Outline

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- Testing Efforts
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- Overview of Results
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Why WMA?

- Hot Mix Asphalt control section with 64-22 neat binder
- Foamed Asphalt trial section with 64-22 binder
- Sasobit Wax Additive trial section 64-22 with 1.5% wax by weight (Plant mixed)
WMA Test Site

- Two-lane collector with low truck traffic
- 12.5mm NMAS mix with primarily basaltic aggregate
- 50mm overlay on selected milling/leveling surface
- 1-km sections for each trial mix
Placement

- Same crew and equipment for all 3 sections
- Material Transfer Vehicle used prior to paver
- Notched-wedge joint construction
- 20 minute/16 mile haul from plant
Objectives

“…evaluate the effects of Sasobit wax modifier and foamed asphalt mixes on the field performance, laboratory rutting resistance and fracture energy of asphalt mixes.”

- Evaluate the rutting susceptibility of plant-sampled, laboratory-compacted specimens in the Hamburg Wheel-Tracking device
- Evaluate the indirect tensile (IDT) creep compliance of plant-sampled, laboratory compacted specimens
- Evaluate the fracture energy of plant-sampled laboratory-compacted specimens

Compare road survey data for 3 test sections after 1-year of in-situ conditions
Hamburg Wheel Tracking

- 150mm diameter, 75mm height gyratory compacted specimens
- Submerged in water bath at 45°C and 50°C
- Sensors monitor rut depth as steel wheels pass over specimens
- Compare inflection points of depth/time curve for moisture susceptibility
Cracking Performance

- Instron 1331 Load Frame
- FastTrack8800
- Epsilon Strain Gauges
- ATS Temperature controller/environmental chamber.
- Liquid Nitrogen Cooled
- Capable of closed-loop testing
Indirect Tensile Creep Compliance

Compliance

\[ D(t) = \frac{\Delta X \times D \times b}{P_{\text{ave}} \times GL} \times C_{\text{compl}} \]

Tensile Strength:

\[ S_{t,n} = \frac{2 \times P_{f,n}}{\pi \times b_n \times D_n} \]

- Condition at temperature for 2 hours
- 38 mm thick specimen
- Initial load to 100 \( \mu \)s on strain gauge
- Load held for 1000 sec.
- Tensile strength test upon completion
Disk Compact Tension

Fracture Energy:
\[ G_f = \frac{A_c}{B \times l} \]

Fracture Toughness:
\[ K_Q = \frac{P_Q}{B \sqrt{W}} \times f_3 \left( \frac{a}{W} \right) \]

- Condition at temperature for 1 hour
- 50 mm thick specimen
- Specimen loaded to maintain 0.003mm/min crack opening
Disk Compact Tension

\[
f_3 \left( \frac{a}{W} \right) = \frac{\left( 2 + \frac{a}{W} \right) \left[ 0.76 + 4.8 \left( \frac{a}{W} \right) - 11.58 \left( \frac{a}{W} \right)^2 + 11.43 \left( \frac{a}{W} \right)^3 - 4.08 \left( \frac{a}{W} \right)^4 \right]}{\left( 1 - \frac{a}{W} \right)^{3/2}}
\]
Field Performance Evaluation

- Two Automatic Road Analyzer vans used
- Collected high-resolution front facing and pavement images every 5 meters
- Continuous rut depth, IRI, roadway geometry and GPS data
- Both ran East and West data collection 1 year after placement
Field Performance Evaluation

- Pavement image from strobe-based Fugro ARAN Van acquisition system
- Original condition in all 3 test sections was similar
Test Effort

- For HWT test, 36 GCS were produced for 6 tests.
- For cracking performance, the table shown indicates quantities.
- Cracking specimens were divided by top, middle and bottom of a GSC to distribute the variance of air voids.

<table>
<thead>
<tr>
<th>Cutting Procedure</th>
<th>Location in Specimen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mix</td>
<td>Top</td>
</tr>
<tr>
<td>Conventional</td>
<td>2 IDT</td>
</tr>
<tr>
<td></td>
<td>2 DCT</td>
</tr>
<tr>
<td>Foamed</td>
<td>1 IDT</td>
</tr>
<tr>
<td></td>
<td>4 DCT</td>
</tr>
<tr>
<td>Sasobit</td>
<td>1 IDT</td>
</tr>
<tr>
<td></td>
<td>2 DCT</td>
</tr>
</tbody>
</table>
Results: HWT

<table>
<thead>
<tr>
<th>Mix</th>
<th>Rut Depth (mm)</th>
<th>Inflection (Passes)</th>
<th>Rut Depth (mm)</th>
<th>Inflection (Passes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>-6.04</td>
<td>16666</td>
<td>-6.934</td>
<td>11111</td>
</tr>
<tr>
<td>Foamed</td>
<td>-</td>
<td>-</td>
<td>-5.275</td>
<td>11111</td>
</tr>
<tr>
<td>Sasobit Wax</td>
<td>-7.922</td>
<td>20000</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Results: IDT Mastercurves
Results: IDT Tensile Strength

- Conventional
- Foamed
- Sasobit

<table>
<thead>
<tr>
<th>Temp C</th>
<th>Conventional</th>
<th>Foamed</th>
<th>Sasobit</th>
</tr>
</thead>
<tbody>
<tr>
<td>-24</td>
<td>4.5</td>
<td>3.2</td>
<td>3.8</td>
</tr>
<tr>
<td>-12</td>
<td>3.0</td>
<td>3.5</td>
<td>3.3</td>
</tr>
<tr>
<td>0</td>
<td>2.5</td>
<td>2.8</td>
<td>2.9</td>
</tr>
</tbody>
</table>
Results: DC(T) Toughness

![Bar graph showing fracture toughness at different temperatures for conventional, foamed, and Sasobit samples.](image-url)
Results: Field Performance
Results: Field Performance

The bar chart shows the rut depth (mm) for different wheel paths (L, R) and different types (Conventional, Foamed, Sasobit). The chart indicates that Sasobit has the highest rut depth, followed by Foamed and then Conventional.
Summary and Conclusions

I. Sasobit wax had the longest time until the stripping inflection point, but had the greatest amount of rutting.

II. Conventional HMA and Foamed Asphalt mixes had nearly identical creep compliance master curves whereas Sasobit had a visually greater resistance to creep.

III. Tensile strength did not vary significantly between any of the specimens when temperature was fixed.

IV. DC(T) fracture toughness had no significant difference by mix when temperature was fixed.

V. Sasobit wax showed higher cracking in the field. This performance could be related to variance in subsurface conditions.
The authors would like to thank the Connecticut Advanced Pavement Laboratory for providing the resources and assistance with laboratory procedures. Connecticut DOT for access to the construction site coordination and access to their ARAN Van staff and data, Tilcon Connecticut, Inc. for access to their plant.
Questions?

Thank you for your time

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