

Recent Research – TRB Compendium of Papers 2006

Testing Wisconsin Asphalt Mixtures for the AASHTO 2002 Mechanistic Design Procedure WHRP Project [0092-04-07](#)

The paper(s) abstracted below report recent research that may be related to the subject matter or methodologies of this WHRP project. For access to the CD-ROM and full text of the paper, contact Hussain Bahia (bahia@engr.wisc.edu) or Greg Waidley (gwaidley@engr.wisc.edu) at WHRP or John Cherney (john.cherney@dot.state.wi.us) at the WisDOT Library.

Evaluation of Testing Protocols for Dynamic Modulus of Hot Mix Asphalt

Paper No. 06-1511

Authors: Kevin D. Hall, Nam H. Tran

Abstract: The dynamic modulus ($|E^*|$) of hot-mix asphalt (HMA) is one of the fundamental inputs in the mechanistic-empirical (M-E) Design Guide developed in NCHRP Project 1-37A. The M-E Design Guide provides three levels for $|E^*|$ input, which are related nominally to the reliability of pavement performance estimates generated by the Guide. Level 1 $|E^*|$ inputs require laboratory measured $|E^*|$ values while level 2 and 3 $|E^*|$ inputs are estimated using a predictive equation. To provide the laboratory measured $|E^*|$ inputs for implementation of the M-E Design Guide, a comprehensive research effort was completed in Arkansas. The research included a study evaluating different $|E^*|$ testing protocols, derived by varying combinations of the number of test replicates and the number of measurement instruments affixed on each test specimen recommended in AASHTO TP 62-03. The testing protocols were evaluated in terms of the variability of the resulting $|E^*|$ test results. The total research effort included three replicate specimens from each of four aggregate types, three nominal maximum aggregate sizes, two PG binder grades, and two air-void levels. The $|E^*|$ tests were conducted using five test temperatures and six loading frequencies. Even though all evaluated testing protocols produced standard errors of less than 15% (which is the requirement specified in AASHTO TP62-03) a program utilizing four measurement instruments and two replicate specimens is recommended for future $|E^*|$ testing.

Improving Prediction Accuracy in Mechanistic-Empirical Pavement Design

Paper No. 06-2500

Authors: Maqdy Abdelrahman, Scott Schram

Abstract: Model calibration plays a fundamental role in the implementation of the Mechanistic-Empirical Pavement Design Guide. The data used in the default calibration effort, which was afforded by the Long Term Pavement Performance (LTPP) database, has a network-level inference space. As implementation proceeds, State Highway Agencies may be inclined to calibrate at a local network-level. However, by focusing the calibration dataset to local project-level conditions, model prediction error can be reduced further. Under this study, Nebraska Department of Roads (NDOR) Pavement Management data was used to calibrate two Design Guide smoothness models at the local project-level. The focused dataset was categorized by annual daily truck traffic (ADTT) and surface layer thickness. Results showed that project-level calibrations reduced default model prediction error by nearly twice that of network-level calibration. This study offers a window into the accuracy that can be achieved with local focus calibrations of Design Guide prediction models.

Pavement Design Analysis Using AASHTO 2002 Design Guide Software

Paper No. 06-1703

Authors: Christopher J. Robinette, Christopher R. Williams

Abstract: There has been a continuous evolutionary process in hot mix asphalt pavement design. In the beginning it was primarily based upon past experience. Through research, empirical methods were developed based on the materials response to specific loading at the AASHO Road Test. Today, pavement design has progressed to a mechanistic-empirical method. This methodology takes into account the mechanical properties of the individual layers and uses empirical relationships to relate material properties to performance. The mechanical tests that are used as part of the current methodology include dynamic modulus and flow number, which have been shown to correlate with

field pavement performance. This paper examines the use of the dynamic modulus test and its impact upon pavement design with the current Design Guide (2002) and its associated software. The three pavement structures that are examined were derived from the 1972 AASHTO Design Guide approach and were constructed in Wisconsin during the 2004 construction season. Through iterative changes in the hot mix asphalt layer thickness, the major distresses of permanent deformation and fatigue were examined. Included in the examination were changes in air voids and asphalt binder content over ranges that were believed to be typical of hot mix asphalt production and paving. All three pavements were predicted to perform well in terms of permanent deformation for the as designed layer thicknesses. The 2002 Design Guide software, however, indicates that two of the three pavements considered may be prone to fatigue cracking, specifically, at higher air void contents (+7.0%).

Permanent Deformation Analysis of HMA Mixtures Using Simple Performance Tests and the 2002 Mechanistic Empirical Pavement Design Software

Paper No. 06-1798

Authors: Louay N. Mohammad, Zhong Wu, Sandeep Obulareddy, Sam Cooper, Chris Abadie
 Abstract: This paper presents a complex laboratory study in characterization of permanent deformation resistance of hot-mix asphalt (HMA) mixtures. Six plant-produced HMA mixtures were selected in this study. The main objective was to characterize the permanent deformation characteristics of HMA mixtures based on four laboratory tests, namely, the dynamic modulus $|E^*|$, flow number, frequency sweep at constant height (FSCH), and Hamburg-type loaded wheel tracking tests. The secondary objective was to evaluate the sensitivity of the dynamic modulus $|E^*|$ test results in pavement rutting performance prediction using the 2002 Mechanistic-Empirical (M-E) pavement design software. Test results indicate that the $|E^*|$ test was sensitive to the nominal maximum aggregate size in a HMA mixture. Larger aggregates combined with aged materials tend to have high $|E^*|$ values at high temperatures. However, both the $|E^*|$ and FSCH tests could not correctly rank the permanent deformation characteristics for the six HMA mixtures considered in this study. On the other hand, test results from the flow number and Hamburg tests correlated fairly well and both tests were sensitive to the permanent deformation characteristics for the mixtures evaluated. The mixture ranking order obtained from the flow number tests was consistent with the use of those mixtures in the field. The predicted rut depths from the 2002 M-E pavement design software basically followed a same trend found in the $|E^*|$ test results at high temperatures.

Sensitivity Study of Iowa Flexible Pavements Using Mechanistic-Empirical Pavement Design Guide

Paper No. 06-2139

Authors: Sunghwan Kim, Halil Ceylan, Kasthurirangan Gopalakrishnan, and Michael Heitzman
 Abstract: In the newly released Mechanistic-Empirical Pavement Design Guide (MEPDG) (1), the coefficients of the distress prediction models were determined through national calibration efforts using the Long-Term Pavement Performance (LTPP). But the LTPP database used to develop the calibrated distress models did not include test sections from Iowa. Thus, there is a need to recalibrate the models, if required, to use them for pavement design and rehabilitation in Iowa. As a first step in this direction, a preliminary sensitivity study was undertaken to assess the comparative effect of design input parameters pertaining to material properties, traffic and climate on performance of two existing flexible pavements in Iowa with relatively thick Asphalt Concrete (AC) layers. A total of 20 individual inputs were evaluated by studying the effect of each input on five different performance measures (longitudinal cracking, alligator cracking, transverse cracking, rutting, and roughness) for each pavement structure resulting in about 200 simulations using the MEPDG. A limited set of runs were also conducted to study the two-way interaction among the input variables (e.g., effect of traffic distribution on performance for varying AC surface thicknesses). The results showed that the predicted longitudinal cracking was influenced by most input parameters. Alligator cracking, roughness and rutting in unbound layers remained insensitive to most input parameters. There is no input parameter that is sensitive to all the performance measures. Future research will focus on comparing the predicted measures against the recorded pavement distresses in the Iowa DOT's Pavement Management Information System (PMIS) database.

A Strategic Plan for Implementing Mechanistic-Empirical Pavement Design Guide in Iowa

Paper No. 06-2784

Authors: Halil Ceylan, Kasthurirangan Gopalakrishnan, Brian Coree

Abstract: With the release of the new Mechanistic-Empirical Pavement Design Guide (MEPDG), pavement design has taken a “quantum” leap forward. It is clear that the basis of the current empirically-based AASHTO pavement design procedures are no longer applicable to current conditions in Iowa. The Iowa Department of Transportation (Iowa DOT) will significantly benefit by implementing the MEPDG as a reliable pavement performance prediction tool. The major benefits of adopting the MEPDG are long-term which include (1) more appropriate designs focusing on minimizing or mitigating the predominant distress types that occur in Iowa, (2) better performance predictions resulting in significant long-term savings by eliminating the possible premature failures and over-designing the pavement sections, (3) better materials-related research reducing the need to conduct extensive, lengthy and costly field trials, and (4) the use of MEPDG software as a powerful forensic tool for analyzing the condition of existing pavements. In order to effectively and efficiently transition to the MEPDG, the Iowa DOT needs a detailed implementation and training strategy. In support of the MEPDG implementation initiatives, sensitivity studies were conducted using the MEPDG software to identify design inputs pertaining to both rigid pavements and flexible pavements that are of particular sensitivity in Iowa as well as those factors that are of no particular sensitivity. Based on a study of the MEPDG design components, the results of sensitivity analyses and past experience, a strategic plan for implementing the MEPDG in Iowa is presented.

Validation of Material-Level Performance Models Using Third-Scale Model Mobile Loading Simulator

Paper No. 06-2854

Authors: S. Soon Lee, Youngguk Seo, and Y. Richard Kim

Abstract: This paper presents research in which a mechanistic pavement analysis with laboratory fatigue cracking and rutting models is validated using the response and performance measured from asphalt pavements with different air void contents that are tested using the third-scale Model Mobile Loading Simulator (MMLS3). The fatigue life prediction algorithm adopts a cumulative damage analysis; the permanent deformation prediction algorithm uses a sublayering method. These algorithms, which are very similar to the ones adopted in the NCHRP 1-37A Mechanistic-Empirical Pavement Design Guide (MEPDG), account for the loading rate and temperature variation along the depth of the pavements. The major difference between the algorithms used in this study and the ones in the MEPDG is that the difference in loading frequencies between the laboratory test method and the MMLS3 test was accounted for in this study using the time-temperature superposition principle with growing damage. The predictions of fatigue life and permanent deformation growth in the MMLS3 tests reveal that the proposed algorithms do a reasonable job in predicting these parameters, although improved predictions may be achieved by adopting more fundamental models. It is expected that the resulted alliance among the accelerated pavement test, laboratory material level test, and performance models can serve as a cornerstone for the successful estimation of the service life of in situ pavements.