Project Summary

Texas Department of Transportation

0-5123: Development of An Advanced Overlay Design System Incorporating Both Rutting and Reflection Cracking Requirements

Background

Selecting appropriate overlay thickness and combinations of aggregates and binder types are important decisions that Texas Department of Transportation (TxDOT) engineers make on a routine basis. However, this selection is a difficult balancing act. To perform well in the field, the asphalt overlay must have a balance of both good rut and crack resistance and must also have sufficient thickness to withstand the traffic loads and environmental conditions. TxDOT already has the Hamburg wheel tracking device (HWTD) to screen out mixtures that are susceptible to rutting and moisture damage. Meanwhile a new device, the upgraded overlay tester (OT), has been developed for TxDOT engineers to characterize the reflection cracking resistance of asphalt mixes. The main objectives of this research study were to: 1) propose and demonstrate a balanced mix design concept where proposed mixes meet both rutting and reflection cracking requirements, and 2) develop an asphalt overlay thickness design and analysis system where lab-measured properties can be used to predict overlay performance.

What the Researchers Did

The work conducted in this study is described below:

- First, 11 mixes commonly used in Texas were designed following the current TxDOT mixture design process and evaluated using the HWTD and OT.
- The researchers developed a balanced hot-mix asphalt (HMA) mixture design method in which the HWTD and OT were used to evaluate rutting and cracking resistance of HMA mixtures. The balanced design procedure proposed in this project recommended minor changes to TxDOT's current mixture design procedure. Seven mixtures including dense-graded and Superpave mixtures were used to verify and demonstrate this balanced mixture design approach, where the final design would pass TxDOT's current Hamburg requirement and also last more than 300 cycles in the overlay tester.
- A mechanistic-empirical reflective cracking model was developed, calibrated, and verified. The Paris' law based reflective cracking model was recommended for use in this study where both stress intensity factors (SIF) and fracture properties (A and n) are the fundamental required inputs. Regression equations were developed for the SIFs and a methodology was developed by which A and n can be determined using the overlay tester. The proposed reflective cracking model computes cracking damage from either temperature cycling or truck load. It was calibrated using field performance data for in-service pavements from Texas and Illinois. The model was further demonstrated using performance results from California's Heavy Vehicle Simulator tests. To predict asphalt overlay rutting, the well-known VESYS layer rutting model was used and later calibrated using the field rutting data from the National Center for Asphalt Technology (NCAT) test track 2006. The rutting model was then further verified by the rutting data from NCAT test track 2000.

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Project Completed: 8-31-08

- A critical part of the overlay design process is structural evaluation of existing pavement conditions. The researchers developed guidelines for evaluating existing flexible or rigid pavements using the nondestructive testing tools available in Texas, which include ground penetration radar, the falling weight deflectometer, and rolling dynamic deflectometers. These are used to evaluate existing pavement layer thickness, identify subsurface defects, and calculate layer moduli and load transfer efficiencies at joints and cracks.
- The calibrated reflective cracking and rutting models were integrated with the existing pavement conditions, traffic loads, and environmental conditions into the advanced asphalt overlay thickness design and analysis software program. Default material properties for all of the common overlay mixes used in Texas were included in the program. This program predicts the life of any proposed overlay until either rutting or reflection cracking failure occurs. The software has the capability of handling two different materials in the overlay design; for example, a crack resistant level-up layer and a dense-graded wearing surface.
- As part of this study a sensitivity analysis was performed on the new software to evaluate its reasonableness at predicting the impact of climate, mix type, truck loads, and overlay thickness on the predicted performance. These lab results clearly reflected the predicted superior field performance. All of the trends obtained from the completed sensitivity analysis were judged as reasonable.

What They Found

The major findings from this study are:

- TxDOT's current mix design procedures for the dense-graded and Superpave mixes tend to design mixes that do not rut but tend to exhibit early cracking. Incorporating an overlay tester requirement into the mix design process is one approach to develop longer-lasting overlays (without the fear of causing a rutting problem).
- The balanced HMA mixture design procedure proposed is very promising. A balanced HMA mixture could always be designed providing the aggregates used were not highly absorptive. Typically this involved increasing the required asphalt content over that proposed in the current volumetric procedure from 0.5 to 0.7 percent.
- The reflective cracking and rutting models developed and their predictions appear rational and reasonable. The asphalt overlay thickness design and analysis program is user friendly and has significantly shorter running time than the MEPDG.
- Through a series of sensitivity analyses, the seven most important input parameters identified for asphalt overlay design emerged as: 1) traffic load level, 2) climate, 3) asphalt overlay thickness, 4) overlay mix type, 5) asphalt binder type, 6) load transfer efficiency, and 7) existing base layer modulus.

What This Means

TxDOT spends millions of dollars each year designing and placing overlay on its existing highways. The tools developed in this study will assist TxDOT engineers in designing and implementing longer-lasting overlays. This software can address issues such as where to use high-performance mixes, optimal thicknesses, particularly in the area of jointed concrete pavements where joints must be repaired prior to placing any overlay.

Researchers recommend pilot implementation of both the balanced mix design concept and the new thickness design software. Pilot projects could be evaluated with the new lab design approach, prediction software, and the lessons learned incorporated into a future overlay design school.

Researchers also recommend that TxDOT construct experimental test sections in four of its districts to validate and/or refine the proposed design procedure and software program.

For More Information:

0-5123-1 Integrated Asphalt (Overlay) Mixture Design, Balancing Rutting and Cracking Requirements

0-5123-2 Guidelines for Evaluation of Existing Pavements for HMA Overlay

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