# Factors Affecting Permeability of Superpave Mixes

RESEARCH SYNOPSIS 03-02

## Problem Statement

Asphalt pavement layers designed with dense-graded asphalt mixes are intended to be impermeable, and if they are not, pavement life is reduced. That's because, infiltration of water or air into a pavement can affect its durability. Infiltration of water may lead to moisture damage of the asphalt-aggregate bond and result in other forms of pavement distress such as raveling, cracking or rutting. Infiltration of air is likely to increase the potential of premature oxidation of the asphalt binder in HMA.

A 2001 survey indicated that coarse-graded Superpave mixes appeared to be more permeable than dense-graded Marshall mixes at similar air void levels. Past experience suggests that conventional dense-graded HMA pavements become excessively permeable to water at air void contents above eight percent. However, field permeability tests by NCAT indicate that coarse-graded Superpave mixes can be excessively permeable below eight percent air voids. Research by the Florida Department of Transportation indicates that coarse-graded Superpave mixes can be excessively permeable to water at air void levels around six percent. Further research is needed to quantify the impact of water and air infiltration on the durability of asphalt pavements.

## Objective

The objective of this study was to evaluate the permeability of Superpave-designed mixes in order to determine the effect of gradation, HMA lift thickness, and in-place air voids on the permeability of these mixes.

## Test Plan

Five Superpave field projects were examined in this study. These projects included coarse-graded 9.5 mm, 12.5 mm, 19.0 mm and 25.0 mm nominal maximum aggregate size (NMAS) mixes and one fine-graded 9.5 mm NMAS mix. A falling-head field permeameter developed at NCAT and modified by the Worcester Polytechnic Institute (WPI) was used to evaluate the in-place permeability of the pavements at each project. The permeameter is illustrated in Figure1. Pavement cores were obtained to determine in-place density (air voids) at each of the test locations. Loose HMA samples were compacted to five percent air voids using a Superpave gyratory compactor. HMA lift thickness to NMAS ratios of 2.5, 3.0, 3.5 and 4.0 were investigated. The permeability of the compacted specimens was determined using a fallinghead laboratory permeameter.

## Key Findings

1. Field and laboratory permeability results were compared for the different mixes over a range of air void content levels. In most cases the laboratory permeability results were slightly higher than the field permeability values. For the 9.5 mm fine, 9.5 mm coarse and the 12.5 mm coarse mixes, the difference between lab and field results were not significant. However, for the 19 mm coarse and 25 mm coarse mixes, the permeability differences were significant. Field permeability tended to be higher than the laboratory permeability for these two mixes, with the difference increasing as air voids increase.

2. The relationship between permeability and in-place air voids is best modeled with an exponential equation. The data indicates that permeability increases significantly at an in-place air void content of about seven percent in all pavements studied.

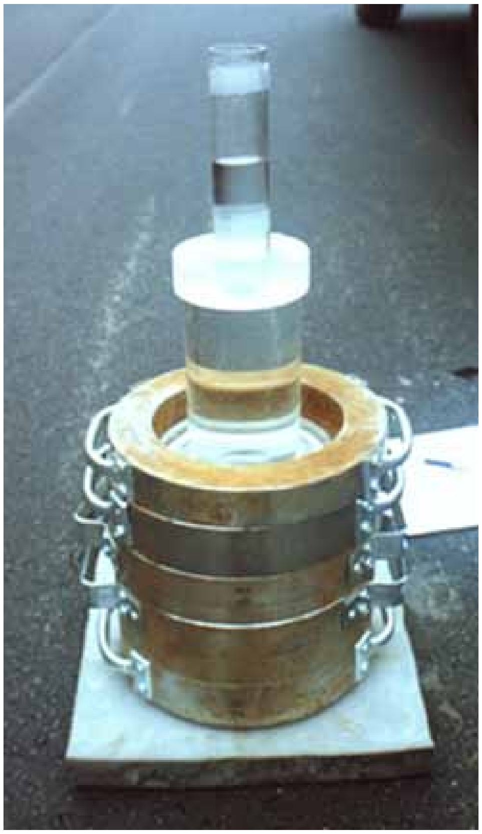

Figure 1. Field Permeameter used in study

3. At a given air void level, permeability increases for mixes with larger nominal maximum aggregate sizes. Table 1 shows the permeability values for each NMAS at an in-place air void content of six percent. For the mixes evaluated, the permeability increased by an order of magnitude for each increase in NMAS. This data clearly shows that larger NMAS mixes have more potential to be permeable. This is also evident in Figure 2.

4. It appears that a pavement consisting of a coarse 9.5 mm NMAS mix would have a critical in-place air void content close to 8 percent. The term "critical air void content" refers to the point where a small increase in air voids would result in a dramatic increase in permeability. Similarly, a coarse 12.5 mm NMAS mix has a critical in-place air void content at about 7 percent; a coarse 19.0 mm NMAS has a critical air void content at 6.5 percent; and a coarse 25.0 mm NMAS mix has a critical air void content at about 6 percent.

5. At a thickness to NMAS (t/NMAS) ratio of 2.5, the three coarse-graded 9.5 mm, 12.5 mm and 19 mm NMAS mixes exhibited the largest permeability value. Likewise, at the t/NMAS ratio of 4, the mixes had the lowest permeability value. The data clearly shows that thicker pavements (lifts) tend to be less permeable.

## Recommendations

This study clearly showed that 19.0 and 25.0 mm NMAS course-graded mixes are significantly more permeable at similar air void levels than typical surface type mixes (9.5 and 12.5 mm NMAS). Therefore, it is recommended that the agencies consider specifying mixes that are placed 100 mm below the pavement surface to be designed on the fine side of the maximum density line. This way, these mixes could be made less permeable than coarse-graded mixes at similar air void levels and thus less susceptible to propagation of moisture or moisture vapor through the pavement structure. This in turn should reduce the potential for moisture damage within the pavement structures (assuming the surface layers are reasonably impermeable).

| NMAS, mm | Permeability, cm/sec |
|---|---|
| 9.5 | 6 • 10-5 |
| 12.5 | 40 • 10-5 |
| 19.0 | 140 • 10-5 |
| 25.0 | 1200 • 10-5 |

Table 1. Permeability test data of different NMAS mixes at six percent in-place air voids.

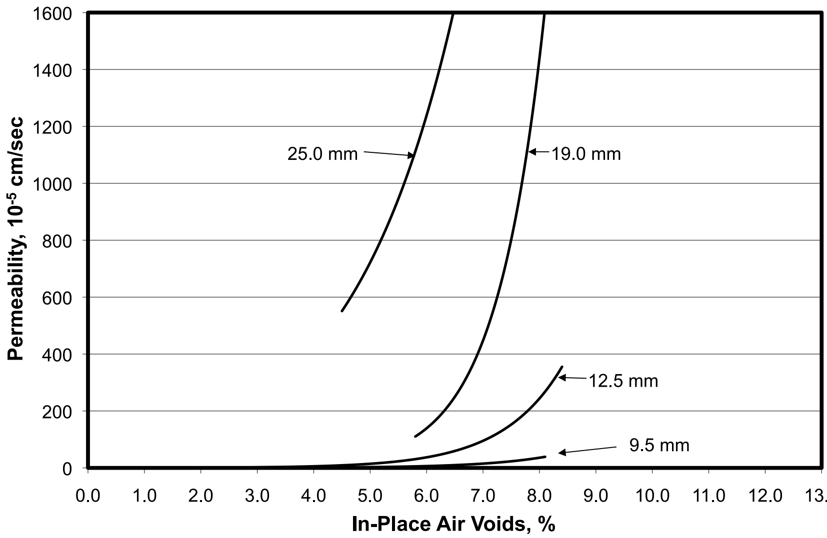


Figure 2. Effect of in-place air-voids on permeability for different NMAS mixes


Acknowledgements and Disclaimer

The Maine Department of Transportation sponsored this study. This research synopsis provides a brief summary of the study's final publication. This document is for general guidance and reference purposes only. NCAT, Auburn University, and the Maine Department of Transportation assume no liability for the contents or their use.