PUTTING RESEARCH TO WORK **BRIEF**

Applying M-E Design Methods to Wisconsin HMA Pavements

WisDOT's continuing effort to adopt the latest, most sophisticated pavement design methods outlined in the new AASHTO Mechanistic-Empirical Pavement Design Guide requires extensive work. The new methods characterize the mechanical properties of a pavement's structural components, using these *mechanistic* values as inputs in functions that predict performance based on *empirical* relationships between structures, the environment and performance.

Similar to WisDOT's current empirical design methods, which use WisPave software, the M-E design guide relies on software that evaluates design alternatives from specific inputs. Designers enter mechanical values, traffic expectations, environmental conditions and other variables, and the software uses formulas to generate estimated performance evaluations. The most critical parameter for M-E design of hot-mix asphalt pavements is dynamic modulus, a laboratory measure of a pavement material's ability to spring back from the stress of repeated loading (simulating truck traffic in the field).

What's the Problem?

WisDOT has not used dynamic modulus extensively as a design input in the past. M-E practices determine dynamic modulus using the Superpave Simple Performance Test, a method WisDOT has not yet used. To effectively use the new M-E design guide, WisDOT needs to obtain dynamic modulus values for existing Wisconsin pavements and learn how M-E designs will differ from current designs.

Research Objectives and Methodology

This research sought to:

- Characterize Wisconsin asphalt mixtures with the SPT.
- Determine if SPT results are reasonable as compared with WisDOT's asphalt experience.
- Compare the design results of the WisPave and M-E methods, and determine the implications of dynamic modulus results for WisDOT's adoption of the new M-E design guide.
- Provide WisDOT with dynamic modulus and flow number values for a range of typical Wisconsin HMA mixes.

The researchers performed a literature review and examined sample requirements and available mixes. Research tasks included:

- Selecting 21 HMA mixes used across Wisconsin during 2004 and 2005, pulling samples from mix batches at plants immediately after the trucks were loaded.
- Evaluating mixes and predicted performance in terms of three important factors in design: level of anticipated traffic, nominal mean aggregate size in mix, and whether mixes were dense-graded or open-graded.
- Testing mixes with the SPT to determine dynamic modulus and flow number, effective predictors of rutting and fatigue.
- Evaluating M-E design results for reasonability, and compare designs and predicted performance to those generated by WisPave for the same mixes.

Results

Investigators provided WisDOT with dynamic modulus, flow number data and more for all the tested mixes. The findings that followed from their analysis included:

- Variation of asphalt binder content by 0.3 percent, as allowed by WisDOT, does not impact flow number.
- Binder grade has more impact on dynamic modulus than aggregate angularity does.

Investigator

"This research produced important values for WisDOT to use with the new M-E design guide, and it confirmed a number of WisDOT design practices that should continue to work well with the new design methods."

–Christopher Williams
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Investigators sampled 21 HMA mixtures directly from trucks at batch plants right before asphalt was delivered to construction sites.

- Dynamic modulus increases with an increase in air void content and flow number.
- Aggregate size impacts both dynamic modulus and flow number, and the SPT effectively assesses that impact.
- Generally, a mix's dynamic modulus and flow number increase as the mix design's traffic level increases, except in 10 million equivalent single-axle load mixes, a surprising result.
- Current WisDOT designs resist rutting well, but may be susceptible to longitudinal cracking.
- M-E designs resist rutting well, and may also resist cracking.
- M-E designs will lead to thicker pavements, and likely to longer pavement lives.

Benefits

WisDOT has already used the dynamic modulus and flow number values from this study in design and in related research. This study confirms the effectiveness of WisDOT's quality control of binder content variation; confirms expected relationships between aggregate angularity, binder content, dynamic modulus, flow number and air voids; and confirms that WisDOT is on the correct path toward M-E adoption.

Implementation

WisDOT will continue to monitor the performance of these mixes for localized calibration of M-E design inputs. After further research, WisDOT may implement findings regarding simplified versions of SPT testing methods, in which tests are conducted on whole compacted specimens rather than on cores drawn from these samples. This will eliminate a time-consuming step in SPT testing.

Further Research

WisDOT will continue to examine aggregate size in mixtures, studying mixes with a nominal maximum aggregate size of 25 mm (this study examined mixes with NMAS of 12.5 mm and 19 mm). The department will also weigh the results of this study against newer versions of the M-E design guide as they are released.

WisDOT has acquired SPT equipment for evaluating mixes and is using it to follow up on some of these results and to pursue related objectives in a new project, 0092-08-06, "Wisconsin Mixture Characterization Using the SPT on Historical Aggregate Structures" (see http://www.whrp.org/Research/Flex/flex_0092-08-06/index.html).

This brief summarizes Project 0092-04-07, "Testing Wisconsin Asphalt Mixtures for the AASHTO 2002 Mechanistic Design Procedure," produced through the Wisconsin Highway Research Program for the Wisconsin Department of Transportation Research Program, 4802 Sheboygan Ave., Madison, WI 53707.

Nikki Hatch, WisDOT Research and Communication Services

Project Manager

"This was a very useful study. WisDOT is already using the dynamic modulus data that was generated."

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