Update

NCHRP Project 9-61
Short- and Long-Term Binder Aging Methods to Accurately Reflect Aging in Asphalt Mixtures

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Research Team

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Today’s Outline

• Review Objectives and Tasks
• Review Evaluation of Conditioning Procedures
• Planned Experimental Work
• Schedule
Objectives

• Evaluate laboratory conditioning procedures
  – AASHTO T 240, AASHTO R 28 and alternatives

• Recommend improvements
  – New procedure
  – Modifications to existing procedures

• Calibrate the improved procedures to accurately simulate aging
  – Mixture production, transport, and placement
  – Service life of the pavement
Approach

- Task 1. Evaluate and Select Methods
- Task 2. Prepare Experimental Plans
- Task 3. Prepare Interim Report
- Task 4. Conduct and Analyze Experiments
- Task 5. Perform Industry Impact Assessment
- Task 6. Prepare Methods in AASHTO Format
- Task 7. Prepare Final Report
Guiding Principles

• Binder aging is a two stage process
  – Short-Term or Construction
    • High temperature
    • Oxidation and volatile loss
  – Long-Term or Service life
    • Service temperature
    • Oxidation
  – Laboratory conditioning needs to address both
    • Short-term at typical construction temperatures
    • Long-term requires a compromise to accelerate the process
Guiding Principles

- Conditioning procedures must yield enough binder for current specification testing
  - 4 mm DSR is an excellent tool for research and forensic evaluation but it is not ready for use in practice

- Conditioning procedures need to be calibrated to pavements
Transverse Cracking in SPS 8 Sections

Length of Transverse Cracks, m

Pavement Age, yrs

- AR
- CA
- MS
- NM
- NC
- MO
- NY
- OH
- WI
Practice Related Conditioning Issues

AASHTO T 240 (RTFOT)
- Uniformity of the film
- Some modified binders tend to crawl out of the bottle
- Shape of the bottle makes recovery of the binder and cleaning difficult
- Procedure does not address WMA

AASHTO R 28 (PAV)
- Concern that conditioning is not severe enough
- Service life that is simulated is not well defined
# Alternatives Considered

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Short-Term</th>
<th>Long-Term</th>
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</thead>
<tbody>
<tr>
<td>Ageing Profile Test (UK)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Modified German Rotating Flask</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>PAV Modifications</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>• Film Thickness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Pressure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Mixing (Ultrasonic or Acoustic)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rotating Cylinder Ageing Test</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Stirred Air Flow Test</td>
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</tr>
<tr>
<td>Universal Simple Aging Test (USAT)</td>
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<td>X</td>
</tr>
</tbody>
</table>
Evaluation Criteria

- Address issues with current procedures
- Quantity of binder
- Number of binders per run
- Conditioning time
- Field calibration
- Standardization
- Equipment availability and cost
- Training effort and cost
Short-Term Selections

- Modifications to AASHTO T 240 made in the U.K. Ageing Profile Test

- Thicker Film USAT
  - Around 0.8 mm rather than 0.3 mm to increase yield
Long-Term Selection

• PAV Optimization
  – Thinner film
  – Longer condition times
  – Increased temperatures
  – Ruled Out
    • Increased pressure
      – Current vessel design
      – Shape of pressure dependency of oxidation reactions
  • Ultrasonic or Acoustic Mixing
    – Not successful in preliminary testing
PAV Film Thickness

- AAF-1, 20 hrs
- AAF-1, 40 hrs

Log Stiffness, MPa

m-value

0.45
0.40
0.35
0.30
0.25
0.20

1.70 1.75 1.80 1.85 1.90 1.95 2.00 2.05

3.18 mm
1.59 mm
1.08 mm
0.80 mm

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"Engineering Services for the Asphalt Industry"
Phase 2 Experiments

• Short-Term
  – Selection
  – Calibration

• Long-Term
  – PAV Operating Parameters
  – Calibration

• Sensitivity Study
Short-Term Selection

• Make final selection of short-term procedure
  – AASHTO T 240
  – AASHTO T 240 with mixing screw
  – Static thin film (0.8 mm)

• Compare binder conditioning procedures to binder recovered from short-term oven conditioned mixtures
  – NCHRP 9-52 recommendations
    • HMA 2 hours at 135 °C
    • WMA 2 hours at 116 °C
# Short-Term Selection Binders

<table>
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<tr>
<th>Binder</th>
<th>Viscosity Pa·s</th>
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<tr>
<td></td>
<td>135 C</td>
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<tr>
<td>Neat PG 52-34</td>
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<tr>
<td>Terpolymer PG 64-34</td>
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<tr>
<td>Neat PG 64-22</td>
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<tr>
<td>SBS PG 76-22</td>
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<tr>
<td>SBS PG 64-34</td>
<td>1.21</td>
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<tr>
<td>SBS PG 76-28</td>
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Initial Results
Initial Results

![Graph showing the relationship between Viscosity and Conditioning Temperature with data points for 163 C and 135 C.]
Short-Term Calibration

- Calibrate the selected procedure (varying conditioning time) to reproduce properties of binder recovered from short-term conditioned loose mix
- NCHRP 9-52 recommendations
  - HMA 2 hours at 135 °C
  - WMA 2 hours at 116 °C
PAV Operating Parameters

• Investigate how to reasonably simulate more aging using the PAV

• Vary
  – Thickness: 1.59 mm to 0.8 mm
  – Time: 20 to 40 hours
  – Temperature: 100 to 120 ºC

• Compare to recovered binders
  – Hot Climate ARC Arizona Validation (4 & 9 yrs)
  – Cool Climate ARC Minnesota Validation (5 &11 yrs)
  – 3 depths
# Factorial Design

<table>
<thead>
<tr>
<th>Run</th>
<th>Temp., °C</th>
<th>Mass, g</th>
<th>Time, hrs</th>
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<td>2</td>
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<td>9</td>
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<td>18.8</td>
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<tr>
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<td>120</td>
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## ARC AZ and MN Binders

<table>
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<tr>
<th>Site</th>
<th>Grade</th>
<th>Source</th>
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<tbody>
<tr>
<td>Arizona US 93</td>
<td>PG 76-16</td>
<td>WTI/WTS blend</td>
<td>Airblown</td>
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<tr>
<td></td>
<td>PG 76-16</td>
<td>Venezuelan</td>
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<tr>
<td></td>
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<td>Terpolymer</td>
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<tr>
<td></td>
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<td>Middle East Blend</td>
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<tr>
<td></td>
<td>PG 58-28</td>
<td>Venezuelan Blend</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Recovered Binder Locations

**Minnesota Sections**
Built 2006
Cores from 2011 and 2017 (years 5 and 11)

**Arizona Sections**
Built 2001
Cores from 2005 and 2010 (years 4 and 10)
Long-Term Calibration Using Original Binders and Cores From LTPP

30 Pavements
Age: 8 to 19 yrs
Degree Days: 1400 to 5800
Sensitivity Study

• AASHTO M 320 Table 1 and AASHTO M 332 grade several binders
  – Current AASHTO T 240 and AASHTO R 28
  – Improved procedures developed in NCHRP 9-61
  – Materials with proven performance
  – Newer materials
  – 10 binders

• Information for the Industry Assessment
Status

• Phase 1 complete
  – Interim report available from NCHRP

• In-Progress
  – Short-Term Selection Experiment
  – PAV Operating Parameters Experiment

• Panel review prior to calibration this summer

• Project completion date August 31, 2019
Questions/Discussion

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