PUTTING RESEARCH TO WORK BRIEF

Non-Destructive System to Evaluate Critical Properties of Asphalt Compaction

Investigator

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The Wisconsin Highway Research Program sponsored a two-stage investigation to develop a non-destructive system to evaluate critical compaction properties and characteristics of asphalt pavements during the densification process. Stage One activities defined critical characteristics during compaction, investigated non-destructive testing (NDT) technologies to measure these characteristics and ranked the NDTs to evaluate selected systems in the second stage of the study. Stage Two activities required collecting field data from three projects, analyzing the data using a variety of methods and developing an implementation plan based upon the findings.

What's the Problem?

During the mid-1990s, the Wisconsin Department of Transportation (WisDOT) specifications related to in-place asphalt pavement density shifted from the primary use of cored samples to nondestructive measurement using nuclear density guages. While the current system has maintained a defined level of resultant performance, concerns were raised surrounding increased variability when attempting to properly evaluate:

- The influx of new materials going into asphaltic pavements
- Uniformity of mat compaction and densification
- A change in department emphasis toward pavement textures
- Rising construction zone safety issues
- Joint constructability and associated acceptance methods.

Recent advancements in NDT technologies provide WisDOT with the opportunity to expand beyond in-place density as the sole parameter used to evaluate and accept flexible pavements.

Research Objectives

The objectives of the research were as follows:

- Define critical compaction properties for measurement and justify their importance
- Develop a compaction evaluation system employing more than one technology
- Rank potential systems based on technical merits, cost, practicality and other factors
- Perform fieldwork, collect and analyze supporting data
- Develop specifications and guidance for implementation of the defined system.

Summary of impact of critical characteristics on pavement performance

CRITICAL CHARACTERISTIC	IMPACT ON PAVEMENT
Mix Segregation	Pavement permeability, mechanical stability, rutting, raveling, bleeding
In-Place Compaction	Pavement mechanical stability, rutting, permeability
Smoothness	Safety, comfort
Temperature Segregation	Densification, mechanical stability
Layer Thickness	Pavement density, permeability, structural capacity
Layer Interface Bonding	Structural capacity, slippage, compaction difficulty, premature fatigue, near-surface cracking, moisture damage
Pavement Modulus	Structural capacity, various distresses

Methodology

The research utilized several NDT technologies capable of measuring asphalt pavement during compaction:

- Deflectometers
- Ground Penetration Radar
- Impact Echo
- Ultrasonic Pulse Velociy
- Infrared Thermography
- Intelligent Compaction
- Lasers
- Permeameters
- Ultrasonic Seismic

Each technology was evaluated against 12 specific attributes: operational principle; measures and indicators; test equipment; portability of the test; complexity of execution in the field; testing time; environmental limitations; data reliability; committee-approved test protocols; degree of training required; cost; and states using the technology in practice. Critical properties and characteristics were aligned with available NDTs and a quantitative ranking was created. The ranking provided an objective and unbiased scoring system to determine the most appropriate NDTs for continued field evaluation.

Based on the scoring results, the three higher-ranked NDTs selected for Stage Two field evaluation were Infrared Thermography, Ground Penetrating Radar (GPR) and Portable Seismic Pavement Analyzer (PSPA). The nuclear density gauge was also used in the evaluation.

Results

Data analysis for the three projects found no definitive relationship between continuous thermal temperatures behind the paver and final density measured by GPR. Additionally, there was no relationship between pavement modulus measured by the PSPA and mat density measured by both the GPR annd nuclear gauge. The correlation slope among variables was inconsistent for any combination of variables, except for negative correlations between mean infrared (IR) temperature and GPR thickness. In this study, there was a very weak or no correlation between variability in IR temperature and nuclear density on the three projects. Based on these results it is not feasible to implement a measurement system that interrelates IR, GPR and PSPA at this point in their development.

Implementation

Recommendations for future implementation of these NDT technologies were enumerated using findings from the field data and previous research.

Findings for thermal readings suggest further research and development is necessary to create a structured system that generates reliable data, primarily due to calibration differences between the thermal camera and PAVE-IR sensor bar. Ideally, the relationship between temperature variability and performance should be established prior to implementation in order to ensure measurable success.

Findings for GPR indicate that the technology is state-of-the-art for hot mix asphalt (HMA) construction. This technology is valuable in mapping the thickness and density by offset and was able to detect more density variability along the centerline of the mat.

Portable Seismic Pavement Analyzer findings suggest that this technology is state-of-the-art for HMA construction, with a high level of variability (coefficient of variation). This technology is of interest in determining pavement strength with a seismic wave technique. However, it is not a function of pavement density, but rather the layer of thickness, which is plausible since there is generally greater pavement strength with added thickness.

Immediate deployment of the studied measurement tools as an interrelated system presents certain risk to the department at this time. However, implementing the use of any of these technologies may enhance the current practice for the measurement and acceptance of pavement compaction efforts.

This brief summarizes Project 0092-11-01,
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