



Project Summary Report O-4467-S

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Project O-4467: Developing an Upgraded Overlay Tester System
to Characterize the Reflection Cracking Resistance
of Asphalt Concrete

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Developing an Upgraded Overlay Tester System to Characterize the Reflection Cracking Resistance of Asphalt Concrete: Summary Report

The Texas Department of Transportation's (TxDOT) recent focus on hot-mix asphalt (HMA) design has been to use the Hamburg wheel tracking device to evaluate the rutting potential and moisture susceptibility of new mixes. Less attention has been paid to crack resistance of new HMA surfaces. This crack resistance is a concern because to perform well in the field an HMA overlay must have a good balance of both rut and crack resistance properties.

Stiffer binders and good stone-to-stone contact may provide improved rut resistance, but they may also reduce mix flexibility and crack resistance. Cracks appear in flexible pavements primarily through either fatigue or reflection cracking mechanisms. The reflection cracking mechanism has received less attention than classic fatigue.



Figure 1. Reflection Cracking.

However, for many TxDOT applications fatigue cracking is not the prime concern. The main performance issue is reflection cracking. Reflection cracking is an issue particularly in selecting HMA surfaces for rigid pavements and for flexible pavements with stabilized bases, or when the existing pavement is badly cracked.

Reflection cracking like that shown in Figure 1 is initiated by existing discrete subsurface defects such

as joints, cracks, or areas of stripping. The cause of reflection cracking can be either environmental or load associated. It is well known that when reflection cracks propagate through the HMA overlay, the infiltration of water can cause rapid deterioration of the underlying pavement structure and foundation. Although reflection cracks significantly shorten pavement service life, there is a lack of simple and rapid



test equipment and procedures for routine use to characterize the reflection cracking resistance of asphalt mixtures before they are placed on existing cracked pavements.

Furthermore, neither of the National Cooperative Highway Research Program (NCHRP) reports—NCHRP 1-37A, *Mechanistic-Empirical Pavement Design Guide*, or NCHRP 9-19, *Superpave Support and Models Management*—specifically addressed the laboratory test for reflection cracking. Therefore, there is an urgent need to develop practical, rapid, and performance-related test equipment and associated test protocol for characterizing the reflection cracking resistance of asphalt mixtures. The upgraded Texas Transportation Institute (TTI) overlay tester developed in this project addresses this problem.

What We Did...

The work undertaken for this project in the past two years included the following tasks:

- **Upgrade TTI's Existing Overlay Tester.** First, TTI's existing overlay tester was upgraded to an automatic and computer-controlled system. Then both repeatability and sensitivity studies were conducted. Two types of TxDOT's mixtures (Type D and Coarse Matrix High Binder [CMHB]-C) were used. The overlay tester results all were reasonable.

Finally, an overlay tester protocol was developed.

- **Validate the Overlay Tester Using Known Performance Field Cores.** Many cores with variable reflection cracking performance in the field were used to validate the effectiveness of the overlay tester. Results correlated well with the field performance. Furthermore, the overlay tester results were compared with beam fatigue test results and low temperature performance of asphalt mixtures in the Minnesota test road. These measures all showed good correlations.
- **Evaluate Influence of Modified Binder and Aggregate on Reflection Cracking Resistance.** A Type D mix from U.S. 281 was used to study the influence of modified binder on reflection cracking resistance. This project evaluated the mixes with nine different binders (PG64-22, PG70-22, PG76-16, PG76-22TR, PG76-22Elvaloy, PG76-22SBS, PG64-22+3% Latex, PG58-22+4% Latex, PG64-22+4% Latex) but the same aggregate (limestone). In addition, one PG64-22 binder with three limestone aggregates (with different absorptive properties) was tested using the overlay tester. It was found that aggregate absorption has substantial impact on reflection cracking resistance of asphalt mixtures.

- **Evaluate Reflection Cracking Resistance of TxDOT's Typical Mixtures.**

A series of TxDOT's typical mixtures were evaluated. These mixtures included Type C, Type D, CMHB-C, Stone Matrix Asphalt (SMA), Superpave, and CMHB-F. Generally, the mixtures with high binder content showed better reflection cracking resistance.

- **Recommend a Framework of Asphalt Overlay Mixture Design and Reflection Cracking Analysis System.**

A preliminary framework of asphalt overlay mixture design and associated criteria were proposed. The overlay tester was recommended to characterize the potential reflection cracking, and the Hamburg wheel tracking test and asphalt pavement analyzer (APA) were recommended to control the rutting problems of top-layer mixture and bottom-layer mixture, respectively. Based on the framework, two examples of asphalt overlay mixtures design were presented in Report 0-4467-2. This framework and the associated criteria were preliminary, and further refinement was necessary.

- **Manufacture a New Overlay Tester for TxDOT.** A brand new overlay tester, shown in Figure 2, was manufactured and delivered to TxDOT's Flexible Pavements Branch at the Cedar Park office in Austin, Texas.



What We Found...

Based on the work done in the past two years, significant progress has been made on laboratory characterization of reflection cracking resistance of asphalt mixtures. The major findings from this project are:

- The overlay tester can be run on standard size samples, typically 6 in. (150 mm) long by 3 in. (75 mm) wide by 1.5 in. (38 mm) high. These specimens can be prepared from either field cores or from Superpave Gyratory Compactor molded specimens.
- The test is repeatable and rapid, with poor samples failing in minutes. It characterizes both crack initiation and crack propagation properties of asphalt mixtures. Based on test results, three replicates were recommended for accurate results.
- The overlay tester identified three crack mechanisms: crack through binder, crack through the interface between the binder and aggregate, and crack through aggregates. The “crack through binder” mechanism is preferred from the reflection cracking point of view.
- Sensitivity studies indicate that the overlay tester provides reasonable test results. Raising the asphalt performance grade, increasing the opening displacement, and decreasing the testing temperature

will lead to shortened reflection cracking life of asphalt mixtures. However, increasing asphalt content will significantly improve the reflection cracking resistance of asphalt mixtures.

- A series of tests on TxDOT mixtures determined that aggregate absorption has a major impact on the performance of specimens in the overlay tester. In the laboratory, these highly absorptive aggregates did not severely impact the rutting performance, but they had a major impact on cracking life. This topic has not received much attention but obviously needs further investigation.
- The effectiveness of the overlay tester was validated by five case studies in Texas. The overlay tester results all correlated well with field performance. Furthermore, overlay tester results have good correlations with beam

fatigue test results and low-temperature performance of asphalt mixture in the field.

The Researchers Recommend...

The upgraded overlay tester is a practical device that can be incorporated into mixture design systems to complement the current systems, which often focus on minimizing rutting potential. In many instances, it is necessary to optimize both cracking resistance and rutting potential to obtain adequate long-term pavement performance.

The influence of aggregate on the asphalt overlay performance, especially reflection cracking, should be further investigated.

Future research studies should be directed at optimizing both rutting and cracking potential of asphalt layers. The criteria for each will vary based on the existing structure, traffic level, and performance requirements.

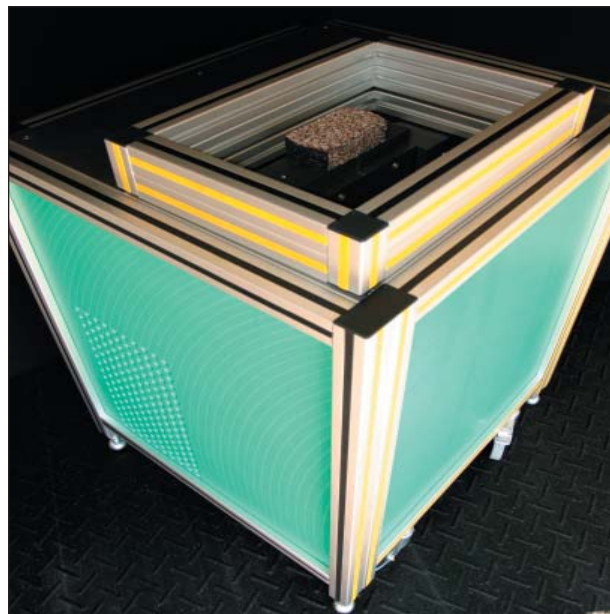


Figure 2. TxDOT New Overlay Tester.



For More Details...

Report 0-4467-1: *Upgraded Overlay Tester and Its Application to Characterize Reflection Cracking Resistance of Asphalt Mixtures*

Report 0-4467-2: *Overlay Tester: A Rapid Performance Related Crack Resistant Test*

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TxDOT Implementation Status—May 2005

The recommendations of this project are being implemented in TxDOT Project 0-5123, “Development of an Advanced Overlay Design System Incorporating both Rutting and Reflection Cracking Requirements,” and in asphalt overlay projects in the Houston District. TxDOT is also planning to create an implementation project to purchase three additional testing units for implementation in the districts.

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