Evaluation of Incorporating Different Dosages of ADVERA® Warm Mix Asphalt (WMA) Technology on HMA Volumetrics and Workability

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By:
Professor Walaa S. Mogawer, PE
University of Massachusetts Dartmouth
Pavement Research Institute of Southeastern Massachusetts (PRISM)
Objectives

- Investigate the effects on the volumetric properties of HMA from the addition of ADVERA® at varying dosage rates and reduced mixing/compaction temperatures.

- Determine the effects on the workability of HMA from the addition of ADVERA® at varying dosage rates.
Experimental Plan

- Control Mix
  - 0% ADVERA®
  - M: 325°F C: 309°F

- Mix With Varying Dose of ADVERA®
  - 0.1% by wt. of mix
  - 0.2% by wt. of mix
  - 0.3% by wt. of mix

- HMA Mix (SP 9.5mm)

- Mix Workability Evaluation
  - Control
  - 0.1% by wt. of mix
  - 0.2% by wt. of mix
  - 0.3% by wt. of mix

- Evaluate Mix Workability in PRISM Prototype Asphalt Workability Device (AWD)

- Volumetric Property Evaluation

- Air Voids, VMA, VFA

- M: 325°F C: 309°F
  - M: 275°F C: 259°F
  - M: 255°F C: 239°F
Mix Design

- 9.5mm Superpave mix design
- Design ESALs of 3 to <30 million ($N_{\text{Design}} = 100$)
- Aggregates From crushed stone source in Massachusetts
  - Aggregate stockpiles:
    - 9.5 mm Aggregate
    - Stone Dust
    - Washed Sand
- PG64-28 Binder (Non-PPA Modified)
## Job Mix Formula (JMF)

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>9.5mm Superpave Mix</th>
<th>Superpave Specification Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.5 mm</td>
<td>100.0</td>
<td>100 min.</td>
</tr>
<tr>
<td>9.5 mm</td>
<td>98.4</td>
<td>90-100</td>
</tr>
<tr>
<td>No. 4</td>
<td>68.4</td>
<td>90 max.</td>
</tr>
<tr>
<td>No. 8</td>
<td>42.6</td>
<td>32-67</td>
</tr>
<tr>
<td>No. 16</td>
<td>29.1</td>
<td>-</td>
</tr>
<tr>
<td>No. 30</td>
<td>20.0</td>
<td>-</td>
</tr>
<tr>
<td>No. 50</td>
<td>13.0</td>
<td>-</td>
</tr>
<tr>
<td>No. 100</td>
<td>8.0</td>
<td>-</td>
</tr>
<tr>
<td>No. 200</td>
<td>5.2</td>
<td>2-10</td>
</tr>
<tr>
<td>% Binder</td>
<td>5.75%</td>
<td>-</td>
</tr>
</tbody>
</table>
9.5mm Superpave Gradation

![Graph showing percent passing vs sieve size for 9.5mm Superpave gradation.](image)
Binder Testing

- Binder was graded in accordance with AASHTO R29 to confirm Performance Grade (PG).

- Viscosity of binder was determined in order to establish the mixing and compaction temperatures as required by AASHTO T312.

- Mixing temperature range was 159-163°C (318-325°F).

- Compaction temperature range was 148-154°C (298-309°F).
## Test Matrix for Specimen Fabrication

<table>
<thead>
<tr>
<th>Percent ADVERA®</th>
<th>Mixing Temperature</th>
<th>Compaction Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% - CONTROL</td>
<td>325°F (163°C)</td>
<td>309°F (154°C)</td>
</tr>
<tr>
<td>0.1%</td>
<td>325°F (163°C)</td>
<td>309°F (154°C)</td>
</tr>
<tr>
<td></td>
<td>275°F (135°C)</td>
<td>259°F (126°C)</td>
</tr>
<tr>
<td></td>
<td>255°F (124°C)</td>
<td>239°F (115°C)</td>
</tr>
<tr>
<td>0.2%</td>
<td>325°F (163°C)</td>
<td>309°F (154°C)</td>
</tr>
<tr>
<td></td>
<td>275°F (135°C)</td>
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<td>239°F (115°C)</td>
</tr>
</tbody>
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Test Specimen Fabrication

- Mixing and compaction temperatures were as outlined in test matrix.

- For each ADVERA® dosage level and temperature range three (3) Superpave gyratory specimens and two (2) maximum theoretical specific gravity specimens were fabricated.

- Each specimen short-term aged in accordance with AASHTO R30 for two hours at the specified compaction temperature.

- Specimens compacted to $N_{Design}$ gyrations = 100
Incorporation of ADVERA® into Binder

- ADVERA® incorporated into the binder at mixing temperature using rotary stirrer driven by a drill.

- Binder temperature was maintained using a hot plate.
# Volumetric Results

<table>
<thead>
<tr>
<th></th>
<th>0% ADVERA</th>
<th>0.3% ADVERA</th>
<th>0.2% ADVERA</th>
<th>0.1% ADVERA</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mixing Temp. °F</strong></td>
<td>325</td>
<td>325</td>
<td>275</td>
<td>255</td>
<td>-</td>
</tr>
<tr>
<td><strong>Compaction Temp. °F</strong></td>
<td>309</td>
<td>309</td>
<td>259</td>
<td>239</td>
<td>-</td>
</tr>
<tr>
<td><strong>Air Voids, %</strong></td>
<td>4.6</td>
<td>4.9</td>
<td>5.3</td>
<td>3.4</td>
<td>3-5%</td>
</tr>
<tr>
<td><strong>VMA, %</strong></td>
<td>15.9</td>
<td>16.0</td>
<td>16.4</td>
<td>14.7</td>
<td>15.0% min</td>
</tr>
<tr>
<td><strong>VFA, %</strong></td>
<td>71.1</td>
<td>69.4</td>
<td>67.5</td>
<td>77.1</td>
<td>73-76</td>
</tr>
<tr>
<td><strong>Dust-to-Binder Ratio</strong></td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.6-1.2</td>
</tr>
</tbody>
</table>
Volumetrics - Discussion

- Addition of ADVERA® and reduction of the mixing and compaction temperatures did change the mix volumetrics.

- Results indicate that mix designs incorporating ADVERA® should be completed at the anticipated reduced mixing and compaction temperatures for the specific project.
ADVERA® was added at dosages of 0.1%, 0.2% & 0.3% by weight of mix.

Workability evaluation conducted utilizing prototype device (patent pending) developed by the UMass Dartmouth PRISM.

Device operates on basic principle of measuring reactionary torque of the mix at varying temperatures.
Workability Evaluation

UMass Dartmouth PRISM – Asphalt Workability Device (AWD)
Patent Pending
**Typical Raw Workability Data**

Torque vs. Temperature - Control 0% ADVERA

\[ y = 826.57e^{-0.0048x} \]

\[ R^2 = 0.8481 \]
**Typical Raw Workability Data**

*Torque vs. Temperature - 0.3% ADVERA*

\[ y = 494.04e^{-0.0029x} \]

\[ R^2 = 0.7474 \]
Workability Data

- Exponential and linear fit models from raw data utilized to compare mixes.
- Data and previous trials suggest exponential model better represents workability of HMA mixes.
- Models plotted over a finite temperature range.
Workability Model - Exponential

Torque vs. Temperature Workability (Exponential)

Temperature (F)

Torque (in-lb)

- Control -0% ADVERA
- 0.3% ADVERA
- 0.2% ADVERA
- 0.1% ADVERA
Workability Model – Linear

Torque vs. Temperature Workability (Linear)

Temperature (F)

Torque (in-lb)

- Control -0% ADVERA
- 0.3% ADVERA
- 0.2% ADVERA
- 0.1% ADVERA
The exponential and linear models indicated that ADVERA® improved the workability of the mix at temperatures below the temperature range of 270-280°F (132-138°C).

At temperatures above 270-280°F (132-138°C) the control mix exhibited better workability. The reasons for this are unknown and further investigations are needed.
The typical dosage of ADVERA® is 0.3% by weight of the mix. The data has shown that a dosage of 0.2% or 0.1% might have similar workability to the 0.3% dosage.

These workability trends need to be further verified with other mix designs of varying sizes and binder contents to determine if the trend is applicable to all HMA mixes.
Acknowledgements

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- Alexander Austerman – PRISM
Thank you!