ASPHALT RUBBER – EXPERIENCE & SPECIFICATION DEVELOPMENT

NEAUPG - PORTSMOUTH, NH - OCTOBER 25, 2013
Asphalt Rubber

- Asphalt Rubber – ASTM D6114 Type 2.
- SAMI – 1986 Standard Specifications
  - Rubber Chip SAMI– DOT
  - Wooden Bridge Decks SAMI/Surface- DOT
  - Surface Treatment - Municipals
- 1991 ISTEA Rubber Mandates
- “Generation 1 AR HMA”
  - 1992 Project – Rt 140 Freetown
    - Dense “Recipe” HMA Mixture
  - 1996 – MassDOT Participated in a NIOSH Study
  - I-95 Foxboro Southbound (1997)
    - Dense “Recipe” Mix and 3/8” OGFC-AR.
Terminal Blend GTR

2004 – “Pavement Preservation” Thin Overlays
- “Terminal Blends” GTR & Polymer (PGAB 76-34)
  - “RI Mix”
  - Rt 146 Uxbridge-Milville (2006)

“Terminal Blends” OGFC
  - GTR clogged plant screens/filters for AC pump
  - Low Binder Control Strip high speed lane – left in place
    - 5% rather than 6.2% AC
    - Still performing adequately.
    - No discernible performance impact to date.

I-295 Attleboro-North Attleboro Terminal Blend vs Asphalt Rubber Project.
Asphalt Rubber HMA – “2’nd Generation”

- I-295 Attleboro-North Attleboro
- Terminal Blend - Asphalt Rubber demo.
  - Asphalt Rubber Gap Graded (ARGG) PG 58-28
  - Terminal Blend – “RI Specification” PG 76-34.
  - Bonded Ultrathin Overlay w/PG 64-28
  - Bonded Ultrathin Overlay w/PG 58-28 + AR
- Availability of Terminal Blend GTR Binder
  - Supply/Contractor concerns
- Bid 2007 - Built 2008
- Construction Changes – Advera WMA ARGG mix substituted for Terminal Blend PG76-34.
ARGG – Specification Development?

- DOT Needs
  - T/O Maintenance Mix
  - OGFC Maintenance Mix
  - Dense/Gap Graded/Open Graded
- Looked to other States for specs...
  - Arizona.. California.. Texas...
- Developed Draft Volumetric Mix Design Specification working with UMASS Dartmouth – HSRC.
  - Dr. W. Magower at UMass Dartmouth’s HSRC instrumental in specification Development.
Specification

- Section 450 HMA Quality Assurance Spec’s.
- Five Quality Criteria
  - Acceptance, Incentives & Disincentives
  - Statistical Percentage within limits for:
    - Plant Air Voids
    - Binder Content
    - Compacted Thickness
    - Density (by cores)
    - Ride Quality (IRI)
- Demo Projects – QA for informational purposes.
Specification (cont.)

- Density for Typical Dense HMA
  - 95.0% Target Density
  - ± 2.5% Specification Limits
  - ± 3.0% Engineering Limits
  - Spec’s had little information on density requirements
  - Other DOT’s believed there was a relationship between low density prior failures.

- ARGG? Minimum 92.0 on initial projects
  - Objective was to benchmark field density.
  - How uniform and repeatable?
  - Standard Deviation – same as HMA?
Specification (cont.)

- **Plant Air Voids**
  - 4% Target
  - ± 1.5% Specification Limits
  - ± 2.0% Engineering Limits

- **Thickness**
  - 1.25” Specified
  - Not subject to statistical analysis.

- **Binder Content**
  - Target = Mix Design (6.5% min. later = 7.6%)
  - ± 0.3% Specification Limits
  - ± 0.4% Engineering Limits
Ride Quality

- Target IRI = 65 in/mi.
- Surface courses ≤ 1.5” not subject to ride.

Contractor must place Control Strip on first night production

- 600-1800 tons.
- Contractor and DOT QC must each perform random sampling (3x locations)
- Must meet specified PWL before proceeding to full paving.
ARGG vs. OGFC vs. 12.5mm SUPERPAVE

Percent Passing vs. Sieve Size (mm)

- ARGG
- OGFC
- 12.5mm
- SSC
### Sieve Designation

<table>
<thead>
<tr>
<th>Sieve Designation</th>
<th>Percent by Mass Passing</th>
<th>Tolerances</th>
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</thead>
<tbody>
<tr>
<td>19.0 mm (3/4”)</td>
<td>100</td>
<td>±0</td>
</tr>
<tr>
<td>12.5 mm (1/2”)</td>
<td>90-100</td>
<td>±6</td>
</tr>
<tr>
<td>9.5 mm (3/8”)</td>
<td>83 – 87</td>
<td>±6</td>
</tr>
<tr>
<td>4.75 mm (#4)</td>
<td>28 - 42</td>
<td>±6</td>
</tr>
<tr>
<td>2.36 mm (#8)</td>
<td>14 – 22</td>
<td>±4</td>
</tr>
<tr>
<td>1.18 mm (#16)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>0.075 mm (#200)</td>
<td>0 – 6</td>
<td>±1</td>
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</table>

### Property

<table>
<thead>
<tr>
<th>Property</th>
<th>Criteria</th>
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<tbody>
<tr>
<td>Air Voids</td>
<td>3 - 6 %</td>
</tr>
<tr>
<td>Voids in Mineral Aggregates (VMA)</td>
<td>18 - 23 %</td>
</tr>
<tr>
<td>Draindown</td>
<td>0.3 % maximum</td>
</tr>
<tr>
<td>% Binder content*</td>
<td>7.6 % minimum</td>
</tr>
<tr>
<td>PGB Content – Specification limits**</td>
<td>±0.4%</td>
</tr>
<tr>
<td>PGB Content – Engineering limits**</td>
<td>±0.6%</td>
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</tbody>
</table>
Post-Construction Spec. “Adjustments”

- Plant Air Voids seemed erratic.
  - Control Strip Nights
    - 6 Tests for plant air voids inconsistent.
    - Tests Taken in short production night.
    - Specimens removed from mold “hot”.
    - Visible swelling in mixes.
    - Cause for concern?

- Field Densities were good
  - 92% minimum achieved.
  - Consistent.
  - Need target and tolerances

- Ride Quality
  - 50-60in/mile.
Post Construction Spec. “Adjustments”

“Borderline” Tests for binder content.

- Binder content near specification limits.
  - Ignition ovens required correction for AR.
  - Ignition ovens required more frequent cleaning.
  - Black residue could sometimes be seen after burn.
    - Carbon black?

**Adjusted binder content tolerances.**

- Increased Spec Limits from ±0.3% to ±0.4%
- Increased Engineering Limits from ±0.4 to ±0.6.

**Eliminated plant air void testing for QC.**

**Required Ride (IRI) testing for thin lifts.**

**Target Density Later Increased to 94%.**
I-95 Attleboro “Before”

- I-95 Attleboro (2008)
- 4.57+ miles (37.56 lane miles)
- 3 lanes + Breakdown lane & Shoulder
- Distress
  - Ravelling & Weathering OGFC
  - Delamination & Thermoplastic
  - Longitudinal Joints & Plow Damage
- Rehab
  - Micromill & 1.25” ARGG Thin Overlay
- Bid $3,022,045.35
  - Clearing & Grubbing
  - Frames/Grates (lockdowns)
  - Guardrail repairs & Safety items
  - Traffic Control, Striping, etc.
- Cost $82.6K/lane mile

<table>
<thead>
<tr>
<th>Pre-Construction Ride Statistics</th>
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</thead>
<tbody>
<tr>
<td><strong>ROUTE</strong></td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>0095N</td>
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<tr>
<td>ROUTE</td>
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<tr>
<td>0095N</td>
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## I-95 Attleboro “After”

<table>
<thead>
<tr>
<th>ROUTE</th>
<th>FROM</th>
<th>TO</th>
<th>LIRI</th>
<th>% REDUCED</th>
<th>RIRI</th>
<th>% REDUCED</th>
<th>AVG IRI</th>
<th>% REDUCED</th>
</tr>
</thead>
<tbody>
<tr>
<td>0095N</td>
<td>0.00</td>
<td>4.57</td>
<td>34.09</td>
<td>45.7%</td>
<td>29.77</td>
<td>34.7%</td>
<td>31.93</td>
<td>39.8%</td>
</tr>
</tbody>
</table>
I-95 North Attleboro – Foxboro
“Before”

- 6.39+ miles (51.12 lane miles)
- 3 lanes + Breakdown & Shoulder
- Distress
  - Ravelling & Weathering OGFC
  - Delamination & Thermoplastic
  - Longitudinal Joints & Plow Damage
- Rehab
  - Micromill & 1.25” ARGG Thin Overlay
- Bid $6,008,093.25
  - Bridge Repairs, ramp & interchanges ($0.9M)
  - Clearing & Grubbing
  - Frames/Grates (lockdowns)
  - Guardrail repairs & Safety items
  - Traffic Control, Striping, etc.
- Cost $ 117.5K/lane mile

Pre-Construction Ride Statistics

<table>
<thead>
<tr>
<th>ROUTE</th>
<th>FROM</th>
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<th>LIRI</th>
<th>RIRI</th>
<th>AVG IRI</th>
<th>COMMENTS</th>
<th>COLLECTION YEAR</th>
<th>PROJECT #</th>
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<td>4.57</td>
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<td>0095N</td>
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<td>68.90</td>
<td>Before</td>
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### I-95 North Attleboro - Foxboro

#### Construction Ride Statistics

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<td>% REDUCED</td>
<td>AVG IRI</td>
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<td>28.48</td>
<td>40.5%</td>
<td>1.86</td>
<td>2.8%</td>
<td>15.17</td>
<td>22.0%</td>
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I-495N Milford – Southborough
“Before”

- I-495N Milford - Southboro (2008)
- 11.12+ miles (44.48 lane miles)
- 3 lanes + Breakdown & Shoulder
- Distress
  - Ravelling & Weathering OGFC
  - Delamination & Thermoplastic
  - Longitudinal Joints & Plow Damage
  - Structural Cracking north of I-90
- Rehab
  - Micromill & 1.25” ARGG Thin Overlay
  - Added 1.75” pavement structure north of I-90
- Bid $4,800,781.00
  - Clearing & Grubbing
  - Frames/Grates (lockdowns)
  - Traffic Control, Striping, etc.
- Cost $ 107.9.5K/lane mile

Pre-Construction Ride Statistics

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<td>61.67</td>
<td>83.94</td>
<td>81.17</td>
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<td>Before</td>
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## Reduction In IRI After Project Completion

<table>
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<tr>
<th>ROUTE</th>
<th>FROM</th>
<th>TO</th>
<th>LIRI</th>
<th>% REDUCED</th>
<th>RIRI</th>
<th>% REDUCED</th>
<th>AVG IRI</th>
<th>% REDUCED</th>
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<tr>
<td>0495N</td>
<td>50.55</td>
<td>61.67</td>
<td>46.05</td>
<td>54.9%</td>
<td>28.31</td>
<td>34.9%</td>
<td>37.18</td>
<td>45.0%</td>
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</table>
Rt 24 Brockton – Raynham

“Before”

- 12.38+ miles (99.04 lane miles)
- 3 lanes + Breakdown & Shoulder
- Distress
  - Ravelling & Weathering OGFC
  - Delamination & Thermoplastic
  - Extensive temporary patching
  - Structural Cracking at bridges only!
- Rehab
  - Micromill & 1.25” ARGG Thin Overlay
  - Added 2” pavement structural inlay at bridge approaches.
- Bid $12,275,737.50
  - Extensive Bridge Work
  - Clearing & Grubbing
  - Frames/Grates (lockdowns)
  - Traffic Control, Striping, etc.
  - Major Interchange work at I-495.
- Cost $123.9K/lane mile

### Pre-Construction Ride Statistics

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<tr>
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<th>FROM</th>
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<th>RIRI</th>
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<th>COMMENTS</th>
<th>COLLECTION YEAR</th>
<th>PROJECT #</th>
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<tr>
<td>0024N</td>
<td>21.43</td>
<td>33.81</td>
<td>80.06</td>
<td>68.28</td>
<td>74.17</td>
<td>Before</td>
<td>2010</td>
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### Ride Statistics

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<th>RIRI</th>
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## Reduction In IRI After Project Completion

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<th>FROM</th>
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<th>LIRI</th>
<th>% REDUCED</th>
<th>RIRI</th>
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<tr>
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<td>21.43</td>
<td>33.81</td>
<td>14.72</td>
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<td>11.32</td>
<td>16.6%</td>
<td>13.02</td>
<td>17.6%</td>
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**Rt 24 Brockton – Raynham “Today”**
RT 24 Avon Stoughton
“Before”

- 4.02± miles (31.16 lane miles)
- 3 lanes + Breakdown & Shoulder
- Distress
  - Ravelling & Weathering OGFC
  - Delamination & Thermoplastic
  - Thermoplastic markings gone
- Rehab
  - Micromill & 1.25” ARGG Thin Overlay
- Bid $4,349,096.25
  - Bridge Patching & Repairs
  - Clearing & Grubbing
  - Frames/Grates (lockdowns)
  - Traffic Control, Striping, etc.
  - Guardrail repairs & interchanges.
- Cost $ 139.5K/lane mile

### Pre-Construction Ride Statistics

<table>
<thead>
<tr>
<th>ROUTE</th>
<th>FROM</th>
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<th>LIRI</th>
<th>RIRI</th>
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<th>COMMENTS</th>
<th>COLLECTION YEAR</th>
<th>PROJECT #</th>
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# Post-Construction Ride Statistics

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<th>COMMENTS</th>
<th>COLLECTION YEAR</th>
<th>PROJECT #</th>
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### Reduction In IRI After Project Completion

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<th>ROUTE</th>
<th>FROM</th>
<th>TO</th>
<th>LIRI</th>
<th>% REDUCED</th>
<th>RIRI</th>
<th>% REDUCED</th>
<th>AVG IRI</th>
<th>% REDUCED</th>
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<td>0024N</td>
<td>33.82</td>
<td>37.84</td>
<td>37.03</td>
<td>49.6%</td>
<td>43.17</td>
<td>50.3%</td>
<td>40.10</td>
<td>50.0%</td>
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</table>
Asphalt Rubber, WMA & RAP

- I-295 Attleboro Demo Project
  - Advera (Zeolite WMA)
- Rt 3 Plymouth Late Season Paving
  - PaveCool and Wax-based WMA
    - Increased compaction time
    - No impact to stability or moisture damage
    - No temperature reduction.
- I-495 HAMS – questioned “no-RAP”
- Performance Questions using WMA & RAP.
  - Task under ISA with UMASS Dartmouth HSRC.
UMASS HSRC undertook an extensive Research Project evaluating use of RAP & WMA with AR.

WMA - Lower production/placement temperatures, reduced emissions and odors, decreased energy consumption for production & improved environmental working conditions

Higher binder content for ARGG mixtures may improve mixture cracking resistance, improve rutting performance, and resist aging/oxidation

Meet the DOT/ industry goal of producing a sustainable, cost effective, and environmentally friendly mixture
Concerns with RAP&WMA AR Mixtures

- **Higher amounts of RAP**
  - Mixture may become too stiff and may be more prone to failure
  - RAP/virgin binder blending at higher RAP contents unknown
  - Potential reduction in compactability and workability

- **WMA**
  - May increase mixture moisture susceptibility
Binder & WMA

- PG58-28 base binder + 17% rubber
- Conformed to ASTM D 6114 Type II specifications
- Mixing temperature = 177°C (351°F)
- Compaction temperature = 154°C (309°F)
- SonneWarmix™ added at a dosage rate of 1.0% by weight of total binder (Virgin +RAP).
- Reduced mixing and compaction temperatures for WMA mixtures corresponded to temperatures that the asphalt rubber supplier had been using when producing similar mixtures with the same WMA technology.
Mixture Gradations

- Control
- 25% RAP
- 40% RAP

Percent Passing vs. Sieve Size (mm)
Mixture Stiffness – Dynamic Modulus

Conducted to determine changes in mixture stiffness due to the incorporation of RAP and/or WMA Technology.

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Frequency</th>
</tr>
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<tbody>
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<td>4°C</td>
<td>10 Hz, 1Hz, 0.1Hz</td>
</tr>
<tr>
<td>20°C</td>
<td>10 Hz, 1Hz, 0.1Hz</td>
</tr>
<tr>
<td>40°C</td>
<td>10 Hz, 1Hz, 0.1Hz, 0.01Hz</td>
</tr>
</tbody>
</table>

Specimens were fabricated at a target air void level of 7.0 ± 1.0%.
Master Curves – No WMA
Mixture Master Curves – with WMA

Dynamic Modulus $E^*$, MPa

Reduced Frequency, Hz
Mixture Master Curves - ALL

Dynamic Modulus $E^*$, MPa

Reduced Frequency, Hz

Control
25% RAP
40% RAP
Control + WMA
25% RAP + WMA
40% RAP + WMA
Mixture Stiffness
Conclusions

- The addition of RAP to the control mixture resulted in an increase mixture stiffness.

- The stiffness increase in the mixtures containing RAP was mitigated through the use of a WMA technology and corresponding reduced aging temperatures.

- The addition of the WMA technology to the control mixture had little to no effect on the stiffness of the mixture.
Fatigue – Four Point Bending Beam

- Specimens were fabricated at a target air void level of 7.0 ± 1.0%

- Testing conducted in strain control mode

- Loading Frequency = 10Hz

- Sinusoidal Wave Form

- Failure Criteria = 50% reduction in initial stiffness per AASHTO T321 method

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Strain Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>15°C (59°F)</td>
<td>300µε, 500µε, 700µε &amp; 900µε</td>
</tr>
</tbody>
</table>

Testing in Accordance with AASHTO T321
**Fatigue – Four Point Bending Beam**

<table>
<thead>
<tr>
<th>Strain Level, $\mu e$</th>
<th>Control</th>
<th>Control + 25% RAP</th>
<th>Control + 40% RAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>6,025,590</td>
<td>3,724,655</td>
<td>2,390,822</td>
</tr>
<tr>
<td>500</td>
<td>614,053</td>
<td>677,983</td>
<td>289,898</td>
</tr>
<tr>
<td>700</td>
<td>544,687</td>
<td>197,625</td>
<td>46,895</td>
</tr>
<tr>
<td>900</td>
<td>25,567</td>
<td>24,984</td>
<td>16,255</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Strain Level, $\mu e$</th>
<th>Control + WMA</th>
<th>Control + 25% RAP + WMA</th>
<th>Control + 40% RAP + WMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>2,946,065</td>
<td>1,759,123</td>
<td>1,526,473</td>
</tr>
<tr>
<td>500</td>
<td>705,290</td>
<td>775,690</td>
<td>306,746</td>
</tr>
<tr>
<td>700</td>
<td>196,372</td>
<td>99,901</td>
<td>51,134</td>
</tr>
<tr>
<td>900</td>
<td>21,616</td>
<td>27,026</td>
<td>4,697</td>
</tr>
</tbody>
</table>
Fatigue –
Four Point Bending Beam
Four Point Bending Beam - Conclusions

- The resistance to fatigue cracking decreased with the incorporation of RAP. The same trend was also apparent with the incorporation of the WMA technology.

- At each strain level, the number of cycles to failure for each mixture was reduced when WMA was incorporated.

- For the mixtures incorporating WMA, the mixing and compaction temperatures were dropped 17°C and 13°C respectively. This drop in the temperature might have caused the RAP and AR binders not to comingle sufficiently.
Reflective Cracking – +Overlay Tester

- Test Temperature = 15°C (59°F)
- Test Termination at 1,200 cycles or 93% Load reduction
- Testing in accordance with Tex-248-F

## Reflective Cracking – Overlay Tester

<table>
<thead>
<tr>
<th>Mixture</th>
<th>Average OT Cycles to Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>351</td>
</tr>
<tr>
<td>25% RAP</td>
<td>43</td>
</tr>
<tr>
<td>40% RAP</td>
<td>54</td>
</tr>
<tr>
<td>Control + 1% WMA</td>
<td>275</td>
</tr>
<tr>
<td>25% RAP + 1% WMA</td>
<td>64</td>
</tr>
<tr>
<td>40% RAP + 1% WMA</td>
<td>21</td>
</tr>
</tbody>
</table>
Overlay Tester – Conclusions

- The reflective cracking resistance of the mixture decreased with the incorporation of higher amounts of RAP. The same trend was apparent when WMA was incorporated.

- Generally, the OT data agreed with the results of the beam fatigue which showed a reduced cracking resistance for the mixture incorporating WMA.
Moisture Susceptibility & Rutting - Hamburg Wheel Tracking Device (HWTD)

- HWTD testing conducted in accordance with AASHTO T324

- Water temperature of 50ºC (122ºF) during testing

- Test duration of 20,000 cycles
Stripping Inflection Point (SIP)
## HWTD Results

<table>
<thead>
<tr>
<th>Mixture</th>
<th>Stripping Inflection Point</th>
<th>Average Rut Depth at 10,000 Passes (mm)</th>
<th>Average Rut Depth at 20,000 Passes (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>NONE</td>
<td>0.88</td>
<td>1.09</td>
</tr>
<tr>
<td>25% RAP</td>
<td>NONE</td>
<td>0.41</td>
<td>0.51</td>
</tr>
<tr>
<td>40% RAP</td>
<td>NONE</td>
<td>0.23</td>
<td>0.28</td>
</tr>
<tr>
<td>Control + 1% WMA</td>
<td>NONE</td>
<td>0.45</td>
<td>0.65</td>
</tr>
<tr>
<td>25% RAP + 1% WMA</td>
<td>NONE</td>
<td>0.14</td>
<td>0.23</td>
</tr>
<tr>
<td>40% RAP + 1% WMA</td>
<td>NONE</td>
<td>0.85</td>
<td>0.96</td>
</tr>
</tbody>
</table>

NONE = Mixture passed 20,000 cycle test with no SIP.
All mixtures evaluated passed the moisture susceptibility testing in the HWTD.

The magnitude of the average total rut depth observed at the end of each test was less than 1.10 mm (0.043 inch).
Workability Evaluation

- Mixture workability evaluation was conducted to determine the impact of RAP, AR and/or WMA on mixture workability.

- Workability evaluation was conducted using prototype device designed and built by UMass Dartmouth known as the Asphalt Workability Device (AWD).

- The AWD operates on the torque measurement principles.
Workability Evaluation

UMass Dartmouth AWD

AWD Paddle Configuration
Workability Results

**Graph**: Torque (N-m) vs. Temperature (°C)

- **Control**
- **Control + 1% WMA**
- **25% RAP**
- **25% RAP + 1% WMA**
- **40% RAP**
- **40% RAP + 1% WMA**
Mixtures without the WMA technology showed that as the amount of RAP incorporated into the mixture was increased there was a corresponding decrease in mixture workability (i.e. increase in torque).

Overall, the addition of the WMA improved the workability of the mixtures with RAP to a level similar to the control mixture without RAP and WMA.
How were any results from the Study Implemented by the DOT?

- WMA required in all Asphalt Rubber Mixtures.
- **10% RAP Permitted in ARGG!**
- Must be capable of lowering production temperatures to 280F.
- DOT has waived its initial temperature requirement of 55F for placement of ARGG.
Hot Mix Asphalt - ARGG
Warm Mix Asphalt– ARGG
DOT assigned a task to UMASS HSRC for comparison of plant produced ARGG mixture to 12.5mm Superpave.

Use this testing for AASHTO ME Design Analysis.

Testing included:

- Beam Fatigue
- Dynamic Modulus
- Flow Number
- Hamburg Wheel Tester
- Overlay Tester
- TSRST.
Plant Mix
Beam Fatigue (500 µstrain)

AASHTO T321 Beam Fatigue Nf to 50% Reduction in Initial Stiffness

Mixtures

Nf = Number of Cycles to Failure at 15°C

12.5mm Control  Bridge  ARGG

- 69,002
- 90,038
- 2,858,460

2,858,460
Plant Mix
Beam Fatigue (750 µstrain)

AASHTO T321 Beam Fatigue Nf to 50% Reduction in Initial Stiffness

Nf = Number of Cycles to Failure at 15C

Mixtures

- 12.5mm Control
  - 11,135 cycles

- Bridge
  - 9,776 cycles

- ARGG
  - 136,281 cycles

750µε
Plant Mix
Dynamic Modulus

Dynamic Modulus $E^*$, ksi

Reduced Frequency, Hz

- Control
- ARGG
- BRIDGE
Plant Mix
Flow Number

Flow Number - AASHTO TP79 - 50°C 600 kPa Deviator Stress
MassDOT Control vs ARGG vs BRIDGE

Flow Number

12.5mm CONTROL  |  ARGG  |  BRIDGE

259  |  451  |  233
Plant Mix
Hamburg Wheel Testing

AASHTO T324 Hamburg Results
MassDOT Control vs ARGG vs BRIDGE

MassDOT 12.5mm Control
Test Temperature: 50°C
Stripping Inflection Point: NONE
Rut Depth at 10,000: 1.63 mm
Rut Depth at 20,000: 2.21 mm

MassDOT ARGG
Test Temperature: 50°C
Stripping Inflection Point: NONE
Rut Depth at 10,000: 3.04 mm
Rut Depth at 20,000: 4.70 mm

MassDOT BRIDGE
Test Temperature: 50°C
Stripping Inflection Point: NONE
Rut Depth at 10,000: 2.11 mm
Rut Depth at 20,000: 3.43 mm
Plant Mix

TSRST Results

TSRST Results - AASHTO TP10
MassDOT Control vs ARGG vs BRIDGE

- Control: -24.9
- ARGG: -27.8
- BRIDGE: -22.3
Plant Mix
Overlay Test Results

Overlay Test Results - Tex-248-F - 15°C
MassDOT Control vs. ARGG vs BRIDGE

OT Cycles to Failure

12.5mm Control | ARGG | BRIDGE

23 | 294 | 21
Currently evaluating how overlay thicknesses can be impacted by using ARGG.

Specified ARGG as an overlay on Composite (HMA over Jointed PCC Roadways).

Specified ARGG on I-90 Weston in toll-plaza area.

Two OGFC-AR Projects that we will be looking at.

Full-Depth Porous Pavement containing AR and shingles for highway median.

We’ll be running these specifications and mixtures through HSRC for verification and other testing.
MassDOT specifies Stress Absorbing Membrane Interlayers (SAMI) to mitigate reflective cracking in some applications. Item #466.

SAMI can be placed independent of an overlay and left open to traffic.

Four test sections were constructed on Route 8 in the towns of Cheshire- Lanesboro.

Two Sections included a Rubber Chip Seal SAMI.
  - SAMI & HMA Overlay
  - SAMI & Bonded Thin Overlay
Route 8 Cheshire Lanesboro Construction
Cheshire - Lanesboro
HMA over Rubber Chip Seal
SAMI

- First Core on shoulder – no SAMI
- Second Core through SAMI
- Effective on most longitudinal cracking
- Effective on less light to moderate transverse cracking
Cheshire Lanesboro
HMA over Rubber Chip Seal SAMI
Route 8 Cheshire Lanesboro

- HMA over Rubber Chip Seal SAMI
- Crack stops at SAMI.
- Effective on most longitudinal cracking.
- Effective on less severe transverse cracking.
Route 8 Cheshire Lanesboro
Bonded Thin Overlay on Asphalt Rubber SAMI
Light Reflective Cracking visible
SAMI and core appear intact.
Cheshire Lanesboro
Bonded Thin Overlay on Rubber Chip
SAMI
Kernwood Drawbridge
Salem, MA
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