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DEPARTMENT OF TRANSPORTATION

OFFICE OF RESEARCH & INNOVATION

TECHNICAL SUMMARY

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PROJECT COST:
$125,529

Low pavement air voids commonly occur where pavement sections meet, an area that is difficult to compact.

Quantifying the Benefits of Improved Compaction

What Was the Need?

Transportation professionals have long known that asphalt density directly affects a pavement's long-term durability, but the exact correlation has not been well understood. Establishing an optimal pavement density is a topic of interest to MnDOT and other public transportation agencies across the country charged with managing roads with limited resources. A pavement that isn't dense enough is susceptible to water infiltration, which can cause freeze-thaw damage, stripping of the asphalt off the aggregate, delamination of the asphalt layers, raveling of the asphalt mixture and, eventually, potholes forming on the roadway. Too dense and the pavement can't expand properly, making it susceptible to flushing or too brittle and similarly prone to cracking. Additionally, overcompaction may break aggregate particles in the mixture.

Comparing Minnesota pavement samples collected soon after they were constructed more than a decade ago and monitoring their performance over time, MnDOT will eventually have enough data to understand the relationship between pavement density and long-term performance.

In Minnesota, pavements after construction typically have air voids of 7% to 8% and as much as 10% at the longitudinal joint between travel lanes where compacting the pavement is more challenging. A national study conducted in 2016 estimated that decreasing the amount of air voids in a finished pavement by just 1% could help it last 10% longer. These results suggest transportation agencies could save significant costs on road maintenance and rehabilitation over the course of the pavement's service life.

What Was Our Goal?

This project sought to help MnDOT understand the relationship between pavement density and performance in Minnesota. As part of its construction process, MnDOT cuts core samples the day after a pavement is finished to test and verify the pavement was built according to the agency's specifications for air voids. By creating a database and compiling information from hundreds of past road construction projects and measurements of pavement performance in the intervening years, MnDOT may be able to prove what connections exist between compaction and long-term performance and durability.

What Did We Do?

Researchers began by reviewing previous studies on compaction and performance to learn more about the relationship between air voids and compaction as well as air voids and long-term pavement performance. The research team also reviewed the longitudinal joint density specifications used by Midwestern states to understand what agencies require and how they test to ensure compliance.

Next, the research team developed criteria for selecting which of Minnesota's historical construction data should be used for evaluating density. For this study, the team chose to include data collected from core samples taken from large-scale road projects constructed between 2008 and 2018. In addition to air voids, the data offered a number of comparative values for each of the projects, such as the formulation of the asphalt mix that was used, the size of the aggregate, amount of recycled material used in the mixture and the origin of the materials. Data from 43 past projects were found to meet the researchers' criteria and availability for this study.

continued

"Identifying the reasons for a pavement's long-term performance can be difficult. This study brought to light some of the challenges with tracking and assessing pavement performance over time."

—Kyle Hoegh,
Research Project Scientist,
MnDOT Office of Materials
& Road Research

"Proper compaction during construction is directly related to how well an asphalt pavement performs."

—R. Christopher Williams,
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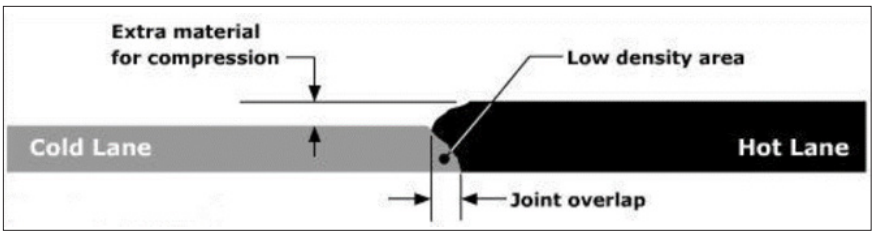

This cross section of a latitudinal joint shows where the pavements overlap, typically the location of lowest density on a finished road.

The team then used pavement distress surveys from 2017 and 2018 to evaluate how the roads had performed. Of the 43 pavements, several had undergone treatments to fill cracks, two had received crack sealing treatments, and one had been patched. Several other pavements had not experienced any maintenance between the time they were constructed and when the distress surveys were conducted.

The researchers then compiled all of the relevant data into a single database that can be expanded to include additional data as MnDOT constructs new pavements and evaluates their performance over time.

What Did We Learn?

While only a sample of data was available, the team was able to find several notable patterns, including:

- Immediately after construction, most pavements in Minnesota have air voids between 4% and 8%.
- The characteristics of the asphalt mix have a significant effect on the density of the finished pavements.
- Pavement air voids can vary even on a single project, possibly because of the asphalt mix design, equipment rolling patterns, weather, the condition of the base material and structure of the pavement.

What's Next?

As more projects are completed over the coming years and more data are added to the newly developed database, MnDOT will gradually grow the data set it uses to recognize and analyze potential relationships between pavement density and performance.

With a greater amount of comparable information, the agency will be better positioned to draw conclusions about what, if any, changes should be made in the future.

This Technical Summary pertains to Report 2021-28, "Quantifying Benefits of Improved Compaction," published December 2021. The full report can be accessed at mndot.gov/research/reports/2021/202128.pdf.