Recycle as a Resource
Benefits, Performance, and Equipment Technology

Topics...
- Value of RAP
- Performance of RAP Mixes
- Equipment Technology and Processing

What does GREEN mean?
- Conserving our resources
- Reducing energy cost
- Reducing Greenhouse Emission
- Being more environmentally friendly
- And building a better, longer-lasting pavement

RAP IS A RESOURCE
NOT A WASTE
SUSTAINABILITY

UPHILL BATTLE
RAP is worth the virgin material it replaces.

Why?

Recycle makes a better road

Pavement Quality Issues

- Overlays can experience cracks and rutting
- Milling and inlays prevent re-rutting

Milling ensures consistent paving density

No shoulder or guardrail changes with milling

What about mix performance?

Mechanical Foaming

- Uses water (steam bubbles) to decrease viscosity
NCAT Pavement Test Track

2009 Group Experiment (+)
Six-State Sponsored

WMA

50% RAP
6 Test Sections

"Rutting" Results

Truck Fleet Operations

Actual Strain Response
Beam Fatigue Apparatus

- Cyclically applies a set amount of “strain” to the specimen.
- It bends the test specimen (beam) until it fails.

Actual Strain Response

Fatigue Performance Expectations Actual

Virgin Mixes @ 350µ / RAP @ 250µ

10 million ESAL strain cycles

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Fatigue Performance Expectations Actual

Virgin Mixes @ 350µ / RAP @ 250µ

10 million ESAL strain cycles

Data courtesy of NCAT
Fatigue Performance Expectations

<table>
<thead>
<tr>
<th>Virgin @ 350µε</th>
<th>RAP @ 250µε</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>1.6</td>
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<td>5.0</td>
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<tr>
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<td>0.2</td>
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<tr>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>1.6</td>
<td>3.0</td>
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</tbody>
</table>

10 million ESAL strain cycles

12.7 X

Other Foamed WMA Benefits
- Use less fuel due to lower temperature (approx. 50°F [28°C] reduction)
- Less CO₂ emissions and VOC emissions
- Better working conditions / Better neighbor
- Less oxidation of mix
- Can be used as a compaction aid
- Extended hauling distances

WMA Benefit: Reduced Emissions

<table>
<thead>
<tr>
<th>Mix Temperature (°C)</th>
<th>Load-out Emissions (Kg/yr)</th>
<th>Silo-filling Emissions (Kg/yr)</th>
<th>% Reduction</th>
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</thead>
<tbody>
<tr>
<td>163</td>
<td>1064</td>
<td>3317</td>
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<td>135</td>
<td>303</td>
<td>945</td>
<td>71.5</td>
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<tr>
<td>127</td>
<td>208</td>
<td>649</td>
<td>80.4</td>
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</table>

WMA Benefit: Reduced Emissions

<table>
<thead>
<tr>
<th>Mix Temperature (°F)</th>
<th>Load-out Emissions (lb/yr)</th>
<th>Silo-filling Emissions (lb/yr)</th>
<th>% Reduction</th>
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</thead>
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<tr>
<td>325</td>
<td>2346</td>
<td>7312</td>
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<td>2084</td>
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<tr>
<td>260</td>
<td>459</td>
<td>1430</td>
<td>80.4</td>
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</tbody>
</table>

Based upon a plant producing mix at 400TPH with a total yearly production of 600,000 tons using USEPA emissions factors for HMA production.

Other Foamed WMA Benefits

Data courtesy of NCAT
Sequential Mixing

- Virgin aggregate mixing begins on collecting conveyor
- Virgin aggregate mixing continues at the scalping (oversize) screen
- Vigorous mixing in the dryer
- Gentle mixing in the mixing chamber

Vigorous mixing in the dryer.

Thorough mixing in the mixing chamber.

Conclusions:
- RAP is a RESOURCE
- Milling enhances infrastructure function and maintainability
- RAP and bitumen foaming are not new technologies
- RAP + WMA → longer life pavements (NCAT data)