Flexible Pavements Annual Meeting

Warm Mix Asphalt

2008 ODOT Field Trials and The Future

Ohio Department of Transportation
Warm Mix Asphalt

What is it?

2009 Flexible Pavements Annual Meeting
Warm Mix Asphalt

Why?

• Reduce production and laydown temperatures
• Reduce emissions
• Reduce energy costs
• Reduce aging of binder
• Other Possible Benefits:
  – Cool weather paving (extend season)
  – Compaction aid for stiff mixes

2009 Flexible Pavements Annual Meeting
Warm Mix Asphalt

Why Foaming?

• Improved Workability / Coating
• No Smoke, Less Smell
• Longer Life Pavement
• 11% Less Plant Fuel
• 11% Higher Production
• Some Decrease in Cost

2009 Flexible Pavements Annual Meeting
Warm Mix Asphalt

Why Foaming?

![Graph showing viscosity and temperature for Warm Mix Asphalt with compactability range for PG 64-22 and foamed asphalt.]

2009 Flexible Pavements Annual Meeting
Warm Mix Asphalt

How much water?

About 1% $H_2O$ of liquid AC by weight.

1 ton mix – 2,000 lb.
5.3% AC liquid – 106 lb.
1 lb $H_2O$
Volume of liquid – 0.016 cu. ft.

1 lb $H_2O$ when converted to steam = 30 cu. ft.

Expansion = $\frac{30}{0.016} = 1875$
Warm Mix Asphalt

Unknowns with Foaming

• Production limitations
• Several different foam technologies
• Emissions
• Mix life
• Cost
• Quality Control
• Placement

2009 Flexible Pavements Annual Meeting
Warm Mix Asphalt

Foaming Technologies

Astec

WATER IS THE ONLY ADDITIVE. WATER IS PUMPED FROM A TANK TO THE FOAM NOZZLES.

2009 Flexible Pavements Annual Meeting
Warm Mix Asphalt

Foaming Technologies

Terex

2009 Flexible Pavements Annual Meeting
Warm Mix Asphalt

Foaming Technologies

Gencor and others

2009 Flexible Pavements Annual Meeting
Warm Mix Asphalt

2008 ODOT Field Trials

Projects with Water Injection for Foaming

In 2008 6 projects were sold to:

1) Determine asphalt plant emissions data

2) Create projects with control sections of equivalent HMA mixes to compare performance and laydown.

3) On some, sell as alternate to determine if realistic cost savings.

2009 Flexible Pavements Annual Meeting
Warm Mix Asphalt
2008 ODOT Field Trials
Projects with Water Injection for Foaming

One additional project was let as an alternate but was awarded as a hot mix due to the way multiple contractors bid the job for mix placement vs. mix producer.

One existing project not sold as WMA had it’s 301 base mix change ordered to WMA at a savings.

Total WMA tonnage – approx. 50,000 tons in 2008

2009 Flexible Pavements Annual Meeting
### Warm Mix Asphalt

#### 2008 ODOT Field Trials

Projects with Water Injection for Foaming

<table>
<thead>
<tr>
<th>Dist</th>
<th>PID</th>
<th>Section</th>
<th>Length</th>
<th>Sale</th>
<th>Contractor</th>
<th>Stack Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>77838</td>
<td>POR-224-13.42</td>
<td>4.9 mi</td>
<td>6/4/08</td>
<td>Shelly</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>25554</td>
<td>SUM-303-8.14</td>
<td>2.4 mi</td>
<td>6/4/08</td>
<td>Karvo</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>22640</td>
<td>LIC-40-0.58</td>
<td>5.7 Lmi</td>
<td>change order</td>
<td>Shelly</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>78156</td>
<td>PIC-62-0.00</td>
<td>7.64 mi</td>
<td>5/21/08</td>
<td>Kokosing</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>77424</td>
<td>DAR/MIA-49-0.00</td>
<td>9.75 mi</td>
<td>5/21/08</td>
<td>Valley/Walls</td>
<td>Yes</td>
</tr>
<tr>
<td>8</td>
<td>25378</td>
<td>CLE-132-0.00</td>
<td>12.43 mi</td>
<td>6/4/08</td>
<td>Barrett</td>
<td>Yes</td>
</tr>
<tr>
<td>8</td>
<td>83808</td>
<td>HAM-50</td>
<td>change order</td>
<td>Valley</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>22896</td>
<td>CUY-176-12.76</td>
<td>0.59 mi</td>
<td>7/23/08</td>
<td>Karvo</td>
<td></td>
</tr>
</tbody>
</table>

2009 Flexible Pavements Annual Meeting
## Warm Mix Asphalt

### Projects with Water Injection for Foaming

<table>
<thead>
<tr>
<th>Dist</th>
<th>Contr.</th>
<th>Section</th>
<th>Project Cost</th>
<th>Item</th>
<th>Cubic Yards</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Shelly</td>
<td>POR-224-13.42</td>
<td>1,411,473</td>
<td>Mill 1.5, place 1.75 446-2, 64-22</td>
<td>2512 WMA/ 1897 HMA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Place 2.5 446-1, 70-22M</td>
<td>1539 WMA/ 1840 HMA</td>
</tr>
<tr>
<td>4</td>
<td>Karvo</td>
<td>SUM-303-8.14</td>
<td>962,912</td>
<td>Mill 1.5, place 1.5 448-1 70-22M</td>
<td>1835 WMA/ 937 HMA</td>
</tr>
<tr>
<td>5</td>
<td>Shelly</td>
<td>LIC-40-0.58</td>
<td>- 3341</td>
<td>301 base only for WMA</td>
<td>6683 WMA</td>
</tr>
<tr>
<td>6</td>
<td>Kokosing</td>
<td>PIC-62-0.00</td>
<td>934,073</td>
<td>Mill 1.5, place 1.5 446-1, 64-22</td>
<td>2665 HMA/ 2928 WMA</td>
</tr>
<tr>
<td>7</td>
<td>Valley</td>
<td>DAR/MIA-49-0.00</td>
<td>1,662,762</td>
<td>Place 0.5 448-1 64-22</td>
<td>1222 WMA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Place 1.5 448-1H, 70-22M</td>
<td>3433 HMA/ 3667 WMA</td>
</tr>
<tr>
<td>8</td>
<td>Barrett</td>
<td>CLE-132-0.00</td>
<td>2,263,252</td>
<td>Mill 2.0, place 1.75 446-2</td>
<td>3713 total</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Place 1.5 446-1H 70-22M</td>
<td>3283 total</td>
</tr>
<tr>
<td>8</td>
<td>Valley</td>
<td>HAM-50</td>
<td></td>
<td>Place 1.5 448-1H 70-22M</td>
<td>8974 WMA</td>
</tr>
<tr>
<td>12</td>
<td>Karvo</td>
<td>CUY-176-12.76</td>
<td>255,843</td>
<td>Mill 0.5, place 1.0 424-B</td>
<td>1179 WMA</td>
</tr>
</tbody>
</table>
Warm Mix Asphalt
2008 ODOT Field Trials

General Project Requirements:
- Project split HMA/WMA with same JMF
- When stack test required: NOx, CO$_2$ and VOC
- Use Astec multi point water injection
- Perform QC lab compaction at 25 F less than design
- Field compact as needed for density measure
- Perform T 283 moisture damage testing each day
- Collect all QC, stack and fuel data and report to ODOT

2009 Flexible Pavements Annual Meeting
POR-224

2009 Flexible Pavement
POR-224

2009 Flexible Pavement
CUY- 176
424 w/ PG76-22M

<table>
<thead>
<tr>
<th>Temp</th>
<th>% Density</th>
<th>Pay Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>277</td>
<td>90.0</td>
<td>0.80</td>
</tr>
<tr>
<td>280</td>
<td>93.0</td>
<td>1.00</td>
</tr>
<tr>
<td>276</td>
<td>92.8</td>
<td>1.00</td>
</tr>
<tr>
<td>296</td>
<td>93.7</td>
<td>1.04</td>
</tr>
</tbody>
</table>
## Fuel and Emissions

### POR-224 Summary of Fuel and Emissions

<table>
<thead>
<tr>
<th></th>
<th>T 1 HMA</th>
<th>T 1 WMA</th>
<th>Percent Reduction</th>
<th>T 2 HMA</th>
<th>T 2 WMA</th>
<th>Percent Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production tons/hr</td>
<td>430</td>
<td>330</td>
<td></td>
<td>452</td>
<td>478</td>
<td></td>
</tr>
<tr>
<td>Plant Fuel Usage gal/ton</td>
<td>2.08</td>
<td>1.71</td>
<td>17.8</td>
<td>1.77</td>
<td>1.57</td>
<td>11.3</td>
</tr>
<tr>
<td>Temp °F</td>
<td>290</td>
<td>261</td>
<td></td>
<td>298</td>
<td>260</td>
<td></td>
</tr>
<tr>
<td>NOx lb/hr</td>
<td>31.97</td>
<td>19.10</td>
<td>40</td>
<td>30.46</td>
<td>27.33</td>
<td>10</td>
</tr>
<tr>
<td>CO₂ lb/hr</td>
<td>16599</td>
<td>11378</td>
<td>31</td>
<td>17258</td>
<td>15253</td>
<td>12</td>
</tr>
<tr>
<td>VOC lb/hr</td>
<td>8.7</td>
<td>6.39</td>
<td>27</td>
<td>6.92</td>
<td>6.54</td>
<td>5</td>
</tr>
</tbody>
</table>

*2009 Flexible Pavements Annual Meeting*
## 2008 Warm Mix Asphalt

### Fuel and Emissions

**DAR/MIA-49 Summary of Fuel and Emissions**

<table>
<thead>
<tr>
<th></th>
<th>Hot Mix</th>
<th>Warm Mix</th>
<th>Percent Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production tons/ hr</td>
<td>301.07</td>
<td>297.48</td>
<td></td>
</tr>
<tr>
<td>Plant Fuel Usage gal/ton</td>
<td>1.64</td>
<td>1.40</td>
<td>14.8</td>
</tr>
<tr>
<td>Temp ºF</td>
<td>330</td>
<td>295</td>
<td></td>
</tr>
<tr>
<td>NOx lb/hr</td>
<td>21.04</td>
<td>17.65</td>
<td>16.1</td>
</tr>
<tr>
<td>CO₂ lb/hr</td>
<td>14,830</td>
<td>12,789</td>
<td>13.8</td>
</tr>
<tr>
<td>VOC lb/hr</td>
<td>5.9</td>
<td>4.0</td>
<td>31.9</td>
</tr>
</tbody>
</table>

**2009 Flexible Pavements Annual Meeting**
Warm Mix Asphalt

2009 Specifications

http://www.dot.state.oh.us/Divisions/ConstructionMgt/Pages/ProposalNotesSupplementalSpecificationsandSupplements.aspx

STATE OF OHIO
DEPARTMENT OF TRANSPORTATION
SUPPLEMENTAL SPECIFICATION 800
REVISIONS TO THE 2008 CONSTRUCTION & MATERIAL SPECIFICATIONS

DATED 01-16-2009

2009 Flexible Pavements Annual Meeting
401.05, Mixing Plants
On page 170.
Add as a last sentence in this section the following sentence: Asphalt mixtures may be produced using the warm mix asphalt method according to 402.09 except as restricted by specification.
Warm Mix Asphalt

2009 Specifications

402.09 Water Injection System for Warm Mix Asphalt.

When allowed by specification use a Department approved water injection system for the purpose of foaming the asphalt binder and lowering the mixture temperature. Only use equipment that has been proven stable and effective thru project use on non-ODOT projects. Ensure equipment for water injection meets the following requirements:

• Injection equipment computer controls are in the plant control room and are tied to the plant computer metering.
• Injection equipment has variable water injection control controlled by the plant operation rate and the water injection can never exceed 1.8% by weight of asphalt binder.
• Water injection rate cannot be manually overridden by the plant operator once in the computer.
• Injection equipment stops water flow when a control or equipment failure in the injection system occurs.
• The water injects into the asphalt binder flow before the asphalt binder spray hits aggregate. Do not allow water to touch aggregate before the binder spray.
• Injection equipment includes water storage and pump control tied to the injection computer controls.
• Water storage low water alarm installed in the control room.
• Provide a PG binder sampling valve between the last piping tee on the tank side of the line and the injection equipment to sample PG binder before water is injected.
• Provide a PG Binder sampling valve at the injection equipment to sample binder prior to spray.
2009 Specifications

Warm Mix Asphalt

442.01
On page 234. **Description**, **Add** to the end of second paragraph in 442.01 the following sentence: Do not use the warm mix asphalt method for 12.5mm mixtures.

2009 Flexible Pavements Annual Meeting
441.09  **Add:** For warm mix asphalt according to 402.09 use a lab compaction temperature 30.0 °F (16.7 °C) less than the JMF lab compaction temperature for hot mix asphalt. Record on the TE-199 if the mixture produced was ran at the asphalt plant as a hot mix asphalt (HMA) or as a warm mix asphalt (WMA) produced according to 402.09 or another approved method.
**Warm Mix Asphalt**

**2009 Specifications**

Job Mix Formula for WMA

<table>
<thead>
<tr>
<th>District / Project / County</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mix type</td>
<td></td>
</tr>
<tr>
<td>Submittal date</td>
<td>Approved date</td>
</tr>
<tr>
<td>Job Mix Formula (JMF) numbers (HMA/WMA)</td>
<td>B442331   W442331</td>
</tr>
<tr>
<td>Calibration number</td>
<td></td>
</tr>
</tbody>
</table>
Thank You!

david.powers@dot.state.oh.us
Office of Materials Management
Ohio DOT (dot.state.oh.us)
614-275-1387

2009 Flexible Pavements Annual Meeting