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PUTTING RESEARCH TO WORK BRIEF

Estimating Permeability for Superpave Mixes

A pavement's permeability plays a role in its durability—as water seeps into a pavement, moisture damage can cause distresses such as raveling and premature rutting. Several physical characteristics of pavement materials contribute to a pavement's permeability, including aggregate gradation, density, and distribution of air voids.

In 2000, WisDOT began using Superpave criteria for asphalt pavement design. Superpave mixes use more angular aggregates of different and coarser gradations than traditional Wisconsin mixes.

What's the Problem?

Since there is currently no standard protocol for evaluating mix permeability in the laboratory during the design process, permeability is not considered in mixture design approval. With coarser grades and greater lift (layer) thicknesses, Superpave mixes will be difficult to compact sufficiently in Wisconsin. This may result in pavement layers with lower density than intended (and thus higher permeability), as observed in other states. Furthermore, design mixes may meet laboratory density criteria but be difficult to compact in the field, contributing to the problem of low density and high permeability.

Research Objectives

Investigators sought to better understand the relationships of permeability, density and lift thickness in Superpave asphalt pavement designs. Specific objectives included:

1. Determining the influence of maximum aggregate size, lift thickness, and aggregate source on density and permeability of Superpave mix designs.
2. Developing guidelines for selecting layer thickness based on aggregate size and gradation.
3. Evaluating the effects of void characteristics, distribution and interconnectivity on permeability.
4. Recommending laboratory and field permeability testing procedures and equipment for design and quality control of Superpave mixtures.
5. Recommending permeability and density criteria for Wisconsin Superpave designs based on traffic, lift thickness, field drainage and moisture conditions.

Methodology

Investigators approached these objectives in field and laboratory phases. Steps included:
• Performing a literature review on density and permeability in Superpave mixes.
• Conducting field and lab tests on paving projects, including an analysis of the relationships between field permeability, lab permeability of field cores, and lab permeability of lab-compacted specimens.
• Analyzing data and preparing guidelines for testing and mix design, including recommendations for lab procedures to effectively predict field permeability for design mixes.

Results

Researchers found some correlations between permeability and material characteristics, particularly for fine-graded mixes. However, they found no discernible trend between density and permeability for coarse-graded mixes, and could not establish a clear relationship between layer thickness and permeability. Ultimately, researchers recommend that WisDOT establish target permeability and density values for Superpave mixes based on the performance of in-service pavements. Findings included:

1. **Aggregate characteristics and lift thickness.**
   • In fine-graded mixes, the ratio of thickness to nominal maximum aggregate size (t/NMAS) impacted density. No clear relationship between t/NMAS ratios and permeability emerged.

Investigator

"This study provides Wisconsin with a better understanding of how asphalt pavement permeability relates to layer thickness, density and other mixture variables."

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To investigate the effects of void pathways on lab permeability testing, researchers developed a void pathways indicator that allows water to exit a sample laterally as well as vertically (Fig. 4.9, page 109 of final report).

- Aggregate gradation was linked to permeability in fine mixes. Researchers identified a ratio of coarse to fine particles that could be used in mix design to limit permeability; however, the trends could not be used for coarse-graded mixes.

2. **Thickness guidelines.** Investigators recommend no changes to current layer thickness values and t/NMAS ratios in WisDOT specifications, because other variables not controlled in this study could impact density and permeability.

3. **Void characteristics.** A method and equipment were developed to quantify vertical void pathways in compacted asphalt layers; these pathways were reduced as pavement layer thickness increased.

4. **Permeability tests.**
   - Field tests were performed with a permeameter developed by the National Center for Asphalt Technology. For some fine-graded mixes, field permeability measured by the NCAT permeameter strongly correlated with lab permeability of field cores. For coarser mixes, however, measurements with the NCAT device correlated poorly with lab permeability. More work is needed to find a more reliable device for measuring permeability in the field.
   - Researchers developed a method of compacting samples in the lab with the Superpave Gyratory Compactor that allows relatively accurate estimation of field core permeability.
   - A new procedure for controlling permeability during mix design and/or quality control of fine-graded Superpave mixtures was developed. This method involves measuring permeability of lab-compacted specimens; using the relationship between density and field permeability to predict the permeability of field-compacted specimens; and using the NCAT permeameter to measure permeability in the field for quality control and acceptance.

5. **Permeability and density criteria.** Researchers recommend that WisDOT establish target permeability and density values from in-service pavements with recorded performance histories. In the meantime, a minimum density of 93.8% for fine-graded mixes will limit permeability adequately. For coarse mixes, researchers could not establish a clear relationship between density and permeability.

Implementation and Benefits

By clarifying effective lab and field permeability measurements and refining current knowledge on permeability and thickness relationships, this study will help optimize WisDOT's use of Superpave procedures and specifications. These changes will help ensure acceptable permeability levels that limit moisture intrusion in the pavement structure and minimize moisture damage.

This brief summarizes Project 0092-02-14c, "Effect of Pavement Thickness on Superpave Mix Permeability and Density," produced through the Wisconsin Highway Research Program for the Wisconsin Department of Transportation Research, Development & Technology Transfer Program, 4802 Sheboygan Ave., Madison, WI 53707.

Nina McLawhorn, Research Administrator

Project Manager

"This research shows us that for coarse mixes, we need to take a core from the field and test it in the lab to get an accurate measure of the pavement's permeability."

–Leonard Makowski
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