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DEPARTMENT OF TRANSPORTATION
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TECHNICAL SUMMARY

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$149,762

Crews lay down asphalt pavement at night. Pavement mixtures must be thoroughly tested for crack susceptibility.

Testing Methods for Crack Resistance in Asphalt Materials

Researchers proposed four tests to evaluate the susceptibility of asphalt materials to cracking. All four tests generated repeatable results. The three mixture tests can be used for forensic analyses. The fourth test for binders can be used in binder selection.

What Was the Need?

A number of factors lead to cracking and other damage in asphalt. Cold temperatures cause pavements to contract, triggering internal tensions that lead to low-temperature cracking. Aging asphalt binder grows brittle and under loading pressure generates bottom-up, or fatigue, cracking. A variety of causes may contribute to top-down cracking, such as mixture properties, construction practices, tire design and loading.

MnDOT, in partnership with the National Center for Asphalt Technology, and four other state transportation agencies are part of a pooled fund study to develop mixture performance testing focused on cracking. This group, termed the Cracking Group, installed eight different pavement cells at MnROAD in the summer of 2016 to examine pavement performance and testing approaches for low-temperature, top-down and fatigue cracking.

The group's approach does not embrace every potential test, including some examinations other agencies and research organizations have found potentially valuable in predicting cracking behavior of asphalt pavement materials.

What Was Our Goal?

MnDOT sought to investigate the viability of testing methods not included in Cracking Group studies. These tests would be conducted on asphalt mixtures sampled during construction of the test sections at MnROAD to help in material selection, quality control and forensic investigation of paving materials.

What Did We Do?

Preliminary testing focused on the eight MnROAD cells, pulling cores from the existing pavement before reconstructing new sections. Researchers tested these cores to refine methods for proposed tests. The team then gathered details on the binders and mixtures used in the 2016 reconstruction to use in its planned tests.

Researchers ran three tests on the eight asphalt mixtures and one test on the five asphalt binders used in the pavement mixtures at MnROAD. The asphalt mixture tests were:

- Bending beam rheometer (BBR) test of mixtures to obtain creep stiffness and strength of asphalt mixtures. This approach uses small beam specimens useful in forensic investigations.
- Low-temperature semicircular bend (SCB) test to measure fracture energy in mixtures. Currently there is no national standard test for fracture energy, but based on previous pooled fund work, MnDOT implemented the disk-shaped compact tension (DCT) test. The SCB results will be used to tie in the previous work and compare to the DCT.
- Dynamic modulus test of mixture resilience that uses smaller cylindrical specimens, a benefit in forensic studies.

To obtain asphalt binder strength, researchers used a variation of the BBR test for mixtures.

continued

"This was a knowledge-building, data-gathering study that will help fill out our materials library database to correlate test results of asphalt materials to field performance."

—David Van Deusen,
Research Operations Engineer, MnDOT Office of Materials and Road Research

"These test methods produce repeatable, consistent results, are simple to perform and differentiate between mixtures. They could provide critical information on the evolution of pavement performance since they can be used for forensic analyses."

—Mihai Marasteanu,
Professor, University of Minnesota Department of Civil, Environmental and Geo-Engineering

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The SCB test applies pressure diametrically on an asphalt pavement puck along the axis of a 6-inch pavement cylinder to measure susceptibility to cracking at low temperatures.

What Did We Learn?

The four tests proved to be viable options for materials selection testing, quality control and forensic examination of samples from existing asphalt pavements. The SCB and dynamic modulus can be run with research equipment. These tests yielded repeatable results and identified differences in the eight mixtures that are expected to impact performance. In particular, the BBR test of mixture has potential for being a practical field screening test.

The BBR test of mixtures measures strength and creep of ½-inch-thick asphalt mixture specimens compared to an indirect tensile test of strength on 2-inch asphalt pucks, and the test produces similar results. The dynamic modulus test uses the same configuration as the indirect tensile test, but instead of applying vertical compression to a 6-inch asphalt core, it applies pressure on a 1.5-inch puck diametrically, yielding similar results on an asphalt mixture's resistance to loading.

The SCB test, an alternative to the DCT test, provides similar results in measuring the fracture energy of asphalt pavement mixtures. Either of these two newer tests is viable for MnDOT use. The binder BBR strength test represents a viable alternative to the direct tension test that, due to complex sample preparation and expensive equipment, is not frequently used.

All tests found sample performance highly dependent on temperature. Fracture resistance does not correlate directly with other tested values; two mixtures that share similar creep stiffness, for example, may not have similar fracture resistance. Results indicate the eight mixtures tested may perform similarly, although one with high recycled asphalt content and another with a highly modified asphalt binder may be outliers. Based on the laboratory test results, mixtures with performance-graded binders do not differ markedly when one is mixed with recycled asphalt materials. As is the case with all pavement field studies, time is required for the mixes to begin to distinguish themselves from one another in terms of field performance.

What's Next?

MnDOT will share test results from this study with the Cracking Group team and include them in the overall examination of the MnROAD test cells. Researchers recommend comparing results to observed distresses and core tests periodically from these pavement cells to correlate field conditions and tested mixture performance over time. MnDOT will consider some of these testing methods and findings in its continuing effort to develop a performance-based balanced mix design approach for asphalt pavement.

This Technical Summary pertains to Report 2019-03, "Investigation of Cracking Resistance of Asphalt Mixtures and Binders," published January 2019. The full report can be accessed at http://mndot.gov/research/reports/2019/201903.pdf.