A Cross-Cutting Comparison between
Hot Mix Asphalt & Warm Mix Asphalt

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The “Gist”

- Results of early WMA experiments did not indicate drastic difference with HMA
- Agreed with positive field experience
What were you doing in 2003?

**WMA comes to the United States!**

- **The Challenge:**
  - No long-term performance information
  - No previous demonstration projects
  - Laboratory studies

- **Early Experiments:**
  - Compare WMA to HMA
  - Probable Performance
  - Lessons learned
Early Questions

1. Is rutting potential higher for WMA than HMA?
2. Does WMA compact similar to HMA?
3. How does water and foaming affect performance?
4. How do wax additives impact low temperatures?
Maryland Interstate Case Study
Simulated Traffic Opening - French Rut Tester

- Pneumatic wheel
- Pre-compacted HMA & WMA
- Slabs were re-heated and load testing commenced when temperature reached typical traffic opening temperature
Sasobit WMA actually less rut susceptible than HMA
Field Evaluation of WMA Compaction
(I-95/I-495 Capitol Beltway MD, Intermediate course SMA with High RAP)

![Graph showing surface temperature (°F) against roller pass for different compaction methods: Conventional SMA and Sasobit SMA.](image)
It is imperative these trendlines be considered in light of statistical analyses.

Intelligent Roller
Breakdown and Intermediate – No Finish

Intelligent Compactor Stiffness, Evib (100 psi)

- Conventional SMA
- Sasobit SMA

Roller Pass

0 1 2 3 4 5 6
### Field Evaluation of WMA Compaction
(I-95/I-495 Capitol Beltway MD, Intermediate course SMA with High RAP)

<table>
<thead>
<tr>
<th>Pass</th>
<th>Mean Mat Compaction Temperature</th>
<th>Mean IC Roller $E_{\text{VIB}}$ Stiffness</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Conventional ≠ Sasobit</td>
<td>Conventional ≠ Sasobit</td>
</tr>
<tr>
<td>2</td>
<td>Conventional ≠ Sasobit</td>
<td>Conventional = Sasobit</td>
</tr>
<tr>
<td>3</td>
<td>Conventional ≠ Sasobit</td>
<td>Conventional = Sasobit</td>
</tr>
<tr>
<td>4</td>
<td>Conventional ≠ Sasobit</td>
<td>Conventional = Sasobit</td>
</tr>
</tbody>
</table>

- Densities of cut cores reported by MDSHA were more insightful than nuclear gauges (poor correlation with IC)
- Cores indicated Sasobit and conventional SMA exhibited essentially same densities from same rolling pattern
Reduced Temperature Laboratory Binder Study

- 10 binders
- RTFO (AASHTO T 240) aged at 3 temperatures: 163°C, 130°C, and 110°C
- Results show that:
  - Temperature reductions of 30°C ~ half a grade change in high temperature continuous grade
  - Temperature reductions of 50°C ~ almost a grade change in high temperature continuous grade
- May be binder dependent
NCHRP 9-43 Mix Design Practices for WMA

Results used to develop preliminary production temperature limitations

- Increasing high temperature performance grade
- Additional long-term aging and low temperature evaluation
  - Low temperature binder grade selection for WMA temperatures
What is the impact of foaming on moisture sensitivity?
Impact of Water / Foaming on Performance

- WAMFoam
- Precursor to current foaming systems
- Loaned Lab device
- No Lime antistrip added

**Results showed:**
- Potential moisture sensitivity in Hamburg
- Opposite of that with TSR
- Behavior observed in other studies
Impact of Water / Foaming on Performance

- WAM Foam average
- WAM Control average

Rut depth (mm)

Number of passes

Hamburg Wheel Tracking
Impact of Water / Foaming on Performance

Tensile Strength Retained TSR
How do wax additives impact low temperatures?
Impact of Wax Additives on Low Temperatures

- Thermal Stress Restrained Specimen Tests (TSRST)
- Two aggregates – Three binders
- Two wax additives – High rate of modification (3%)
## Low Temperature TSRST Experiment

<table>
<thead>
<tr>
<th>Binder</th>
<th>Natural Wax Content</th>
<th>Mix Design Aggregate</th>
<th>WMA Wax Modifier</th>
<th>Continuous Low Temp. PG (°C)</th>
<th>Temperatures at Fracture (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAM-1 (PG64-16)</td>
<td>4.21%</td>
<td>Diabase, Limestone</td>
<td>none, 3% Sasobit</td>
<td>-22, -16</td>
<td>-22.9, -23.0, -24.2, -22.4, -23.0, -20.8</td>
</tr>
<tr>
<td>Generic PG64-22</td>
<td>Not Measured</td>
<td>Limestone</td>
<td>none, 3% Sasobit</td>
<td>-26, -22</td>
<td>-29.0, -26.4, -28.5, -29.0, -27.7, -29.3</td>
</tr>
</tbody>
</table>
Impact of Wax Additives on Low Temperatures

- **Results:**
  - Statistical comparisons of the mixtures’ TSRST fracture temperatures
    - Impact of WMA wax modification not significant
    - May cause slight increase in critical temperature or loss of low temperature PG
    - Amount of loss affected by aggregate type for SHRP binders
So, what did we accomplish?

- Confirmed WMA may be produced & constructed at lower temperatures with similar workability & properties to HMA.

- Provided confidence for WMA use

- Highlight needed additional research
  - Binder grade choice with WMA
  - Laboratory methods for mixing and conditioning WMA
  - Moisture sensitivity
Future NPT Program Study

- **Full-scale Evaluation of High Recycled Content & WMA Mixtures for Performance**

- **Objectives:**
  - Quantify performance of combined use of WMA and high recycled content (RAP, RAS, rubber)
  - Verify guidance as a result of recent and on-going NCHRP research projects
  - Develop recommendations for RAP/RAS use by percent binder replacement and binder grade changes when using high recycled content
Implementation and Payoff - “Benefits”

- Takes risk off of State Highway Agencies
- Understanding field performance of WMA & high RAP mixture under actual conditions
- Controlled materials, processing, construction, and test sections including extensive laboratory characterization and performance monitoring
- Addresses climatic region not addressed by other test tracks
- The widespread use of WMA with high RAP may provide the largest impact for improved performance and direct cost savings.
Thank you!