AASHTO TP-125: Bending Beam Rheometer for Low Temperature Performance of Asphalt Mixtures

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Expert Task Group Meeting
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Outline

• Background
• Sample Preparation
• Are the beams too small to test mixes?
• Is the test repeatable?
• Do test results relate to performance?
Background

• Transverse Cracking- also known as thermal cracking

Transverse Cracking

• Existing tests used to evaluate the asphalt mixtures’ low-temperature mechanical properties and predict low-temperature distress:
  • Indirect Tensile test (IDT)
  • Thermal Stress Restraint Specimen test (TSRST)
• Tests are not used on a regular basis
  • Equipment
  • Materials
  • Complexity
Background Cont’d

• Bending Beam Rheometer test (BBR)
• Normally used in binder grading
• Researches at University of Utah and University of Minnesota have shown that the modified BBR test, adopted from the AASHTO BBR binder test, is valid for asphalt mixtures
• Recently voted as AASHTO TP 125 Provisional Standard
Sample Preparation

From SGC to Beams
Sample Preparation

12.7 mm x 6.35 mm x 127 mm
± 0.25 mm tolerance
Span of BBR = 101.6 mm
Beam Measurement

12.7 mm x 6.35 mm x 127 mm (width x thickness x length)
± 0.25 mm tolerance
Span of BBR = 101.6 mm
Is the BBR test too small for asphalt mixtures?

Representative Volume Element Analysis
Property Being Measured

- Composite Theory
  - In materials having spatial disorder with no microstructural periodicity (Asphalt Concrete) the stress, strain, or energy field is averaged over domain
- Approach not valid for Strength (fracture) of Material
- BBR Measures Flexural Creep Modulus
Aggregate to Beam Dimensions Ratio

- **4.75-mm Mixture**
  - NMAS / Width Ratio ~ 1/3
  - NMAS / Thickness Ratio ~ 3/4

- **9.5-mm Mixture**
  - NMAS / Width Ratio ~ 3/4
  - NMAS / Thickness Ratio ~ 1.5/1

- **12.5-mm Mixture**
  - NMAS / Width Ratio ~ 1/1
  - NMAS / Thickness Ratio ~ 2/1
Visual Analysis

- 13 Different Areas Within Each Mixture
  - Each area cropped and magnified
- Statistical analysis confirmed equal amounts of aggregate between scaled images of mixtures
Statistical Analysis

• Homogeneity of Variances
  • Equal variances across sample groups

• If creep modulus data sets for all mixtures have equal variances then the beams 12.7-mm x 6.35-mm x 127-mm meet RVE requirements.
Beam Size Conclusions

- Three mixtures of descending NMAS:
  - Evaluate large particles effect on variability compared to small particle effect.
- 18 sample groups prove to have equal variance.
- 12.5-mm, 9.5-mm, 4.75-mm
- Optimum AC, +0.5% to -0.5%.
- Analysis performed for 60 & 120 seconds.

12.5-mm NMAS introduce no more variability in BBR testing than a scaled equivalent 4.75-mm NMAS mixture.

Large aggregates do not create outliers within data sets.
Is the BBR Test Repeatable?

Multi-lab comparison
Time since cutting analysis
Objective

- Even though the BBR Test has been shown to be valid, there is no standardized specification.
  - Ruggedness Study
  - Precision - Bias Statement
- In order to use this as a quality control device, the repeatability of the test must be understood.
  - 1. The reproducibility of the BBR test across Labs
  - 2. The effect of time interval on Material's low-temperature properties
Experiment Procedures

- 60 beams were **cut** from 3 asphalt mixture pucks
- 40 of them were chosen at random from these 60 beams
- 20 beams for U of U Lab, 20 beams for UDOT Lab
- Each lab’s set of 20 specimens was divided into 4 groups of 5 beams to run each group at different time intervals
  - 2 days since cutting
  - 3 days since cutting
  - 1 week since cutting
  - 2 weeks since cutting
Multi-lab Differences

Stiffness

m-value
Interval Comparison

Stiffness and m-value variation for both labs over different test interval at 60s.
Repeatability Conclusions

- The BBR test has reasonable reproducibility across multiple laboratories for quantifying the low temperature properties of asphalt concrete.
- Steric hardening has no effect on BBR test results after 48 hours, since measurements of stiffness and m-value did not vary with time interval.
- Stiffness has less variation than m-value in all of the comparisons.
Are the Results Related to Performance?

Field Evaluation of Mixes
Field Samples

- 7 State Roads
- Deep pavements
  - No reflective cracking
- Low-temperature required binder grade = -28°C
# Test Results

## Same binder grade

<table>
<thead>
<tr>
<th>Project</th>
<th>Creep Modulus @ 60s Min PG + 10°C (MPa)</th>
<th>m-Value @ 60s</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR 48</td>
<td>10 605</td>
<td>0.155</td>
</tr>
<tr>
<td>SR 68</td>
<td>4 416</td>
<td>0.183</td>
</tr>
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### Test Results

#### High Modulus

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## Test Results

### Low m-value

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Results

Black Space Diagram

Field Sample Creep Modulus vs. m-Value
@ 60s Min PG + 10°C

Creep Modulus (MPa)

Likely to Crack
Not Likely to Crack
Field Surveys

June 13th, 2012 - No Visible Distresses
January 9th, 2013 - No Visible Distresses
Temperature data
SR 111

June 13, 2012 →

January 23, 2013 →
Results

Field Sample Creep Modulus vs. m-Value
@ 60s Min PG + 10°C

Creep Modulus (MPa)

- C13
- C14

m-Value

Likely to Crack
Not Likely to Crack
Results

3 out of 4 predictions cracked
Field Validation Conclusions

• Binder testing alone is not sufficient to determine mixture performance
  • All mixtures used PG 64-28, but had varying creep moduli and m-Values
• BBR test results can be used to predict sections with potential for low temperature cracking
Overall Conclusions

• BBR testing is practical
  • Coring or compacting, cutting, and testing at one temperature could be completed in one work day
• BBR testing on mixtures is repeatable across labs

• A specification to predict low-temperature performance of asphalt concrete must include the creep modulus and relaxation modulus
  • In Black Space, a possible thermal stress failure envelope could be developed
• Performance-related specification will allow for innovation
Questions

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