Update for the
FHWA ALF Research Activities
Project #1:
High RAP (RAS) + WMA
Accelerated Pavement Test
RAP/RAS and WMA

• **Purpose**
  – Advance Use of Recycled Asphalt in Flexible Pavement Infrastructure: Develop and Deploy Framework for Proper Use and Evaluation of Recycled Asphalt in Asphalt Mixtures

• **Objective**
  – Quantify cracking resistance of high RAP/RAS mixtures that considers the use of lower temperature production with warm-mix asphalt (WMA); Investigate limitations and provide recommendations for combining the two technologies
The Experiment

Structure
- 10 Lanes (10 Mixes)
- Build in 2013

Materials
- 2 Binder Grades
- RAP/RAS
- 2 WMA Technologies
- 3 ABR contents
# ALF Experimental Design

<table>
<thead>
<tr>
<th>HMA / WMA</th>
<th>Warm Mix Technology</th>
<th>Recycle Content</th>
<th>300°F - 320°F</th>
<th>240°F - 270°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drum Discharge Temperature</td>
<td>0%</td>
<td>PG64-22</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>20% ABR RAP</td>
<td>PG64-22</td>
<td>PG64-22</td>
<td>PG64-22</td>
</tr>
<tr>
<td></td>
<td>20% ABR RAS</td>
<td>PG64-22</td>
<td>PG58-28</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>40% ABR RAP</td>
<td>PG64-22</td>
<td>PG58-28</td>
<td>PG58-28</td>
</tr>
</tbody>
</table>
Loading Conditions

- **Tire**
  - 425/65R22.5 wide base
  - Tire pressure: 100 psi
- **Total load**: 14,200 lbf
- **Speed**: 11 mph (4.9 m/s)
- **Isothermal at 20°C (target temperature at AC mid-thickness)**
Cracking Measurements

Crack lengths are individually traced with planimeter.
Lane 1-0% ABR Control PG64-22
Lane 2-40% ABR RAP PG58-28 WMA Foamed
Lane 3-20% ABR RAS PG64-22
Lane 4-20% ABR RAP PG64-22 WMA Evotherm
Lane 5-40% ABR RAP PG64-22
Lane 6-20% ABR RAP PG64-22
Lane 7-20% ABR RAS PG58-22
Lane 8-40% ABR RAP PG58-22 WMA Evothermβ
Lane 9-20% ABR RAP PG64-22 WMA Foamed
Lane 11-40% ABR RAP PG58-28
## Crack Data Summary

<table>
<thead>
<tr>
<th>Lane</th>
<th>Mix</th>
<th>Age when tested (months)</th>
<th>Duration (Days)</th>
<th>Cycles to First Crack (Calculated)</th>
<th>Total Passes</th>
<th>Total Cracking (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0% ABR Control PG64-22</td>
<td>7</td>
<td>286</td>
<td>368,254</td>
<td>400,000</td>
<td>160</td>
</tr>
<tr>
<td>2</td>
<td>40% ABR RAP PG58-28 WMA Foamed</td>
<td>38</td>
<td>79</td>
<td>123,035</td>
<td>200,000</td>
<td>1,336</td>
</tr>
<tr>
<td>3</td>
<td>20% ABR RAS PG64-22</td>
<td>14</td>
<td>28</td>
<td>42,399</td>
<td>100,000</td>
<td>587</td>
</tr>
<tr>
<td>4</td>
<td>20% ABR RAP PG64-22 WMA Evotherm</td>
<td>16</td>
<td>71</td>
<td>88,740</td>
<td>125,000</td>
<td>271</td>
</tr>
<tr>
<td>5</td>
<td>40% ABR RAP PG64-22</td>
<td>11</td>
<td>98</td>
<td>36,946</td>
<td>60,000</td>
<td>670</td>
</tr>
<tr>
<td>6</td>
<td>20% ABR RAP PG64-22</td>
<td>24</td>
<td>81</td>
<td>122,363</td>
<td>175,000</td>
<td>403</td>
</tr>
<tr>
<td>7</td>
<td>20% ABR RAS PG58-22</td>
<td>18</td>
<td>43</td>
<td>23,005</td>
<td>62,200</td>
<td>526</td>
</tr>
<tr>
<td>8</td>
<td>40% ABR RAP PG58-22 WMA Evotherm</td>
<td>31</td>
<td>47</td>
<td>47,679</td>
<td>54,844</td>
<td>602</td>
</tr>
<tr>
<td>9</td>
<td>20% ABR RAP PG64-22 WMA Foamed</td>
<td>2</td>
<td>163</td>
<td>179,167</td>
<td>255,397</td>
<td>1,439</td>
</tr>
<tr>
<td>11</td>
<td>40% ABR RAP PG58-28</td>
<td>3</td>
<td>147</td>
<td>81,044</td>
<td>123,052</td>
<td>512</td>
</tr>
</tbody>
</table>
Mixture Field Sample Testing

Reduced Size (38mmx110mm)

- Dynamic Modulus
- Fatigue (AASHTO TP 107)
- Monotonic Direct Tension

*All testing done on AMPT*
Air Void Content of Field Cores

Need to take construction variation into account analyzing performance testing data
Field Core Sampling and Testing

- **2013**
  - t = 0m
  - Top
  - Bottom
  - Cores Taken: ✔
  - Testing Done: ✔
  - Binder Extraction & Testing: ✔
  - Data Analysis: ✔

- **2014**
  - t = 12m
  - Top
  - Bottom
  - Cores Taken: ✔
  - Testing Done: ✔
  - Binder Extraction & Testing: ✔
  - Data Analysis: ✔

- **2015**
  - t = 24m
  - Top
  - Bottom
  - Cores Taken: ✔
  - Testing Done: ✔
  - Binder Extraction & Testing: ✔
  - Data Analysis: ✔
  - Undergoing

- **2016**
  - t = 36m
  - Top
  - Bottom
  - Cores Taken: ✔
  - Testing Done: ✔
  - Binder Extraction & Testing: ✔
  - Data Analysis: ✔
  - Undergoing
  - Will do

Extracted Binder Testing

- DSR Fatigue: Linear Amplitude Sweep (LAST)
- BBR $\Delta T_{\text{critical}}$: $P_G(S)\text{tiffness} - P_G(m)\text{-creep}$
- Double Notched Tension: Cracking Strain Tolerance
ΔT INCREASE

Delta T increase after 2 years, top layer

<table>
<thead>
<tr>
<th></th>
<th>Degrees Celsius, °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% RAP/RAS (64-22)</td>
<td>1</td>
</tr>
<tr>
<td>Lane 1</td>
<td></td>
</tr>
<tr>
<td>H2O foam 40% RAP (58-28)</td>
<td>1</td>
</tr>
<tr>
<td>Lane 2</td>
<td></td>
</tr>
<tr>
<td>20% RAS (64-22)</td>
<td>4</td>
</tr>
<tr>
<td>Lane 3</td>
<td></td>
</tr>
<tr>
<td>Evotherm 20% RAP (64-22)</td>
<td>2</td>
</tr>
<tr>
<td>Lane 4</td>
<td></td>
</tr>
<tr>
<td>40% RAP (64-22)</td>
<td>2</td>
</tr>
<tr>
<td>Lane 5</td>
<td></td>
</tr>
<tr>
<td>20% RAP (64-22)</td>
<td>4</td>
</tr>
<tr>
<td>Lane 6</td>
<td></td>
</tr>
<tr>
<td>20% RAS (58-28)</td>
<td>8</td>
</tr>
<tr>
<td>Lane 7</td>
<td></td>
</tr>
<tr>
<td>40% RAP (58-28)</td>
<td>2</td>
</tr>
<tr>
<td>Lane 8</td>
<td></td>
</tr>
<tr>
<td>H2O foam 20% RAP (64-22)</td>
<td>1</td>
</tr>
<tr>
<td>Lane 9</td>
<td></td>
</tr>
<tr>
<td>Evotherm 40% RAP (58-28)</td>
<td>1</td>
</tr>
<tr>
<td>Lane 10</td>
<td></td>
</tr>
<tr>
<td>Evotherm 40% RAP (58-28)</td>
<td>2</td>
</tr>
</tbody>
</table>
Next Steps

• Second run at aged conditions
  – Lanes 3, 4, 5 and 8

• Data analysis
  – Data library
  – Data processing
  – Investigations

• Post-mortem evaluations

• Reporting and Documentation
Project #2:
Effect of In-Place Density and Aggregate Base Geosynthetic Reinforcement on the Asphalt Pavement Durability
AC Field Density and CAB Geosynthetic Reinforcement

• **Premise**
  – Compaction of asphalt concrete (AC) mixtures is critical to achieving optimal pavement performance.
  – Quality and strength of the substructure (base and subgrade) have great influence of pavement performance.

• **Objectives**
  – Investigation of Asphalt Concrete Compaction and Its Impact on Performance of Pavements Built with and without Geosynthetic Base Reinforcement
The Experiment

• One AC mixture
• Four Lanes (4 different AC compaction levels)
  – High (>92% compaction)
  – Medium (90-92%)
  – Low (< 90%)
• Two structures per lane
  – Unreinforced
  – Reinforced with a Standard BS-1200
• Performance measures
  – Cracking
  – Rutting
Pavement Structure

No Reinforcement

- 4 in Asphalt Concrete
- 12 in New Crushed Aggregate Base
- 10 in Remaining Crushed Aggregate Layer
- Subgrade

With Reinforcement

- 4 in Asphalt Concrete
- 12 in New Crushed Aggregate Base
- GeoSynthetic
- Subgrade
## Air voids of field cores

<table>
<thead>
<tr>
<th>Lane</th>
<th>SSD Whole</th>
<th>SSD Bottom Trimmed</th>
<th>CoreLok Whole</th>
<th>CoreLok Bottom Trimmed</th>
</tr>
</thead>
<tbody>
<tr>
<td>L9 (Low)</td>
<td>10.6</td>
<td>0.8</td>
<td>10.2</td>
<td>0.8</td>
</tr>
<tr>
<td>L10 (Mid)</td>
<td>8.6</td>
<td>1.2</td>
<td>8.3</td>
<td>1.1</td>
</tr>
<tr>
<td>L11 (High)</td>
<td>7.9</td>
<td>0.7</td>
<td>7.7</td>
<td>0.7</td>
</tr>
<tr>
<td>L12 (High)</td>
<td>7.1</td>
<td>0.9</td>
<td>6.8</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Air voids of field cores (cont’d)
Proposed Testing

• Cracking
  – Loading temperature: 20°C
  – Terminal state: total cracking length > 1,000 inches
    • Early stages of cracking in which preventive maintenance would be optimum intervention in real pavements
  – All lanes will be tested at least twice for fatigue cracking:
    • One at one unreinforced base site, and
    • One at one geosynthetic reinforced base site
  – Effects of aging
    • Two lanes will have one extra fatigue test at aged conditions
Current Status

• Construction completed October 2016
• Fatigue testing (Phase 1)
  – May and June/2017
  – Winter/2017 through Spring/2018
• Rutting testing
  – Late Summer through Early Winter/2017
• Fatigue testing (Phase 2)
  – Late Winter/2018 through Early Summer/2018
• Fatigue testing (Phase 3)
  – Fall/2018 through Spring/2019
Laboratory Performance Testing

- Dynamic Modulus
- Fatigue (AASHTO TP 107)
- Monotonic Direct Tension
- Flow Number + Stress Sweep Rutting
- All testing done on AMPT
Loose Mix Dynamic Modulus Testing

Dynamic modulus increases with compaction level.
Loose Mix Flow Number Testing

Tested at 50°C, unconfined
Proposed Testing (Cont’d)

- Rutting
  - Terminal state: 0.5 inches of total rut
  - Loading temperature:
    - Two proposed approaches for discussion:
      - Fixed temperature at 45°C
      - Variable temperature:
        » 25K passes at 40°C
        » 25K passes at 50°C
        » Repeat until terminal state is reached
  - All lanes will have at least one rutting test at one reinforced base site
  - Two lanes will be tested twice:
    - Impact of base reinforcement on performance
    - Impact of aging on performance
Team

- **Jack Youtcheff**
  - Pavement Testing Facility
    - Regis Carvalho
    - Mario Tinio
    - Karl Staaf
    - Tim and Michael
  - Mix and Binder Labs
    - Sean Li
    - Adrian Andriescu
    - Susan Needham
    - Scott Parobeck
    - Frank Davis
Questions/Comments?

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