Team members

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Their efforts on the projects and presentation are greatly appreciated.
FHWA MATT Program

• Mobile Asphalt Testing Trailer (MATT)
• AASHTO Accredited
• Superpave™ Technology
  – Test
  – Evaluate
  – Refine
  – Improve
  – Implement
Challenges

- National discussions of GTR modified binder testing ongoing challenges
  - Aging: RTFO & Long Term conditioning
  - Solubility
  - Separation
  - DSR testing: Different gap sizes, Concentric Cylinder testing
  - Low temperature specimen preparation
Project Description – AZ 2015

• Project Location:
  – Arizona

• Open Graded Friction Course (OGFC) mixtures:
  – Three different Terminal blended Asphalt Rubbers
  – Hybrid Binders: GTR + SBS
    ✓ PG70-22 SBS
    ✓ PG70-22 TR+  (8 % GTR + 2 % SBS; solubility limit of 97%)
    ✓ PG70-22 TR+ S92  (8 % GTR + 2 % SBS; solubility limit of 92%)
Solubility

- Use of toluene as the solvent
- The addition of an analytical filter
- Some differences in solubility
Separation tests conducted following ASTM D7173: samples are stored in vertical tubes in an oven at 163 °C for 48 hours. Test specimens taken from the top and bottom of the vertical storage tube are measured using AASHTO T 315. GTR is separating and sinking to the bottom of the separation tube.
PG Results: PG 70-22 TR+ (S97)

1 & 2 mm gap vs. Cup and Bob

- Same PG grade
- Cup & Bob (CC 17) slightly higher $G^*/\sin\delta$ value: perhaps due to shelf-aging of material
- Cup & Bob: smallest values of standard deviation
PG Results: PG 70-22 TR+ (S92)

1 & 2 mm gap vs. Cup and Bob - Original

- PP 1mm shows different material behavior
- PP 1mm: possible particle interactions with plates -> 
  higher stiffness & more elastic type behavior
- Similar results for PP 2mm and Cup & Bob
DSR PG Results: 1 vs. 2 mm gap

PG 70-22 TR+ (S 92) – Original binder at 76 °C

For gap sizes of 1 to 2 mm: when there is an interaction of the rubber particles with the testing plates ->

↑ gap : ↓ variability, ↓ the complex modulus, ↑ the phase angle.

Lower G*/sinδ and phase angle for 1mm
PG Results: PG 70-22 TR+ (S92)

1 & 2 mm gap vs. Cup and Bob - RTFO

- Same PG grade
- PP 1mm: possible particle interactions with plates -> lower phase angle (more elastic type behavior)
- Differences decreased after RTFO conditioning
DSR PG Results: PG 70-22 TR+ (S 92)

- 2mm vs. Cup & Bob: most similar results
- Differences decreased after RTFO aging ...
**DSR PG Results: 1 vs. 2 mm gap**

*Statistical Analysis – Effect of 1mm increase in gap*

<table>
<thead>
<tr>
<th>Binder</th>
<th>Original Complex Modulus</th>
<th>RTFOT Complex Modulus</th>
<th>Original Phase Angle</th>
<th>RTFOT Phase Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>PG 70-22 TR+</td>
<td>Increases 0.04 kPa</td>
<td>Increases 0.07 kPa</td>
<td>Increases 0.63°</td>
<td>Zero difference</td>
</tr>
<tr>
<td></td>
<td>Not significant</td>
<td>Significant</td>
<td>Not significant</td>
<td>Not significant</td>
</tr>
<tr>
<td>PG 70-22 TR+ (S 92)</td>
<td>Decreases 0.22 kPa</td>
<td>Increases 0.22 kPa</td>
<td>Increases 4.05°</td>
<td>Increases 1.90°</td>
</tr>
<tr>
<td></td>
<td>Significant</td>
<td>Significant</td>
<td>Significant</td>
<td>Not significant</td>
</tr>
</tbody>
</table>

- Only PG 70-22 TR+ (S 92) original binder show effects consistent with particle interaction.
- When used to test binders modified with GTR, this gap may be too small to accommodate the rubber particles.
- **Concentric Cylinder** (Cup & Bob) needed as testing geometry for these materials.
MSCR Results: PG 70-22 TR+ (S92)

1 vs. 2 mm gap - RTFO

- \( J_{nr} \) differences are increased with increasing temperatures
- PP 1mm: possible particle interactions with plates -> lower permanent deformation
- Percent recovery (R%) : very similar results
Summary of Findings

• Solubility: **Toluene** was found to be an acceptable alternative to Trichloroethylene as a solvent for solubility testing.

• Separation: **GTR**, due to its higher specific gravity than neat asphalt binder, is separating and sinking to the bottom of the separation tube. Separation of TR+ (S 92) binder during non-agitated long-term storage should be expected.

• DSR testing: Results indicate that particle interaction with the plates likely occurs when testing the PG 70-22 TR+ (S 92) using the parallel plate geometry.
• Project Location:
  – Florida

• Hot mix asphalt (HMA) produced with an asphalt rubber binder (ARB):
  – FDOT revised Section 916-1
  – ARB must contain at least 7% GTR by weight of asphalt binder.
  – No Solubility required
  – Separation & DSR PP with 2mm gap
  – Binder: PG 76-22 ARB
Separation

Separation tests conducted following *ASTM D7173*

- Test specimens taken from the top and bottom of the vertical storage tube are measured using *AASHTO T 315*

- GTR is separating and sinking to the bottom of the separation tube.

<table>
<thead>
<tr>
<th>Binder</th>
<th>Continuous High Temperature Grade for Top Specimen, (°C)</th>
<th>Continuous High Temperature Grade for Bottom Specimen, (°C)</th>
<th>Continuous High Temperature Grade Difference Top-Bottom, (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PG 76-22 ARB</td>
<td>80.0</td>
<td>86.5</td>
<td>-6.5</td>
</tr>
</tbody>
</table>
PG Results: PG 76-22 ARB

1 & 2 mm gap vs. Cup and Bob

- Same PG grade
- Cup & Bob slightly higher $G^*/\sin \delta$ value
- No indication of significant particle interaction with plates: due to finer mesh size & low percentage of rubber
- Very similar results overall
### Long Term Conditioning

*Low Temperature Cracking - PG 76-22 ARB*

<table>
<thead>
<tr>
<th>PAV Conditioning Time (h)</th>
<th>AASHTO M 320 Table 1 Intermediate Temperature Continuous Grade (°C)</th>
<th>AASHTO M 320 Table 1 Low Temperature Continuous Grade (°C)</th>
<th>AASHTO M 320 Table 1 ΔT_c (°C)</th>
<th>AASHTO M 320 Table 2 Critical Cracking Temperature (°C)</th>
<th>ABCD Low Temperature Grade (°C)</th>
<th>ABCD AASHTO TP 92 Cracking Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>18.5</td>
<td>-27.7</td>
<td>-2.3</td>
<td>-27.7</td>
<td>-28.6</td>
<td>-35.5</td>
</tr>
<tr>
<td>40</td>
<td>18.5</td>
<td>-24.5</td>
<td>-5.2</td>
<td>-25.8</td>
<td>-27.7</td>
<td>-34.4</td>
</tr>
</tbody>
</table>

- Reasonable agreement between the three measurements for 20 hours PAV conditioning.
- The ABCD is less sensitive than the other two tests to conditioning time.
- Doubling PAV time:
  - 1.1 °C ↑ of cracking temp (ABCD)
  - 3.2 °C ↑ of cracking temp (Table 1)
  - 1.9 °C ↑ of cracking temp (Table 2)
Long Term Conditioning

Master Curve - PG 76-22 ARB

- More conditioning causes the master curves to become flatter with R increasing and ωc decreasing.
Summary of Findings

• Separation: Separation of PG 76-22 ARB during non-agitated long-term storage should be expected.

• DSR testing: Results show no indication of particle interaction with the plates when testing the PG 76-22 ARB using the parallel plate geometry: due to finer mesh size & low percentage of rubber.

• For extended PAV conditioning, binder becoming highly m-value controlled.

• 40 h PAV conditioning reveals more information about material behavior.
Takeaway

• Separation: Needs to be considered for Asphalt Rubber Material. (ASTM D7173)

• DSR testing: All Asphalt Rubber Binders are not the same! Some may work with PP and some not. Cup & Bob is a scientific & practical solution.

• Extended PAV conditioning, may better differentiate between different materials in terms of low temperature cracking.
• RTFO challenges need to be considered: materials creeping out of bottle

• DSR testing:
  **PP issues**: trimming, edge effect, particle interactions, rubber swelling, rubber mesh size and percentage, etc.
  **Cup & Bob**: no trimming, exact volume filling, no edge effect

• Low temperature testing (BBR & DDT): specimen preparation, trimming, demolding.

• **PAV** conditioning?
FHWA Field Support
Mobile Asphalt Testing Trailer (MATT)

- Mobile Asphalt Pavement Materials Lab
  - Site Visits
  - Field Data/Testing/Evaluation
  - Use/Demo Emerging Test Devices
  - POC: Matthew Corrigan
Thank You!!

FHWA’s Mobile Asphalt Testing Trailer
Office of Asset Management, Pavement, and Construction

www.fhwa.dot.gov/pavement/asphalt