U.S. Department of Transportation
Federal Highway Administration

Office of Pavement Technology
Asphalt Pavement Program

*Long-Life Asphalt Pavements for the 21st Century*

# WARM MIX ASPHALT TECHNOLOGY

50th Annual Illinois
Bituminous Paving Conference

ILLINOIS CENTER FOR TRANSPORTATION

December 9, 2009
Champaign, IL

warmmixasphalt.com

U.S. Department of Transportation
Federal Highway Administration

# *WMA Investigation and Implementation Premise*

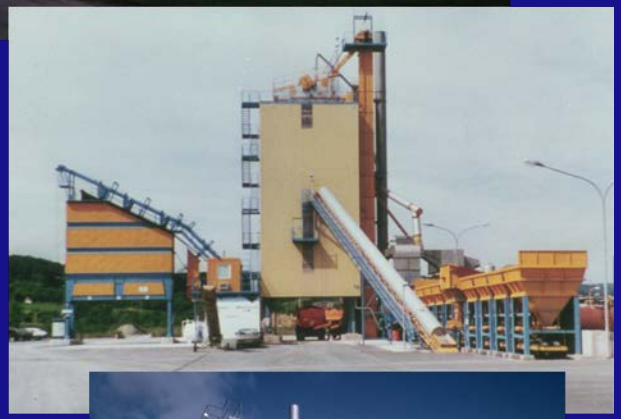
- Although there are many factors driving the development and implementation of WMA technologies globally, in order for WMA to succeed in the U.S., WMA pavements must have equal or better performance when compared to traditional HMA pavements

# *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



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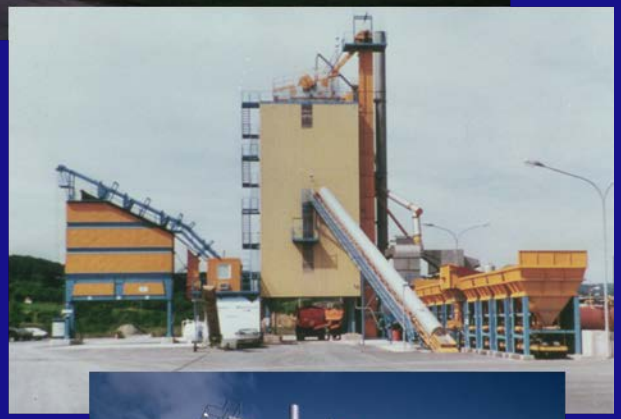
 **Advantages will only be realized by optimizing production operations and utilizing best practices

# *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??


**Advantages will only be realized by optimizing production operations and utilizing best practices

# 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





NAPA
NATIONAL ASPHALT PAVEMENT ASSOCIATION

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# 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


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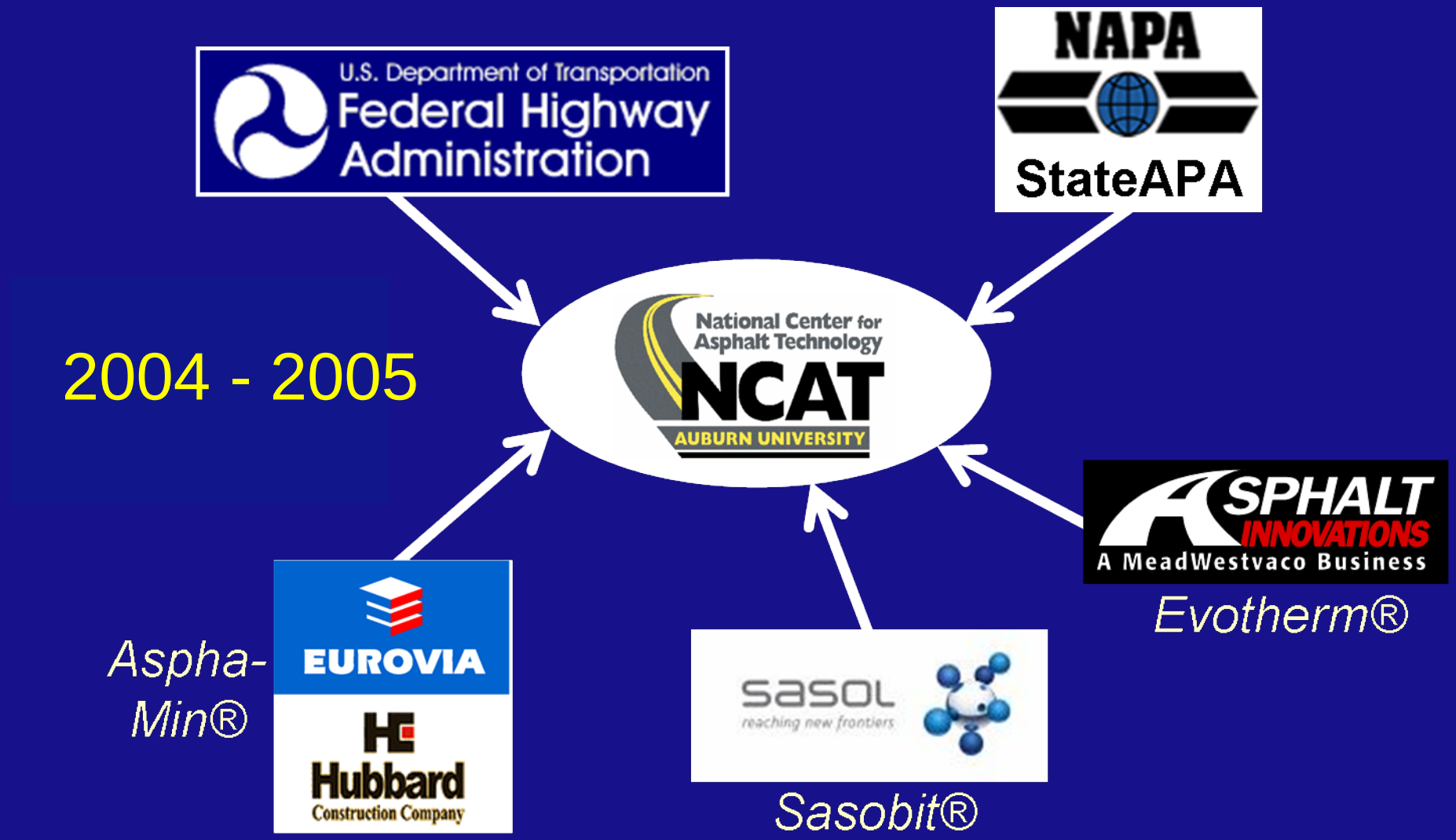
# Initial U.S. Research Partners



# 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
- Low Emission Asphalt
- Aspha-Min
- Advera
- Sasobit
- REVIX
- Evotherm
- Cecabase RT
- Thiopave
- Rediset WMX
- AquaFoam
- Ultrafoam GX
- Terex
- Accu•Shear
- Aquablack
- Double Barrel Green

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



**FHWA does not endorse any particular proprietary product or technology.

# Technology Overview**

- TLA-X — Lake Asphalt of Trinidad and Tobago
- Iterlow-T & Hyperpave — ITERCHIMICA, CHIMICA INNOVATIVA PER LE PAVIMENTAZIONI STRADALI
- Static Inline Vortex Asphalt Blender — AESCO SINCE 1980 / MADSEN SINCE 1910
- Ad-RAP (ECOBIT) — sonneborn REFINED PRODUCTS

More to come …

Many other technologies are also used Internationally.



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# *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

# *WMA Technical Working Group (TWG)*

- FHWA / NAPA sponsored
- Co-Chairs
  - Matthew Corrigan, FHWA
  - Ron White, Industry
- Represented
  - State DOT
  - State APA
  - NCAT
  - Hot Mix Asphalt Industry
  - AASHTO
  - Labor
  - NIOSH

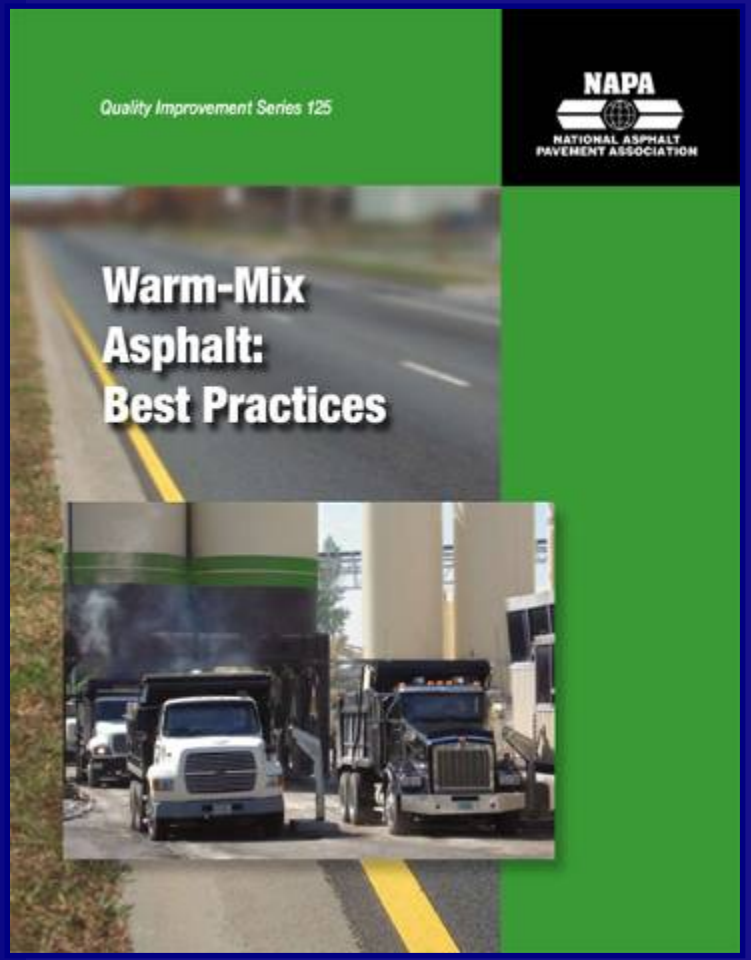
# WMA TWG Accomplishments

- 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

warmmixasphalt.com

# 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





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# AASHTO Guide Specification for Highway Construction 2008

DIVISION 400 FLEXIBLE PAVEMENTS

SECTION 401 HOT MIX ASPHALT (HMA) PAVEMENTS

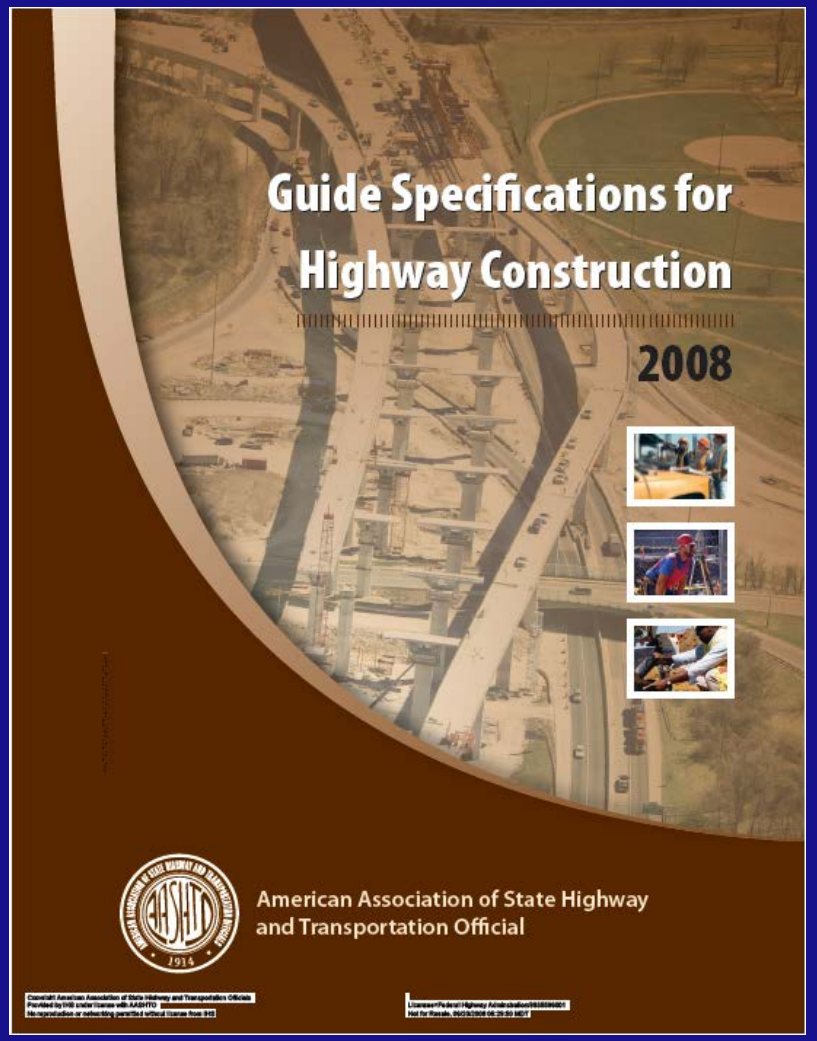
401.01 Description

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

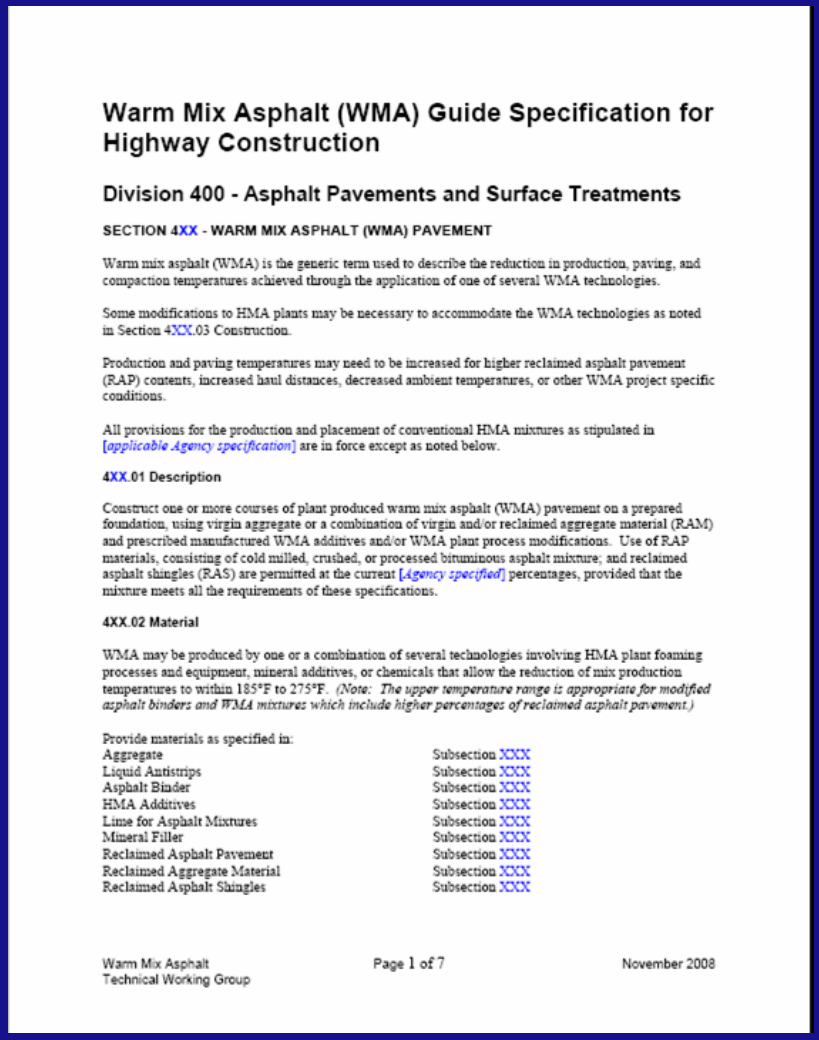
4XX.01 Description

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



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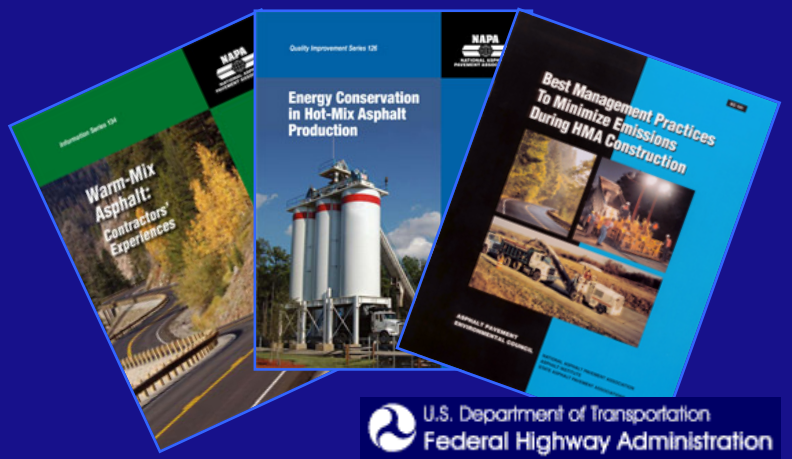
The following references detail specifics related to plant modifications and operational changes in order to maximize the benefits of WMA production:

- 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”

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# Ongoing National Research

TRB 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

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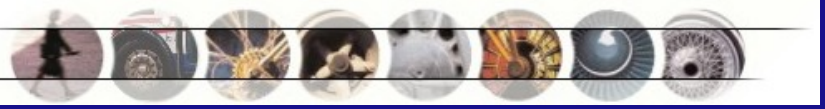
# Future National Research?

TRB 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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# 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


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# WMA Trials and Demonstrations

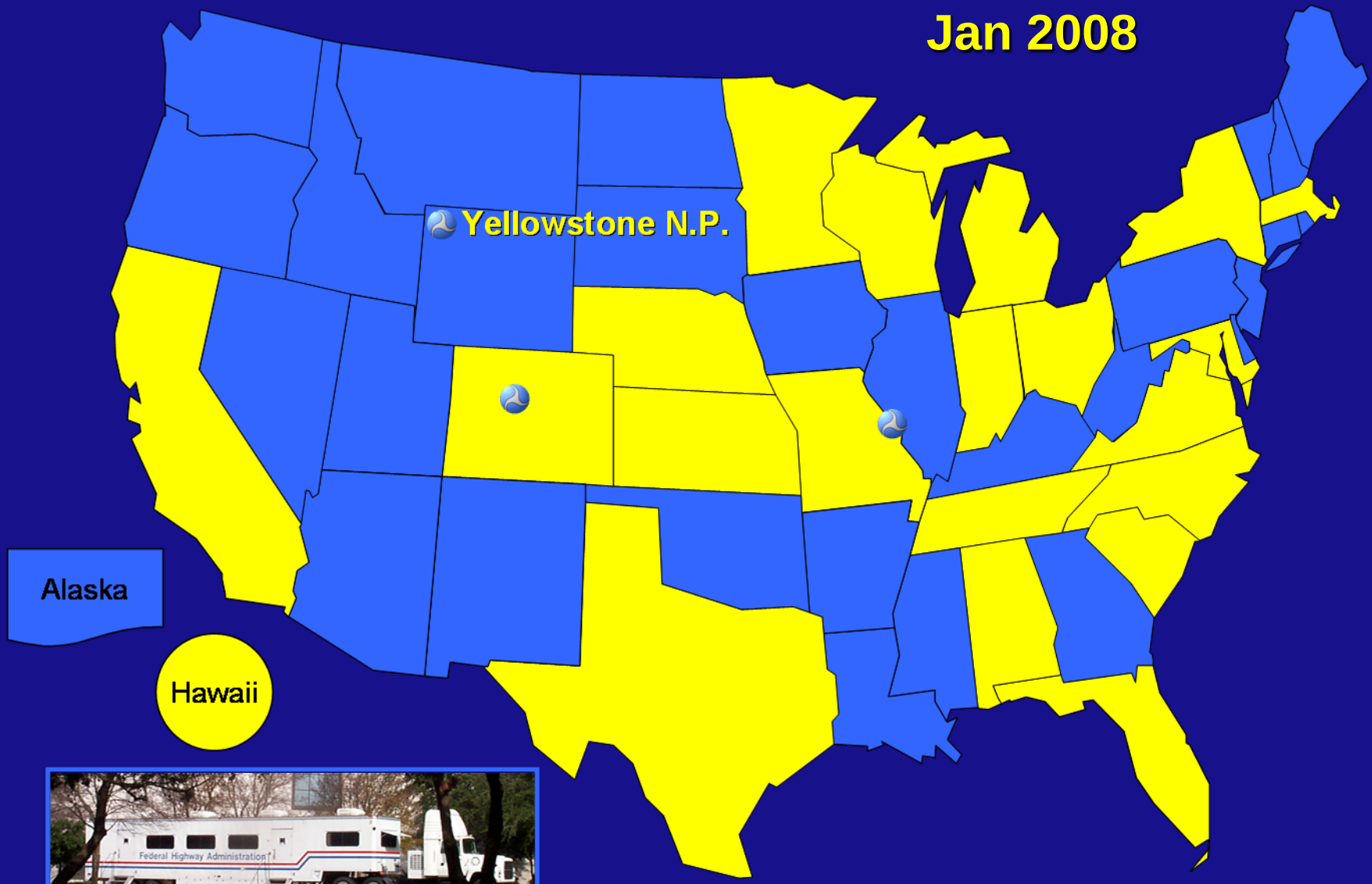
Jan 2007

Alaska

Hawaii


Mobile Asphalt Mixture Testing Laboratory (MAMTL)

# WMA Trials and Demonstrations

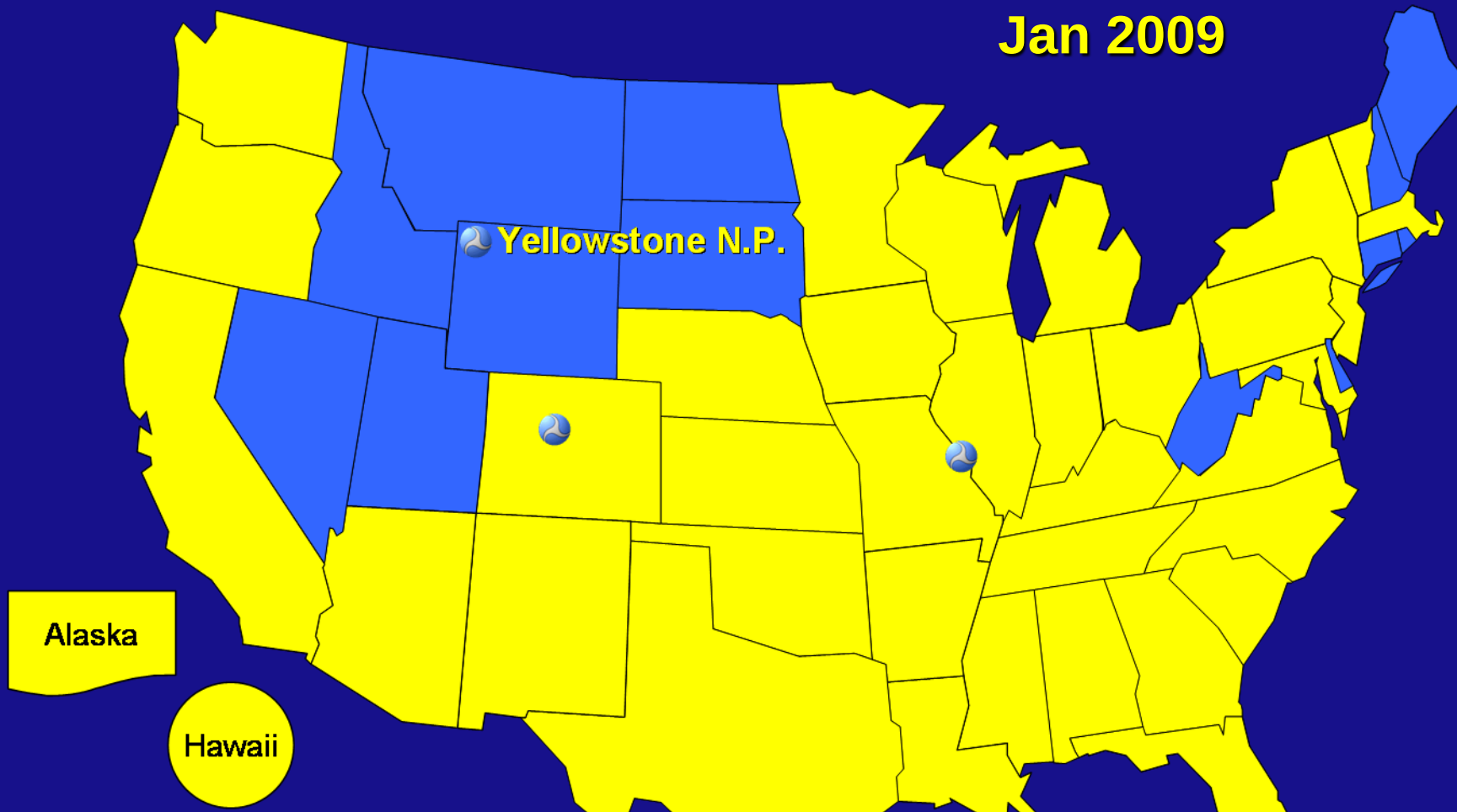






Mobile Asphalt Mixture Testing Laboratory (MAMTL)

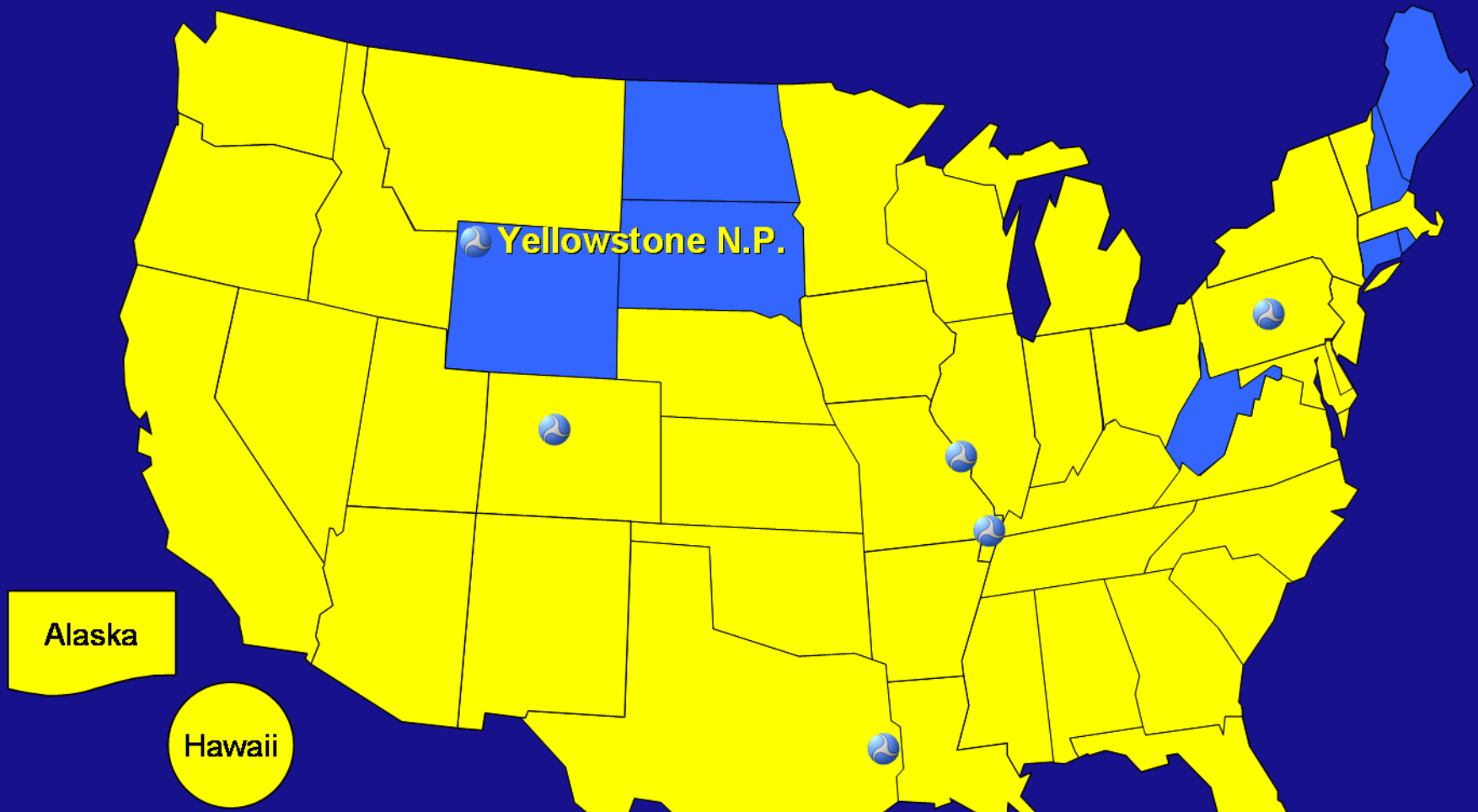
# WMA Trials and Demonstrations





Mobile Asphalt Mixture Testing Laboratory (MAMTL)

# WMA Trials and Demonstrations





Mobile Asphalt Mixture Testing Laboratory (MAMTL)

# Mobile Asphalt Testing Laboratory (MATL)

# MAMTL Trailer WMA Projects

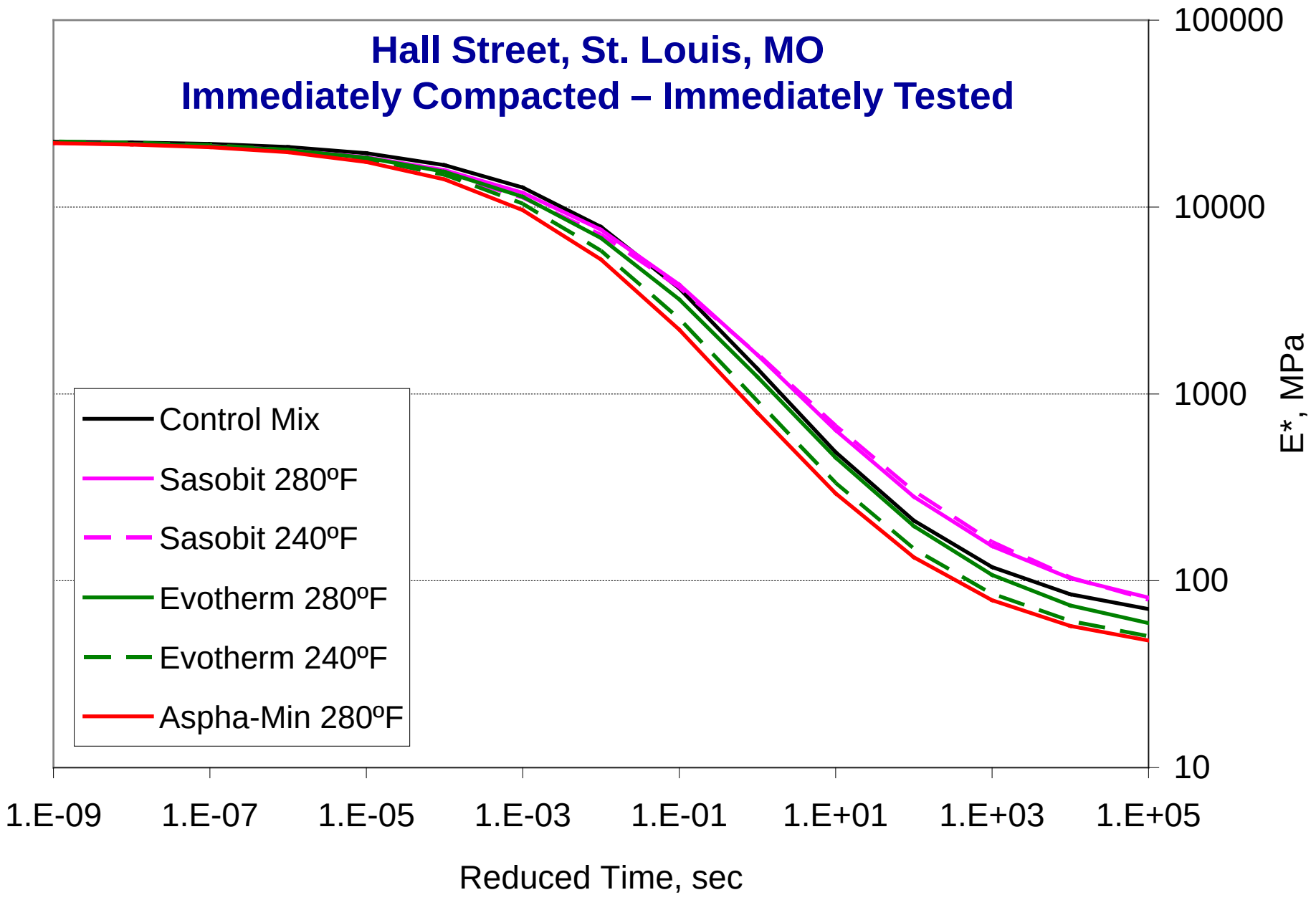
| Warm Mix Asphalt Projects | | | | |
|---|---|---|---|---|
| **Location** | **Mix Design** | **Lab Compaction Level, Gyrations** | **Base Binder Grade** | **Technologies** |
| Hall St., St. Louis, MO | 12.5 mm Superpave | 100 | PG 70-22 | Aspha-min, Evotherm, Sasobit |
| I-70, Dillon, CO, West of Eisenhower 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*)

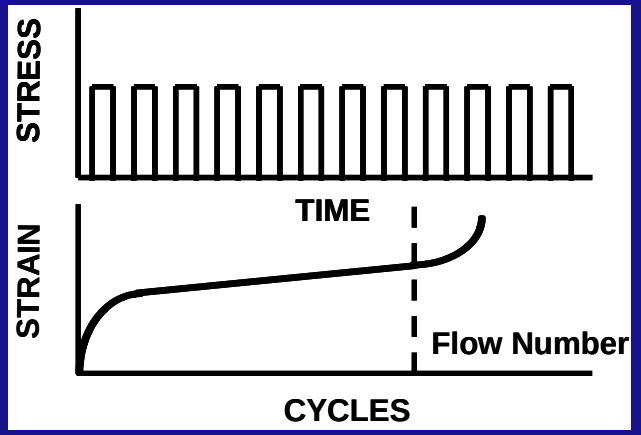
- Test Temperatures
  - **4.4º C** (40º F)
  - **21.1º C** (70º F)
  - **37.8º C** (100º F)
  - **54.4º C** (130º F)
- Frequencies
  - **0.1, 0.5, 1, 5, 10, 25 Hz**

IPC Global
AMPT Device



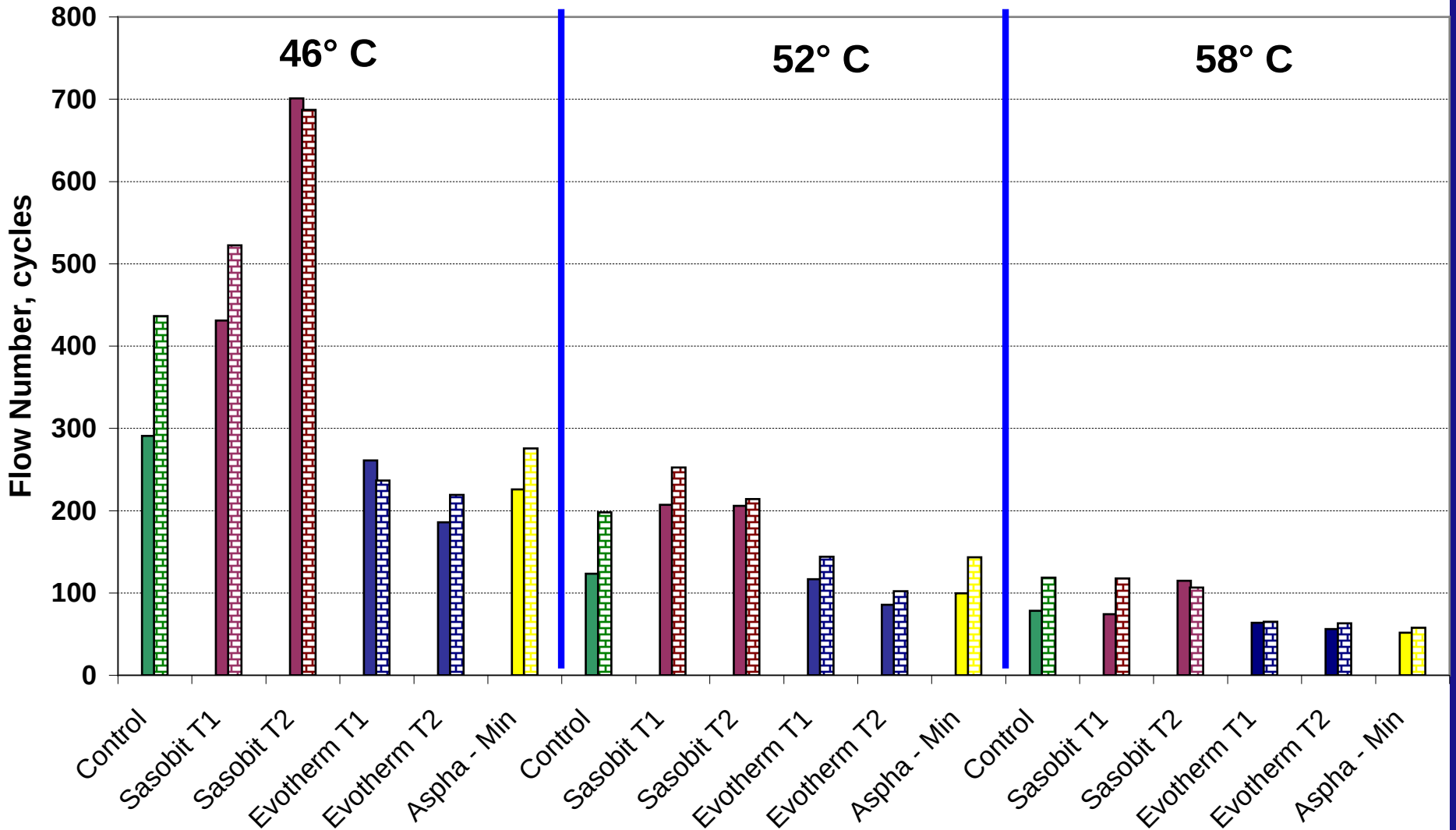
# *Flow Number, Fn*

- 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



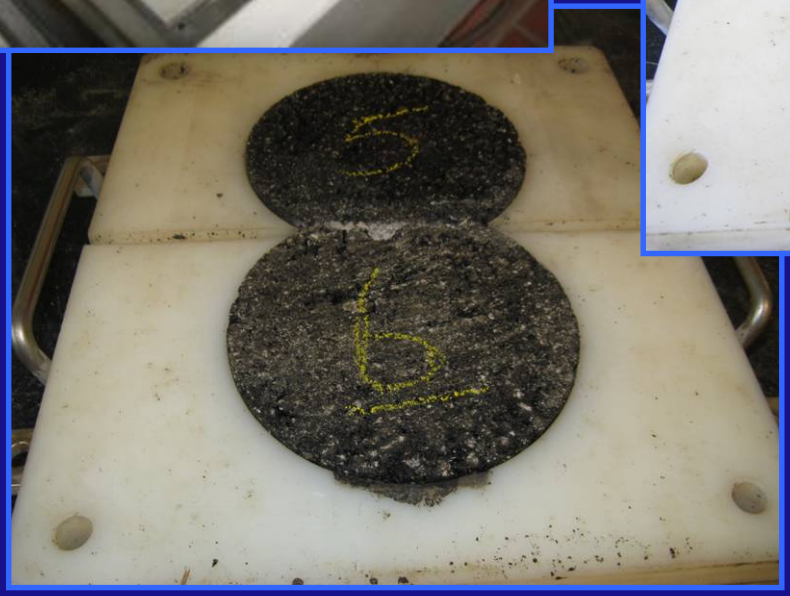

IPC Global AMPT Device

# Immediate and Delayed Test Specimens



# Hamburg Wheel Track Test

AASHTO T 324



50° F to maximum of 20,000 passes

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# 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**

*Data and Photos are Courtesy of CODOT

**ADVERA**
**9.79 mm**

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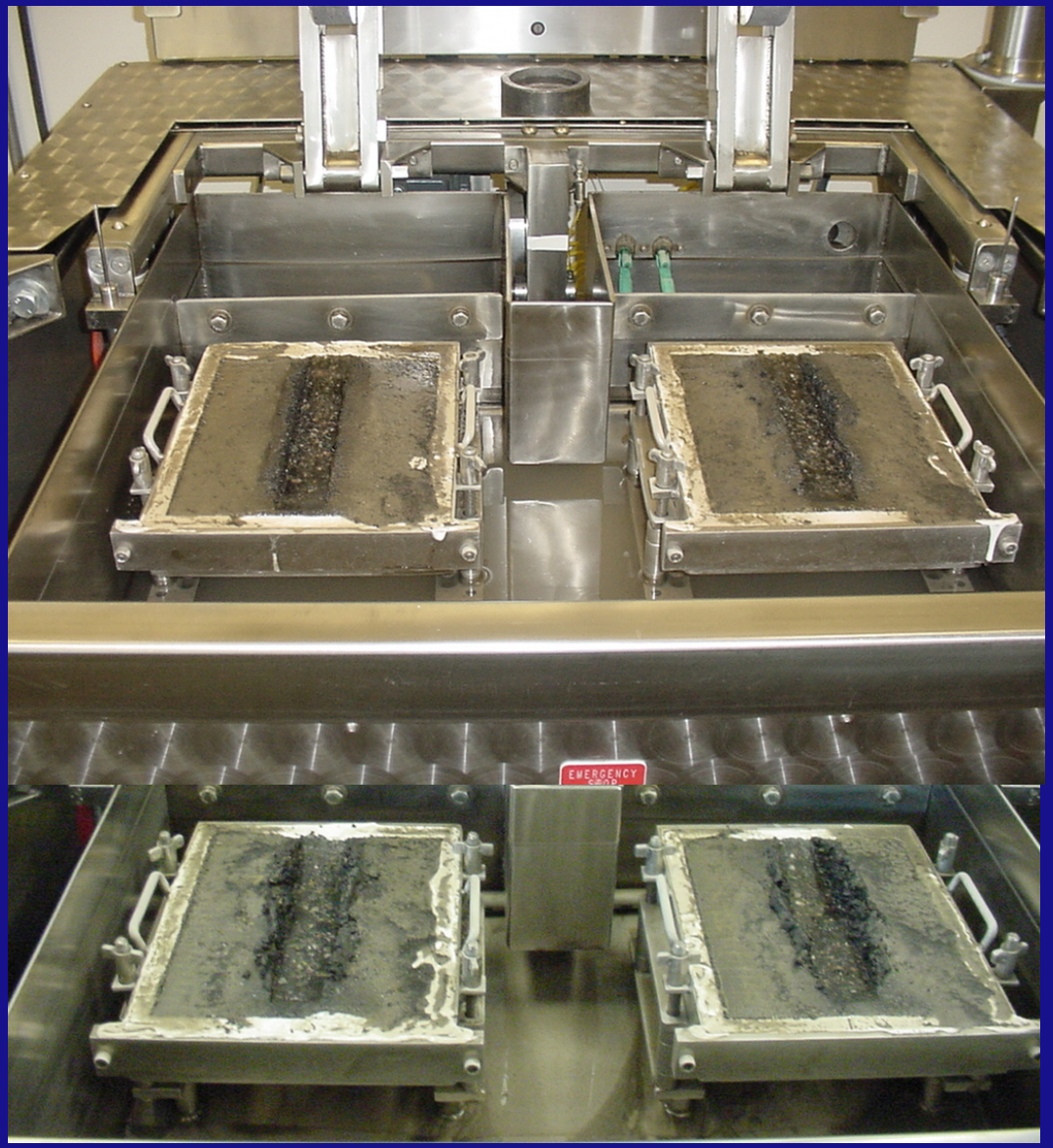
# I-70 Hamburg Sasobit




**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**

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# Yellowstone Hamburg

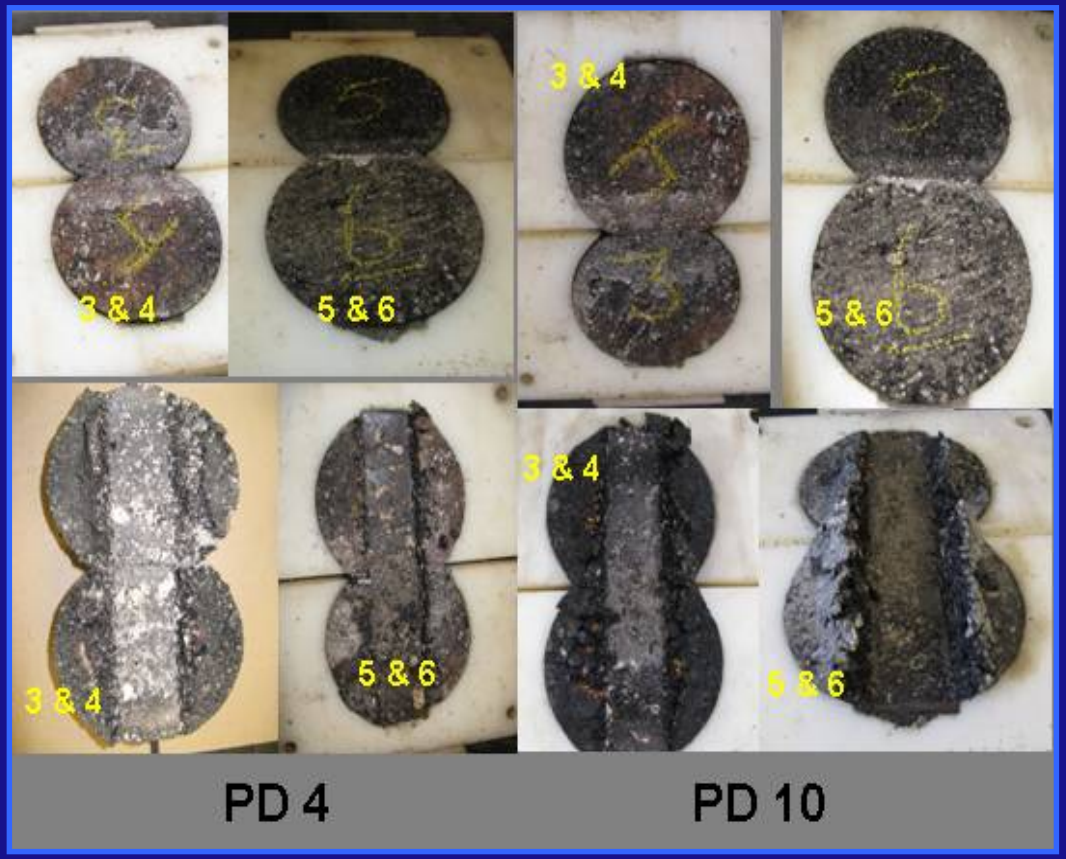
- Control - 3.82 mm and 4.00 mm
- Advera - 3.80 mm and 3.25 mm
- Sasobit - 3.28 mm and 2.60 mm

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

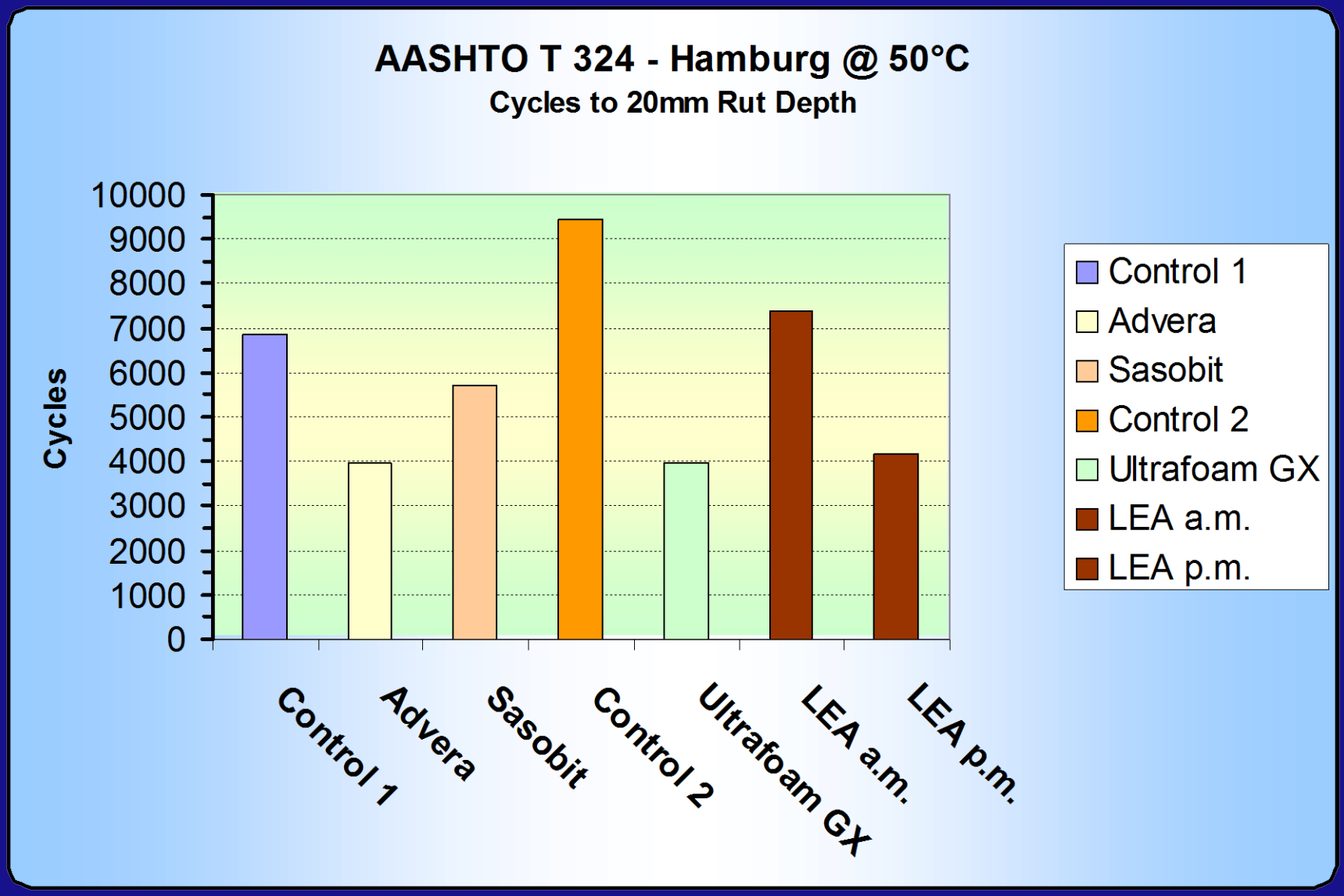
# Jasper, TX Hamburg

Rediset WMX

- PD 4 - 13.18 mm
- PD 10 - 18.80 mm



# Centre Hall, PA Hamburg



# I-55 Sikeston, MO Hamburg

Aquablack by Maxam

- Testing currently being conducted

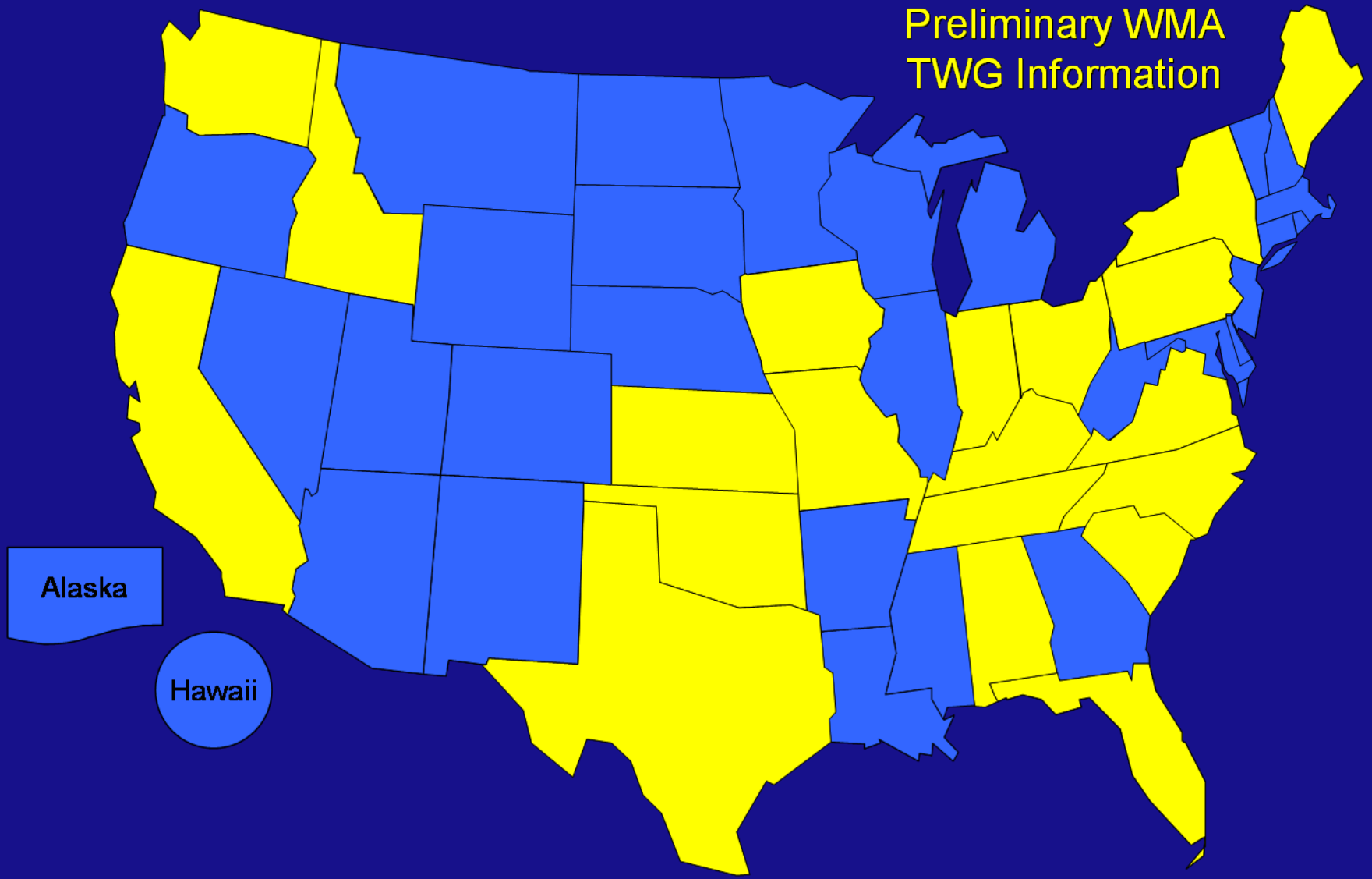
General Trend:

# Yellowstone TSR

AASHTO T 283

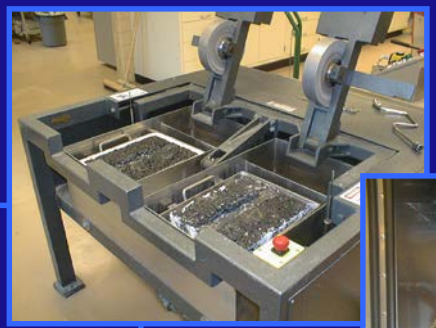
- Control Mixture
  - Dry = 67 psi, Wet = 57 psi; 85% retained
- Advera Mixture
  - Dry = 69 psi, Wet = 56 psi; 81% retained
- Sasobit Mixture
  - Dry = 76 psi, Wet = 64 psi; 84% retained

# WMA Specification Language



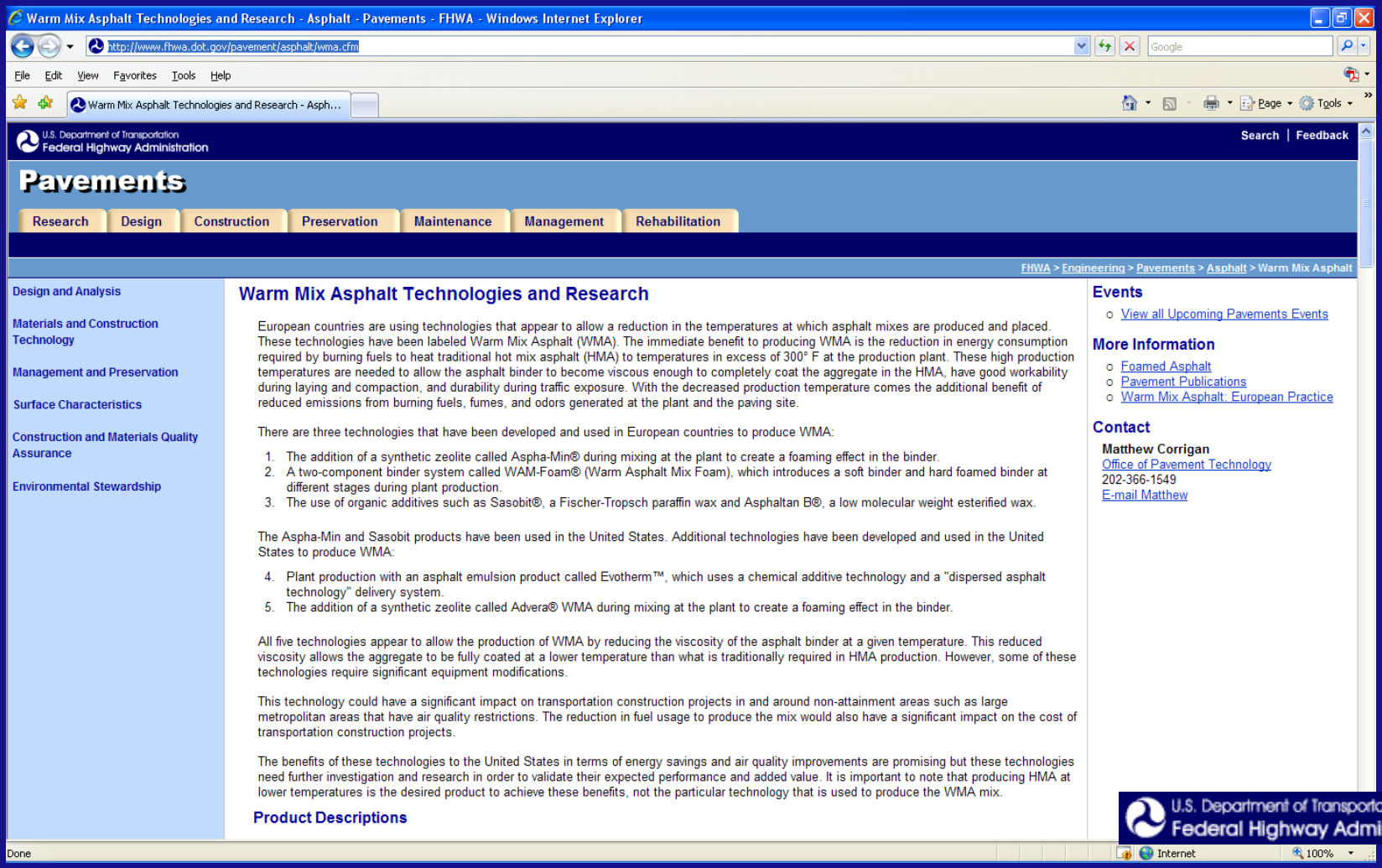
# Future WMA Specifications

- 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



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Office of Pavement Technology
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# Matthew Corrigan, P.E.

Mobile Asphalt Laboratory Program Manager
Warm Mix Asphalt Program Manager

Office of Pavement Technology
HIPT-10, Room E73-465
1200 New Jersey Ave. S.E.
Washington, DC 20590

matthew.corrigan@fhwa.dot.gov
www.fhwa.dot.gov/pavement