Research Brief

Wisconsin Highway Research Program
Project 0092-18-06
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Enhanced Moisture Sensitivity Study for Asphalt Concrete Pavements

Research Objectives

- Identify reliable methods for measuring asphalt pavement's sensitivity to moisture damage and the effectiveness of moisture susceptibility treatments
- Develop specifications for reducing the risk of moisture damage in asphalt pavements

Research Benefits

- Developed protocols for effectively inducing moisture damage in asphalt pavements to simulate field conditions under various traffic loads
- Established pass/fail criteria for moisture damage in asphalt pavements

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Background

Asphalt pavements suffer moisture damage through loss of adhesion between asphalt and aggregate (i.e., stripping of asphalt from aggregate) and due to cohesive failure of the binder. Both phenomena contribute to reductions in strength or stiffness of the asphalt concrete layer that lead to pavement distresses. Accurately predicting and mitigating moisture damage is difficult due to wide variance in aggregate types, construction practices, environmental conditions and traffic loads. The goal of this research was to identify suitable test protocols to assess the moisture damage sensitivity of asphalt concretes commonly used in Wisconsin under conditions typical to the state.

Methodology

Four mixes with aggregates sourced from different Wisconsin quarries were selected for this study based on laboratory tests and field performance. Two mixes had dolostone sources, one from Menasha with a low tensile strength ratio (TSR) and one from Waukesha with a high TSR. Two mixes had siliceous sources with marginal-to-poor field performance, one from Rock Springs and one from Olsen located in Chippewa Falls and Downing.

The research team performed four moisture conditioning schemes on each mix: vacuum saturation followed by freezing and hot water conditioning (AASHTO T 283); vacuum saturation followed by hot water conditioning (AASHTO T 283); Moisture-induced Stress Tester (MiST) conditioning (ASTM D7870); and submerged load-induced conditioning with a Hamburg Wheel Tracking Device (HWTD) (AASHTO T 324). Specific properties were measured before and after each test to evaluate the capability of each procedure in manifesting the susceptibility of the mix to moisture damage: indirect tensile strength; indirect tensile dynamic modulus; modulus from ultrasonic pulse velocity (UPV), and rut depth under repeated wheel passes.

Measuring dynamic modulus of asphalt concrete in indirect tensile mode

"This research shows the complexity of moisture damage in asphalt pavements. Results highlight the need to consider more advanced testing protocols for higher traffic level mixtures."
– Erik Lyngdal, WisDOT

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Results

The various conditioning and test protocols produced different rankings of mixture moisture sensitivity. The rankings were combined to deliver a final moisture-sensitivity score for each mixture; scores in order from highest (the best mix in resisting moisture damage) to lowest (the worst mix in resisting moisture damage) were: Rock Springs (marginal performing, siliceous), Waukesha (high-TSR dolomite), Olsen (poorly performing, siliceous) and Menasha (low-TSR dolomite).

These rankings align closely with those given by the HWTD test, dynamic modulus ratio and UPV modulus ratio based on freeze-thaw conditioning. Rankings do not align with test results using current WisDOT acceptance methods (TSR without freeze-thaw). TSR defines the ratio of strengths before and after conditioning and does not directly address the strength level of the mixture. The HWTD test simulates load/water interaction with the mix under repeated loading, for which results are heavily strength dependent. Results suggest that a combination of wet strength and TSR should be used to more accurately capture moisture susceptibility.

Recommendations for implementation

The research team recommends using AASHTO T 283, HWTD and MiST to induce moisture damage; however, HWTD and MiST best simulate field conditions, since they induce suction and pressure in the mix through repeated cycles.

Load effects should be considered when establishing the damage criteria; therefore, the research team recommends a tiered approach based on traffic volume. MiST conditioning should be used for evaluating the effect of moisture conditioning on mixes' engineering properties and changes in mixes' dynamic modulus, as change in the modulus is a major input parameter in recently developed performance prediction models. HWTD testing should be used for medium- and high-volume roads, and AASHTO T 283 (with criterion on minimum required wet strength and minimum indirect TSR) should be used for low-volume roads.

This brief summarizes Project 0092-18-06,
"Enhanced Moisture Sensitivity Study"
Wisconsin Highway Research Program