

NCHRP 9-49A Update: Performance of WMA Technologies: Stage II – Long- term Field Performance

Global Warm Mix Asphalt Workshop

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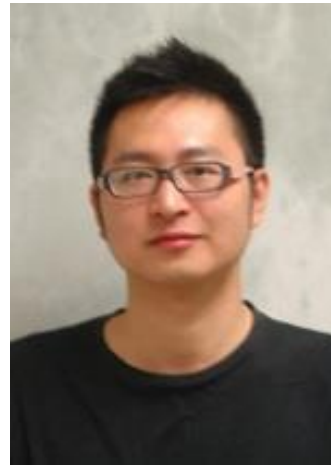
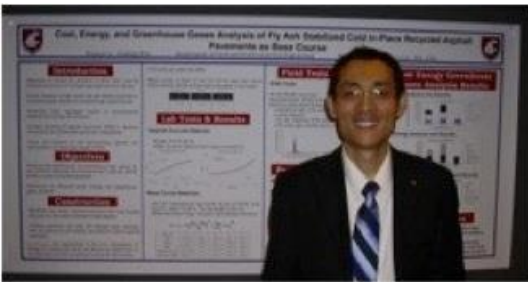
Washington Center for Asphalt Technology (WCAT)

- **Established through partnership between**
 - **Washington State Department of Transportation (WSDOT),**
 - **Washington Asphalt Paving Association (WAPA), and**
 - **Washington State University (WSU)**
- **Funding also contributed by National Science Foundation (NSF)**
- **Website: wcat.cee.wsu.edu**

Members



Graduate Students



WCAT Activities

- **Education**
 - **Undergraduate and graduate students**
- **Industry services**
 - **Mix design and verification**
 - **Studies**
- **Research and development**
 - **NCHRP 09-49A, 04-36**
 - **FHWA EAR**
 - **National Science Foundation**
 - **WSDOT, ITD, WisDOT, Counties**
 - **University Transportation Centers**

Laboratory Experiments

- **WCAT is AASHTO accredited**
 - **Mix design**
 - **Mix verification**
- **Binder Tests**
 - **Extraction and recovery**
 - **Asphalt Content of Compacted Bituminous Mixtures using Ignition Oven or Solvent**
 - **Dynamic Shear Rheometer**
 - **Bending Beam Rheometer**
 - **Rolling Thin Film Oven**
 - **Pressure Aging Vessel**
 - **Rotational Viscometer (Brookfield)**



Laboratory Experiments

- Mix performance tests
 - Dynamic Modulus Test - stiffness
 - Static Creep Test (Flow Time) - rutting
 - Repeated Load Test (Flow Number) – rutting
 - Indirect Tensile Test – fatigue and thermal cracking
 - Modified Lottman – moisture damage
 - Studded Tire Simulator
 - Beam Fatigue



NCHRP 09-49A

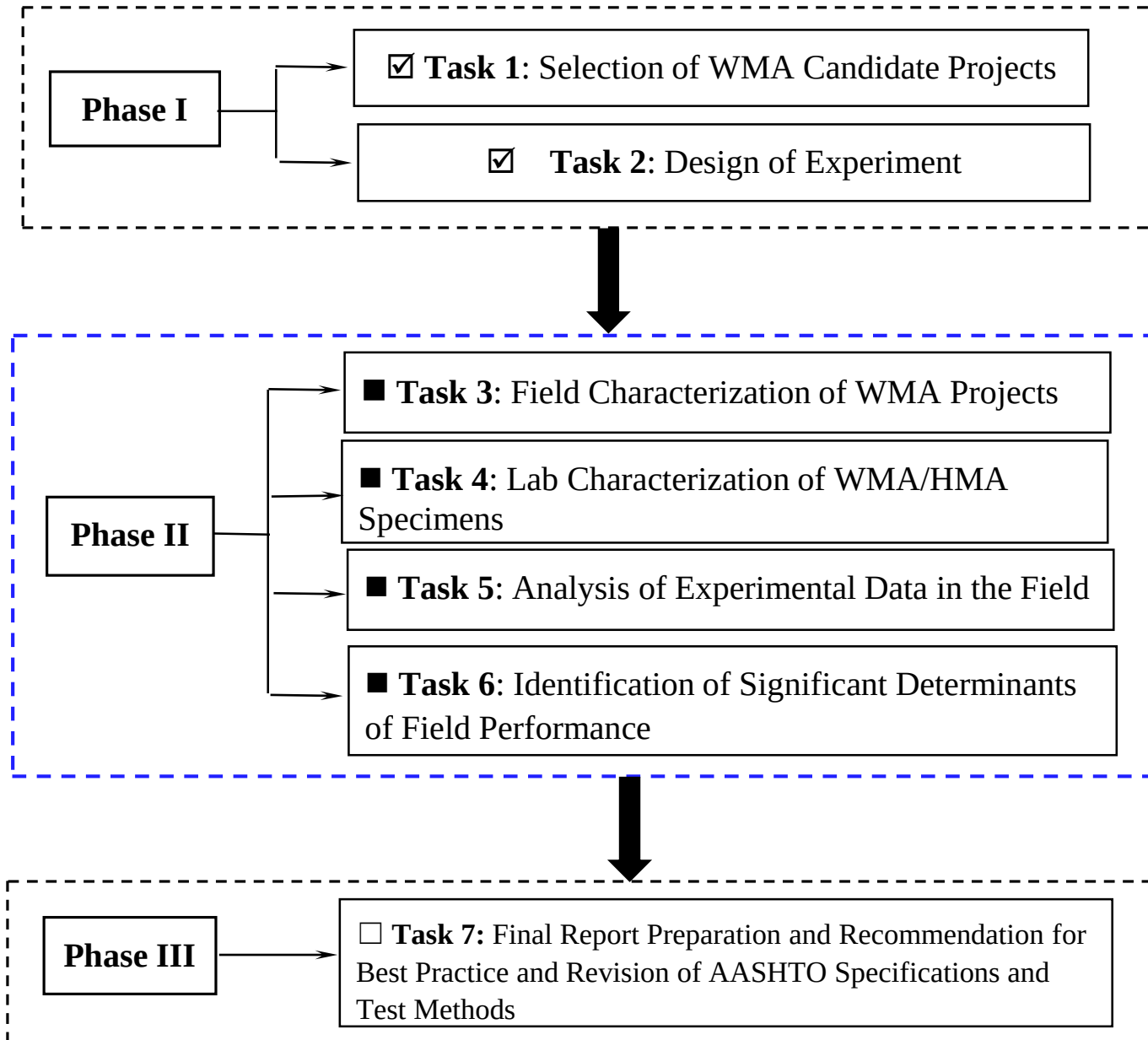
Introduction

- **Team member**
 - Haifang Wen and Shihui Shen - Washington State University (Prime)
 - Louay Mohammad-Louisiana State University
 - Braun Intertech
 - Bloom Companies
- **Project duration: 04/2011-07/2016**

Research Objectives

- To identify the material and engineering properties of WMA pavements that are significant determinants of their long-term field performance, and
- To recommend best practices for the use of WMA technologies.

Research Progress



WMA Types in this Project

- Organic additive (e.g. Sasobit)
- Chemical additives
 - Evotherm
 - Rediset
 - Cecabase
- Foaming
 - Water-containing: Advera etc.
 - Water-based: DBG (Double Barrel Green); Aquablack; Gencor

New Pavements

Climatic Zones

- -Wet-Freeze
- -Dry-Freeze
- -Dry-No Freeze
- -Wet-No Freeze

5 projects = 10 HMA-WMA pairs



Summary of Project Information

Project Name	MT I-15	TN SR 125	IA US 34	TX FM 973	LA US 61
Climate Zone	DF	WNF	WF	DNF	WNF
Year	09/2011	10/2011	09/2011	12/2011	05/2012
Warm Mix	Sasobit, Evotherm DAT, Foaming	Evotherm 3G	Sasobit, Evotherm 3G	Evotherm 3G, Foaming	Sasobit, Evotherm 3G
Mixing Temp., °F	HMA(315-320) WMA (283-300)	HMA(320-350) WMA(290-320)	HMA(330-340) WMA (265-280)	HMA(310-340) WMA(249-290)	N/A
Compaction Temp., °F	HMA(290-300) WMA(269-285)	HMA(311-335) WMA (275-290)	HMA(253-265) WMA (220-239)	HMA(268-291) WMA(221-268)	HMA(277-316) WMA(245-250)
Traffic-Design ESAL	3 million	0.39 million	3 million	3 million	N/A
AADT/ %Truck	3,170/26.3	3,470/13.0	6,450/10.9	11,300/4.3	N/A
Aggregate	Siliceous	Gravel & Sand	Limestone, Quartzite & Sand	Gravel, Limestone & Dolomite	Granite & Limestone
Asphalt Binder	PG 70-28	PG 70-22	PG 58-28	PG 70-22	PG 76-22
Polymer Modified	SBS	NO	NO	NO	SBS
Asphalt Content(AS), %	4.6(1.4%lime)	6.0((0.3LAS)	5.44	5.2	4.7(0.6%LAS)
RAP or RAS	NO	10% RAP	17% RAP	NO	15% RAP

Project Data Collected

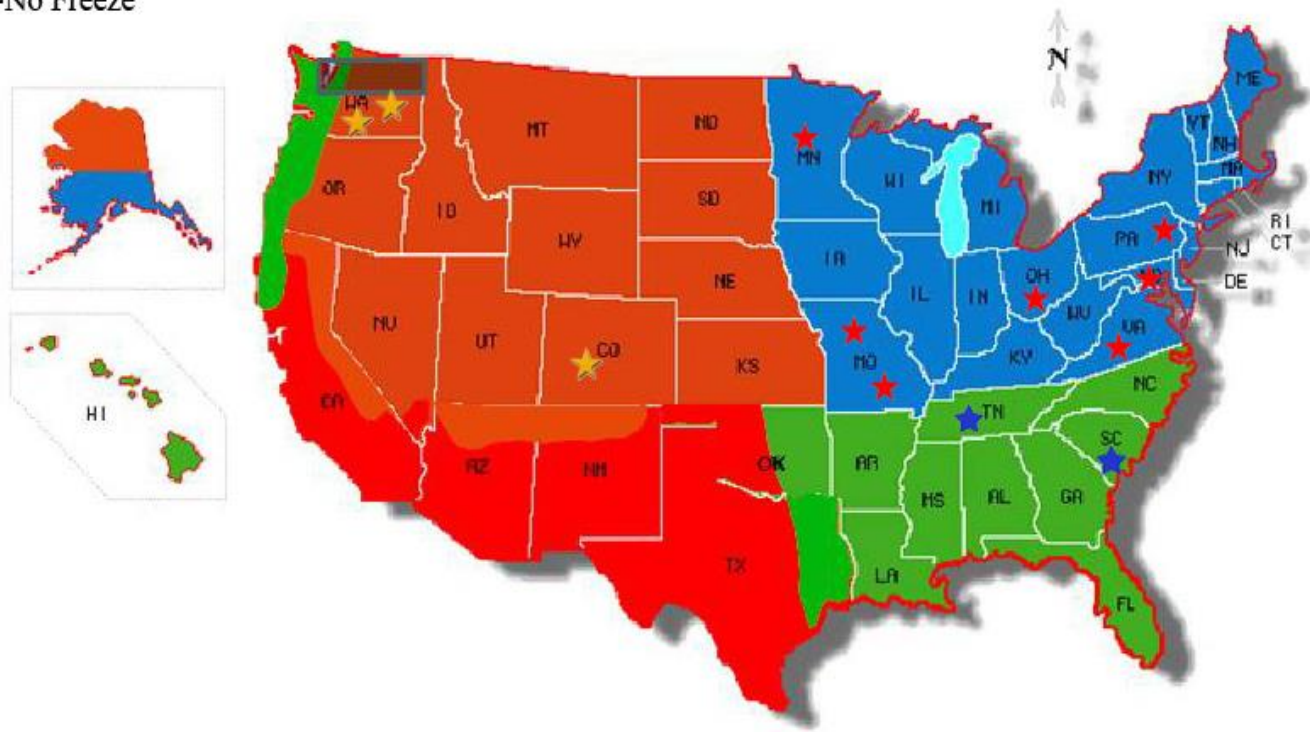
- **Pre-construction pavement condition**
 - manual distress survey
 - LTPP distress survey manual
- **On-site sample compaction**
- **Raw and loose mix collection**
- **Construction data**
 - Production and mixing temperature
 - In-place density
 - Pavement thickness, etc.
- **Moisture content check**

In-Service Pavements

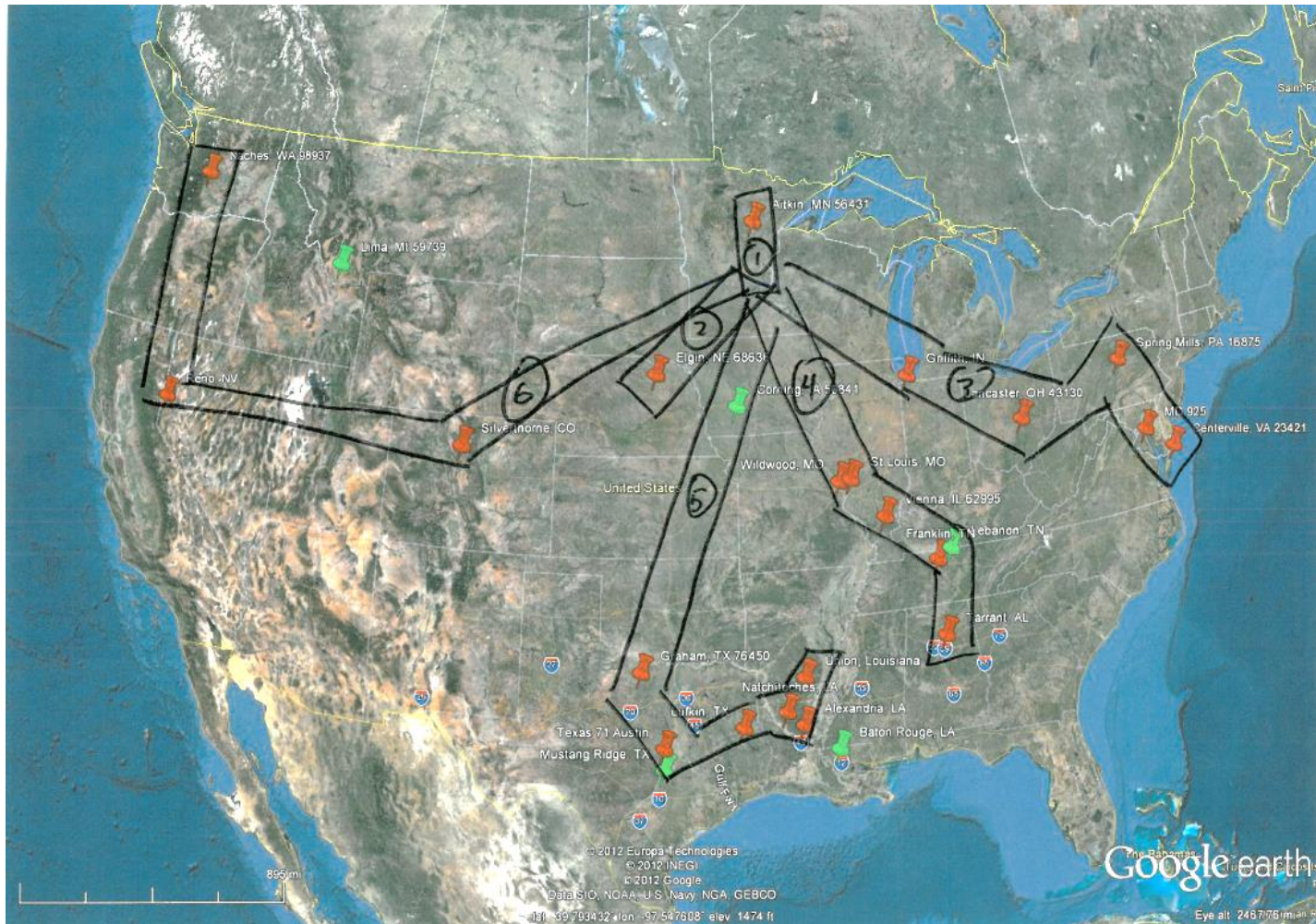
Climatic Zones

- -Wet-Freeze
- -Dry-Freeze
- -Dry-No Freeze
- -Wet-No Freeze

40 HMA-WMA pairs

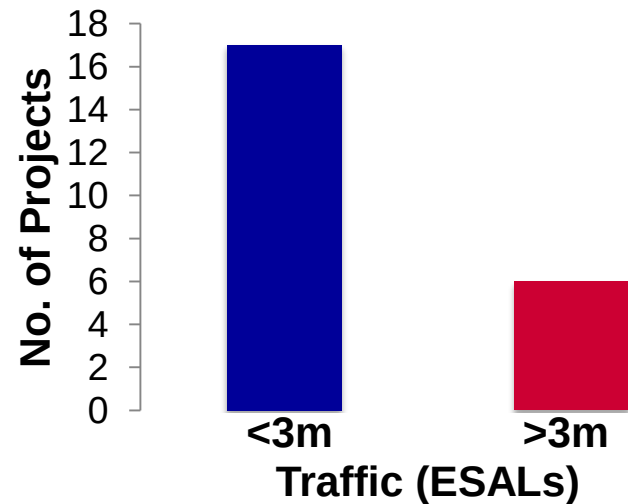
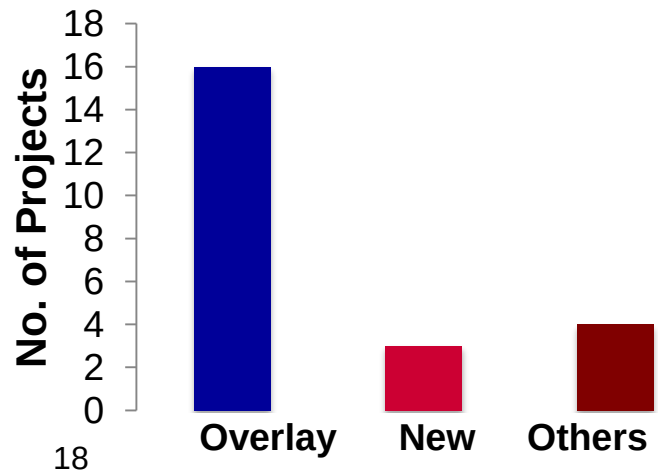
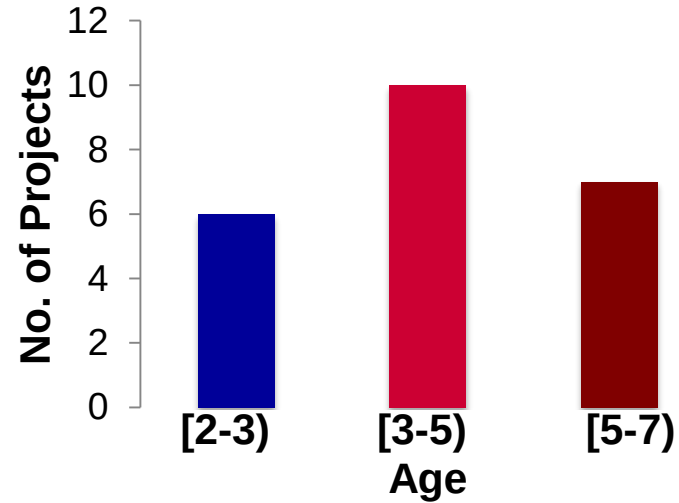
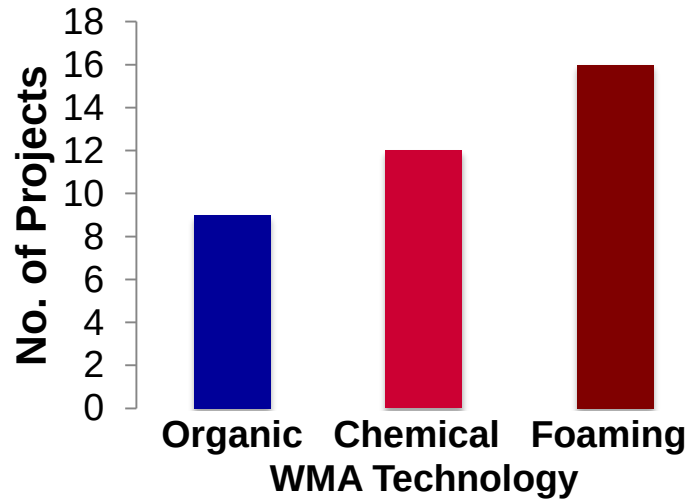


In-service Pavements



In-service Pavements Distribution

(Total 23 projects)



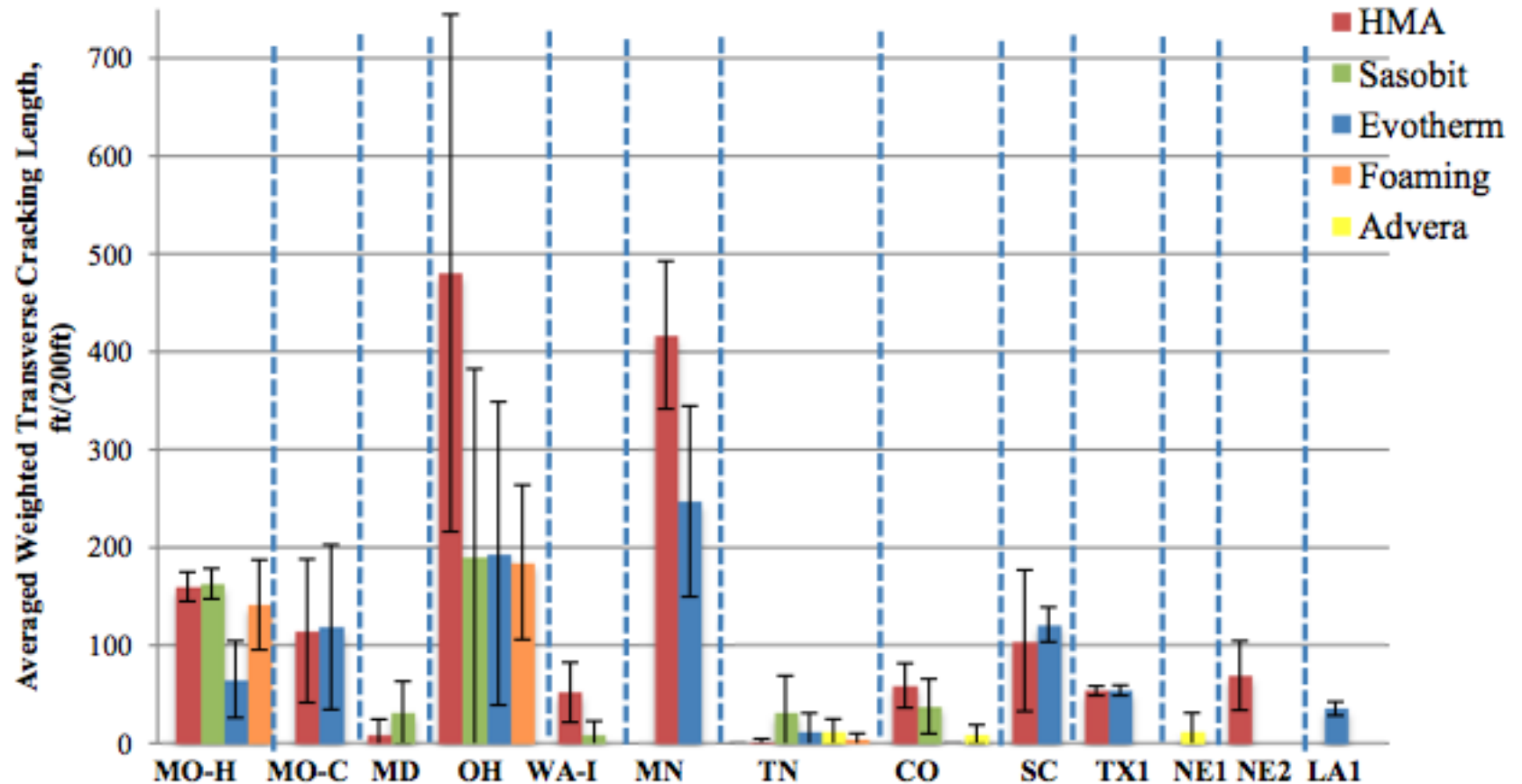
Field Investigation Procedure

- **Manual distress survey: LTPP distress survey manual**
- **Three 200-foot sections**
- **Distress summary**
 - Averaged distress for three sections
 - Consider weighed factors for low, medium, and high severity levels

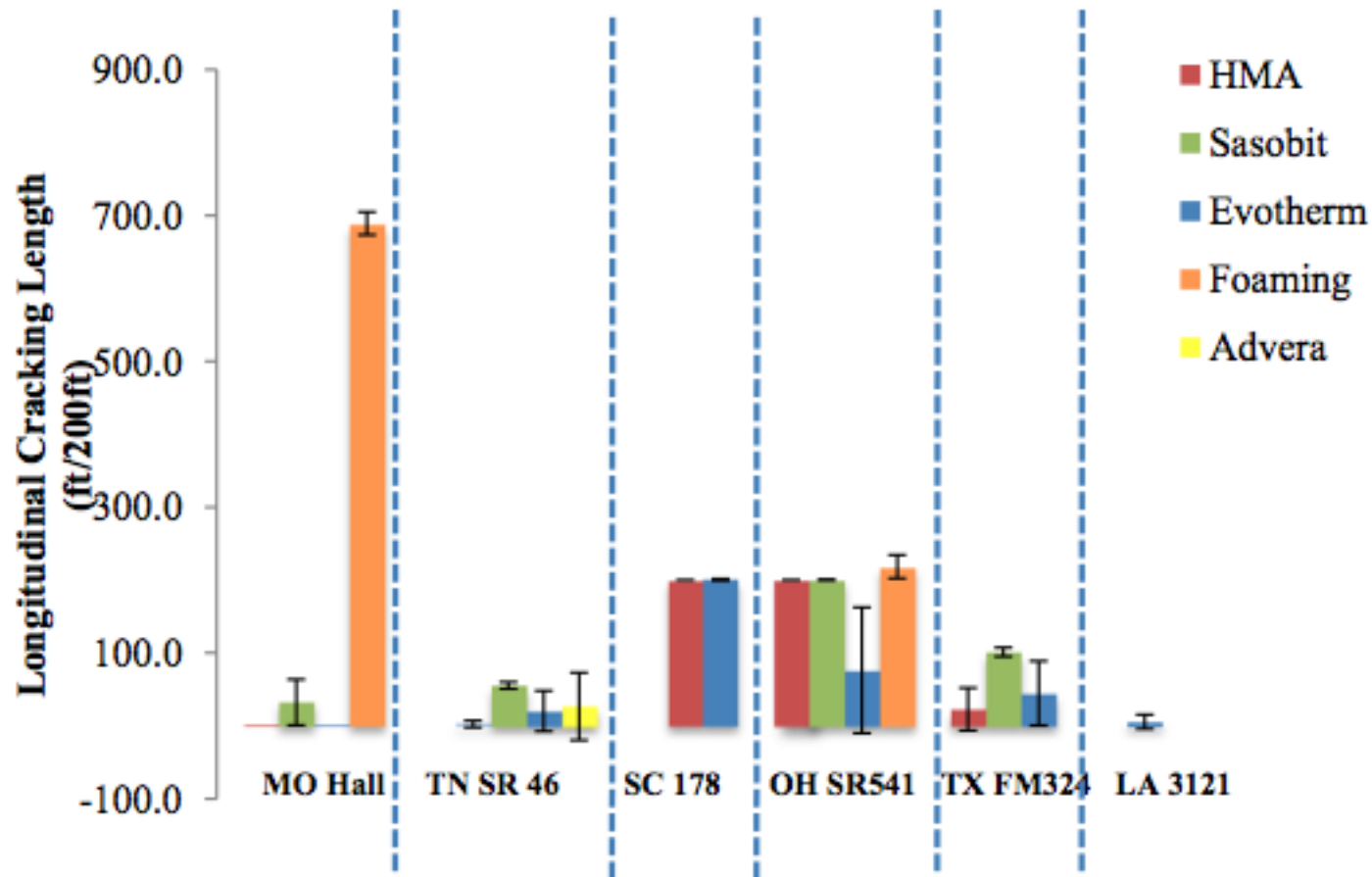
Field Investigation Procedure

- **Falling Weight Deflectometer (FWD)**
- **Field cores between the wheelpath**

Weighted Averages of Transverse Cracking Lengths for HMA/WMA for 11 Projects

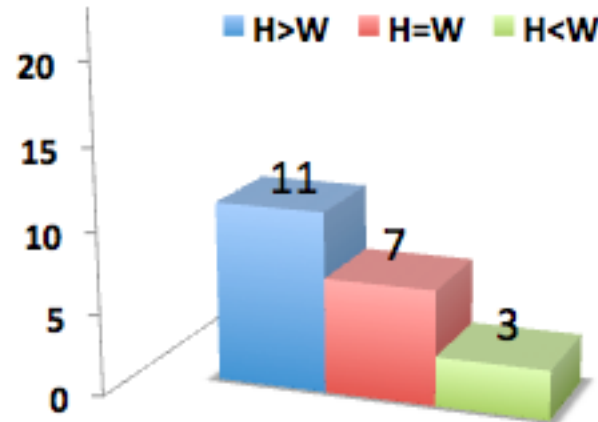


Weighted Averages of Longitudinal Cracking Lengths for HMA/WMA for 6 Projects



Transverse Cracking

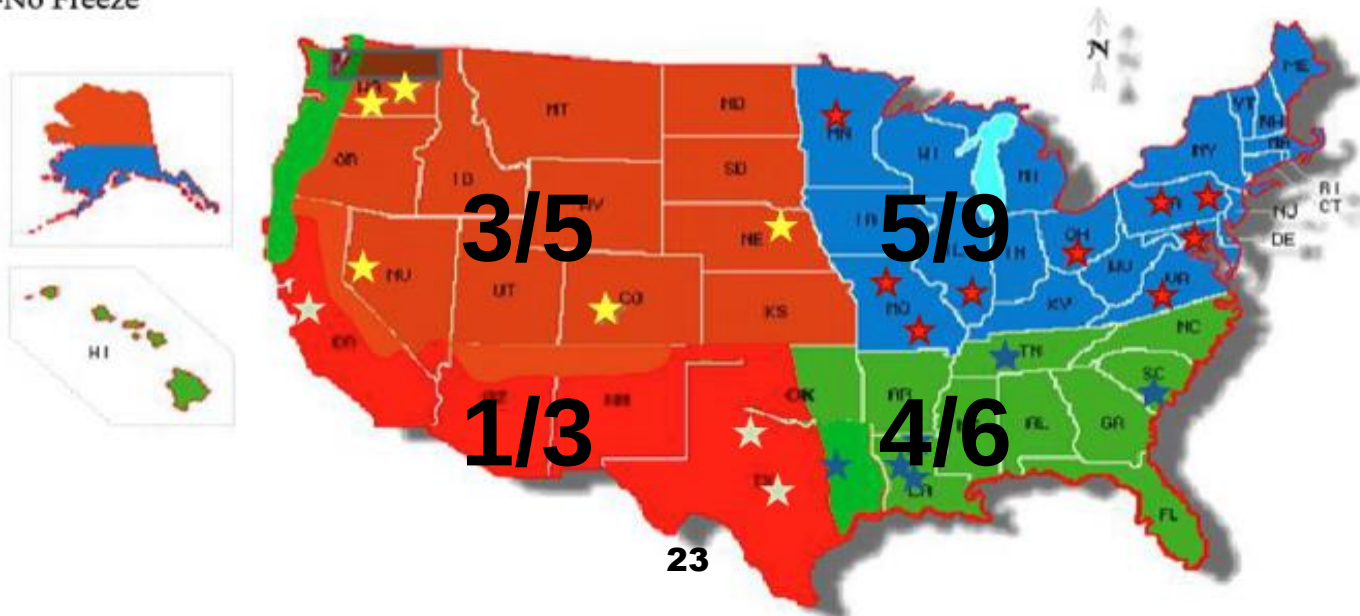
Total 13 out of 23 projects, 21 H-W pairs



WMA better or comparable in transverse cracking performance

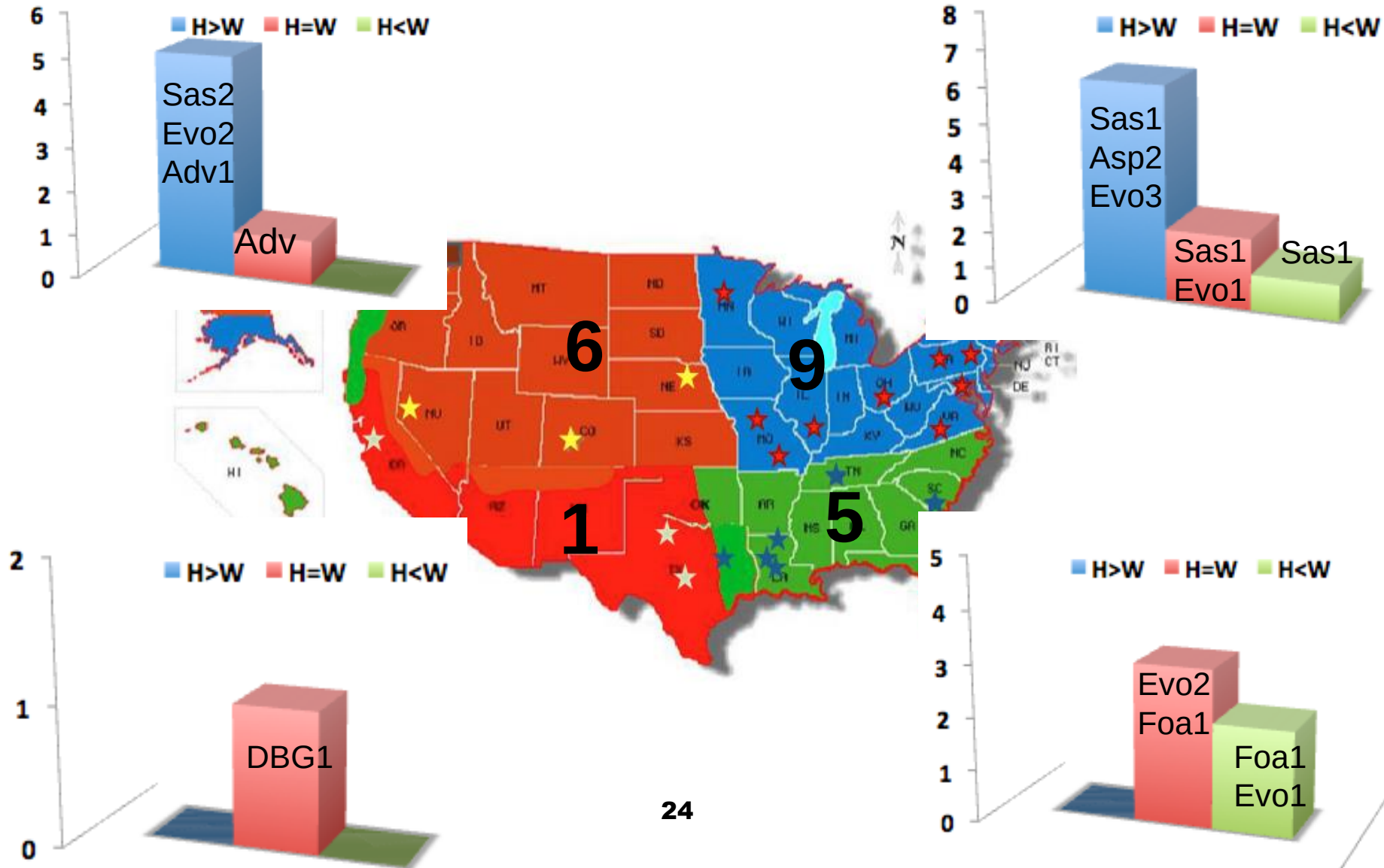
Climatic Zones

- Wet-Freeze
- Dry-Freeze
- Dry-No Freeze
- Wet-No Freeze



Transverse Cracking

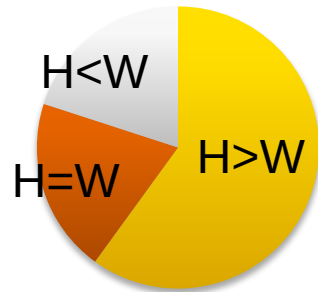
Total 21 H-W pairs excluding TN SR46



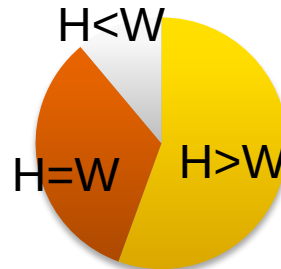
Transverse Cracking

In terms of WMA technology

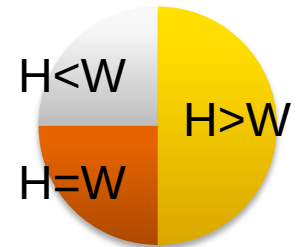
(HMA-Sasobit)



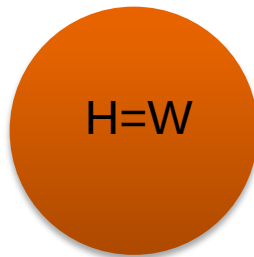
(HMA-Evotherm)



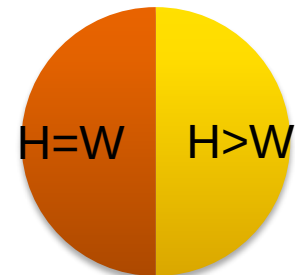
(HMA-Foaming)



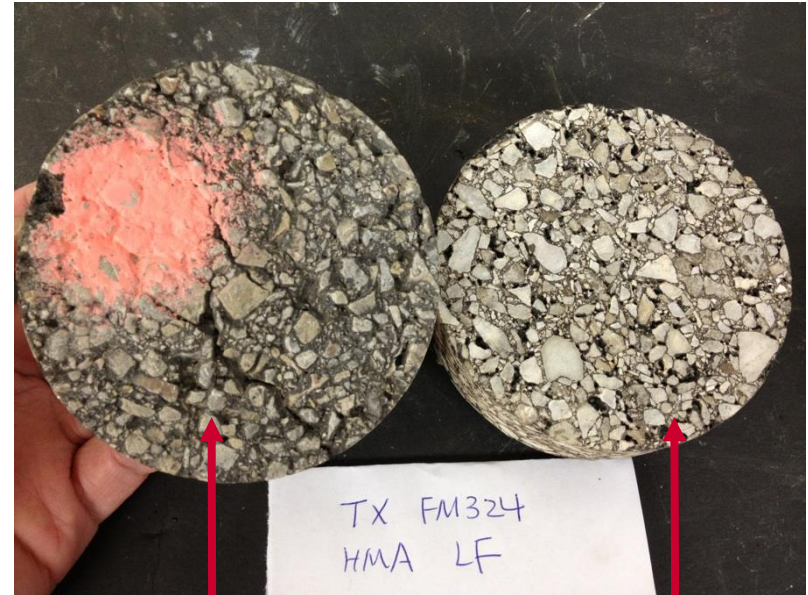
(HMA-DBG)



(HMA-Advera)



Longitudinal Top-down Cracking



Overlay

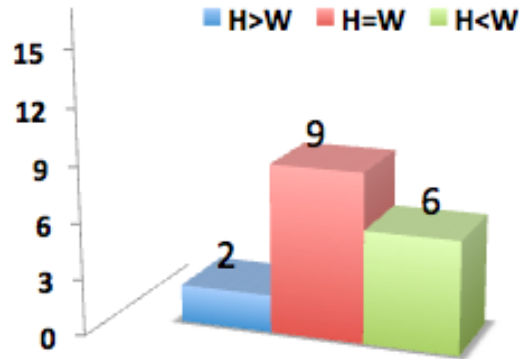
2nd layer

Fatigue Cracking (Longitudinal WP)

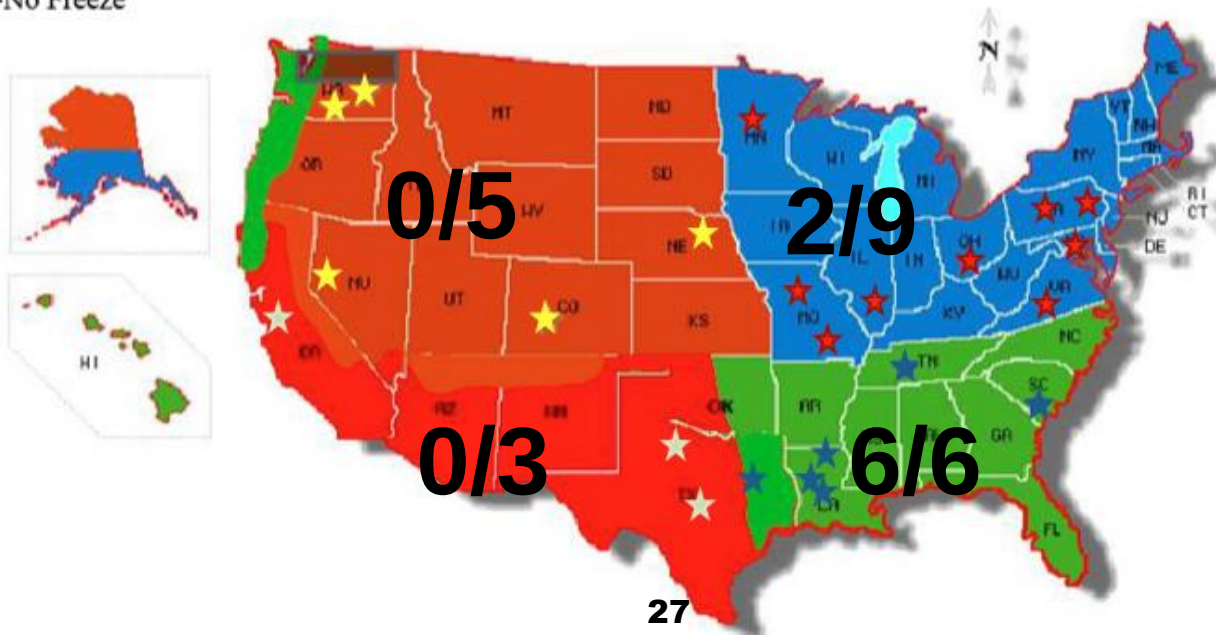
Total 8 out of 23 projects, 17 H-W Pairs

Climatic Zones

- -Wet-Freeze
- -Dry-Freeze
- -Dry-No Freeze
- -Wet-No Freeze



HMA better or comparable in fatigue cracking performance

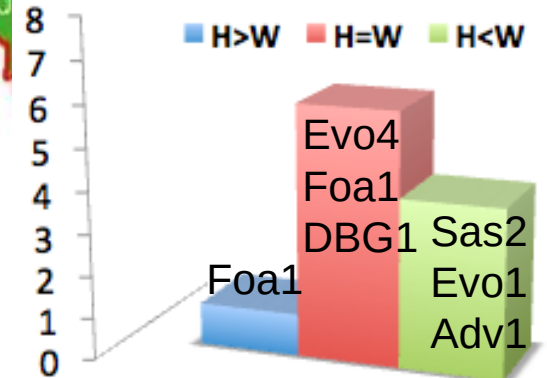
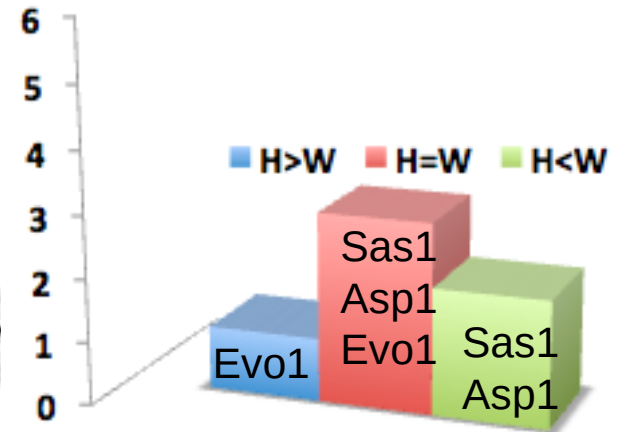
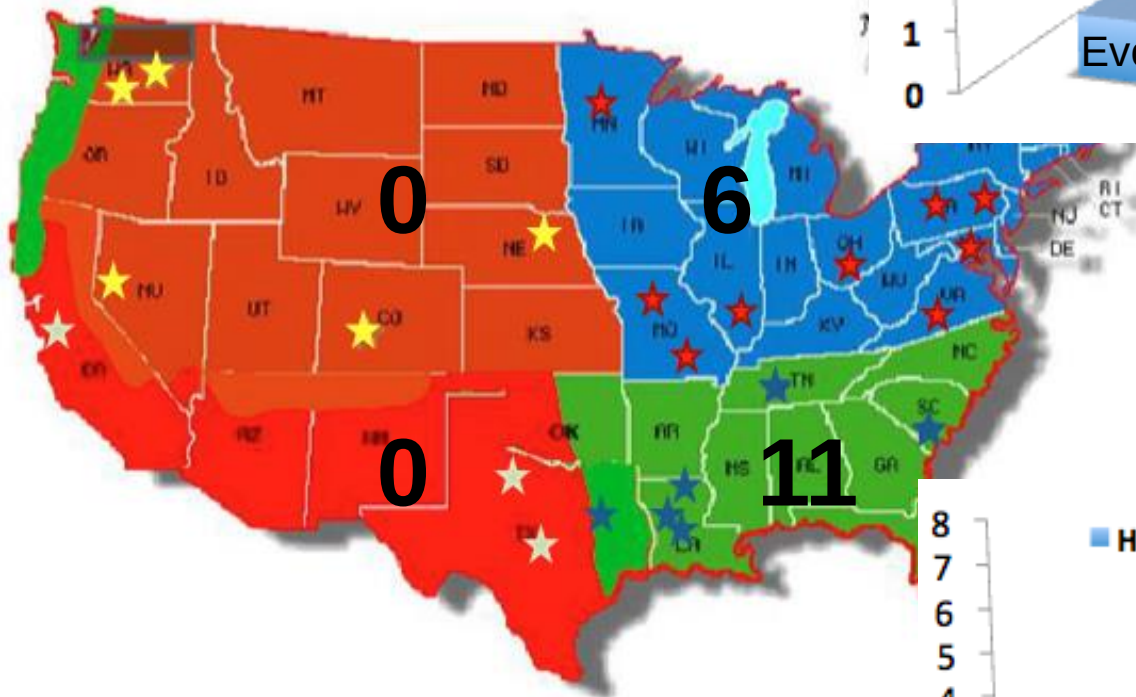


Fatigue Cracking (Longitudinal WP)

Total 17 H-W pairs

Climatic Zones

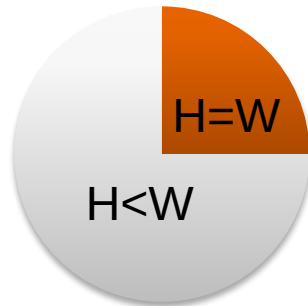
- -Wet-Freeze
- -Dry-Freeze
- -Dry-No Freeze
- -Wet-No Freeze



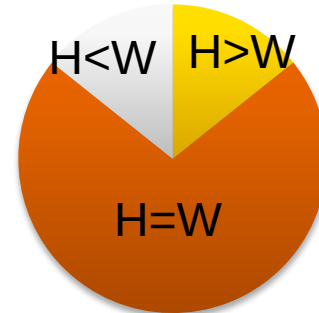
Fatigue Cracking (Longitudinal WP)

In terms of WMA technology

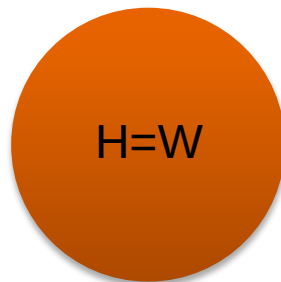
(HMA-Sasobit)



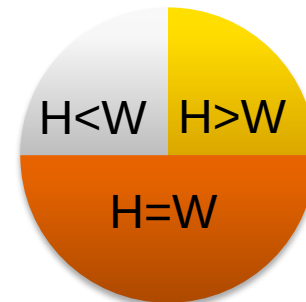
(HMA-Evotherm)



(HMA-DBG)



(HMA-Foaming)



Mixture Testing

Test	Volumetrics	AMPT E*	AMPT FN	IDT E*	IDT Creep Compliance	Fatigue (IDT)	Thermal Cracking (IDT)	Hamburg Test
PMLC samples	√	√	√	√	√	√	√	√
PMFC samples	√			√	√	√	√	√

Asphalt Binder Testing

	Binder PG Grading	MSCR	Fatigue	Thermal Cracking
Original binder	√	√	√	√
Recovered binder	√	√	√	√

Mixture Testing

New Project	MT I-15		IA US 34		TN SR 125		TX FM 973		LA US 61			
	2011	2013	2011	2013	2011	2013	2011	2013	2012	2014		
Mixture Test	✓		✓		✓		✓					
Binder Test	✓		✓		✓		✓					
Hamburg Test	✓		✓		✓		✓		✓			
<u>AASHTOWare</u>	✓		✓		✓		✓					
In-service Project	MD 925	MO Hall St.	MO Rte. CC	MN TH 169	OH SR 541	PA SR 2012	VA I-66	SC US 178	TN SR 46	CO IH 70	WA I-90	WA SR 12
Mixture Test	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Binder Test	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Hamburg Test	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓
<u>AASHTOWare</u>	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓
In-service Project	TX SH 251	NE US 14	TX FM 324	LA 3121	LA 116	LA 3191	TX SH 71	IL 147	PA SR 2006	NV Bravo	CA HVS	
Mixture Test	✓	✓	✓	✓	✓							
Binder Test	✓	✓	✓	✓								
Hamburg Test								✓	✓			
<u>AASHTOWare</u>		✓										

Note: “✓”: completed; Blank: to be completed.

Field Characterization

	FWD/coring/ experiments on cores	Lab sample preparation/ experiments	Distress survey
In-service WMA/HMA pavements	2012	2012	2012, 2014
2011 WMA/HMA pavements	2011, 2013	2011	2013, 2015

Questions?