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OFFICE OF TRANSPORTATION SYSTEM MANAGEMENT

TECHNICAL SUMMARY

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PROJECT COST:
$80,000

This project was MnDOT's first effort to use the DCT test on actual construction projects.

New Lab Test Leads to More Crack-Resistant Asphalt Pavements

In Minnesota's first effort to use the disk-shaped compact tension test to reduce low-temperature cracking in MnDOT pavement projects, researchers performed the test on five asphalt construction projects and used the results to adjust the mixes of three pavements that did not meet minimum fracture energy standards.

What Was the Need?

Transverse cracking due to low temperatures is a significant form of distress that affects asphalt roadways in Minnesota. Cracks allow water to seep into the pavement, leading to increased deterioration.

One indication of a pavement's resistance to low-temperature cracking is its fracture energy. Traditionally, engineers have only been able to assess the LTC resistance of a particular pavement mix by evaluating the properties of the mix's individual components, in particular the liquid asphalt binder performance grade. Although PG XX-34 binders have proven effective in reducing thermal cracking, this does not account for other factors such as aggregate type, gradation, presence of recycled materials, or plant and field aging.

Two phases of a pooled fund study (available as MnDOT reports 2007-43 and 2012-23) investigated several tests for determining the fracture energy of an asphalt mixture in the laboratory. These studies concluded that binder tests alone are insufficient to predict LTC performance in the field; testing asphalt mixtures is necessary to obtain a reliable performance prediction. Furthermore, the studies determined that the disk-shaped compact tension test accurately predicted LTC of asphalt pavement in the field and recommended it for implementation. In the DCT test, a test specimen of asphalt is notched and pulled apart to determine its fracture energy.

What Was Our Goal?

This pilot project represented the first attempt to use the DCT test to measure the fracture properties of mixes used on actual construction projects rather than mix designs and to adjust the mixes if they did not meet required fracture energy values. That is a step toward broader implementation of the DCT test into pavement design and construction.

What Did We Do?

Researchers selected five asphalt pavement projects slated for construction in Minnesota in 2013 for evaluation using the DCT test. These projects represented a variety of climates, binders and construction types. Contractors provided test specimens from the mix design stage to MnDOT, and researchers performed DCT tests on them. If the specimens did not achieve a minimum fracture energy (400 J/m^2), researchers recommended adjustments to the mix before retesting and construction. Under ideal circumstances, mixes would continue to be tested and adjusted until they met the minimum fracture energy requirements, but due to time constraints only one mix adjustment was possible for each project. Researchers also performed the DCT test on the final production mixes to evaluate differences between lab and plant production.

About nine months (encompassing one winter season) after construction, researchers conducted distress surveys on four of the five projects. They calculated the amount of cracking using two methods: the length of cracking as a percentage of the total length of

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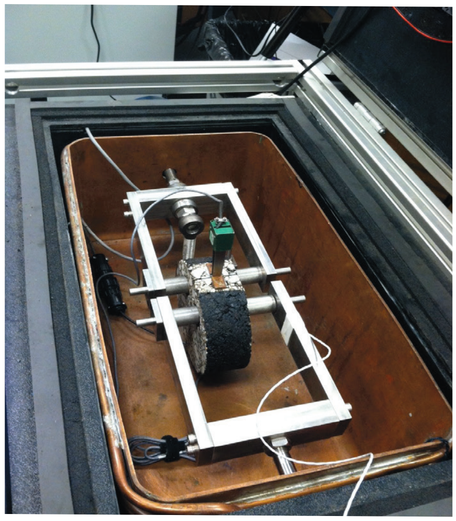

The DCT test notches and pulls apart an asphalt sample to determine its fracture energy. The test is conducted at 10 degrees Celsius above the asphalt binder's performance-graded low-temperature grade for 98 percent reliability, which ranged from -18 degrees Celsius to -30 degrees Celsius for the pavements analyzed in this project.

"This project was the first step in implementing the DCT test into actual construction projects and using it to make adjustments to mix designs."

—Chelsea Hanson,
Assistant Scientist, University of Minnesota Duluth

"This can really pay off as we get pressure to control costs and use more recycled material. We're uncomfortable varying pavement components from specifications, but the performance test will let us see if a new additive will perform the way we want it to before we construct it."

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

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the section evaluated, and the total length of cracking and number of transverse cracks. While severity of individual cracks was not reported, researchers did count the number of cracks 12 feet or longer in each project.

What Did We Learn?

Initial DCT tests found that three of the five mixes failed to meet the minimum fracture energy and were adjusted before construction. These adjustments included increasing virgin binder content in one case and reducing the reclaimed asphalt pavement content in two cases. These adjustments improved the fracture energy in all three cases, although only one of them achieved the minimum specified value.

In all five cases, the fracture energy determined at mix design stage was higher than the field production stage. Researchers could not determine the reason for the change in fracture energy within the scope of this project.

One mix, prepared for Trunk Highway 310 in District 2, had a particularly low fracture energy of 195 J/m^2. Further investigation found that the binder used in the design samples was leftover from the previous summer and had been reheated several times. This demonstrates that materials tested at mix design—particularly binders—must match production mix or a representative fracture energy will not be obtained.

After nine months, projects constructed with mill and overlay had higher amounts of cracking overall, possibly due to reflective cracking from the underlying pavement. Projects with full depth reclamation or stabilized full depth reclamation had the least cracking.

What's Next?

MnDOT has started two follow-up research projects. The first will investigate why the fracture energy of constructed pavements was lower than the mix designs by testing pavement specimens obtained at four stages (mix design, both field- and lab-compacted production mix, and cores) from eight different projects. In the second, four independent laboratories will test samples from 16 construction sites to determine how repeatable the DCT test results are at different labs.

Future implementation of this research will require determining how to add the testing requirements to contracts, which MnDOT is currently evaluating. MnDOT will also need to determine which types of projects are best-suited for DCT testing—likely new construction and reconstruction projects, but not overlays.

In the short term, the DCT test is likely to be performed by MnDOT on its own construction projects. But a long-range goal is to expand its use to local agency projects as well.

This Technical Summary pertains to Report 2015-20, "DCT Low Temperature Fracture Testing Pilot Project," published May 2015. The full report can be accessed at mndot.gov/research/TS/2015/201520.pdf.