Warm Mix Asphalt in Minnesota

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Mn/DOT

North Dakota 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
Environmental Benefits of WMA

Green Technology

- Lower greenhouse gas emissions (~30-90%)
  - CO₂, NOₓ, SO₂, VOC, etc.
- Lower fuel consumption (~30%)
- Reduced exposure of workers to fumes
- Eliminates the need for fume evacuation equipment on plant and paver
Operational Benefits of WMA

Construction Practices

- Lower plant wear
- Longer haul distances
- Late season paving
- Better compaction
- Early site opening
- More comfortable working conditions for plant and paving crews
Performance Benefits of WMA

Better Pavement Performance

- Can use RAP and/or shingles with WMA
- Reduced binder aging
- Less susceptible to low temperature and fatigue cracking
-Eliminates bump at joint when overlaying concrete
- Rutting and stripping performance still being investigated

As good as or better than traditional HMA
WMA Technologies

Foaming Technologies
- Water
- Additive

Organic Additives
- Wax

Chemical Additives
- Surfactants
- Anti-strip agents
Technology Overview

- WAM-Foam
- Low Emission Asphalt
- Aspha-Min
- Advera
- Sasobit
- REVIX
- Evotherm
- Cecabase RT
- Thiopave

- Rediset WMX
- AquaFoam
- Ultrafoam GX
- Terex
- Accu•Shear
- Aquablack
- Double Barrel Green

**FHWA does not endorse any particular proprietary product or technology.**
OVERVIEW OF WMA TECHNOLOGIES
Foam (water)

- Astec Double Barrel Green
- Stansteel Accu-Shear
- Gencor Ultrafoam GX
- Maxam AQUABlack
- TEREX Warm Mix
Foam (additive)

Aspha-Min

Readiset WMX

Advera

Low Emission Asphalt
Organic

Sasobit

2000 lb “Supersack”

Shell Thiopave
Chemical
WMA Technology Applications

Asphalt terminal blend
Added to binder line at plant
Added to aggregate stream at plant
Mineral filler feed line

Range from zero to moderate plant modifications
WMA EXPERIENCE IN MINNESOTA
Oil Gravel

- Cell 32 (1998) – Cold Mix Paving Practice
- Cell 27 (1999) – Chip Seal / Large Stone Base
- Cell 28 (1999) – Oil Gravel (luke warm mix) / Large Stone Base
- Cell 26 (2000) – Oil Gravel (warm mix) / Reclaimed Base
- Cell 27 (2000) – Oil Gravel (warm mix) / Large Stone Base
- Several County Roads throughout Minnesota

★ Oil Gravel requires solid base
★ No Transverse Cracking or Rutting
★ Some Fatigue and Rough Ride
Olmsted & Goodhue Counties

First known true WMA jobs in MN (2007)

- Revix (Evotherm 3G) technology
- Olmsted CR 104
  - 5 mile stretch
- Goodhue CSAH11
  - 537 tons placed in 4,200 feet of the EB lane
Crow Wing County

County Road 108 (2008)

- 2913 tons WMA, 272 tons HMA
- 58-34 HMA vs. 58-28 WMA
  - WMA is $3-$4 lower than HMA
- Estimated 5 years of extended service life
  - Life cycle cost analyses are favorable for WMA
- *ASCE Cold Regions paper 2009*

County now allows alternate bids on several projects

- 20,000 tons WMA in 2009 (CR 2)
# 2008 MnROAD Construction

<table>
<thead>
<tr>
<th>Warm Mix Asphalt</th>
<th>Control</th>
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<tbody>
<tr>
<td></td>
<td>15</td>
</tr>
<tr>
<td>3&quot; WM 58-34</td>
<td>12&quot; 58-34</td>
</tr>
<tr>
<td>11.1&quot; 64-22 1993 HMA</td>
<td>12&quot; 50% recycle PCC</td>
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<tr>
<td>Clay 58-34 Surface Binder</td>
<td>12&quot; Cl3sp</td>
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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

Next several slides courtesy of Chris Miller, Hardrives
REVIX™ Technology

Developed by Mathy Technology and Engineering and Paragon Technical Services, Inc.

- Chemical additive added at terminal or HMA plant
- Requires no plant modification
- Binder shipped from Mathy with WMA chemical package already added

This technology is now marketed as Evotherm 3G
Mix Design

Existing SPWEB440 Mix Design
- ¾” 100% Crushed Stone
- ½” Granite Chips
- Washed Granite Sand
- Crushed Millings from MnROAD

Replaced Standard Binder with WMA Binder
- Lab compaction temperature 235° - 245° F

Ran points to find optimum AC content for SPWEB440
Non-Wear MDR written from trial point data
WMA Production

Day 1 – 990 tons of SPNWB430C

- No change in GMM from design
- Drastic increase in Gmb (about 0.040)
- Lower than expected Air Voids and VMA
- Lower gyrating temperature gave equal results
WMA Production

Day 2 – 1996 tons of SPWEB440C

- Aggregate proportion change as well as add AC% reduction
- Air Voids on target
- VMA drop of about 1.0
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
Stripping Potential

The graph shows the stripping potential of materials with different tensile strength ratios (TSR), expressed as percentage values. The x-axis represents wear and non-wear conditions, while the y-axis shows the strength in psi. Two conditions are compared:

- **Dry**
- **Wet**

The graph indicates:

- **Wear**:
  - 85.6% (Dry)
  - 83.4% (Wet)

- **Non-Wear**:
  - 83.4% (Dry)
  - 80.0% (Wet)

These results suggest that the dry condition generally has a higher stripping potential compared to the wet condition, particularly for non-wear conditions.
Binder DSR Testing

T = 58°C

G*/sinθ, kPa

Original
RTFO

PG 58-34
PG 58-34 WMA
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
Mn/DOT Trunk Highway 95

Late season paving (2009)

★ Contractor was delayed, needed to finish paving before winter
★ Supplemental Agreement – Mn/DOT paid extra $0.60 per ton for WMA
★ Business as usual – good density, etc.
Bituminous Roadways

Maxam AquaBlack

- Installed on 2 local plants
- 15% of production was WMA
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](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 Projects in the U.S. (Dec 2009)
Outstanding Issues

Early Rutting

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

Moisture Damage

Long Term Performance
Research In Progress

NCHRP 09-43, Mix Design Practices for Warm Mix Asphalt

NCHRP 09-47A, Properties and Performance of Warm Mix Asphalt Technologies

NCHRP 09-49, Performance of WMA Technologies: Stage I - Moisture Susceptibility
Mn/DOT 2010 Bituminous Specification

Previously WMA was handled on a case-by-case basis

- 2009 Position Memo
- www.dot.state.mn.us/materials/bituminous.html

<table>
<thead>
<tr>
<th>Air Temperature</th>
<th>1 inch [25 mm]</th>
<th>1-1/2 inch [40 mm]</th>
<th>2 inch [50 mm]</th>
<th>≥3 inch [75 mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>°F [°C]</td>
<td></td>
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(A) Based on approved or specified compacted lift thickness.
(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.
(C) Not applicable if a WMA additive or process is used.
Production and Paving Best Practices

Work to minimize aggregate moisture
Make sure the burner is tuned for the temperature
Keep baghouse temperature above condensation point
Consider superheating aggregate ahead of RAP
Follow normal placement practices
WMA Investigation and Implementation

FHWA working in partnership with AASHTO and Industry to establish clear targets for implementation

WMA Technical Working Group (TWG)
FHWA Expert Task Groups
First projects requiring WMA
★ Binder, Mixture, and Models
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

Warm-Mix Asphalt: European Practice

Warm-Mix Asphalt: Contractors’ Experiences

Warm-Mix Asphalt: Best Practices

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Federal Highway Administration

In Cooperation With:
American Association of State Highway and Transportation Officials
National Cooperative Highway Research Program

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Mn/DOT
Office of Materials
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
Thank You!

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