Project Summary

Texas Department of Transportation

0-5132: Analysis of Laboratory Compactive Effort to Optimize the Durability of Superpave Mixture Design

Background

The Texas Department of Transportation (TxDOT) recently established Hamburg Wheel Tracking Device (HWTD) specification criteria for Superpave mixtures. This step has introduced a performance-related feature into an otherwise volumetric mix design approach structured to design asphalt mixtures with high shear and stripping resistance. The Superpave mixture design procedure is in itself geared toward the production of mixtures with high rutting resistance and may produce mixtures with lower binder contents than had previously been used. While this shift is advantageous for rutting resistance, local reports show that these mixtures are prone to cracking, which is becoming a significant problem in Texas.

What the Researchers Did

In an attempt to design mixes with higher binder contents to alleviate cracking problems, this study investigated possible modifications to the current design criteria for Superpave mixtures. The initial findings of this study indicate that the current compaction effort expressed by the number of design gyrations (Ndesign) could be lowered from 100 to 80 without compromising the rutting resistance of the mixes, while improving cracking resistance and durability.

An extensive experimental program was devised to investigate the performance characteristics of asphalt mixes designed using the revised Ndesign levels and accounting for nominal maximum aggregate size and concentration of coarse aggregate. The experiment included two aggregate types (limestone and gravel), three binder grades (PG 64, 70, and 76), and three nominal maximum aggregate sizes (9.5, 12.5, and 19 mm). Although the testing was extensive, the proposed recommendations should be considered preliminary until more comprehensive experimental evidence is gathered.

The basis of the approach followed in this research was simple: ***"to use as much binder in the mix as possible without compromising its rutting resistance."*** By following this philosophy, not only was fatigue resistance improved but mix durability was enhanced. Expected rutting resistance was evaluated by means of the HWTD. Indirect Tensile Strength (ITS) and Third-Point Bending Beam were used to assess cracking resistance.

The procedure consisted of designing a Superpave mix using the current approach: determining the optimum binder content such that 96% of the theoretical maximum density was achieved at 100 gyrations. Three alternative asphalt contents were then determined at a different number of gyrations (50, 75, and 125) and specimens were prepared and tested at all four binder contents.

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After defining the optimum binder content for a specific mix that simultaneously optimizes both rutting and cracking criteria, the optimum Ndesign that ensured 4% air voids was back calculated. By reducing the compaction effort for the same target density, the voids in the mineral aggregate (VMA) increased, thus making it easy to meet VMA specifications and ensuring a performing mix.

What They Found

Following are the main findings established as a result of the study and based on the analyzed mixes. Implementation of these findings would result in Superpave mixes of improved fatigue resistance and durability:

1) Both the PG grade and the binder content have a significant effect on rutting resistance (as measured by the HWTD).
2) Only the PG grade has a significant effect on the ITS; however, the ITS was relatively uniform for each mix and does not appear to be a good indicator of expected performance.
3) Fatigue resistance is significantly affected by both binder PG grade and content, as well as by aggregate source and gradation.
4) For Texas conditions, the number of design gyrations using the Superpave Gyratory Compactor can be significantly reduced in order to improve the fatigue resistance of the asphalt mixes, without significantly affecting their rutting performance.
5) This reduction in the compaction effort results in a thicker asphalt film that has the additional potential benefit of increasing the mix durability in the field.

What This Means

This research study provided evidence indicating that reducing the number of design gyrations to 80 may optimize the field performance of the asphalt mixes. This base Ndesign level should be adjusted according to environmental conditions and traffic levels. Researchers' recommendations are based on the testing of a limited combination of asphalt binders and aggregates. For this reason, it is recommended that similar analyses be performed on those asphalt mixes that are most commonly used throughout Texas so that more general Ndesign recommendations can be developed for specific aggregate and binder combinations under specific environmental conditions.

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