Binder Extended Aging & Cracking Behavior

Mobile Asphalt Testing Trailer Program (MATT)
Long-Life Asphalt Pavements for the 21st Century

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Images: FHWA
The success of this study is made possible through the great efforts from the Mobile Asphalt Testing Trailer Program. We wishes to express sincere thanks to the Mr. Matt Corrigan, Mr. Chuck Paugh, and Dr. Ray Bonaquist for their various leadership roles in these projects. We also would like to thank Mr. Satish Belagutti and Mr. Butch Heidler for their help in testing and providing raw data for these binders.
Agenda

- FHWA MATT program
- Binder Activities & Studies
- Materials & Methods
- Results Discussion
- Questions
Program Mission

- Provide guidance, leadership, and technology for the delivery of long life pavements.

- Advance new and improved technologies and innovations into common practice.

- Raise awareness, assist, support, and provide guidance to FHWA field offices, State Highway Agencies, and their industry partners.
MATT visits since 2007

Field Work
Workshop/Hands-on Training/Presentation/Open House/Technical Assistance
Both
Example: Asphalt Rubber

- **Seven** projects between 2013 to 2015.

- Collaboration with **four State DOTs** to evaluate their specifications based on project results.

- Working with FHWA ETG to develop AASHTO standard for asphalt rubber testing.
Technical Workshops

Images FHWA
Field visits
Field Visit Tasks

- Kickoff meeting
- Open house
- Hands-on training
- Mix design replication
- Shadow QA testing
- AMPT testing
- Binder grading
- Binder performance testing
Other MATT Activities

- Conferences
- Expert Task Group Support
- NCHRP Panels and Project Participation
- Division Office Rotational Assignments
- Academic journal papers and presentations
Program Objective

- Provide Support to National Initiatives
  - Performance Engineered Mix Design (PEMD)
  - Mixture Performance Testing and the AMPT
  - Increased Pavement Density
  - Development of New QA Concepts for HMA
  - Understanding Asphalt Rubber Testing
  - Binder Performance Testing
  - Long-Term Aging
# Materials

<table>
<thead>
<tr>
<th>Binder ID</th>
<th>Performance Grade (PG)*</th>
<th>Description</th>
<th>AASHTO M 320 Continuous Grade: PG HT (IT) LT**</th>
</tr>
</thead>
<tbody>
<tr>
<td>F7</td>
<td>PG 58-28</td>
<td>Base Binder + Flux Oil</td>
<td>PG 62.2 (17.2) -30.5</td>
</tr>
<tr>
<td>O6</td>
<td>PG 64-22</td>
<td>Unmodified</td>
<td>PG 66.6 (16.9) -25.9</td>
</tr>
<tr>
<td>V6</td>
<td>PG 64-22</td>
<td>Unmodified</td>
<td>PG 66.5 (20.9) -27.9</td>
</tr>
<tr>
<td>F51</td>
<td>PG 70-22</td>
<td>GTR modified (ARB-5)</td>
<td>PG 74.4 (20.4) -24.3</td>
</tr>
<tr>
<td>F52</td>
<td>PG 76-22</td>
<td>GTR modified (ARB)</td>
<td>PG 80.0 (18.5) -27.7</td>
</tr>
<tr>
<td>A51</td>
<td>PG 70-22</td>
<td>Hybrid (GTR &amp; SBS, TR+)</td>
<td>PG 75.5 (20.7) -28.8</td>
</tr>
<tr>
<td>A52</td>
<td>PG 70-22</td>
<td>Hybrid (GTR &amp; SBS, TR+ S92)</td>
<td>PG 80.7 (13.1) -32.0</td>
</tr>
<tr>
<td>A53</td>
<td>PG 70-22</td>
<td>SBS modified</td>
<td>PG 75.6 (15.1) -30.9</td>
</tr>
<tr>
<td>F53</td>
<td>PG 76-22</td>
<td>GTR modified (ARB)</td>
<td>PG 79.7 (21.5) -27.4</td>
</tr>
<tr>
<td>W41</td>
<td>PG 52-34</td>
<td>Unmodified</td>
<td>PG 52.5 (7.9) -36.0</td>
</tr>
<tr>
<td>W42</td>
<td>PG 58-28</td>
<td>Unmodified</td>
<td>PG 60.3 (17.3) -29.4</td>
</tr>
<tr>
<td>W43</td>
<td>PG 52-34</td>
<td>SBS modified</td>
<td>PG 61.5 (8.4) -36.9</td>
</tr>
</tbody>
</table>

* Labeled by the asphalt producer

**HT = high temperature, IT = intermediate temperature, LT = low temperature
# Binder Characterization

<table>
<thead>
<tr>
<th>DSR</th>
<th>Low temperature</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<tr>
<td>• Performance Grading</td>
<td>• BBR (AASHTO T 313)</td>
</tr>
<tr>
<td></td>
<td>• DTT (AASHTO T 314)</td>
</tr>
<tr>
<td></td>
<td>• ABCD (AASHTO TP 92)</td>
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<td></td>
<td></td>
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<tr>
<td>• Frequency Sweep</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Master curve</td>
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</tbody>
</table>

- AASHTO T 315
- AASHTO T 350 (MSCR)
Low Temperature ABCD Test: AASHTO TP 92

Asphalt Binder Cracking Device (ABCD)

- Cracking Temperature
- Fracture Stress
- Low Temperature Grade

courtesy of EZ Asphalt Technology.
AASHTO M 320 Table 1, Table 2 and ABCD test

- **Standard PAV aging (20 h)**

<table>
<thead>
<tr>
<th>Low Temperature Continuous Grade (°C)</th>
<th>Neat</th>
<th>GTR</th>
<th>Hybrid</th>
<th>SBS</th>
<th>GTR</th>
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</thead>
<tbody>
<tr>
<td>M 320 Table 1</td>
<td>M 320 Table 2</td>
<td>ABCD</td>
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<tr>
<td>-20</td>
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</tbody>
</table>
AASHTO M 320 Table 1, Table 2 and ABCD test

- Change in low temperature continuous grade after 40 hours PAV
Change in $\Delta T_c$ after 40 hours PAV

- AASHTO M 320 Table 1 $\Delta T_c$ (°C)
Summary of Findings

- Ranking between different criteria
  - AASHTO M 320 Tables 1 and 2, as well as the ABCD provide different low temperature PG values
  - The ranking between binders were different among these three criteria

- Sensitivity to extended aging
  - The ABCD test showed the smallest change in low temperature PG
  - The BBR test is the most sensitive to aging

- $\Delta T_c$
  - The relationship between this parameter and aging duration may not be linear
  - Data did not exhibit simple doubling of the value after 40 hours PAV aging when compared to 20 hours
Conditioning time effect on rheological parameters: Cross Over Frequency ($\omega_c$)

- Data at original, RTFO, 20 h PAV, and 40 h PAV
Conditioning time effect on rheological parameters: Rheological Index (R)

- Data at original, RTFO, 20 h PAV, and 40 h PAV

R² values for different conditions:
- R² = 0.9095
- R² = 0.7785
- R² = 0.9939

Graph showing the relationship between PAV (hours) and Rheological Index (R) for different samples:
- A51
- A52
- W41

Log. (A52) vs. Linear (A52) vs. Linear (W41)
Data at original, RTFO, 20 h PAV, and 40 h PAV
Data at original, RTFO, 20 h PAV, and 40 h PAV
Summary of Findings

- Relationships between rheological parameters and aging duration
  - Strong relationships between \( \omega_c \), R value, & cross-over temperature and conditioning time
  - These correlations may not be able to accurately predict binder behavior after extended aging

- G-R
  - Data show that the rate of change for this parameter increases as aging increases
  - Help to track the aging susceptibility of binder and identify the potential cracking issues
It should be noted that the relationship between other rheological parameters were examined too.
Topics for Discussions

- Need to do the frequency sweep?
  - Master curve

- One parameter alone is sufficient to detect cracking issues?
  - Shape parameter or point parameter or both?

- A parameter determined at one temperature and one frequency can be used for all binders?
Encourage all to request MATT Program data

Readily available data from 2006 onwards:

- Alabama
- Arizona
- Colorado
- Delaware
- Florida
- Indiana
- Kansas
- Louisiana
- Maine
- Maryland
- Minnesota
- Missouri
- Montana
- New Hampshire
- New Jersey
- New Mexico
- Oklahoma
- Oregon
- Pennsylvania
- South Dakota
- Texas
- Virginia
- Wisconsin
If you have upcoming projects for which you would like MATT technical assistance, contact:

- David Mensching, david.menschning@dot.gov, 202.366.1286
- Amir Golalipour, amir.golalipour.ctr@dot.gov, 202.366.3982

http://www.fhwa.dot.gov/pavement
Thank You – Questions?

- We’re here to assist!