



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

Cathrina Barros, PE - Caltrans
Office of Roadway Materials Testing
cbarros@dot.ca.gov

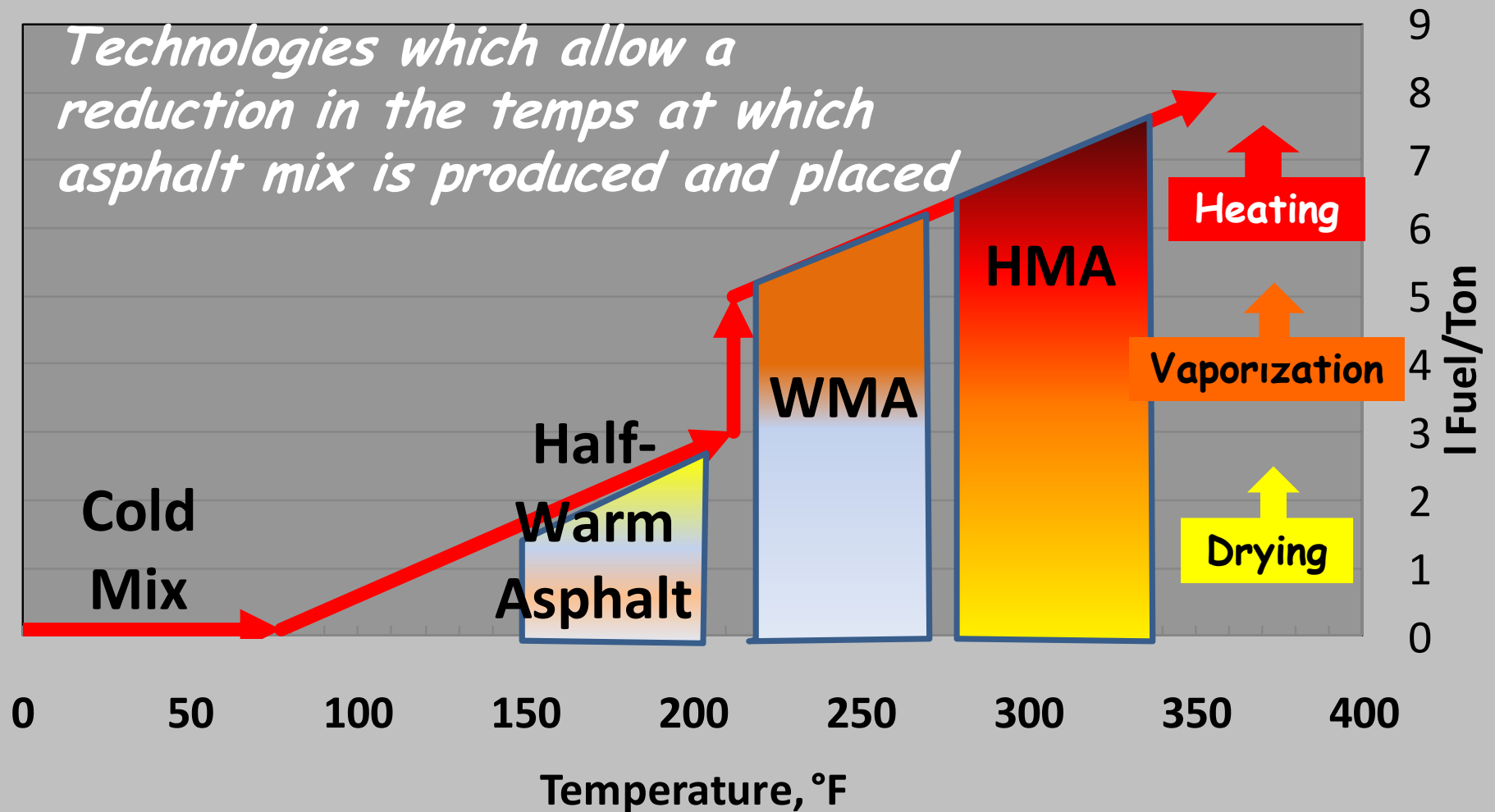
Acknowledgements

- Joe Peterson – Caltrans
- Matt Corrigan – FHWA
- Carl Monismith & Dave Jones – UC-Pavement Research Center
- Dave Newcomb – NAPA
- Adam Hand & Tony Limas -Granite Construction
- Rita Leahy – APACA
- Annette Smith – Advera
- John Shaw – Sasol
- Ray Hess – AkzoNobel
- Roger Sandberg – Maxam
- Kent Hansen – NAPA
- Scott Dmytrow – Telfer Oil Companies
- Brian Prowell – Advanced Materials Services, LLC

Presentation Overview

- What
- Why
- Technologies
- National Perspective
- Research
- Projects
- Resources

WMA – What?



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

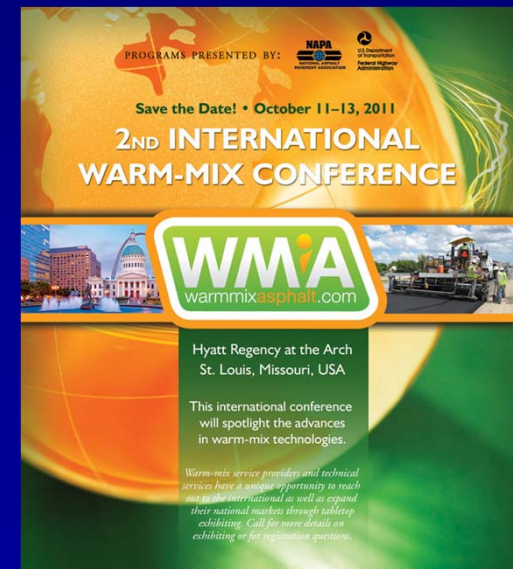
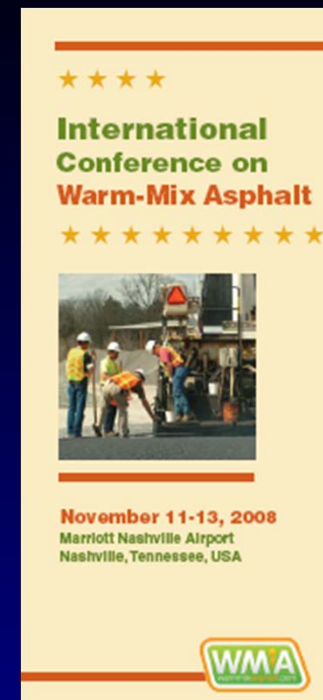


- 1995 – 1999
 - European Experiments & Pavement Construction
- 2002
 - NAPA European Scan Tour (Denmark, Germany and Norway)
- 2004
 - WMA Demonstration at World of Asphalt
 - First field trials FL and NC
- 2005
 - National Technical Working Group (TWG) formed
 - Field trials in FL, IN, MD, NH, OH, 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!

Reduced Emissions

Control 330°F

Warm Mix 270° F

04/09/2007

Yellowstone Paving

Control
Temp = 320°F



Warm Mix
Temp = 245°F

Technologies

Technology Providers

3 Categories

Chemical

Foaming

Organic (Wax)

WAM-Foam



Rediset WMX



AKZO NOBEL

Low Emission Asphalt

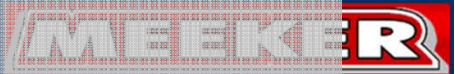
Asphal



Aspha-Min



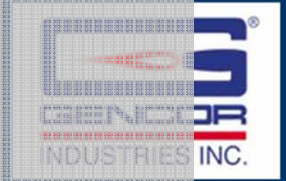
AquaFoam



Advera



Ultrafoam GX



Sasobit



Foaming



REVIX



Accu-Shear



Evothem



Aquablack



Cecabase RT



Double Barrel



Thiopave



Green

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

AquaFoam 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

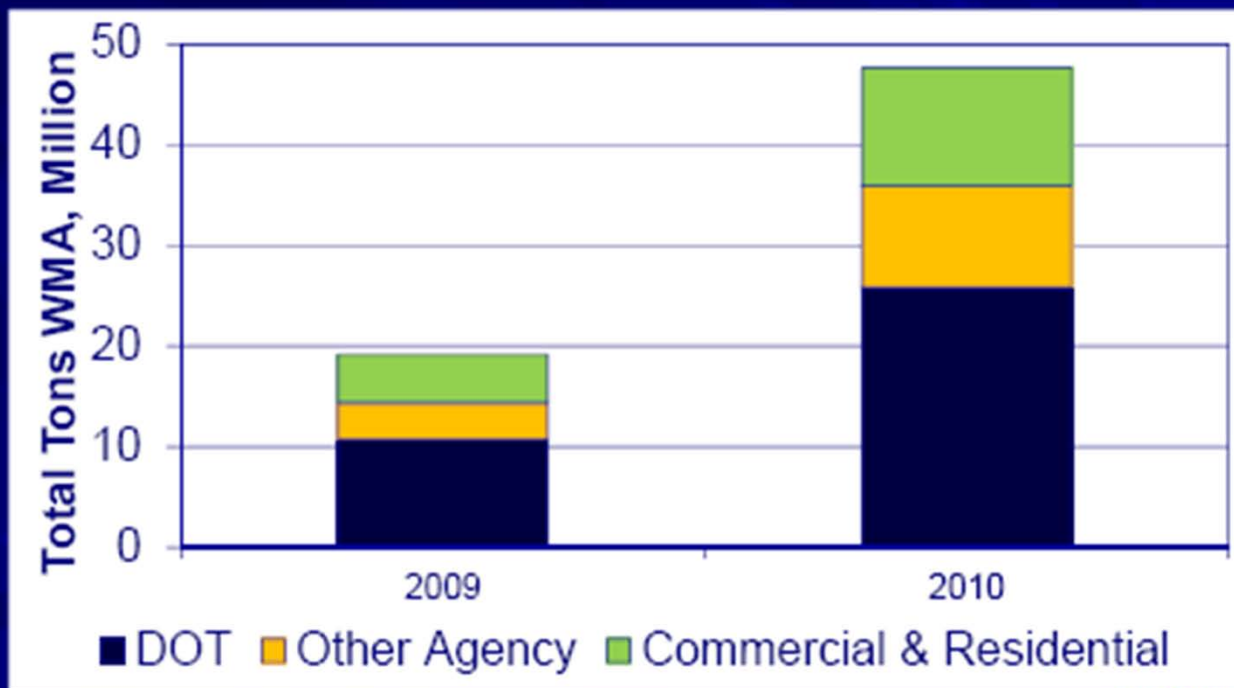
National Perspective

Progress in 6 Years

	2005	2011
Technology Providers	3	30+
States with Field Trials	7	46
States with WMA Specs	1	30

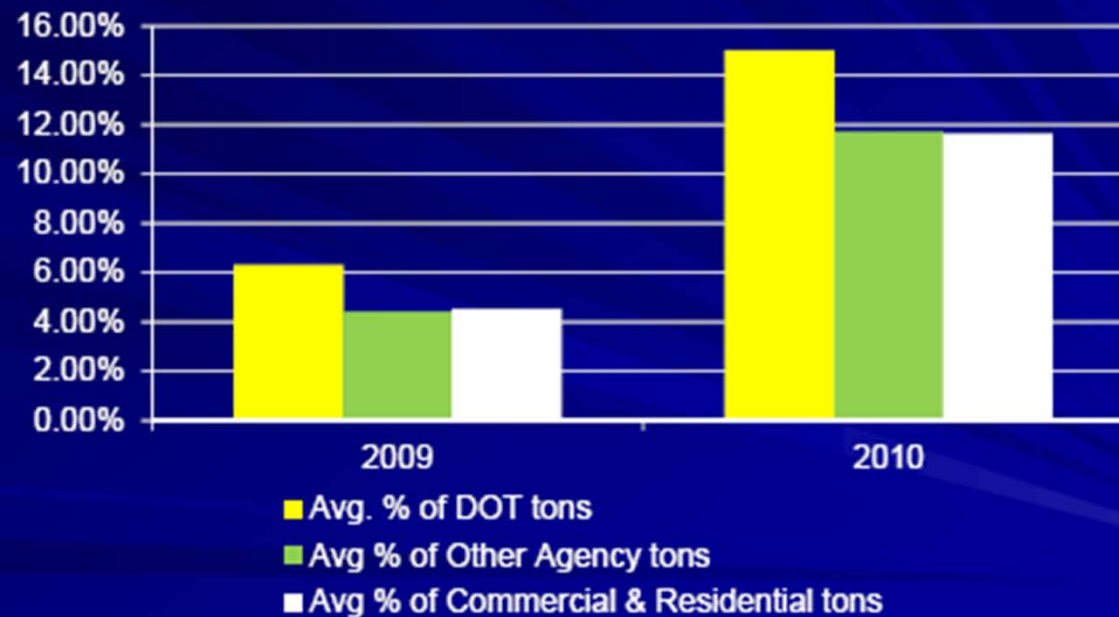
2010 Tonnage (from NAPA)

Estimated Total Tons WMA



2010 Tonnage (from NAPA)

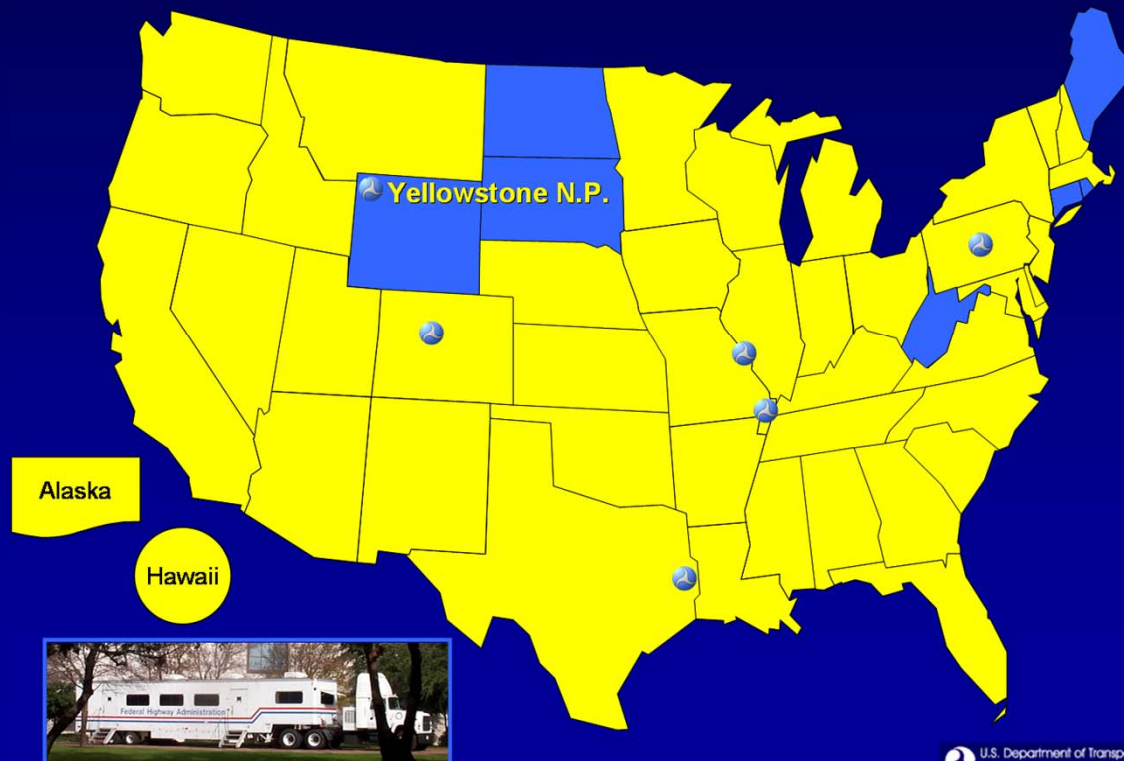
Reported WMA



State DOT Perspective

30 States have WMA Specifications

WMA Trials and Demonstrations



National Perspective

INGENUITY IMAGINATION



INVENTION INNOVATION

- 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



INGENUITY IMAGINATION

INVENTION INNOVATION

- 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

- NCHRP 20-07 TASK 311
 - *Development of a Warm Mix Asphalt Technology Evaluation Program*
- NCHRP 9-52 (2012)
 - *Short-Term Laboratory Conditioning of Asphalt Mixtures - \$800,000*
- NCHRP 9-53 (2012)
 - *Asphalt Foaming Characteristics for Warm Mix Asphalt Applications - \$700,000*

NCHRP Project 9-43

- Appendix to AASHTO R35
- WMA Mix Design Workshop/Training Module (FREE!)



NCHRP Project 9-43

Special Mixture Design Considerations and for Warm Mix Asphalt - WEB-BASED

PROGRAM AREA: Pavements and Materials

COURSE NUMBER: FHWA-NHI-131137

CALENDAR YEAR	LENGTH	CEU	FEE
2011	2 Hours	0 Units	\$0 Per Participant
2012	2 Hours	0 Units	\$0 Per Participant

TRAINING LEVEL: Basic

CLASS SIZE: Minimum:1; Maximum:1

DESCRIPTION:

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.

NCHRP Project 9-43 (101)

ITEM	HMA AASHTO R35	WMA PROPOSED
WMA Process	N/A	Producer Selected
RAP Selection	AASHTO M323	Compaction Temperature
Mixing and Compaction Temperatures during mixture design	Viscosity Based	Coating and compactability evaluated at planned temperatures
Specimen Preparation	Standard	Process Specific
Mixture Evaluation for Rutting	None	Flow Number Test

California Research



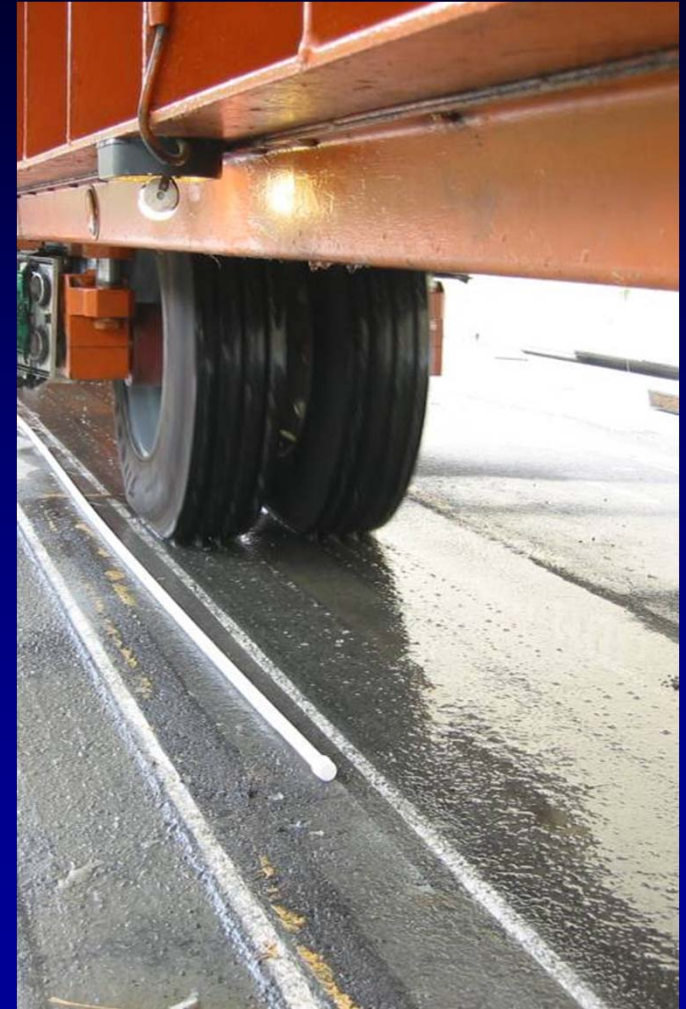
California Research Objectives

- 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

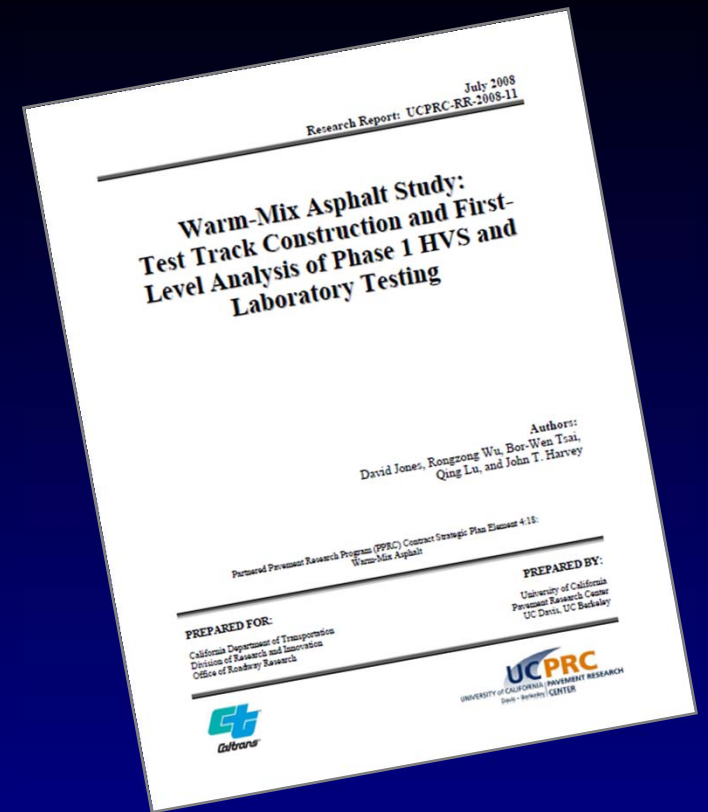


Heavy Vehicle Simulator



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

★ 2010 - 2011

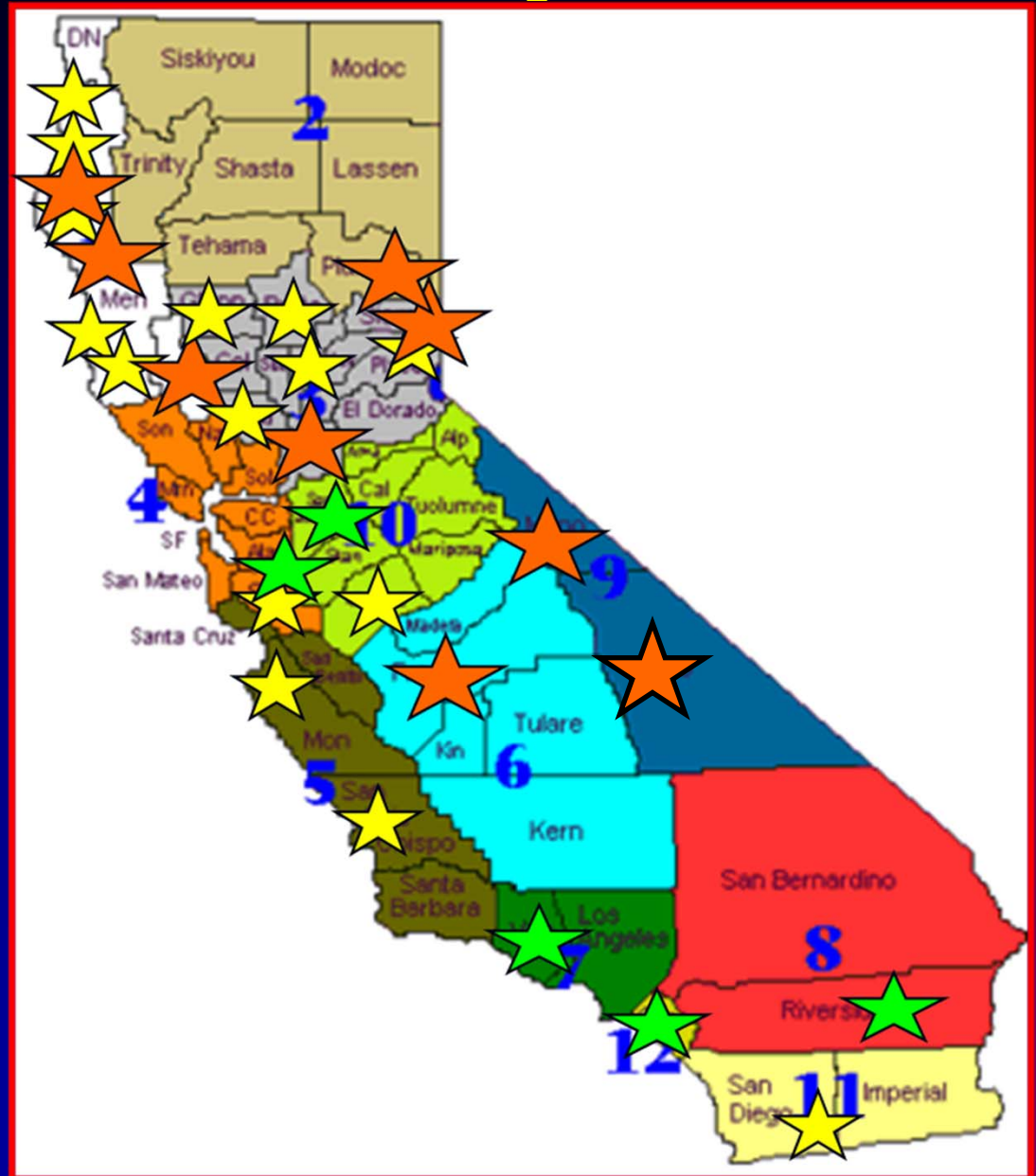
★ Local Agency

2006 - 2010: 14 projects

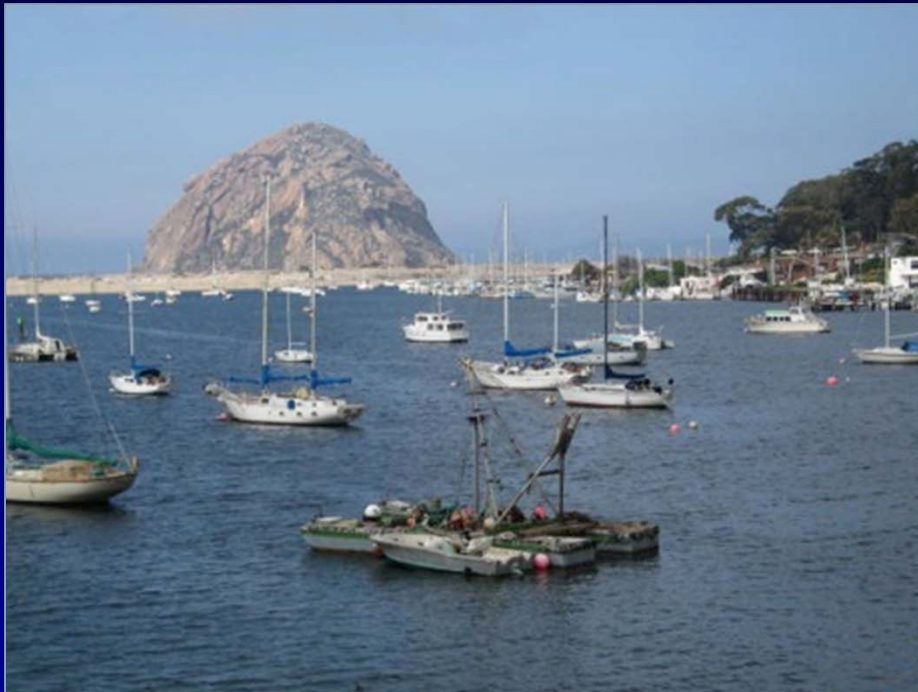
70,000 tons

2010-11: 24 projects

OGFC, RHMA, DGAC
over 1 million tons



CA 1in 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 °F and 60 °F
- Mixing temps 260 °F to 290 °F (vs. 320 °F)
- Final compaction by 220°F (vs. 250 °F)



Morro Bay: 2008 - 2011



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

Fire Raw Materials	Sys. No.	Wet TPH	Percent Moisture	Dry TPH	Required Dry TPH	Percent Error	% Error to Alarm	Percent of Dry Agg
1/2	1	20.2	1.40	19.9	20.0	0.0	20.0	10.97
CRDUST	2	34.3	3.95	32.9	32.8	0.0	20.0	18.13
3/4	3	46.1	1.40	45.5	45.5	0.2	20.0	25.04
3/8	5	85.4	1.40	84.2	83.7	0.9	20.0	48.41

Liquid Raw Materials	Sys. No.	Gal / Min.	Pounds / Gal	Tons / Hour	Required TPH	Percent Error	% Error to Alarm	Percent of Dry Agg
PG 64-16	1	50.6	8.563	13.0	13.0	0.0	±1.50%	7.14

Current Scale		Virgin Mat.	Recycled Mat.	Combined Mat.	Temperatures	
Dry Agg	181 TPH	Dry Agg	182 TPH	182 TPH	Mix	30 F
Dry Rap	0 TPH	AC	13.0 TPH	13.0 TPH	AC	365 F

Tons Today	1213	Selected Mix	Output Rate	Tons This Week	6214
Agg Moi	1.86 %	1509	194 TPH	Selected Target	195 TPH
		EZ Blend			

Plant I/O Status	
AC Divert to	Loaded Start Input
Line Pad Fill	Start/Stop Input
Material on Vir. Sol	Loaded Stop Output
Grb Hopper Open	Sec Stop Output

Time: 11:50:30 Date: 05/20/2009

F1 Help ALT Menu CTRL-S Stop CTRL-C Change CTRL-H Mix CTRL-N Inc/Dec 5TPH



Orland: May 2011



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

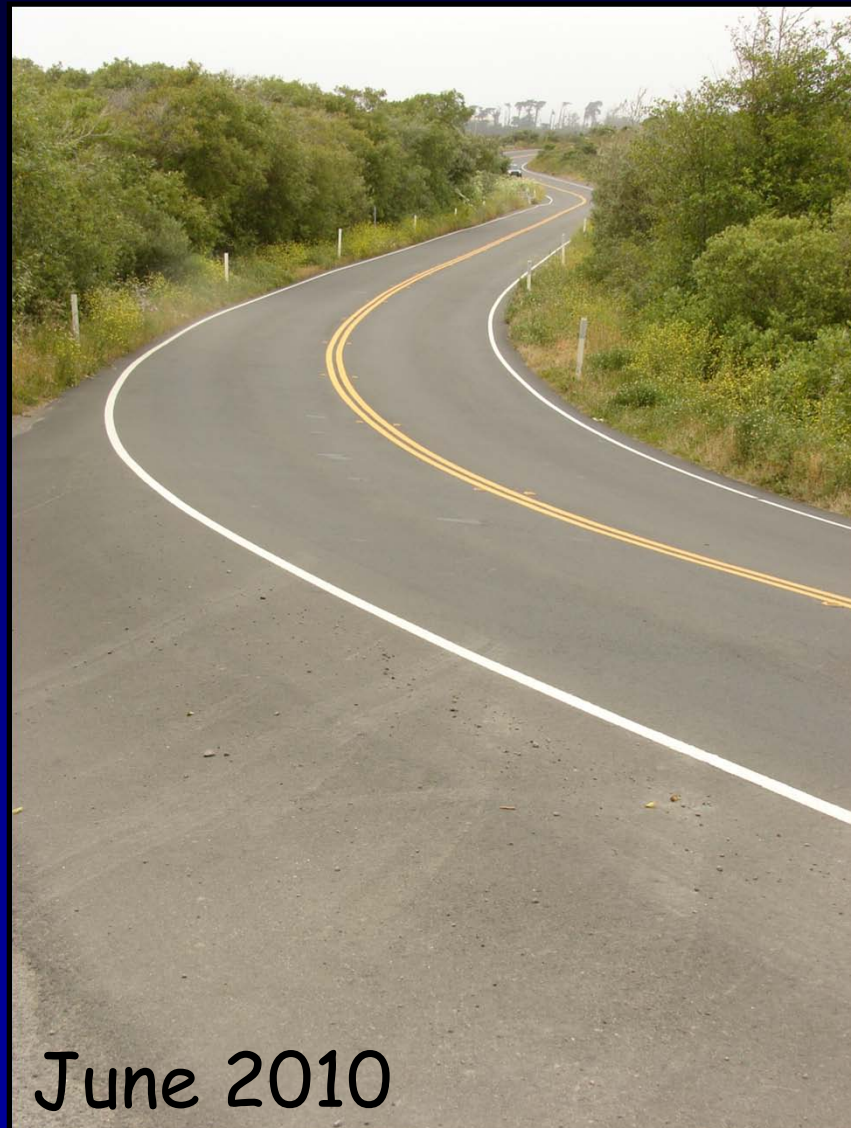




June 2010



April 2009



June 2010

I-5 Slab Replacements (2011)

- 9" DGAC, PG 64-10
- 3 Lifts
- 8 hours, night paving
- Mix Temp: 255°F



18
5 6 7

TROXLER

Dens: 145.6 PCF
3MR: 92.25%
100-3MR: 71.75%
%WTD: 71.75%

4640-B

159 C

ON

OFF

YES ENT	NO/ICE GCE	7	8	9
STORE MR	THICK MR	4	5	6
W/1 VOIDLESS	TIME	1	2	3
SHIFT	STD	0		START/ ENTER

FINGER TIGHTEN ONLY

THIN LAYER DENSITY GAUGE


 TROXLER
 CALIBRATION
 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025



Resources

www.warmmixasphalt.com



Warm Mix Asphalt

warmmixasphalt.com

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ABOUT WMA

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[December TWG Meeting](#) >>>

[WMA Test Frameworks](#) >>>

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](#) >>>

SUBMIT FOR PUBLICATION

Do you have a presentation or report on Warm Mix Asphalt to share?

[SUBMIT NOW](#) >>>



<http://www.fhwa.dot.gov/pavement/asphalt/wma.cfm>

Research Design Construction Preservation Maintenance Management Rehabilitation

FHWA > Engineering > Pavements > Asphalt > Warm Mix Asphalt

Design and Analysis

Materials and Construction Technology

Management and Preservation

Surface Characteristics

Construction and Materials Quality Assurance

Environmental Stewardship

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 Asphaltan B®, 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 Avera® 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

Events

- o [View all Upcoming Pavements Events](#)

More Information

- o [Foamed Asphalt](#)
- o [Pavement Publications](#)
- o [Warm Mix Asphalt: European Practice](#)

Contact

Matthew Corrigan
[Office of Pavement Technology](#)
202-366-1549
[E-mail Matthew](#)


U.S. Department of Transportation
Federal Highway Administration

Done Internet 100%

UC Pavement Research Center

www.ucprc.ucdavis.edu

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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](#).
- Lifecycle Analysis Framework Kick-off Workshop held at UCPRC, May 2010. More 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

INTERNATIONAL TECHNOLOGY SCANNING PROGRAM

Warm-Mix Asphalt: European Practice



SPONSORED BY:



IN COOPERATION WITH:

American Association of State Highway
and Transportation Officials

National Cooperative Highway
Research Program

FEBRUARY 2008

NAPA Publications

PS-30

Warm-Mix Asphalt: The Future of Asphalt

QIP 125

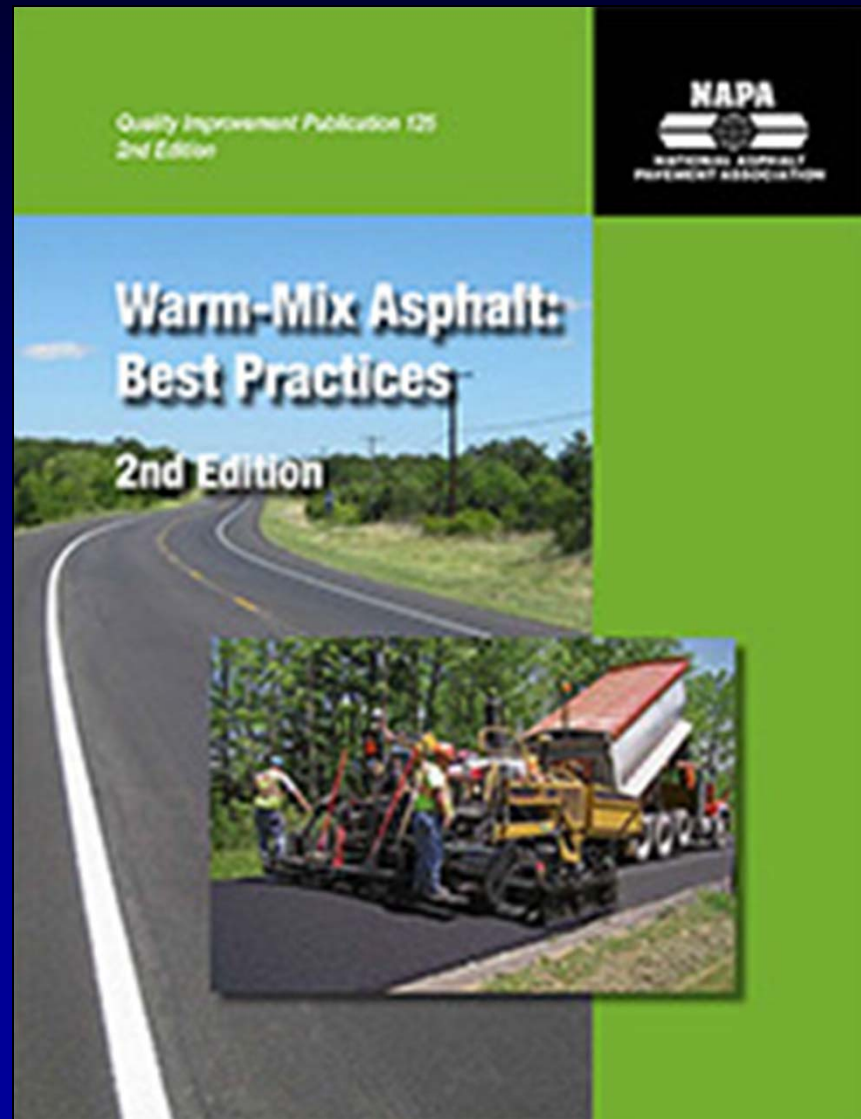
Warm Mix Asphalt: Best Practices

IS-134

Warm-Mix Asphalt: Contractors' Experiences



Newest NAPA Publication!



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. Proc
doe

1. Wa
eng
pra



res

ood



Questions?