Warm Mix Asphalt in Texas

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Warm Mix Asphalt (WMA) is defined as additives or processes that allow a reduction in the temperature at which asphalt mixtures are produced and placed.

When WMA allowed, temperatures should be from 215°F to 350°F.

When WMA required, temperatures should be from 215°F to 275°F.
Warm Mix Benefits

- More Durable Pavement
  - Less oxidized + less absorption = better fatigue life
- Better in-place densities
  - Improved fatigue life
  - better bonus for contractor
- Wider Paving Window
  - Winter Paving
  - Night Paving
- Reduced Emissions, Smoke & Odor
- Direct Energy Savings ~ $1/ton
- Less problems with crack seals swelling
Current Status

- WMA is allowed for use at Contractor’s option on most HMA projects
- A few districts require WMA by plan note
  - Environmental reasons – non attainment areas
  - Overlays on pavements with rubber crack seal
- Most Contractor’s have or are in the process of installing a WMA additive system
TxDOT Warm Mix Jobs

- October 2007: ~2000 tons
- October 2008: ~120,000 tons
- October 2009: 1,000,000 tons ++
- October 2010: Widespread Implementation
Many WMA Proprietary Technologies Available (19+)

- **Foaming Processes**
  - Introduce small amounts of water which turns into steam, expanding the binder phase and reducing mix viscosity.
    - Astec Double Barrel Green
    - Terex WMA System
    - Maxam Aqua Black
    - Advera

- **Chemical Modifiers**
  - Rely on a variety of different mechanisms, such as surfactants to help coat the aggregate at lower temperatures or waxes which decrease the viscosity above their melting point.
    - Evotherm
    - Rediset
    - Sasobit
TTI Research

What we did……

- Effects of Warm Mix Additive on Mixture Design
  - 3 Mixing and Compaction Temperatures
- Effects of Warm Mix Additive on Performance Tests
  - Hamburg
  - Overlay Test
  - Resilient Modulus
  - Fatigue Analysis
- Field and Laboratory Evaluation/Demonstration Projects
- Field Performance Evaluations
Field Evaluation

- Cores
  - Hamburg
  - Overlay Test
  - Indirect Tension
  - Density
  - X-ray computed tomography
- Ground Penetrating Radar (uniformity of construction)
- Falling Weight Deflectometer
## Field Projects Evaluated

<table>
<thead>
<tr>
<th>District</th>
<th>Service Age</th>
<th>Quantity of WMA</th>
<th>WMA Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Antonio</td>
<td>5 years</td>
<td>2000 tons</td>
<td>Evotherm</td>
</tr>
<tr>
<td>Lufkin</td>
<td>4 years</td>
<td>800 tons 800 tons</td>
<td>Evotherm Advera Rediset Sasobit</td>
</tr>
<tr>
<td>Fort Worth</td>
<td>4 Years</td>
<td>36000 tons</td>
<td>Evotherm</td>
</tr>
<tr>
<td>Austin</td>
<td>4 Years</td>
<td>8000 tons</td>
<td>Evotherm</td>
</tr>
<tr>
<td>Wichita Falls</td>
<td>4 Years</td>
<td>68000 tons</td>
<td>Double Barrel Green</td>
</tr>
<tr>
<td>Beaumont</td>
<td>4 years</td>
<td>1000 tons</td>
<td>Rediset</td>
</tr>
</tbody>
</table>
What we found.........

*in terms of*

- Effect of WMA on Selection of AC Content (Mix Design)
- Effect of WMA on Performance Tests
- Effect of WMA on QC Requirements
- Effect of WMA on Field Performance
Item 340/341 Mix Design
Texas Gyratory Mix Designs

Asphamin
Warm Mix 76-22 Design

Asphalt Content
Average Air Voids

Asphalt Content
Average Air Voids

Sasobit
Warm Mix 64-22 Design

Asphalt Content
Average Air Voids

Evotherm
Warm Mix 64-22 Design

Asphalt Content
Average Air Voids

Asphalt Content
Average Air Voids
Effect of Warm Mix Additive on Mix Design – Asphalt Content

WMA should be designed without the additive to avoid low AC content mixes.
Effect of WMA on Performance Tests

- Hamburg Wheel Tracking
  - Decrease in rutting resistance

- Overlay Test
  - Increase in cracking resistance

- Indirect Tensile Strength
  - Decrease in tensile strength

- Dynamic Mechanical Analysis
  - Improvement in fatigue life

- Surface Energy Measurements
  - Decrease in moisture resistance
Hamburg Results
Lab-Molded Plant Mix

Number of Passes to 1/2 in Rut

- HMA
- Sasobit
- Evotherm
- Advera
- Rediset

Number of Passes to 1/2 in Rut (in thousands): 14000, 10000, 8000, 6000, 8000
TTI Overlay Test
Overlay Test Results
Lab-Molded Plant Mix

![Bar chart showing cycles to failure for different materials.]

- HMA
- Sasobit
- Advera
- Evotherm
- Rediset
Hamburg At Different Curing Conditions

<table>
<thead>
<tr>
<th>Material</th>
<th>Curing Condition 1</th>
<th>Curing Condition 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>PG 64-22 Control</td>
<td>9000</td>
<td>12000</td>
</tr>
<tr>
<td>PG 64-22 Asphamin</td>
<td>4000</td>
<td>7000</td>
</tr>
<tr>
<td>PG 64-22 Sasobit</td>
<td>16000</td>
<td>18000</td>
</tr>
<tr>
<td>PG 64-22 Evotherm</td>
<td>10000</td>
<td>15000</td>
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</table>
Hamburg Wheel Tracking Data
San Antonio (Loop 368)
Overlay Test Data
San Antonio (Loop 368)
US 71 Austin District

Hamburg Rut Depth at 20,000 Cycles

<table>
<thead>
<tr>
<th>Material</th>
<th>0 months of service</th>
<th>1 year of service</th>
</tr>
</thead>
<tbody>
<tr>
<td>HMA</td>
<td>2.3 mm</td>
<td>1.6 mm</td>
</tr>
<tr>
<td>WMA</td>
<td>12.2 mm</td>
<td>3.2 mm</td>
</tr>
</tbody>
</table>
Significance of Aging/Stiffening Effect

- The oven curing time and temperature is a critical factor in performance tests and laboratory molded density (QC).
  - Curing at compaction temperature may yield poor Hamburg results for WMA which may not reflect field performance.
  - Curing at temperatures above compaction temperature can yield very high lab molded densities (in the pay penalty range).
FM 324 - Lufkin

WMA

HMA
Lufkin Project after 4 years
Field Performance

- Equivalent to HMA
- Uniformity of construction
- Uniformity of density
- Structurally equivalent to HMA
BU 287 Fort Worth District
Using GPR to detect compaction problems in full depth hot mix
Structural Strength Testing with FWD

Perpetual Pavement SH 114
Type B Chico Limestone
4.5% PG 64-22
E @ 106 F 580 ksi
E @ 77 F 1392 ksi

Warm Mix Shoulder on BU 287
Type B Chico Limestone
4.3% PG 64-22 WMA (Evotherm)
E @ 93 F 739 ksi
E@ 77 F 1256 ksi

No significant difference
X-Ray CT Image

Air Void
X-Ray CT of Cores

Air Voids Content (%)

Position (mm) Beaumont SMA HMA
Beaumont SMA WMA

HMA
Mean 3.76% SD 1.25

WMA
Mean 3.44% SD 0.62
Pending WMA Issues/Concerns

- Long Term Performance?
- Constructability Issues – Tenderness.
- Use of RAP and RAS with WMA.
- Mandated Use of WMA may be on the Horizon.
- Use in Mixes other than dense-graded.
4 month old new surfacing
IH 20  SMA F  Summer 2010

- Designed with PG 76-22
- Changed to PG 70-22 after passing Hamburg
- Warm Mix (foam) selected as contractor option
- Temperatures not reduced because of thin mat
- Severe bleeding experienced all lanes all directions
- Problems observed during record high temps in summer 2010
Findings

- Warm mix additives improve compactability which can lead to a reduction in asphalt content if incorporated in the mixture design process.
- WMA is initially less stiff than HMA but stiffens considerably within the first year of service and with increases in laboratory oven curing time/temperature.
- Field performance of WMA is comparable to HMA. Uniformity of WMA construction may be better than HMA.
Recommendations

- Design WMA mixtures without the additive for selection of asphalt content.
- Do performance tests on WMA with the additive.
- For quality control of WMA, oven cure mix at the warm mix compaction temperature.
- For performance testing, increase oven curing time/temperature to better represent data from field core testing and to standardize a process for curing all warm mixes similarly.
San Antonio Loop 368
Performance Good After 5 Years