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TECHNICAL SUMMARY

Technical Liaison:
Shongtao Dai, MnDOT
Shongtao.Dai@state.mn.us

Project Coordinator:
Nelson Cruz, MnDOT
Nelson.Cruz@state.mn.us

Principal Investigator:
Eshan Dave, University of Minnesota Duluth

PROJECT COST:
$66,816

Poorly performing asphalt pavements motivated laboratory tests to predict the behavior of MnDOT's asphalt mix designs.

Laboratory Test of Asphalt Mixes Predicts Pavement Cracking Performance in the Field

What Was the Need?

MnDOT's asphalt mixture design and acceptance procedures are currently governed by mixture composition requirements, such as air content, asphalt film thickness and aggregate gradation. But how well do these indirect measures reflect the actual pavement performance in the field?

A 2011 MnDOT synthesis found that several other state highway agencies have adopted laboratory performance testing requirements, such as fracture energy tests, to determine the predicted resistance of a particular mix design to low-temperature cracking distress. The fracture energy test was partly refined through a national pooled fund effort. Research was needed to determine how MnDOT's mix design specifications could best be updated to incorporate laboratory performance testing as well as volumetric testing.

This study demonstrated that the DCT test is an accurate measure of MnDOT's asphalt mix designs and a predictor of cracking performance in the field. Performance-based specifications have been developed, and an implementation effort is underway.

What Was Our Goal?

The objectives of this study were to determine if MnDOT's current asphalt mix design composition requirements were sufficient to assure acceptable pavement performance in the field, determine what kind of laboratory performance test was necessary if composition requirements were judged to be insufficient, and develop draft performance-based specifications.

What Did We Do?

In the first phase of this study, the research team conducted a review of previous and current MnDOT projects to extract material testing and pavement performance data. Then the team developed a comprehensive database that includes the asphalt mix design records and field cracking performance data for the majority of MnDOT's asphalt mixtures and pavements. The database was then used to extract a number of data sets on which to conduct statistical analyses to determine correlations between pavement performance and properties of asphalt mixtures.

The primary objectives of these analyses were to determine whether the indirect tensile strength test, which measures the effect of moisture on the mix design, can be used as a pavement cracking performance measure; and to determine the effects of mix design parameters (asphalt binder type and amount, asphalt film thickness, voids in mineral aggregates and presence of recycled materials) on pavement cracking performance.

The research team then selected nine Minnesota roadway projects representing a diverse cross section of asphalt mixture designs and pavement structures. Team members evaluated construction plans, conducted site visits, determined field cracking performance and developed field sampling plans. Next, researchers tested 13 core samples from the roadways using the disk-shaped compact tension test to compare field cracking performance and laboratory performance test results.

continued

"MnDOT doesn't have a way to tell if its mix designs work in the field. This study has provided a relationship between the mix designs and pavement performance in the field."

—Shongtao Dai,
Research Operations Engineer, MnDOT Office of Materials and Road Research

"This MnDOT study is on the cutting edge of asphalt testing. A national effort, funded through NCHRP, is also examining lab tests for field validation of asphalt, but MnDOT's effort is aimed at incorporating the outcomes into MnDOT's specifications and laboratory testing protocols."

—Eshan Dave,
Associate Professor, College of Science and Engineering, University of Minnesota Duluth

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Minnesota Department of Transportation
Research Services & Library
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
651-366-3780
www.mndot.gov/research

The DCT testing apparatus, which measures the fracture energy of a sample asphalt core in the lab, was found to be a good indicator of field performance.

Finally, the researchers conducted an analysis to determine if any correlation exists between mix design properties and laboratory performance testing. These efforts allowed the research team to validate some of the findings from phase one of the project and determine whether any of the mix parameters could be used as cracking performance prediction parameters.

What Did We Learn?

Researchers found that the indirect tensile strength parameter was not suitable for use as a performance measure because most asphalt mix volumetric properties do not have a significant effect on indirect tensile strength. They also discovered that as the fracture energy of the cored samples decreases, a resultant increase occurs in transverse cracking performance. Thus, researchers concluded that the DCT test accurately forecasts asphalt cracking performance in the field.

The mix design parameters below resulted in improved asphalt cracking performance:

- Use of softer binders (-34 versus -28 low-temperature grades).
- Higher amounts of binder content.
- Lower asphalt film thickness.
- Higher voids in mineral aggregates.

The presence of recycled materials in asphalt mixes may cause a greater fraction of pavements to undergo cracking; however, this conclusion is preliminary since the amount of data that was available for pavements with all virgin materials was limited.

What's Next?

A follow-up project, Disc Shaped Compact Tension (DCT) Specifications Development for Asphalt Pavement, is underway to implement the findings from this study. The research team also expects to train MnDOT personnel about the laboratory methodology to be used for materials analysis using the DCT fracture energy test.

This Technical Summary pertains to Report 2015-24, "Laboratory Performance Test for Asphalt Concrete," published June 2015. The full report can be accessed at mndot.gov/research/TS/2015/201524.pdf.

*The research implemented through this project can be found in Report 2011-22, "Synthesis of Performance Testing in Asphalt Concrete" (*mndot.gov/research/TS/2011/2011-22.pdf*), and in study summary TPF-5(132), "Investigation of Low Temperature Cracking in Asphalt Pavements - Phase II (MnROAD Study)" (*www.pooledfund.org/Details/Study/395*).*