Asphalt Mix Performance Testing for PA
An Update

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DISCUSSION TOPICS

1. Performance Based Testing/SCB Initiative

2. Long Life Asphalt Pavements

3. An Update on SCB Test Results
DISCUSSION TOPICS

1. Performance Based Testing/SCB Initiative

2. Long Life Asphalt Pavements

3. An Update on SCB Test Results
Design/Place A Mix that Does Not Rut Crack
Balanced Mix Design
The Goldilocks Principle
Need Proper Performance Test for Balanced Mix Design

• Two Important Considerations:
  • Need Right Test and Reliable Criteria
  • Don’t Forget the Effect of Pavement Structure
Examples of Performance Tests

Wheel Tracking

DCT

SCB
Industry SCB Testing: 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
SCB Test Setup

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

Fracture Energy

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

**B:** Specimen Thickness  
**L:** Ligament Length

Flexibility Index

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

**A:** Constant

Stiffness Index

Slope @ 50% Peak Load in Pre-Peak Curve
Performance Test & LLAP driven by:

- TQI
- STIC
DISCUSSION TOPICS

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Heavy Duty ID2 placed in 1991 – 25 years

Trying to make this the rule rather than the exception.
LLAP Best Practices

- MTV Required
- Longitudinal Joint Density Specification
- Ride Specification Optional
- Tack Coat Every Layer (New Section 460)
- % Within Tolerance (PWT) Acceptance
- Incentivize Critical Elements (i.e. Mat Density)
LLAP Performance Tests
Rutting Test

- **Hamburg Wheel Tacking Test. (AASHTO T 324)**
  - Measures rutting potential and gives an indication of moisture sensitivity.
  - Gyratory samples %7.0 (+/- %1.0) air voids
  - Test run at 131°F (55°C)
  - 12.5mm (0.5 inch) rut at 20,000 cycles general rule of thumb for limit on superpave.
Cracking Test

- **Disk-Shaped Compact Tension (DCT) testing. (ASTM D7313)**
  - Measures fracture energy
  - Gyratory samples ±7.0% (±1.0% air voids).
  - Test run at 10°C above the low PG mix designation. (-12°C (10.4°F) for PG64-22)
  - Fracture energy requirements vary depending on mix type (SMA) and layer (wearing, binder)
Cracking Test

- **Semi-Circular Bending (SCB)** testing. (AASHTO TP 105)
  - Measures fracture energy

- Samples fabricated from gyratory samples or cores.

- Test run at $10^0\,\text{C}$ above the low PG mix designation. (-$12^0\,\text{C}$ ($10.4^0\,\text{F}$) for PG64-22)

- Fracture energy requirements vary depending on mix type (SMA) and layer (wearing, binder)
Cracking Test

- **Illinois Flexibility Index** Test (IFIT) (AASHTO TP 124)
  - Measures fracture energy and post peak slope.
  - Uses fracture energy and load/displacement slope to compute Flexibility Index.
  - Gyratory samples %7.0 +/- %1.0 air voids
  - Test run at 25°C +/- 0.5°C (77°F).
  - Flexibility Index requirements vary depending on mix type (SMA) and layer (wearing, binder)
Cracking Test

- **Overlay Test** (OT). (TEX-248-F)
  - Measures fatigue or reflective cracking potential.
  - Gyratory samples %7.0 +/- %1.0 air voids.
  - Test run at 25° C (77°F).
  - Applies load to induce 0.025 (3/128ths) inches displacement.
  - Number of cycles to failure is reported along with percent decline in load.
Long Life Asphalt Projects – DCT data

DCT Performance Diagram

DC(T) Fracture Energy (J/m²)

Hamburg Rut Depth (mm)

Producer 1

Producer 2

Producer 3
Long Life Asphalt Projects – IFIT data
Long Life Asphalt Projects – Overlay Test data
Long Life Asphalt Projects – SCB Test data

SCB Data at -12C and -24C degrees
Fracture Energy (J/m²)

Hamburg Rut Depth (mm)

-24 Degrees C
-12 Degrees C
### Data Comparison

<table>
<thead>
<tr>
<th>Producer 1</th>
<th>Producer 2</th>
<th>Producer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eff. AC</strong> – 6.6%</td>
<td><strong>Eff. AC</strong> – 6.5%</td>
<td><strong>Eff. AC</strong> – 6.2%</td>
</tr>
<tr>
<td><strong>VMA</strong> – 18.7</td>
<td><strong>VMA</strong> – 18.2</td>
<td><strong>VMA</strong> – 18.1</td>
</tr>
<tr>
<td>Pass #4 – 38% = 47% retained</td>
<td>Pass #4 – 39% = 52% retained</td>
<td>Pass #4 – 48% = 54% retained</td>
</tr>
<tr>
<td>Pass #8 – 22% = 16% retained</td>
<td>Pass #8 – 21% = 18% retained</td>
<td>Pass #8 – 25% = 23% retained</td>
</tr>
<tr>
<td><strong>Coarse</strong></td>
<td><strong>Coarse</strong></td>
<td><strong>Coarse</strong></td>
</tr>
<tr>
<td>Type – Calcareous Sandstone</td>
<td>Type – Sandstone</td>
<td>Type – Sandstone / Shale</td>
</tr>
<tr>
<td>Sodium – 1%, LA – 21%</td>
<td>Sodium – 5%, LA – 32%</td>
<td>Sodium – 2%, LA – 15%</td>
</tr>
<tr>
<td>Flat &amp; Elongated 3:1 – 8.7%</td>
<td>Flat &amp; Elongated 3:1 – 3.0%</td>
<td>Flat &amp; Elongated 3:1 – 1.4%</td>
</tr>
<tr>
<td><strong>Fine</strong></td>
<td><strong>Fine</strong></td>
<td><strong>Fine</strong></td>
</tr>
<tr>
<td>Type – Limestone</td>
<td>Type – Limestone</td>
<td>Type – Limestone / Dolomite</td>
</tr>
<tr>
<td>Sodium 5%</td>
<td>Sodium 5%</td>
<td>Sodium 2%</td>
</tr>
</tbody>
</table>
Mix Comparison

Producer 1

Producer 3
Long Life Asphalt Paving Project - IFIT

IFIT Performance Diagram

IFIT Flexibility Index

Lab Samples

Core Samples
Challenges

• Limits from one region may not apply in all others.

• Aggregates seem to matter. (Not just liquid asphalt)

• Testing labs that can do the tests are very limited.
Implementation Challenges

• Implementation will not be quick or simple.
  • Pick performance test(s)
  • Decide on test protocols.
  • Specification pilot(s).
  • Who will be doing testing and how large of an investment is the equipment?
    • Contractors / Producers
    • Special Testing Labs
  • Enough lead time between project bid and paving?
  • Trained technicians to run testing?
  • After the initial rush to get testing done will there be enough tests run to sustain an industry?
DISCUSSION TOPICS

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3. An Update on SCB Test Results
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
Statistics

TOTAL NUMBER OF SGC PLUGS RECEIVED = 85

Number of Plugs in each Category

<table>
<thead>
<tr>
<th>NMAS, mm</th>
<th>Count</th>
</tr>
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<tbody>
<tr>
<td>4.7</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>9.5</td>
<td>3</td>
</tr>
<tr>
<td>75</td>
<td>75</td>
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<table>
<thead>
<tr>
<th>RAP Content, %</th>
<th>Count</th>
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</tr>
<tr>
<td>1</td>
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<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>52</td>
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# Summary of SGC Plugs Tested

(total of 85)

<table>
<thead>
<tr>
<th>Source</th>
<th>Mix Origin</th>
<th>Mix Condition</th>
<th>NMAS, mm</th>
<th>Binder Grade</th>
<th># of Binder Contents</th>
<th>RAP</th>
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<tbody>
<tr>
<td>01</td>
<td>Plant</td>
<td>Long</td>
<td>9.5</td>
<td>64-22</td>
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<td>15</td>
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<tr>
<td>02</td>
<td>Plant/Lab</td>
<td>Short/Long</td>
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<td>64-22</td>
<td>6</td>
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<tr>
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<td>Plant</td>
<td>Short/Long</td>
<td>9.5</td>
<td>64-22</td>
<td>2</td>
<td>0</td>
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<tr>
<td>04</td>
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<td>Long</td>
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<td>64-22</td>
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<td>0</td>
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<tr>
<td>05</td>
<td>Plant/Lab</td>
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<td>06</td>
<td>Plant/Lab</td>
<td>Short/Long</td>
<td>9.5</td>
<td>64-22</td>
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<td>9.5, 19</td>
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<td>15, 20</td>
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<tr>
<td>11</td>
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<td>Long</td>
<td>9.5</td>
<td>64-22</td>
<td>1</td>
<td>0, 15</td>
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</tbody>
</table>
Asphalt Content

Number of Plugs in each BC Category

<table>
<thead>
<tr>
<th>Binder Content, %</th>
<th>Number of Plugs</th>
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</thead>
<tbody>
<tr>
<td>4.6</td>
<td>3</td>
</tr>
<tr>
<td>4.7</td>
<td>4</td>
</tr>
<tr>
<td>4.8</td>
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</tr>
<tr>
<td>5.0</td>
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<td>5.2</td>
<td>2</td>
</tr>
<tr>
<td>5.4</td>
<td>2</td>
</tr>
<tr>
<td>5.5</td>
<td>8</td>
</tr>
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<td>5.6</td>
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<td>5.7</td>
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<tr>
<td>6.8</td>
<td>5</td>
</tr>
<tr>
<td>6.9</td>
<td>2</td>
</tr>
</tbody>
</table>
Industry SCB Test Results
Reported vs. NECEPT Measured Air Void Comparison

![Graph showing the comparison between NECEPT Measured Air Void and Reported Air Void. The graph plots NECEPT Measured AV, % on the vertical axis against Reported AV, % on the horizontal axis. The data points are scattered along the line of best fit, indicating a strong correlation.]
Specimen Preparation

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

Specimens After Cutting
Ready for Testing

Specimens Before (L) / After (R)
Testing

5 mm/min
Industry SCB Test Results

Results from Specimens Prepared with High Quality, COV of AV < 5%
Industry SCB Test Results

Overall Data Range and Distribution: Air Void (After Cutting)

STOA, Average: 5.04%

LTOA, Average: 5.36%
Industry SCB Test Results

Overall Data Range and Distribution: Fracture Energy

**STOA**

![Fracture Energy Graph (STOA)](image)

**LTOA**

![Fracture Energy Graph (LTOA)](image)
Industry SCB Test Results

Overall Data Range and Distribution: Flexibility Index

![Graph showing flexibility index for STOA and LTOA](image-url)
Industry SCB Test Results

Overall Data Range and Distribution: Peak Load

**STOA**

**LTOA**
General Observations (G.O.)

1. Higher AC Content → higher F.I.
2. Higher RAP content lower F.I.
3. Longer aging → lower F.I.
4. Plant mix has higher F.I. than lab mix
5. Higher voids → higher F.I.
6. SMA mix delivers high F.I.
7. Finer mix with high BC → higher F.I.
Binder Content Effect

![Graph showing the effect of binder content on flexibility index for different plant mixes (STOA and LTOA). The graph plots binder content, %, against flexibility index. STOA shows a linear increase with higher binder content, while LTOA has a more gradual increase.]
RAP Content Effect

All Specimens were STOA

Flexibility Index

RAP Content, %

NMAS=9.5
NMAS=4.75
NMAS=25
RAP Content Effect

All Producers

Flexibility Index vs Stiffness Index, Newtons/mm

- STOA-With RAP
- STOA-No RAP
Aging Effect

\[ y = 0.2694x + 0.9484 \]

\[ R^2 = 0.6801 \]
Aging Effect

All Producers

Graph showing the relationship between Stiffness Index (in Newtons/mm) and Flexibility Index for STOA and LTOA producers.
SMA vs Conventional Mix

- STOA
- 9.5mm
- PG64-22/PG76-22

<table>
<thead>
<tr>
<th>Specimen</th>
<th>BC (%)</th>
<th>AV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specimen 1</td>
<td>6.4%</td>
<td>4.5%</td>
</tr>
<tr>
<td>Specimen 2</td>
<td>6.9%</td>
<td>5.3%</td>
</tr>
</tbody>
</table>

Bar chart showing:
- PG64-22 + 15%RAP: BC 5.9%, AV 4.7%
- PG76-22 + 0%RAP: BC 6.9%, AV 5.3%

Legend:
- BC: 5.9/6.4/6.9%
- AV: 4.5/4.7/5.3%
- 0/15% RAP
Where should we go next?

1. Gather information from producers on details of aging protocol and specimen preparation
2. More SCB testing to fill in some of the gaps.
3. Test mix(es) with proven good long term performance.
4. Test to determine long term effects of rejuvenators.
5. Track mix performance in the field to verify lab predictions.