

State Study No. 198

Transtech PQI 301 Pavement Quality Indicator Device Evaluation

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Prepared October 2010

Conducted By:

Research Division

Mississippi Department of Transportation

In Cooperation With:

Mississippi Department of Transportation, District One
Mississippi Department of Transportation, District Six
U.S. Department of Transportation
Federal Highway Administration

1. Report No. FHWA/MS-DOT-RD-00-198		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle Quality Verification of PQI 301 Asphalt Density Device				5. Report Date October 2010	
				6. Performing Organization Code MDOT Research Div 86-01	
7. Author(s) Jordan Whittington, Matthew Strickland, and Paula Wiles				8. Performing Organization Report No. MS-DOT-RD-00-198	
9. Performing Organization Name and Address Mississippi Department of Transportation Research Division P O Box 1850 Jackson MS 39215-1850				10. Work Unit No. (TRAIS)	
				11. Contract or Grant No.	
12. Sponsoring Agency Name and Address Federal Highway Administration and Mississippi Department of Transportation				13. Type Report and Period Covered Final Report	
				14. Sponsoring Agency Code	
15. Supplementary Notes					
16. Abstract The PQI 301 Asphalt Density device, developed by Transtech Systems, Inc., was evaluated by MDOT to determine if it could be used in lieu of the currently required nuclear density gauge. Nuclear density gauges require MDOT personnel to have a license, to be certified and wear a badge, and to be exposed to radiation. The PQI 301 was advertised as being easy and cost-effective to own, lightweight and easy to transport, as well as being quick and accurate. MDOT purchased two PQI 301 devices, one placed in the Gulfport Project Office and the other in the MDOT Materials Division. Both devices were used for comparison of results. During the study 236 density readings were taken with the PQI 301. However, difficulties in training, the lack of a standardized method of data collection and documentation, and lack of uniformity in data collection made data comparison between the PQI and the nuclear density gauge impossible. MDOT could seek further investigation into quality assurance, training, and standardized data collection methods if the agency wishes to implement the PQI 301 device.					
17. Key Words PQI, Asphalt Density				18. Distribution Statement Unclassified	
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of Pages 20	22. Price

Form DOT F 1700.7 (8-72)

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ACKNOWLEDGMENTS

The study reported herein was conducted by the Mississippi Department of Transportation (MDOT) under the sponsorship of the Federal Highway Administration, Mississippi Division Office. This work was accomplished under the supervision of Mr. James Watkins, State Research Engineer. This report was prepared by Mr. Matthew J. Strickland and Mr. Jordan Whittington, both formerly of the MDOT Research Division.

The author wishes to express his appreciation to the many people whose efforts contributed to the success of this study.

During the period of this study, the Executive Director of MDOT was Mr. Larry “Butch” Brown and the Deputy Executive Director / Chief Engineer was Mrs. Melinda McGrath.

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Introduction

Background

Under the current Mississippi (MDOT) specifications, field densities are required to ensure adequate compaction of each lift of Hot Mix Asphalt (HMA) construction. Achieving an adequate level of compaction in HMA is essential to ensure a pavement's long term durability. A denser layer of asphalt-aggregate mixture will achieve a higher level of structural stability and pavement strength. If this adequate level of compaction is not achieved, pavements can fall victim to early oxidation, cracking, rutting, raveling, and stripping (Blankenship).

According to the *Mississippi Department of Transportation's Field Manual for Hot Mix Asphalt (HMA)* it is acceptable to evaluate roadway density with either asphalt cores or a calibrated nuclear density gauge. The number of required density tests is determined by the daily production of asphalt in tons and also at the discretion of the Engineer. In order for a nuclear density gauge to be properly calibrated it must maintain an accurate gauge bias. This gauge bias is a relationship of density values obtained from cores taken in new construction lifts of HMA pavements and the values obtained from the nuclear density gauge. Either method of density determination is accepted to determine the payment schedule for compaction, although only densities determined from asphalt cores shall be used to determine the limits of a removal and replacement section.

Nuclear density gauges are currently used by the Mississippi Department of Transportation (MDOT) to determine the in-situ density of hot mix asphalt (HMA) layers. These Devices include a radioactive source which requires:

- MDOT must have a special license and follow regulatory controls
- Each user must be specially trained and certified
- Each user must wear a badge which is periodically tested to ensure that the employee has not been exposed to an excessive amount of radiation
- Designated special storage areas

The 6th District will purchase a PQI 301 Pavement Quality Indicator. This device is advertised to provide accurate density measurements of HMA while eliminating every negative aspect of the use of the nuclear density gauge. The Gulfport Project Office will use this device in conjunction with the nuclear density gauge on upcoming projects to provide comparison test results. These results will be evaluated to determine if the PQI 301 can be used in lieu of the nuclear density gauge.

Objectives

Using asphalt cores to determine the density of HMA pavements is a more accurate technique to determine a pavement's density than using a nuclear gauge but does have drawbacks. For instance, although repairing the hole left by the extraction of a core is not terribly difficult but many people are not keen on the idea of destructive testing to a brand new pavement. A nuclear density gauge is not as accurate as the core density method but it does offer the advantages of being more portable, less time consuming to obtain results and it is not destructive to the pavement. Nuclear density gauges, like the core density method, are not without drawbacks. They contain a radioactive source which requires that MDOT have a special license authorizing their possession and all operators of the nuclear density gauge must be specially trained and certified. In addition, the nuclear density gauge operator must wear a badge that monitors radiation exposure to ensure that radiation levels remain acceptable. Lastly, the nuclear gauge itself must be transported and stored in an approved container.

In an effort to provide a highly portable, accurate, and easy to use method of collecting pavement densities; Transtech Systems, Inc. developed the Pavement Quality Indicator (PQI) 301. This meter uses an electromagnetic field to obtain pavement densities versus the radioactive source of the nuclear density gauge. This lack of a nuclear source allows Transtech Inc. to advertise the PQI 301 as being:

- Easy and cost-effective to own and operate
- Lightweight and easy to transport
- Non-nuclear source means no licensing, service fees, or safety concerns
- Quick, accurate density measurement of HMA mats

The objective of this study is to test the validity of the claims made by Transtech Inc. as well as the potential benefit to the Mississippi Department of Transportation of implementing the PQI 301 non-nuclear density gauge in its field testing of in place HMA.

Scope

For this study, a PQI 301 non-nuclear density gauge was loaned to the Gulfport Project Office to test the initial usefulness of the device. After a discussion of the initial data, it was determined that further testing was needed to provide a conclusive statement in relation to the PQI 301 device. Two PQI 301 devices were purchased by the Mississippi Department of Transportation for further investigation. One device was placed with the Gulfport Project Office while the other was placed with the MDOT Materials Division to rotate throughout other Mississippi Department of Transportation districts. These two devices were to be used in conjunction with asphalt cores and nuclear density gauges on MDOT projects to provide comparison test results. The results gathered from this comparison testing will then be used to

determine whether or not the PQI 301 device can be used as an acceptable substitute to the nuclear density gauge.

Testing and Results

Summary of Testing

Since the purpose of this study is to obtain a comparison between the density measured by the PQI 301 and the density given by both the nuclear gauge and asphalt cores, the PQI 301 will be used in field density measurements of newly constructed HMA pavements by MDOT personnel. Both the Gulfport Project Office and the District 1 Materials Lab were given a PQI 301 non-nuclear device to use at their discretion for comparative testing of new asphalt pavements. Each staff will implement the use of the non-nuclear device as well as the standard nuclear density gauge in their quality assurance testing program.



Figure 1. MDOT's District 1 Arthur Parham with the PQI Device

The density measured by the PQI 301 will be taken and recorded as well as the value obtained by either an asphalt core, nuclear density gauge, or both. The results from these field experiments will be recorded for several different kinds of HMA pavements. From these results an analysis will be performed to determine the accuracy, repeatability, and feasibility offered by the PQI 301 device.

Difficulties in Testing

With the absence of a radioactive source there are several inherent features of the PQI 301 that make using it advantageous to the standard nuclear density gauge. For instance, it is much easier to transport and store than the traditional nuclear density gauge. However, since the PQI 301 non-nuclear device is a new type of technology there will also be difficulties associated with implementing the technology.

The first and largest difficulty associated with the testing of the PQI 301 device was the absence of a standardized method of data collection and documentation. Since the majority of MDOT personnel responsible for the field inspection of newly constructed asphalt pavements have been properly trained and are experienced with the use of nuclear gauges they are comfortable with the data collection and documentation procedure that goes along with it. Since there is no MDOT specification available pertaining to the use of non-nuclear density gauges, the data collection and documentation process varied from person to person responsible for testing.

The second problem encountered in testing was the process of collecting data uniform enough for comparison. In order to make valid arguments in research it is essential that data be collected in a manner consistent enough to eliminate guess work and the need for assumptions. Near the end of data collection the method by which moisture was monitored at the time of testing was altered and the change of collection parameters was not documented. Without knowing exactly what setting was changed and how it affected the density reported by the PQI device it is impossible to relate this data with the previous data collected. This accidental reconfiguration of the PQI device invalidated nearly thirty points of data from the information gathered during testing.

It should also be mentioned that personnel changes within MDOT's Research Division during the course of this study also made the coordination of uniform data collection and documentation difficult. This staff transition also impeded the transfer of knowledge previously acquired in the study. Despite all of the difficulties encountered during testing it is the hope of all parties involved that this study still produces a recommendation that will be helpful in decision of the future implementation of the PQI 301 device.

Results and Discussion

Results Obtained from Testing

Throughout the experimental program portion of this research study there were 236 total density readings taken with the two PQI 301 non-nuclear devices. As mentioned previously in this report nearly 28 of the readings were deemed invalid because of a complication resulting from a modification in the moisture data collection method. All readings were the result of the combined efforts of MDOT District 1 Materials Division and District 6 personnel. All density measurements collected with the non-nuclear device were also accompanied by a nuclear gauge density, an asphalt core density, or both. Without a specified method of data collection, many of the density readings were also accompanied with different points of data including time of collection, project location, type of asphalt mat being tested, and the ambient humidity during the density measurement.

Data Collection

As mentioned in the previous section, there was not an established method of data collection used for this study. This lack of a definitive method of data collection created several difficulties when attempting to analyze the data. First, the method in which the data was collected and documented was left at the discretion of the personnel responsible for the field testing. For this reason much of the data collected lacks the uniformity needed to make direct comparisons between sets of data. As mentioned in the previous paragraph, 28 of the readings collected for this study were deemed unusable after the method of monitoring moisture at the time of testing was altered without documentation. This brought the total number of applicable density readings to 208. Of these 208 readings only 83 readings were reported with a documented gauge bias for both the nuclear and non-nuclear devices. Although the nuclear density gauge is used by MDOT for quality acceptance, for the purposes of this study it is believed that the correlation of the density reading reported by the PQI device would be most valid when compared to the value obtained from asphalt cores tested in the lab. Of the 83 readings which contained a documented gauge bias for both devices, only six were supported

with density values obtained from asphalt cores. According to the PQI 301 Operator's Handbook it is imperative that a calibration be performed for each type of asphalt mat the device is used on in order to ensure accurate density values are reported. Of the data sets that were collected there were none which documented the proposed layer thickness of pavement being tested and very few listed what aggregate size the pavement contained. Lastly, the environment in which each density reading was collecting was not adequately documented for every case in this study. In order to adequately characterize the effects of environmental and pavement factors as to the consistency of the PQI device it is necessary that these conditions be recorded for each reading as well as the calibrated bias, type of pavement, and the density obtained in the lab from cores. For these reasons it seems inappropriate to conduct a statistical analysis of the data gathered to draw conclusions as to the accuracy and repeatability of the PQI 301 device.

Limitations of the PQI Device

While the PQI 301 device does eliminate the radioactive source present in traditional density gauges it lacks the versatility offered by the nuclear gauges already in use by the Mississippi Department of Transportation. The nuclear gauges currently in use by MDOT are not only used for the density testing of newly constructed asphalt pavements but they also return usable density readings for compacted soil layers of excavations and embankments. The PQI 301 devices used for the testing portion of this study are not designed by their manufacturer to give accurate densities for soil layers. With this limitation, implementation of the PQI 301 non-nuclear device would only reduce, not eliminate, the need for the nuclear density gauge. While this would reduce the exposure of employees to radiation from density testing, it would not eliminate this exposure completely nor would it eliminate the need for employees to obtain training with the nuclear device, licensing of technicians, or monitoring of radiation exposure associated with the nuclear density gauge. This is important to note since the implementation of the non-nuclear gauge would not mean a complete replacement of the nuclear technology already in place.

Conclusions and Recommendations

Conclusions

A review of the results obtained in the testing portion of this study concludes that a statistical analysis is not a valid technique given the variability in documentation of the data.

Much of the data received from testing personnel reported a non-nuclear density yet lacked the environmental and procedural documentation to make direct comparisons between data sets and justifiable conclusions with regard to the implementation of the PQI 301 non-nuclear device.

It is also evident from examining the data submitted that a strategic test procedure should be developed as well as a uniform method of data collection. This would minimize the amount of variability in results and allow involved parties to make more effective decisions using the density data obtained from field personnel.

Recommendations for PQI 301

Based on the results of this study, it is recommended that further investigation of the PQI 301 device be conducted if the Mississippi Department of Transportation further seeks its implementation into the quality assurance program of newly constructed asphalt pavements. From the testing program utilized for portions of this study it has become evident that several variables need be monitored and documented in order to gather comparable data. These variables should include but are not limited to:

- Time elapsed since compaction
- Proposed asphalt lift thickness
- Asphalt type being tested
- Underlying asphalt layer material type
- Ambient Temp
- Pavement Temp
- Ambient Moisture (humidity)
- Density of asphalt by nuclear gauge (including bias used)
- Density of asphalt by non-nuclear gauge (including bias used)
- Calibration method used for non-nuclear gauge
- Density of asphalt determined by lab core method

Also, in order to conduct a valid statistical analysis it is recommended that efforts be made to collect significant data on asphalt pavements with similar aggregate blends and varying lift thicknesses as well as pavements with similar lift thicknesses and varying aggregate blends in order to test the effects of lift thickness and aggregate type on densities reported by the PQI non-nuclear device.

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Appendix A--Results Gathered with PQI 301 Devices

