Kansas
Department of Transportation

TECHNICAL SUMMARY

Development of Test Procedures to Evaluate Moisture Susceptibility of Asphalt Mixtures Used in the State of Kansas, Phase I: Surface Free Energy of Binders

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Introduction

Moisture damage is the primary distress that causes premature failure in HMA pavements. The loss of cohesion/adhesion and the tendency of water to displace the bond between aggregate and binder are the major mechanisms that lead to moisture damage. Therefore, test methods and specification guidelines must be developed and enhanced to select aggregate-binder (unmodified and modified) pairs that are compatible and resistant to moisture degradation.

The current state of practice at the Kansas Department of Transportation (KDOT) and many other agencies is to conduct mechanical tests on moisture-conditioned and dry specimens to evaluate moisture susceptibility of asphalt mixtures. However, these simple tests may be unreliable due to the following deficiencies:

- Poor correlation with field performance,
- Substantial variability in test results and lack of repeatability,
- Inability to address specific failure mechanisms and underlying root causes,
- Extended testing time, and
- Required repetition of tests when slight modifications are made (e.g., addition of modifiers).

These deficiencies have led KDOT researchers to evaluate the efficacy of applying more fundamental lab tests and characterization methods to determine moisture susceptibility of asphalt mixtures. Therefore, current research must identify an efficient test method to select asphalt concrete constituents that result in moisture damage-resistant asphalt mixtures.

Project Description

The surface free energy of asphalt binders and aggregates is a critical material property related to the moisture sensitivity of asphalt mixtures. Surface free energies of these materials can be used to quantitatively determine the interfacial adhesive bond strength between two materials and the tendency of water to displace this bond based on fundamental principles of thermodynamics. Because the utilization of surface free energies to determine the moisture sensitivity of asphalt mixtures is already well established, efficient,, and accurate methods to routinely measure the surface energies of asphalt binders and aggregates are needed to enhance material selection when designing moisture-resistant asphalt mixtures. Surface energies of these materials can also be combined with other material properties in conjunction with the principles of fracture mechanics to determine fatigue cracking and healing characteristics of asphalt mixtures.

Therefore, the results from this study that calculates surface free energy components of different asphalt binders can be used to select test methods and mathematical models based on fracture mechanics that relate material properties, including surface energy, to asphalt mixture performance. Surface energies of these materials can be used to calculate the energy ratio (ER) of asphalt binder-aggregate combinations to identify moisture resistance levels. A higher value of work of adhesion indicates that more work is required to break the adhesive bond between the asphalt binder and the aggregate, implying improved resistance to moisture damage. A lower magnitude of work of debonding indicates less energy potential for water to displace an asphalt binder from its interface with the aggregate and a higher resistance to moisture damage.

Project Results

The surface free energy of an asphalt binder and aggregate is essential for determining the moisture susceptibility of asphalt mixtures. This project proposed an efficient method to routinely measure the surface energies of asphalt binders and aggregates to help design asphalt mixtures that are increasingly resistant to moisture damage. Surface energies of these materials can be used to calculate the energy-based parameter (ER) of asphalt binder-aggregate combinations to identify moisture resistance levels. Due to variability in the results, at least four probe liquids should be used in the future to enhance calculation accuracy. In addition, future tests should be conducted in a controlled environment that limits significant temperature change. Results from this analysis could be used to select test methods and mathematical models that relate surface energy to the performance of asphalt mixtures.

Project Information

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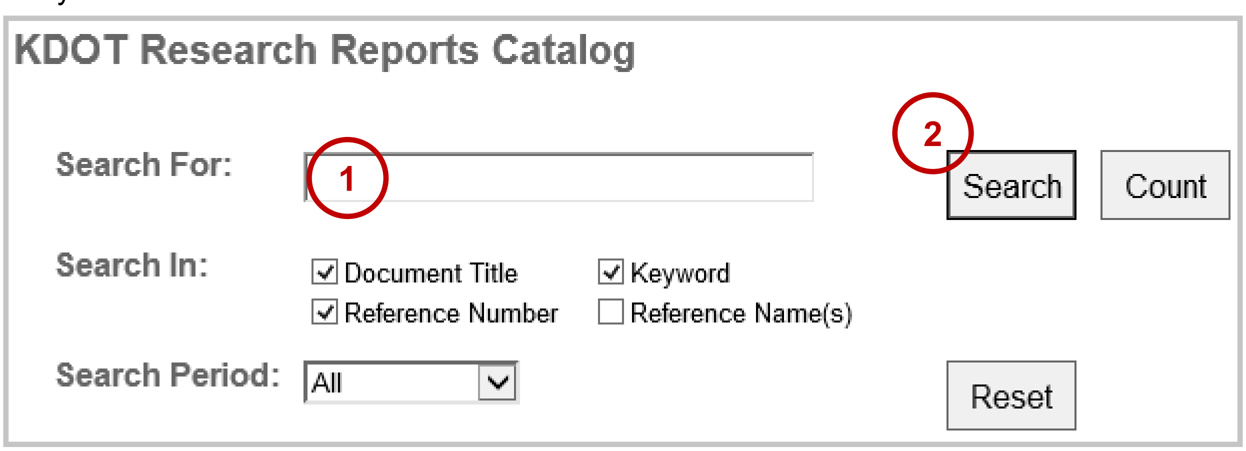

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