MDOT
OFFICE OF RESEARCH & BEST PRACTICES
Michigan Department of Transportation

RESEARCH UPDATE

JULY 2011

National Guidance for Pavement Design

Over the last half-century, pavement design has been largely guided by experience, with designers benefiting from the empirical evidence gleaned from carefully observing how existing pavements perform under traffic, both on test tracks and on highways. At the other end of the spectrum is a mechanistic approach to pavement design, which relies on the theories of mechanics and the scientific properties of pavement materials to predict how a particular pavement design will perform.

The MEPDG *allows designers to predict the performance of both asphalt and concrete pavements.*

In This Issue:
Engineering Pavements for Longer Life

The focus is on pavement in this issue of *Research Update*, with highlights of MDOT research results and innovative processes that contribute to high-quality, long-lasting pavements in Michigan.

RBP

An integrated approach

With the 2004 publication of the *Mechanistic-Empirical Pavement Design Guide (MEPDG)*, pavement designers could begin to reap the benefits of both approaches—empirical and mechanistic—using a single design guide. The guide was developed over a number of years by the American Association of State Highway and Transportation Officials (AASHTO).

The *MEPDG* manual and software help design the pavement cross-section that will carry the anticipated traffic loads over a pavement's intended design life. *MEPDG* models evaluate the impact of design features, traffic, climate and materials on pavement performance, accounting for interactions among these factors. The result is a more reliable pavement design.

Preparing for the transition

MDOT's current pavement design processes are guided by the empirically based 1993 *AASHTO Guide for Design of Pavement Structures*. In recent years, MDOT has undertaken a series of research projects to prepare for the transition from the current design approach to the *MEPDG*.

In a project that wrapped up in 2008, researchers analyzed the performance of sample sections of new and reconstructed pavements and compared them to the outputs predicted by the *MEPDG* software. A 2009 study examined Michigan traffic-related data needed to replace the default values included in the *MEPDG* program.

MDOT's transition to use of the *MEPDG* continues with a project that

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National Guidance for Pavement Design

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gets under way this fall, "Preparation for Implementation of the *Mechanistic-Empirical Pavement Design Guide* in Michigan." The new project addresses three key needs for *MEPDG* implementation in Michigan:

- **Hot-mix asphalt (HMA) mixtures.** Researchers will determine MDOT's typical HMA mixture properties that can be used as inputs in the *MEPDG* to create HMA pavement designs for use in Michigan.
- **Pavement rehabilitation.** This project will evaluate designs for rehabilitated pavements produced using the *MEPDG* to ensure that the designs provide acceptable results for Michigan pavements.
- **Calibration and validation.** *MEPDG* models are initially populated with default data derived from national research. Researchers will identify the sources for Michigan-specific *MEPDG* inputs and use existing pavements to verify the performance of the newly calibrated models.

For more information

Read more about the research project that began MDOT's examination of the *MEPDG* in the *Research Spotlight* available at www.michigan.gov/documents/mdot/MDOT_Research_Spotlight_Implementing_MEPDG_298420_7.pdf.

The *Research Spotlight* describing MDOT's efforts to gather Michigan-specific data for the *MEPDG*'s traffic inputs is available at www.michigan.gov/documents/mdot/MDOT_ORBP_traffic_inputs_to_MEPDG_324114_7.pdf.

Combating Pavement Distress

If left unchecked, pavement distresses can shorten the service life of a concrete roadway. A flawed pavement design can be the culprit, or the distress can arise from the materials that make up the pavement mix.

Materials-related distress (MRD) is the result of an adverse interaction between pavement materials and the surrounding environment. The types of MRD range from cracking or crumbling at the joints to expansion-related distresses such as joint closure and blowups that lead to shattered pavement.

"Proper selection of the highest possible quality materials is critical to producing durable concrete, which is essential for the long-term performance of concrete pavements and structures."

—John F. Staton, P.E.
MDOT Engineer Manager of Materials

An undesirable chemical reaction

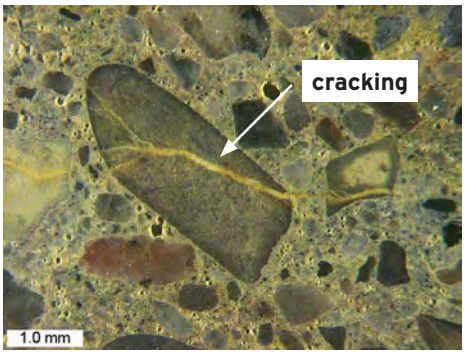
In a recently completed MDOT research project, "Evaluation of Concrete Pavements with Materials-Related Distress," researchers examined six pavement samples representing a range of MRD severities. Some of the samples exhibited indications of a chemical mechanism that causes MRD—alkali-silica reactivity, or ASR.

ASR is the undesirable chemical reaction between components of the pavement mix—high-alkali cement paste and reactive silica in the aggregate. As the two components react, rims of calcium-rich silica gels form around the perimeter of the reactive aggregate particles (sand or chert, for example). In the presence of water, these gels expand, creating cracks in the surrounding concrete.

Finding solutions

Researchers focused their efforts on identifying strategies to reduce the likelihood of the occurrence of ASR in new concrete pavements and structures. MDOT is in the process of implementing researchers' recommendations, including:

- Partial substitution of portland cement with supplementary cementitious material such as Class F fly ash and slag cement, which provide excellent mitigation of ASR.



This test slab evaluated in the MDOT study shows an alkali-silica reaction, and the associated cracking, in fine aggregate.

- In 2011, MDOT is piloting a specification that includes three predictive lab tests that assess the potential for ASR in a concrete mixture. If test results indicate an unacceptable level of expansion of the test specimens, the mix is rejected and the contractor must select more suitable components for the pavement mix.

The 2012 MDOT Standard Specifications for Construction will include a frequently used special provision for concrete quality control and quality assurance that reflects specification requirements refined during the 2011 pilot of ASR lab tests.

For more information

Learn more about ASR and methods to combat it in the MDOT research report and its appendices, available online at www.michigan.gov/mdot/0,1607,7-151-9622_11045_24249-233245--,00.html.

National Trends

Going Green with Warm-Mix Asphalt

Hot-mix asphalt is the pavement mix of choice for many types of urban and rural highways, as well as local roads. HMA has two components: high-quality aggregate, which can be crushed stone, gravel or sand; and asphalt cement (also called asphalt binder), a dark, viscous hydrocarbon substance produced by refineries during petroleum processing.

The traditional mix

At the production plant, the aggregate and binder are heated and mixed. The binder, which is sticky and semisolid at room temperature, liquefies when heated and returns to a solid state when cooled. When heated to a high temperature—above 300°F—the binder becomes more fluid and completely coats the aggregates, holding them together to form the pavement.

The high temperature required during mixing is maintained during transportation to the construction site to ensure good workability of the mixture as it is placed and compacted. The HMA mixture cools after compaction to form the asphalt pavement.

A greener solution

In recent years, warm-mix asphalt (WMA) has gained favor as a cost-effective and environmentally friendly alternative to HMA. Used in Europe for more than 10 years, WMA was first used in the United States in 2004. As of 2009, more than 40 states had installed WMA pavements.

WMA is produced, transported, placed and compacted at temperatures from 30°F to 120°F lower than traditional HMA, reducing the energy needed for manufacturing the pavement mix. WMA's other benefits include improved asphalt compaction and reduced fuel emissions.

Defining the Michigan WMA mix

MDOT researchers are investigating WMA technologies in a research study expected to conclude this fall, "Laboratory Evaluation of Warm-Mix Asphalt." The project's final report will include recommendations for use of WMA in Michigan, specifying the appropriate mix components and climatic factors to consider when placing WMA.

Yellowstone National Park plans to use WMA for future maintenance work after the success of this test site. (Courtesy of FHWA.)

Learn more about WMA at the Federal Highway Administration's Every Day Counts Web site at **www.fhwa.dot.gov/everydaycounts/technology/asphalt/**.

Research in Progress

Preserving Pavements, Maximizing Investments

Microsurfacing is the application of a mixture of asphalt emulsion, aggregate and other additives to improve skid resistance.

Transportation agencies across the country are meeting the challenge of preserving and maintaining the nation's highways with shrinking budgets and dwindling workforces. MDOT's Capital Preventive Maintenance (CPM) program plays a key role in the department's efforts to contain costs and maximize investments by keeping minor pavement problems from becoming big ones.

An exemplary program

Since 1992, CPM projects have extended the service life of the state highway system in Michigan with cost-effective pavement fixes that postpone costly reconstruction or rehabilitation. CPM fixes employ a combination of surface seals and functional enhancements to keep good pavements in good condition and allow MDOT to address more miles of pavement with each taxpayer dollar.

In recent years, MDOT's CPM program has dedicated between $80 million and $100 million per year to preventive maintenance treatments, making it one of the largest and most successful preventive maintenance programs in the country.

The right projects at the right time

Last fall, MDOT undertook a research project, "Cost-Effectiveness of the

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Preserving Pavements, Maximizing Investments

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MDOT Preventive Maintenance Program," to develop guidelines for cost-effective preventive maintenance treatments and assess the overall benefits of the CPM program.

Researchers are gathering historical data on completed preventive maintenance projects, the cost of each treatment, and the pavement distress before and after treatment (condition data for a particular pavement is gathered every two years). The resulting cost/benefit analysis will help CPM managers select an appropriate time, location and preservation technique based on a candidate project's type of pavement distress.

A chip seal improves skid resistance and seals fine surface cracks to reduce water infiltration.

Research results will be available after the project concludes in fall 2012. Contact Project Manager Kevin Kennedy at KennedyK@michigan.gov to learn more about this ongoing project.

Current MDOT Pavement Research

Project Title	Start Date	End Date
Laboratory Evaluation of Warm-Mix Asphalt	Fall 2008	Fall 2011
Carbon Footprint for Hot-Mix Asphalt and Portland Cement Concrete Pavements	Spring 2009	Spring 2011
Improved Performance of Concrete Overlays	Fall 2009	Spring 2012
Alternative Materials for Sustainable Transportation	Fall 2009	Fall 2011
Cost-Effectiveness of the MDOT Preventive Maintenance Program	Fall 2010	Fall 2012
Evaluating the Financial Cost and Impact on Long-Term Pavement Performance of Expediting Michigan's Road Construction Work	Fall 2011	Fall 2012
Preparation for Implementation of the *Mechanistic-Empirical Pavement Design Guide* in Michigan	Fall 2011	Spring 2014
Density Testing Utilizing Non-Nuclear Methods	Fall 2012	Fall 2013

Program News

Emerging technology presentations: Are you interested in innovation? ORBP is planning a series of presentations about emerging technologies and would like your input on topics. During the next fiscal year, pavement and bridge experts from Michigan university Centers of Excellence will be coming to MDOT to speak on topics of your choice. If you have a topic you would like to hear more about, please e-mail your idea to mdot-research@michigan.gov.

Region visits: ORBP will be coming to an MDOT region office near you. We would like to hear innovative ideas from our experts in the field. What should we be researching? How can ORBP help? ORBP has already had a productive meeting with the Superior Region.

ORBP

VISION: *To be a recognized leader in coordinating applied research and implementing results by identifying cutting-edge research topics, implementing research results and coordinating development of research projects. Our core strength results from a highly integrated network of dynamic partnerships among transportation professionals.*

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This publication is intended to disseminate technical information and is published by the Office of Research and Best Practices. Three hundred copies of this document were printed at a cost of $0.10 per copy for a total of $30. It is printed in accordance with Executive Directive 2007-17.