0-6045: Laboratory Evaluation of Influence of Operational Tolerance (Acceptance Criterion) on Performance of HMAC

Background

The development of high performing mixtures is a major objective of hot-mix asphalt (HMA) design; however, most mix design methods are based on volumetrics because volumetric properties correlate with performance. This correlation is by no means perfect, therefore, more reliable methods use performance-related tests. Performance predictions based on performance-related tests are not ideal but allow more confident performance estimation within reasonable costs.

Research Performed by:

Center for Transportation Research (CTR), The University of Texas at Austin

Research Supervisor:
Jorge A. Prozzi, CTR

Researchers:
Jose P. Aguiar-Moya, CTR
Andre de F. Smit, CTR
Christian G. Vazquez, CTR

Project Completed: 8-31-09

In Texas, HMA design is primarily based on a volumetric approach. Key relationships between the volume and mass of the mixture components are tightly controlled, as they are believed to control the performance of the mixtures in the field. This method is complemented with additional tests that are aimed at accepting or rejecting a given mixture. These tests are Indirect Tensile Strength (ITS), Hamburg Wheel Tracking Device (HWTD) and, more recently, the Texas Overlay Tester (OT).

No matter how sophisticated the HMA design method and how effective the quality control plan is, deviations from the job mix formula (JMF) are always present. Therefore, agencies have implemented operational tolerances that allow some flexibility. Concerns about the effect that these tolerances have on the performance of the asphalt mixtures gave origin to this research project.

What the Researchers Did

Three performance-related tests were selected to assess the performance of five typical TxDOT mixtures as their binder content, gradation and densities were changed: three limestone mixtures (Type C, Type D, and SMA-D) and two gravel mixtures (Type C and Type D). The performance tests utilized were: Beam Fatigue Tests (BFT), Hamburg Wheel Tracking Device (HWTD), and Overlay Tester (OT).

In all cases, the specified densities of the test specimens have to be between 92 and 94 percent of the maximum theoretical density. This range of densities proved to be insufficient for quantifying the effect of density on performance. There is, however, enough evidence in the literature indicating that lower densities will negatively affect performance.

What They Found

The effect of asphalt content on performance was captured by the three tests to different extents. The less variable and most sensitive test was the HWTD, followed by the BFT and then the OT. Most results of the OT did not identify any statistically significant trends.

It should be noted, however, that most mixtures tested were dense-graded mixtures (Items 340/341), which do not perform well under the OT.

The effect of gradation on performance was captured by some of the tests for some of the mixtures; however, the trends varied for the different mixtures and aggregates tested. In some cases the mixture with the target gradation performed the best while in other cases it was the coarse or the fine mixture. Conclusions cannot be generalized and should be determined on a case-by-case basis. We found some evidence that suggest that mixes to the finer side of the operational tolerances should be avoided when possible. This conclusion cannot be generalized at this time but it deserves further research.

One of the most important findings from this study is that the expected performance of four of the five mixtures tested could be improved by increasing their binder content without significantly compromising their expected deformation resistance under the HWTD.

It was observed that all mixes, except for the SMA-D, have the potential for increased asphalt content, still meeting current HWTD criterion. By doing that, the fatigue resistance of the mixture could be significantly improved by the fatigue sensitivity. The fatigue sensitivity expresses the ratio of the fatigue life, as measured by the BFT, when the binder content of the mix is increased by one percent.

What This Means

For the mixtures tested in this research, variations in density and gradation within current operational tolerances were found not to have a significant effect on laboratory performance. This does not mean that density and gradation do not have an effect on performance, in fact, they do. However, as long as these properties are varied within current tolerances, these effects are not statistically significant. Consequently, this study indicates that current operational tolerances for gradation and density are adequate.

In terms of binder content, the findings were different. As the binder content of a given mixture varies one percent around its optimal value, the permanent deformation and fatigue performance were significantly affected. As the binder content increased, the deformation resistance significantly decreased and the fatigue life significantly increased. Accordingly, this research recommends that the operational tolerances for the asphalt content given in the 2004 *"Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges"* should be reviewed. This recommendation affects Table 7 Item 340, Table 9 Item 341, and Table 9 Item 346. This research recommends that the allowable difference from the current JMF target should be reduced from ± 0.3 to ± 0.2%. Furthermore, it is also recommended that Note 3 in Table 9 should be reviewed and modified as follows: *"Tolerance between JMF1 and JMF2 may not exceed ± 0.3."*

The above recommendations are based solely on the laboratory test results performed as part of this research project. Practical considerations should also be weighed at the time of setting the final specifications. The implementation of these recommendations will result in a more consistent and homogeneous asphalt concrete layer.

For More Information:
Research Engineer - German Claros, TxDOT, 512-416-4730
Project Director - Rene Soto, TxDOT, 956-712-7725
Research Supervisor - Jorge A. Prozzi, CTR, 512-232-3488

Technical reports when published are available at:
http://library.ctr.utexas.edu/index.html

www.txdot.gov
keyword: research

Texas Department of Transportation
Research and Technology Implementation Office
P.O. Box 5080
Austin, Texas 78763-5080
512-416-4730