

Long-Life Asphalt Pavements for the 21st Century

WARM MIX ASPHALT TECHNOLOGY



50th Annual Illinois
Bituminous Paving Conference



December 9, 2009
Champaign, IL

warmmixasphalt.com



WMA Investigation and Implementation Premise

- ✚ Although there are many factors driving the development and implementation of WMA technologies globally, in order for WMA to succeed in the U.S., WMA pavements must have equal or better performance when compared to traditional HMA pavements



What is WMA?

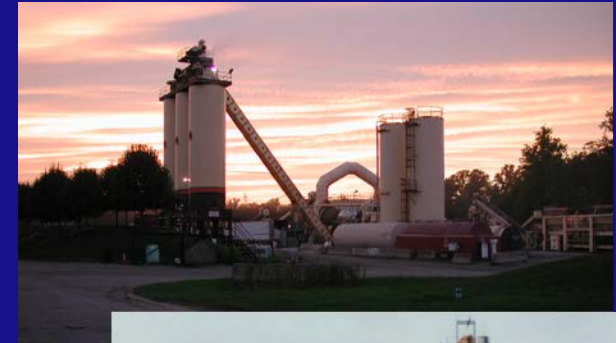
- ✚ Allows a reduction in the temperatures at which asphalt mixes are produced and placed
- ~~✚ Reduced viscosity at lower temps~~
 - Complete aggregate coating



Why WMA?

❖ Potential Advantages**

- ❖ Energy Savings
- ❖ Decreased Emissions
 - Visible and Non-Visible
- ❖ Decreased Fumes
- ❖ Decreased Binder Ageing
- ❖ Extended Paving Season
- ❖ Compaction Aid
- ❖ Increased RAP usage

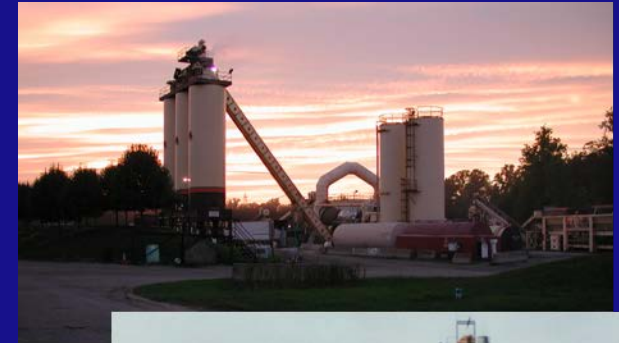




Why WMA?

❖ Potential Advantages**

- ❖ Energy Savings
- ❖ Decreased Emissions
 - Visible and Non-Visible
- ❖ Decreased Fumes
- ❖ Decreased Binder Ageing??
- ❖ Extended Paving Season
- ❖ Compaction Aid
- ❖ Increased RAP usage??





Brief World History

- 1995 Preliminary Lab Experiments
- 1997 German Bitumen Forum
- 2000 First International Conference of Asphalt Pavements (Sydney)
- 2000 Second Euroasphalt & Eurobitume Congress (Barcelona)
- NAPA 2002 European Scan Tour
 - Germany and Norway
- NAPA 2003 Annual Meeting
 - San Diego





Brief U.S. History

- ❁ NAPA European Scan 2002
 - ❁ Germany and Norway
- ❁ NAPA Annual Meeting 2003
 - ❁ San Diego
- ❁ World of Asphalt 2004
 - ❁ Nashville
- ❁ WMA TWG 2005
- ❁ FHWA International Scan 2007
- ❁ International WMA Conference 2008



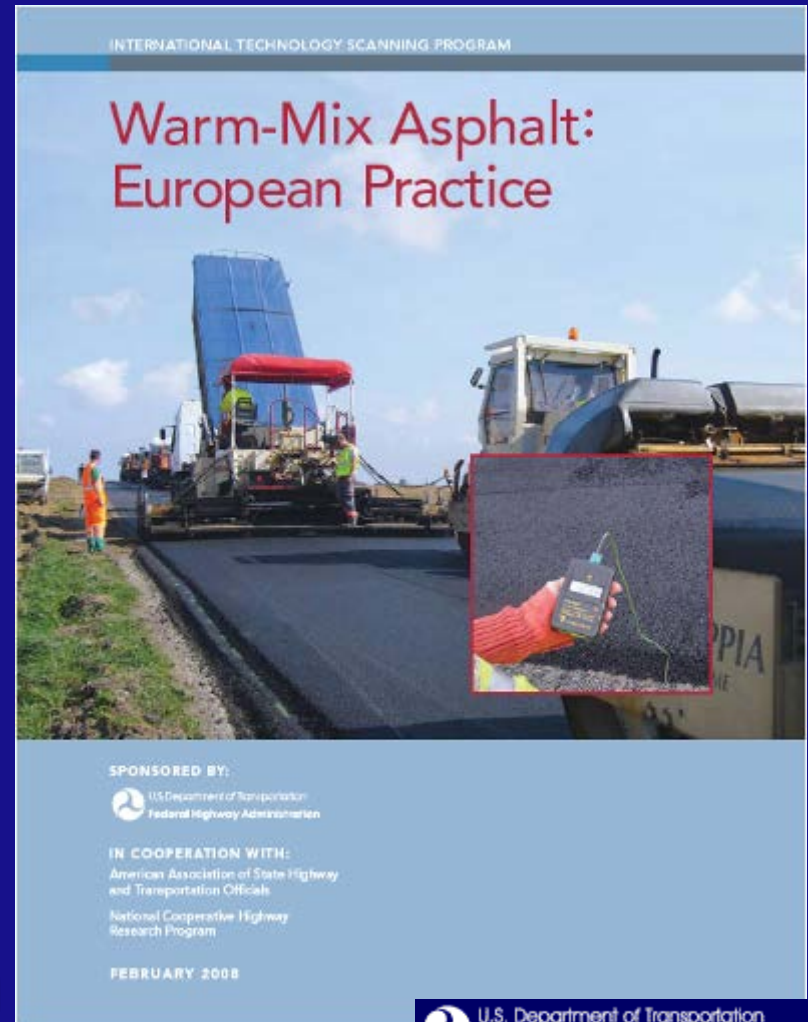


WMA European Scan Tour

- Joint Program w/
FHWA, AASHTO,
NCHRP and Industry
- Publication
FHWA-PL-08-007
- Scan Final Report

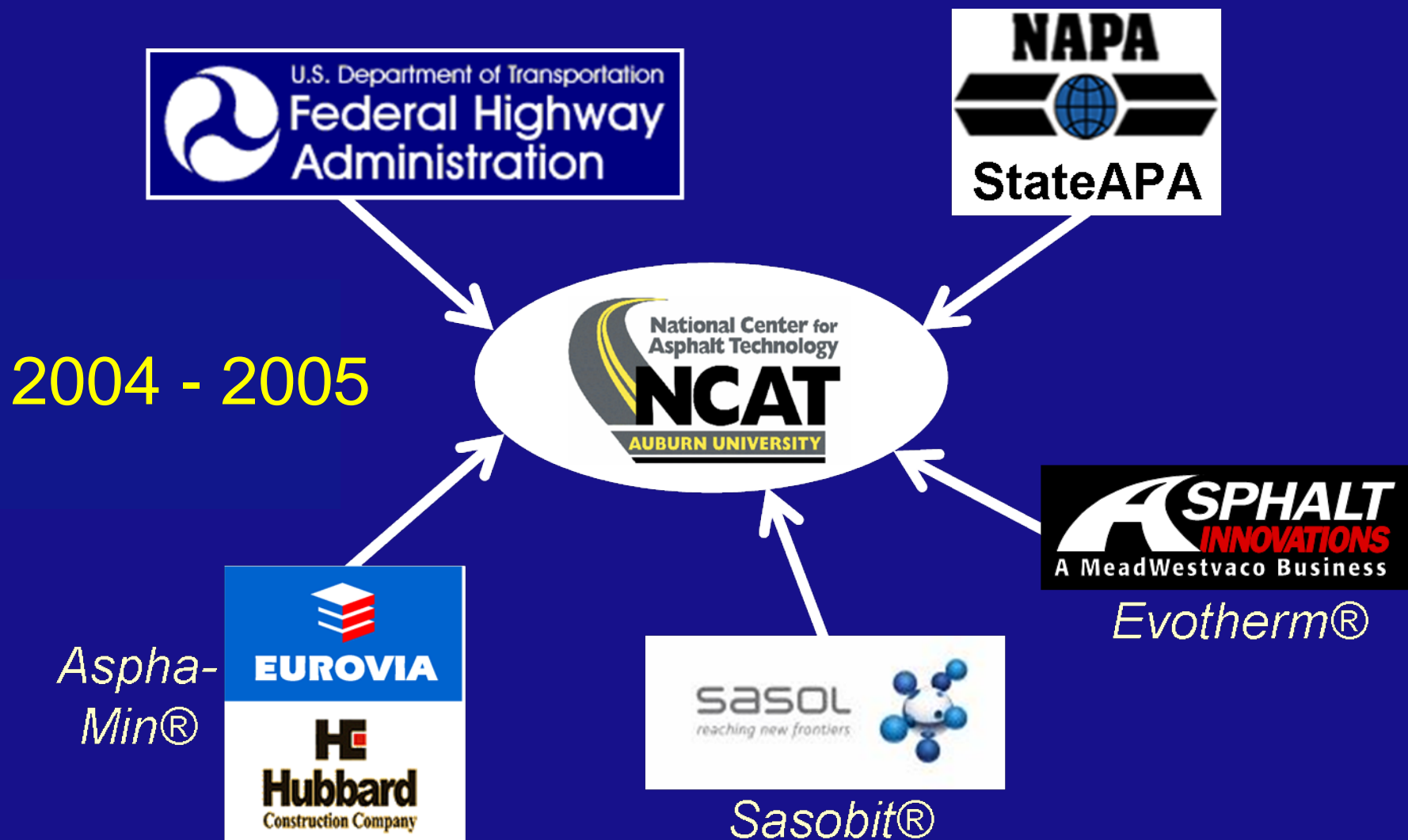
 .pdf available at

<http://international.fhwa.dot.gov/pubs/pl08007/index.cfm>





Initial U.S. Research Partners





How Many WMA Technologies are Available in the U.S.?



How Many WMA Technologies are Available in the U.S.?

Currently Twenty (20) Technologies Marketed and Available in the U.S.



Technology Overview**

WAM-Foam



Rediset WMX



Low Emission Asphalt



Aspha-Min



AquaFoam



Advera



Ultrafoam GX



Sasobit



Terex



REVIX

Mathy Tech. & Eng. Services and
Paragon Technical Services, Inc

Accu•Shear



Evotherm



Aquablack



Cecabase RT



Double Barrel



Thiopave



Green





Technology Overview**

■ TLA-X



Lake Asphalt of
Trinidad and Tobago

■ Iterlow-T & Hyperpave



■ Static Inline Vortex Asphalt Blender



■ Ad-RAP (ECOBIT)



More to come ...

Many other technologies are also used
Internationally.



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- ✚ Although there are many factors driving the development and implementation of WMA technologies globally, in order for WMA to succeed in the U.S., WMA pavements must have equal or better performance when compared to traditional HMA pavements



WMA Technical Working Group (TWG)

● FHWA / NAPA sponsored

● Co-Chairs

■ Matthew Corrigan, FHWA

■ Ron White, Industry

● Represented

■ State DOT

■ AASHTO

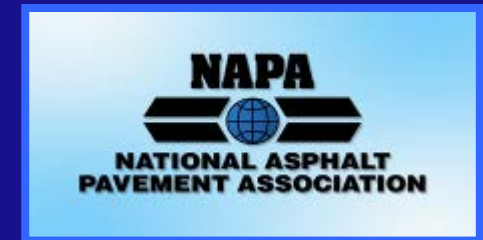
■ State APA

■ Labor

■ NCAT

■ NIOSH

■ Hot Mix Asphalt Industry





WMA TWG Accomplishments

- www.warmmixasphalt.com
- Material Testing Framework
- Emission Testing Framework
- WMA Best Practices Document
- WMA Guide Spec for Highway Construction
- Research Needs Identified
 - Developed five (5) research statements
 - Submitted through AASHTO to NCHRP
 - All projects highly ranked by SCOR
 - Total \$2.9 million

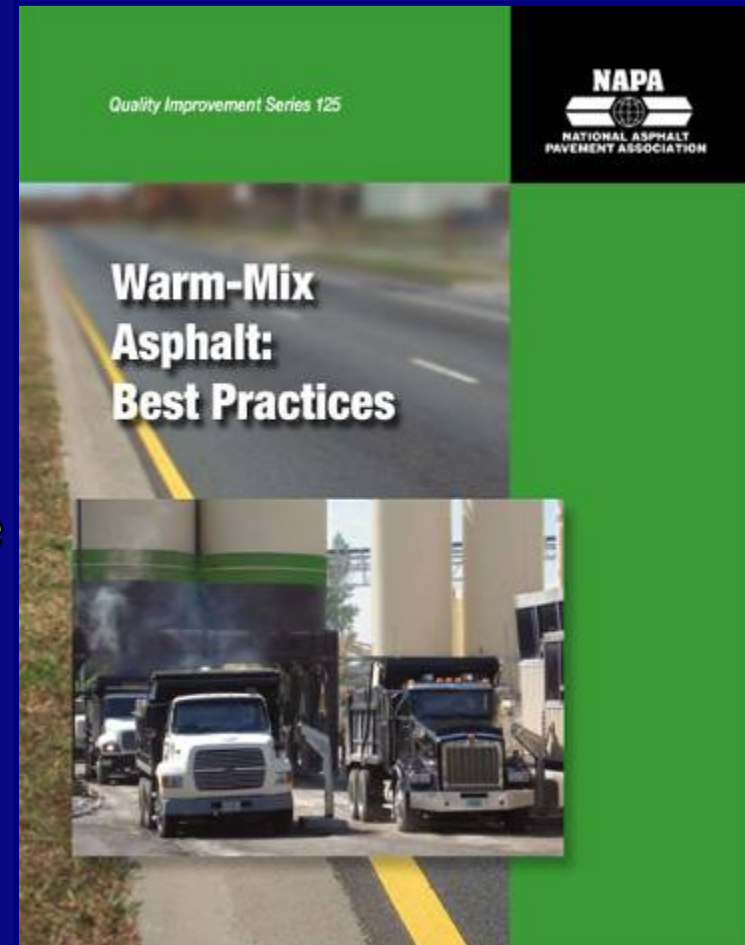




Warm Mix Asphalt: Best Practices

❖ Quality Improvement Series (QIP) 125

- ❖ Stockpile Moisture Management
- ❖ Burner Adjustments and Efficiency
- ❖ Aggregate Drying and Baghouse Temperatures
- ❖ Drum Slope and Flighting
- ❖ Combustion Air
- ❖ RAP usage
- ❖ Placement Changes



AASHTO Guide Specification for Highway Construction 2008

DIVISION 400 FLEXIBLE PAVEMENTS

SECTION 401 HOT MIX ASPHALT (HMA) PAVEMENTS

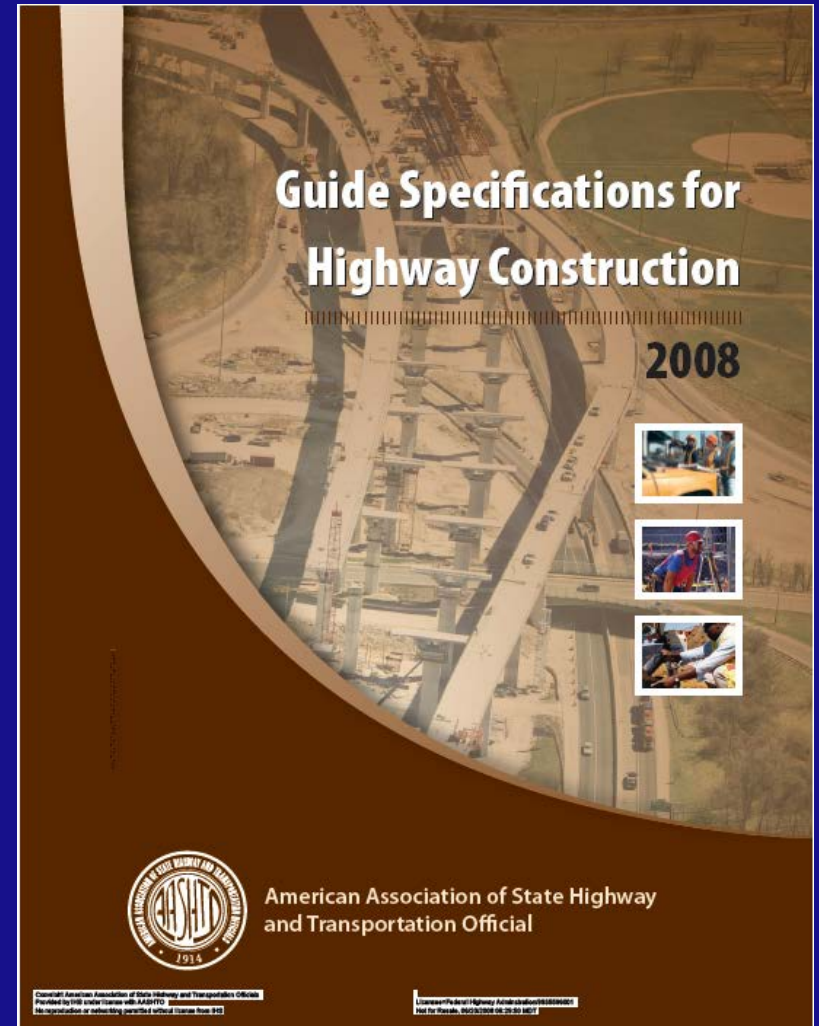
401.01 Description

401.02 Material

401.03 Construction

401.04 Measurement

401.05 Payment



Warm Mix Asphalt (WMA) Guide Specification for Highway Construction

DIVISION 400 - Asphalt Pavements and Surface Treatments

SECTION 4XX - WARM MIX ASPHALT (WMA) PAVEMENTS

4XX.01 Description

4XX.02 Material

4XX.03 Construction

4XX.04 Measurement

4XX.05 Payment

Warm Mix Asphalt (WMA) Guide Specification for Highway Construction

Division 400 - Asphalt Pavements and Surface Treatments

SECTION 4XX - WARM MIX ASPHALT (WMA) PAVEMENT

Warm mix asphalt (WMA) is the generic term used to describe the reduction in production, paving, and compaction temperatures achieved through the application of one of several WMA technologies.

Some modifications to HMA plants may be necessary to accommodate the WMA technologies as noted in Section 4XX.03 Construction.

Production and paving temperatures may need to be increased for higher reclaimed asphalt pavement (RAP) contents, increased haul distances, decreased ambient temperatures, or other WMA project specific conditions.

All provisions for the production and placement of conventional HMA mixtures as stipulated in [\[applicable Agency specification\]](#) are in force except as noted below.

4XX.01 Description

Construct one or more courses of plant produced warm mix asphalt (WMA) pavement on a prepared foundation, using virgin aggregate or a combination of virgin and/or reclaimed aggregate material (RAM) and prescribed manufactured WMA additives and/or WMA plant process modifications. Use of RAP materials, consisting of cold milled, crushed, or processed bituminous asphalt mixture, and reclaimed asphalt shingles (RAS) are permitted at the current [\[Agency specified\]](#) percentages, provided that the mixture meets all the requirements of these specifications.

4XX.02 Material

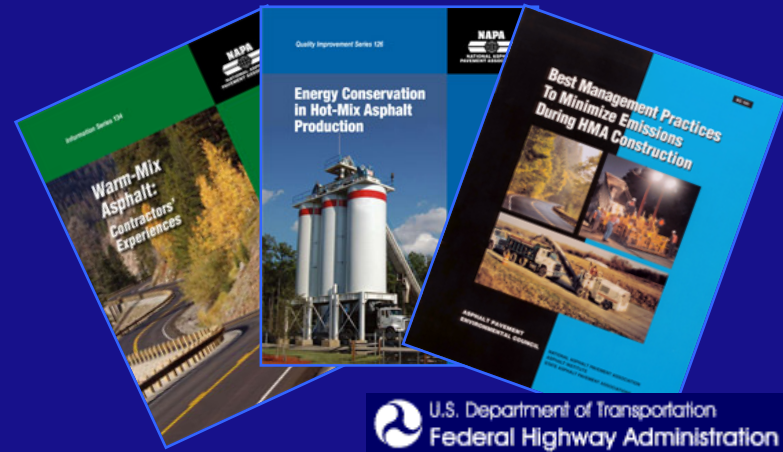
WMA may be produced by one or a combination of several technologies involving HMA plant foaming processes and equipment, mineral additives, or chemicals that allow the reduction of mix production temperatures to within 185°F to 275°F. (Note: The upper temperature range is appropriate for modified asphalt binders and WMA mixtures which include higher percentages of reclaimed asphalt pavement.)

Provide materials as specified in:

Aggregate	Subsection XXXX
Liquid Antistrips	Subsection XXXX
Asphalt Binder	Subsection XXXX
HMA Additives	Subsection XXXX
Lime for Asphalt Mixtures	Subsection XXXX
Mineral Filler	Subsection XXXX
Reclaimed Asphalt Pavement	Subsection XXXX
Reclaimed Aggregate Material	Subsection XXXX
Reclaimed Asphalt Shingles	Subsection XXXX

The following **references** detail specifics related to **plant modifications and operational changes** in order to **maximize the benefits of WMA** production:

- Quality Improvement Series 125 (QIP 125),
“Warm Mix Asphalt: Best Practices”,
- Quality Improvement Series 126 (QIP 126),
“Energy Conservation in Hot Mix Asphalt Production”
- Environmental Council 101 (EC-101),
“Best Management Practices to Minimize Emissions During HMA Construction”





Ongoing National Research



TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES



- ❖ NCHRP 9-43 “Mix Design Practices for Warm Mix Asphalt” \$500,000
- ❖ NCHRP 9-47A “Engineering Properties, Emissions, and Field Performance” \$900,000
- ❖ NCHRP 9-49 “Long Term Field Performance of Warm Mix Asphalt Technologies”
 - ❑ Phase I, Moisture Susceptibility
 - ❑ Phase II, Long-Term Performance



Future National Research?



TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES



- ❖ Short Term Ageing of WMA Binders During Production
- ❖ Differences between Field Produced WMA and HMA Volumetric Properties
- ❖ Increased RAP Usage with WMA
- ❖ More to come ...??



Additional Research

Binder ETG Research Projects

- ❖ Laboratory Evaluation: Wax Additives in Warm-Mix Asphalt Binder
- ❖ Evaluate the effect of wax additives on physical properties and characteristics of asphalt binders and their subsequent performance in mixtures.
- ❖ Project Completed and Final Report is near completion



Binder ETG Research Projects

✚ Asphalt – One (1)

- ▣ Lion Oil PG64-22 Eldorado, AR Refinery

✚ Wax Additives – Nine (9)

- ▣ Non-Paraffin Wax Additives

✚ Aggregates

- ▣ Vulcan Barin Quarry Granite, Columbus, GA

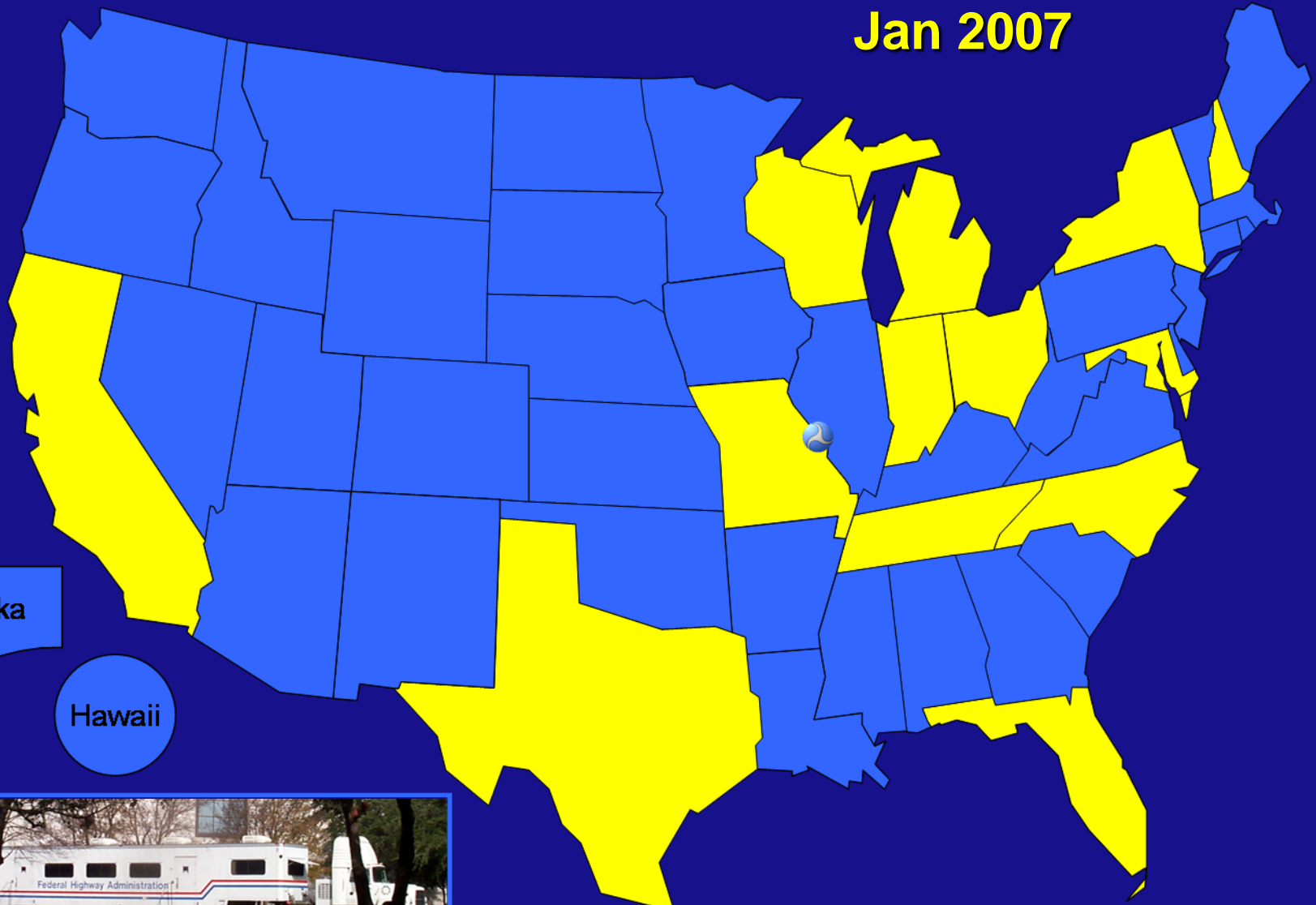
✚ Mix Design

- ▣ 12.5mm Dense Graded SuperPave Gyratory
 - ~5.5% Binder
 - ~7.0% Air Voids



WMA Trials and Demonstrations

Jan 2007



Alaska

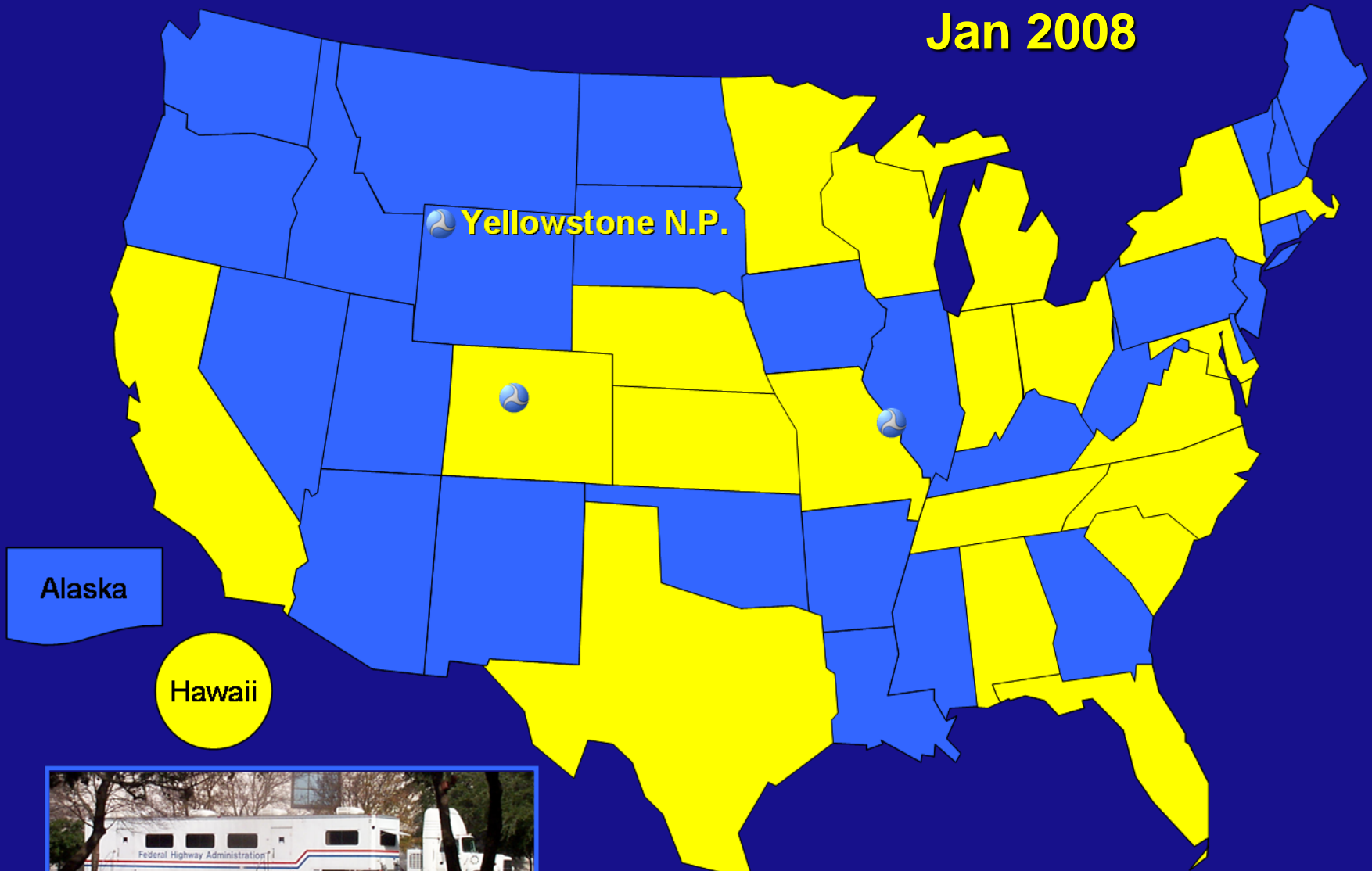
Hawaii





WMA Trials and Demonstrations

Jan 2008





Yellowstone N.P.

Hawaii







Mobile Asphalt Testing Laboratory (MATL)





MAMTL Trailer WMA Projects

Warm Mix Asphalt Projects

Location	Mix Design	Lab Compaction Level, Gyrations	Base Binder Grade	Technologies
Hall St., St. Louis, MO	12.5 mm Superpave	100	PG 70-22	Aspha-min, Evotherm, Sasobit
I-70, Dillon, CO, West of Eisenhower Tunnel	9.5 mm Superpave	75	PG 58-28	Advera, Evotherm Sasobit
East Entrance Road, Yellowstone National Park, WY	19 mm Hveem	75	PG 58-34	Advera Sasobit
US 190, Jasper, TX	19 mm Superpave	55	PG 70-22	Rediset WMX
SR2006 Centre Hall & SR 2012 Spring Mills, PA	9.5 mm Superpave	75	PG 64-22	Aspha-min, Sasobit, LEA UltraFoam GX
I-55, Sikeston, MO	19 mm Superpave	125	PG 76-22	Aquablack



Asphalt Mixture Performance Tester

Dynamic Modulus (E^*)

Test Temperatures

- 4.4° C (40° F)
- 21.1° C (70° F)
- 37.8° C (100° F)
- 54.4° C (130° F)

Frequencies

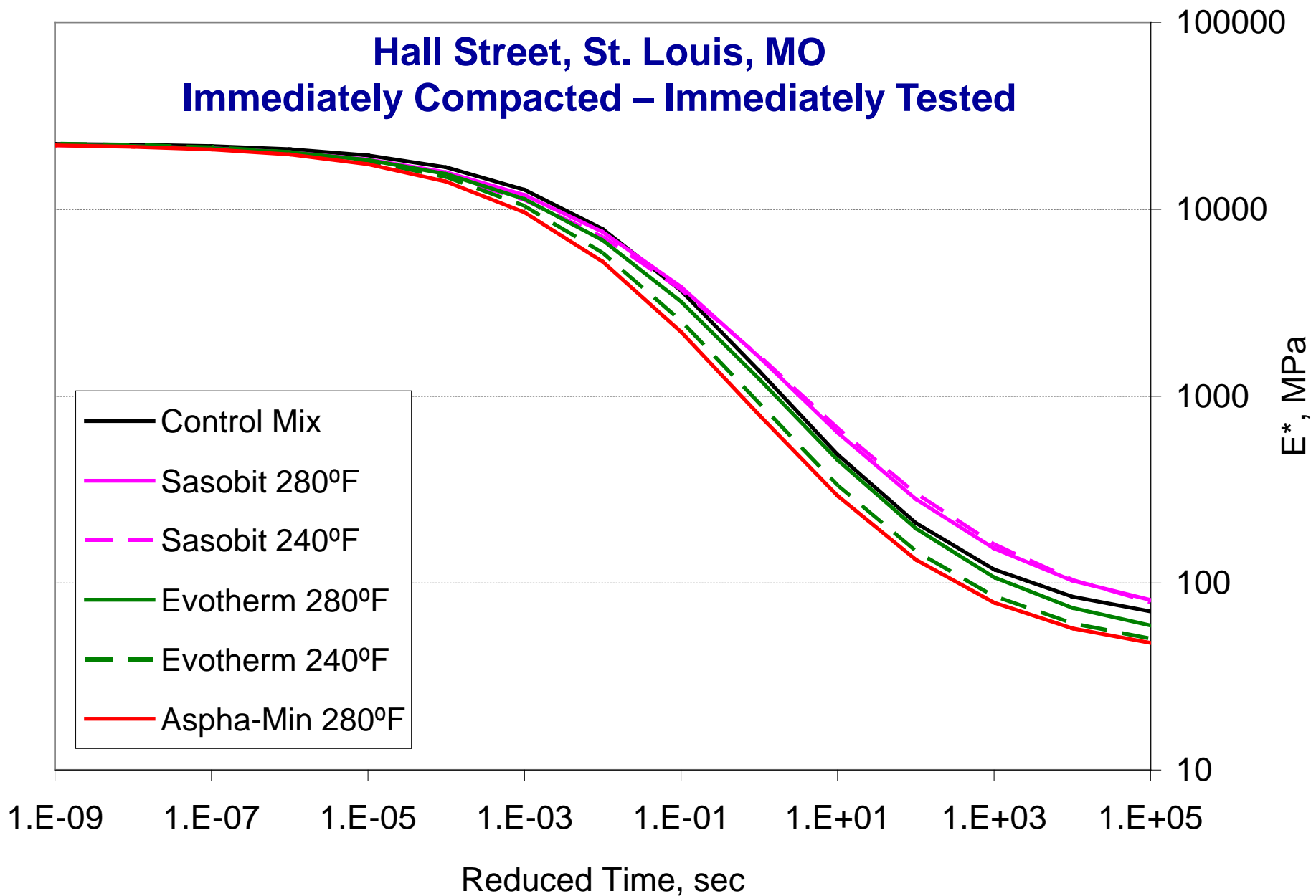
- 0.1, 0.5, 1, 5, 10, 25 Hz



IPC Global
AMPT Device



Hall Street, St. Louis, MO Immediately Compacted – Immediately Tested





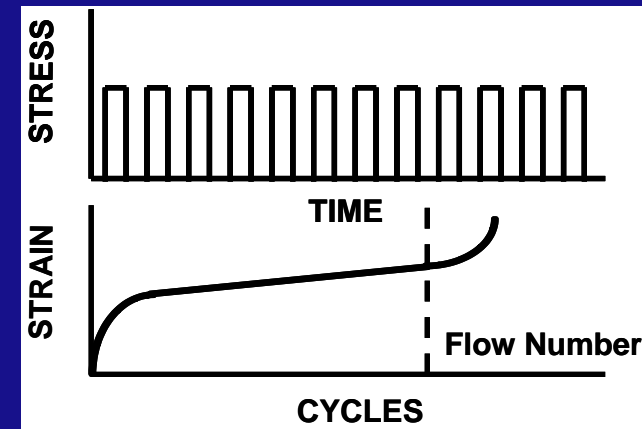
Flow Number, F_n

❖ Loading

- ❑ Axial load applied for 0.1 second with 0.9 second rest period

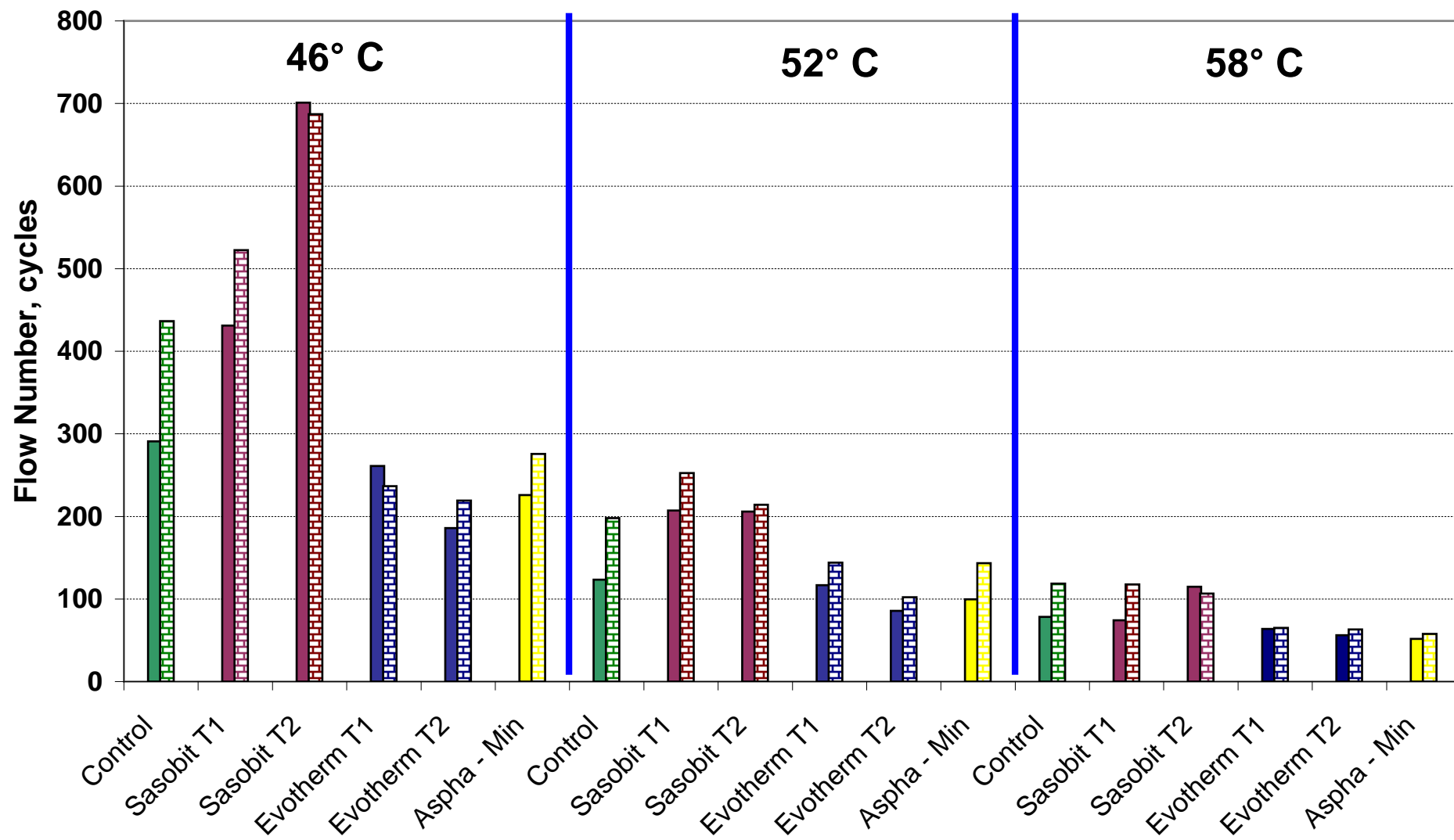
❖ Test Temperatures

- ❑ LTTPBind, Version 3.1 Software
- ❑ Site pavement temperature at 50% Reliability
 - Pavement Temperature
 - Pavement Temperature + 6° C
 - Pavement Temperature - 6° C



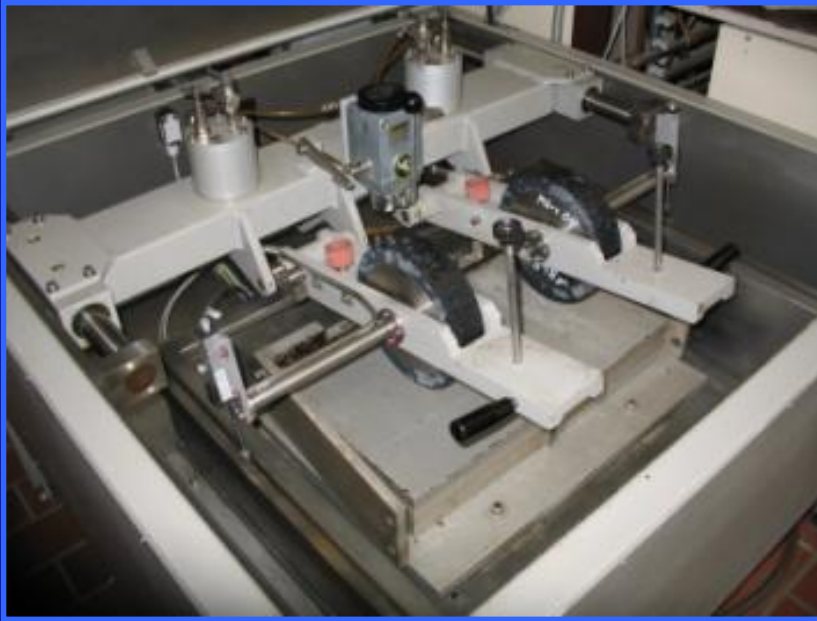
IPC Global AMPT Device

Immediate and Delayed Test Specimens

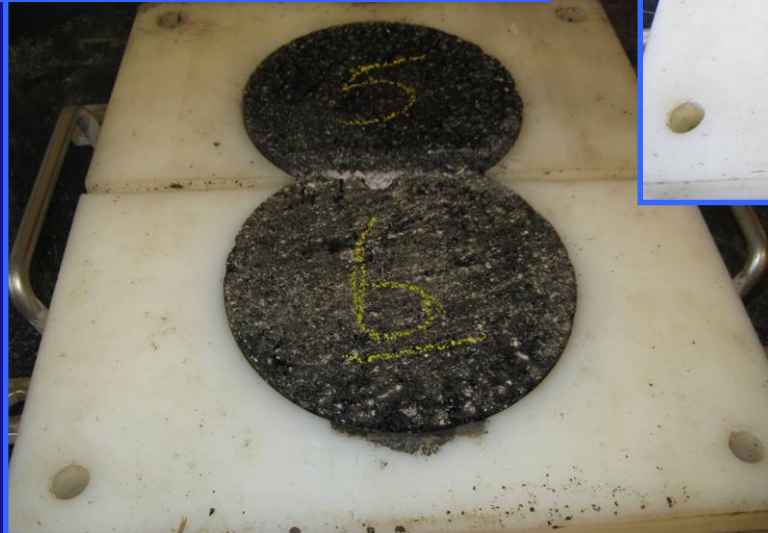




Hamburg Wheel Track Test



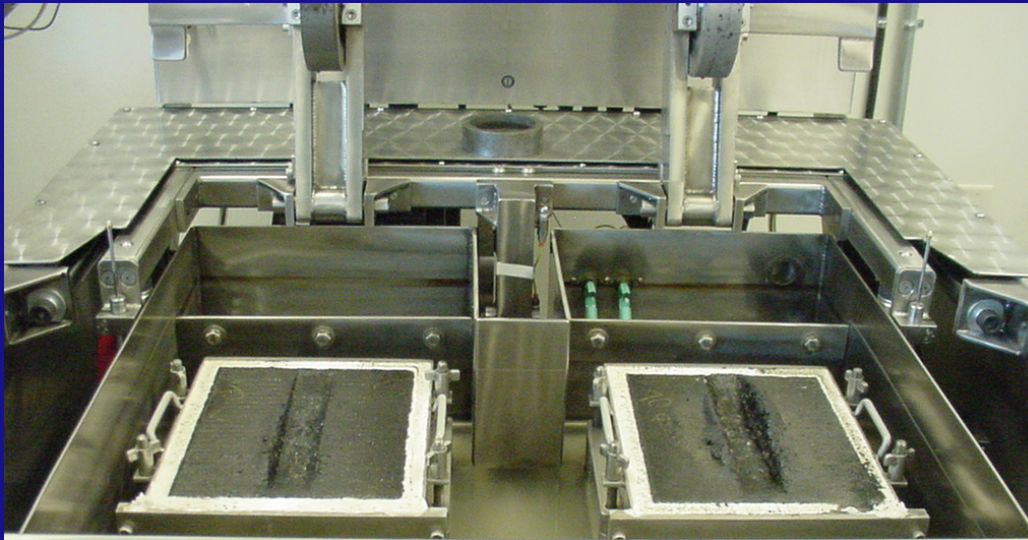
AASHTO T 324



50° F to maximum of
20,000 passes



I-70 Hamburg Advera



CDOT Hamburg History:
75 gyration mixtures
typically fail Hamburg, but
fail primarily due to plastic
flow rutting rather than
stripping/moisture damage

CONTROL
9.46 mm



ADVERA
9.79 mm

*Data and Photos are
Courtesy of CODOT



I-70 Hamburg Sasobit



CONTROL
17.31 mm

*Data and Photos are
Courtesy of CODOT

SASOBIT
10.49 mm



I-70 Hamburg Evotherm



CONTROL
10.10 mm

*Data and Photos are
Courtesy of CODOT

Evotherm
14.86 mm



Yellowstone Hamburg

- ⊕ Control - 3.82 mm and 4.00 mm
- ⊕ Advera - 3.80 mm and 3.25 mm
- ⊕ Sasobit - 3.28 mm and 2.60 mm

*All the testing was performed at 40°C wet and reported at 20,000 passes.



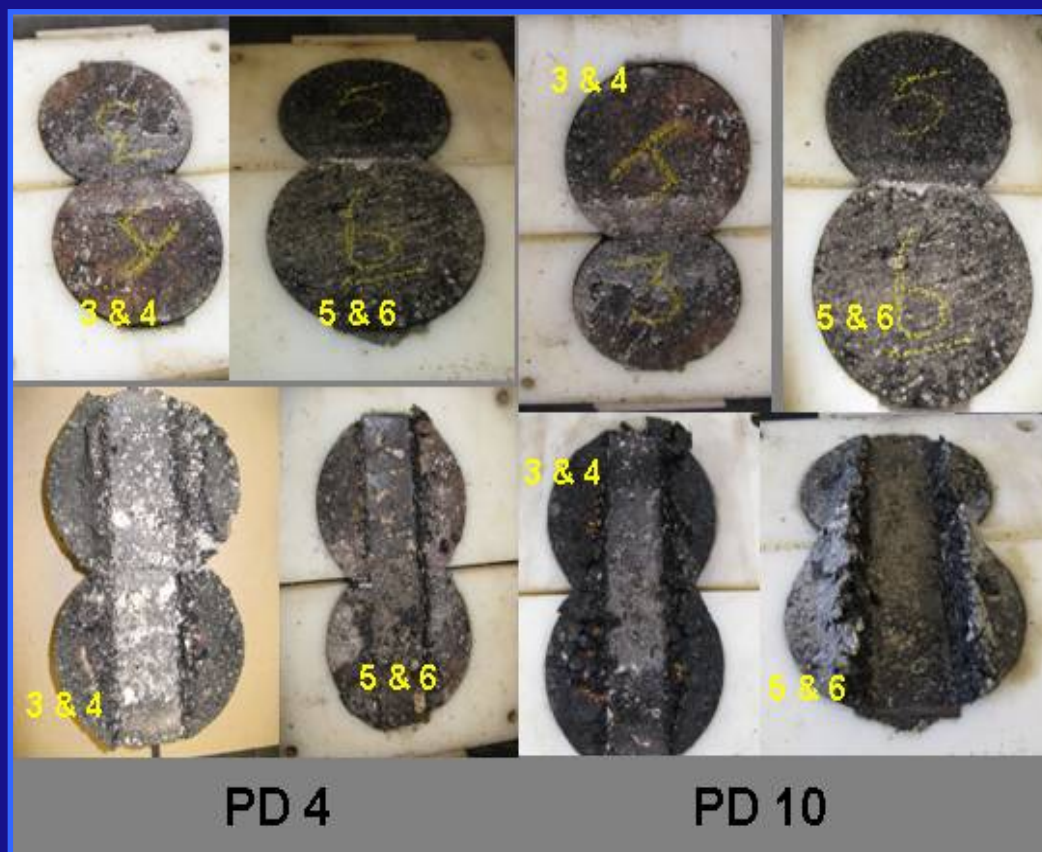


Jasper, TX Hamburg

Rediset WMX

⊕ PD 4 - 13.18 mm

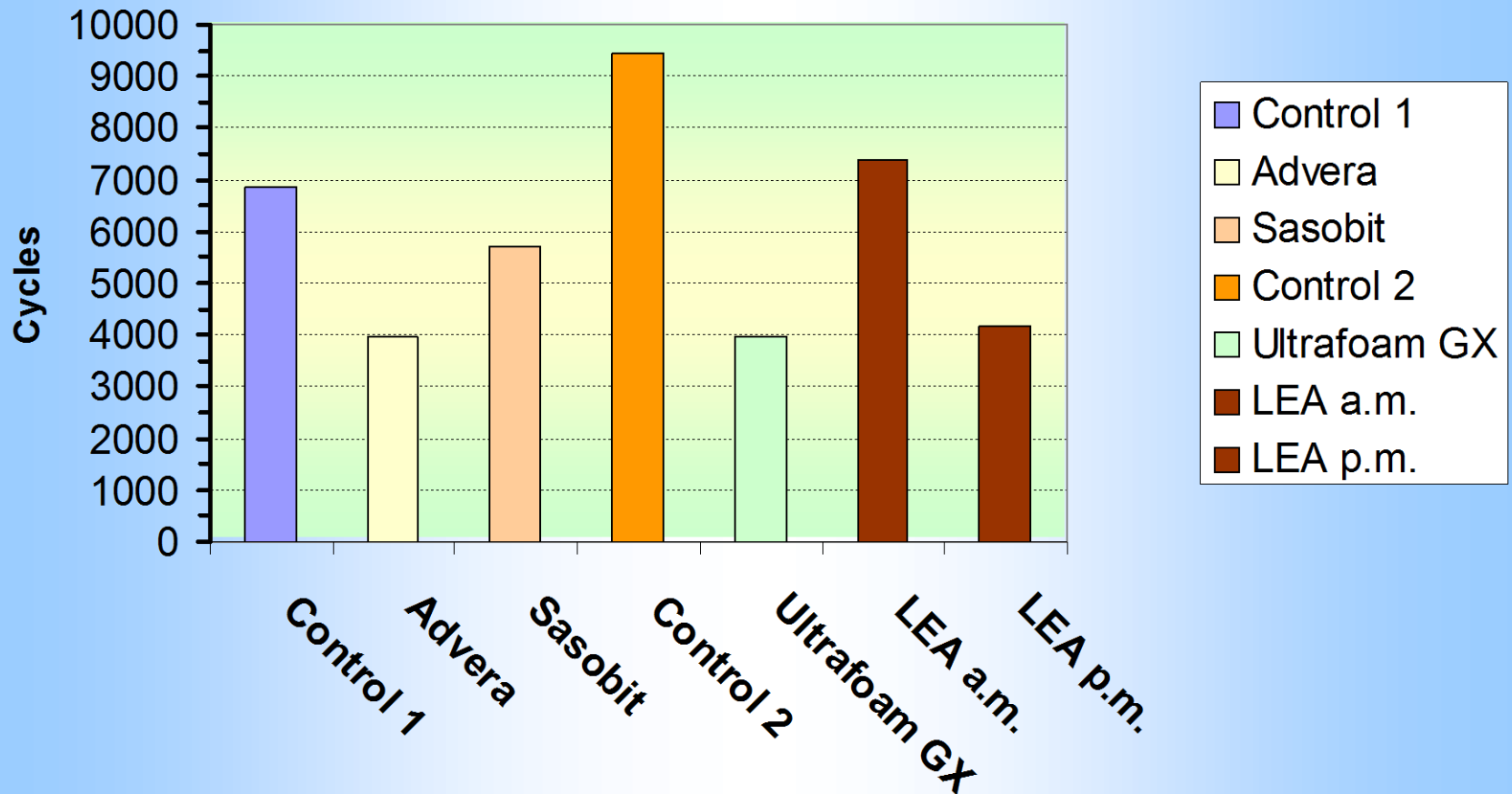
⊕ PD 10 - 18.80 mm





Centre Hall, PA Hamburg

AASHTO T 324 - Hamburg @ 50°C
Cycles to 20mm Rut Depth





I-55 Sikeston, MO Hamburg

Aquablack by Maxam

🔧 Testing currently being conducted

General Trend:

Cycles to
20 mm
rut depth



Total Rut
Depth





✚ Control Mixture

■ Dry = 67 psi, Wet = 57 psi; 85% retained

✚ Advera Mixture

■ Dry = 69 psi, Wet = 56 psi; 81% retained

✚ Sasobit Mixture

■ Dry = 76 psi, Wet = 64 psi; 84% retained

Strength



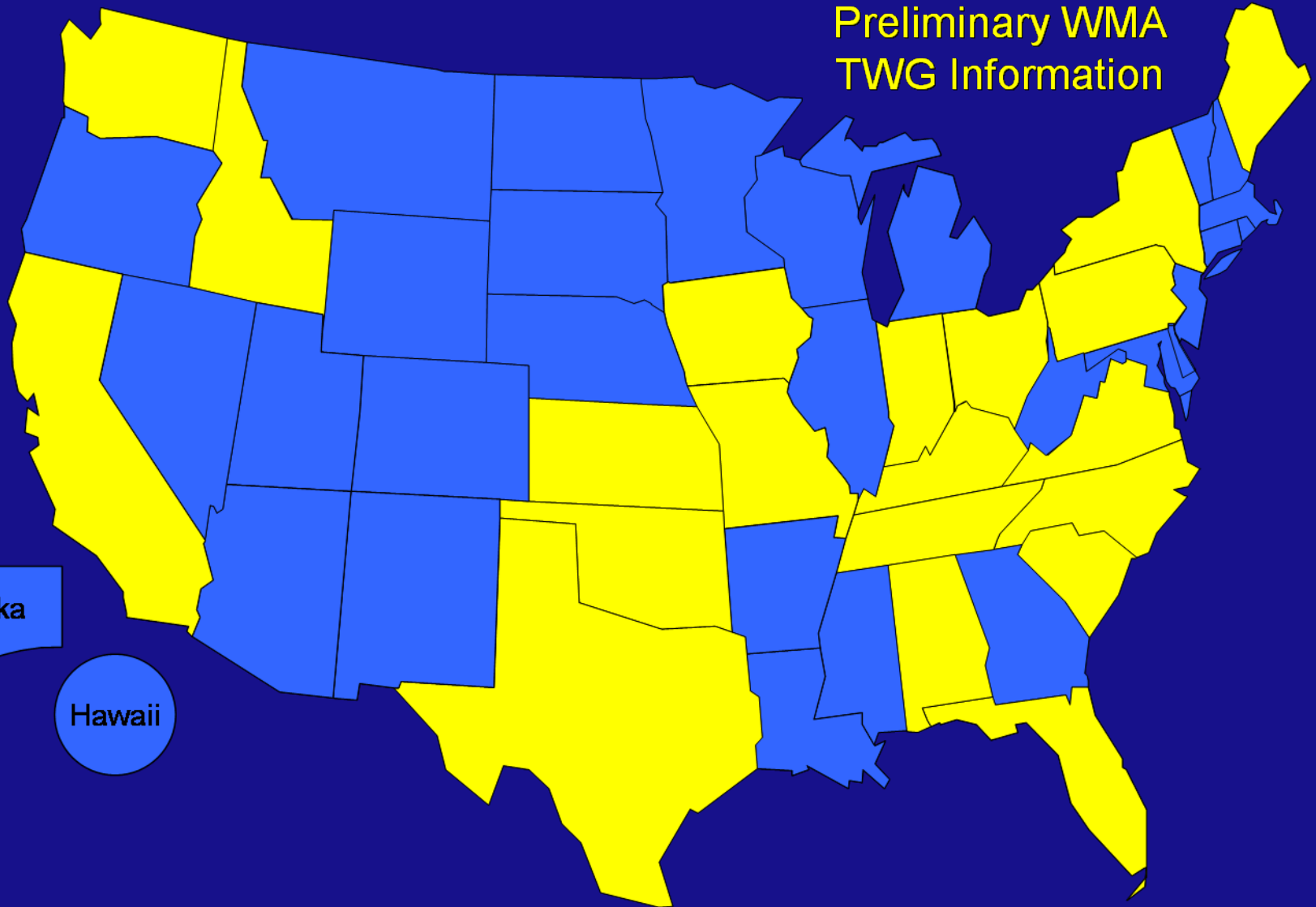
TSR





WMA Specification Language

Preliminary WMA
TWG Information



Alaska


Hawaii



Future WMA Specifications

❖ Emphasis on Performance

❖ Asphalt Mixture Performance Tester (AMPT)

- 
- Flow Number (Fn), mixture rutting
 - Dynamic Modulus (E^*), mixture stiffness
 - Cyclic Tension – Compression, fatigue cracking

❖ IDT Creep and Strength

- fatigue and thermal cracking



❖ Hamburg wheel tracking

❖ Moisture Susceptibility Testing





Written Summary of WMA @

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

Warm Mix Asphalt Technologies and Research - Asphalt - Pavements - FHWA - Windows Internet Explorer

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

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U.S. Department of Transportation
Federal Highway Administration

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Pavements

Research Design Construction Preservation Maintenance Management Rehabilitation

FHWA > Engineering > Pavements > Asphalt > Warm Mix Asphalt

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 Asphalten 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 Advera® 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

- [View all Upcoming Pavements Events](#)

More Information

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

Contact

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U.S. Department of Transportation
Federal Highway Administration



U.S. Department of Transportation
**Federal Highway
Administration**

Office of Pavement Technology
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