Monday 3/13/2017

2–3:30 p.m.

Modeling of Pavement Variability

Chairs: Charles Schwartz, University of Maryland; Mahmoud Enad, University of Texas, Rio Grande Valley

Base Course Resilient Modulus for the Mechanistic-Empirical Pavement Design Guide

Aditya Ayithi, Loadtest Inc.; Dennis Hiltunen, University of Florida

The Mechanistic-Empirical Pavement Design Guidelines (MEPDG) recommend use of material modulus in lieu of structural number for pavement base layer thickness design. In this study a methodology was developed to determine a single effective modulus for a base layer using laboratory nonlinear modulus characterization data and a nonlinear finite element response model. With this model, a single representative modulus can be determined by a backcalculation procedure in which pavement surface deflections from a nonlinear analysis are matched via an equivalent linear analysis. An equivalent linear analysis using effective moduli for both an unbound base and the subgrade can predict the structural response of an asphalt surface layer in a flexible pavement. It should be possible to utilize these structural response predictions in the assessment of cracking performance of the surface layer. However, caution is warranted in predicting the structural response of the unbound base and subgrade layers using an equivalent linear analysis. Use of an effective modulus for a nonlinear base layer appears reasonable for very thick pavement structures, but appears to under predict vertical strain at the top of subgrade.

Moisture Sensitivity of Warm and Hot Mix Asphalt: Comparison of Loaded Wheel Tracking and Modified Lottman Tests

Shadi Saadeh, California State University, Long Beach; Louay Mohammad, Louisiana State University

Concerns about ever-increasing construction costs coupled with the negative impacts on the environment have led the asphalt industry to search for alternatives that can potentially mitigate these effects. One type of technology that addresses both production cost and environmental issues is the Warm Mix Asphalt (WMA). It allows for mixing, production, placing, and compaction of asphalt mixtures at significantly lower temperatures than conventional Hot Mix Asphalt (HMA). The goal of this study is to compare the laboratory moisture susceptibility and permanent deformation performance of HMA and WMA mixtures. Further, to ascertain early field performance of HMA and WMA. Six field rehabilitation projects across Louisiana were selected for the evaluation of WMA technologies. Several chemical additives and processes were evaluated. A total of 18 mixtures were included in this study. The field experiment included three types of WMA technologies, chemical additives (Evotherm® and Rediset), organic (Sasobit), and foaming processes (Astec Double Barrel Green system and Accu-Shear system), two mixture compaction levels (design traffic levels 1 and 2), two asphalt binder types (PG70-22M and PG76-22M per Louisiana Department of Transportation and Development (DOTD) specifications), two projects where higher Reclaimed Asphalt Pavment (RAP) contents were evaluated; and two nominal maximum aggregate sizes (12.5 mm [1/2 in] and 19.0 mm [3/4 inch]). The results of this study showed comparable performance of conventional HMA and WMA in terms of moisture sensitivity tests. The modified Lottman and Loaded Wheel Tracking (LWT) tests had, in general, good agreement for mixture evaluation in terms of moisture sensitivity and field performance results. The field performance confirmed the prediction of the moisture sensitivity tests, modified Lottman and the LWT.

Probabilistic Modeling of Material Properties of Flexible Pavements for Mechanistic Empirical and Reliability Analysis

Sudip Bhattacharjee, Alabama A&M University

The objectives of this research were to model and incorporate the uncertainty in pavement material properties for Mechanistic Empirical (ME) analysis. The uncertainty in aggregate gradation and volumetric properties in Superpave mixture design was considered for hot mix asphalt (HMA). The uncertainty in the properties of the granular materials was modeled in terms of the uncertainties in resilient modulus and degree of saturation using Thornthwaite Moisture Index (TMI) and climatic database. The distributions of HMA dynamic modulus and resilient modulus of granular materials were determined from the distributions of the constituent random variables. Reliability analysis was performed using different allowable cracking. The research concluded that TMI can be used to model the uncertainties in climatic factors and response surface method can be used to incorporate material uncertainties in pavement analysis. The reliability curves developed in the study can be used to determine pavement thickness for a given reliability.

Inherent Variability in the Parameters Describing the Linear Viscoelastic Response of Asphalt Concrete

Hussein Kassem, Shadi Najjar, and Ghassan Chehab, American University of Beirut

Mechanistic methods are introduced to provide a realistic prediction of the performance of asphalt pavements. Despite the advantage of these methods in providing accurate and advanced material characterization, they should take into account the uncertainties associated with material properties and models. Such material properties include the linear viscoelastic response functions that characterizes the behavior of asphalt concrete such as relaxation modulus E(t). Typically, complex modulus E* data is obtained by lab testing and then used to determine E(t) through mathematical interconversion methods. The objective of this study is to propagate the inherent variability in E* data for various reduced times into E(t). This was achieved by analyzing the data of E* testing and interconverted E(t) from three different mixes that include at least eight replicates with a probabilistic framework that allows for a preliminary quantification of uncertainty. Monte Carlo simulations were used to propagate the uncertainties of the Prony series coefficients to determine the mean, coefficient of variation (COV), and probability distribution in E(t) as a function of reduced time.

Discrete Element Analysis of SCB Variability – Asphalt Mixtures

Enad Mahmoud, University of Texas, Rio Grande Valley; David Renteria, University of Texas, Rio Grande Valley; Rolando Yanez, University of Texas, Rio Grande Valley; Victoria Burbach, University of Texas, Rio Grande Valley

Fracture of asphalt mixtures was modeled using a Heterogeneous 2D-Discrete Element Method simulating the Semi-Circular Bending (SCB) test. The 2D internal structure was generated virtually utilizing 2D images of aggregate particles. The internal structure was produced to match specific mixes gradation, namely: Superpave, Porous Friction Course, and Coarse Matrix High Binder mixes. The variability of SCB testing results was studied by producing 50 virtual cases for each of the mixes. In addition to randomly selecting the location of the aggregates within the internal structure, the location of air-voids was also random. The results indicated that the location of the aggregates and air-voids has a strong influence on the crack initiation, propagation and the crack path. Analysis of SCB fracture behavior for aggregates from different sources with different strength and shape properties indicated

that the aggregate source plays a role in the variability, but none of the strength-shape combinations led to a significantly lower variability.

Probability Density Functions Associated with Resilient Modulus of Virgin Aggregate Bases

Pranav R.T. Peddinti, Indian Institute of Technology, Hyderabad; Munwar B Basha, Indian Institute of Technology, Hyderabad; Sireesh Saride, Indian Institute of Technology, Hyderabad

The accuracy of the reliability-based designs for pavements mostly depends on the probability density functions (PDF) associated with the resilient modulus of the pavement layer. The present study attempts to find out the appropriate PDF corresponding to the base resilient modulus (Mr) of different virgin aggregates that are used in the flexible pavements. Extensive literature study has been conducted and about 120 data points were collected from various global studies performed on virgin aggregate base materials for their use in flexible pavements. Histogram and statistical analyses are performed on the dataset. An accurate PDF is then proposed from the available distributions by using percentile (P-P) and quantile (Q-Q) fit assessment plots. The proposed mean, standard deviation and coefficient of variation associated with the best PDF are further useful for developing the reliability based design optimization methods for pavements.