PUTTING RESEARCH TO WORK

BRIEF

Alternatives to Nuclear Gauges for HMA Density Measurement

In the 1990s Wisconsin DOT shifted from the use of core samples to measure asphalt pavement density to the use of nuclear density gauges. Capable of producing fast results without damaging the pavement, nuclear gauges are used during asphalt construction for quality control to assure proper density (a characteristic of durable asphalt pavement), and again later for quality assurance.

What's the Problem?

Though effective and nondestructive, nuclear density gauges involve a variety of challenges. Using these gauges requires WisDOT to annually renew its radioactive materials license, as well as annually certify each gauge at additional cost. Calibrating the gauges for each project site adds yet another cost. In addition, due to their use of radioactive materials, nuclear gauges require special handling and present potential health risks to operators, paving project crews, and the public.

Furthermore, nuclear gauges provide data of variable accuracy when used to evaluate WisDOT standard Superpave mix designs. These mixes typically use coarser aggregates than traditional hot-mix asphalt mixes.

The accuracy of non-nuclear gauges has improved over time, and these devices offer an alternative nondestructive density measurement process without the disadvantages of radioactive materials. Non-nuclear gauges can collect more data than nuclear gauges in the same time period, potentially offering more effective quality assurance and control while eliminating the licensing and handling requirements associated with nuclear gauges. However, non-nuclear gauges have not been tested extensively in Wisconsin.

Research Objectives and Methodology

The investigators sought to evaluate non-nuclear density gauges in the field for WisDOT use. Specific objectives included:

- Through a literature search, identify promising non-nuclear gauge models and technical challenges associated with their use.
- Evaluate selected gauges in the field on coarse, Superpave HMA pavements for effectiveness and practicality in quality control and assurance.
- Evaluate the nuclear gauge testing process for effectiveness and as a baseline for non-nuclear gauge evaluation.
- Recommend test protocols and systems for non-nuclear density measurement.

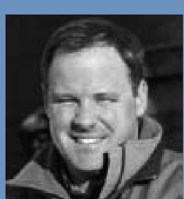
To achieve these objectives, the researchers performed a literature review and selected three non-nuclear density gauges for field evaluation: the TransTech Pavement Quality Indicator (PQI) 300, the TransTech PQI 301, and the Troxler PaveTracker 2701b. They evaluated these gauges on 16 HMA pavement projects against density measurements from 6-inch-diameter cores, and compared their readings with those from a CPN MC-3 nuclear density gauge. Ten of the projects involved multiple testing days and mix types. Investigators also reviewed and analyzed WisDOT nuclear density testing specifications and procedures for effectiveness in determining in-place density.

Results

The researchers found that all three non-nuclear density gauges provided data quickly and effectively. Specific findings included:

- The literature review of previous field studies found consistent differences between the density readings from non-nuclear gauges and measurements from cores or nuclear gauges. These differ-

Investigator



"Non-nuclear density gauges provide more rapid, proactive measurements for quality control, and reduce the need for handling radioactive materials."

–Robert Schmitt
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This Troxler PaveTracker, shown here testing asphalt specimens produced by a Superpave Gyratory Compactor, will be easier and safer to use in quality control of HMA density than nuclear density gauges (Fig. A.4 of the final report).

Flexible Pavements TOC Chair

"This research will reduce WisDOT's reliance on the expensive, time-consuming and complicated use of nuclear gauges and minimize the associated safety risks."

–Len Makowski
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ences were generally below 10 pounds per cubic foot (pcf). Based on this level of bias, researchers in these studies typically recommended using non-nuclear gauges for quality control but not for quality assurance or acceptance.

- In field tests in this project, non-nuclear gauges consistently produced lower density readings than the nuclear gauge. The PQI Model 301 read 11.2 to 27.2 pcf lower than the nuclear gauge, while the PQI Model 300 ranged from 4.2 to 26.6 pcf lower. The PaveTracker varied from 1.8 to 17.7 pcf lower.
- Current WisDOT procedures for nuclear density gauges require seven tests per lot, which takes about 40 minutes to complete. To increase confidence in the estimated pavement density, at least 15 tests per lot are recommended.
- Several factors affected the difference between nuclear and non-nuclear density gauge readings, including mixture- and project-specific factors such as aggregate source, design loads, lab air voids, asphalt content, aggregate specific gravity, and pavement layer thickness.
- To offset the effects of these factors, investigators recommended that non-nuclear gauges be calibrated daily at each project site. Various calibration methods were found unsuitable, leaving nuclear gauge readings as the most effective method for calibrating non-nuclear gauges.

Researchers recommend that technicians using non-nuclear gauges take at least 30 readings within each lot to ensure acceptable confidence levels, which requires about 55 minutes to complete. In addition, the researchers presented a statistically based procedure for determining and correcting statistical differences between two non-nuclear density gauge devices.

Further Research and Implementation

The researchers identified several implementation issues, including the continued need for nuclear density gauge use and the need to train operators on the new devices. Other issues include a need to adjust to the more frequent battery charging required by non-nuclear gauges, and the greater effort required to lay out test sites for 30 samples rather than seven (or 15).

Implementation of the study findings would require WisDOT to adjust its current specifications, which are based on the use of nuclear density gauges. New specifications for non-nuclear density gauges would have to be developed and field-tested. As non-nuclear gauge technologies improve, future research may succeed in eliminating the use of nuclear instruments in density measurements altogether.

This brief summarizes Project 0092-05-10, "Non-Nuclear Density Testing Devices and Systems to Evaluate In-Place Asphalt Pavement Density," produced through the Wisconsin Highway Research Program for the Wisconsin Department of Transportation Research Program, 4802 Sheboygan Ave., Madison, WI 53707.

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