Warm Mix Asphalt
State of the Practice
(The Reader’s Digest Version)

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Presentation Overview

• What
• Why
• Technologies
• National Perspective
• Research
• Projects
• Resources
Technologies which allow a reduction in the temps at which asphalt mix is produced and placed.
WMA- What?

• Like HMA, but Cooler
  – Typically produced at 212-280°F
• Many WMA Technologies
• Technologies tend to provide better aggregate coating
• Produced with minor plant modifications
• Placed with conventional equipment
Brief History

• 1995 - 1999
  - European Experiments & Pavement Construction

• 2002
  - NAPA European Scan Tour (Denmark, Germany and Norway)

• 2004
  - WMA Demonstration at World of Asphalt
  - First field trials FL and NC

• 2005
  - National Technical Working Group (TWG) formed
  - Field trials in FL, IN, MD, NH, OH, TX and Canada

• 2006
  - Trials in CA, MI, NY, MO, SC, VA and WI
Brief History

• 2007
  - NCRHP 9-43 research initiated
  - 5 new WMA technologies in the US
• 2008
  - Documented WMA trials in 32 states
  - 13 WMA technologies marketed in the US
  - 1st International WMA Conference in TN
• 2010
  - Documented WMA trials in 45 US States and all 10 Canadian providences
  - Over 20 WMA technologies in the US
• 2011
  - 2nd International Conference in St Louis
WMA – Why?

- Reduce fumes, odors and emissions
- Improved workability
- Extended paving season
- Longer haul potential
- Ability to use higher RAP content
- Better working conditions!
Control 330°F

Warm Mix 270°F

Reduced Emissions
Yellowstone Paving

Control
Temp = 320°F

Warm Mix
Temp = 245°F
Technologies
Technology Providers

3 Categories

Chemical Foaming

Organic (Wax)
Chemical

Cecabase® RT

Evotherm™ (DAT/3G)

Hypertherm™ / Qualitherm

Rediset™ WMX
MeadWestvaco Evotherm DAT

- Added at ~5% of the AC content
- 85% water + 15% “chemical package”
AkzoNobel - Rediset® WMX

- Solid Additive - Pastilles
- Built-in Anti-strip
- Added to the asphalt
- Also can be added to the mix at the hot-mix plant
Organic Additive

- Astech PER®
- Sasol - Sasobit®
- SonneWarmix™
- Thiopave™
Sasol - SASOBIT
(Organic paraffin wax)

- Added at 1 to 1.5% of AC Content
- Blend into binder or mix
- Improves rut resistance
- Non-Toxic; safe for crew
Mechanical Foaming

Accu-Shear™
AquaBlack™ WMA System
Aqua Foam WMA System
Double Barrel® Green
Eco-Foam II
Green Machine Ultra Foam GX
LEA (Low Emission Asphalt)
Meeker Warm Mix
Terex ® WMA System
Tri-Mix Warm Mix Injection Systems
Ultrafoam GX2™ System
WAM Foam
Mechanical Foaming

Various WMA Foaming Systems
Chemical Foaming

• Advera® WMA
• Aspha-min®
PQ Corporation - Advera® WMA

Dosage: 0.25% by weight of mix
National Perspective
## Progress in 6 Years

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2011</th>
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<tbody>
<tr>
<td>Technology Providers</td>
<td>3</td>
<td>30+</td>
</tr>
<tr>
<td>States with Field Trials</td>
<td>7</td>
<td>46</td>
</tr>
<tr>
<td>States with WMA Specs</td>
<td>1</td>
<td>30</td>
</tr>
</tbody>
</table>
2010 Tonnage
(from NAPA)

Estimated Total Tons WMA

Total Tons WMA, Million

- DOT
- Other Agency
- Commercial & Residential

2009
2010
2010 Tonnage
(from NAPA)

Reported WMA

- Avg. % of DOT tons
- Avg % of Other Agency tons
- Avg % of Commercial & Residential tons
State DOT Perspective

30 States have WMA Specifications

WMA Trials and Demonstrations
Warm-Mix Asphalt Part of FHWA's "Every Day Counts" Initiative

EDC is designed to identify and deploy innovation aimed at shortening project delivery, enhancing the safety of our roadways, and protecting the environment.

ACCELERATING TECHNOLOGY DEPLOYMENT
National Perspective

• By Dec 2011, 40 state DOT’s and all Federal Lands Divisions will have a specification that allows WMA on federal aid projects.

• By Dec 2012, at least 30 DOT’s will have achieved set targets for WMA usage.
National Technical Working Group (TWG)

- FHWA & NAPA (Co-Sponsors)
- Matt Corrigan & Ron White (Co-Chairs)
- Representatives
  - State DOTs
  - State APA
  - AASHTO
  - NCAT
  - NIOSH
  - HMA Industry
  - Labor
  - Research Centers
TWG Deliverables

- WMA Guide Specs
- Best Practices Guide
- Testing Framework for Initial Pilot Projects
- Support for National Cooperative Highway Research Program (NCHRP) Research to Address Spec Challenges
Research
Ongoing National Research

- **NCHRP 9-43**
  - Mix Design Practices - completed ($500,000)

- **NCHRP 9-47a**
  - Engineering Properties, Emissions & Field Performance - $900,000

- **NCHRP 9-49**
  - Performance of WMA Technologies: Stage I Moisture Susceptibility - $450,000

- **NCHRP 9-49A**
  - Performance of WMA Technologies: Stage II - Long Term Field Performance - $900,000
Ongoing National Research

- NC HRP 20-07 TASK 311
  - Development of a Warm Mix Asphalt Technology Evaluation Program

- NC HRP 9-52 (2012)
  - Short-Term Laboratory Conditioning of Asphalt Mixtures - $800,000

- NC HRP 9-53 (2012)
  - Asphalt Foaming Characteristics for Warm Mix Asphalt Applications - $700,000
NCCHRP Project 9-43

- Appendix to AASHTO R35
- WMA Mix Design Workshop/Training Module (FREE!)
Highway transportation agencies are exploring the use of warm mix asphalt (WMA) for pavement projects. One of their main questions, particularly for agency mixture design technicians and engineers, is how WMA design differs from hot mix asphalt (HMA) design. "Mixture Design for Warm Mix Asphalt" is a Web-based training that presents the modifications to the current Superpave volumetric design procedure, as described in AASHTO R35, that are needed to complete a WMA mixture design. The training highlights key differences in WMA and HMA design procedures, and provides an opportunity to apply the AASHTO R35 standard practice to a WMA design modification.
<table>
<thead>
<tr>
<th>ITEM</th>
<th>HMA AASHTO R35</th>
<th>WMA PROPOSED</th>
</tr>
</thead>
<tbody>
<tr>
<td>WMA Process</td>
<td>N/A</td>
<td>Producer Selected</td>
</tr>
<tr>
<td>RAP Selection</td>
<td>AASHTO M323</td>
<td>Compaction Temperature</td>
</tr>
<tr>
<td>Mixing and Compaction Temperatures during mixture design</td>
<td>Viscosity Based</td>
<td>Coating and compactability evaluated at planned temperatures</td>
</tr>
<tr>
<td>Specimen Preparation</td>
<td>Standard</td>
<td>Process Specific</td>
</tr>
<tr>
<td>Mixture Evaluation for Rutting</td>
<td>None</td>
<td>Flow Number Test</td>
</tr>
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</table>
California Research
California Research Objectives

- Determine whether the addition of additives to reduce the production and construction temperatures of asphalt concrete influences performance.

- Investigate additional benefits:
  - Use in rubberized AC
  - Increased RAP content
  - Night paving
  - Late season paving
  - Long hauls
  - Overcome environmental constraints, etc.

- Guide the implementation of WMA in California.
Workplan Summary

• Objectives met through:
  - Laboratory studies
  - Accelerated pavement testing
  - Field testing

• Phased approach followed

• Phase 1 & 2 DGAC (complete)
  - 3 most prominent technologies in 2007
    • Advera WMA®
    • Evotherm™
    • Sasobit®
  - Rutting and moisture sensitivity
Workplan Summary

• Phase 3, R-WMA-G
  - 7 technologies/each group
    • Advera® WMA.
    • Astec Double Barrel® Green.
    • Cecabase RT®.
    • Evotherm DAT™.
    • Gencor Ultrafoam GX™.
    • Rediset™ WMX.
    • Sasobit®

• Lab studies
  - Rutting & cracking performance
  - Moisture sensitivity
  - Other
    • Durability (OGFCs)
    • Aging
    • Emissions
    • Stability
Heavy Vehicle Simulator
Phase 1 & 2 Summary

• Testing
  - 18 months of HVS testing
  - 12 months of lab testing
  - Months of data analysis

• Reports completed:
  - 1st Level Report: Construction & Phase 1 Study
  - 1st Level Report: Phase 2 Study & forensic investigation
HVS Phase 1 and 2 Findings

• Laboratory fatigue tests indicate WMA technologies assessed will not influence fatigue performance

• Moisture sensitivity testing indicates comparable performance between WMA technologies and control section

• A suite of lab tests were developed to correlate performance in the lab with HVS testing, which assists in evaluating upcoming WMA technologies
Phase 1 & 2 Conclusions

- No indication that the three warm-mix additives tested influence long-term rutting & fatigue performance or increase moisture sensitivity.
- Construction quality/engineering remains a key concept.
- Key issues:
  - Beware wet aggregates.
  - Beware initial "tenderness" because of less binder oxidation.
Phase 3: RWMA-G Summary

- **Project 1**
  - Technologies
    - Control
    - Cecabase
    - Evotherm
    - Gencor Ultrafoam GX
  - Binder content - 7.3%
  - Rubber content - 18%
  - Haul time - 60 mins
  - Paving air temp - 50° F-59° F
Phase 3: RWMA-G Summary

- **Project 2**
  - Technologies
    - Control
    - Advera
    - Astec DBG
    - Rediset
    - Sasobit
  - Binder content - 8.3%
  - Rubber content - 19%
  - Haul time - 120 mins
  - Paving air temp - 50° F - 59° F
Phase 3 - Control
Phase 3 - Control
Phase 3 - WMA
Phase 3 - WMA
Phase 3 Summary

• Testing
  - 9 months of HVS testing
  - 9 months of lab testing
  - Additional APT to assess aging effect

• Reports completed:
  - 1st Level Report: Phase 3 Study
  - 1st Level Report: Construction emissions
  - 1st Level Report: Lab mix, lab compact study
Ph 3 Observations & Conclusions

- WMA mixes had significantly less smoke and odor
- WMA mixes were notably more workable
- Compaction generally poor
  - Set production temperatures based on required compaction temperature
Ph 3 Observations & Conclusions

• WMA generally had equal or better performance
  - Lower performance on 2 (subgrade moisture)
  - Comparative performance on 1 (incorrect binder content)
  - Lab performance dependent on air void content

• Key Issues
  - Beware temperature limits
  - Final conclusions after completion of lab testing and aging effects study
  - Emissions dependent on technology
CA Approval Process

• Supplier to submit comprehensive report that includes:
  - Laboratory testing data
  - 3 field trials
    • 10,000 AADT, 15% truck traffic
    • Follow-up site assessment in 12 months

• Approved product list on CT website:
  www.dot.ca.gov/hq/esc/approved_products_list
Projects
“The coldest winter I ever spent was a summer in San Francisco...”

Photo taken August 2010
Central Federal Lands WMA job near SF
Caltrans - 12 districts with distinctly different & varying needs
Location of WMA Projects

- **2006 - 2010**: 14 projects, 70,000 tons
- **2010 - 2011**: 24 projects, OGFC, RHMA, DGAC, over 1 million tons
CA 1 in Morro Bay - May 2008
Project Information

- 1.2” (30mm) OGFC PG 58-34 PM
- 2000 ton control section and 3 WMA test sections (Evotherm, Advera & Sasobit)
- Ambient temperature between 50 ºF and 60 ºF
- Mixing temps 260 ºF to 290 ºF (vs. 320 ºF)
- Final compaction by 220ºF (vs. 250 ºF)
Interstate 5 in Orland, CA

AADT 26,000
25.3 % Trucks
Project Information

- 1.2” (30mm) RHMA-O PG 64-16
- 3,000 tons of Control (320°F)
- 12,000 tons Evotherm WMA (285°F to 305°F)
- Ambient temperature between 60°F and 70°F
- Mix workable down to 230°F
CA 1 Point Arena - Sept 2008

- 0.10' OGFC w/ PG 58-34 PM
- Mix production temperature: 320°F to 290°F (vs. 320°F)
- Breakdown temperature: 240°F to 210°F (vs. 240°F)
- 3 - 4 hour haul time
- Air temp 55°F and “misty”
- MTV required
I-5 Slab Replacements (2011)

- 9” DGAC, PG 64-10
- 3 Lifts
- 8 hours, night paving
- Mix Temp: 255ºF
Resources
About Us

The Warm Mix Asphalt Technical Working Group (WMA TWG) is led by individuals in the public and private sectors who are committed to the development of Warm Mix Asphalt in the United States. Experts from the National Asphalt Pavement Association (NAPA), State Departments of Transportation (DOTs), Federal Highway Administration (FHWA), National Center for Asphalt Technology (NCAT), American Association of State Highway and Transportation Officials (AASHTO), and many others meet regularly to discuss issues and share knowledge for the advancement of Warm Mix Asphalt.

For more information on these organizations, visit the following websites:

National Asphalt Pavement Association
Departments of Transportation
Federal Highway Administration
National Center for Asphalt Technology
American Association of State Highway and Transportation Officials
Warm Mix Asphalt Technologies and Research

European countries are using technologies that appear to allow a reduction in the temperatures at which asphalt mixes are produced and placed. These technologies have been labeled Warm Mix Asphalt (WMA). The immediate benefit to producing WMA is the reduction in energy consumption required by burning fuels to heat traditional hot mix asphalt (HMA) to temperatures in excess of 300°F at the production plant. These high production temperatures are needed to allow the asphalt binder to become viscous enough to completely coat the aggregate in the HMA, have good workability during laying and compaction, and durability during traffic exposure. With the decreased production temperature comes the additional benefit of reduced emissions from burning fuels, fumes, and odors generated at the plant and the paving site.

There are three technologies that have been developed and used in European countries to produce WMA:

1. The addition of a synthetic zeolite called Aspha-Min® during mixing at the plant to create a foaming effect in the binder.
2. A two-component binder system called WAM-Foam® (Warm Asphalt Mix Foam), which introduces a soft binder and hard foamed binder at different stages during plant production.
3. The use of organic additives such as Sasobit®, a Fischer-Tropsch paraffin wax and Asphaltian B®9, a low molecular weight esterified wax.

The Aspha-Min and Sasobit products have been used in the United States. Additional technologies have been developed and used in the United States to produce WMA:

4. Plant production with an asphalt emulsion product called Evotherm™, which uses a chemical additive technology and a “dispersed asphalt technology” delivery system.
5. The addition of a synthetic zeolite called Adhera® WMA during mixing at the plant to create a foaming effect in the binder.

All five technologies appear to allow the production of WMA by reducing the viscosity of the asphalt binder at a given temperature. This reduced viscosity allows the aggregate to be fully coated at a lower temperature than what is traditionally required in HMA production. However, some of these technologies require significant equipment modifications.

This technology could have a significant impact on transportation construction projects in and around non-attainment areas such as large metropolitan areas that have air quality restrictions. The reduction in fuel usage to produce the mix would also have a significant impact on the cost of transportation construction projects.

The benefits of these technologies to the United States in terms of energy savings and air quality improvements are promising but these technologies need further investigation and research in order to validate their expected performance and added value. It is important to note that producing HMA at lower temperatures is the desired product to achieve these benefits, not the particular technology that is used to produce the WMA mix.

Product Descriptions
Dedicated to providing knowledge, the Pavement Research Center uses innovative research and sound engineering principles to improve pavement structures, materials, and technologies.

NEWS
- APT2012, the 4th International Conference on Accelerated Pavement Testing, will be held in Davis, California, in September 2012. Information is available here.

Summer 2010 UCPRC Activities

**SHRP 2 R21 Composite Pavement Systems.** In 2008, UCPRC started work on the federal Strategic Highway Research Program (SHRP 2) R21 Project on Composite Pavement Systems. One of three major participants in the study, UCPRC is focusing on the use of hot-mix asphalt (HMA) surfaces over portland cement concrete (PCC) in new pavement construction. UCPRC activities have included performing agency surveys, modeling performance, designing and installing instrumentation, and constructing test sections.

Heavy Vehicle Simulator (HVS) testing currently underway at the UCPRC’s UC Davis facility will yield data on the rutting performance of two HMA types, PG64-28PM and RHMA-G, that are candidates for use as the surface layer on composite pavements. After the HVS rutting performance tests end, the composite pavement sections will undergo further testing to examine HMA and PCC cracking performance.

The HMA/PCC portion of this SHRP 2 project has several aims: to determine HMA and PCC behavior and identify their critical material and performance parameters; to develop and validate mechanistic-empirical performance models and...
WMA European Scan Tour

• Joint Program w/ FHWA, AASHTO, NCHRP & Industry
• FHWA-PL-08-007
NAPA Publications

PS-30  
Warm-Mix Asphalt: The Future of Asphalt

QIP 125  
Warm Mix Asphalt: Best Practices

IS-134  
Warm-Mix Asphalt: Contractors' Experiences
Newest NAPA Publication!

Warm-Mix Asphalt: Best Practices
2nd Edition
Top 5 List re: WMA

5. WMA Information is everywhere!

4. Different technologies have different advantages and disadvantages. (See number 5)

3. Warm mixes can improve workability and compaction. (See number 4)
Top 5 List re: WMA

2. Production at lower temperatures does reduce odors and smoke.

1. Warm mix is not pixie dust. Good engineering and construction practices are key!