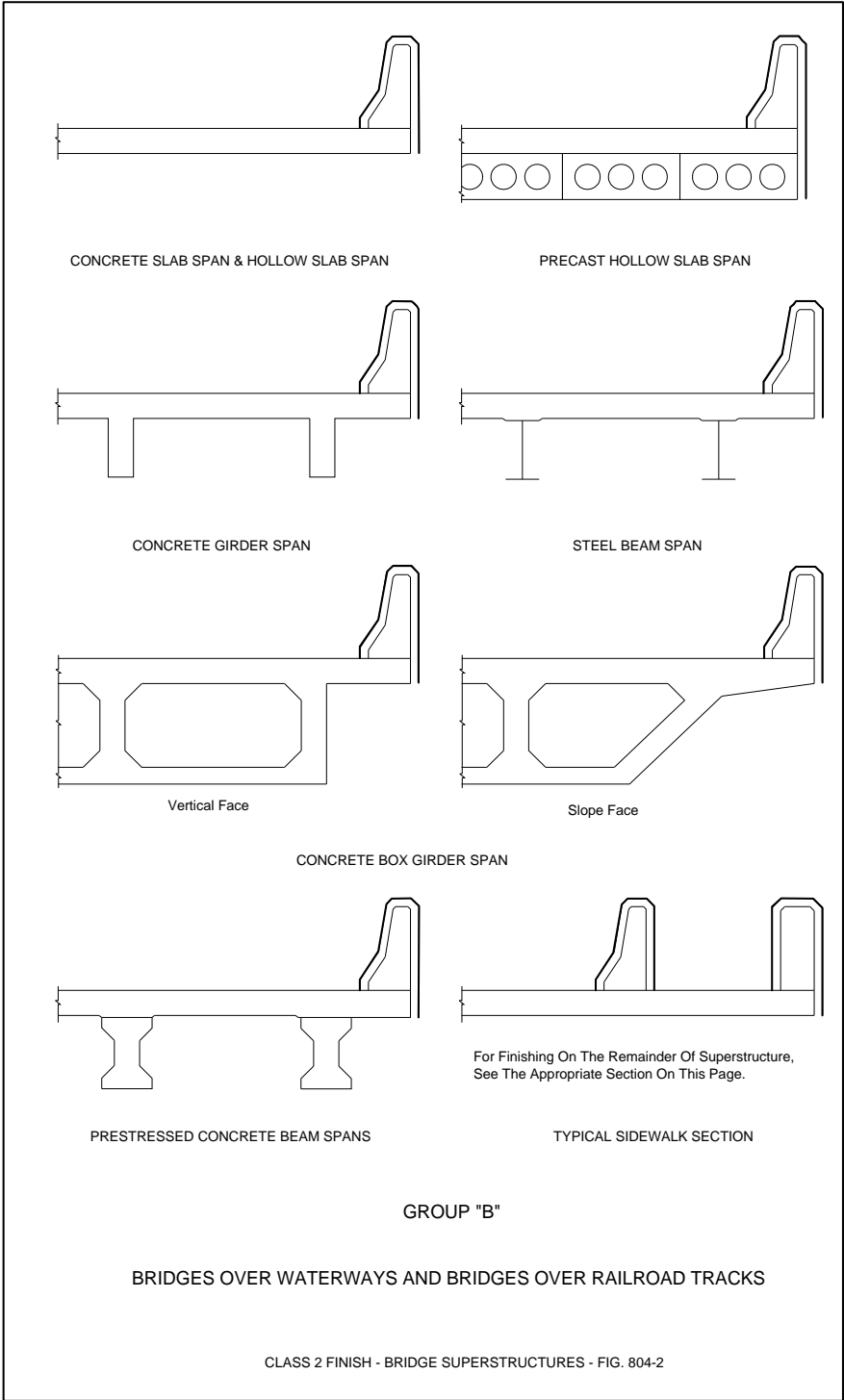
For Finishing On The Remainder Of Superstructure,
See The Appropriate Section On This Page.

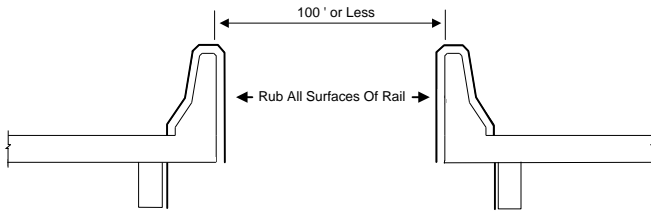
TYPICAL SIDEWALK SECTION

GROUP "A"

BRIDGES OVER HIGHWAYS, ROADS & STREETS

CLASS 2 FINISH - BRIDGE SUPERSTRUCTURES - FIG. 804-1





GROUP "B B" - ADJACENT BRIDGES

GROUP "B B"

TWIN or DUAL BRIDGES

CLASS 2 FINISH - BRIDGE SUPERSTRUCTURES - FIG. 804-3

804.03.19.7--Finishing Bridge Decks.

804.03.19.7.1--General. Concrete bridge decks shall be struck off and finished by the method(s) designated on the plans.

In the event a method is not designated, the Contractor may use either the longitudinal or transverse method subject to the requirements contained in these specifications.

Except when indicated otherwise on the plans, the finish of the bridge deck shall be a belt finish, a broom finish, or one of the following drag methods: pan, double pan, burlap, or pan and burlap. Manual finishing of the bridge deck shall be performed only in areas inaccessible by the finishing equipment mounted to the strike-off screed, but shall not hinder the requirements for curing in accordance with Subsection 804.03.17.1. The surface texture specified and surface requirements shall be in accordance with the applicable requirements of Subsections 501.03.17 and 501.03.18 modified only as the Engineer deems necessary for bridge deck construction operations.

At no time shall water on the surface of the concrete from bleeding, fogging, curing, or other sources be worked into the concrete or used as an aid for finishing.

Regardless of the method of finishing selected, requirements for curing per Subsection 804.03.17 shall be completed within the specified time limits. If the requirements in Subsection 804.03.17 are not completed within the specific time limits, the Contractor shall cease operations, revise his operations up to and including acquiring new or additional equipment or additional personnel in order to satisfy the requirements in Subsection 804.03.17, and, on approval from the Engineer, resume operations.

804.03.19.7.2--Longitudinal Method. The longitudinal method may be used for repairs to bridge decks or bridge widening projects. For bridge widening projects, curing in accordance with Subsection 804.03.17 shall be completed within 30 minutes of initial strike-off for bridges without skew and within 35 minutes of initial strike-off for bridges with skew.

The longitudinal method requires that the strike-off screed be supported on accurately graded and supported bulkheads or templates placed across the full width at the end(s) of the pour. Before the concrete is placed, approved fixed templates or wooden bulkheads of not less than 1¼-inch lumber shall be placed perpendicular to the centerline of the roadway, or in the case of skew bridges at the angle of skew. At least one dry run shall be made the length of each pour with a "tell-tale" device attached to the screed to assure the specified clearance to the reinforcing steel. The upper surface of the template or bulkheads shall be accurately set to conform to the required grade and crown.

Special attention shall be given to the gutter lines where the strike-off screed cannot reach. The gutters shall be finished by hand and tested with the straight edge. Floor drains shall be set lower than the finished gutter line and finished over. After initial set, the concrete shall be dishd out and finished around the drains to form an outlet.

After the concrete has been deposited and rough graded, it shall be struck off by means of a strike-off screed resting on the bulkheads or fixed templates. The strike-off screed shall be of a type satisfactory to the Engineer and shall have sufficient strength to retain its shape

under all working conditions. The final surface shall comply with the applicable requirements of Subsections 501.03.17.6 and 501.03.18, and unless otherwise specified in the contract, the final finish under this method shall be the belt finish.

In general, the overall strike-off screed should be trussed, with bracing heavy enough to support the weight of a man without deflecting, and should be adjustable for camber and correction of sag.

The strike-off screed will ride on the bulkheads or fixed templates at the ends of the section being finished. Care shall be taken to see that the bulkhead or fixed template elevations are accurately set since the entire span surface will be controlled by them. The manipulation of the screed shall be such that neither end is raised from the bulkheads or templates during the process.

The concrete shall be struck off by beginning at one curb and proceeding entirely across the span. A slight excess of concrete shall be kept in front of the cutting edge at all times. This operation shall be repeated at least three times. In each case, the strike-off screed shall be picked up and carried back to the point of beginning. No backward strokes will be allowed. The strike-off screed shall be moved along the bulkheads or fixed templates with a combined longitudinal and transverse motion. This operation may be manual or mechanical. Standing or walking in the fresh concrete ahead of the strike-off screed will not be permitted.

804.03.19.7.3--Transverse Method. The transverse method requires that the screeding equipment be supported on accurately graded and supported rails placed beyond the gutter lines and parallel with the centerline of the bridge.

The machine shall be constructed and operated in a manner that produces a bridge deck of uniform density with minimum manipulation of the fresh concrete in the shortest possible time. Manual transverse methods of screeding will not be permitted.

The finishing machine shall be supported on vertically adjustable rails set a sufficient distance from the gutter line to allow free movement of the screed from gutter line to gutter line. Satisfactory means of load distribution with minimum rail deflection shall be provided. The screed rails for a deck pour shall be completely in place for the full length of the pour and shall be firmly secured prior to placing concrete. The screed rails shall be adjusted as necessary to compensate for settlement and deflection occurring during the screeding operations. Supports for the screed rail shall be located directly over slab overhang support brackets as referenced in Subsection 804.03.14.1.

At least one dry run shall be made the length of each pour with a "tell-tale" device attached to the screed carriage to assure the specified clearance to the reinforcing steel.

The screed shall be equipped with a metal cutting edge or other approved mechanical means for accurately fine grading the plastic concrete to the required grade and surface smoothness and shall be supported by a bridging structure sufficiently rigid and heavy to perform operations satisfactorily on concrete of minimum slump without vibration, distortion, and wrecking of forms. The screed shall be mechanically actuated to deliver the screeding action and for travel in a longitudinal direction at a uniform rate along the bridge deck.

The screed shall complete sufficient passes to strike off all of the excess concrete with ample mortar along the entire leading edge to assure filling of low spots. Care shall be taken to remove all objectionable material from the gutters where final hand finishing will be required.

The selection of the transverse method may require the Contractor to furnish bridge deck concrete that contains an approved water-reducing set-retarding admixture in the quantities approved by the Engineer at no additional cost to the State. See Subsection 713.02 for more information.

Other finishing requirements shall be in accordance with the general requirements in Subsection 804.03.19.7.1 and as specified on the plans.

804.03.19.7.4--Acceptance Procedure for Bridge Deck Smoothness. After the bridge decks and bridge end slabs are completed and preferably before the construction of the bridge railing, they shall be tested for ride quality using a Contractor furnished profilograph. Profile Index Values shall be determined in accordance with Department SOPs and these specifications. The profilograph shall meet the requirements of Subsection 804.03.19.7.5. Profiles will be obtained in the wheel paths of the main thru lanes and, where conditions allow, in the wheel paths of any auxiliary lanes or tapers. Profile Index Values for bridge decks and bridge end slabs shall be obtained for all State roads with four lanes or more, on State roads three lanes or less where the current traffic count is 2000 ADT or higher, or as designated on the plans. Ride quality tests will begin at a point where the rearmost wheel of the profilograph is as close to the beginning of the bridge end slab as possible and shall proceed forward across the remainder of the bridge end slab, across the bridge deck and continue across the next bridge end slab to a point where the front-most wheel of the profilograph reaches the far-most edge of the bridge end slab. In addition to the Profile Index test, all bridge decks and bridge end slabs shall meet a 1/8 inch in 10-foot straightedge requirement in both the longitudinal and traverse directions. Bridges and bridge end slabs not requiring a ride quality test must meet a 1/8 inch in 10-foot straightedge requirement in both the longitudinal and transverse directions. Bridges in horizontal curves having a radius of less than 1000 feet at the centerline and bridges within the superelevation transition of such curves are excluded from a test with the profilograph.

The Profile Index Value for bridge decks including the bridge end slabs shall be averaged for the left and right wheel path for each lane and where applicable, each auxiliary lane and taper, and shall not exceed 65 inches per mile for each lane. Auxiliary lanes, tapers, shoulders and other areas that are not checked with the profilograph, shall meet a 1/8 inch in 10-foot straightedge check made transversely and longitudinally across the deck or slab. In addition, individual bumps or depressions exceeding 0.3 of an inch, when measured from a chord length of 25 feet, shall be corrected and the surface shall meet a 1/8 inch in 10-foot straightedge check made transversely across the deck or slab.

Bridge decks and bridge end slabs not meeting the preceding requirements shall be corrected. Corrective work shall be done at no additional cost to the Department. Corrective work shall consist of grinding the bridge deck in accordance with this specification. All corrective work shall precede final surface texturing. After completion of final surface texturing, all surface areas corrected by grinding shall be sealed with a nonstaining 40% minimum alkylalkoxysilane penetrating sealant applied per the manufacturer's directions.

In case the bridge end slabs are to be constructed on a future project, the bridge deck(s) alone shall be tested for ride quality using the acceptance procedure outlined above, except that the ride quality test will begin at a point where the rearmost wheel of the profilograph is as close to the beginning of the bridge as possible and shall proceed forward across the bridge deck to a point where the front-most wheel of the profilograph reaches the far-most edge of the bridge.

Expansion joint installation shall be delayed and the joint temporarily bridged to facilitate operation of the profilograph and grinding equipment across the joint wherever feasible.

It shall be the Contractor's responsibility to schedule profilograph testing. The Contractor shall notify the Department at least five (5) days in advance of profilograph testing. The Contractor shall ensure that the area to be tested has been cleaned and cleared of all obstructions. Profilograph testing of bridge decks and bridge end slabs shall be performed by the Contractor under supervision of the Engineer. All profilograph testing shall be performed at no additional cost to the Department. The Contractor will be responsible for traffic control associated with this testing operation.

804.03.19.7.4.1--Grinding Bridge Decks.

804.03.19.7.4.1.1--Equipment. The grinding equipment shall be a power driven, self-propelled machine that is specifically designed to smooth and texture hydraulic cement concrete pavement with diamond blades. The effective wheel base of the machine shall not be less than 12.0 feet. It shall have a set of pivoting tandem bogey wheels at the front of the machine and the rear wheels shall be arranged to travel in the track of the fresh cut pavement. The center of the grinding head shall be no further than 3.0 feet forward from the center of the back wheels.

The equipment shall be of a size that will cut or plane at least 3.0 feet wide. It shall also be of a shape and dimension that does not encroach on traffic movement outside of the work area. The equipment shall be capable of grinding the surface without causing spalls at cracks, joints, or other locations.

804.03.19.7.4.1.2--Grinding. The grinding areas will be determined by the Contractor and approved by the Engineer. The Contractor shall develop and submit to the Engineer for approval a Grinding Plan. The Contractor shall allow up to 45 days for the Department to review the Plan prior to starting any grinding operations. This plan shall include as a minimum:

- (a) Name of the project superintendent in charge of the grinding operation.
- (b) List and description of all equipment to be used.
- (c) Maximum depth of each pass allowed by the grinding equipment.
- (d) Maximum width of each pass allowed by the grinding equipment.
- (e) Details of a sequence of the grinding operation.
- (f) Complete data from Profilograph runs, based on a 0.3 inch bump height, for each wheel path over the entire bridge including bridge end slabs, which shall include profile index, bump locations (in stations), bump heights and proposed final cross-slopes. When a computerized profilograph is used, a complete printout of the profile including the header information for each wheel path will be required.
- (g) Data showing reinforcing steel clearance in all areas to be ground.

- (h) A detailed drawing of the deck showing areas to be ground with station numbers and grinding depths clearly indicated.
- (i) A description of grinding in areas where drains are in conflict with grind areas.
- (j) Details of any changes in deck drainage, anticipated ponding, etc.

The Engineer will evaluate the grinding plan for conformance with the plans and specifications, after which the Engineer will notify the Contractor of any additional information required and/or changes that may be needed. Any part of the plan that is unacceptable will be rejected and the Contractor shall submit changes for reevaluation. All approvals given by the Engineer shall be subject to trial and satisfactory performance in the field, and shall not relieve the Contractor of the responsibility to satisfactorily complete the work.

The construction operation shall be scheduled and proceed in a manner that produces a uniform finished surface. Grinding will be accomplished in a manner that eliminates joint or crack faults while providing positive lateral drainage by maintaining a constant cross-slope between grinding extremities in each lane. Auxiliary or ramp lane grinding shall transition as required from the mainline edge to provide positive drainage and acceptable riding surface.

The operation shall result in a finished surface that conforms as close as possible to the typical cross-section and the requirements specified in Subsection 804.03.19.7.4.1.3.

The Contractor shall establish positive means for removal of grinding residue. Residue shall not be permitted to flow across lanes used by public traffic or into gutters or drainage facilities.

804.03.19.7.4.1.3--Final Surface Texture. The grinding process shall produce a finish surface that is as close as possible to grade and uniform in appearance with a longitudinal line type texture. The line type texture shall contain parallel longitudinal corrugations that present a narrow ridge corduroy type appearance. The peaks of the ridges shall be approximately 1/16 inch higher than the bottoms of the grooves with approximately 53 to 57 evenly spaced grooves per foot. Grinding chip thickness shall be a minimum of 0.080 inches thick.

The finished bridge decks and bridge end slabs shall be retested for riding quality using a Contractor furnished profilograph meeting the requirements of Subsection 804.03.19.7.5. The finished results shall meet the following conditions:

- (a) Individual bumps or depressions shall not exceed 0.3 inches when measured from a chord length of 25 feet.
- (b) The final index value for the bridge deck and bridge end slabs shall be an average of both the right and left wheel paths of each lane and shall not exceed 65 inches per mile.

The final profilogram will be furnished to the Engineer for informational purposes.

804.03.19.7.5--Profilograph Requirements. The smoothness of the bridge deck will be determined by using a California Profilograph to produce a profilogram (profile trace) at each designated location. The surface shall be tested and corrected to a smoothness index as described herein with the exception of those locations or specific projects that are

excluded from a smoothness test with the profilograph.

The profilograph, furnished and operated by the Contractor under supervision of the Engineer, shall consist of a frame at least 25 feet in length supported upon multiple wheels having no common axle. The wheels shall be arranged in a staggered pattern so that no two wheels will simultaneously cross the same bump. A profile is to be recorded from the vertical movement of a sensing mechanism. This profile is in reference to the mean elevation of the contact points established by the support wheels. The sensing mechanism, located at the mid-frame, may consist of a single bicycle-type wheel or a dual-wheel assembly consisting of either a bicycle-type (pneumatic tire) or solid rubber tire vertical sensing wheel and a separate bicycle-type (pneumatic tire) longitudinal sensing wheel. The wheel(s) shall be of such circumference(s) to produce a profilogram recorded on a scale of one (1) inch equal to 25 feet longitudinally and one (1) inch equal to one (1) inch (full scale) vertically. Motive power may be provided manually or by the use of a propulsion unit attached to the center assembly. In operation, the profilograph shall be moved longitudinally along the pavement at a speed no greater than 3 MPH so as to reduce bounce as much as possible. The testing equipment and procedure shall comply with the requirements of Department SOP.

The Contractor may elect to use a computerized version of the profilograph in lieu of the standard profilograph. If the computerized version of the profilograph is used, it shall meet the requirements of Subsection 804.03.19.7.5.1.

804.03.19.7.5.1--Computerized Profilograph.

804.03.19.7.5.1.1--General. The computerized profilograph, furnished and operated by the Contractor under the supervision of the Engineer, shall be equipped with an on-board computer capable of meeting the following conditions of this subsection.

Vertical displacement shall be sampled every three (3) inches or less along the bridge deck. The profile data shall be bandpass filtered in the computer to remove all spatial wavelengths shorter than two (2) feet. This shall be accomplished by a third order, low pass Butterworth filter. The resulting band limited profile will then be computer analyzed according to the California Profilograph reduction process to produce the required inches per mile index. This shall be accomplished by fitting a linear regression line to the length of bridge. This corresponds to the perfect placement of the blanking band bar by a human trace reducer. Scallops above and below the blanking band are then detected and totaled according to the California protocol. Bump/Dip analysis shall take place according to the California Profilograph reduction process.

The computerized profilograph shall be capable of producing a plot of the profile and a printout that gives the following data: Stations every twenty five (25) feet, bump/dip height and bump/dip length of specification (3/10 of an inch and 25 feet respectively), the blanking band width, date of measurement, total profile index in inches per mile for the measurement, total length of the measurement, and the raw inches for each segment.

804.03.19.7.5.1.2--Mechanical Requirements. The profilograph shall consist of a frame twenty five (25) feet long supported at each end by multiple wheels. The frame shall be constructed to be easily dismantled for transporting. The profilograph shall be constructed from aluminum, stainless steel and chromed parts. The end support wheels shall be arranged in a staggered pattern such that no two wheels cross a transverse joint at the same

time. The relative smoothness shall be measured by the vertical movement of an eight (8) inch or larger diameter sensing wheel at the midpoint of the 25-foot frame. The horizontal distance shall be measured by a twenty (20) inch or larger diameter pneumatic wheel. This profile shall be the mean elevation referenced to the twelve points of contact with the pavement established by the support wheels. Recorded graphical trace of the profile shall be on a scale of one inch equals one inch (full scale) vertical motion of the sensing wheel and one inch equals 25 feet horizontal motion of the profilograph.

804.03.19.7.5.1.3--Computer Requirements. The computer shall have the ability to produce output on sight for verification. The computerized output shall indicate the profile index for each specified section of bridge deck. Variable low and high pass third-order Butterworth filtering options shall be available. The printout shall be capable of showing station marks automatically on the output. Blanking band positioning for each specified section of the bridge deck shall be placed according to the least squares fit line of the collected data. Variable bump and dip tests shall be available to show “must correct” locations on the printout. The computer must have the ability to display on screen “must correct” conditions and alert the user with an audible warning when a “must correct” location has been located. The computer must have the ability to store profile data for later reanalysis. The measurement program must be menu driven and PC compatible. User selected options, identification, calibration factors, and time and date stamps shall be printed at the top of each printed report for verification. The control software must be upgradeable. A power source shall be included for each profilograph and be capable of supplying all power needs for a full days testing.

804.03.19.8--Finishing Horizontal Surfaces of Footings or Top Slabs of Box Bridges, Culverts, or Other Structures. The finishing of horizontal surfaces of footing or top slabs of box bridges, culverts, or other structures shall be achieved by placing an excess of material in the form and removing or striking off the excess with a template, forcing the coarse aggregate below the mortar surface. After the concrete has been struck off the surface shall be given a Class 6 finish.

804.03.19.9--Finishing Exposed Surfaces of Sidewalks. After the concrete has been deposited in place it shall be consolidated and the exposed surface shall be given a Class 6 finish. An edging tool of the required radius shall be used on all edges and at all expansion joints. The surface shall have a granular texture that will not be slick when wet.

Sidewalk surfaces shall be laid out in blocks with an approved grooving tool as shown on the plans or as directed.

804.03.20--Opening Bridges.

804.03.20.1--Public Traffic. Unless otherwise specified, concrete bridge decks shall be closed to public highway traffic for a period of at least 21 days after placing concrete.

804.03.20.2--Construction Traffic. Unless otherwise specified, concrete bridge decks shall be closed to construction traffic for the time required for curing in Subsection 804.03.17 and the minimum required compressive strength for the concrete placed is obtained.

804.03.21--Final Cleanup. Upon completion of the work all equipment, surplus materials, forms, and waste material shall be removed, the bridge cleaned, and the site of the work given a final cleanup.

804.03.22--Precast-Prestressed Concrete Bridge Members.

804.03.22.1--General. All installations and plants for the manufacture of precast-prestressed bridge members shall be PCI (Precast / Prestressed Concrete Institute) Certified. Bridge members manufactured in plants or installations not so approved will not be accepted for use in the work. The Contractor or other manufacturer shall employ a technician skilled in the adopted system of prestressing to supervise the manufacturing operations. This technician shall be certified according to the guidelines of this specification. The Contractor shall develop and implement a Quality Control Program as per Division I of PCI Quality Control Manual, Latest Edition. The Quality Control Program shall be submitted to the District Materials Engineer for approval.

804.03.22.2--Stressing Requirements. The jacks for stressing shall be equipped with accurate calibrated gauges for registering the jacking pressure. Means shall be provided for measuring elongation of strands to at least the nearest 1/16 inch.

Prior to beginning work, the Contractor or manufacturer shall have all jacks to be used, together with their gauges, calibrated by an approved laboratory. All jacks and gauges shall have an accuracy of reading within two percent. The testing agency shall furnish the Engineer a statement certifying that the jacks and gauges meet this requirement. During the progress of the work, if a gauge appears to be giving erratic results or if the gauge pressure and elongations indicate materially differing stresses, recalibration will be required.

Calibration of jacks and gauges shall be repeated at intervals deemed necessary by the Engineer. These intervals for calibration shall not exceed one year.

Shop drawings of prestressed beams, including an erection plan, shall be submitted in duplicate to the Bridge Engineer for approval prior to manufacture of members.

804.03.22.2.1--Methods. Plans for the particular bridge members will show prestressing by one of the following methods:

(A) Pretensioning. The prestressing strands are stressed initially. After the concrete is placed, cured, and has attained the compressive strength shown on the plans, the stress is transferred to the member. The method used for pretensions shall be in accordance to Division V of PCI Quality Control Manual, Latest Edition.

(B) Posttensioning. The posttensioning tendons are installed in voids or ducts and are stressed and anchored after development of the compressive strength specified on the plans. The voids or ducts are then pressure grouted.

(C) Combined Method. Part of the reinforcing is pretensioned and part posttensioned. Under this method all applicable requirements for the two methods specified shall apply to the respective stressing elements being used.

804.03.22.2.2--Alternate Details for Prestressed Members. In the event that the Contractor / Manufacturer desires to use materials or methods that differ in any respect from those shown on the plans or described in these specifications, the Contractor shall submit for approval full plan details on acceptable tracings suitable for reproduction and specifications that shall become the property of the Department. In order for alternate materials and/or methods to be considered, they will be required to comply fully with the following:

- (a) Provisions equal to those stipulated in these specifications.
- (b) Current AASHTO Specifications.
- (c) Recommendations of materials manufacturer.
- (d) Camber tolerance of beams and spans shown on plans.

Note: Alternate materials and methods will not be authorized on Federal-Aid Projects.

The Engineer shall be the sole judge as to the adequacy and propriety of any variation of materials or methods.

804.03.22.2.3--Stressing Procedure.

(A) General. Stressing shall be performed by suitable jacks working against unyielding anchorages and capable of maintaining the required stress for an indefinite period without movement or yielding. Strands may be stressed singularly or in a group.

The tension to be applied to each strand shall be as shown on the plans. The tension shall be measured by both jacking gauges and elongations in the strands and the result shall check within close limits.

It is anticipated that there will possibly be a difference in indicated tension between jack pressure and elongation of about five (5) percent. In this event, the discrepancy shall be placed on the side of slight overstress rather than understress.

In the event of an apparent discrepancy between gauge pressure and elongation of as much as five (5) percent, the entire operation shall be carefully checked, and the source of error determined before proceeding further.

Elongation is to be measured after the strands have been suitably anchored, and all possible slippage at the anchorages has been eliminated.

In all stressing operations, the stressing force shall be kept as nearly symmetrical about the vertical axis of the member as practicable.

(B) Pretensioning. All strands to be prestressed shall be brought to a uniform initial tension prior to being given their full pretensioning. This uniform initial tension of approximately 1000 to 2000 pounds shall be measured by suitable means such as a dynamometer so that its value can be used as a check against elongation computed and measured.

After the initial tensioning, the strand or group shall be stressed until the required elongation and jacking pressure is within the limits specified.

When the strands are stressed in accordance with the plan requirements and these specifications and all other reinforcing is in place, the concrete shall be placed in the prepared forms.

Strand stress shall be maintained until the concrete between anchorages has attained the required compressive strength as determined by cylinder tests, after which the strands shall be cut off flush with the ends of column members, and cut as shown on the plans for beams, girders, etc. Strands shall be cut or released in such a manner that eccentricity of prestress will be kept to a minimum and no damage to the member will result. The strand cutting pattern shall be as shown on the plans or as approved by the Bridge Engineer.

(C) Posttensioning. For all posttensioning tendons/bars the anchor plates shall set exactly normal in all directions to the axis of the tendon/bar. Parallel wire anchorage cones shall be recessed within the beams. Tensioning shall not take place until the concrete has reached the compressive strength shown on the plans.

Elongation and jacking pressures shall make appropriate allowance for all possible slippage or relaxation of the anchorage. Posttensioning tendons/bars shall be stressed in the order and manner shown on the plans.

The units shall be tensioned until the required elongations and jacking pressures are attained and reconciled within the limits specified in Subsection 804.03.22.2.3(A) with such overstresses as approved by the Engineer for anchorage relaxation.

Independent references shall be established adjacent to each anchorage to indicate any yielding or slippage that may occur between the time of initial stressing and final release of the strands.

Straight tendons/bars may be tensioned from one end. Unless otherwise specified, curved tendons shall be stressed by jacking from both ends of the tendons.

(D) Combined Method. In the event that girders are manufactured with part of the reinforcement pretensioned and part posttensioned, the applicable portions of the requirements listed herein shall apply to each type.

804.03.22.3--Manufacture.

804.03.22.3.1--Forms. The forms used for precast-prestressed bridge members shall meet the requirements of Division II of the PCI Quality Control Manual, Latest Edition.

804.03.22.3.2--Placing and Fastening Steel. Placing and fastening of all steel used for precast-prestressed bridge members shall meet the requirements of Division V of the PCI Quality Control Manual, Latest Edition.

804.03.22.3.3--Holes for Prestressing Tendons/Bars. Holes provided in girders for prestressing tendons/bars shall be formed by means of inflatable rubber tubing, flexible metal conduit, metal tubing, or other approved means.

804.03.22.4--Placing and Curing Concrete.

804.03.22.4.1--Placing. The placing of concrete shall meet the applicable requirements of Division III of PCI Quality Control Manual, Latest Edition.

804.03.22.4.2--Curing. Initial and accelerated curing of all members shall meet the applicable requirements of Division IV of PCI Quality Control Manual, Latest Edition except for the requirements listed in this subsection.

The source of heat for accelerated cure shall be steam. Calibrated thermocouples shall be implanted into the concrete members to monitor areas expected to have maximum and minimum heat. Curing methods and procedures listed in the prestress producer's PCI Quality System Manual shall be approved by the Department before their implementation.

804.03.22.4.3--Removal of Side Forms. Side forms may be removed after the concrete has attained sufficient strength to maintain a true section. In order to obtain "sufficient strength," it may be necessary to cure members for 12 hours or more as prescribed in Subsection 804.03.22.4.2, or to attain a minimum compressive strength of 1000 psi.

If high-early-strength concrete is obtained by use of low slump (0 to 1.5-inch) concrete, vacuum process, or other approved methods, side forms may be removed earlier; however, approval of the methods and revision from normal schedules will be made only after inspections by the District Materials Engineer and Materials Division have determined that satisfactory results will be attained by the methods and schedules proposed.

804.03.22.4.4--Grouting. The holes through posttensioned members in which the tendons are installed shall be equipped with approved grouting vents. All prestressing tendons to be bonded shall be free of dirt, loose rust, grease, or other deleterious substances. Before grouting, the ducts shall be free of water, dirt, and other foreign substances. The ducts shall be blown out with compressed air until no water comes through the ducts. For long members with draped tendons, an open tap at low points may be necessary. After completion of stressing, the annular space between sides of tendon and sides of hole shall be grouted as outlined in the following paragraphs.

With the grouting vent open at one end of the core hole, grout shall be applied continuously under moderate pressure at the other end until all entrapped air is forced out through the open grout vent, as evidenced by a steady stream of grout at the vent. The open vent shall then be closed under pressure. The grouting pressure shall be gradually increased to a refusal of at least 75 psi and held at this pressure for approximately 10 seconds, and the vent shall then be closed under this pressure.

Hydraulic cement grout shall consist of a mixture of:

- 1 part Type 1 hydraulic cement
- 1/4 part fly ash
- 3/4 part washed sand *
- 4 to 6 gallons of water per bag of cement.

* all passing No. 16 sieve and not more than 5% retained on No. 30

Water-reducing admixtures, subject to approval by the Engineer, shall be used in accordance with the manufacturer's recommendations.

The grout shall be mixed in a mechanical mixer, shall have the consistency of heavy paint, and shall be kept agitated until placed.

Members shall not be moved before the grout has set, ordinarily at least 24 hours at 80°F or higher.

804.03.22.5--Finishing and Marking. Units shall be given a Class 1 finish at the plant and shall be given a Class 2 finish after erection when required.

Recesses in girders at end of diaphragm bars, holes left by form ties, and other surface irregularities shall be carefully cleaned and patched with an approved non-shrink commercial grout or a non-shrinkage mortar of the following composition:

- 1 part Type 1 hydraulic cement
- 1 1/2 to 2 parts fine sand
- 1/2 to 3/4 ounces aluminum powder per bag of cement
- Approved admixture per Subsection 713.02.
- Sufficient water to produce a workable but rather stiff mix.

The units shall be clearly marked in accordance with Department's *Materials Division Inspection, Certification and Testing Manual*.

804.03.22.6--Handling, Storage, and Installation. Posttensioned members may be handled immediately after completion of stressing and grout has set. Pretensioned members may be handled immediately after release of tensioning. In either case, the members shall have developed a minimum compressive strength of 4000 psi prior to handling. In the event stressing is not done in a continuous operation, members shall not be handled before they are sufficiently stressed, as determined by the Engineer, to sustain all forces and bending moments due to handling. In the handling, storage, and transporting of beams or girders, they shall be maintained in an upright position (position as cast) at all times and shall be picked up from points within distance from beam ends equal to beam depth or at pick-up points designated on the plans. Disregard of this requirement and dropping of units may be cause for rejection, whether or not injury to the unit is apparent. Piles shall be picked up and loaded for shipment at points shown by the suspension diagram on the plans. Extreme care shall be used in handling and storing piles to prevent damage. The dropping of a pile may be cause for rejection of same, whether or not there is apparent injury to the member.

Care shall be exercised during the storage, hoisting, and handling of precast units to prevent damage. Damaged units shall be replaced by the Contractor at no additional costs to the State.

When members are stacked for storage, each layer shall be supported at or near the pick-up points. Supports shall be carefully placed in a vertical line in order that the weight of any member will not stress an underlying member. To prevent damage in moving members it is suggested that rigid supports be covered with a cushion of wood or other resilient material.

Members shall not be transported until at least one day after the concrete has reached a compressive strength of 5000 psi or greater strength when shown on the plans.

Piles used in salt water shall not be driven until concrete is seven days old, and air-entrained concrete shall be used in such piles.

After prestressed concrete voided slab units are set, doweled and bolted in their final position, the keyways and dowel holes shall be filled with an approved non-shrink grout. Traffic shall not be permitted on the spans for 24 hours after grouting, and heavy construction equipment exceeding 15 tons will not be permitted on the spans for a period of 72 hours after grouting.

Adjacent slab units that mismatch more than one-fourth inch shall be adjusted prior to grouting of the shear keys. The maximum deviation from cross-section and grade (exclusive of camber) at any point shall not exceed one-fourth inch. When the surface is checked with a ten-foot straightedge applied both parallel and perpendicular to the centerline, the variance shall not exceed one-fourth inch.

In addition to the requirements set out in this section, the applicable requirements of Section 803 shall apply.

804.03.22.7--Tolerances for Accepting Precast Prestressed Concrete. Members shall meet the dimension tolerances set by Division VII of PCI Quality Control Manual, Latest Edition.

804.03.22.8--Testing of Materials. Concrete and aggregate testing shall meet the requirements of Division VI of PCI Quality Control Manual, Latest Edition, except that the concrete mixture design shall meet the requirements of Subsection 804.02.10. Also, in addition to concrete compressive tests samples made for detensioning and 28-day strength, test samples shall be made and tested in order to prove compliance to the requirements of Subsection 804.03.22.6 for handling and shipping prestressed members. Compressive strength test cylinders for detensioning, handling and shipping shall receive the same type curing as the prestressed members for which they represent. Compressive strength samples shall be made each day for each prestress casting bed.

804.03.22.9--Testing Personnel. Technicians testing hydraulic cement concrete used in the production of precast-prestressed members shall be PCI Quality Control Technician/Inspector Certified. Each producer of precast-prestressed members shall have at least one PCI Level II certified technician on site during production for Department projects.

804.03.22.10--Documentation. The Precast-Prestressed Producer for each precast-prestressed concrete bridge member shall maintain documentation as set forth in the Department's *Materials Division Inspection, Certification and Testing Manual*. Testing and inspection record forms shall be approved by the Central Laboratory and as a minimum contain information listed in Division VI of PCI Quality Control Manual, Latest Edition.

804.03.22.11--Use in the Work. Before any precast-prestressed member is incorporated into the work, documentation as described in Subsection 804.03.22.10 is required along with visual inspection of the member at the bridge construction site. Project Office personnel as per the Department's *Materials Division Inspection, Certification and Testing Manual* will make visual inspection of the precast-prestressed member at the bridge construction site.

804.04--Method of Measurement. Concrete, complete and accepted, will be measured in cubic yards. The concrete volume will be computed from the neat dimensions shown on the plans, except for such variations as may be ordered in writing by the Engineer. The quantity of concrete involved in fillets, scorings, and chamfers one square inch or less in cross-sectional area will be neglected. Deductions shall be made for the following:

- (a) The volume of structural steel, including steel piling encased in concrete.
- (b) The volume of timber piles encased in concrete, assuming the volume to be 0.80 cubic foot per linear foot of pile.
- (c) The volume of concrete piles encased in concrete.

The volume of concrete in the fillets between the bottom of nominal slab and the top of the beams has been estimated by using one half (1/2) of the fillet height at the bearing multiplied by the top flange width for the full length of the beam. This volume shall be used for final pay quantity. The calculated volume of concrete may or may not be equal to the actual volume of concrete that is placed in the fillet. The volume of fillet concrete used for final pay quantity is based upon the plan fillet height at bearing and a zero inch (0") plan fillet height at midspan. If the Contractor feels that variations from these dimensions will be encountered, they should adjust their bid accordingly.

No deduction will be made for the volume of concrete displaced by steel reinforcement, floor drains, or expansion joint material that is one inch or less in width normal to the centerline of the joint. Where railing is bid as a separate item, that portion of the railing above the top of the curb, above the surface of the sidewalk, or above the bridge roadway, as the case may be, will not be included in the measurement of concrete, but will be measured as railing. Massive pylons or posts that are to be excluded from payment for railing and are intended to be measured for as concrete will be so noted on the plans.

When shown on the plans or directed by the Engineer, concrete placed as a seal for cofferdams will be measured by the cubic yard actually in place, except that no measurement will be made of seal concrete placed outside of an area bounded by vertical planes 18 inches outside the neat lines of the footing as shown on the plans or as directed and parallel thereto.

Reinforcing steel will be measured and paid for in pounds as set out in Section 805.

Unless otherwise specified, structural steel will be measured and paid for as set out in Section 810.

Excavation for bridges will be measured and paid for as in Section 801.

Piling will be measured and paid for as set out in Sections 802 and 803.

Railing will be measured and paid for as set out in Section 813.

Prestressed concrete beams and plank will be measured by the linear foot.

Prestressed concrete voided slab units, interior and exterior with railing, and precast concrete caps, intermediate and end cap with winged abutment wall, of the size and type specified will be measured by the unit complete in place and accepted. Railing, winged

abutment walls, grout, tie rods, nuts, washers, bearing pads and other appurtenances will not be measured for separate payment.

804.05--Basis of Payment. Concrete will be paid for at the contract unit price per cubic yard for the class or classes specified, complete in place. Prestressed concrete beams and plank will be paid for at the contract unit per linear foot of specified size and type.

Prestressed concrete voided slab units and precast caps will be paid for at the contract unit price per each for the specified types and sizes, complete in place and accepted, which price shall be full compensation for furnishing, hauling and erecting the members, including all prestressing reinforcement and other reinforcement in the members. Payment at the contract unit price shall be full compensation for furnishing all materials, equipment, tools, labor and incidentals necessary to complete the work.

Payment will be made under:

804-A: Bridge Concrete, Class ____	- per cubic yard
804-B: Box Bridge Concrete, Class ____	- per cubic yard
804-C: <u>Length</u> Prestressed Concrete Beam, Type ____	- per linear foot
804-D: <u>Length</u> Prestressed Concrete Plank	- per linear foot
804-E: <u>Length</u> Prestressed Concrete Voided Slab, <u>Size</u> Interior	- per each
804-F: <u>Length</u> Prestressed Concrete Voided Slab, <u>Size</u> Exterior	- per each
804-G: <u>Length</u> Precast Concrete Caps, End Unit with Wall	- per each
804-H: <u>Length</u> Precast Concrete Caps, Intermediate Unit	- per each

SECTION 805 - REINFORCEMENT

805.01--Description. This work consists of furnishing and placing steel reinforcement for bridges in accordance with these specifications and in reasonably close conformity with the dimensions, bending, spacing, and other requirements shown on the plans.

805.02--Materials. Materials used shall conform to the requirements of Section 711.

Supports for bar reinforcement shall meet the requirements of Subsection 711.02.7.

805.02.1--Order Lists. Before ordering reinforcement, all order lists and bending diagrams shall be furnished by the Contractor for the approval of the Engineer, and no materials shall be ordered until the lists and bending diagrams have been approved. All expense incident to the revision of material furnished in accordance with such lists and diagrams to make it comply with the design drawings shall be borne by the Contractor.

805.03--Construction Requirements.

805.03.1--Protection of Material. Steel reinforcement shall be protected at all times from damage. Damaged material will not be approved for use in the work. When placed in the work and immediately prior to placing the concrete, the reinforcement shall be free from dirt, oil, paint, grease, and other foreign substances and shall be free of loose or thick rust or millscale that could impair bond of the steel with the concrete.

805.03.2--Fabrication. Bent bar reinforcement shall be cold bent to the shapes shown on the plans, and unless otherwise provided on the plans or by authorization, bends shall be made in accordance with Subsection 711.02. Bars partially embedded in concrete shall not be field bent except as shown on the plans or permitted.

Bar reinforcement shall be bundled, tagged and marked in accordance with Code of Standard Practice of the Concrete Reinforcing Steel Institute.

805.03.3--Placing and Fastening. Reinforcement shall be accurately placed in the positions shown on the plans and firmly held during the placing and setting of concrete. Bars shall be tied at all intersections. Where spacing is less than one foot in each direction, alternate intersections shall be tied.

Distances from the forms shall be maintained by means of stays, blocks, ties, hangers, or other approved supports. Blocks for holding reinforcement from contact with the forms shall be precast mortar blocks of approved shape and dimensions or metal chairs, reference Subsection 711.02.7. Layers of bars shall be separated by precast mortar blocks or by other equally suitable devices. The use of pebbles, pieces of broken stone or brick, metal pipe, and wooden blocks will not be permitted. The clear distance between parallel bars, except in columns and between multiple layers of bars in beams, shall not be less than the nominal diameter of the bars, 1 1/3 times the maximum size of the coarse aggregate, nor one inch.

Where reinforcement in beams or girders is placed in two or more layers, the clear distance between layers shall not be less than one inch, and the bars in the upper layers shall be placed directly above those in the bottom layer.

In spirally reinforced and in tied columns, the clear distance between longitudinal bars shall not be less than 1½ times the bar diameter, 1½ times the maximum size of the coarse aggregate, nor 1½ inches.

The clear distance between bars shall also apply to the clear distance between a contact splice and adjacent splices or bars.

Reinforcement in any member shall be inspected and approved by the Engineer before the placing of concrete begins. Concrete placed in violation of this provision may be rejected and removal and replacement of concrete and reinforcement required.

If fabric reinforcement is shipped in rolls, it shall be straightened into flat sheets before being placed.

805.03.4--Splicing of Bars. All reinforcement shall be furnished in the full lengths indicated on the plans. Except when shown on the plans, Splicing of bars will not be

permitted without the written approval of the Engineer. Splices shall be staggered insofar as possible.

The minimum distance to the surface of the concrete shall be as specified on the plans. Reinforcement shall not be welded except if detailed on the plans or if authorized by the Engineer in writing. Welding shall conform to the current AWS specifications for Recommended Practices for Welding Reinforcement Steel, Metal Inserts, and Connections in Reinforced Concrete Construction.

805.03.5--Lapping of Mesh or Mats. Sheets of mesh or bar mat reinforcement shall overlap each other sufficiently to maintain a uniform strength and shall be securely fastened at the ends and edges. The edge lap shall not be less than one mesh in width.

805.03.6--Substitutions. Substitutions of different size bars will be permitted only with specific authorization by the Engineer. If steel is substituted, it shall have an area equivalent to the design area or larger.

805.03.7--Epoxy Coated Bars.

805.03.7.1--Repair of Damaged Epoxy Coating. When required, damaged epoxy coating shall be repaired with patching material conforming to ASTM A 775. Repair shall be done in accordance with the patching material manufacturer's recommendations.

805.03.7.2--Handling of Epoxy Coated Bars. The Contractor shall use padded or non-metallic slings and padded straps to protect the coated reinforcement from damage. The bundled bars shall not be dropped or dragged and must be stored on wooded cribbing. If, in the opinion of the Engineer, the coated bars or plates have been damaged as a result of the Contractor's negligence, the material will be rejected. The Contractor may propose, for the approval of the Engineer, alternate precautionary measures.

805.03.7.3--Placing of Epoxy Coated Bars. Epoxy-coated reinforcing bars supported from formwork shall rest on coated wire bar supports, or on bar supports made of dielectric material or other acceptable materials. Wire bar supports shall be coated with dielectric material for a minimum distance of two inches from the point of contact with the epoxy-coated reinforcing bars. In walls having reinforcing bars, spreader bars where specified by the Engineer shall be epoxy coated. Proprietary combination bar clips and spreaders used in walls with epoxy-coated reinforcing bars shall be made of corrosion resistant material. Epoxy-coated reinforcing bars shall be fastened with nylon-, epoxy-, or plastic-coated tie wire or other acceptable materials.

805.04--Method of Measurement. Steel reinforcement incorporated in bridge concrete and accepted will be measured in pounds based on the total computed weight for the sizes and lengths of bars, mesh or mats shown on the plans or authorized. Reinforcement for box bridge concrete will be measured and paid for in accordance with Section 602.

Epoxy coated reinforcement bars, not included in other pay items, will be measured in pounds based on the computed weight from the theoretical weight of plain round bars of the same nominal size as shown in the table of areas and masses in Section 711.

Corrosion resistant reinforcement (CCR) bars, not included in other pay items, will be measured in pounds based on the computed weight from the theoretical weight of plain

round bars of the same nominal size as shown in the table of areas and masses in Section 711.

The weight of mesh will be computed from the theoretical weight of plain wire. If the weight per square foot is given on the plan, that weight will be used.

The weight of plain or deformed bars, or bar mat, will be computed from the theoretical weight of plain round bars of the same nominal size as shown in the table of area and weights in Section 711.

The weight for payment of structural steel reinforcement, incorporated in the work and accepted, will be the theoretical weight of the material used.

The weight of reinforcement used in railings measured on a linear foot basis will not be measured. The weight of reinforcement in precast piles and other items where the reinforcement is included in the contract price will not be measured.

No allowance will be made for clips, wire, separators, wire chairs, and other material used in fastening the reinforcement in place. If bars are substituted upon the Contractor's request and as a result more steel is used than specified, only the bars specified will be measured.

When splices, other than those shown on the plans, are made for the convenience of the Contractor, the extra steel will not be measured.

805.05--Basis of Payment. Reinforcement will be paid for at the contract unit price per pound, which shall be full compensation for completing the work.

Payment will be made under:

805-A: Reinforcement	- per pound
805-B Reinforcement, Epoxy Coated	- per pound
805-C Reinforcement, Corrosion Resistant	- per pound

SECTION 806 - PRECAST CONCRETE BRIDGE CAPS, SPANS AND WINGS

806.01--Description. This work consists of furnishing and installing precast concrete caps, precast concrete spans complete with post, bridge railing or concrete barrier rail and precast wings for bridges in accordance with these specifications and in reasonably close conformity with the dimensions and design indicated on the plans and placed on a prepared substructure to the lines and grades established by the Engineer.

806.02--Materials. The materials used in this construction, in addition to the general requirements of these specifications, shall conform, unless otherwise stipulated, to the requirements prescribed in Division 700, Material and Tests, for the particular kind and type of material specified.

806.02.1--Sampling and Testing. As referenced in Subsection 106.03, approval of the source of supply of cement, fine and coarse aggregate, water, reinforcement and other materials used in the construction of the caps, slabs and wings and the results of tests showing their suitability for use shall be obtained prior to their use in any construction. Samples shall be submitted as directed.

The Contractor/Manufacturer without extra compensation, shall supply the Engineer's plant inspector with the necessary materials and representative concrete mix for making a minimum of one test cylinder of concrete for each seven caps, slabs, or wings or a minimum of one test cylinder per day if less than seven caps, slabs, or wings are constructed. Other test cylinders may be required by the Engineer to establish strength for handling slabs or caps. Cylinders are to be cured with the same method used in curing the caps, slabs, or wings, as the case may be. Only those caps, slabs, or wings bearing identification marks of acceptance by the Department or approved laboratories will be permitted for use in the construction. The acceptance of any precast concrete member at the production plant shall in no way be final and further inspection will be made at the structure site before and after the member has been placed in its final position.

806.03--Construction Requirements.

806.03.1--General. The methods of construction shall conform, unless otherwise stipulated, to the provisions and requirements prescribed in these specifications and indicated on the plans for the several items that constitute the complete structure.

806.03.2--Substructure. The substructure shall be constructed in conformity with Section 803 and as indicated on the plans. Payment for same will be made under Section 803, unless otherwise indicated.

The piles shall be so driven that the cap may be placed in its proper location without excessive manipulation of the piles.

806.03.3--Precast Caps, Slabs, and Wings.

806.03.3.1--Proportioning and Mixing Concrete. The composition, proportioning and mixing of the concrete used in this construction shall be as specified in Section 804, Concrete Bridges and Structures, and shall be the class concrete specified on the plans.

806.03.3.2--Reinforcing Steel. Reinforcing steel shall be of the quality, type, and size specified on the plans and placed as indicated. It shall meet the requirements set out in Subsection 711.02, as applicable.

Separate payment will not be made for reinforcing steel.

806.03.3.3--Forms. All forms shall be of metal or wood. They shall be built mortar-tight and of sufficient rigidity to prevent any distortion due to pressure of the concrete and other loads incident to the construction operations. The forms shall be substantial and unyielding and shall be so designed that the finished concrete will conform to the proper dimensions and contours. The design of the forms shall take into account the effect of vibration of concrete as it is placed.

Forms shall be filleted at all sharp corners and shall be given a bevel or draft in the case of all projections to ensure easy removal.

All forms shall be set and maintained true to the lines designated until the concrete is sufficiently hardened or for periods as hereinafter specified.

Forms shall be treated with oil immediately before placing concrete in them. Any material that will adhere to, or discolor, the concrete shall not be used. Extreme care shall be exercised to make sure that no oil gets on the reinforcing steel.

806.03.3.4--Handling and Placing Concrete. Prior to the placing of any concrete, the forms shall be thoroughly cleaned of any construction debris and extraneous matter and the reinforcing bars of the size and type indicated placed and secured in the forms as indicated on the plans. Concrete shall not be deposited in the forms until the inspector has checked the placing of the reinforcement and has given approval to proceed.

Ready mix concrete transported in a truck mixer or truck agitator shall be discharged at the site of the work and placed in its final position in the forms within one hour after the introduction of the mixing water to the cement and aggregate or the cement to the aggregate whichever occurs first, except that in abnormal weather, or under other conditions contributing to the quick stiffening of the concrete, the Engineer may make a determination of a lesser time for placement considering all factors affecting initial set of the concrete. When mixed concrete is transported in approved non-agitating trucks, the concrete shall be discharged at the work site within thirty minutes after the introduction of the mixing water to the cement and aggregate.

The concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement. Open troughs and chutes used shall be of metal or metal lined and shall be kept clean and free from coating of hardened concrete by flushing with water after each pour. Water used for flushing shall be discharged clear of the cap, slab, or wing forms.

806.03.3.5--Compaction. Concrete for the caps, slabs, and wings during and immediately after depositing shall be thoroughly compacted by the use of vibrators and suitable spading tools. Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. The vibration shall be internal and shall be of sufficient duration and intensity to thoroughly compact the concrete, but shall not be continued so as to cause segregation. Vibration shall not be continued at any one point to the extent that localized areas of grout are formed.

The entire operation of depositing and consolidating the concrete shall be so conducted that the concrete shall be smooth, dense and free from any honeycomb or pockets of segregated aggregates. The roadway surface of slabs and tops of caps and wings shall be finished with a wood float.

Concrete in the precast caps, slabs and wings shall be placed in one continuous operation for each cap, slab, and wing.

806.03.3.6--Placing Bolts, Drains, Bolt Holes, etc. All bolts, drains, bolt holes, etc., indicated on the plans as necessary or desirable shall be placed in the concrete at the

locations indicated on the plans. They shall be formed by approved methods and operations and shall be such as to ensure proper connections.

806.03.3.7--Removal of Forms and Curing. Side forms for precast concrete bridge caps, slabs and wings may be removed after the concrete has attained sufficient strength to maintain a true section. The minimum time for removal, using alternate types of curing, is considered to be as follows:

- (a) With a minimum of three thicknesses of wetted burlap, cotton mats, or constant fogging with temperatures of more than 40°F and less than 80°F -- 24 hours; with temperatures 80°F and higher -- 20 hours.
- (b) Steaming in enclosures at temperatures of not less than 80°F and not more than 150°F -- 12 hours.

When Type III Cement is permitted, side forms may be removed after 12 hours using all types of curing.

Bottom forms shall remain in place until the concrete has obtained a minimum compressive strength of 2,500 psi as determined by cylinder tests. When the caps, slabs, or wings are moved, they shall be deposited directly on a level hard-surfaced true-plane area without stacking and shall remain undisturbed for seven days beyond the period of initial handling while the curing continues.

Caps, slabs and wings shall be covered with wetted burlap immediately after the finishing operations.

Liquid membrane curing may be used, but shall be white pigmented and applied at the rate of not less than one gallon per 150 square feet of surface. The entire surface and exposed edges shall be sprayed with the membrane as soon as practicable after finishing is complete and as side forms are removed. The seal shall be applied to the surface as a fine mist that shall provide a continuous, uniform, water impermeable film. The bottom of the caps, slabs, or wings shall be sealed with the membrane when they are removed from the bottom supporting forms.

The Contractor may use steam curing provided the Engineer has given written approval prior to casting operations. Steam curing shall be according to stipulations set out in Subsection 804.03.22.4.2.

The cap, slab, wing and rail units shall not be shipped until the concrete has obtained the specified minimum compressive strength as determined by cylinder tests.

806.03.4--Tolerance of Dimensions.

806.03.4.1--Caps. The width and length of the caps shall not vary more than one-quarter inch from the plan dimensions. The bottom of the cap shall be smooth and shall not vary more than one-eighth of an inch when tested with a straightedge in a horizontal direction for any ten-foot length. The top of the caps shall not vary more than one-sixteenth inch from the slope shown on the plans.

806.03.4.2--Slabs. The four sides of the slab shall not vary more than one-eighth inch for the full depth of the slab when tested with a straightedge in a vertical direction, nor more

than one-quarter inch in the full length of the slab when tested with a straightedge in a horizontal direction, nor shall the top of the slab vary more than one-eighth inch in any ten-foot length.

806.03.4.3--Wings. The width and length of the wings shall not vary more than one-quarter inch from the plan dimensions.

806.03.4.4--Concrete Barrier Rail. The width of the rail shall not vary more than one-eighth inch and the length shall not vary more than one-quarter inch. The sides shall be smooth with no discolorations. In the event patching is required, the entire rail shall be given a Class 2 finish.

806.03.5--Handling and Placing Precast Caps, Slabs, Barrier Rail and Wings. The precast caps, slabs, barrier rail, and wings shall be handled in such a manner that they will not be subjected to excessive and undue abuse producing crushing, spalling, or undue marring of the concrete. Injury to units may be cause for rejection whether the injury to the unit is apparent or not. Damaged units shall be replaced by the Contractor at no additional costs to the State.

Where the caps, slabs, barrier rail, and wings are to be loaded or stored in tiers, the blocking between the tier should be in a vertical plane so that the weight of the upper caps, slabs or wings cannot produce bending in those of a lower tier.

After the caps are set and doweled, welded, or grouted to the piling, the dowel holes shall be filled with grout or AC-13 before the slabs are set.

Each section or unit shall be placed as closely as possible to its final position in the structure so that the use of bars or other tools that might mar the concrete will be eliminated. The abutting edges of each slab unit shall be carefully cleaned of any concrete or extraneous matter in order that the longitudinal joints may be bolted tightly together.

After the slab units are set, doweled and bolted in their final position, the keyways and dowel holes shall be filled with an approved non-shrink grout. Traffic shall not be permitted on the spans for 24 hours and heavy construction type traffic, or other loads exceeding 15 tons, will not be allowed on the spans for a period of 72 hours after grouting. When epoxy grout is allowed, these time requirements may be reduced to 12 hours. When a non-shrink commercial grout is used, the 72-hour time requirement may be reduced to 24 hours.

Expansion material shall be placed between all bearing points of the slabs and surfaces of the caps. When not otherwise specifically provided, three layers of No. 15, Type I, roofing felt shall be used.

806.03.5.1--Transverse Joints. When a bridge consists of more than one span, bituminous premolded joint filler, one-quarter inch in thickness, shall be placed in the joint between spans. This joint filler shall be for the full thickness of the concrete, less one inch at the top of the slab, and for the full width of the structure, including curb. When the spans are completely in place and bolted the transverse joints shall be sealed with AC-13 or other joint sealer approved by the Engineer.

806.03.5.2--Railing. The bridge railing shall be installed after all other work on the bridge has been completed.

The material used shall meet the dimensions and requirements specified on the plans and the railing shall be constructed in conformity with the details indicated and to the lines and grades established.

806.04--Method of Measurement. Precast concrete slab units, either interior or curb units, precast barrier rail units and precast concrete caps either intermediate or end bent with winged abutment wall of the size and type specified will be measured by the unit per each.

Winged abutment walls, grout, tie rods, nuts, washers, bearing pads and other appurtenances will not be measured for separate payment.

806.05--Basis of Payment. Precast concrete slab units, precast barrier rail units and precast concrete caps, measured as prescribed above, will be paid for at the contract unit price per each for the specified types and sizes. This price shall be full compensation for furnishing all materials, hauling and erecting, equipment, tools, labor and incidentals necessary to complete the work.

Payment will be made under:

806-A: ___' Precast Concrete Slab Units, ___' Interior	- per each
806-B: ___' Precast Concrete Slab Units, Curb	- per each
806-C: ___' Precast Barrier Rail Units	- per each
806-D: ___' Precast Concrete Caps, Intermediate Unit	- per each
806-E: ___' Precast Concrete Caps, End Unit with Wall	- per each

SECTION 808 - JOINT REPAIR

808.01--Description. All joints requiring repair shall be reconstructed with specified materials according to details shown on the plans and instructions contained herein. All other requirements shall be in accordance with the applicable provisions of Sections 501 and 804 of the Standard Specifications.

808.02--Materials.

808.02.1--General. When materials from the Department's current list of approved materials are to be used, the Contractor shall submit documentation to the Engineer that the epoxy and all components meet the requirements of the contract.

If the materials proposed for use are not from the Department's current list of approved materials, a sample of the epoxy and all components required for the epoxy mortar mix shall be submitted to the Engineer for evaluation and approval at least 30 calendar days prior to placement.

Subsequent approval of each new lot may be by certification. The manufacturer must certify that the new lot of material is the same composition as that originally approved by the Department and that the material has not been changed or altered in any way.

A representative of the epoxy manufacturer must be present for sufficient time to assure that the Contractor is properly schooled in the use of the epoxy materials.

808.02.2--Epoxy Resin. The material shall meet the requirements of ASTM C 881, Type I, Grade 2, Class C.

808.02.3--Silica Sand. The material shall be bagged general purpose blast cleaning sand.

808.02.4--Epoxy Mortar Mix. The mortar mix shall consist of one part liquid epoxy to 3.5 parts clean dry sand by volume.

808.02.5--Mixing and Curing. Mixing of all epoxy materials shall be accomplished with a mechanical mixer.

A trial batch of mortar, approximately one cubic foot, will be mixed and used for joint repair. From this batch, the pot life and subsequent amount of material to be mixed will be determined.

Workers should wear rubber gloves and any other protective measures necessary to minimize contact with skin, eyes, etc.

The curing time shall be regulated so the repaired area may be open to traffic in four hours from time of placement.

To meet the above requirement, it may be necessary to store materials in heated enclosures and provide temporary cover and heat to the repaired area.

808.03--Construction Details. All repair areas are to be thoroughly cleaned by chipping and sandblasting to sound concrete.

To form joints, insert styrofoam or other approved forming materials to desired grade. Forms are to be greased lightly to assist in removal.

The mortar mix shall be prepared and placed during periods of warm weather if at all possible.

The prepared surface shall be lightly primed with neat epoxy prior to placement of the mortar mix.

Placement of the mortar mix shall start at the earliest practical time and may continue until approximately four and one-half hours prior to opening the section of roadway or bridge to traffic.

The mortar mix shall be finished to the line of the existing joint and to the grade of the adjacent pavement or bridge deck.

After final finish of the mortar mix, the surface shall be sprinkled with sand to provide texture. Excess sand to be hand broomed from surface after mortar has set.

Acetone alcohol may be used to clean and lubricate trowels to assist with the surface finishing.

808.04--Method of Measurement. When specified for payment, joint repair, measured as prescribed above, will be measured by the linear foot for joint preparation and by the gallon for the mortar mix. When the mortar mix consists of epoxy and sand, the volume of measurement for the mortar mix will be determined from the summation of the volumes of the epoxy components and the volume of sand will not be measured for payment.

808.05--Basis of Payment. The accepted quantities of joint repair will be paid for at the contract unit price per linear foot for joint preparation and per gallon for the mortar mix, which price shall be full compensation for furnishing and placing all materials including sand and forming materials and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work. No payment will be made for the sand used in the epoxy mortar mix. The price bid for each item of work shall include the cost of continuous maintenance of traffic and protective services as required by the Department's Traffic Control Plan. This shall include all required individual traffic control devices.

Payment will be made under:

808-A: Joint Preparation - per linear foot

808-B: Kind Mortar Mix - per gallon

SECTION 809 - RETAINING WALL SYSTEMS

809.01--Description. This work shall consist of designing and installing one of the retaining wall systems described herein in accordance with the lines, grades and dimensions shown in the plans and specifications.

809.01.1--General. Retaining wall systems shall comply with all material, fabrication and construction requirements found in the Standard Specifications and the plans. The submitted retaining wall system shall be as shown in the plans or consist of one of the following three types: Conventional Cantilevered Gravity Wall, Mechanically Stabilized Earth Wall (MSEW), or Precast Gravity Wall. All costs associated with the design and construction of the wall system selected by the Contractor shall be included in the bid price for the wall. The Contractor may select different wall types for different sites, as provided for on the plans.

In the event a MSEW System is chosen, the wall system supplier shall have submitted their system to the Highway Innovative Technology Evaluation Center (HITEC) for review and shall have had a formal evaluation completed for all components of the wall system. The wall system is considered to be the wall facing and the associated geosynthetic or steel soil reinforcement. Three copies of HITEC's final evaluation report for the chosen MSEW System shall be included with the initial design submittal.

The time required for preparation and review of wall shop drawings shall be charged to the allowable contract time. No additional compensation will be made for any additional

material, equipment, or other items found necessary to comply with the project specifications as a result of review by the Department. All submittals shall be submitted to the Bridge Engineer for approval prior to construction.

The retaining wall system shall follow the lines, grades, and location as shown in the plans. In the event that plan dimensions are revised due to field conditions or other reasons, the Contractor shall be responsible for revising the wall plans, design calculations, and summary of quantities.

809.01.2--Submittals.

809.01.2.1--Initial Design Submittal. The initial design submittal shall include three sets of wall plans and three sets of design calculations and notes. The wall plans and design calculations and notes shall clearly state the wall type chosen. The wall plans and design calculations will be returned to the Contractor within thirty (30) calendar days of receipt. All final design calculations and plans shall be prepared, stamped and signed by a Professional Engineer licensed to practice in the State of Mississippi. The calculations shall include, but not be limited to, those items listed below. The designer/supplier furnishing the plans and calculations for the wall system proposed shall be responsible for the internal and external stability of the wall system.

The drawings shall include all details, dimensions, quantities and cross-sections necessary to construct the wall. Prints of the original cross sections will be available to purchase with plans. The wall system plans shall include, but not be limited to, the following items:

- (a) A plan and elevation sheet(s) for each wall shall contain the following:
 1. The elevation view of the wall that indicates the elevation at the top of the wall, at all horizontal and vertical break points, and at least every 50 feet along the wall, elevations at the top of leveling pads and footings, and the original and final ground line.
 2. The plan view of the wall that shows the offset from the construction centerline to the face of the wall at all changes in horizontal alignment. Also included should be the limits of the soil reinforcement, if required, and any drainage structures or pipes lying behind or extending through or under the wall.
 3. General notes required for construction of the wall.
 4. All horizontal and vertical curve data affecting the wall shall be included.
 5. A list of all required materials and the required quantity of each shall be provided on the elevation sheet of each wall.
- (b) All bar bending details shall be included.
- (c) All details for foundations and leveling pads shall be shown including steps in the footings or leveling pads. Foundations and leveling pads shall have a minimum cover of two feet.
- (d) All panels, modular blocks, coping, and lagging shall be detailed. The details shall include all dimensions necessary to construct the element.
- (e) Details should be included for the walls around any existing drainage facilities.
- (f) All details concerning the appearance of the wall face shall be included.

Three sets of wall plans shall be submitted with the initial submittal. The plans that are submitted with the initial design submittal shall be prepared on standard 24-inch by 36-inch sheets. Each sheet shall have a title block in the lower right hand corner. The title

block shall include the sheet number of the drawing, type of wall designated, the project number, and the Contractor.

The initial design submittal shall include a set of design calculations and notes for the wall(s). Three sets of design calculations and notes shall be submitted. The design calculations and notes shall contain the project number, type of wall designated, date of preparation, and the name of the designer. The package shall have a clear index outlining the design notes and shall include an explanation of the design procedure, explanation of any symbols, and technical documentation of any computer programs used. The design calculations shall clearly state the factors of safety for sliding, pullout, and overturning. In addition, the bearing pressures beneath the wall footing used in the calculations shall be noted.

809.01.2.2--Final Plan Submittal. All final construction plans shall be submitted on 24-inch by 36-inch reproducible mylar sheets. In addition, the plans shall be accompanied by either flash drive or compact disk containing the plans in Tagged Image File Format (TIFF) for archive purposes. The final construction plans shall reflect all changes made on the plans submitted for the design submittal.

809.01.3--Design Criteria. The design for any proposed wall shall consider the internal and external stability of the wall including the bearing pressure, overturning and sliding. The design shall consider lateral earth pressures, including any applicable surcharge loads. In addition, the following general guidelines shall be followed.

- (a) The chosen wall system shall be designed in accordance with the current version of the *AASHTO Standard Specifications for Highway Bridges*.
- (b) Prior to the design of the wall system, the designer/supplier shall be required to perform an in-house geotechnical review of the available geotechnical information with the Geotechnical Branch of Materials Division. The purpose of the geotechnical review will be to obtain the pertinent design information relating to global stability as well as answer questions concerning any of the geotechnical information provided in the plans. The final design shall take into account any global stability issues that are brought forth by the geotechnical review. A generic analysis for global stability will be conducted by the Department and the results provided to the Retaining Wall System Designer at the geotechnical review. Any allowed changes to the wall lines and grades or stabilized soil mass that affect the global stability calculations will require the wall supplier to include a global stability analysis with the final design. The Geotechnical Engineer may be contacted to schedule an appointment.
- (c) The minimum factors of safety to be used in design are as listed below.
 - (1) External Stability
 - Sliding 1.5
 - Overturning 2.0
 - Eccentricity, e, at Base $\leq L/6$ for MSEW, where L is the length of the reinforced soil mass
 - Bearing Capacity 2.5
 - Temporary Slopes 1.2
 - Global Stability 1.4, as noted above
 - (2) Internal Stability
 - Pullout Resistance for MSEW 1.5

- (d) The wall design shall take into account all appurtenances behind, in front of, under, mounted upon, or passing through the wall and supply the appropriate construction details. These items should be accounted for in the internal and external stability calculations.
- (e) Leveling pads, foundations, or footings shall have a minimum cover of two feet. For design purposes, passive pressure in front of the wall shall be assumed to be zero.
- (f) The front face of the wall may be battered into the slope to improve stability as long as this does not interfere with other project appurtenances such as drainage features or right-of-way.
- (g) The wall design shall provide positive drainage behind the wall to assure that the backfill material remains in a drained condition.
- (h) Where geogrid is to be used for MSEW structures as the soil reinforcement, the following design criteria should be followed:
 - (1) The allowable tensile load (T_A) shall be calculated using the following equation and be based on a 100 year design life. The variables used in the equation shall be as allowed by AASHTO or as demonstrated with supporting data in the HITEC evaluation.

Allowable Design Strength of Geogrid:

$$T_A = \frac{T_{CR}}{FS_{ID} \times FS_D \times FS_{UN}}$$

Where:

- T_A = Maximum Design Strength
- T_{CR} = Creep Limited Strength
- FS_{ID} = Factor of Safety For Installation Damage
- FS_D = Factor of Safety For Durability
- FS_{UN} = Factor of Safety For Uncertainties

- (2) The maximum design tensile load of the geogrid shall not exceed the laboratory tested ultimate strength of the geogrid/facing unit connection divided by a factor of safety of 1.5. The connection strength testing and computation procedures shall be in accordance with AASHTO and demonstrated in the HITEC evaluation.

809.02--Materials. Material requirements will vary depending on the type of wall system chosen. Specific material requirements for each wall type are given below.

809.02.1--Conventional Cantilevered Gravity Wall. Concrete for conventional cantilevered gravity walls shall meet the requirements for Class “AA” concrete as set forth in Section 804 of the Standard Specifications. Reinforcing steel shall conform to the requirements set forth in Subsection 711.02 of the Standard Specifications. Driven Piles shall meet the requirements set forth in Sections 803 and 804.

Unless otherwise indicated on the plans, the exposed concrete surfaces of the wall shall have a Class “2” finish as defined in Section 804.

809.02.2--Mechanically Stabilized Earth Walls (MSEW). Materials for Mechanically Stabilized Earth Walls shall meet the following minimum standards.

809.02.2.1--Precast Concrete Facing Panels. Precast concrete facing panels shall be fabricated in accordance with Section 804 with the following exceptions and additions.

- (a) Concrete for the precast concrete facing panels shall conform to Class “AA” concrete.
- (b) In addition to the requirements of Section 804, the units shall be fully supported until the concrete reaches a minimum compressive strength of 1,000 psi. The units can be shipped after reaching a minimum compressive strength of 3,000 psi. At the option of the Contractor, the units may be installed after the concrete reaches a minimum compressive strength of 3,400 psi.
- (c) Unless otherwise indicated on the plans, the concrete surface for the front face shall have a Class “1” finish as defined in Section 804 of the Specifications and the rear face a uniformed surface finish. The rear face of the panel shall be screeded to eliminate open pockets of aggregate and surface distortions in excess of 1/4 inch. The panels shall be cast on a flat area. The soil reinforcing strips or other galvanized attachment devices used to attach the precast concrete facing panel to the soil reinforcement shall not contact or be attached to the face panel reinforcement steel.
- (d) The date of manufacture, the production lot number, and the piece mark shall be clearly scribed on an unexposed face of each panel.
- (e) All units shall be handled, stored, and shipped in such a manner as to eliminate the dangers of chipping, discoloration, cracks, fractures, and excessive bending stresses. Panels in storage shall be supported on firm blocking to protect the panel connection devices and the exposed exterior finish.
- (f) All units shall be manufactured within the following tolerances:
 - (1) Panel Dimensions – Position of the panel connection devices shall be within one inch. All other dimensions shall be within 3/16 inches.
 - (2) Panel Squareness – Squareness shall be determined by the difference between the two diagonals and shall not exceed 1/2 inches.
 - (3) Panel Surface Finish – Surface defects on smooth formed surfaces measured over a length of five feet shall not exceed 1/8 inch. Surface defects on the textured-finish surfaces measured over a length of five feet shall not exceed 5/16 inch.
- (g) Section 804 of the Specifications will be modified as follows:
 - (1) Acceptance of concrete panels with respect to compressive strength will be determined on the basis of production lots. A production lot is defined as a group of panels that will be represented by a single compressive strength sample and will consist of either 40 panels or a single day’s production, whichever is less.
 - (2) During the production of the concrete panels, the manufacturer will randomly sample the concrete in accordance with AASHTO T 141. A single compressive strength sample, consisting of a minimum of four cylinders, will be randomly selected for every production lot.
 - (3) Compression tests shall be made on standard 6-inch by 12-inch test specimen prepared in accordance with AASHTO T 23. Compressive strength testing shall be conducted in accordance with AASHTO T 22.
 - (4) Air content will be performed in accordance with AASHTO T 152 or AASHTO T 196. Air content samples will be taken at the beginning of each

day's production and at the same time as compressive samples are taken to insure compliance with the specifications. The slump will be determined at the beginning of each day's production and at the same time as the compressive samples are taken.

- (5) For every compressive strength sample, a minimum of two cylinders shall be cured in accordance with AASHTO T 23 and tested at 28 days. The average compressive strength of these cylinders, when tested in accordance with AASHTO T 22, will provide a compressive strength test result that will determine the compressive strength of the production lot.
- (6) If the Contractor wishes to remove forms or ship the panels prior to 28 days, a minimum of two additional cylinders shall be cured in the same manner as the panels. The average compressive strength of these cylinders when tested in accordance with AASHTO T 22 will determine whether the forms can be removed or the panels shipped.
- (7) Acceptance of a production lot will be made if the compressive strength test result is greater than or equal to 4,000 psi. If the compressive strength test result is less than 4,000 psi, then the acceptance of the production lot will be based on its meeting the following acceptance criteria in its entirety:
 - (i) 90% of the compressive strength test results for the overall production exceeds 4,150 psi
 - (ii) The average of any six consecutive compressive strength test results exceeds 4,250 psi
 - (iii) No individual compressive strength test result falls below 3,600 psi
- (8) Units shall be rejected because of failure to meet any or all of the requirements specified above. In addition, any or all of the following defects shall be sufficient cause for rejection.
 - (i) Defects that indicate imperfect molding
 - (ii) Defects indicating honeycombed or open texture concrete
 - (iii) Cracked or severely chipped panels
 - (iv) Color variation on from face of panel due to excess form oil or other reasons

809.02.2.2--Modular Block.

809.02.2.2.1--General and Architectural Requirements for Modular Block Units.

Unless otherwise specified in the plans, general and architectural requirements of modular block units shall be as follows:

- (a) Face Color – Gray
- (b) Face Finish – sculptured rock face in angular multi-planer configuration
- (c) Bond Configuration – running with bonds nominally located at the midpoint of vertically adjacent units, in both straight and curved alignments

Exposed surfaces of units shall be free of chips, cracks or other imperfections when viewed from a distance of 10 feet under diffused lighting.

Modular block units shall be manufactured in accordance with ASTM C 90 and C 140.

809.02.2.2.2--Material Requirements for Modular Block Units. Material requirements shall be as follows:

- (a) **Cement:** Materials shall conform to the following applicable specifications and requirements:
 - (1) Hydraulic Cement: AASHTO M 85
 - (2) Modified Hydraulic Cement: Hydraulic cement conforming to AASHTO M 85, modified as follows:
 Limestone: calcium carbonate, with a minimum 85% content, may be added to the cement, provided these requirements of AASHTO M 85 as modified are met:
 - i) Limitation on insoluble residue, percent 1.5
 - ii) Limitation on air content of mortar,
 maximum volume percent 22
 - iii) Limitations of loss of ignition, percent 7
 - (3) Blended Cements: AASHTO M 295
 - (4) Pozzolans: AASHTO M 295
 - (5) Blast Furnace Slag Cement: AASHTO M 302
- (b) **Aggregates:** Aggregates shall conform to the following specifications, as applicable.
 - (1) Normal Mass Aggregates: ASTM C 33
 - (2) Lightweight Aggregates: ASTM C 331
- (c) **Other Constituents:** Air entraining agents, coloring pigments, integral water repellents, finely ground silica, and other constituents shall be previously established as suitable for use in modular block retaining wall units and shall conform to applicable AASHTO or ASTM standards or shall be shown by test or experience to not be detrimental to the durability of the modular block units or any material customarily used in retaining wall construction.

809.02.2.2.3--Structural Requirements for Modular Block Units. Structural requirements for modular block units shall be as follows:

- (a) 28-day Compressive Strength: 4,000 psi, minimum
- (b) Absorption:..... 6% maximum by weight
- (c) Maximum horizontal gap between erected units:..... 0.5 inch

809.02.2.2.4--Base Leveling Pad Material. Base leveling pad material shall be constructed using non-reinforced concrete and be a minimum of six inches thick by 12 inches wide. Class C concrete shall be used for the base leveling pad material unless otherwise noted in the plans.

809.02.2.2.5--Unit Infill or Drainage Fill. Unit Infill or Drainage Fill shall consist of clean, free draining crushed stone or gravel with a one inch maximum particle size and shall meet the gradation listed below.

<u>Sieve Size</u>	<u>Percent Passing</u>
1"	100
3/4"	75 – 100
# 4	0 – 10
# 40	0 – 5

The Engineer shall approve the gradation of the Unit Infill or Drainage Fill. Pea gravel shall not be used. A minimum of 1.5 cubic foot of drainage fill shall be used for each square foot of wall face. Drainage fill may be placed between, behind, and within the cores of units to meet this requirement. In no case will a geotextile or geocomposite be used as a substitute for the drainage fill.

809.02.2.3--Reinforced Backfill for Mechanically Stabilized Earth Walls. Reinforced backfill shall be free of debris and meet the following gradation requirements:

<u>Sieve Size</u>	<u>Percent Passing</u>
3/4"	75 – 100
# 4	20 – 100
# 40	0 – 60
# 200	0 – 15

The maximum aggregate size shall be limited to ¾-inch unless field tests have been performed to evaluate potential strength reductions to the geogrid design due to damage during construction.

The plasticity index (P.I.) as determined by AASHTO T 90 shall not exceed 6.

The backfill material, when compacted to 95% of Standard Proctor, AASHTO T 99, at optimum moisture content, shall exhibit an angle of internal friction of not less than 34° as determined by a standard direct shear test, AASHTO T 236, or triaxial test, AASHTO T 296. In addition, the in-place density shall be within 5% of the assumed density used in wall design calculations.

When metallic reinforcing strips are used, all backfill material shall conform to the following electrochemical requirements:

<u>Electrochemical Properties</u>	<u>Requirements</u>	<u>Test Method, AASHTO</u>
pH	5 – 10	T-289
Resistivity	>3,000 ohms/cm minimum	T-288
Chlorides	<100 ppm maximum	T-291
Sulfates	<200 ppm maximum	T-290
Organic Content	<1%	T-267

Contractor shall submit reinforced backfill sample and laboratory test results to the Engineer for approval prior to the use of any of the proposed reinforced backfill material.

809.02.2.3.1--Metallic Reinforcing and Attachment Devices. All reinforcing and attachment devices shall be inspected to ensure they are true to size and free from defects that may impair their strength and durability, and shall meet the following conditions.

- (a) Reinforcing Strips – Reinforcing strips shall be hot rolled from bars to the required shape and dimensions. Their physical and mechanical properties shall conform to ASTM A709 Grade 50/50W or A 572, Grade 65 or equal. Galvanization shall conform to the minimum requirements set forth in AASHTO M 111.
- (b) Reinforcing Mesh – Reinforcing mesh shall be shop fabricated of cold drawn steel wire conforming to the minimum requirements of AASHTO M 32M/M and shall

be welded into the finish mesh fabric in accordance with AASHTO M 55M/M. Galvanization shall be applied after the mesh is fabricated and conform to the minimum requirements of AASHTO M 111.

- (c) Tie Strips – The tie strips shall be shop fabricated of a hot rolled steel conforming to the minimum requirements of ASTM A 572, Grade 50 or equivalent. Galvanization shall conform to AASHTO M 111.
- (d) Fasteners – Fasteners shall consist of 1/2-inch diameter, hexagonal cap screw bolts and nuts that are galvanized and conform to the requirements of AASHTO M 164 or equivalent.
- (e) Connector Pins – Connector pins and mat bars for the MSEW system shall be fabricated from A36 steel and welded to the soil reinforcement mats as shown on the plans. Galvanization shall conform to AASHTO M 111.

809.02.2.4--Geogrid Reinforcement for Mechanically Stabilized Earth Walls.

809.02.2.4.1--General. A geogrid is defined as a geosynthetic formed by a regular network of integrally connected elements with apertures greater than 0.25 inch to allow interlocking with surrounding soil, rock, earth and other surrounding materials to function primarily as reinforcement.

The geogrid(s) to be utilized in the Modular Block Retaining Wall System shall be creep tested in accordance with ASTM D 5262. The long term design strength (T_{CR} – Creep Limited Strength) shall be obtained from tests run on representative samples for no less than 10,000 hours. The long term design strength shall be defined as the load at which no more than 10% strain occurs over a 100-year design life.

The geogrid shall be mildew resistant and inert to biological degradation and naturally encountered chemicals, alkalis and acids. The geogrid shall contain stabilizers and/or inhibitors, or a resistance finish or covering to make it resistant to deterioration from direct sunlight, ultraviolet rays, and heat.

809.02.2.4.2--Marking, Shipment and Storage. Each roll or container of geogrid shall be visibly labeled with the name of the manufacturer, trade name of the product, lot number, and quantity of material. In addition, each roll or container shall be clearly tagged to show the type designation that corresponds to that required by the plans. During shipment and storage the geogrid shall be protected from direct sunlight, and temperatures above 120°F or below 0°F. The geogrid shall either be wrapped and maintained in a heavy duty protective covering or stored in a safe enclosed area to protect from damage during prolonged storage.

809.02.2.4.3--Manufacturer's Certification. The Contractor shall furnish the Engineer three copies of the manufacturer's certified test reports indicating that the geogrid furnished conforms to the requirements of the specifications and is of the same composition as that originally approved by the Department.

809.02.2.4.4--Acceptance Sampling and Testing. Final acceptance of each shipment will be based upon results of tests performed by the Department on verification samples submitted from the project, as compared to the manufacturer's certified test reports. The Engineer will select one roll or container at random from each shipment for sampling. A sample extending full width of the randomly selected roll or container and being at least

five (5) square yards in area will be obtained and submitted by the Engineer. The sample from each shipment shall be provided at no cost to the State.

809.02.3--Precast Gravity Walls. Materials for precast gravity walls shall meet the following minimum requirements.

809.02.3.1--Foundation Preparation and Base Leveling Pad. The foundation bed for the structure shall be graded as required before erection is started. Prior to wall construction the foundation shall be compacted as specified in Section 203 of the Standard Specifications.

The base leveling pad may be either precast or cast-in-place, as directed by the wall supplier. The base leveling pad shall be constructed of Class “C” concrete unless otherwise specified and shall be cured until a compressive strength of 2,000 psi is attained before placement of wall modules. The completed surface shall be constructed in accordance with the lines and grades shown on the final wall plans. The base leveling pad shall be plane to within 1/8 inch in 10 feet.

809.02.3.2--Prefabricated Modular Units. Prefabricated modular units shall be designed for developed earth pressures behind the wall and from pressures developed inside the modules. Prefabricated modular units shall be constructed in accordance with *AASHTO Standard Specifications for Highway Bridges, Section 5.*

Concrete for prefabricated modular units shall have a minimum 28-day compressive strength of 5,000 psi. The prefabricated modular units shall not be shipped before attaining the required 5,000 psi compressive strength. Unless otherwise indicated on the plans, the concrete surface for the front face shall have a Class “1” finish as defined in Section 804.

The manufacturing process shall be such that it produces uniform modular units and shall be subject to inspection by the Engineer prior to shipment. Precast units will be subject to rejection if they fail to conform to any of the specification requirements or fail to meet the following tolerances.

- (a) Dimensions not conforming to the following tolerances:
 - Face of Panes, length or width $\pm 3/16$ inch
 - Deviation From Square, diagonals across front face $5/16$ inch
- (b) Honeycombed or open texture
- (c) Any damage which would prevent making a satisfactory joint.
- (d) The date of manufacture, lot number, and type of unit in accordance with the approved erection drawings shall be clearly marked on the inside face of each unit.

809.02.3.3--Backfill Material for Modular Units. Backfill material and the embankment behind the wall shall be placed and compacted in accordance with Section 203 of the Standard Specifications. In the event the select backfill recommended by the wall supplier consists of open-graded rock with insufficient fines for conventional compaction controls, the material shall be compacted to a maximum practical density as determined by the Engineer. Otherwise, the select backfill material shall be placed and compacted to at least 95% density as determined by AASHTO T 99.

When the modular backfill material consists of open-graded rock containing insufficient fines to fill the voids between particles in a compacted state, any exposed modular backfill material shall be covered by a layer of Type V nonwoven geotextile to prevent migration of fines into the modular backfill material. The geotextile shall overlap the module a minimum of six inches, except for the front cell.

809.03--Construction Requirements.

809.03.1--General Construction Requirements for All Wall Types.

809.03.1.1--Excavation. The Contractor shall excavate to the lines and grades shown on the final wall plans. The Contractor shall be careful not to disturb the embankment and foundation materials beyond the lines shown. The Engineer will inspect the excavation and give approval prior to placement of the base leveling pad. Soils that the Engineer deems to be unstable or unsuitable shall be excavated and replaced with select borrow material.

Excavation for the wall system shall be as directed by the plans or as directed by the Engineer. Where excavation is required in the immediate vicinity of adjacent structures and/or properties, extreme caution should be exercised. It shall be the Contractor's responsibility to place what bracing, shoring, or ground support system deemed necessary to prevent a failure and protect the persons working near the excavation. The soil supporting the wall system shall be inspected and approved by the Engineer to confirm that the actual foundation soil conditions meet or exceed the assumed design conditions. Over-excavated areas shall be backfilled with select borrow material.

809.03.1.2--Backfill Material. All backfill material shall be compacted in accordance with Section 203 of the Standard Specifications unless otherwise noted on the wall plans. Unless otherwise noted all backfill material shall be placed in non-compacted lifts not to exceed eight inches and be compacted to at least 95% density as determined by AASHTO T 99. Compaction of the backfill within three feet of the back face of the wall shall be accomplished by making at least three passes with a lightweight mechanical tamper, roller, or vibratory system.

At the end of each day's operation, the Contractor shall slope the last level of backfill away from the wall facing to rapidly direct runoff away from the wall face. In addition, the Contractor shall not allow surface runoff from adjacent areas to enter the wall construction site.

809.03.2--Conventional Cantilevered Gravity Wall. The Contractor shall be responsible for all temporary shoring required to construct the conventional cantilevered gravity wall in accordance with the wall design.

809.03.3--Mechanically Stabilized Earth Walls. All components of the MSEW wall system shall be installed in strict accordance with the plans and the manufacturer's recommendations. A representative of the wall manufacturer shall be present at the start of construction of the wall to train the Contractor in the proper installation procedures for the chosen wall system.

809.03.3.1--Foundation Preparation. The foundation for the structure shall be graded level for a width equal to the length of the reinforcement elements plus one foot or as

directed by the wall plans. Prior to wall construction, the foundation shall be compacted with a smooth wheel vibratory roller. Any foundation soils found to be unsuitable shall be removed and replaced as outlined in Subsection 809.03.1.1.

809.03.3.2--Wall Erection.

809.03.3.2.1--Precast Concrete Facings. Precast concrete panels shall be placed so that their final position is vertical or battered as shown on the wall plans. For erection, panels shall be handled by means of lifting devices connected to the upper edge of the panel. Panels should be placed in successive horizontal lifts in the sequence shown on the wall plans as backfill placement proceeds. As backfill material is placed behind the panels, the panels shall be maintained in position by means of temporary wedges or bracing according to the wall supplier's recommendations. Concrete facing vertical tolerances and horizontal alignment tolerances shall not exceed 3/4 inch when measured with a 10-foot straightedge. During construction, the maximum allowable offset in any panel joint shall be 3/4 inch. The overall vertical tolerance of the wall from top to bottom shall not exceed 1/2 inch per 10 feet of wall height. Reinforcement elements shall be placed normal to the face of the wall, unless otherwise shown on the plans.

809.03.3.2.2--Modular Block Facings. The first course of modular block units shall be carefully placed on the base leveling pad and each unit checked for level and alignment.

The following sequence of operations shall then be followed:

- (a) The modular block units shall be placed so that they are in full contact at the base and properly seated. The modular block units are to be placed side by side for full length of wall alignment. Alignment may be done by means of a string line or offset from a base line.
- (b) The voids in and around the modular block units shall be filled with unit drainage fill material. Tamp or rod unit drainage fill to insure that all voids are completely filled.
- (c) The maximum stacked vertical height of wall units, prior to wall drain fill and backfill placement, shall not exceed two courses.
- (d) Excess material shall be swept from the top of the modular blocks prior to installation of the next course. Ensure that each course of modular block units is completely filled with unit drainage fill before proceeding to next course.
- (e) Position vertically adjacent units as recommended by the wall manufacturer.
- (f) Whole or cut units on curves and corners shall be erected with running bond approximately centered on units above and below.
- (g) Reinforcing shall be laid at the proper elevations and oriented such that the strong direction is normal to the wall alignment. Correct orientation of the reinforcing shall be verified by the Engineer.
- (h) Splicing of geogrid pieces shall not be allowed unless approved by the Engineer.

809.03.3.2.3--Precast Gravity Walls. At each foundation level, the base leveling pad shall be given a wood float finish and shall be cured a minimum of 72 hours or reach a compressive strength of 2,000 psi before placement of any modular units. The completed surface of the base leveling pad shall not vary more than 1/8 inch in 10 feet.

All precast modular units above the first course shall interlock with lower courses. Vertical joints shall be staggered with each successive course. The vertical joint opening on the

front face of the wall shall not exceed $\frac{3}{4}$ inch. Joint filler and neoprene pads shall be installed in the horizontal joints of both faces.

All vertical joints between modules shall be covered on the back side of the front face of the wall by a Type V nonwoven geotextile that is a minimum of 18 inches wide. Joints at the corners or angle points shall be closed in accordance with the recommendations of the wall manufacturer.

When the modular backfill material is a rock backfill containing insufficient fines to fill the voids between particles in a compacted state, any exposed modular backfill material shall be covered by a layer of Type V nonwoven geotextile to prevent migration of soil fines into the modular backfill material.

The overall vertical tolerance of the wall, plumbness from top to bottom, shall not exceed $\frac{1}{2}$ inch per 10 feet of wall height.

809.04--Method of Measurement. The retaining wall system of the type specified will be measured by the square foot of accepted vertical face area of the completed structure, constructed as directed by these specifications. The area measured for payment will be computed from the horizontal length of the wall segments and the average wall height between the bottom of the wall or top of the base leveling pad and the top of the wall. In the case of a battered wall, either specified in the plans or battered at the Contractor's option, the vertical distance will be used in the area calculation and not the slope distance along the face of the wall.

809.05--Basis of Payment. The retaining wall system shall be paid for at the contract unit price per square foot, which price shall be full compensation for the design and construction of the retaining wall system, all excavation, select backfill material, leveling pads, undercut, all the materials for the wall drainage system, facing materials, soil reinforcement, equipment, labor, and incidentals necessary to complete the work as directed by the Engineer.

Payment will be made under:

809-A: Retaining Wall System * - per square foot

* Type of wall may be specified

SECTION 810 - STEEL STRUCTURES

810.01--Description. This work consists of furnishing, fabricating, preparing, assembling, erecting, and painting structural steel and all accessories and other metal parts required in steel spans. This work shall be constructed as indicated on the plans, in reasonably close conformity with the lines, grades, dimensions, and design shown, and in accordance with the applicable provisions and requirements in other sections of these specifications for the different items that constitute the complete structure.

All structural steel work shall be performed in accordance with these specifications and the *AASHTO Guide Specification for Highway Bridge Fabrication with HPS70W Steel*. Fabricators shall be certified in accordance with the AISC Quality Certification Program

in the Major Steel Bridges (CBR) category with Fracture Critical Endorsement (F) prior to the start of fabrication.

These specifications apply to bolted and welded construction when indicated in the contract.

810.02--Materials.

810.02.1--General. Unless otherwise specified, structural steel, miscellaneous metals, and paints shall conform to the applicable requirements of this section and Sections 710, 716, 717, and 814. Unless otherwise specified, structural carbon steel, ASTM A709 Grade 50/50W, shall be furnished.

810.02.2--Drawings. The Contractor shall prepare shop drawings for all materials to be fabricated. The size of the sheets on which the drawings are prepared shall conform to the standard bridge sheet of the Department. Two complete sets of prints shall be submitted to the Bridge Engineer for approval prior to ordering any materials for fabrication.

For all fabrication to be done by welding, two copies of welding procedures in accordance with the provisions of ANSI/ASSHTO/AWS D1.5 Bridge Welding Code, hereinafter referred to as the Welding Code, shall also be submitted to the Bridge Engineer for approval. After final approval of the shop drawings and welding procedures, if applicable, six complete sets of prints shall be submitted to the Bridge Engineer. As required by special conditions, the Bridge Engineer shall be furnished with as many additional sets of prints as may be necessary. Shop drawings for railroad bridges shall be prepared with ink on linen tracing cloth or other approved equal, which shall be delivered to the Bridge Engineer prior to final acceptance of the project. No changes shall be made in a shop drawing after it has been approved, nor shall steel sections different from those shown on the plans be substituted except with the written consent or direction of the Engineer.

Prior to the fabrication of any part of a structure, shop drawings and welding procedures for that part of the structure shall have been given final, unconditional approval by the Bridge Engineer. Work performed prior to approval of drawing and procedures may be rejected.

810.02.3--Shop Painting. Shop painting, unless otherwise designated or permitted, shall consist of inorganic zinc primer, Section 710, applied as specified in Section 814. Machine-finished surfaces of pins, pin rollers and bores shall be coated as soon as practicable after acceptance with a heavy coat of Petrolatum meeting the requirements of ASTM D 217, NLGI Consistency Grade 2 or 3, or other approved coating prior to removal from the shop.

810.02.4--Storage of Materials. Structural material, either plain or fabricated, shall be stored at the bridge shop above ground on platforms, skids, or other supports. It shall be kept free from dirt, grease, and other foreign matter and shall be protected as far as practicable from corrosion.

810.02.5--Straightening Material. Rolled material, before being laid off or worked, must be straight. If straightening is necessary, it shall be done by methods that will not injure the metal. Heat straightening of ASTM A514/A517 steel shall be done only under rigidly controlled procedures and each application subject to the approval of the Engineer. In no

case shall the maximum temperature of the steel exceed 1125°F. Sharp kinks and bends will be cause for rejection of the material.

810.02.6--Curving Rolled Beams and Welded Girders. Steels that are manufactured to a yield point greater than 50,000 psi shall not be heat curved.

810.02.6.1--Type of Heating. Beams and girders may be curved by either continuous or V-type heating as approved by the Engineer. For the continuous method, a strip along the edge of the top and bottom flange shall be heated simultaneously. The strip shall be of sufficient width and temperature to obtain the required curvature. For the V-type heating, the top and bottom flanges shall be heated in truncated triangular or wedge-shaped areas having their bases along the flange edge and spaced at regular intervals along each flange. The spacing and temperature shall be as required to obtain the required curvature, and heating shall progress along the top and bottom flange at approximately the same rate.

For the V-type heating, the apex of the truncated triangular area applied to the inside flange surface shall terminate just before the juncture of the web and the flange is reached. To avoid unnecessary web distortion, special care shall be taken when heating the inside flange surface so the heat is not applied directly to the web. When the radius of curvature is 1000 feet or more, the apex of the truncated triangular heating pattern applied to the outside flange surface shall extend to the juncture of the flange and web. When the radius of curvature is less than 1000 feet, the apex of the truncated triangular heating pattern applied to the outside flange surface shall extend past the web for a distance equal to 1/8 of the flange or three (3) inches, whichever is less. The truncated triangular pattern shall have an included angle of approximately 15 to 30 degrees, but the base of the triangle shall not exceed 10 inches. Variations in the patterns prescribed above may be made with the approval of the Engineer.

For both types of heating, the flange edges to be heated are those that will be on the inside of the horizontal curve after cooling. Heating both inside and outside flange surfaces is only mandatory when the flange thickness is 1¼ inches or greater, in which case the two surfaces shall be heated concurrently. The maximum temperatures shall be as prescribed below.

810.02.6.2--Temperature. The heat-curving operation shall be conducted in such a manner that the temperature of the steel does not exceed 1150°F as measured by temperature indicating crayons or other suitable means. The girder shall not be artificially cooled until after naturally cooling to 600°F. The method of artificial cooling is subject to the approval of the Engineer.

810.02.6.3--Position for Heating. The girder may be heat- curved with the web in either a vertical or a horizontal position. When curved in the vertical position, the girder shall be braced or supported in such a manner that the tendency of the girder to deflect laterally during the heat- curving process will not cause the girder to overturn.

When curved in the horizontal position, the girder must be supported near its ends and at intermediate points, if required, to obtain a uniform curvature. The bending stress in the flanges due to the dead weight of the girder must not exceed the usual allowable design stress. When the girder is positioned horizontally for heating, intermediate safety catch blocks must be maintained at the mid-length of the girder within two inches of the flanges

at all times during the heating process to guard against a sudden sag due to plastic flange buckling.

810.02.6.4--Sequence of Operations. The girder shall be heat curved in the fabrication shop before it is painted. The heat curving operation may be conducted either before or after all the required welding of transverse intermediate stiffeners is completed. However, unless provisions are made for girder shrinkage, connection plates and bearing stiffeners shall be located and attached after heat curving. If longitudinal stiffeners are required, they shall be heat curved or oxygen cut separately and then welded to the curved girder. When cover plates are to be attached to rolled beams, they may be attached before heat curving if the total thickness of one flange and cover plate is less than 2½ inches and the radius of curvature is greater than 1000 feet. For other rolled beams with cover plates, the beams must be heat-curved before the cover plates are attached. Cover plates must be either heat curved or oxygen cut separately and then welded to the curved beam.

810.02.6.5--Camber. Girders shall be cambered before heat curving. Camber for rolled beams may be obtained by heat-cambering methods approved by the Engineer. For plate girders, the web shall be cut to the prescribed camber with suitable allowance for shrinkage due to cutting, welding, and heat curving. The heat-curving process may tend to change the vertical camber present before heating. This effect will be most pronounced when the top and bottom flanges are of unequal widths on a given transverse cross section. However, subject to the approval of the Engineer, moderate deviations from specified camber may be corrected by a carefully supervised application of heat.

810.02.6.6--Measurement of Curvature and Camber. Horizontal curvature and vertical camber shall not be measured for final acceptance before all welding and heating operations are completed, and the flanges have cooled to a uniform temperature. Horizontal curvature shall be checked with the girder in the vertical position by measuring off-sets from a string line or wire attached to both flanges or by using other suitable means. Camber shall be checked by adequate means.

810.02.7--Finish. Portions of work exposed to view shall be finished neatly. Shearing, flame cutting, and chipping shall be done carefully and accurately.

810.02.8--Bolt Holes. All holes for bolts shall be either punched or drilled. Material forming parts of a member composed of not more than five thicknesses of metal may be punched 1/16 inch larger than the nominal diameter of the bolts whenever the thickness of the material is not greater than 3/4 inch for structural steel, 5/8 inch for high strength steel, or 1/2 inch for quenched and tempered alloy steel, unless subpunching and reaming is required under Subsection 810.02.11.1.

When there are more than five thicknesses or when any of the main material is thicker than 3/4 inch for structural steel, 5/8 inch for high strength steel, or 1/2 inch for quenched and tempered alloy steel, all holes shall either be subdrilled or drilled full size.

When required under Subsection 810.02.11, all holes shall be either subpunched or subdrilled 3/16 inch smaller and after assembling, reamed 1/16 inch larger or drilled full size to 1/16 inch larger than the nominal diameter of bolts. Holes shall be subdrilled if thickness limitation governs.

810.02.9--Punched Holes. The diameter of the die shall not exceed the diameter of the punch by more than 1/16 inch. If any holes must be enlarged to admit the bolts, such holes shall be reamed. Holes must be clean cut without torn or ragged edges. Poor matching of holes will be cause for rejection.

810.02.10--Reamed or Drilled Holes. Reamed or drilled holes shall be cylindrical, perpendicular to the member, and shall comply with the requirements of Subsection 810.02.8 as to size. Where practicable, reamers shall be directed by mechanical means. Burrs on the outside surfaces shall be removed. Poor matching of holes will be cause for rejection. Reaming and drilling shall be done with twist drills. If required by the Engineer, assembled parts shall be taken apart for removal of burrs caused by drilling. Connecting parts requiring reamed or drilled holes shall be assembled and securely held while being reamed or drilled and shall be match marked before disassembling.

810.02.11--Preparation of Field Connections.

810.02.11.1--Subpunching and Reaming of Field Connections. Unless otherwise specified, holes in all field connections and field splices of main members of trusses, arches, continuous beam spans, bents, each face of towers, plate girders, and rigid frames shall be subpunched or subdrilled if subdrilling is required by Subsection 810.02.8, and subsequently reamed while assembled or to a steel template, as required by Subsection 810.02.16.

All holes for floorbeam and stringer field end connections shall be subpunched and reamed to a steel template or reamed while assembled.

Reaming or drilling full size of field connection holes through a steel template shall be done after the template has been located with utmost care as to position and angle and firmly bolted in place. Templates used for reaming matching members, or the opposite faces of a single member, shall be exact duplicates. Templates used for connections on like parts or members shall be accurately located so that the parts or members are duplicates and require no match-marking.

For any connection, in lieu of subpunching and reaming or subdrilling and reaming, the fabricator shall have the option of drilling holes full size with all thicknesses of material assembled in proper position.

If additional subpunching and reaming is required, it shall be as specified on the plans.

810.02.11.2--Numerically-Controlled Drilled Field Connections. Alternately, for any connection or splice designated in Subsection 810.02.11.1 in lieu of sub-sized holes and reaming while assembled, or drilling holes full-size while assembled, the Contractor shall have the option to drill bolt holes full-size in unassembled pieces and/or connections including templates for use with matching sub-sized and reamed holes by means of suitable numerically-controlled (N/C) drilling equipment subject to the specific provisions contained in this article.

If N/C drilling equipment is used, the Engineer, unless otherwise stated in the special provisions or on the plans, may require the Contractor, by means of check assemblies, to demonstrate that this drilling procedure consistently produces holes and connections meeting the requirements of Subsections 810.02.13 and 810.02.16.

The Contractor shall submit to the Engineer for approval a detailed outline of the procedures proposed to be followed in accomplishing the work from initial drilling through check assembly, if required, to include the specific members of the structure that may be N/C drilled, the sizes of the holes, the location of common index and other reference points, composition of check assemblies, and all other pertinent information.

Holes drilled by N/C drilling equipment shall be drilled to appropriate size either through individual pieces or any combination of pieces held tightly together.

810.02.12--Accuracy of Punched and Drilled Holes. All holes punched full size, subpunched, or subdrilled shall be so accurately punched that after assembling, before any reaming is done, a cylindrical pin $\frac{1}{8}$ -inch smaller in diameter than the nominal size of the punched hole may be entered perpendicular to the face of the member, without drifting, in at least 75 percent of the contiguous holes in the same plane. If this requirement is not fulfilled, the badly punched pieces will be rejected. If any hole will not pass a pin $\frac{3}{16}$ inch smaller in diameter than the nominal size of the punched hole, this will be cause for rejection.

810.02.13--Accuracy of Reamed and Drilled Holes. When holes are reamed or drilled, 85 percent of the holes in any contiguous group shall, after reaming or drilling, show no offset greater than $\frac{1}{32}$ inch between adjacent thicknesses of metal.

All steel templates shall have hardened steel bushings in holes accurately dimensioned from the center lines of the connection as inscribed on the template. The center lines shall be used in accurately locating the template from the milled or scribed ends of the members.

810.02.14--Fitting for Bolting. Surfaces of metal in contact shall be cleaned before assembling. The parts of a member shall be assembled, well pinned, and firmly drawn together with bolts before reaming is commenced. Assembled pieces shall be taken apart, if necessary, for the removal of burrs and shavings produced by the reaming operation. The member shall be free from twists, bends, and other deformation.

Preparatory to the shop riveting of full-sized punched material, the rivet holes, if necessary, shall be spear-reamed for the admission of the rivets. The reamed holes shall not be more than $\frac{1}{16}$ inch larger than the nominal diameter of the rivets.

End connection angles, stiffener angles, and similar parts shall be carefully adjusted to correct position and bolted, clamped, or otherwise firmly held in place until riveted.

Parts not completely riveted in the shop shall be secured by bolts, insofar as practicable, to prevent damage in shipment and handling.

810.02.15--Unpainted Weathering Structural Steel. Unless otherwise specified, material designated as A709 Grade 50W and A709 HPS70W structural steel that is not to be painted shall be blast cleaned to remove mill scale or other substances. Blast cleaning shall conform to SSPC-SP6, Commercial Blast Cleaning. Care shall be taken that dents, scratches, gouges or identification marks will not appear on exposed surfaces. All steel is to remain in the unpainted condition and shall be handled so that it is kept free of all grease, oil, concrete, chalk marks, dirt, or any other foreign material that might affect the natural and uniform weathering of the steel.

Any foreign material that adheres to the steel during the fabrication or construction process that will inhibit the formation of the oxide film shall be removed as soon as practicable according to the SSPC Surface Preparation Specification by one of the following four methods.

1. SSPC-SP1, Solvent Cleaning
2. SSPC-SP2, Hand Tool Cleaning
3. SSPC-SP3, Power Tool Cleaning
4. SSPC-SP7, Brush-off Blast Cleaning

810.02.16--Shop Assembling.

810.02.16.1--General. The field connections of main members of trusses, arches, continuous beam spans, bents, each face of towers, plate girders, and rigid frames shall be assembled in the shop with milled ends of compression members in full bearing, and then shall have their subsize holes reamed to specified size while the connections are assembled. Assembly shall be Full Truss or Girder Assembly unless Progressive Truss or Girder Assembly, Full Chord Assembly, Progressive Chord Assembly, or Special Complete Structure Assembly is specified in the special provisions or on the plans. Modifications to these assemblies may be allowed when approved in writing by the Bridge Engineer.

When required on the plans, check assemblies and N/C drilled field connections shall be in accordance with the provisions of Subsection 810.02.16.7.

Each assembly, including camber, alignment, accuracy of holes, and fit of milled joints, shall be approved by the Engineer before reaming is commenced or before an N/C drilled check assembly is dismantled.

A camber diagram shall be furnished the Engineer by the Fabricator showing the camber at each panel point in the cases of trusses or arch ribs, and at the location of field splices and fractions of span length in case of continuous beam and girders or rigid frames. Fraction points of span lengths shall be 1/4 points minimum, 1/10 points maximum. When the shop assembly is full truss or girder assembly or special complete structure assembly, the camber diagram shall show the camber measured in assembly. When any of the other methods of shop assembly is used, the camber diagram shall show calculated camber.

810.02.16.2--Full Truss or Girder Assembly. Full truss or girder assembly shall consist of assembling all members of each truss, arch rib, bent, tower face, continuous beam line, plate girder, or rigid frame at one time.

810.02.16.3--Progressive Truss or Girder Assembly. Progressive truss or girder assembly shall consist of assembling initially for each truss, arch rib, bent, tower face, continuous beam line, plate girder, or rigid frame at least three contiguous shop sections or all members in at least three contiguous panels but not less than the number of panels associated with three contiguous chord lengths, i.e., length between field splices, and not less than 150 feet in the case of structures longer than 150 feet. At least one shop section or panel or as many panels as are associated with a chord length shall be added at the advancing end of the assembly before any member is removed from the rearward end, so that the assembled portion of the structure is never less than that specified above.

810.02.16.4--Full Chord Assembly. Full chord assembly shall consist of assembling, with geometric angles at the joints, the full length of each chord of each truss or open spandrel arch, or each leg of each bent or tower, then reaming their field connection holes while the members are assembled and reaming the web member connection to steel templates set at geometric not cambered angular relation to the chord lines.

Field connection holes in web members shall be reamed to steel templates. At least one end of each web member shall be milled or shall be scribed normal to the longitudinal axis of the member and the templates at both ends of the member shall be accurately located from one of the milled ends or scribed lines.

810.02.16.5--Progressive Chord Assembly. Progressive chord assembly shall consist of assembling contiguous chord members in the manner specified for full chord assembly and in the number and length specified for progressive truss or girder assembly.

810.02.16.6--Special Complete Structure Assembly. Special complete structure assembly shall consist of assembling the entire structure, including the floor system. This procedure is ordinarily needed only for complicated structures such as those having curved girders, or extreme skew in combination with severe grade or camber, and will be required only when so indicated on the plans.

810.02.16.7--Check Assemblies with Numerically Controlled Drilled Field Connections. Unless otherwise indicated, a check assembly shall be fabricated for each major structural type and shall consist of at least three contiguous shop sections or, in a truss, all members in at least three contiguous panels but not less than the number of panels associated with three contiguous chord lengths, i.e., length between field splices. Check assemblies should be based on the proposed order of erection, joints in bearings, special complex points, and similar considerations. Such special points could be the portals of skewed trusses, etc.

Use of either geometric angles, giving theoretically zero secondary stresses under dead-load conditions after erection, or cambered angles, giving theoretically zero secondary stresses under no-load conditions, should be designated on the plans or in the special provisions.

The check assemblies shall preferably be the first such section of each major structural type to be fabricated.

No match-marking and no shop assemblies other than the check assemblies will be required.

If the check assembly fails in some specific manner to demonstrate that the required accuracy is being obtained, further check assemblies may be required by the Engineer, for which there shall be no additional cost to the State.

810.02.17--Drifting of Holes. The drifting done during assembling shall be only such as to bring the parts into position and not sufficient to enlarge the holes or distort the metal. If any holes must be enlarged to admit the rivets, they shall be reamed.

810.02.18--Match-Marking. Connecting parts assembled in the shop for the purpose of reaming holes in field connections shall be match-marked, and a diagram showing such marks shall be furnished to the Engineer.

810.02.19--Blank.

810.02.20--Bolts and Bolted Connections. Bolted connections fabricated using high strength bolts shall conform to Subsection 810.02.21.

810.02.20.1--General. Bolts shall be unfinished, turned, or ribbed bolts conforming to the requirements for Grade A Bolts of Specification for Low-Carbon Steel Externally and Internally Threaded Standard Fasteners, ASTM A 307. Bolted connections shall be used only as indicated by the plans or special provisions. Bolts shall have single self-locking nuts or double nuts unless otherwise shown on the plans or in the special provisions. Beveled washers shall be used where bearing faces have a slope of more than 1:20 with respect to a plane normal to the bolt axis.

810.02.20.2--Unfinished Bolts. Unfinished bolts shall be furnished unless other types are specified.

810.02.20.3--Turned Bolts. The surface of the body of turned bolts shall meet the ANSI roughness rating value of 125. Heads and nuts shall be hexagonal with standard dimensions for bolts of the nominal size specified or the next larger nominal size. Diameter of threads shall be equal to the body of the bolt or the nominal diameter of the bolt specified. Holes for turned bolts shall be carefully reamed with bolts furnished to provide for a light driving fit. Threads shall be entirely outside of the holes. A washer shall be provided under the nut.

810.02.20.4--Ribbed Bolts. The body of ribbed bolts shall be of an approved form with continuous longitudinal ribs. The diameter of the body measured on a circle through the points of the ribs shall be 5/64 inch greater than the nominal diameter specified for the bolts.

Ribbed bolts shall be furnished with round heads conforming to ANSI B 18.5 unless otherwise specified. Nuts shall be hexagonal, either recessed or with a washer of suitable thickness. Ribbed bolts shall make a driving fit with the holes. The hardness of the ribs shall be such that the ribs do not mash down enough to permit the bolts to turn in the holes during tightening. If for any reason the bolt twists before drawing tight, the hole shall be carefully reamed and an oversized bolt used as a replacement.

810.02.21--Connections Using High Strength Bolts. This subsection covers the assembly of structural joints using ASTM A 325 high strength bolts for structural steel joints or ASTM A 490 quenched and tempered alloy bolts for structural steel joints, or equivalent fasteners, tightened to a high tension. The bolts are used in holes conforming to the requirements of Subsections 810.02.8, 810.02.9 and 810.02.10.

810.02.21.1--Bolts, Nuts, Washers and Direct Tension Indicators (DTI). All bolts, nuts, washers and DTI shall conform to the requirements of Section 717 for such items.

Unless otherwise shown on the plans, all threaded bolts shall be of sufficient length to provide at least full-thread engagement, as defined in Subsection 810.04.4, immediately prior to final tensioning.

All markings on bolts, nuts, washers and DTIs must include the symbol of the manufacturer and not the distributor or any other trading entity. This is spelled out in all ASTM specifications covering these product categories. A325 bolts shall be marked "A325" and A490 bolts marked "A490." Type 1 A325 bolts shall be marked with three radial lines 120° apart. Type 3 A325 bolts shall have A325 underlined plus other distinguishing marks indicating that the bolt is atmospheric corrosion resistant and of a weathering type. Type 2 A325 bolts shall be marked with three radial lines 60° apart. DTIs shall also be marked "325" in the case of Type "325" or "490".

810.02.21.2--Bolted Parts. The slope of surfaces of bolted parts in contact with the bolt head and nut shall not exceed 1:20 with respect to a plane normal to the bolt axis. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible material.

When assembled, all joint surfaces, including those adjacent to the bolt heads, nuts, or washers, shall be free of scale, except tight mill scale, and shall also be free of dirt, loose scale, burrs, other foreign material, and other defects that would prevent solid seating of the parts. Paint is permitted in bearing-type connections.

Contact surfaces within friction-type joints shall be free of oil, paint, lacquer or other coatings, except as listed below:

- a. Hot dip galvanizing, if contact surfaces are scored by wire brushing or blasting after galvanizing and prior to assembly. The wire brushing treatment shall be a light application of manual brushing, not power wire brushing, that marks or scores the surface but removes relatively little of the zinc coating. The blasting treatment shall be a light "brush-off" treatment that will produce a dull gray appearance. However, neither treatment should be severe enough to produce any break or discontinuity in the zinc surface.
- b. Inorganic zinc rich paints as specified in Subsection 710.03.

ASTM A 325 Type 2 and ASTM A 490 bolts shall not be galvanized nor shall they be used to connect galvanized material.

810.03--Construction Requirements.

810.03.1--Installation.

810.03.1.1--Bolt Tension. Each fastener shall be tightened to provide, when all fasteners in the joint are tight, at least the minimum bolt tension for the size and grade of fastener used, as shown in the following table:

BOLT TENSION

Bolt Size, inches	Minimum Bolt Tension, pounds	
	<u>ASTM A 325 Bolts</u>	<u>ASTM A 490 Bolts</u>
1/2	12,050	14,900
5/8	19,200	23,700
3/4	28,400	35,100
7/8	39,250	48,500
1	51,500	63,600
1 1/8	56,450	80,100
1 1/4	71,700	101,800
1 3/8	85,450	121,300
1 1/2	104,000	147,500

The rotational-capacity test described in Subsection 717.02.3.4 shall be performed on each rotational-capacity lot prior to the start of bolt installation. Hardened steel washers are required as part of the test although they may not be required in the actual installation procedure.

A Skidmore-Wilhelm Calibrator or an equivalent tension measuring device shall be required at each job site during erection. Periodic testing, at least one each working day when the calibrated wrench method is used, shall be performed to assure compliance with the installation requirements for calibrated wrench tightening, turn-of nut tightening or DTI tightening.

The Contractor shall provide all wrenches necessary for obtaining the specified bolt tension, and shall also provide, at no additional costs to the State, the necessary inspection wrenches and provisions for calibration of such wrenches as specified in this subsection and in Subsection 810.03.2.

Threaded bolts shall be checked for tension with properly calibrated wrenches, by the turn-of-nut method, or by the use of DTIs. When required because of bolt entering and wrench operating clearances, tightening may be accomplished by turning the bolt while the nut is prevented from rotating, provided the requirements of Subsections 810.03.1.2 and 810.03.1.5 are met.

Impact wrenches, if used, shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately 10 seconds.

ASTM A490 and galvanized ASTM A325 bolts shall not be reused. Other ASTM A325 bolts may be reused, but not more than once, if approved by the Engineer. Retightening previously tightened bolts that may have been loosened by the tightening of adjacent bolts shall not be considered as a reuse.

Galvanized nuts shall be checked to verify that a visible lubricant is on the threads. Black bolts shall be "oily" to the touch when delivered and installed. Weathered or rusted bolts and nuts shall be cleaned and re-lubricated prior to installation. When required, bolt, nut and washer combinations as installed shall be from the same rotational-capacity lot, reference Subsection 717.02.

810.03.1.2--Washers. All fasteners shall have a hardened washer under the element (nut or bolt head) turned in tightening except that ASTM A325 bolts installed by the turn of the

nut method in holes that are not oversize or slotted may have the washer omitted. Hardened washers shall be used under both the head and nut regardless of the element turned in the case of ASTM A490 bolts if the material against which it bears has a specified yield strength less than 40 ksi. When ASTM A 490 bolts over one inch in diameter are used in conjunction with short slotted or oversized holes, the hardened washers shall be at least 5/16 inch thick.

Where an outer face of the bolted parts has a slope of more than 1:20 with respect to a plane normal to the bolt axis, a smooth beveled washer shall be used to compensate for the lack of parallelism.

810.03.1.3--Calibrated Wrench Tightening. When calibrated wrenches are used to provide the bolt tension specified in Subsection 810.03.1.1, their setting shall be such as to induce a bolt tension five percent to ten percent in excess of this value. These wrenches shall be calibrated at least once each working day by tightening, in a device capable of indicating actual bolt tension, not less than three typical bolts of each diameter to be installed. Power wrenches shall be adjusted to stall or cut-out at the selected tension. If manual torque wrenches are used, the torque indication corresponding to the calibrating tension shall be noted and used in the installation of all bolts of the tested lot. Nuts shall be in the tightening direction when torque is measured. When using calibrated wrenches to install several bolts in a single joint, the wrench shall be returned to "touch up" bolts previously tightened, which may have been loosened by the tightening of subsequent bolts, until all are tightened to the specified tension.

The required torque for calibrated wrenches may be approximated by the following formula:

$$T \text{ (inch-pounds)} = 0.2 \times \text{Bolt Diameter (inches)} \times \text{Bolt Tension (pounds)}$$

810.03.1.4--Turn-of-Nut Tightening. When the turn-of-nut method is used to provide the bolt tension specified in Subsection 810.03.1.1, there shall first be enough bolts brought to a "snug tight" condition to ensure that the parts of the joint are brought into full contact with each other. "Snug tight" is defined as the initial tightening of the nut such that a load in the bolt of not less than 10% of the specified proof load for each type and size bolt used is produced. Following this initial operation, bolts shall be placed in the remaining holes in the connection and brought to snug tightness. All bolts in the joint shall then be tightened additionally by the applicable nut rotation specified in the following table with tightening progressing systematically from the most rigid part of the joint to its free edges. During this operation there shall be no rotation of the part not turned by the wrench.

NUT ROTATION⁽¹⁾ FROM SNUG-TIGHT CONDITION

For coarse thread heavy hexagon structural bolts of all sizes and lengths and heavy hexagon semi-finished nuts

Bolt Length, as measured from underside of head to extreme end of point	Disposition of Outer Faces of Bolted Parts		
	Both faces normal to bolt axis	One face normal to bolt axis and other face sloped not more than 1:20. Bevel washer not used.	Bolt faces sloped not more than 1:20 from normal to bolt axis. Bevel washers not used.
Up to and including 4 diameters	1/3 turn*	1/2 turn*	2/3 turn**
Over 4 diameters but not exceeding 8 diameters	1/2 turn*	2/3 turn**	5/6 turn**
Over 8 diameters but not exceeding 12 diameters	2/3 turn**	5/6 turn**	1 turn**

⁽¹⁾ Nut rotation is rotation relative to bolt regardless of the element, nut or bolt, being turned.

* Rotation Tolerance: Plus or minus 30 degrees

** Rotation Tolerance: Plus or minus 45 degrees

810.03.1.5--Direct Tension Indicators Tightening. When DTI are required on the plans, the Contractor shall furnish a copy of the manufacturer's written installation instructions to the Bridge Engineer for approval prior to beginning work.

It shall be the Contractor's responsibility to have a manufacturer's representative on the job site during initial installation of bolted connections to instruct personnel on the correct method of installation and inspection of the DTI.

The DTI shall be installed and the bolts tightened in strict accordance with the manufacturer's written instruction. The DTI are in addition to washers required by the plans and Standard Specifications.

DTI protrusions for all installations shall bear against a hardened unturned surface, normally either the underside of the bolt head or a hardened washer, and never directly against the turned element.

Prior to the final tightening of all high strength bolts, all the plies of steel shall be drawn together by partially compressing DTI protrusions to ensure "snug tight" conditions. The final tightening shall progress systematically from the most rigid part of the joint to its free edges until the DTI on all bolts are closed to 0.005 inch.

DTI shall not be reused. If it becomes necessary to loosen a bolt previously tensioned, the DTI shall be discarded and replaced.

Bolts shall be of sufficient length to accommodate an indicator and washers made necessary by its use.

The Contractor shall furnish a Skidmore-Wilhelm device or approved equal capable of measuring actual bolt tension. At least three typical bolts and DTIs shall be tightened in a device capable of determining their performance characteristics prior to the start of bolt placement. The device shall be made available thereafter during bolt placement for similar checks not to exceed intervals of one week unless directed otherwise by the Bridge Engineer.

High strength bolts, nuts, washers, and DTIs shall be shipped to the project site in sealed metal containers or an approved equal. They shall be stored out of the weather in a location approved by the Engineer. The containers shall remain unopened until the contents are needed for erection. Bolts that, before use, have been exposed and become dried out or rusty will be rejected and will not be used until they are cleaned and lubricated.

810.03.1.6--Lock-Pin and Collar Fasteners. The installation of lock-pin and collar fasteners shall be by methods and procedures approved by the Engineer.

810.03.2--Inspection. The Engineer will observe the installation and tightening of bolts to determine that the selected tightening procedure is properly used and will determine that all bolts are tightened. When the calibrated wrench method of tightening is used, the Engineer will have full opportunity to witness the calibration tests prescribed in Subsection 810.03.1.3.

The following inspection shall be used unless a more extensive or different inspection procedure is specified.

810.03.2.1--Inspecting Wrench. Either the Engineer, or the Contractor in the presence of the Engineer, shall use an inspecting wrench that may be either a torque wrench or a power wrench that can be accurately adjusted in accordance with the requirements of Subsection 810.03.1.3.

810.03.2.2--Calibration Device. Three bolts of the same grade, size and conditions as those under inspection shall be placed individually in a calibration device capable of indicating bolt tension. The length of the bolt may be any length representative of bolts used in the structure. There shall be a washer under the part turned in tightening each bolt.

810.03.2.3--Torque Wrench. When the inspecting wrench is a torque wrench, each bolt specified in Subsection 810.03.2.2 shall be tightened in the calibration device by any convenient means to the minimum tension specified for its size in Subsection 810.03.1.1. The inspecting wrench then shall be applied to the tightened bolt and the torque necessary to turn the nut or head five degrees, approximately one inch at 12-inch radius, in the tightening direction shall be determined. The average torque measured in the tests of three bolts shall be taken as the job inspecting torque to be used in the manner specified in Subsection 810.03.2.5.

810.03.2.4--Power Wrench. When the inspecting wrench is a power wrench it shall be adjusted so that it will tighten each bolt specified in Subsection 810.03.2.2 to a tension at least five but not more than ten percent greater than the minimum tension specified for its

size in Subsection 810.03.1.1. This setting of wrench shall be taken as the job inspecting torque to be used in the manner specified in the following subsection.

810.03.2.5--Bolts. Bolts represented by the sample prescribed in Subsection 810.03.2.2 that have been tightened in the structure shall be inspected by applying, in the tightening direction, the inspecting wrench and its job inspecting torque to ten percent of the bolts, but not less than two bolts, selected at random in each connection. If no nut or bolt head is turned by this application of the job inspecting torque, the connection shall be accepted as properly tightened. If any nut or bolt head is turned by the application of the job inspecting torque, this torque shall be applied to all bolts in the connection, and all bolts whose nut or head is turned by the job inspecting torque shall be tightened and re-inspected, or alternatively, the fabricator or erector, at no additional cost to the State, may re-tighten all of the bolts in the connection in the manner required and subject to the limitations imposed for the initial tightening and then resubmit the connection for the specified inspection.

810.03.2.6--Direct Tension Indicators. When DTIs are used, the Department's inspector will check for correct tensioning by inserting a correct-thickness pointed feeler gage into the opening between adjacent flattened protrusions in accordance with the manufacturer's instructions and Subsection 810.03.1.5. At least ten percent, but no less than two, of the bolts in each connection will be examined.

A nil gap on ASTM A325 bolts is not cause for rejection. A nil gap for ASTM A490 bolts is not allowed.

810.03.2.7--Lock-pin and Collar Fasteners. The procedures for inspecting and testing the lock-pin and collar fasteners and their installation to ensure that the required pre-load tension is provided shall be as approved by the Engineer.

810.03.3--Blank.

810.03.4--Plate Cut Edges.

810.03.4.1--Edge Planing. Sheared edges of plates more than 5/8 inch in thickness and carrying calculated stress shall be planed to a depth of 1/4 inch. Re-entrant cuts shall be filleted to a minimum radius of 3/4 inch before cutting.

810.03.4.2--Visual Inspection and Repair of Plate Cut Edges. Visual inspection and repair of plate cut edges shall be in accordance with the Welding Code.

810.03.5--Welds. Welding of steel structures, when authorized on the plans or on approved working drawings, and pre-qualification of welding operators shall conform to the Welding Code.

Welding shall be tested by non-destructive methods as prescribed in the Welding Code and as indicated on the plans. Edge blocks shall be used when radiographing butt welds greater than 1/2 inch thickness. The edge blocks shall have a length sufficient to extend beyond each side of the weld centerline for a minimum distance equal to the weld thickness, but no less than two inches, and shall have a thickness equal to or greater than the thickness of the weld. The minimum width of the edge blocks shall be equal to half the weld thickness, but not less than 1 inch. The edge blocks shall be centered on the weld with a snug fit

against the plate being radiographed, allowing no more than 1/16 inch gap. Edge blocks shall be made of radiographically clean steel and the surface shall have a finish of ANSI 125 μinch, or smoother. Non-destructive testing shall be performed at the expense of the Contractor.

Welded girders utilizing A709 HPS70W steels shall be fabricated in accordance with the *AASHTO Guide Specification for Highway Bridge Fabrication with HPS70W Steel* and *ANSI/AASHTO/AWS D1.5 Bridge Welding Code*.

Only weld processes and consumables recommended by the *Guide Specification for Highway Bridge Fabrication with HPS70W Steel* will be permitted when welding high performance steel. Consumable handling requirements shall be in accordance with AWS D1.5, Sections 12.6.5, 12.6.6 and 12.6.7 and the *AASHTO Guide Specification for Highway Bridge Fabrication with HPS70W Steel*.

Unless otherwise noted on the plans, filler metals shall be provided for all fillet welds in conformance with AWS D1.5, Table 4.1 (H8 maximum) for A709 Grade 50W base metal. Filler metals for single pass fillet welds need not meet the requirements for exposed bare applications.

Filler metals for all full penetration groove welds connecting A709 HPS70W plate to A709 Grade 50W plate shall conform to the requirements for Grade 50W base metal as listed in AWS D1.5, Table 4.1 (H8 maximum).

Filler metals for all full penetration groove welds connecting A709 HPS70W plates shall conform to the requirements for Grade HPS70W base metal as listed in AWS D1.5, Table 4.1 (H8 maximum).

The Contractor may request approval of alternate consumables for matching strength welds. The request for approval must include documentation of successful welding in accordance with AWS D1.5, and include diffusible hydrogen tests as described in AWS D1.5, Article 12.6.2 indicating the deposited weld metal has a diffusible hydrogen level equivalent to H8 or less.

810.03.6--Oxygen Cutting. All oxygen cutting shall conform to the Welding Code.

810.03.7--Facing of Bearing Surfaces. The surface finish of bearing and base plates and other bearing surfaces that are to come in contact with each other or with concrete shall meet the ANSI surface roughness requirements as defined in ANSI B 46.1, Surface Roughness, Waviness, and Lay, Part 1:

Steel Slabs	ANSI 2,000
Heavy plates in contact in shoes to be welded	ANSI 1,000
Milled ends of compression members, milled or ground ends of stiffeners and fillers	ANSI 500
Bridge rollers and rockers	ANSI 250
Pins and pin holes	ANSI 125
Sliding bearings	ANSI 125

810.03.8--Abutting Joints. Abutting joints in compression members and girder flanges, and in tension members where so specified on the drawings, shall be faced and brought to an even bearing. Where joints are not faced, the opening shall not exceed 1/4 inch.

810.03.9--End Connection Angles. Floorbeams, stringers and girders having end connection angles shall be built to the exact length shown on the plans measured between the heels of the connection angles, with a permissible tolerance of zero inch to minus 1/16 inch. Where continuity is to be required, end connections shall be faced. The thickness of the connection angles shall not be less than 3/8 inch or that shown on the detail drawings.

810.03.10--Lacing Bars. The ends of lacing bars shall be neatly rounded unless another form is required.

810.03.11--Fabrication of Members. Unless otherwise shown on the plans, steel plates for main members and splice plates for flanges and main tension members, not secondary members, shall be cut and fabricated so that the primary direction of rolling is parallel to the direction of the main tensile and/or compressive stresses.

Fabricated members shall be true to line and free from twists, bends and open joints.

810.03.12--Web Plates. In girders having no cover plates and not to be encased in concrete, the top edge of the web plate shall not extend above the backs of the flange angles and shall not be more than 1/8 inch below at any point. Any portion of the plate projecting beyond the angles shall be chipped flush with the backs of the angles. Web plates of girders having cover plates may be 1/2 inch less in width than the distance back to back of flange angles.

Splices in webs of girders without cover plates shall be sealed on the top with red lead paste prior to painting.

At web splices, the clearance between the end of the web plates shall not exceed 3/8 inch. The clearance at the top and bottom ends of the web splice plates shall not exceed 1/4 inch.

810.03.13--Bent Plates. Unwelded, cold-bent, load-carrying, rolled-steel plates shall conform to the following:

- (a) They shall be so taken from the stock plates that the bend line will be at right angles to the direction of rolling, except that cold-bent ribs for orthotropic decks may be bent in the direction of rolling if permitted by the Engineer.
- (b) Bending shall be such that no cracking of the plate occurs. Minimum bend radii, measured to the concave face of the metal, are shown in the following table:

THICKNESS IN INCHES

	Up to 1/2	Over 1/2 to 1	Over 1 to 1 1/2	Over 1 1/2 to 2 1/2	Over 2 1/2 to 4
All grades of steel	2t	2 1/2t	3t	3 1/2t	4t

Note: Low alloy steel in thicknesses over 1/2 inch may require hot bending for small radii.

Allowance for springback of ASTM A514 and A517 steels should be about three times that for structural carbon steel. For break press forming, the lower die span should be at least 16 times the plate thickness. Multiple hits are advisable.

If a shorter radius is essential, the plates shall be bent hot at a temperature not greater than 1200°F, except for ASTM A514/A517 steel. If ASTM A514/A517 steel plates to be bent are heated to a temperature greater than 1125°F, they must be re-quenched and tempered in accordance with the producing mill's practice. Hot bent plates shall conform to requirement (a).

- (c) Before bending, the corners of the plate shall be rounded to a radius of 1/16 inch throughout the portion of the plate at which the bending is to occur.

810.03.14--Fit of Stiffeners. End stiffeners of girders and stiffeners intended as supports for concentrated loads shall have full bearing, either milled, ground or on weldable steel in compression areas of flanges, welded as shown on the plans or specified, on the flanges to which they transmit load or from which they receive load. Stiffeners not intended to support concentrated loads shall, unless shown or specified otherwise, fit sufficiently tight to exclude water after being painted. Fillers under stiffeners shall fit within 1/4 inch at each end.

810.03.15--Eyebars. Pin holes may be flame cut at least two inches smaller in diameter than the finished pin diameter. All eyebars that are to be placed side by side in the structure shall be securely fastened together in the order that they will be placed on the pin and bored at both ends while so clamped. Eyebars shall be packed and match marked for shipment and erection. All identifying marks shall be stamped with steel stencils on the edge of one head of each member after fabrication is completed so as to be visible when the bars are nested in place on the structure. The eyebars shall be straight and free from twists and the pin holes shall be accurately located on the centerline of the bar. The inclination of any bar to the plane of the truss shall not exceed 1/16 inch to a foot.

The edges of eyebars that lie between the transverse centerline of their pin holes shall be cut simultaneously with two mechanically operated torches abreast of each other, guided by a substantial template, in such a manner as to prevent distortion of the plates.

810.03.16--Annealing and Stress Relieving. Structural members that are indicated to be annealed or normalized shall have finished machining, boring, and straightening done subsequent to heat treatment. Normalizing and annealing, full annealing, shall be as specified in ASTM E 44. The temperatures shall be maintained uniformly throughout the furnace during the heating and cooling so that the temperature at no two points on the member will differ by more than 100°F at any one time.

Members of ASTM A514/A517 steels shall not be annealed or normalized and shall be stress relieved only with the approval of the Engineer.

A record of each furnace charge shall identify the pieces in the charge and show the temperatures and schedule actually used.

Proper instruments, including recording pyrometers, shall be provided for determining at any time the temperatures of members in the furnace. The records of the treatment

operation shall be available to and meet the approval of the Engineer. The holding temperature for stress relieving ASTM A514/A517 steel shall not exceed 1125°F.

Members, such as bridge shoes, pedestals, or other parts that are built up by welding sections of plate together shall be stress relieved in accordance with the Welding Code.

810.03.17--Pins and Rollers. Pins and rollers shall be accurately turned to the dimensions shown on the drawings and shall be straight, smooth, and free from flaws. Pins and rollers more than nine inches in diameter shall be forged and annealed. Pins and rollers nine inches or less in diameter may be either forged and annealed or cold-finished carbon-steel shafting.

In pins larger than nine inches in diameter, a hole not less than two inches in diameter shall be bored full length along the axis after the forging has been allowed to cool to a temperature below the critical range under suitable conditions to prevent injury by too rapid cooling and before being annealed.

810.03.18--Boring Pin Holes. Pin holes shall be bored true to the specified diameter, smooth, and straight, at right angles with the axis of the member, and parallel with each other unless otherwise required. The final surface shall be produced by a finishing cut.

The distance outside to outside of end holes in tension members and inside to inside of end holes in compression members shall not vary from that specified by more than 1/32 inch. Boring of holes in built-up members shall be done after the riveting is complete.

810.03.19--Pin Clearances. The diameter of the pin hole shall not exceed that of the pin by more than 1/50 inch for pins five inches or less in diameter or 1/32 inch for larger pins.

810.03.20--Threads for Bolts and Pins. Threads for all bolts and pins for structural steel construction shall conform to the Unified Standard Series UNC-ANSI B1.1, Class 2A for external threads and Class 2B for internal threads, except that pin ends having a diameter of 1 3/8 inches or more shall be threaded six threads to the inch.

810.03.21--Pilot and Driving Nuts. Two pilot nuts and two driving nuts for each size of pin shall be furnished, unless otherwise specified.

810.03.22--Notice of Beginning Work. The Contractor shall give the Engineer ample notice of the beginning of work at the mill or in the shop so that inspection may be provided. The term "mill" means any rolling mill or foundry where material for the work is to be manufactured. No material shall be manufactured or work done in the shop before the Engineer has been so notified.

Prior to any fabrication, the fabricator shall have on hand Shop Drawings, Weld Procedures and a procedure for storage and handling of welding electrodes, wire and flux that have been approved by the Bridge Engineer. No fabrication shall begin until a prefabrication conference has been held and the facilities have been inspected and approved by the Bridge Engineer.

When ordering structural steel, the fabricator shall specify the current ASTM designation for the material based on the date of advertisement for bids.

810.03.23--Facilities for Inspection. The Contractor shall furnish facilities for the inspection of material and workmanship in the mill and shop, and the inspectors shall be allowed free access to the necessary parts of the works.

Inspection at the mill and shop is intended as a means of facilitating the work and avoiding errors, and it is expressly understood that it will not relieve the Contractor from any responsibility in regard to imperfect material or workmanship and the necessity for replacing same.

810.03.24--Inspector's Authority. Inspectors shall have the authority to reject any material or work that does not meet the requirements of the specifications. In case of dispute, the Contractor may appeal to the Engineer, whose decision shall be final.

The acceptance of any material or finished members by the inspector shall not be a bar to their subsequent rejection, if found defective. Rejected material and workmanship shall be replaced promptly or made good by the Contractor.

Material and workmanship not previously inspected will be inspected after its delivery to the site of the work.

810.03.25--Working Drawings and Identification of Steel During Fabrication.

810.03.25.1--Working Drawings. Shop drawings and other required drawings shall be submitted to the Engineer in accordance with and subject to the provisions of Subsection 810.02.2.

Shop drawings for steel structures shall give full detailed dimensions and sizes of component parts of the structure and details of all miscellaneous parts such as pins, nuts, bolts, rivets, drains, etc.

The Contractor expressly acknowledges by execution of the Contract that the Engineer's approval of the working drawings cover the requirements for "strength and detail" and that the Engineer assumes no responsibility for errors in dimensions.

810.03.25.2--Identification of Steels During Fabrication.

810.03.25.2.1--Identification by Contractor. The Engineer shall be furnished with four complete copies of certified mill test reports showing chemical analysis and physical tests for each heat of steel for all members, unless excepted by the Engineer. Each piece of steel to be fabricated shall be properly identified for the Engineer.

Shop drawings shall specifically identify each piece that is to be made of steel other than ASTM A709 Grade 50/50W. Pieces made of different grades of steel shall not be given the same assembling or erecting mark, even though they are of identical dimensions and detail.

The Contractor's system of assembly-marking individual pieces, required to be made of steel other than ASTM A709 Grade 50/50W, and the issuance of cutting instructions to the shop, generally by cross-referencing of the assembly-marks shown on the shop drawings with the corresponding item covered on the mill purchase order, shall be such as to maintain identity of the mill test report number.

Material the Contractor can identify by heat number and mill test report may be furnished from stock.

All excess material placed in stock for later use shall be marked with the mill test report number and shall be marked with its ASTM A6 specification identification color code (see table below) when separated from the full-size pieces furnished by the supplier.

810.03.25.2.2--Identification of Steels During Fabrication. During fabrication, up to the point of assembling members, each piece of steel, other than ASTM A709 Grade 50/50W, shall show clearly and legibly its specification identification color code shown in the table below.

Individually marked pieces of steel that are used in furnished size, or reduced from furnished size only by end or edge trim and do not disturb the heat number or color code or leave any usable piece, may be used without further color coding provided that the heat number or color code remains legible.

Pieces of steel, other than ASTM A709 Grade 50/50W, that are to be cut to smaller size pieces shall, before cutting, be legibly marked with the ASTM A6 specification identification color code.

Individual pieces of steel, other than ASTM A709 Grade 50/50W, that are furnished in tagged lifts or bundles shall be marked with the ASTM A6 specification identification color code immediately upon being removed from the bundle or lift.

Pieces of steel, other than ASTM A36, that, prior to assembling into members, will be subject to fabricating operations such as blast cleaning, galvanizing, heating for forming, or painting that might obliterate paint color code marking shall be marked for grade by steel die stamping or by a substantial tag firmly attached.

The following identification color code shall be used to identify material required to meet the individual specifications listed.

IDENTIFICATION COLOR CODES

ASTM A709 Grade 50/50W	White
ASTM A 514	Red
ASTM A 517	Red and Blue
ASTM A 572, Grade 50	Green and Yellow
ASTM A 588	Blue and Yellow
ASTM A 852	Blue and Orange

Other steels, except ASTM A709 Grade 50/50W, not covered above, nor included in the ASTM A6 Specification, shall have an individual color code that shall be established and on record for the Engineer.

810.03.25.2.3--Certification of Identification. Upon request, the Contractor shall furnish an affidavit certifying that throughout the fabrication operation, the identification of steel has been maintained in accordance with this specification.

810.03.26--Full Size Tests. When full size tests of fabricated structural members or eyebars are required, the plans or specifications will state the number and the nature of the tests, the results to be attained, and the measurements of strength, deformation, or other performance that are to be made. The Contractor shall provide suitable facilities, material, supervision, and labor necessary for making and recording the tests. The members tested in accordance with the contract will be measured for payment in accordance with Subsection 810.04. The cost of testing including equipment, handling, supervision, labor, and incidentals for making the tests shall be included in the contract price for the fabrication or fabrication and erection of structural steel, whichever is the applicable item in the contract, unless otherwise specified.

810.03.27--Marking and Shipping. Each member shall be painted or marked with an erection mark for identification, and an erection diagram shall be furnished with erection marks shown thereon.

The Contractor shall furnish to the Engineer as many copies of material orders, shipping statements, and erection diagrams as the Engineer may direct. The weights of the individual members shall be shown on the statements. Members weighing more than three tons shall have the weights marked thereon. Structural members shall be loaded on trucks or cars in such a manner that they may be transported and unloaded at their destination without being excessively stressed, deformed or otherwise damaged.

Bolts of one length and diameter and loose nuts or washers of each size shall be packed separately. Pins, small parts, and packages of bolts, washers, and nuts shall be shipped in boxes, crates, kegs, or barrels, but the gross weight of any package shall not exceed 300 pounds. A list and description of the contained material shall be plainly marked on the outside of each shipping container.

When DTIs are required on plans, the bolts, nuts, washers and DTI shall be shipped and stored in accordance with Subsection 810.03.1.5.

810.03.28--Erection of Structure. If the substructure and superstructure are built under separate contracts, the Department will provide the masonry, constructed to correct lines and elevations and properly finished.

The Contractor shall erect the metal work, remove the temporary construction, and do all work required to complete the bridge or bridges as covered by the contract, including the removal of the old structure if stipulated, all in accordance with the plans and these specifications.

810.03.28.1--Plans. If the fabrication and erection of the superstructure are done under separate contracts, the Department will furnish detail plans for the bridge or bridges to be erected, including shop details, camber diagrams, erection diagrams, list of field rivets and bolts, and copy of shipping statements showing a list of parts and their weights.

810.03.28.2--Plant. The Contractor shall provide the falsework and all tools, machinery, and appliances, including drift pins and fitting-up bolts necessary for the timely prosecution of the work.

810.03.28.3--Delivery of Material. If the contract is for erection only, the Contractor shall receive the materials entering into the finished structure, free of charge at the place designated and loaded or unloaded as specified.

810.03.28.4--Handling and Storing Materials. Material to be stored shall be placed on skids above the ground. It shall be kept clean and properly drained. Girders and beams shall be placed upright and shored. Long members, such as columns and chords, shall be supported on skids placed near enough together to prevent injury from deflection. If the contract is for erection only, the Contractor shall check the material supplied against the shipping lists and report promptly in writing all shortages or injuries discovered. After receiving the material, the Contractor shall be responsible for the loss of any material and for all damage caused to it.

810.03.28.5--Falsework. The falsework shall be properly designed and substantially constructed and maintained for the loads that will come upon it. The Contractor, if required, shall prepare and submit to the Engineer for approval plans for falsework or for changes in an existing structure necessary for maintaining traffic. Approval of the Contractor's plans shall not be considered as relieving the Contractor of any responsibility.

810.03.28.6--Methods and Equipment. Before starting erection, the Contractor shall inform the Engineer fully as to the proposed method of erection and the amount and character of equipment proposed for use, all of which shall be subject to the approval of the Engineer. The approval of the Engineer shall not be considered as relieving the Contractor of the responsibility for the safety of the method or equipment used or from carrying out the work in full accordance with the plans and specifications. No work shall be done until the approval of the Engineer has been obtained.

810.03.28.7--Bearings and Anchorages. Masonry bearing plates shall not be placed upon bridge seat bearing areas that are improperly finished, deformed, or irregular. Bearing plates shall be set level in exact position and shall have a full and even bearing upon the masonry. Unless otherwise directed by the Engineer, they shall be placed on a layer of sheet lead one-eighth inch in thickness.

Elastomeric bearing pads, if used, shall be set directly on the masonry.

The Contractor shall drill the holes and set the anchor bolts, except where the bolts are built into the masonry. The bolts shall be set accurately and fixed with hydraulic cement grout completely filling the holes.

Location of anchors and setting of rockers or rollers shall take into account the variation from mean temperature at time of setting and anticipated lengthening of bottom chord or bottom flange due to dead load after setting, the intention being that, as near as practicable, at mean temperature and under dead load the rockers and rollers shall set vertical and anchor bolts at expansion bearings will center their slots. Care shall be taken that full and free movement of the superstructure at the movable bearings is not restricted by improper setting or adjustment of bearings or anchor bolt and nuts.

810.03.28.8--Straightening Bent Material. The straightening of plates, angles, other shapes, and built-up members, when permitted by the Engineer, shall be done by methods that will not produce fracture or damage. Distorted members shall be straightened by mechanical means or, if approved by the Engineer, by the carefully planned and supervised

application of limited localized heat, except that the straightening of ASTM A514/A517 or ASTM A709 HPS70W steel members shall be done only under rigidly controlled procedure, each application subject to the approval of the Engineer. In no case shall the maximum temperature of ASTM A514/A517 or ASTM A709 HPS70W steel exceed 1100°F, nor shall the temperature exceed 950°F at the weld metal or within six inches of the weld metal. Heat shall not be applied directly to the weld metal or within six inches of the weld metal. In all other steels, the temperature of the heated area shall not exceed 1150°F, a dull red, as controlled by temperature indicating crayons, liquids or bimetal thermometers.

Parts to be heat straightened shall be substantially free of stress and from external forces, except stresses resulting from mechanical means used in conjunction with the application of heat.

Following the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of fracture.

810.03.28.9--Cambering. Correction of errors in camber in welded beams and girders of ASTM A514/A517 material shall be done only under rigidly controlled procedures, each application subject to approval of the Engineer.

810.03.28.10--Assembling Steel. The parts shall be accurately assembled as shown on the plans and any match-marks shall be followed. The material shall be carefully handled so that no parts will be bent, broken, or otherwise damaged. Hammering that will injure or distort the members shall not be done. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled. Unless erected by the cantilever method, truss spans shall be erected on blocking so as to give the trusses proper camber. The blocking shall be left in place until the tension chord splices are fully bolted and all other truss connections pinned and bolted. Permanent bolts in splices of butt joints of compression members and permanent bolts in railings shall not be driven or tightened until the span has been swung. Splices and field connections shall have one half of the holes filled with bolts and cylindrical erection pins, half bolts and half pins, before bolting with high strength bolts. Splices and connections carrying traffic during erection shall have three-fourths of the holes so filled.

810.03.28.11--Blank.

810.03.28.12--Pin Connections. Pilot and driving nuts shall be used in driving pins. They shall be furnished by the Contractor without charge. Pins shall be so driven that the members will take full bearing on them. Pin nuts shall be screwed up tight and the threads burred at the face of the nut with a pointed tool.

810.03.28.13--Misfits. The correction of minor misfits involving harmless amounts of reaming, cutting and chipping will be considered a legitimate part of the erection. However, any error in the shop fabrication or deformation resulting from handling and transportation that prevents the proper assembling and fitting up of parts by the moderate use of drift pins or by a moderate amount of reaming and slight chipping or cutting shall be reported immediately to the inspector. The method of correction shall require approval by the inspector in whose presence the correction will be made. If the contract provides for complete fabrication and erection, the Contractor shall be responsible for all misfits, errors, and injury and shall make the necessary corrections and replacements. If the contract is

for erection only, the inspector, with the cooperation of the Contractor, will keep a correct record of labor and materials used, and the Contractor shall render within 30 days an itemized bill for the approval of the Engineer.

810.03.29--Removal of Old Structures and Falsework. Unless the contract indicates that an old structure is to remain in place, the Contractor shall dismantle and dispose of such structure in accordance with the methods and requirements set out in Section 202.

Upon completion of the erection and before final acceptance, the Contractor shall remove all falsework, excess excavation and useless materials.

All excavated material or falsework placed in the stream channel during construction shall be removed by the Contractor before final acceptance.

810.04--Method of Measurement.

810.04.1--General. The steel superstructure will be measured as a lump sum quantity, complete in place. Structural steel will be measured for payment by the pound based on the weight of metal in the fabricated structure as provided in the contract.

Miscellaneous material items such as castings, bearing plates, lead sheets, anchor bolts, and all other metal for which no direct payment is specified and the contract proposal does not include a bid item for miscellaneous bridge appurtenances will be included in the measurement for structural steel except when the plans and specifications provide that payment will not be allowed for certain materials. When DTIs are not required by the contract and the Contractor elects to use such indicators, no measure for payment will be allowed.

810.04.2--Miscellaneous Bridge Appurtenances. When the bid schedule of the contract contains a pay item for Miscellaneous Bridge Appurtenances, measurement will not be made of individual miscellaneous items, but all will be included in a single lump sum quantity, including all miscellaneous metals and other miscellaneous materials and work not specified to be measured for payment under or to be included in other items of work.

810.04.3--Payment of Weights.

Weights of metals to be paid for shall be based on computed weights.

The weights of erection bolts, extra field rivets or high strength bolts, paint, and all boxes, crates, or other containers used for packing, together with sills, struts, and rods used for supporting members during transportation will be excluded. All metals not to remain in the completed structure will not be computed for payment.

Where increases in size or weights of members have been made that were not ordered by the Engineer, but approved by him, measurement will be made on the sizes or weights indicated on the plans.

Full size members tested as required under Subsection 810.03.26 and that meet the requirements of these specifications will be measured for payment at the same rate as for the structure.

810.04.4--Computation of Weights.

The weights of metals specified to be paid for by weight will be computed for payment from the following table:

<u>Metal</u>	<u>Weight in Pounds Per Cubic Foot of Material</u>
Aluminum, cast or wrought	173.0
Bronze, cast	536.0
Copper-alloy	536.0
Copper sheet	558.0
Iron, cast	445.0
Iron, malleable	470.0
Iron, wrought	487.0
Lead, sheet	707.0
Steel, rolled, cast, copper bearing, silicon, nickel and stainless	490.0
Zinc	450.0

The weight of rolled shapes and of plates shall be computed on the basis of their nominal weights and dimensions, as shown on the approved plans and shop drawings, deducting for copes, cuts and open holes.

The weight of castings may be computed from the dimensions shown on the plans, with an addition of five percent for fillets and over-runs, or weighed on approved scales.

No allowance will be made for the weight of paint.

The weight of heads, nuts, single washers, DTIs when required, and threaded stick-through of all high tensile strength shop bolts will be included on the basis of the following weights:

Diameter of Bolt, Inches	Weight per 100 Bolts, Pounds
1/2	19.7
5/8	31.7
3/4	52.4
7/8	80.4
1	116.7
1 1/8	165.1
1 1/4	212.0
1 3/8	280.0
1 1/2	340.0

It shall be understood that the weight of the "threaded stick-through" of the bolts will be on the basis of the full-thread engagement. Full-thread engagement is defined as being accomplished when the end of the bolt is flush with the outer face of the nut. At the discretion of the Contractor, the next longer standard length of bolt than that necessary to accomplish full-threaded engagement may be furnished and used, at no additional cost to the State.

The weight of weld metal will be computed on the basis of the theoretical volume from dimensions of the welds.

810.04.5--Deduction for Fabrication Inspection Cost Overruns. Under separate agreement, the Department will contract with a private company to provide inspection services for structural steel fabrication on the project. By this agreement a maximum amount payable, including a fixed fee will be established beyond which no funds will be authorized for payment without a Supplemental Agreement.

The Department will be responsible for structural steel fabrication inspection costs not to exceed the established maximum amount payable including the fixed fee and any additional amount authorized for payment by Supplemental Agreement.

Structural steel fabrication inspection costs exceeding the above described amount will be deducted from monies due the Contractor under pay items 810-A, Structural Steel; 810-B, Steel Superstructure, and/or 810-C, Miscellaneous Bridge Appurtenances.

Ninety percent (90%) of the amount bid for structural steel items listed above will be the maximum amount paid the Contractor until such time that final fabrication inspection costs have been determined and the Bridge Engineer notifies the Project Engineer to release full payment to the Contractor. Otherwise, the Bridge Engineer will advise the Project Engineer of the amount to withhold from the Contractor's estimate to cover structural steel fabrication inspection costs that exceed the amount approved for payment by the Department.

810.05--Basis of Payment. Structural steel, subject to the deductions set out in Subsection 810.04.5, will be paid for at the contract unit price per pound. Steel superstructure and miscellaneous bridge appurtenances when shown as a pay item will be paid for at the contract price, which price shall be full compensation for completing the work.

Payment will be made under:

810-A: Structural Steel *	- per pound
810-B: Steel Superstructure	- lump sum
810-C: Miscellaneous Bridge Appurtenances	- per pound or lump sum

* Specify the type if other than A 50

SECTION 811 - BRONZE OR COPPER-ALLOY BEARING AND EXPANSION PLATES

811.01--Description. This work consists of furnishing and installing metal plates of the kind and type specified and in the manner shown on the plans.

811.01.1--Disc Bearing. The disc bearing devices shall be adequate for the design loads, movements and other criteria shown on the plans or specified herein, and shall be tested at the appropriate level.

This work shall consist of furnishing Multi-Rotational, High Load Disc Bearings and installing Disc Bearing Devices at the locations shown on the plans in accordance with these specifications and the current *AASHTO LRFD Bridge Design Specifications*, and the *current AASHTO LRFD Bridge Construction Specifications*. Disc bearing devices shall include bearings, distribution plates, distribution pads, and connection hardware.

The disc bearings shall consist of polyether urethane structural element (disc) confined by upper and lower steel bearing plates. The bearing shall be equipped with a shear restriction mechanism to prevent movement of the disc. The bearings shall adequately provide for the thermal expansion and contraction, rotation, camber changes, and creep and shrinkage of structural members, where applicable.

For expansion bearings, the upper steel bearing plate shall have a Polytetrafluorethylene (PTFE) sheet recessed and bonded into the top half of the plate to accommodate the horizontal movement of the superstructure. The PTFE surface of the upper steel bearing plate shall support an upper steel plate fitted with a continuously welded, highly polished stainless steel face. For unidirectional expansion bearings, the upper steel plate shall be fitted with guide bars or a keyway system to restrict the lateral movement of the structure. The guide bars and their opposing guided surfaces shall be faced with opposing strips of PTFE/stainless steel. Guiding off of the fixed base or any extension of it will not be permitted.

Disc bearings shall be designed and constructed in accordance with Section 14 of the current *AASHTO LRFD Bridge Design Specifications* and Section 18 of the current *AASHTO LRFD Bridge Construction Specifications*.

The supplier of the disc bearing devices shall show previous history in the design and fabrication of disc bearings. Documentation showing a minimum of five bridge installations and five years of experience in plan production within the last five years shall be provided to the Director of Structures, State Bridge Engineer.

Sliding bearings shall be stiff in shear, i.e. negligible shear displacements shall occur within the load-bearing element.

811.01.2--Shop Drawings. The following shall be shown on the working drawings:

- The total quantity of each kind of bearing required (fixed, guided expansion, or nonguided expansion), grouped first according to type (load range) and then by actual design capacity.
- The plan view and section elevation view showing all relative dimensions of each type of bearing, along with a placement plan to show location of each bearing.
- The maximum design coefficient of friction as noted on the Contract Drawings.
- The type of materials to be used for all bearing elements.
- If applicable, any welding process used in the bearing manufacturer that does not conform to the approved processes of the American Welding Society (AWS) shall be clearly described and detailed.
- Vertical and horizontal load, rotation, and movement capacity.
- Coating requirements.
- Complete design calculations verifying conformance with these specifications.
- Anchorage details.

- If applicable, bearing preset details.
- The location of the fabrication plant.
- The Manufacturer's name and representative who will be responsible for coordinating production, inspection, sampling, and testing.
- Bearing-to-girder bolt template details.

811.02--Materials. Bearing and expansion plates, of the type and kind specified shall meet the requirements of Subsections 716.06 or 716.07 or 716.08, as applicable.

811.02.1--Bronze Plates. Plates shall be cast according to details shown on the plans. Sliding surfaces shall be planed parallel to the movement of the spans and polished unless detailed otherwise.

811.02.2--Copper-Alloy Plates. Plates shall be furnished according to details shown on the plans. Finishing of the rolled plates will not be required provided they have a plane, true, and smooth surface.

811.02.3--Disc Bearing. All materials for disc bearing devices shall be new and unused with no reclaiming material incorporated in the finished bearing.

The finished properties of the polyether urethane shall conform to the requirements of the current AASHTO LRFD Bridge Construction Specifications, Section 18.

All steel, except stainless steel components of the bearing, shall conform to the requirements of the type of steel designated on the contract drawings. Coating of non-stainless steel components shall be in accordance with the structural steel construction notes per the contract drawings.

Stainless steel shall conform to the requirements of ASTM A167 Type 304, ASTM A240 Type 304. Higher grades of stainless are permissible. Stainless steel in contact with PTFE Sheet shall be polished to a No. 8 bright mirror finish, less than 5 micro-inches root mean square. The minimum thickness of the stainless steel shall be 16 gauge.

PTFE shall be manufactured from pure virgin (not reprocessed) unfilled PTFE resin. The PTFE sheet shall be bonded and recessed into the upper steel bearing plate. The PTFE sheet shall have a minimum thickness of 1/8 of an inch and be recessed one-half of its thickness into its steel substrate. The PTFE sheet shall be acid-etched on the bonded side and polished on the side facing the stainless steel to insure a low coefficient of friction.

The PTFE properties shall conform to the requirements of the current AASHTO LRFD Bridge Construction Specifications, Section 18.

811.02.3.1--Fabrication. The Contractor shall provide the Director of Structures, State Bridge Engineer with written notification sixty (60) days prior to the start of bearing fabrication. This notification shall include all of the information shown on the shop drawings. Fabrication and testing shall not commence until a MDOT representative is on site. Final shipment shall not be made until an approved final inspection is made and the material is appropriately stamped by a MDOT representative.

All non-weathering steel surfaces exposed to the atmosphere, except stainless steel surfaces and metal surfaces to be welded, shall be shop painted in accordance with the contract

plans. Prior to painting, the exposed steel surfaces shall be cleaned in accordance with the recommendations of the coating's manufacturer. No painting will be done to these surfaces prior to the completion of welding.

All weathering steel surfaces exposed to the atmosphere shall be cleaned in accordance with the contract plans.

The fabricator shall provide a bearing-to-girder bolt template with hardened bushings to the steel girder fabricator and contractor to ensure proper fit-up. Details of these templates shall be included in the shop drawing submittal.

Stainless steel sheet shall be attached to its steel substrate with a continuous seal weld.

All welding shall conform to, and all welders shall be qualified in accordance with the requirements of the American Welding Society (AWS).

The finish of the mold used to produce the rotational element shall conform to good machine shop practice. Each bearing shall have a project identification number and lot number marked on a side that will be visible after erection.

Gross bearing dimensions shall have a tolerance of $\pm 1/8$ of an inch. Overall thickness tolerance shall be $\pm 1/8$ of an inch. All bearing surfaces of steel plates shall be finished flat within 0.01 inch.

Every bearing shall have the Project Identification Number, Lot Number, and individual bearing number indelibly marked with ink on a side that will be visible after erection.

After assembly, including sole plates and masonry plates, bearing components shall be held together with steel strapping or other means, to prevent disassembly until the time of installation. Packaging shall be adequate to prevent damage from impact as well as from dust and moisture contamination during shipping and storage.

811.02.3.2--Sampling. Requirements for lot size shall be in accordance with the requirements of the current AASHTO LRFD Bridge Construction Specifications, Section 18.3.4.

811.02.3.3--Testing. The bearing devices to be tested shall be selected by the Director of Structures, State Bridge Engineer at random. The bearing device will be visually examined both during and after the test. Any visual defects shall be cause of rejection.

811.02.3.4--Coefficient of Friction. Sliding coefficient of friction tests will be performed by the manufacturer of one expansion bearing device from each lot. A lot will be the quantity as defined by the Director of Structures, State Bridge Engineer with a maximum of 25 bearings per lot. The coefficient of friction will be measured at the bearing design capacity on the 5th, 50th, and 100th cycle at a speed of one inch/minute.

The sliding coefficient of friction shall be calculated as the horizontal load required to maintain continuous sliding at a given speed divided by the bearing's design capacity vertical load. The vertical load shall have been applied continuously for a minimum of one-hour prior to testing.

The measured sliding coefficient of friction shall not exceed 0.03.

811.02.3.5--Rotation. Rotation tests will be performed by the manufacturer on one bearing device from each lot. The polyether urethane element shall be capable of maintaining its initial uniform contact with the steel bearing plates through a rotation of 1.15 degrees under a comprehensive load equal to 150% of the design capacity of the bearing device.

Any observed separation between the edge of the rotational elements and the bearing plates shall be cause for rejection.

811.03--Construction Requirements. Bearing plates shall be accurately set in correct position as shown on the plans and shall have a uniform bearing over the whole area. Provision shall be made to keep the plates in correct position as the concrete is being placed.

811.03.1--Disc Bearing. Disc bearing devices delivered to the bridge site shall be stored under cover on a platform above the ground surface. Disc bearings shall be protected at all times from injury. When placed, bearings shall be dry, clean, and free from dirt, oil, grease, or other foreign substances.

Disc bearing devices shall not be disassembled unless otherwise permitted by the Director of Structures, State Bridge Engineer or manufacturer.

Disc bearing devices shall be installed in accordance with the alignment plan and installation scheme as shown in the contract plans. Upon final installation of the bearings, the Director of Structures, State Bridge Engineer, in the presence of the manufacturer's representative, shall inspect the bearing components to assure that they are level and parallel to within 0.0311 inch per one foot. Any deviations in excess of the allowed tolerances shall be corrected.

811.03.1.1--Certificate of Compliance. In addition to records of test results, the Contractor's disc bearing supplier shall submit Certificates of Compliance for the disc bearings indicating the materials, fabrication, testing, and installation are as specified herein.

811.04--Method of Measurement. Accepted bearing and expansion plates of the type specified will be measured by the pound. Unless otherwise provided, the measurements will be the Inspector's certified shop scale weight of plates placed in the structure. If specified in the contract, measurement will be computed weights, obtained by methods shown on the plans.

Disc bearing device will be measured per each.

Lubricants will not be measured for separate payment.

811.05--Basis of Payment. Bearing and expansion plates, measured as prescribed above, will be paid for at the contract unit price per pound which price shall be full compensation for completing the work.

Disc bearing device, measured as prescribed above, will be paid for at the contract unit price per each; which price shall be full compensation for completing the work.

Payment will be made under:

811-A: Bronze Plates	- per pound
811-B: Copper-Alloy Plates	- per pound
811-C: Self-Lubricating <u>Type</u> Plates	- per pound
811-D: Disc Bearing Device	- per each

SECTION 812 - STEEL GRID FLOORING

812.01--Description. This work consists of constructing steel grid flooring, open or concrete-filled type as specified, in accordance with these specifications and in reasonably close conformity to the lines and grades shown on the plans or established.

812.02--Materials. Materials shall conform to the provisions of Subsection 717.05.

812.02.1--Arrangement of Sections. Where the main elements are normal to centerline of roadway, the units generally shall be of such length as to extend over the full width of the roadways up to 40 feet, but in every case the units shall extend over at least three panels. Where joints are required, the ends of the main floor members shall be welded at the joints over their full cross-sectional area or otherwise connected to provide full continuity.

Where the main elements are parallel to the centerline of the roadway, the sections shall extend over at least three panels, and the ends of abutting units shall be welded over their full cross-sectional area or otherwise connected to provide full continuity in accordance with the design.

812.02.2--Provisions for Camber. Unless otherwise provided on the plans, provision for camber shall be made as follows:

- (a) Steel units so rigid that they will not readily follow the camber required shall be cambered in the shop. To provide a bearing surface parallel to the crown of the roadway the stringers shall be canted or provided with shop-welded beveled bearing bars. If beveled bars are used, they shall be placed along the centerline of the stringer flange, in which case the design span length shall be governed by the width of the bearing bar instead of by the width of the stringer flange.
- (b) Longitudinal stringers shall be mill cambered or provided with bearing strips so that the completed floor after dead-load deflection will conform to the longitudinal camber shown on the plans.

812.02.3--Welding. All shop and field welding shall be in accordance with Subsection 810.03.5.

812.02.4--Repairing Damaged Galvanized Coatings. All galvanizing that has been chipped off or damaged in handling or transporting or in welding or riveting shall be

repaired by field galvanizing by the application of a paste composed of approved zinc powder and flux with a minimum amount of water. The places to be coated shall be thoroughly cleaned, including removal of slag on welds, before the paste is applied. The surface to be coated shall first be heated with a torch to a sufficient temperature so that all metallics in the paste are melted when applied to the heated surface. Extreme care shall be taken to see that the galvanized surfaces are not damaged by the torch. The flux in the paste will cause a black substance to appear on the surface of the coated parts, and this black substance shall be removed by wiping off with waste or by the quick application of cold water.

812.03--Construction Requirements.

812.03.1--Field Assembly. Areas of considerable size shall be assembled before the floor is welded to its supports. The main elements shall be made continuous, and sections shall be connected together along their edges by welding of bars or by riveting them. The connections shall meet with the approval of the Engineer. The rivets may be cold driven.

812.03.2--Connection to Supports. The floor shall be connected to its steel supports by welding. Before any welding is done, the floor shall either be loaded to make a tight joint with full bearing, or it shall be clamped down. The location, length, and size of the welds shall be subject to the approval of the Engineer, but in no case shall they be less than the manufacturer's standards.

The ends of all the main steel members of the slab shall be securely fastened together at the sides of the roadway for the full length of the span by means of steel plates or angles welded to the ends of the main members, or by thoroughly encasing the ends with concrete.

812.03.3--Concrete Filler. Floor types with bottom flanges not in contact shall be provided with bottom forms of metal or wood to retain the concrete filler without excessive leakage.

Metal form strips, when used, shall fit tightly on the bottom flanges of the floor members and be placed in short lengths so as to extend only about one inch onto the edge of each support, but in all cases the forms shall be such as will result in adequate bearing of slab on the support.

The concrete shall be mixed, placed, and cured in accordance with Section 804. The concrete shall be thoroughly compacted by vibrating the steel grid floor. The vibrating device and the manner of operating it shall be subject to the approval of the Engineer.

812.03.4--Painting. Flooring furnished without galvanizing but with a shop coat of paint shall be given field coats of paint in accordance with Section 814.

When a structural steel plate is used on the bottom of a filled type floor, the bottom surface of the plate shall be given one shop coat, one field intermediate coat, and one field top coat of paint in accordance with Section 814.

812.04--Method of Measurement. Steel grid floor of the type specified will be measured by the square foot complete in place. No separate measurement will be made for galvanizing or painting and concrete filling when required.

812.05--Basis of Payment. Steel grid floor of the type specified, measured as prescribed above, will be paid for at the contract unit price per square foot, which price shall be full compensation for completing the work.

Payment will be made under:

812-A: Steel Grid Floor, Open Type - per square foot

812-B: Steel Grid Floor, Concrete Filled - per square foot

SECTION 813 - RAILING

813.01--General. This work consists of constructing bridge railing of the type specified in accordance with these specifications. Railing for bridges shall include all work constructed above the top of the bridge deck, curb, or sidewalk surface, as applicable.

813.02--Materials. All materials shall conform to the requirements of Division 700 or as specified on the plans. Unless otherwise specified, concrete shall be Class "AA" meeting the requirements of Section 804.

813.03--Construction Requirements.

813.03.1--Line and Grade. Lines and grades of railing shall be in reasonably close conformity to that shown on the plans and shall not follow any unevenness in the superstructure. Unless otherwise specified or shown on the plans, the railing, posts, and curbs on bridges, whether on horizontal grade, superelevated, or not shall be vertical.

813.03.2--Concrete Railing.

813.03.2.1--General. In no case shall concrete railings be placed until the centering or falsework for the span has been released and the span is self-supporting.

813.03.2.2--Railings Cast-In-Place. The portion of the railing or parapet that is to be cast in place shall be constructed in accordance with the requirements of Section 804. Special care shall be exercised to secure smooth and tight-fitting forms that can be rigidly held to line and grade and removed without injury to the concrete.

Forms shall either be of single width boards or other approved material or shall be lined with suitable material that has the approval of the Engineer. Form joints in plane surfaces will not be permitted.

All moldings, panel work, and bevel strips shall be constructed according to the detail plans with neatly mitered joints, and all corners in the finished work shall be true, sharp, and clean-cut and shall be free from cracks, spall, or other defects.

When railing is constructed by the slipform method, placement shall be as specified in Subsection 615.03.2.

813.03.2.3--Surface Finish. The surfaces of concrete railings shall conform to the requirements of Section 804.

813.03.2.4--Expansion Joints. Expansion joints shall be so constructed as to permit freedom of movement. After all other work is completed, all loose or thin shells of mortar likely to spall under movement shall be carefully removed from all expansion joints by means of a sharp chisel.

813.03.3--Metal Railing.

813.03.3.1--Construction. Fabrication and erection of ferrous metal shall be in accordance with the requirements of Section 810. In the case of welded railings, all exposed joints shall be finished by grinding or filling to give a neat appearance.

Fabrication and erection of non-ferrous material shall be in general conformity with applicable requirements of Section 810 and the specific requirements shown on the plans.

Metal railings shall be carefully adjusted prior to fixing in place to ensure proper matching at abutting joints and correct alignment and camber throughout their length. Holes for field connections shall be drilled with the railing in place in the structure at the correct grade and alignment. Welding may be substituted for rivets in field connections with the approval of the Engineer.

Where galvanized ferrous metal railing is designated by the plans, the components shall be hot dip galvanized after fabrication in accordance with the requirements of the plans.

813.03.3.2--Painting. Painting shall conform to the requirements of Sections 710 and 814.

813.03.4--Wood Railings. Wood railings will be constructed and paid for under the provisions of Section 820.

813.04--Method of Measurement. Railing of the type specified will be measured by the linear foot within the nominal measuring points of spans at bridge ends. When the contract includes rails of various heights, the appropriate pay item description listed below will contain the rail height

813.05--Basis of Payment. Railing of the type specified, measured as prescribed above, will be paid for at the contract unit price per linear foot, which price shall be full compensation for completing the work.

Payment will be made under:

813-A: Concrete Railing *	- per linear foot
813-B: Concrete-Steel Railing	- per linear foot
813-C: Concrete-Aluminum Railing	- per linear foot
813-D: Concrete Median Barrier Railing	- per linear foot
813-E: <u>Type</u> Railing	- per linear foot

* Size may be indicated

SECTION 814 - PAINTING METAL STRUCTURES

814.01--Description. This work consists of furnishing all materials and painting of metal structures. It shall include, unless otherwise provided in the contract, the preparation of metal surfaces, application, protection and drying of the paint coatings, supplying of all tackle, scaffolding and other essentials necessary to complete the work in reasonably close conformity with the specifications and as indicated on the plans.

The Coating System will consist of one shop coat of inorganic zinc, one field intermediate coat of acrylic latex and one field top coat of acrylic latex. The shop coat, field intermediate coat and top coat shall each have a dry film thickness of not less than 3 mils or more than 5 mils.

Touch-up paint for field repair of damaged areas in the inorganic zinc shop coat shall consist of epoxy mastic applied to a uniform dry film thickness of not less than 4 mils nor more than 6 mils.

814.02--Materials.

814.02.1--Shop Coat. Paint for the shop or prime coat shall be an inorganic zinc primer and meet the requirements of Subsection 710.03.

814.02.2--Acrylic Latex Intermediate Coat. Paint for the acrylic latex intermediate field coat shall meet the requirements of Subsection 710.03.

814.02.3--Acrylic Latex Top Coat. Paint for the acrylic latex top field coat shall meet the requirements of Subsection 710.03.

814.02.4--Epoxy Mastic Touch-Up Paint. Field touch-up paint for repair of damaged inorganic zinc shop coat shall meet the requirements of Subsection 710.03.

814.03--Construction Requirements.

814.03.1--Mixing of Paint. All paint shall be mixed in accordance with the manufacturer's printed instructions.

814.03.2--Weather Conditions. Solvent base paint shall not be applied when the surrounding air temperature is below 40°F. Waterborne paint shall not be applied when the surrounding air temperature is below 50°F. Paint shall not be applied when the surrounding air temperature is expected to drop to 32°F prior to drying of the paint. Paint shall not be applied when the metal is hot enough to cause blistering or produce a porous film. Paint shall not be applied when the steel surface is less than 5°F above the dew point nor shall it be applied in rain, snow, wind, fog, mist or when, in the opinion of the Engineer, conditions are otherwise unsatisfactory for the work.

814.03.3--Application.

814.03.3.1--Shop Coat. The coating shall be capable of being applied in accordance with specification requirements and shall be applied in accordance with the manufacturer's printed instructions.

After initial mixing, the paint shall be strained through a metal 30-60 mesh screen.

Stirring paddles on the mechanical mixing equipment shall reach to within one inch of the bottom of the paint container.

Airless spray equipment for application of inorganic zinc silicate paint shall provide pressure of not less than 2200 psi at the nozzle. The fluid hose between the pot and nozzle shall not be less than 3/8-inch inside diameter. Pressure may vary depending on tip size and pump.

Conventional spray equipment for application of inorganic zinc silicate paint shall provide pressure of not less than 10 psi at the pot and 30 psi at the nozzle.

814.03.3.2--Acrylic Latex Intermediate and Top Coats. All applications of the acrylic latex intermediate and top coats shall be in accordance with the manufacturer's printed instructions. The primer coat and the intermediate coat shall have dried a minimum of eight hours under normal conditions prior to application of the intermediate and top coats, respectively. All surfaces shall be free of any soluble residue and surfaces on which the primer coat has been applied shall be free of excessive amounts of loose zinc before a subsequent coat is applied. Dust and dirt that may have accumulated on the surface shall be removed from the dried film with a soft brush or rag before application of a subsequent coat.

When applied by brushing or spraying, the coating shall deposit a uniform dry film thickness without running or sagging.

814.03.4--Removal of Paint. If any painting is unsatisfactory, it shall be removed and the metal thoroughly cleaned and repainted.

814.03.5--Thinning Paint. Paint shall be thinned only in strict accordance with the manufacturer's recommendations.

814.03.6--Painting Galvanized Surfaces. Prior to application of the acrylic latex field coats, galvanized surfaces shall be primed with Epoxy Mastic Touch-Up Paint as specified in Subsection 814.02.

814.03.7--Cleaning of Surfaces. Surfaces to be painted shall be thoroughly cleaned, removing rust, loose mill scale, dirt, oil or grease and other foreign substances.

All exposed and accessible surfaces of the metal shall be cleaned by sandblasting in accordance with the requirements of Steel Structures Painting Council SSPC-SP-10, Near White Blast Cleaning. The surface, regardless of starting condition, shall in the opinion of the Engineer or the Engineer's designated representative be at least equal to the appearance of Pictorial Swedish Standard Sa 2 1/2 of SIS 05 59 00, SSPC-VIS 1.

All rust blooms shall be removed by re-blasting before coating. The surface shall be constantly and diligently examined ahead of the coating operations for any traces of rust, oil, grease or blemishes not permitted by the blast cleaning specifications.

814.03.8--Shop Painting. Unless otherwise specified, the shop coat shall be applied immediately after the steel work has been accepted by the inspector.

Shop contact surfaces shall not be painted. Field contact surfaces except for machine finished pins and holes shall receive a shop coat with a minimum dry film thickness of 1½ mils. All other surfaces that will be inaccessible after assembly or erection shall be given all required coats.

Surfaces that will be embedded or in contact with concrete shall not require painting unless otherwise noted on the plans. They may be painted in whole or in part due to overspray provided the paint thickness does not exceed the requirements specified for adjacent areas.

Structural steel that is to be field welded shall not be shop painted within two inches of the field welds.

All surfaces of iron and steel castings except for machine finished pins and holes, shall be given two shop coats of paint.

Erection marks for field identification of members and weight marks shall be painted on areas previously painted with the shop coat. Material shall not be loaded for shipment until it is thoroughly dry and no sooner than 24 hours after the paint has been applied.

814.03.9--Field Painting. When the erection work is complete, including all bolting and straightening of bent metal, all rust, scale, dirt, grease and other foreign material shall be removed.

As soon as the Engineer has approved all field welding and bolting, the surfaces from which the shop coat of paint has worn off or otherwise become defective shall be cleaned and primed with the specified touch-up paint prior to application of the intermediate coat.

Spans with concrete decks shall not be painted until after the deck is placed. All concrete spills and stains shall be washed from the structural steel prior to the mortar taking a set.

Surfaces to be bolted in contact and surfaces that will be in contact with concrete shall not have a field coat applied. When the paint applied for retouching the shop coat has thoroughly dried and the field cleaning has been satisfactorily completed, the intermediate coat shall be applied. After the intermediate coat has thoroughly dried, the top coat shall be applied. In no case shall a subsequent coat be applied until the previous coat has dried throughout the full thickness of the paint film.

To secure a maximum coating on edges of plates or shapes, bolt heads and other parts subjected to special wear and attack, the edges shall be stripped with a longitudinal motion and bolt heads with a rotary motion of the brush followed immediately by the general painting of the whole surface, including recoating of the edges and bolt heads.

If, in the opinion of the Engineer, traffic produces an objectionable amount of dust, the Contractor shall, at no additional cost to the State, abate the dust for the necessary distance on each side of the bridge and take any other precautions necessary to prevent dust and dirt from coming in contact with freshly painted surfaces or surfaces prepared for painting.

The Contractor shall protect pedestrian, vehicular and other traffic upon or underneath the bridge and also all portions of the bridge superstructure and substructure against damage

or disfigurement by spatters, splashes and smirches of paint or paint material. Any such disfigurement shall be removed at the direction of and to the satisfaction of the Engineer.

814.03.10--Inspection. The completed shop coat shall be inspected by the Contractor for thickness by means of elcometer or other approved magnetic detector thickness gauge. Detection of insufficiently coated sections shall be marked and shall be coated over or touched up to establish the specified thickness.

All areas of the finished system deficient in thickness shall be coated over with the acrylic latex top coat paint to establish the specified thickness. Excessive thickness in the application of any coating evidenced by mudcracking will be cause for the affected area to be blast-cleaned and repainted.

Where rejection is due to poor workmanship or deficiency in the quality of the work or materials, the Contractor may be required to blast clean the entire defective sections of all previously applied materials prior to repainting.

Inspection shall be done in the presence of and to the satisfaction of the Engineer. The Engineer shall be provided access to the work to allow for proper inspection of the cleaning and painting at both the fabrication plant and the construction site.

814.04--Method of Measurement. Unless shown as a separate pay item in the proposal, painting of metal structures or members will not be measured for separate payment and the cost thereof shall be incidental to and included in the contract unit price(s) bid for other items.

814.05--Basis of Payment. When shown as a separate pay item in the proposal, painting of metal structures or members will be paid for at the contract lump sum price, which price shall be full compensation for completing the work.

Payment will be made under:

814-A: Painting of Metal Structure	- lump sum
814-B: Painting of Description	- lump sum

SECTION 815 - RIPRAP AND SLOPE PAVING

815.01--Description. This work consists of furnishing and placing a protective covering of erosion resistant material including geotextile fabric, where shown on the plans for pier foundation protection, slope, or ditch protection. This work shall be in accordance with these specifications and in reasonably close conformity with the lines, grades and dimensions shown on the plans or established.

815.02--Materials. Materials for riprap and slope paving shall conform to the following.

Geotextile shall meet the requirements of Subsection 714.13.

Aggregate for loose riprap, stone riprap for foundation protection, or that to be grouted shall consist of field stone, broken concrete, or rough, unhewn quarry stone as nearly

rectangular in section as is practicable. The stone shall be dense, free of clay or shale seams, resistant to the action of air and water, and suitable in all other respects for the purpose intended. Quality requirements for rock to be furnished under these specifications will come from a pre-approved source or be visually approved prior to use.

Hydraulic cement concrete aggregates, unless otherwise specified, shall conform to the applicable requirements of Section 703.

Cloth sacks for concrete riprap in bags shall be of suitable cloth or jute that will hold the concrete mixture without leakage when handled. The sacks shall be of uniform size and dimensions, approximately 19½ x 36 inches measured inside the seams when the sack is laid flat. Sound reclaimed cloth sacks meeting the specified requirements may be used.

Paper sacks for concrete riprap in bags shall be a polyester fiber type of scrim reinforced paper. The top and bottom of the sacks shall have a pasted valve. When filled, they shall measure approximately 13 inches wide, 20 inches long, and five inches thick. Perforations shall be overall on one-inch centers with a diameter of 3/32 inch to 1/8 inch per hole. Each bag shall fill a space of approximately 0.71 cubic feet with 38 bags required per cubic yard. Pre-packaged riprap will be accepted on certification from the manufacturer.

Stones for riprap, of the size specified, shall meet the requirements of Subsection 705.04.

Material used for sediment control stone shall be crushed stone or gravel meeting the requirements of Subsection 703.03 for Size No. 57.

815.03--Construction Requirements.

815.03.1--Construction Details. Prior to the construction of riprap or slope paving, the slopes or ground surface shall be shaped to lines and grades indicated on the plans or directed, and shall be thoroughly compacted by the use of mechanical or hand tamps. Unless otherwise stipulated or directed, slopes shall not be steeper than the natural angle of repose of the material upon which riprap is to be constructed.

The outer edges and the top of the riprap or slope paving where the construction terminates shall be formed so that the surface of the riprap or slope paving will be embedded and even with the surface of the adjacent slope or ground, and the bottom of the riprap or slope paving shall be placed at least two feet below the natural ground surface unless otherwise directed.

All riprap or slope paving shall be started at the bottom of the slope and constructed upward.

No grout, bag riprap, or slope paving shall be placed during freezing weather or while there is frost on the ground. Prepackaged riprap in paper bags shall be immediately soaked with water after placement to ensure hydration of the cement. In hot or dry weather grout and bag riprap shall be kept moist and protected from the sun for at least three days after placing. Replacement will be required if the bags do not set up to form a solid mass. Slope paving shall be cured in accordance with the provisions of Subsection 815.03.7.4.

815.03.2--Installation of Geotextile. When required by the contract, geotextile shall be placed in the manner and at locations shown on the plans. The area to receive the geotextile

shall be prepared to a relatively smooth condition free of obstructions, depressions and debris. The geotextile shall be placed loosely without wrinkles or creases with the long dimension perpendicular to the channel. The strips shall be placed to provide a minimum overlap of 18 inches. Securing pins with washers shall be inserted through both strips of overlapped geotextile at mid-point and not greater than two foot intervals. Additional pins shall be installed throughout the geotextile as necessary to prevent any slippage. The geotextile shall be placed so that the upstream strip overlaps the downstream strip and the higher slope strip overlaps the lower strip. Each securing pin shall be pushed through the geotextile until the washer bears against the geotextile and secures it firmly.

The geotextile shall be protected from contamination and damage during installation and placement of the specified cover material. Riprap shall not be dropped from a height greater than three feet. Contaminated geotextile shall be replaced, and damaged geotextile shall be repaired or replaced as directed at no cost to the Department.

The geotextile shall be covered with a layer of the specified material within 14 calendar days after placement. Geotextile not covered within this time period shall be removed and replaced at the Contractor's expense if damage or deterioration is evident, as determined by the Engineer.

815.03.3--Loose Riprap. The stones shall be placed upon a slope not steeper than the natural angle of repose of the slope material. The stones shall be laid with close joints. The courses shall be laid from the bottom of the bank upward with the larger stones being placed in the lower courses. Interstices shall be filled with smaller stones and spalls.

815.03.4--Grouted Riprap. Grout for grouted riprap shall consist of one part of hydraulic cement and three parts of approved sand thoroughly mixed with water to produce grout having a thick, creamy consistency.

The stones shall be of the size designated in the bid schedule of the contract and shall be placed in the same manner as specified for loose riprap. Care shall be taken during placing to keep earth or sand from filling the spaces between the stones.

After the stones are in place, the spaces between them shall be completely filled with grout from bottom to top and the surface swept with a stiff broom.

815.03.5--Stone Riprap for Foundation Protection. Stone riprap for pier and abutment protection shall range in size up to derrick stone and shall be graded from coarse to fine in such manner as to produce a minimum of voids. It shall be deposited where directed and stone deposited contrary to directions will be considered wasted and will not be paid for.

815.03.6--Concrete Riprap in Bags. Concrete riprap in cloth or jute bags shall consist of Class "D" concrete in approved bags and placed in conformity with contract requirements. Each bag shall be filled with approximately one cubic foot of concrete, securely tied, and immediately placed in the work and lightly trampled to cause them to conform with the slope or section required with adjacent bags in place. Unless otherwise specified in the contract, the bagged concrete shall be packed in such a manner as to give a reasonably uniform thickness of approximately 12 inches and shall be lapped and staggered as directed.

Pre-packaged riprap in paper bags shall be filled with kiln-dried mixture of hydraulic cement and sand, or cement, sand and gravel with a ratio of three parts sand or sand and gravel to one part hydraulic cement. The bags shall be placed to conform with the slope or required section and with adjacent bags in place. The bags shall be lapped and staggered as directed.

When shown on the plans, pipe headwalls shall be constructed of concrete riprap in bags in accordance with these specifications and the plan details. In this construction, it is essential that the successive tiers are securely "keyed" by lapping. The bags shall be lapped one-half their length, when practicable.

815.03.7--Slope Paving. Concrete slope paving shall be constructed in a single layer in conformity with the design dimensions and details indicated on the plans.

815.03.7.1--Forms. Forms shall be wood or metal of sufficient strength to withstand the pressure of the concrete without bulging. They shall be adequately and securely staked true to line and grade.

815.03.7.2--Mixing and Placing Concrete. Unless otherwise stipulated, the concrete used in this construction shall be Class "C" Concrete, mixed and placed in accordance with the provisions and requirements of Section 804, except that volumetric batching may be used. Mixers of less than one bag rated capacity shall not be used.

815.03.7.3--Finishing. After spreading, the concrete shall be tamped and puddled until it is compact and sufficient mortar has been flushed to the surface so that it can be finished smooth with a wooden float. All edges shall be neatly edged using an approved short radius sidewalk edge.

815.03.7.4--Curing. After the concrete has set sufficiently, the surface shall be protected from premature drying by covering as soon as possible with a satisfactory material such as wetted burlap or wetted cotton mats and kept moist for a minimum of three days, or cured by other approved methods. Other approved methods include liquid membrane compound as set out in Subsection 713.01.2 and applied in accordance with the provisions of Subsection 501.03.20, except that approved hand spray methods will be acceptable, and white polyethylene sheeting conforming to the requirements of Subsection 713.01.3 and applied in accordance with the provisions of Subsection 501.03.20. Both liquid membrane compound and polyethylene sheeting shall be maintained in place and intact for a minimum period of three days.

815.03.7.5--Soil Sterilization. Prior to placing slope pavement, the areas beneath the pavement shall receive soil sterilization treatment as set out in Subsection 616.03.2.

815.03.8--Cleaning Up. Upon completion of the work, the surface of the riprap or slope paving shall be cleaned, surplus material and debris removed and disposed of as directed, and the site of the work left in a neat presentable condition.

815.04--Method of Measurement. Loose riprap will be measured in square yards or tons, as specified. Sediment control stone will be measured by the cubic yard (LVM) or ton, as specified. The pay area will be determined by using the outside dimensions of the area covered as directed. Tons or fraction thereof will be determined by railway weights or

other satisfactory and approved weighing methods. Stone placed contrary to directions will not be paid for.

Measurement or payment will not be made for grout, and the cost thereof shall be included in the compensation for grouted riprap.

Concrete riprap in cloth or jute bags will be measured in cubic yards as the quantity received or manufactured at the site of the work and acceptably placed in bags as required. From the amount received or manufactured at the site, there will be deducted all excess determined by the Engineer to have been wasted or placed to unauthorized dimensions.

The cubic yards of pre-package riprap in paper bags will be determined from the actual count of bags placed and accepted based on 38 bags per cubic yard.

Slope paving will be measured by the cubic yard computed using the dimensions shown on the plans. If authorized revisions are made in the finish grade or the configuration of the slope pavement, computations will be made considering the changed dimensions.

Geotextile complete in place and accepted will be measured by the square yard of surface area covered. Any overwidth of material installed and additional material required for laps or sewing will not be measured. No separate payment shall be made for shipping, handling, storage, protection, fabrication, securing pins, or installation; the cost of which shall be included in the contract price for geotextile fabric.

815.05--Basis of Payment. Loose riprap, measured as prescribed above, will be paid for at the contract unit price per square yard or ton. Sediment control stone, measured as prescribed above, will be paid for at the contract unit price per cubic yard or ton. Grouted riprap, measured as prescribed above, will be paid for at the contract unit price per square yard. Concrete riprap in bags and concrete slope paving, measured as prescribed above, will be paid for at the contract unit price per cubic yard. Geotextile, measured as prescribed above, will be paid for at the contract unit price per square yard. Such payment shall be full compensation for completing the work.

Payment will be made under:

815-A: Loose Riprap, <u>Size</u>	- per square yard or ton
815-B: Grouted Riprap	- per square yard
815-C: Concrete Riprap in Bags	- per cubic yard
815-D: Concrete Slope Paving	- per cubic yard
815-E: Geotextile under <u>Description</u> , Type <u>*</u> , AOS <u>*</u>	- per square yard
815-F: Sediment Control Stone	- per cubic yard or ton

* When not designated, see Subsection 714.13.

SECTION 816 - MAINTENANCE PAINTING OF METAL STRUCTURES

816.01--Description. This work consists of furnishing all materials, equipment and labor for the cleaning and painting of metal structures. It shall include, unless otherwise provided in the contract, the preparation of metal surfaces, the application, protection and drying of the paint coatings, supplying all tackle, scaffolding and other essentials necessary to complete the work in accordance with the specifications and as specified on the plans.

816.02--Materials. The coating system selected for maintenance painting must be lead free, VOC compliant and must be listed on the Department's APL under "Approved Coating Systems for Upgrading Existing Coatings by Maintenance Forces." The coating system shall consist of three coats as follows; an approved primer coat paint, intermediate coat paint and a top coat paint. The substitution of a primer, intermediate or top coat paint from one approved coating system to another is not permitted. The integrity of each approved coating system must be maintained.

When the project requires the painting of both new and existing metal structures, the different painting systems selected shall be from the same manufacturer and shall have the same top coat color.

816.03--Construction Requirements.

816.03.1--Weather Limitations. Solvent base paint shall not be applied when the surrounding air temperature is below 40°F. Waterborne paint shall not be applied when the surrounding air temperature is below 50°F. Paint shall not be applied when the surrounding air temperature is expected to drop to 32°F prior to drying of the paint. Paint shall not be applied when the metal is hot enough to cause blistering or produce a porous film. Paint shall not be applied when steel surface is less than 5°F above the dew point nor shall it be applied in rain, snow, wind, fog, mist or when, in the opinion of the Engineer, conditions are otherwise unsatisfactory for the work.

816.03.2--Pollution Control During Surface Preparation And Repainting. Generated debris must be confined to the immediate area of the structure. Appropriate screens and barriers must be erected to protect pedestrian and vehicular traffic during waterblasting and painting operation. Overspray must be kept to a bare minimum.

816.03.3--Surface Preparation. Surface preparation will include waterblasting the entire surface followed by spot cleaning with hand tools to remove any remaining loose or flaking paint or rust, dirt, oil, grease and/or other deleterious matter from the steel surface. Tightly bonded paint is not to be removed and it is not necessary to remove tightly bonded rust.

In areas containing a heavy coating of oil, grease and/or deleterious material that cannot be cleaned by waterblasting, cleaning shall be performed using an environmentally sensitive biodegradable solvent. Brush or mop the solvent on the surface with a rubbing action to loosen the film. Wipe off with a clean dry cloth and then rinse by waterblasting. Repeat as necessary until clean. The cleanliness of the surface shall be approved by the Project Engineer or a designated representative prior to beginning painting operations.

816.03.3.1--Waterblasting. The waterblasting unit must be capable of operating at pressures up to 4,000 psi at a water flow rate up to 10 gpm. The unit must be equipped

with a water filter, pressure gauge, nozzle with 1/8-inch orifice or one that will provide a jet stream of water, and sufficient length of hydraulic hose. The unit shall be equipped with a deadman control valve or other control valves that will provide automatic shut-off by release of the trigger. Water for blasting must be potable water to prevent damage to the pump and to ensure a clean surface on the steel. During waterblasting operation, wood, insulation, electrical, instrumentation, etc., must be protected. After waterblasting, remove any remaining loose paint, loose rust and rust scale with wire brushes or other methods as necessary. Using the waterblast unit or compressed air, remove the loose debris generated from the hand tool cleaning operation. To prevent recontamination of the steel surface, the surface preparation operation should not be completed more than eight hours in advance of the painting operation. Should any recontamination occur prior to painting, repeat surface preparation procedures as necessary for removal. Before painting, the surfaces must be clean and dry. To enhance drying of the surfaces, compressed air may be used.

816.03.3.2--Safety and Clean-Up. During the cleaning of the existing steel, the Contractor may encounter hazardous material. The Contractor will be responsible for the health and safety of employees and shall provide such items as protective clothing and respirators and make certain that they are used. The Contractor shall also be responsible for the maintenance and/or replacement of these items. The Contractor is advised that safety precautions for workers during each phase of work shall be in compliance with present OSHA standards.

The Contractor shall take necessary precautions to prevent an excessive amount of removed materials from falling beneath the structure. General debris must be confined to the immediate area of the structure. Appropriate measures shall be taken to protect the traveling public during surface preparation and painting operations.

The Contractor shall clean the area of excessive debris generated from cleaning and properly dispose of it at an approved landfill.

The Contractor shall take necessary steps to become familiar with any applicable Federal, State or local regulations and take the necessary actions for compliance when applicable to any portion of the required work.

816.03.4--Packaging and Marking. Multiple component paints shall be furnished in premeasured packages so as to form one unit of mixed paint when mixed with the vehicle in its container.

The containers for all paints shall be coated as necessary to prevent attack by the paint. Each container shall bear a label with the following information shown thereon: name and address of manufacturer, trade mark or trade name, kind of paint, date of manufacture and lot number, mixing instructions and equipment clean up instructions. The VOC content shall be stated either on the label, product data sheet, or Material Safety Data Sheet.

816.03.5--Acceptance Procedure. Prior to use, the Contractor must furnish the Engineer a certificate from the manufacturer, covering each lot of paint in the shipment, attesting that the paint in the shipment conforms to the same formula as that originally approved by the Department.

Final acceptance of the paint will be based on results of tests performed by the Central Laboratory on samples obtained by the Department's representative prior to or after delivery. The use of any lot of paint prior to its final acceptance shall be prohibited.

816.03.6--Mixing, Thinning and Application. All paint shall be mixed and applied in accordance with the manufacturer's printed instructions. Paint shall be thinned only under conditions that strictly follow the manufacturer's recommendations.

At the Engineer's request, the paint manufacturer's technical representative, who is certified by the National Association of Corrosion Engineers (NACE), shall be present at the job site at the beginning of each separate coating operation to provide technical expertise in the application of the field coats. This technical expertise shall be provided without additional cost to the Department. The Contractor shall be responsible for arranging for the presence of the manufacturer's technical representative.

The Contractor must apply the paint to the Wet Film Thickness (WFT) that will obtain the Dry Film Thickness (DFT) required for the film being applied. The DFT required for each paint film of each approved coating system is set out in the Department's Approved List of Materials.

A subsequent coat shall not be applied until the previous coat has dried throughout the film thickness.

To secure a maximum coating on edges of plates or shapes, rivets, bolt heads and other parts subjected to special wear and attack, the edges shall be stripped with a longitudinal motion and the rivets and bolt heads with a rotary motion of a brush followed immediately by general painting of the whole surface, including recoating of the edges, rivets and bolt heads.

If, in the opinion of the Engineer, traffic produces an objectionable amount of dust, the Contractor shall, at no additional costs to the State, allay the dust for the necessary distance on each side of the bridge and take any other precautions necessary to prevent dust and dirt from coming in contact with freshly painted surfaces or surfaces prepared for painting.

The Contractor shall protect pedestrian, vehicular and other traffic upon or underneath the bridge and all portions of the bridge superstructure and substructure against damage or disfigurement by splatters, splashes and smirches of paint or paint material. Any such disfigurement shall be removed at the direction of and to the satisfaction of the Engineer.

816.03.7--Inspection. The Contractor shall measure the paint thickness with an elcometer or other approved magnetic detector thickness gauges. All areas of the finished system deficient in thickness shall be coated over with the finish paint to establish the specified thickness. Excessive thickness in the application of either coating evidenced by mudcracking will be cause for the affected area to be stripped of paint, cleaned and repainted.

Where rejection is due to poor workmanship or deficiency in the quality of the work or materials, the Contractor may be required to strip the entire defective sections of all previously applied materials and clean prior to repainting.

Inspection shall be done in the presence of and to the satisfaction of the Engineer.

816.04--Method of Measurement. Maintenance painting of structures and members will be measured by the lump sum or per each as provided in the contract.

816.05--Basis of Payment. Maintenance painting of structures and members will be paid for at the contract unit price per each or lump sum, which price will be full compensation for preparation of the surface, for furnishing and applying all materials and for all labor, tools, equipment and incidentals necessary to complete the work.

Payment will be made under:

816-A: Maintenance Painting of Metal Structures	- lump sum
816-B: Maintenance Painting of Metal Structure, <u>Location / Description</u>	- per each
816-C: Maintenance Painting of <u>Description</u>	- lump sum

SECTION 820 - TIMBER STRUCTURES

820.01--Description. This work consists of constructing timber structures in conformity with these specifications and in accordance with lines, grades, dimensions, and details shown on the plans.

820.02--Materials.

820.02.1--Lumber and Timber. Lumber and timber shall conform to the requirements of Section 718, and in the case of exposed permanent structures shall be treated as set out therein. Certain portions of untreated timber shall be coated as set out hereinafter and as may be shown on the plans.

820.02.2--Rods, plates, Eyebars, and Shapes. Rods, plates, eyebars, and shapes shall be of structural steel conforming to the requirements of Section 717.

820.02.3--Castings. Castings shall be cast steel or gray-iron, as specified, conforming to the requirements of Subsections 716.02 or 716.04.

820.02.4--Hardware. Machine bolts, drift bolts, and dowels may be either wrought iron or medium steel. Washers may be cast ogee or malleable castings, or they may be cut from medium steel or wrought iron plate, as specified.

Unless otherwise specified, machine bolts shall have square heads and nuts. Nails shall be cut or round wire of standard form. Spikes shall be cut or wire spikes, or boat spikes, as specified.

Nails, spikes, bolts, dowels, washers, and lag screws shall be galvanized unless otherwise specified.

820.03--Construction Requirements.

820.03.1--Storage of Material. Lumber and timber stored on the site shall be kept in orderly piles or stacks. Untreated material shall be open-stacked on supports at least 12 inches above the ground surface to avoid absorption of ground moisture and to permit air circulation, and it shall be so stacked and stripped as to permit free circulation of air between the tiers and courses. It will be advisable in particular cases for the Engineer to require protection from the weather by a suitable covering. On glued laminated structural members that are not to be treated, an approved end sealer shall be applied after end trimming of each completed member.

820.03.2--Installing Timber Piling.

820.03.2.1--Driving Piling. Timber piles shall be driven in accordance with the requirements of Subsection 803.03.1.7, except as modified herein.

820.03.2.2--Pile Hammer Formulas. Pile hammer formulas shall be per the requirements of Subsection 803.03.1.9.2, except the use of gravity or drop hammers shall be allowed. In the absence of loading test, safe bearing values for piles driven with a gravity or drop hammer shall be determined by the following formula:

$$P = \frac{2WH}{S+1.0} \quad \text{for gravity or drop hammers}$$

820.03.3--Timber Connectors. Timber connectors shall be one of the following types, as specified on the plans: the split ring, the toothed ring, the shear plate, or the spike grid. The split ring and the shear plate shall be installed in pre-cut grooves of dimensions as given herein or as recommended by the manufacturer. The toothed ring and the spike grid shall be forced into the contact surface of the timbers joined by means of pressure equipment. All connectors of this type at a joint shall be embedded simultaneously and uniformly.

Fabrication of all structures using connectors shall be done prior to treatment. When prefabricated from templates or shop details, bolt holes shall not be more than 1/16 inch from required placement. Holes for round drift bolts shall be bored with a bit 1/16 inch less than the bolt to be used. The diameter for square drift bolts shall be equal to the least dimension of the bolt. Holes for machine bolts shall be bored with a bit the same diameter as the bolt. Bolt holes shall be bored perpendicular to the face of the timber.

Timber after fabrication shall be stored in a manner that will prevent changes in the dimensions of the members before assembly.

Dimensions of material and details not otherwise specified shall meet with the approval of the Engineer.

820.03.4--Treated Timber.

820.03.4.1--Handling. Treated timber shall be carefully handled without sudden dropping, breaking of outer fibers, bruising, or penetrating the surface with tools. It shall be handled with rope slings. Cant hooks, peaveys, spikes, or hooks shall not be used. Prior to driving, the timber piling shall not be handled in such a manner that it is subjected to excessive and undue abuse that might produce splitting, splintering or brooming of the wood.

820.03.4.2--Placement. All cutting, framing, and boring of treated timber shall be done before treatment insofar as practicable. When treated timbers are to be placed in waters infected by marine borers, untreated cuts, borings, or other joint framings below high water elevation shall be avoided.

820.03.4.3--Cuts and Abrasions. All cuts in treated piles or timbers, and all abrasions, after having been carefully trimmed, shall be covered with two applications of a mixture of 60 percent creosote oil and 40 percent roofing pitch, or brush coated with at least two applications of hot creosote oil and covered with hot roofing pitch.

820.03.4.4--Bolt Holes. All bolt holes bored after treatment shall be treated with creosote oil by means of an approved pressure bolt hole treater. Any unfilled holes, after being treated with creosote oil, shall be plugged with creosoted plugs.

820.03.4.5--Temporary Attachment. Whenever, with the approval of the Engineer, forms or temporary braces are attached to treated timber with nails or spikes, the holes shall be filled by driving galvanized nails or spikes flush with the surface or plugging holes as required for bolt holes.

820.03.5--Untreated Timber. In temporary structures of untreated timber, the following surfaces shall be thoroughly coated with two coats of hot creosote oil before assembling: ends, tops, and all contact surfaces of sills, caps, floor beams, and stringers; and all ends, joints, and contact surfaces of bracing and truss members. The back faces of bulkheads and all other timber that is to be in contact with earth, metal or other timber shall be similarly treated.

Bolts passing through non-resinous wood shall be galvanized.

820.03.6--Treatment of Pile Heads. The heads of treated timber piles shall be protected as specified on the plans. If not specified, the fabric covering shall be used. The heads of timber piles, when the nature of the driving will unduly injure them, shall be protected by driving caps. When the area of the head of a timber pile is greater than that of the face of the pile hammer, a suitable cap shall be provided to distribute the blow of the hammer throughout the cross section of the pile. Fresh heading of a timber pile is recommended prior to driving. The head shall be cut square and shall be shaped or chamfered to prevent splitting at its periphery. Heads of all piling shall be square and a driving cap shall be provided to hold the axis of the pile in line with the axis of the hammer.

820.03.6.1--Cutting Off of Timber Piles. The tops of all piling shall be sawed to a true plane, as shown on the plans, and at the elevation fixed by the Engineer. Piles that support timber caps or grillage shall be sawed to conform to the plane of the bottom of the superimposed structure. In general, the length of pile above the cut-off elevation shall be sufficient to permit the complete removal of all material injured by driving, but piles driven to very nearly the cut-off elevation shall be carefully adzed or otherwise freed from all broomed, splintered or otherwise injured material. Pile heads, after cutting to receive the caps and prior to placing the caps, shall be treated in accordance with Subsection 820.03.6.

820.03.6.2--Defective Piles. All piles damaged because of internal defects or by improper driving, driving out of the proper location, or driving below the specified elevation shall

be corrected at no additional costs to the State by one of the following methods approved by the Engineer for the pile in question:

- (a) The pile shall be withdrawn and replaced by a new, and if necessary, a longer pile.
- (b) A second pile shall be driven adjacent to the defective or low pile.
- (c) A sufficient portion of the footing shall be extended to properly embed the pile. Timber piles shall not be spliced. All piles pushed up by the driving of adjacent piles or by any other cause shall be driven down again.

820.03.6.3--Metal Covering. The sawed surface shall be covered with three applications of a mixture of 60 percent creosote oil and 40 percent roofing pitch or thoroughly brush-coated with three applications of hot creosote oil and covered with hot roofing pitch. Before placing the cap, a sheet of 12 gauge, 0.028-inch zinc of good commercial quality or a sheet of 26 gauge iron or steel of the quality of ASTM A 525 and galvanized each side shall be placed on each pile head. The sheet shall be of sufficient size to project at least four inches outside of the pile, and it shall be bent down, neatly trimmed and securely fastened to the face of the pile with large headed galvanized roofing nails.

820.03.6.4--Fabric Covering. The heads of all piles shall be covered with alternate layers of hot pitch and loosely woven fabric similar to membrane waterproofing, using four applications of pitch and three layers of fabric. The cover shall measure at least six inches more in dimensions than the diameter of the pile and shall be neatly folded down over the pile and secured by large headed galvanized nails or by binding or serving with not less than seven complete turns of galvanized wire securely held in place by large-headed galvanized nails and staples. The edges of the fabric projecting below the wire wrapping shall be trimmed to present a workmanlike appearance.

The heads of untreated piles shall be given one of the following treatments, as may be specified or directed by the Engineer:

- (a) The sawed surface shall be thoroughly brush-coated with two applications of hot creosote oil.
- (b) The sawed surface shall be heavily coated with paint, after which it shall be covered with cotton duck of a least eight-ounce weight, which shall be folded down over the sides of the pile and firmly secured thereto with large-headed roofing nails. The edges of the duck shall be trimmed to give a workmanlike appearance. The duck shall then be waterproofed by being thoroughly saturated and coated with one or more applications of red lead paint.

820.03.7--Holes for Bolts, Dowels, Rods and Lag Screws. Holes for round drift bolts and dowels shall be bored with a bit 1/16 inch less in diameter than the bolt or dowel to be used. The diameter of holes for square drift bolts or dowels shall be equal to the least dimension of the bolt or dowel.

Holes for machine bolts shall be bored with a bit the same diameter as the bolt, except as otherwise provided in Subsection 820.03.3.

Holes for rods shall be bored with a bit 1/16 inch greater in diameter than the rods.

Holes for lag screws shall be bored with a bit not larger than the body of the screw at the base of the thread.

820.03.8--Bolts and Washers. A washer, of the size and type specified, shall be used under all bolt heads and nuts that would otherwise come in contact with wood.

The nuts of all bolts shall be effectively locked after they have been finally tightened.

820.03.9--Framing. All lumber and timber shall be accurately cut and framed to a close fit in such manner that the joints will have even bearing over the entire contact surfaces. Mortises shall be true to size for their full depth, and tenons shall fit snugly. No shimming will be permitted in making joints, nor will open joints be accepted.

820.03.10--Pile Bents. Pile bents shall be constructed in accordance with applicable provisions of Section 803.

820.03.11--Framed Bents.

820.03.11.1--Mud Sills. Untreated timber used for mud sills shall be of heart cedar, heart cypress, redwood, or other durable timber. Mud sills shall be firmly and evenly bedded to solid bearings and tamped in place.

820.03.11.2--Concrete Pedestals. Concrete pedestals for the support of framed bents shall be carefully finished so that the sills or posts will take even bearing on them. Dowels of at least 3/4-inch diameter and projecting at least six inches above the tops of the pedestals shall be set in them when they are cast for anchoring the sills or posts.

820.03.11.3--Sills. Sills shall have true and even-bearing on mud sills, piles, or pedestals. They shall be drift-bolted to mud sills or piles with bolts of not less than 3/4-inch diameter and extending into the mud sills or piles at least six inches. When possible, all earth shall be removed from contact with sills so that there will be free air circulation around them.

820.03.11.4--Posts. Posts shall be fastened to pedestals with dowels of not less than 3/4-inch diameter extending at least six inches into the posts.

Posts shall be fastened to sills by one of the following methods, as indicated on the plans:

- (a) By dowels of not less than 3/4-inch diameter extending at least six inches into posts and sills.
- (b) By drift bolts of not less than 3/4-inch diameter driven diagonally through the base of the post and extending at least nine inches into the sill.

820.03.12--Caps. Timber caps shall be placed, with ends aligned, in a manner to secure an even and uniform bearing over the tops of the supporting posts or piles. All caps shall be secured by drift bolts of not less than 3/4-inch diameter extending at least nine inches into the posts or piles. The drift bolts shall be approximately in the center of the post or pile.

820.03.13--Bracing. The ends of bracing shall be bolted through the pile, post or cap with a bolt of not less than 5/8-inch diameter. Intermediate intersections shall be bolted, or spiked with wire or boat spikes, as indicated on the plans. In all cases spikes shall be used in addition to bolts.

820.03.14--Stringers. Stringers shall be sized at bearings and shall be placed in position so that knots near edges will be in the top portions of the stringers.

Outside stringers may have butt joints with the ends cut on a taper, but interior stringers shall be lapped to take bearing over the full width of the floor beams or cap at each end. The lapped ends of untreated stringers shall be separated at least 1/2 inch for the circulation of air and shall be securely fastened by drift-bolting where specified. When stringers are two panels in length the joints shall be staggered.

Cross-bridging between stringers shall be neatly and accurately framed and securely toe nailed with at least two nails in each end. All cross-bridging members shall have full bearing at each end against the sides of stringers. Unless otherwise specified in the contract, cross-bridging shall be placed at the center of each span.

820.03.15--Plank Floors. Unless otherwise specified, planks used in this construction shall conform to the requirements set forth in Subsection 820.02.1.

Single plank floor shall consist of a single thickness of plank supported by stringers or joists. The planks shall be laid heart side down, with 1/4-inch openings between them for seasoned material and with tight joints for unseasoned material. Each plank shall be securely spiked to each joist. The planks shall be carefully graded as to thickness and so laid that no two adjacent planks shall vary in thickness by more than 1/4 inch.

Two-ply timber floors shall consist of two layers of flooring supported on stringers or joists. The lower course shall be pressure treated with creosote oil. The top course may be laid either diagonally or parallel to the centerline of roadway as specified, and each floor piece shall be securely fastened to the lower course. Joints shall be staggered at least three feet. If the top flooring is placed parallel to the centerline of the roadway, special care shall be taken to securely fasten the ends of the flooring. At each end of the bridge these members shall be beveled.

820.03.16--Laminated or Strip Floors. The strips shall be of the grade required in Section 718. The strips shall be placed on edge at right angles to the centerline of the roadway. Each strip shall be spiked to the preceding strip at each end and at approximately 18-inch intervals with the spikes driven alternately near the top and bottom edges. The spikes shall be of sufficient length to pass through two strips and at least half-way through the third strip.

If timber supports are used, every other strip shall be toe-nailed to each timber support. The size of the spikes shall be as shown on the plans. When specified on the plans, the strips shall be securely attached to steel supports by the use of approved galvanized metal clips. Care shall be taken to have each strip vertical and tight against the preceding one and bearing evenly on all the supports.

820.03.17--Wheel Guards and Railing. Wheel guards and railing shall be accurately framed in accordance with the plans and erected true to line and grade. Unless otherwise specified, wheel guards, rails and rail posts shall be surfaced four sides, S4S. Wheel guards shall be laid in sections at least 12 feet long.

820.03.18--Countersinking. Countersinking shall be done wherever smooth faces are required. Horizontal recesses formed for countersinking shall be painted with hot creosote oil, and after the bolt or screw is in place, shall be filled with hot pitch.

820.03.19--Painting. Rails and rail posts of untreated timber, or timber treated with preservative salts, shall be painted with three coats of paint.

Parts of the structure, other than rails and rail posts, that are to be painted, will be designated on the plans or in the special provisions.

Metal parts, except hardware, shall be given one coat of shop paint and after erection two coats of field paint as specified on the plans.

820.04--Method of Measurement. Timber remaining in the structure will be measured by the thousand feet board measure (MBM) which shall include the cost of all hardware, galvanizing, paint and painting. Computations of the amount of lumber and timber in the structure will be based on nominal sizes and the lengths indicated on the plans.

Piling will be measured in accordance with Subsection 803.04.

Metal parts, other than hardware, will be measured in accordance with Section 810.

820.05--Basis of Payment. Timber will be paid for at the contract unit price per thousand feet board measure, which price shall be full compensation for completing the work. Acceptable piling will be paid for at the respective contract prices per linear foot for the types and sizes specified, which price shall be full compensation for completing the work.

Payment will be made under:

820-A: Treated Timber	- per MBM
820-B: Untreated Timber	- per MBM
820-C: Untreated Timber Piling	- per linear foot
820-D: Treated Timber Piling	- per linear foot

SECTION 822 - NEOPRENE EXPANSION JOINTS

822.01--Description. This work consists of furnishing and installing neoprene expansion joints in accordance with these specifications and details shown on the plans.

822.02--Materials. Expansion joints shall meet the requirements of Subsection 707.07.

822.03--Construction Methods. Expansion joints shall be installed in accordance with the manufacturer's recommendations. The expansion material shall seal the deck surface, gutters and curbs to prevent moisture or other contaminants from leaking through the joints. Anchor bolts shall be cast-in-place or drilled and grouted at a spacing recommended by the manufacturer. The expansion material shall be installed in such a manner that the top

surface of the material will be parallel to but not protrude above the roadway or bridge surface.

822.04--Method of Measurement. Neoprene expansion joints of the types specified will be measured in linear feet.

822.05--Basis of Payment. Neoprene expansion joints will be paid for at the contract unit price per linear foot, which price shall be full compensation for completing the work.

Payment will be made under:

822-A: ____" Neoprene Expansion Joint, Type____ - per linear foot

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