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Testing HMA Density with Electromagnetic Gauges

tech transfer summary

Electromagnetic gauges offer nondestructive testing of in-place HMA with real-time results for effective QC/QA decision making.

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RESEARCH PROJECT TITLE
Investigation of Electromagnetic Gauges for Determining In-Place HMA Density

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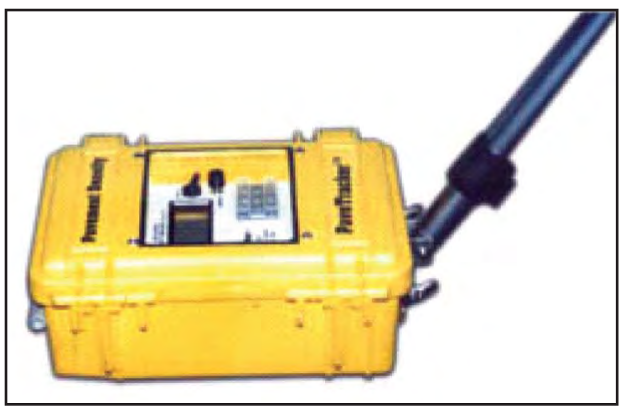
Objectives

- Compare the accuracy and precision of two electromagnetic gauges—the Pavement Quality Indicator (PQI) model 301 and the PaveTracker model 2701—to that of core density testing of hot-mix asphalt (HMA) pavement.
- Determine which gauge, if either, should be considered for quality control and quality assurance testing.

Problem Statement

Density is a critical factor that directly influences HMA pavement quality and long-term performance, as well as contractor incentives and disincentives. The coring process traditionally used for obtaining density is time-consuming, costly, and can create imperfections in new pavements—even though the sample locations are properly repaired.

Nuclear density gauges are an alternative to coring, but they involve other complications, including the risk of exposure to radiation and strict licensing, record-keeping, usage, and storage requirements. Consequently, there is demand for a density-measuring device that is reliable, easy-to-use, rapid, nondestructive, and nonradioactive.



PaveTracker gauge manufactured by Troxler Electronics Laboratory

Research Description

Test data were collected in the field during and after paving operations as well as on field mixes compacted in a laboratory for PaveTracker, PQI, and cores. PQI density readings were collected both in single mode and multi mode.

Data were analyzed and grouped by variable to determine which of the following tested factors affected density readings:

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- Fifteen different sites
- Two conditions (wet and dry HMA pavements)
- Seven different contractors
- Two nominal maximum aggregate sizes (NMASs) (12.5 mm and 19.0 mm)
- Five traffic levels (ranging from 300,000 to 30 million ESALS)
- Three aggregate types (limestone, slag/limestone, and quartzite)
- Three separate roller passes

Key Findings

Analysis revealed the following with regard to specific gauges and operational modes:

- The statistical analysis of PaveTracker density readings implied that condition (i.e., wet or dry), contractor, aggregate type, NMAS, traffic level, and roller pass were all significant variables affecting density measurements.
- For the single-mode PQI operation, the statistical analysis revealed that station, pavement width, distance across pavement width, and temperature are significant.
- Statistical analysis of multi-mode PQI data revealed that site, station, pavement width, contractor, aggregate type, binder content, roller pass, and distance across pavement width were significant variables.

Analyses of both electromagnetic devices, the PaveTracker and PQI, indicate that both are sensitive to density changes due to roller passes, which suggests that these devices could be used for quality control. Other results from this research include the following:

- As the application of quality indices reveals, quality assurance conclusions based on PQI data would be equivalent to those based on cores in most cases. If used for determination of payment, PaveTracker densities in this study would result in contractor penalties more often than PQI densities.
- According to the statistical analysis, no variables are considered statistically significant for all three electromagnetic gauge data sets. However, two out of three data sets (i.e., PaveTracker and multi-mode PQI readings) are significantly affected by contractor, aggregate type, binder content, and roller pass.
- The location of a core across the width of a pavement can result in significantly different density readings for the same pavement. The PQI's variability tends to be greater than both the PaveTracker and extracted cores.
- In laboratory tests, analyses indicate that only the condition (i.e., wet or dry) and density-reading device affect density results. This implies that mixes with slag can be evaluated with either device and not yield significantly different results than a non-slag mix compacted to the same air void level.
- The newer PQI algorithm was found to be more accurate than the older algorithm with about the same level of precision on laboratory-prepared samples.

Implementation Benefits

The substantial reduction in testing time that results from employing electromagnetic gauges rather than coring makes it possible for more readings to be used in the QC/QA process, offering real-time information without increasing the testing costs. Since electromagnetic gauges offer nondestructive testing, the new pavement does not incur imperfections due to core sampling. Electromagnetic gauges do not require the extensive licensing and record-keeping necessary for nuclear density gauges, nor do they involve the potential radiation hazards.

Implementation Readiness

Using test strips to determine an appropriate adjustment factor is critical for effective QC/QA testing with electromagnetic gauges. Because several different mix- and project-specific factors affect the readings, implementation of these gauges will likely need to rely on test strips for each new project and mix.

To ensure the appropriate implementation of electromagnetic gauges, there is a need for additional research that considers the following elements:

- Increased electromagnetic gauge testing frequency
- Analysis of new electromagnetic gauges that have come onto the market

Further research should be conducted on the PaveTracker and PQI to establish guidelines. It is recommended that the latest algorithms be employed when conducting future research with electromagnetic gauges.

TransTech Systems' Pavement Quality Indicator