The Ohio Department of Transportation
Office of Research & Development
Executive Summary Report

A Simple Test Procedure for Evaluating Low Temperature Crack Resistance of Asphalt Concrete

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Problem

Low temperature cracking is one of the major distress modes in asphalt pavement and is disastrous to pavement performance and service life. A poor riding surface leads to an increase in maintenance and eventual early replacement of the pavement. Currently, there are two approaches to characterize the low temperature thermal cracking potential of asphalt concretes; (1) mechanistic-empirical analysis (Superpave Indirect Tensile Creep and Strength Test, IDT) and performance model and (2) a torture test (Thermal Stress Restrained Specimen Test, TSRST). Both methods have been validated with field performance data and predict the low temperature cracking potential of asphalt concrete mixes. However, neither test can be readily used as a routine test because of the complex test and analysis procedures for IDT and the costly specialized equipment, and the difficulty producing beam specimens for TSRST. A new simple test procedure is needed to evaluate the low temperature cracking potential for a single severe freezing event and thermal fatigue for the environment and materials commonly used in Ohio.

Objectives

This study has four main objectives:

- To determine coefficient of thermal expansion (CTE) of Ohio aggregates and mixes,
- To develop a simple test procedure, as a part of a mix design system, to determine the

thermal cracking resistance of asphalt concrete mixes,

- To validate the simple test device by laboratory testing, and
- To determine the thermal cracking resistance of typical ODOT asphalt concrete mixes prepared with local materials for the future validation of the new test device.

Description

The project includes (a) measurement of CTE of Ohio aggregate, (b) development of composite model to predict CTE of asphalt mixes and to better understand the low temperature cracking of asphalt pavement, (c) development of a ring shape asphalt concrete cracking device (ACCD), and (d) laboratory validation of ACCD.

Operating Principle of ACCD

The ACCD ring is an Invar ring with a 101.6 mm (4 in.) outer diameter, a 76.2 mm (3 in.) inner diameter, and 68.6 mm (2.7) in. height. This ring is instrumented with a strain gage rosette and a temperature sensor on the inside wall of the ring. A 254 mm (10 in.) diameter sample of asphalt is then compacted around this ring with 440 kN (100 kips) static loads. The Invar is a metal alloy with near zero CTE. As the ACCD with the compacted sample is cooled, tensile stress is developed within the asphalt specimen and compressive stress is developed within the ACCD ring due to large CTE difference between them. Ultimately, the stress in the asphalt specimen exceeds its tensile strength and the sample cracks. This crack is evident by a reduction in the strain readings on the Invar ring. The temperature at which this stress is released is defined as the ACCD cracking temperature.

Conclusions and Recommendations

- Of 14 Ohio aggregates studied, the maximum and the minimum CTEs are 11.4 and 4.0 x 10^{-6}/°C, respectively are similar to previously reported values for aggregate CTE.
- A composite model of HMA is developed to describe the low temperature cracking phenomenon.
- Orthotropic and composite nature of asphalt pavement contraction during cooling makes the effects of aggregate CTE important in low temperature thermal cracking of asphalt pavement. For asphalt mixes of similar CTE, one made of aggregate with large CTE may develop 36% more thermally induced strain (or stress) in asphalt binder than another mix with low CTE aggregate.
- A simple test device, named as Asphalt Concrete Cracking Device (ACCD), was successfully developed to measure the low temperature cracking resistance of HMA.
- The ACCD test is repeatable. For the various mixes tested, standard deviations were typically less than 1°C, with 0.78°C average.
- The ACCD test results were indirectly validated by comparing with TSRST test results. The ACCD cracking temperatures of 5 mixes with SHRP core asphalt binder correlate well with the TSRST results of mixes prepared with the same binders but with different aggregate (r^2 =0.86).
- ACCD test is simpler and faster test method than the current TSRST. The ACCD test does not require time consuming trimming and gluing processes needed in TSRST procedure. If specimen curing is not required prior to the test, multiple ACCD samples can be prepared and tested in an 8 hour-day.

Implementation Potential

ODOT may consider to adopt ACCD as screening test for low temperature cracking potential of asphalt mix design.