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Measuring Asphalt Density– Does a Day Make a Difference?

Density or degree of compaction is one important component of asphalt pavement quality and long-term performance. That's why the Wisconsin Department of Transportation has minimum density requirements for asphalt pavement construction. Contractors falling short of required density on placed asphalt are paid less than the full contract amount, following WisDOT's Adjusted Payment Schedule. Payment factor discounts can range from 98 percent of the contract price to as low as 65 percent.

What's the Problem?

Discrepancies between contractors' and WisDOT's readings raised the question of the role of temperature in density measurements. Currently WisDOT measures the density of the asphalt pavement just after it is rolled out, while at a temperature of 100-120°F. Since materials tend to shrink when cooled, the hypothesis was that asphalt density readings may be higher if taken the day after paving, after cooling to ambient temperatures. This could have an impact on payments to contractors. However, if no measurement differences were found, densities could be taken at either time, which would help WisDOT extend the reach of its employees and measuring equipment.

Research Objectives

This project looked for a relationship between density measurements taken just after the pavement is placed and those taken the next day. If significant density gains were seen overnight, investigators would explore the possibility of creating a predictive model from which a correction factor could be calculated. With such a correction factor in hand, WisDOT could adjust for measurements made at times other than immediately after rolling.

Study Design

The researchers collected their raw data from measurements taken in the field at pavement construction sites and at the University of Wisconsin-Madison's Asphalt Laboratory. Because pavement mixes designed for different usage patterns may cool at different rates, the researchers took measurements from hot-mix asphalt (HMA) projects designed for light, medium, high, and very high volume traffic. In all, the researchers collected measurements from 10 construction sites, seven in 1999 and three in 2000. At each site, they collected measurements from 15 to 30 randomly selected locations.

At each location, a nuclear density gauge operator conducted six tests. The first three measurements were taken just after the final cold rolling stage, while the asphalt was still warm, and the second three were taken the next day between 5 and 6 o'clock in the morning, when the asphalt had cooled. All six measurements were made in exactly the same location. For each test the researchers also recorded the HMA's temperature.

In the laboratory the researchers were able to measure density changes directly, rather than rely on readings from a nuclear density gauge. Samples from the asphalt trucks at each of the construction sites were compacted into cylinders of required density using a gyratory compactor, then labeled and weighed. The cylinders were heated to 140°F and measured with specially modified calipers for height and width. They were measured again after overnight cooling to 78°F. By comparing the volume of the cylinders at each temperature, the researchers were able to calculate any differences in density.

The researchers also noted which of the two brands and four models of nuclear density gauges were used for each field measurement. The raw data from all field and lab measurements are included in the final report.

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Investigators measured asphalt pavement density in the field with nuclear density gauges and in the lab by volume determination using calipers.

Figure 2.2 Seaman C-200 Gauge in use

Figure 2.4 Sample Measurement

"This research opens up the possibility of taking density measurements either the day of paving or the day after. The data indicate that there isn't a significant difference between the two measurements."

- Leonard Makowski, WisDOT District 2

Study Results

The researchers found that there was no statistically significant increase in the HMA's density between the day the road surface was finished and the next morning, whether measured in the field or in the laboratory. Researchers concluded that contractors would be unlikely to receive higher payment from density measurements taken the day after paving and that WisDOT could schedule density readings either day with essentially the same results.

Investigators concluded that none of the other factors that they analyzed—whether the type of HMA mixture, the model of nuclear density gauge that was used, or the HMA's temperature—alone had a statistical relationship to any increases in density. When some of these factors are considered together, however, they did have a relationship to HMA density but only as an explanatory, not a predictive, model.

Further Research

Different types of asphalt mixes react differently to temperature changes. But the current project was limited to only a few types of mixes. Collecting and analyzing additional types of mixes as well as other relevant data, such as aggregate gradation, could possibly lead to creation of a predictive model and to better understanding of how asphalt mixes behave with temperature changes.

Implementation

Study results will be presented to the WisDOT Asphalt Industry Technical Committee for review and possible change of current WisDOT procedures requiring density measurements immediately after cold rolling.

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Determining a Temperature-Density Relationship After Completed Rolling of HMA

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