MDOT

RESEARCH ADMINISTRATION
Bureau of Field Services
Michigan Department of Transportation

Research Spotlight

Project Information

REPORT NAME: Preparation for Implementation of the Mechanistic Empirical Pavement Design Guide in Michigan, Parts 1 and 2

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RESEARCH REPORT NUMBER: RC-1593, RC-1594

TOTAL COST: $400,000 (Parts 1, 2 and 3)

COST SHARING: 20% MDOT, 80% FHWA through the SPR, Part II, Program

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Final Steps Toward Using MEPDG in Michigan— Parts 1 and 2

In 2014, MDOT plans to begin implementing the Mechanistic-Empirical Pavement Design Guide (MEPDG) and the associated Pavement ME Design software. The MEPDG is based on both mechanistic predictions of the stresses and strains on a pavement structure and empirical observations of pavement performance. It replaces the 1993 American Association of State Highway and Transportation Officials (AASHTO) method for pavement design, which is based on empirical observations only. This Spotlight describes Parts 1 and 2 of a three-part research project to help the department prepare to implement the MEPDG.

Problem

Mechanistic-empirical design is significantly more complicated than the 1993 AASHTO method. The Pavement ME Design software requires more than 100 data inputs, while the previous method required fewer than 10. The MEPDG requires accurate data about the paving materials used. For some of these materials inputs, MDOT does not have the equipment or experience to run the necessary tests. For the MEPDG to be practical for MDOT to use, researchers needed to identify the most important of these data inputs and determine which could be estimated without significantly affecting the results.

The Asphalt Mixture Performance Tester subjects compacted asphalt mixture specimens to cyclic loading at several different temperatures and frequencies to generate dynamic modulus master curves for each sample, in accordance with procedures described in AASHTO T342.

Research

In Part 1 of the research, investigators conducted laboratory testing on hot-mix asphalt (HMA) and binder samples to gather inputs needed for three MEPDG parameters:

(continued)

> *"Implementing the MEPDG will allow us to move forward with the latest science, technology, and software."*
>
> **Michael Eacker, P.E.**
> Pavement Design Engineer

- **Complex (dynamic) modulus of the mixture,** a measure of how the mix responds to stress and strain.
- **Complex shear modulus of the binder,** a measure of how the binder responds to stress and strain.
- **Indirect tensile strength of the mixture** at low temperatures, which predicts thermal cracking.

Researchers also evaluated two methods of predicting the dynamic modulus of MDOT mixtures that have not undergone lab testing: the modified Witczak model, which is used in the MEPDG software, and the ANNACAP software developed by the Federal Highway Administration's Long-Term Pavement Performance program. ANNACAP uses artificial neural networks, or connected computational units that make predictions.

Part 2 of the project used statistical analysis to determine which of the MEPDG inputs have the greatest impact on the accuracy of pavement performance predictions for rehabilitation techniques in use in Michigan. This builds on previous research that identified the most impactful inputs for new and reconstructed pavements. Several in-service rehabilitated pavements were used to compare MEPDG predictions with observed distresses to verify the accuracy of the models.

Results

In Part 1, researchers characterized the physical properties needed by the MEPDG for 64 unique asphalt mixtures and 44 unique binders in use in all regions of the state.

The modified Witczak model showed a good fit between predicted and measured values, while ANNACAP did not predict values as successfully. Researchers developed another artificial neural network-based model in an effort to generate more accurate predictions. After training the artificial neural network with random weights and biases, researchers evaluated its performance and found a better fit between predicted and actual data than either the modified Witczak model or ANNACAP provided.

Researchers developed a software package, DYNAMOD, which serves as a database for the results of this project's material testing. DYNAMOD would allow MDOT to use both the modified Witczak model and the newly developed artificial neural network model to predict values for other materials. The software can also generate input files that can be imported directly into the Pavement ME Design software.

Part 2 found that the inputs that had the greatest impact on performance predictions were, by rehabilitation type:

- **HMA over HMA:** Overlay air voids, existing thickness, overlay thickness, existing pavement condition rating, overlay effective binder, subgrade modulus and subbase modulus.
- **Composite pavement:** Overlay air voids, overlay thickness and existing PCC thickness.
- **Rubblized pavements:** Overlay air voids, overlay effective binder and overlay thickness.
- **Unbonded overlays:** Overlay PCC thickness, overlay PCC coefficient of thermal expansion, overlay PCC modulus of rupture, overlay joint spacing, existing PCC elastic modulus and climate.

The model verification showed that all four rehabilitation fixes require local calibration.

Value

The MEPDG has the potential to improve MDOT's decision-making in pavement design by combining the latest research and technology with materials data specific to the mixtures used in Michigan. This three-part research effort is helping to make implementation of the MEPDG possible in Michigan. Part 3 of the project, which is addressing calibration and validation, is expected to be completed in September 2014.

Research Administration

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These final reports are available online:

Part 1: www.michigan.gov/documents/mdot/MDOT_RC-1593_417976_7.pdf

Part 2: www.michigan.gov/mdot/0,4616,7-151-9622_11045_24249_24255-311756--,00.html

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