Project Summary

Texas Department of Transportation

0-5798: Develop Test Procedures to Characterize Material Response Behavior, and Transfer Functions for TxDOT M-E Design

Background

There is a national movement to develop Mechanistic-Empirical (M-E) methods for the design of flexible pavements. M-E methods are needed to design pavements under actual loads and environmental conditions. They can evaluate material-specific performance variations that were not evaluated by previous empirical methods. A new M-E design method named the Mechanistic-Empirical Pavement Design Guide (MEPDG) was developed under the National Cooperative Highway Research Program (NCHRP) project 1-37A. In a previous TxDOT research project, MEPDG was reviewed and researchers concluded that it was important for TxDOT to initiate supplemental work in this area since the MEPDG as currently packaged was judged not implementable in the near future. Researchers also concluded that TxDOT's current FPS19 system, which has served well for many years, has several limitations and needs to be updated.

This project was undertaken to provide guidance regarding the development of M-E design procedures for TxDOT. The main objectives were to 1) identify/develop test procedures that characterize material properties needed to predict pavement response and distresses, 2) assemble existing performance prediction models (transfer functions) and evaluate their feasibility of being implemented in Texas, and 3) calibrate the selected transfer functions with available performance data.

Research Performed by:

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Project Completed: 8-31-09

What the Researchers Did

The following items summarize work conducted in this study:

- After reviewing all existing pavement performance models, researchers recommended the VESYS model for predicting flexible pavement layer rutting. An overlay tester-based fatigue cracking model was proposed that includes both crack initiation and propagation models.
- A complete literature review was conducted to identify test procedures for characterizing material properties needed to predict pavement response and distresses. In particular, test procedures were evaluated and revised for Tex-ME regarding: hot-mix asphalt (HMA) dynamic modulus, fracture, and permanent deformation properties; and resilient modulus and permanent deformation properties of base/subbase and subgrade materials.
- The repeated load test was selected for characterizing materials and modeling HMA rutting. This test was validated with field-measured rutting data from both the National Center for Asphalt Technology (NCAT) test track and Texas highways. Use of the overlay tester for characterizing fatigue cracking was verified using accelerated pavement tests such as ALF and HVS.
- A multi-layer linear elastic system was evaluated to compute asphalt pavement response to traffic loading. Its validity was verified through comparing measured tensile strains under accelerated pavement ALF loading with computed ones.

- All existing pavement performance models (or transfer functions) were evaluated and reasonable models for predicting pavement distresses including rutting and fatigue cracking were recommended for Tex-ME. The recommended pavement performance models were further developed and then calibrated using actual field performance data. Specifically, the HMA layer rutting model was calibrated using rutting data from the NCAT test track and the SPS 5 asphalt overlay test sections on US175 near Dallas. During the model calibration, either lab-molded plant mix samples or field cores were characterized using HMA dynamic modulus testing and repeated load testing to develop material properties. Calibration factors for the HMA layer rutting model were developed through minimizing the differences between the measured field rut depths and the ones predicted from the model. A similar approach was used to calibrate the fatigue cracking model.
- For granular bases, the resilient modulus and permanent deformation tests were found to classify base materials in the same rank as observed district performance. The moduli values (at 5 psi confining and 15 psi deviator stress) for the different classes of base were found to be in the range of 35 to 70 ksi, which is very similar to the values obtained from FWD testing and subsequent back-calculation.
- Several experimental test sections were constructed at Texas A&M Riverside campus, and later tested under traffic loads to validate the LoadGage program that was developed for thin pavement design.

What They Found

The major findings from this study are:

- Repeated load tests characterizing HMA rutting correlated excellently with the field rut depths measured on Texas highways and the NCAT test track.
- The overlay tester has the capability to clearly differentiate fatigue cracking resistance of different mixes with unmodified and modified binders. Results enabled very reasonable prediction of fatigue life based on data from the NCAT test track.
- A multi-layer elastic system is valid for predicting pavement response under traffic loading when considering the influence of pavement temperature and vehicle traveling speed.
- The calibrated/validated HMA rutting and fatigue cracking models developed as part of this project are reasonable. The predicted pavement distresses, including both rutting and fatigue cracking, matched the field measured ones well.
- The LoadGage predictions of allowable load limits were judged to be more accurate than those in the current Texas Triaxial check system currently used with FPS19. Very reasonable maximum allowable load limits predicted from the LoadGage were found on the experimental test sections constructed at Texas A&M Riverside campus, when moisture correction factors were applied to the laboratory measure engineering properties.

What This Means

Project 0-5798 demonstrated that calibrated models are now available to make reasonable predictions of the most common distresses found on Texas highways. The proposed Tex-ME system can replace the existing simple M-E check inside of FPS19, and the LoadGage system can replace the Texas Triaxial check. Simple performance-related tests are now available to characterize soils, base, and asphalt materials in the lab and these properties can be incorporated into a new thickness analysis and design system.

For More Information:

0-5798-1 A Review of Performance Models and Test Procedures with Recommendations for use in the Texas M-E Design Program

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