WMA Performance at MnROAD

Tim Clyne
Mn/DOT

MAAPT 57th Annual Asphalt Conference
What is Warm Mix Asphalt (WMA)?

Technology that allows the reduction of mixing temperature by 20 to 100°F

- 50°F typical

Acts as a lubricator, not viscosity reducer

- Reduces surface tension of asphalt binder
- Allows binder to flow and coat aggregates
Potential Benefits of WMA

Environmental
★ Lower greenhouse gas emissions (~30-90%)
★ Lower fuel consumption (~30%)

Operational
★ Lower plant wear
★ Better compaction
★ More comfortable working conditions

Performance
★ Can use RAP and/or shingles with WMA
★ Reduced binder aging
★ Eliminates bumps in overlays
## 2008 MnROAD Construction

<table>
<thead>
<tr>
<th>Warm Mix Asphalt</th>
<th>Control</th>
</tr>
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<tbody>
<tr>
<td>15 16 17 18 19 23</td>
<td>24</td>
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<tr>
<td>3&quot; WM 58-34</td>
<td>3&quot; 58-34</td>
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<tr>
<td>11.1&quot; 64-22 1993 HMA</td>
<td>4&quot; Cl6sp</td>
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<tr>
<td>Clay 58-34 Surface Binder</td>
<td>Sand</td>
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<tr>
<td>12&quot; 100% recycle PCC</td>
<td>100' Fog Seal 2008</td>
</tr>
<tr>
<td>12&quot; 50% RePCC 50% Class 5</td>
<td>100' Chip Seals 2009 2010 2011 2012</td>
</tr>
<tr>
<td>12&quot; Cl3sp</td>
<td></td>
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<tr>
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<td>5&quot; WM 58-34</td>
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<tr>
<td>100' Chip Seals 2009 2010 2011 2012</td>
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<tr>
<td>12&quot; Cl-5</td>
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<tr>
<td>12&quot; Mesabi Ballast</td>
<td></td>
</tr>
<tr>
<td>12&quot; Select Gran</td>
<td></td>
</tr>
<tr>
<td>7&quot; Select Gran</td>
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<tr>
<td>Clay</td>
<td></td>
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<td>Clay</td>
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</table>
Mix Design Requirements

Wear and Non-Wear

12.5 mm NMAS
Traffic Level 4
PG 58-34
20% RAP from MnROAD

No requirements for WMA technology

★Hardrives chose REVIX (Evotherm 3G)
WMA Laydown

Business as usual – only cooler
Positive comments from the crew
Rolling Pattern Challenges
Laydown Temp (224°F)
Density Results

Non-Wear
★ All cores > 93.0%
★ Low air voids

Wear
★ Cores averaged 92%
WMA vs HMA
WMA vs. HMA
Lessons Learned

More lab work needed at mix design to determine compaction temperature range
Definite energy savings
Appears as though fumes/emissions were less
Equal density appears to be achievable with equal or less effort
Laboratory Test Results
Sampling and Testing

Samples Collected
• Asphalt Binder
• Asphalt Mixture

Testing Partners
• NCAT
• FHWA
• Texas Transportation Institute
• Ohio University
• University of Minnesota
• Mn/DOT
Binder DSR Testing

T = 58°C

G*/sinθ, kPa

Original
RTFO

PG 58-34
PG 58-34 WMA
Binder Low Temperature Testing

-36.0

-37.0

-38.0

-39.0

-40.0

-41.0

-42.0

PG 58-34 HMA

PG 58-34 WMA

Low Fail Temperature, °C

Stiffness
m-value
ABCD
DT Strain
Moisture Damage Potential

- Wear: 85.6%
- Non-wear: 83.4%

Dry
Wet
TSR

Tensile Strength Ratio

Strength, psi
Hamburg Rut Testing

Hamburg Rut Testing

WMA Control

WMA Non-Wear

WMA Wear

# of Passes to Failure

0  2000  4000  6000  8000  10000  12000  14000  16000  18000  20000
Lab Cracking Performance

SemiCircular Bend

Fracture Energy, J/m²

<table>
<thead>
<tr>
<th></th>
<th>High</th>
<th>Middle</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>WMA Wear</td>
<td>700</td>
<td>400</td>
<td>300</td>
</tr>
<tr>
<td>WMA Non-Wear</td>
<td>900</td>
<td>400</td>
<td>300</td>
</tr>
<tr>
<td>WMA Control</td>
<td>750</td>
<td>600</td>
<td>350</td>
</tr>
</tbody>
</table>
Lab Cracking Performance (2)

Texas Overlay Tester

<table>
<thead>
<tr>
<th></th>
<th># of Passes to Failure</th>
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</thead>
<tbody>
<tr>
<td>WMA Wear</td>
<td>900</td>
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<tr>
<td>WMA Non-Wear</td>
<td>1000</td>
</tr>
<tr>
<td>WMA Control</td>
<td>700</td>
</tr>
</tbody>
</table>
Field Performance Results
MnROAD Field Performance

Rutting

- Driving
- Passing

Rutting, inches

Cell Number

July 2010
MnROAD Field Performance (2)

Ride Quality

Graph showing ride quality with International Roughness Index in m/km for different cell numbers and months (Oct-09 and Apr-10). The graph indicates a comparison between two time periods, with a dashed line at 1.6 as a reference.
MnROAD Field Performance (3)

1 transverse crack in 5 test sections
  ★ Over instrumentation area (inadequate compaction)
25% reflective cracking on 3” WMA overlay
So far, so good
WMA from a Wider View
Previously WMA was handled on a case-by-case basis

- **2009 Position Memo**
- [www.dot.state.mn.us/materials/bituminous.html](http://www.dot.state.mn.us/materials/bituminous.html)

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### Table 2360.6-C5

<table>
<thead>
<tr>
<th>Air Temperature</th>
<th>Compacted Mat Thickness, inches(\text{A})</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\circ\text{F} \quad \circ\text{C})</td>
<td>1 inch [25 mm]</td>
</tr>
</tbody>
</table>

\(\text{A}\) Based on approved or specified compacted lift thickness.

\(\text{B}\) A minimum of one pneumatic-tire roller shall be used for intermediate rolling unless otherwise directed by the Engineer. The Engineer may specify or modify in writing (with concurrence from the Department Bituminous Engineer) a minimum laydown temperature.

\(\text{C}\) Not applicable if a WMA additive or process is used.
Mn/DOT District 3 and 7 Projects in 2010

First Mn/DOT projects requiring WMA

S-1 (2360) PLANT MIXED ASPHALT PAVEMENT – USE OF WARM MIX ASPHALT TECHNOLOGIES

The provisions of the attached 2360 Plant Mixed Asphalt Pavement (Gyratory Design) Specification is hereby modified as follows in order to use Warm Mix Asphalt (WMA)

All provisions for the production and placement of WMA will be the same as the conventional HMA mixtures as stipulated in 2360 Plant Mixed Asphalt Pavement (Gyratory Design) Specification except as noted below.

S-2.1 MIXTURE DESIGN

The contractor is responsible to use the same design used to produce the Hot Mix Asphalt, then modifying it to accommodate products or processes to meet the Warm mix criteria. This modification process will be limited to the same as described by the WMA Technical Working Group and found at http://www.warmmixasphalt.com/WmaTechnologies.aspx

Recycled Asphalt Shingles will not be allowed in any mixes on this project.

S-3.1 MIXTURE QUALITY MANAGEMENT

The Warm Mix Asphalt produced will not be allowed to exceed temperatures greater than 275 °F. Any WMA over that temperature will not be allowed to be used.
WMA Trials and Demonstrations

Over 140 documented WMA projects constructed to date.

Includes local, city, and county projects.

Jan 2010

Courtesy: Matt Corrigan

Mobile Asphalt Mixture Testing Laboratory (MAMTL)
Outstanding Issues

Early Rutting
- **No known problems have occurred**
- **Binder grade bump may be needed**

Moisture Damage

Long Term Performance
WMA Investigation and Implementation

FHWA working in partnership with AASHTO and Industry to implement warm mix

WMA Technical Working Group (TWG)

FHWA Expert Task Groups
- Binder, Mixture, RAP, and Modeling

Regional User-Producer Groups
- Share data and information

Move out of demonstration phase

Training and Education
Online Resources

www.warmmixasphalt.com
www.fhwa.dot.gov/pavement/asphalt/wma.cfm
www.hotmix.org
www.asphaltisbest.com
Publications
Conclusions

WMA should meet all Superpave requirements
Warm mix is the future of asphalt mixtures
Technology providers coming forward
Industry and agencies must work together to make it happen
Advantages far outweigh concerns
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tim.clyne@state.mn.us