PUTTING RESEARCH TO WORK

BRIEF

Relating Permeability and Performance for HMA Pavements

Roads must be built to accommodate both repeated vehicle loading and the impacts over time of environmental factors such as moisture and temperature. To this end, the performance of hot-mix asphalt pavement requires the careful balancing of design considerations. Roads paved with HMA must be built with sufficient porosity to allow some movement or "flexing" of the binder to resist the formation of ruts in vehicle wheel paths. At the same time, the pavement must be dense enough to prevent water from permeating and causing damage and premature failure.

What's the Problem?

Excessive moisture in HMA pavements can cause significant damage, weakening the adhesion of the aggregate to the binder. However, the full extent of the HMA permeability problem in Wisconsin is unclear. If permeability is a significant issue that causes reduced pavement performance and service life, then current density acceptance values for new HMA pavements may need to be changed to reflect the relationship between permeability and performance.

Research Objectives

WisDOT asked investigators in this preliminary study to:

1. Determine the extent of permeability as a problem in existing HMA pavements in Wisconsin.
2. Develop density acceptance criteria based on permeability and performance.

Because traffic and weather alter the mechanical characteristics of pavements over time, one key research objective was to look at measurable values over time, considering both "as-built" values from the time of pavement construction as well as "in-place" values reflecting current conditions. Correlation of pavement performance, as-built data and in-place data can drive improvements in the design and acceptance of future roads.

Methodology

To gather the data necessary to develop density acceptance criteria, the researchers evaluated 20 fine-graded HMA pavement sections in Wisconsin ranging in age from 3 to 11 years. At each section investigators performed tests in multiple locations both in the wheel paths and between them.

Field testing yielded an array of data, including water permeability and air permeability rates, density, road performance (measured according to a pavement distress index value), rut depth and characterization of voids between the aggregate (filled with air or with a binder). Where possible, investigators examined WisDOT records of as-built density, but this information was not available for a significant number of roads included in this study.

Results

The tested pavements showed uniformly low permeability rates for both water and air. Within this study's limited data set, water permeability—measured as speed of penetration through pavement—ranged from 0 to 0.5 micrometers of water per second (0 to 5×10^{-5} cm/s), and air permeability was typically 10 times greater. The data indicated that the tested pavements currently show a high level of resistance against moisture damage.

Because in-place permeability values were nearly identical for all the test sections, the researchers could not correlate permeability with performance. Consequently, the investigators could not define acceptance criteria based on measured permeability values from this study. However, they proposed an initial theoretical framework for basing acceptance on permeability and performance values.

Investigator

"We gained valuable data and direction in this initial study, developing a framework for basing density acceptance criteria on permeability."

–Bob Schmitt
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An added benefit of this project was the opportunity for a hands-on test of the ROMUS device, an innovative tool for measuring permeability of air through pavement (Fig. 4.4 of the final report).

Benefits and Further Research

This research expands WisDOT's knowledge of permeability and performance of in-service HMA pavements. The low values of water and air permeability found in the study validate current WisDOT practices in fine-graded mix design and density specifications.

The low permeability rates in the studied pavements could also provide a direction for further research: expansion of the data set to include pavements that may have significant permeability and corresponding performance issues. Since as-built data was not available for all pavements included in this investigation, any follow-up project should focus on new HMA pavements from the start of their life cycle and track them over a period of several years. This would ensure a complete set of data from the first day of service and a clearer picture of changes over time. Such a study could provide the necessary correlation between permeability and performance needed to improve acceptance criteria of future HMA pavements put into service in Wisconsin.

Flexible Pavements TOC Representative

"The low permeability values shown for both air and water validate WisDOT's current practices related to HMA mix design."

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