Moving towards Performance Based Testing
Semi-Circular Bend Test

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Mansour Solaimanian,
Pennsylvania State University
Our Great Folks on This Project

Scott Milander
NECEPT Lab Coordinator

Xuan Chen
PhD Candidate
Outline

• A Review of Asphalt Concrete Fatigue Tests
• Semi-Circular Bend (SCB) Test
• PennDOT/Industry Initiative on Performance Testing
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Lab Scale Tests

Monotonic Tests
• Indirect Tensile
• Semi-Circular Bend
• Disk-Shaped Compact Tension

Cyclic Tests
• Four Point Bending Beam
• Indirect Tensile
• Uniaxial Push-Pull
• Texas Overlay

Picture Courtesy: IPC Global, Umass, Penn State
Lab Scale Tests (Cyclic Tests)

Texas Overlay Tester

Fatigue/Cantilever Trapezoid

Bending Beam
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Background on SCB

• Early Work on Rocks (Chong and Kuruppu, 1984)
• Introducing SCB for Asphalt Testing (Molenaar, 2000 & 2002)
• Further Research (Mohammad et al., 2004) - LA
• Further Research – IFIT (Alqadi et al., 2015) - IL
• Implementation in Specs (Mohammad et al., LTRC, 2016)
SCB Test Apply on Rocks (Initial Application)

Photo Source: Lim et al. 1984
SCB Test Applied to Rocks

SCB Testing of Granite Rock

Photo Source: Dynamic Behavior of Materials, Vol.1
SCB Test Applied to Rocks

Compression-Induced Fracture Surfaces and Failure Mechanism

Photo Source: Advances in Materials Science and Engineering Vol. 2014, Article 814504
SCB Test Setup

Specimen Thickness: 50 mm
Notch Depth: 15 mm
Notch Width: 1.5 mm
Parameters Used For Evaluation

Fracture Energy
\[ G_f = \frac{W_f}{B \cdot L} \]

Flexibility Index
\[ FI = A \times \frac{G_f}{\text{abs}(m)} \]

Stiffness Index
Slope @ 50% Peak Load in Pre-Peak Curve

**B**: Specimen Thickness

**L**: Ligament Length

**A**: Constant
Advantages of SCB Test

- Specimen Easily Prepared Using SGC or Field Cores
- Four Specimens from One Compacted Mix
- Easy to Perform and Simple to Analyze
- Possible To Perform Test Using Marshall-Type Stability Tester
Test Loading Rate

Current Protocols:
- 50 mm/min (too fast, not enough data points, higher COV)
- 0.5 mm/min (too slow, affected by creep)

Findings:
- Loading rate between **5 to 20 mm/min** will minimize the effect of creep, and provide a reasonable range for FI for long term aged mix.
Specimens After Cutting
Ready for Testing

Specimens Before (L) / After (R) Testing
Typical Load vs Displacement Curves
3 Replicates, PG 58-28, 25°C
Effect of Binder Grade (Stiffness)

STOA, 7% AV, 5.2% BC
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How Did it Start?

• Move to Performance Testing

• Initiated by Asphalt Quality Improvement Committee and PAPA

• Industry Expressing Interest in Participating
Purpose of the Effort

- Bridge the Gap to Performance Testing
- Investigate Performance of PA Mixes in SCB
- Develop A Database of SCB Test Results
- Evaluate Sensitivity of the PA Mixes to the Test
- Evaluate Correlation with Field Performance
Mix Criteria and Variables

- Air Void: 5.5% (Final SCB Specimen)
- Design Binder Content (and +0.5%)
- Mixes with 15% RAP at Design BC and at 0.5% Higher Binder Content
- Mixes at higher RAP Contents
- NMAS: 4.75, 9.5mm, 12.5mm, 19mm, 25mm
Plant vs Lab, and Aging Effect

**Lab Prepared Mix**
- Short Term Aged (2hr @ 275F)
- Long Term Aged (5 days @ 185F)

**Plant Prepared Mix**
- Short Term Aged
- Long Term Aged
What Do We Do with the Plugs?

Once Received at NECEPT, Enter into Database:

- Identification Code
- Source
- Date of Compaction
- Date of Receipt at NECEPT
- Lab vs Plant Mix
- Aging Condition
- Air Void
Current Status (as of 1/15/18)

- # of producers, 7
- # of plugs, 41
- Of Plant Mixes, 2
- Of Lab Mixes, 2
- Of SCB Tests, 1
- Of plants (4.75, 9.5, 19, 15)
- Of producers (0, 10, 15)
Current Status (As of 1/15/18)

- # of plugs from producers varies: 1, 2, 3, 4, 10, 16
- All with PG 64-22
- First Plug received: 11/28/2017
- Latest Plug received: 1/10/2018
Processing/Testing Specimens

• Photos
• Specific Gravity Measurement
• Cut into 4 Specimens
• Specific Gravity Measurement
• Conduct SCB
Specimen Preparation

- SGC Specimen or Field Cores
- Cut to Ensure Minimum AV Gradient
- Obtain Density
- Condition Specimens at Test Temperature
- Conduct Test
Industry SCB Test Results

Repeatability of Industry SCB Specimens

![Graph showing load vs. displacement for Industry SCB specimens.](image)
Industry SCB Test Results

**Mix Source A:** Plant mix, NMAS 9.5mm, PG64-22, 4.5% AV.
Industry SCB Test Results

Mix Source A: Plant mix, NMAS 9.5mm, PG64-22, 4.5% AV.
Industry SCB Test Results

Mix Source A: Plant mix, NMAS 9.5mm, PG64-22, 4.5% AV.
Waiting for More Specimens

• Continue Receiving Material
• Continue Cataloging/Testing Materials
• Continue Analysis

PLEASE:
• Label Materials Properly
• Ship/Transport Safely
• Include Mix Information/JMF/Compaction Date
Thank You!