Implementation of Low-Temperature Cracking Criteria in Iowa

tech transfer summary

The project assessed the low-temperature cracking resistance of asphalt mixtures used by the Iowa DOT and recommended performance criteria adjustments to the state specifications to ultimately reduce maintenance costs and improve the service life of Iowa pavements.

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RESEARCH PROJECT TITLE
Implementation of Low-Temperature Cracking Criteria in Iowa

SPONSORS
Iowa Department of Transportation (InTrans Project 18-650)

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Goals

The goals of this project were to assess the low-temperature cracking resistance of asphalt mixtures used by the Iowa Department of Transportation (DOT), correlate the laboratory results with field performance, and use those correlations to propose additional performance criteria.

Problem Statement

Thermal stress buildup in pavements due to low temperatures—and often large, sudden drops in temperatures—result in excessive thermal cracking that requires frequent maintenance work. This increases maintenance costs for pavements and reduces pavement service life.

Background

Iowa is among the northern US states that experience fluctuating low temperatures that cause low-temperature thermal cracking. To prevent this distress from occurring too soon in new pavements, engineers use specifications to guide them in designing asphalt pavement mixes.

Current Superpave specifications address thermal cracking at low temperatures based on creep and strength testing of asphalt binders and mixtures, but the specifications only have limiting criteria set forth in the asphalt binder specifications. In addition, these low-temperature characterization methods do not take into account the effect from the aggregate part of the mixture.

Mix test specifications consider the effect from both binder and aggregate. However, mix test specifications do not have clearly set national limits in Superpave; they are set by individual state agencies. Researchers and state DOTs within the Midwestern US have used the disk-shaped compact tension (DCT) test, the semi-circular bend (SCB) test, and the Illinois Flexibility Index Test (I-FIT) to assess low-temperature cracking/fracture in mixtures.

To avoid thermal cracking in the field, characterization of mechanical fracture of the asphalt mixture is important in predicting the pavement performance and assists the design engineer in establishing a mix design that can withstand the cold climate for the design period.

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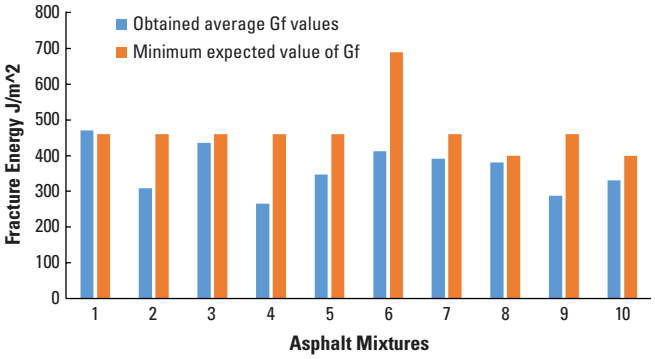
Mixture locations, representing five of six Iowa DOT districts, and regional binder grade recommendation division line



Obtained fracture energy from DCT tests vs. expected minimum values per the specification

Project Description

Ten field-produced asphalt mixtures were obtained from projects that represented typical asphalt mixtures used in Iowa. The mixtures were from Fayette, Hamilton, Harrison, Johnson, Lyon, Marshall, Polk, and Union counties.

Five mixtures were from the old design, and the other five mixtures were from the new design. The mixtures had different binder grades and aggregate gradation, voids in mineral aggregate (VMA), voids filled with asphalt (VFA), binder content, and varying percentage of the recycled material. These mixtures were reheated and laboratory-compacted using a gyratory compactor to produce 6-in. (150 mm) diameter specimens with a height of approximately 2 in. (50 mm).

To determine the fracture energies of the compacted samples, DCT and SCB tests were carried out as specified by ASTM D7313-13 and AASHTO TP 105-13, respectively. Air voids were determined prior to testing to ensure that the specimens used met the air void requirement of 7% for testing. I-FIT Procedure 405 was used for testing at intermediate warmer temperatures to get the flexibility index (FI) as well.

Key Findings

- The 10 mixtures evaluated had an average fracture energy ranging from 265–470 J/m² and 485–905 J/m² for DCT and SCB, respectively.
- The DCT fracture energies did not meet the DCT specifications contained in Instructional Memorandum 510 for the average minimum fracture energies.
- The DCT and SCB fracture energies are lower than those produced for approval to pave.
- The FI obtained for the mixtures ranged from 8.36 to 23.32.

Implementation Readiness and Benefits

This project assessed 10 field-produced asphalt mixtures used in Iowa to determine their low-temperature cracking resistance and recommends performance criteria adjustments to state specifications based on the results.

These recommended performance criteria adjustments to the state specifications will ultimately reduce maintenance costs and improve the service life of Iowa pavements.

Conclusions and Recommendations

Performance criteria adjustments and a pavement distress survey are recommended to ensure that field-produced mixtures meet design specifications from the laboratory to the field.

- The specification on the need for a DCT test should be revised to state that the test is required when the asphalt binder replacement exceeds 15% for mixtures with recycled asphalt pavement (RAP) and reclaimed asphalt shingles (RAS), rather than the current value of 30% and 25% binder replacement, respectively.
- Since most of the pavements have shown that cracking resistance is low during service life, there is a need for revising the specification or improving the quality-control process, just as the Minnesota DOT (MnDOT) has allowed a 50 J/m² range for quality assurance.
- A pavement distress survey is recommended that focuses more on the intensity of thermal- and transverse-cracking distress over the years to assess the field performance of the pavements used in this study in relation to the DCT testing results.