WSDOT Experience

Prior to the software problems WSDOT was able to test three different grades of local asphalt binder. Each of these asphalt binders was aged using the Pressure Aging Vessel (PAV) prior to testing in the ABCD. The grades of binder used in WSDOT testing were:

- PG64-28 – 1 sample
- PG70-22 – 2 samples
- PG76-28 – 4 samples

Preparation and testing of the asphalt binder samples was in accordance with the instructions from the ILS. The test data collected by WSDOT on the local asphalt binders was also sent to EZ Asphalt for analysis. A report of the ILS and Local binder test results is pending and will be sent to WSDOT upon completion.

The ABCD was a relatively simple piece of testing equipment to operate. Sample preparation was completed in approximately 2 hours and the time for completion of testing ranged from 2.5 to 3.5 hours. The amount of time needed to prepare and test multiple samples with this device will obviously impact productivity of a binder testing laboratory and should be considered if this device were considered for implementation.

Conclusions

The ABCD can measure the cracking potential of the asphalt binder under similar stress-strain conditions as found in asphalt pavements which was previously unavailable. Current test methods use data that is extrapolated to determine the low temperature failure. The ABCD directly measures the temperature where the asphalt binder fails. The ability to capture the low temperature failure point of PG binders could provide valuable design information for specifying agencies when selecting PG binders.

Due to the length of time required to condition and test samples the ABCD would be best suited for research. If the ABCD apparatus and test method is approved by AASHTO it could influence the way PG binder low temperature properties are evaluated and specified.

Based on performance of the ABCD during use at the WSDOT laboratory the software operating system may need further development to become a reliable piece of equipment for everyday use.

Contact Information

Joseph R. DeVol
Bituminous Materials Engineer, WSDOT
360-709-5421
devolj@wsdot.wa.gov

Washington State Department of Transportation

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"tech notes" is an effort by the FOSSC Materials Laboratory to share design and construction technology gained from projects done through WSDOT.

Asphalt Binder Cracking Device (ABCD)

Inter-Laboratory Study — 2009

Low temperature cracking (thermal shrinkage).

Background

There are four major failure modes in asphalt pavement – low temperature cracking, rutting, fatigue cracking, and moisture damage. This report focuses on low temperature cracking and the methodology/technology for measuring this mode of failure.

Low temperature cracking (thermal shrinkage) occurs in asphalt pavement when the thermal tensile stress that results from temperature drop within the asphalt pavement exceeds the strength at that temperature. Cracks usually appear as transverse cracks occurring at regular intervals at right angles to the direction of traffic. Thermal cracking has traditionally been controlled by limiting the asphalt binder stiffness with the assumption that binders with higher stiffness will crack at a higher temperature than softer binders. A major problem is that no method exists for validating the assumption that low temperature properties can be extrapolated from test data taken at higher temperatures. The selection of asphalt binders have long been based on this theory. The Asphalt Binder Cracking Device (ABCD) has been developed to test the low temperature properties of asphalt binders.

In the early 1990's, the Strategic Highway Research Project (SHRP) developed the binder specification that was adopted by the Association of American State Highway and Transportation Officials (AASHTO) as provisional standard designated MP1. The MP1 specification has been revised and approved by AASHTO; now designated as AASHTO M320. The asphalt binder is grade based on its performance characteristics in the M320 specification. An example of this grading system would be a Performance Grade (PG) designation such as PG64-22. This grade of binder would have a minimal potential for rutting at temperatures below 64°C or thermal cracking at temperatures above -22°C based on pavement temperature.

Currently the low temperature specification compliance of PG binders is determined from the Bending Beam Rheometer (BBR) and the Direct Tension Tester (DTT) testing. The BBR test determines the failure strain of the asphalt at low temperatures. A high failure strain is generally considered to be ductile and has better resistance to thermal cracking. The BBR test is not performed at the low temperature specified it is performed at the PG low temperature plus 10° C. The other low temperature test referenced in M320 is the DTT, this test is also performed at the PG low temperature plus 10° C. Neither of these tests are capable of determining the actual low temperature failure point of PG binders. Researchers have identified a need for a test that can take binders to failure at the actual PG low temperature specification. Current methodology uses data from the BBR and the Direct Tension Tester (DTT) to determine the critical temperature for thermal cracking (Critical Cracking Temperature). This

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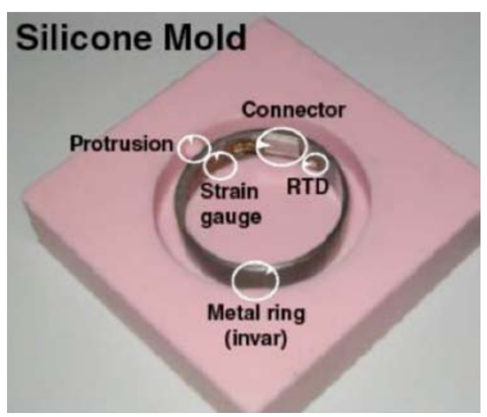
Sang-Soo Kim
Journal of Materials in Civil Engineering,
November/December 2005

temperature is defined when the calculated induced thermal stress equals the tensile strength of the binder, this calculation is both lengthy and complex. Sang-Soo Kim writes in the Journal of Materials in Civil Engineering, November/December 2005, "There is no reliable direct laboratory method to determine the temperature where asphalt binder cracks due to thermally induced stress under conditions that thermal contraction is restrained, as it is in asphalt pavement." The BBR and DTT method oversimplifies the binder rheology and uses an unreasonably large number of tests plus the strain rates used in the DTT are much faster than field rates in asphalt pavements. Therefore, the resulting DTT tensile strengths may not accurately reflect field strength.

A new laboratory testing device and method, the Asphalt Binder Cracking Device is under development by EZ Asphalt Technology. EZ Asphalt Technology was founded in 2007 by Dr. Sang-Soo Kim to create innovative highway technologies. The ABCD measures the cracking potential of the asphalt binder under similar stress-strain conditions as found in asphalt pavements. The ABCD uses a metal ring of Invar, a nickel steel alloy with a very low coefficient of thermal expansion, surrounded by the ring of the asphalt to be tested. As the temperature is lowered at a rate of 20 degrees per hour, the test asphalt shrinks more rapidly than the inner ABCD ring; this results in the development of thermal stresses. The asphalt specimen cracks when the developed thermal stress exceeds the strength of the asphalt. A strain gauge mounted in the inner ring measures these stresses (see figure 1). When the outer ring of asphalt cracks, the strain is released ending the test. The temperature is measured at this point and compared to the low temperature performance grade of the asphalt binder.

Figure 1



The software used with the ABCD is compatible with both Microsoft Windows XP and Vista operating systems. The program directly controls the environmental chamber's testing parameters and allows the technician to complete data analysis for the ABCD testing. The data collected includes cracking temperatures, cooling rate, and other select information.

Inter-Laboratory Study (ILS)

A number of approved laboratories including Washington State Department of Transportation (WSDOT) participated in the ILS. The ILS was performed under the guidelines of ASTM C802 "Standard Practice for Conducting an Inter-laboratory Test Program to Determine the Precision of Test Methods for Construction Materials" to evaluate the repeatability and reproducibility of ABCD. This project was partially funded by the U.S. Department of Transportation Federal Highway Administration and is part of the Highways for Life program. Testing included use of the ABCD device and concurrent Bending Beam Rheometer (BBR) tests on the same sample asphalt binder. At the conclusion of the testing protocol, participating laboratories were given two weeks to use the ABCD equipment for their own testing interests.

Materials Tested

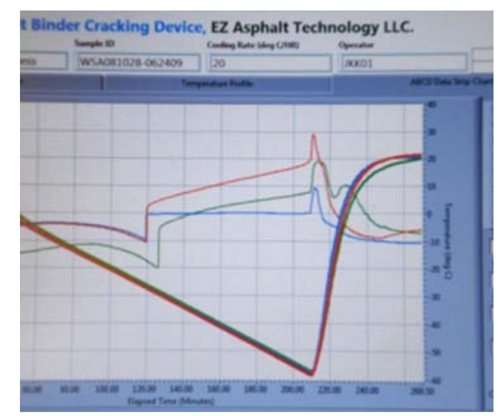
A total of eighteen tins of asphalt were supplied for the ILS. Nine of the tins were for the ABCD testing protocol and nine were for testing on the BBR. There were three different asphalt materials sent for testing. Three tins of each asphalt were designated for ABCD testing and three tins for BBR testing. The types of asphalt supplied were identified as:

- PG70-28 (SBS modified)
- PG76-22 (SBS modified)
- Blending stock

None of the asphalt samples had been aged prior to shipping to the participants. As part of the testing protocol no aging was performed on the samples before ABCD or BBR testing.

Data Collection and Reporting

From each sample tin four replicates were poured, cooled, and trimmed in the ABCD testing molds. The replicates were placed in the cooling chamber and the software program was initiated. The parameters for the test included a cooling rate of 20°C per hour to a temperature of -60°C and data was collected every 10 seconds until completion of the test. The temperature was then increased from -60°C to 25°C in 30 minutes. Data collection was stopped after the replicates reached 25°C. During this test cycle, data on the strain and temperature of each replicate was recorded.



Data Analysis

The ABCD is used to determine the critical cracking temperature of asphalt binder which is defined as the temperature when the induced thermal stress equals the tensile strength of the binder. The data analysis software looks for an increase of greater than 5 micro-strains between two data points and uses that criterion to identify the temperature where cracking occurs. The micro-strain data is displayed graphically and is apparent by a change in direction of the graphed data. The software also displays a chart that shows the cracking temperature, the strain jump, and the cooling rate. Below is an example of ABCD analyzed test data.

While testing the asphalt samples for the ILS study a problem with the software occurred resulting in no testing of the eighth and ninth replicate samples. All of the test data collected by WSDOT was sent to EZ Asphalt for analysis and reporting.

Test Date: Friday, June 19, 2009 Test Started: 4:23:37 PM Set Cooling Rate
File Saved As: **C:\ABCD\Analyzed Tests\MB65-061909 Analyzed** 20 C/hr
Project Name: ABCD Ruggedness Time Analyzed: 6/19/2009 20:21
Sample ID MB65-061909
Comment: Comment Here
Operator: JKK01

ABCD Test Results

	Sample 1	Sample 2	Sample 3	Sample 4	Average	Std Dev
Crack Temperature (C)	-37.4	-39.7	-40.6	-41.6	-39.8	1.77
Strain Jump (με)	28.5	46.7	47.9	60.4	45.9	13.15
Cooling Rate (C/hr)	-21.1	-20.7	-20.7	-20.7	-20.8	0.2

Cooling Rate is the slope of 10 consecutive time-sample temperature data when cracked