Findings of the NCHRP 9-47A Engineering Properties and Performance of WMA Technologies

NEAUPG Meeting

Framingham, MA

October 22, 2014

National Center for Asphalt Technology
NCAT
at AUBURN UNIVERSITY

Outline

- Projects Evaluated
- Engineering Properties
- Field Performance
- Summary of Findings

NCHRP 9-47A Projects

Location	Route	WMA Technologies	Date Const.
St. Louis, MO	Hall Street	Evotherm ET, Sasobit, Aspha-min	May-2006
Iron Mtn., MI	M95	Sasobit	Sep-2006
Silverthorne, CO	I-70	Advera, Sasobit, Evotherm DAT	Aug-2007
Franklin, TN	SR45	Astec DBG, Advera, Evotherm DAT, Sasobit	Oct-2007
Graham, TX	US 380	Astec DBG	Jun-2008
George, WA	I-90	Sasobit	Jun-2008
Walla Walla, WA	US-12	Maxam Aquablack	Apr-2010
Centreville, VA	I-66	Astec DBG	Jun-2010
Rapid River, MI	CR-513	Evotherm 3G, and Advera	Jun-2010
Baker, MT	Route 322	Evotherm DAT	Aug-2010
Munster, IN	Calumet Ave.	Evotherm, Gencor foam, Heritage wax	Sep-2010
Jeff. Co., FL,	SR 30	Terex foaming system	Oct-2010
Queens, NY	Little Neck Pkwy	Cecabase, SonneWarmix, BituTech PER	Oct-2010
Case Grande, AZ	SR 84	Sasobit	Dec-2011

Mixing and Compaction Temperatures

Project Location	Technology	Avg. WMA Temperature, °F		Avg. HMA Temp.,° F	
		Production	Field Comp.	Production	Field Comp.
Walla Walla, WA	Aquablack	275	270	325	310
Centreville, VA	Astec DBG	288	268	318	294
Rapid River, MI	Evotherm 3G	269	239	300	255
Rapid River, MI	Advera	269	227	300	255
Baker, MT	Evotherm DAT	262	NA	298	282
Munster, IN	Wax	268	235	300	249
Munster, IN	Gencor foam	277	222	300	249
Munster, IN	Evotherm 3G	256	210	300	249
New York, NY	BituTech PER	279	238	344	299
New York, NY	Cecabase	247	221	344	299
New York, NY	SonneWarmix	262	222	344	299
Jefferson Co., FL	Terex foam	297	247	336	269
Casa Grande, AZ	Sasobit	276	257	320	297

Engineering Properties

- True Binder Grades
- In Place Densities
- Core tensile strengths
- TSR
- FN
- Hamburg
- E*

Statistical Comparisons

Higher/Lower/Same

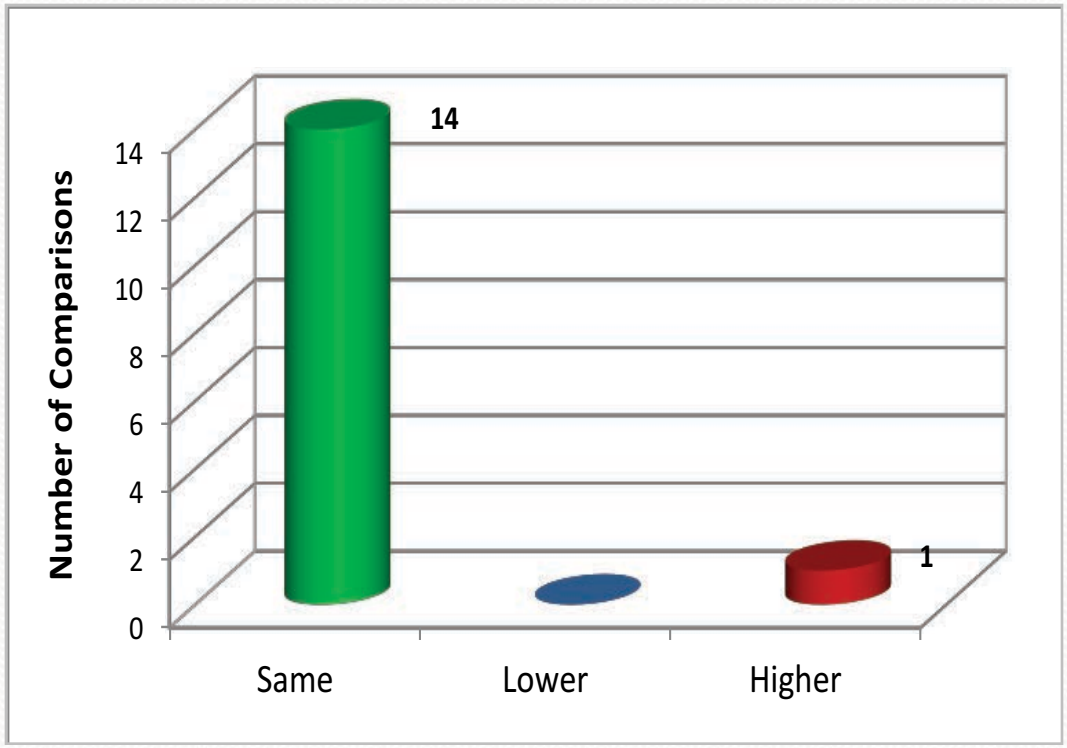
True Binder Grades Differences (WMA-HMA) (Mix Sampled During Construction)

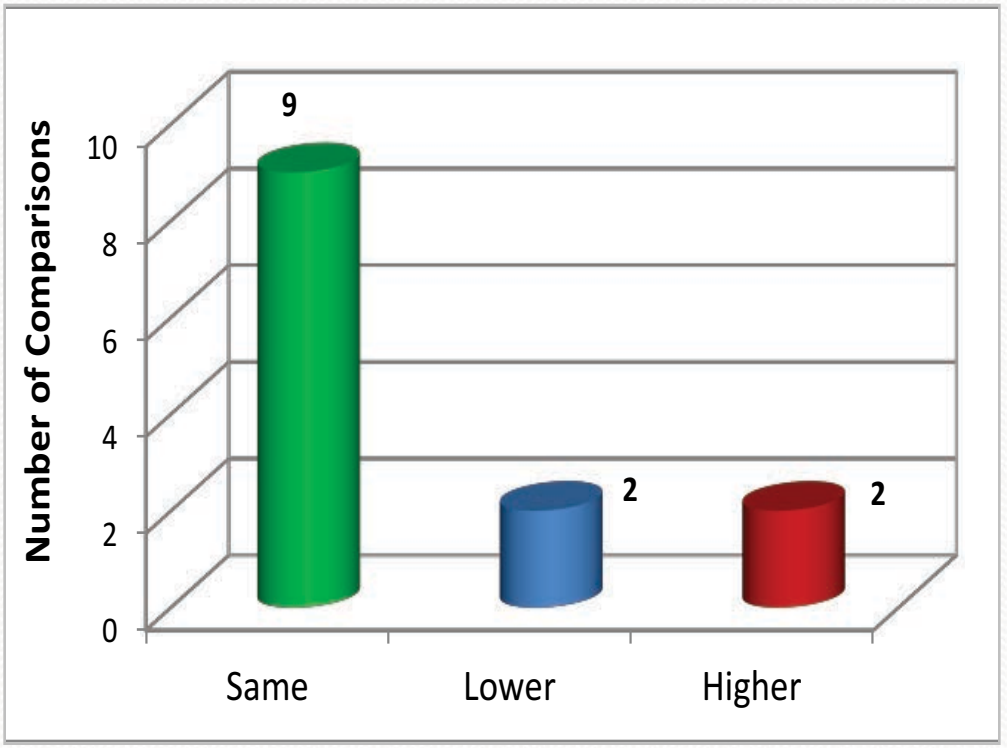
Location	WMA	Construction	
		Δ High Temp	Δ Low Temp
Walla Walla, WA	Aquablack	-2.6	-1.9
Centerville, VA	Astec DBG	1.2	-1.8
Rapid River, MI	Evotherm 3G	-0.9	0.4
	Advera	0.7	0.0
Baker, MT	Evotherm DAT	-0.1	0.4
Munster, IN	Evotherm 3G	-2.7	-2.2
	Gencor Ultrafoam	-4.2	-1.8
	Heritage Wax	-2.1	0.6
Jefferson Co., FL	Terex CMI Foam	-2.1	0.6
New York, NY	Cecabase	-5.7	-4.8
	SonneWarmix	-4.5	-3.3
	BituTech PER	-5.3	-3.5
Casa Grande, AZ	Sasobit	-2.0	0.6
Average		**-2.3**	**-1.3**
Maximum T_{emp} Difference		**-5.7**	**-4.8**
Minimum T_{emp} Difference		**1.2**	**0.6**

True Binder Grades Differences (WMA-HMA)
1st and 2nd Inspection

Location	WMA	1 Year Cores		2 Year Cores	
		Δ High Temp	Δ Low Temp	Δ High Temp	Δ Low Temp
Walla Walla, WA	Aquablack	1	-0.1	2.1	1.8
Centerville, VA	Astec DBG	-8.6	-4.2	1.1	2.1
Rapid River, MI	Evotherm 3G	-1.5	0.7	-3.7	0.0
	Advera	3.0	1.9	-1.6	0.0
Baker, MT	Evotherm DAT	-1.1	-2.3	-3.9	1.2
Munster, IN	Evotherm 3G	-1.1	1.2	-3.5	-0.7
	Gencor Ultrafoam	-2.3	-1.3	-1.3	-0.4
	Heritage Wax	-2.1	1.1	1.9	4.4
Jefferson Co., FL	Terex CMI Foam	-3.0	-1.4	-6.6	-5.7
New York, NY	Cecabase	0.6	-2.0	0.9	-0.6
	SonneWarmix	0.1	-1.8	0.3	-1.3
	BituTech PER	0.5	-3.4	4.4	1.0
Casa Grande, AZ	Sasobit	4.2	-1.0	-	-
Average		**-0.8**	**-1.0**	**-0.8**	**0.2**
Maximum Temp Difference		**-8.6**	**-4.2**	**-6.6**	**-5.7**
Minimum Temp Difference		**4.2**	**1.9**	**4.4**	**4.4**

In Place Densities (=)





After Construction

After ~2 Years

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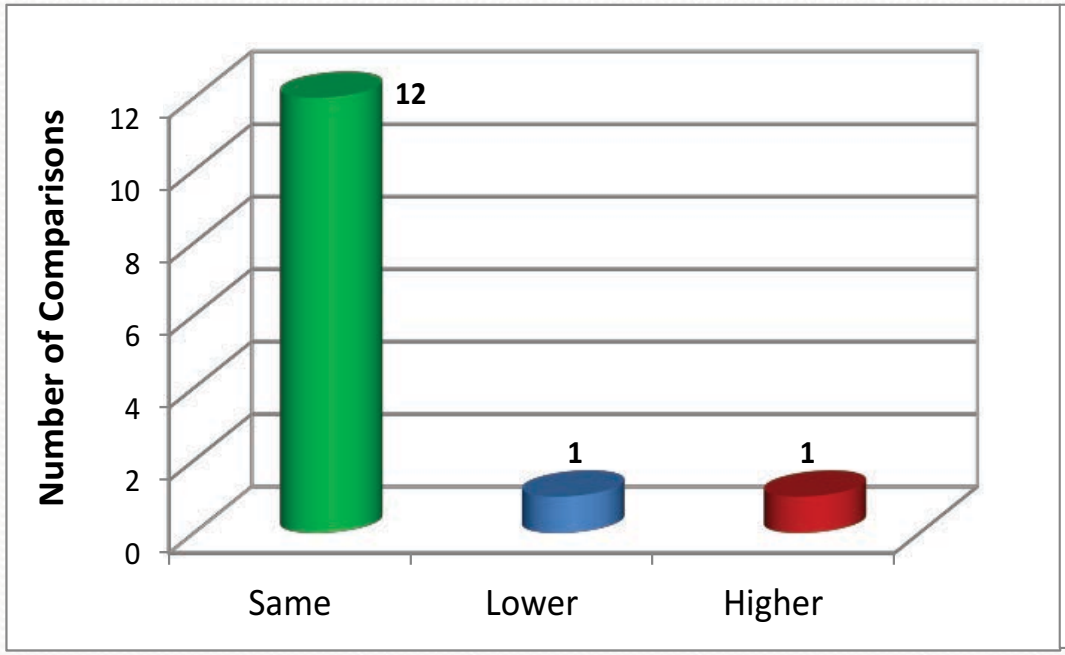
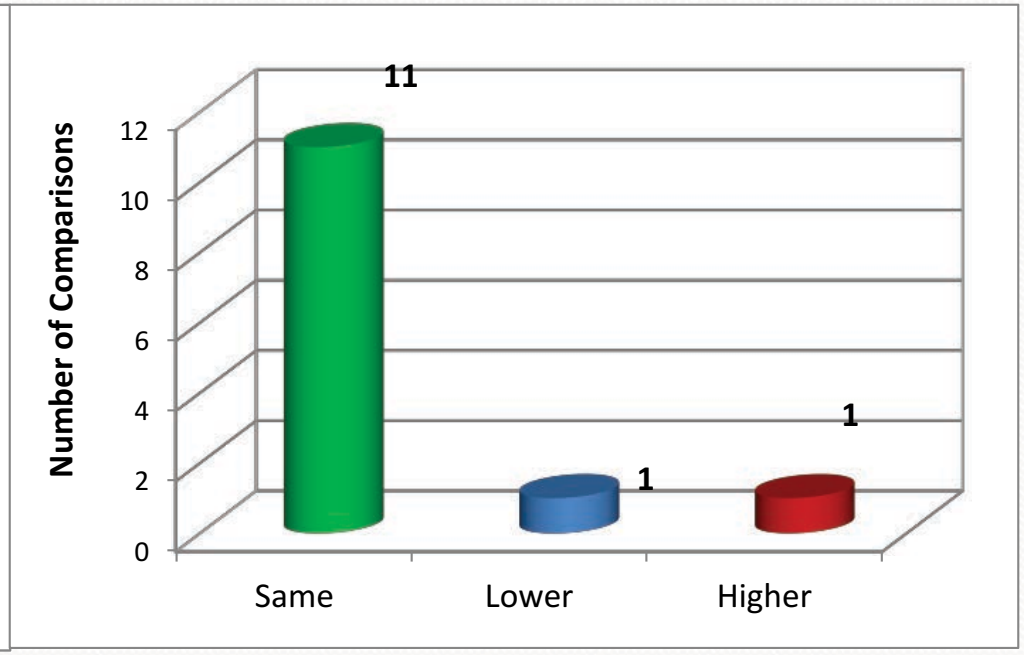
Tensile Strength from Cores (=)





After Construction

After ~2 Years

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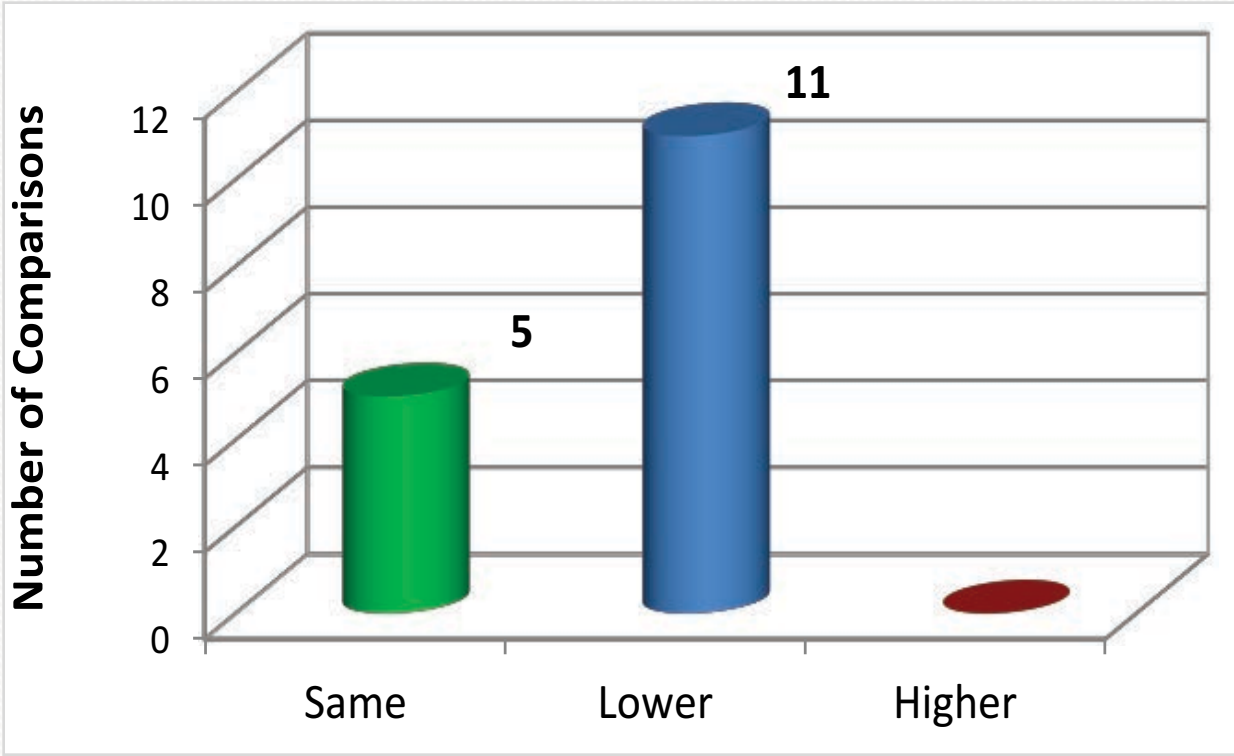
TSR-AASHTO M323 (= or ↓)

Flow Number (↓or =)

- Test Temperature- LTPPBind v3.1; 50% reliability at 20mm (surface layers)
- Repeated deviatoric stress of 87 psi(600 kPa)
- Unconfined conditions



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HMA FN Results vs. Criteria

Project	Route	Mix Heating	FN
Baker, MT	Route 322	Reheated	98
Rapid River, MI	CR-513	Reheated	199
Casa Grande, AZ	SR 84	No	61
Jefferson Co., FL	SR 30	No	414
		Reheated	231
Queens, NY	Little Neck Pkwy	No	291
Munster, IN	Calumet Ave.	No	561
Walla Walla, WA	US-12	No	332
		Reheated	426
Centreville, VA	I-66	Reheated	1855

HMA FN Criteria
NCHRP Rpt. 673
Table 8-20

Traffic, MESALs	Min. Flow No.
<3	NA
3 to <10	53
10 to <30	190
> 30	740

WMA FN Results vs. Criteria

Project	Route	Mix Heating	WMA Additive	FN
Baker, MT	Route 322	RH	Evotherm DAT	58
Rapid River, MI	CR-513	RH	Advera	60
		RH	Evotherm 3G	65
Casa Grande, AZ	SR 84	No	Sasobit	46
Jefferson Co., FL	SR 30	RH	Terex Foam	127
		No	Terex Foam	157
Queens, NY	Little Neck Pkwy	No	Cecabase	115
		No	SonneWarmix	123
		No	BituTech PER	128
Munster, IN	Calumet Ave.	No	Evotherm 3G	177
		No	Gencor Foam	217
		No	Heritage Wax	314
Walla Walla, WA	US-12	No	Maxam Aquablack	200
		RH	Maxam Aquablack	227
Centreville, VA	I-66	RH	Astec DBG	439

NCHRP 9-43 Mix Design Criteria

Traffic, MESALs	Min. Flow No.
<3	NA
3 to <10	30
10 to <30	105
> 30	415

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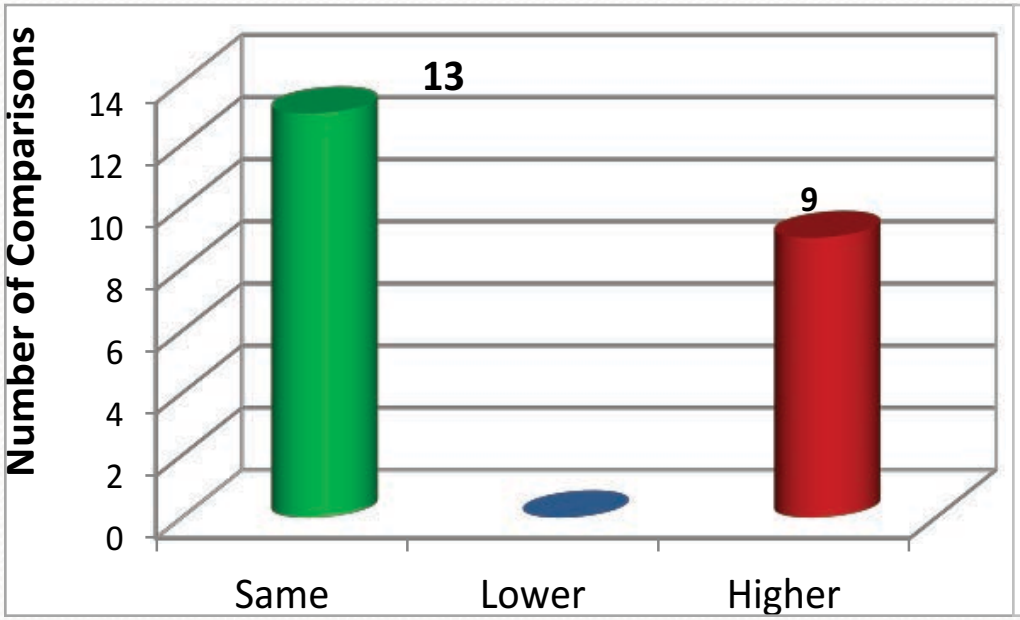
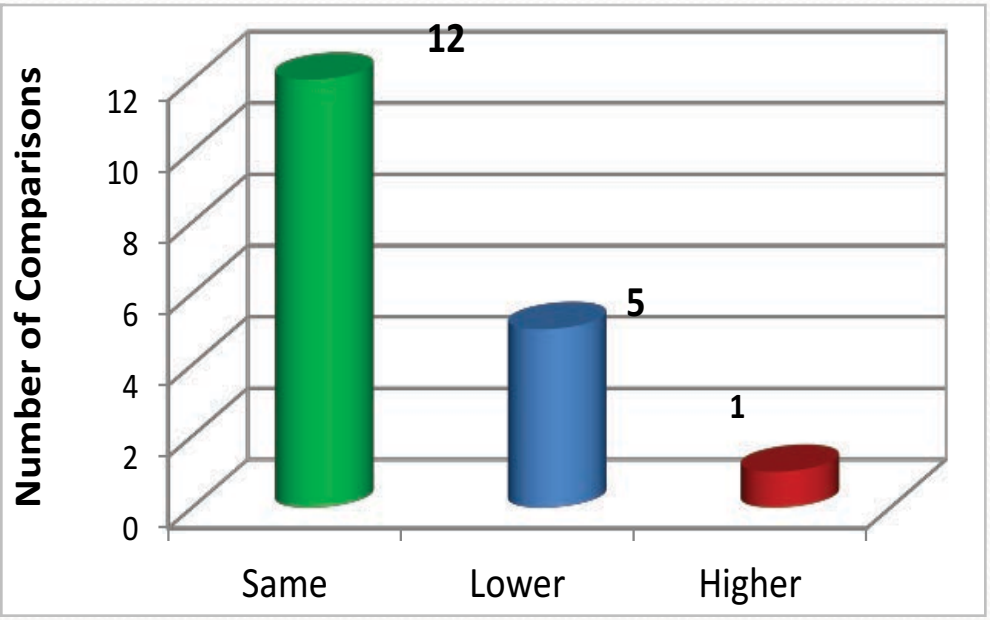
Hamburg-AASHTO T 324 (= or ↓)

Specimens fabricated in the field; 50°C water bath; 10,000 cycles



Rut Depth



Stripping Inflection Point

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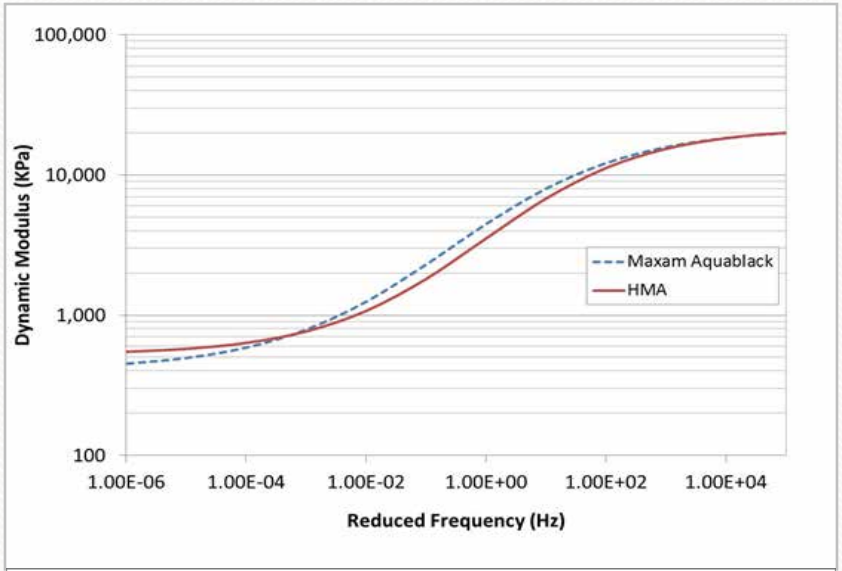
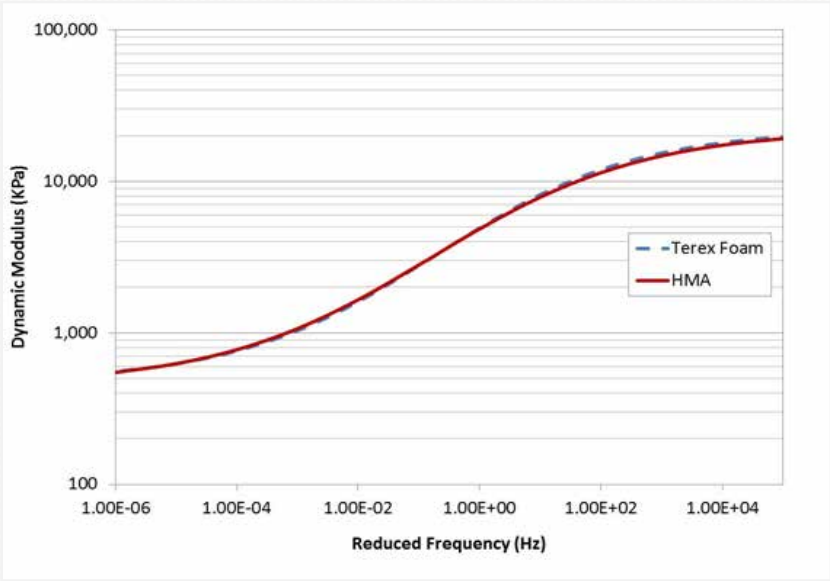
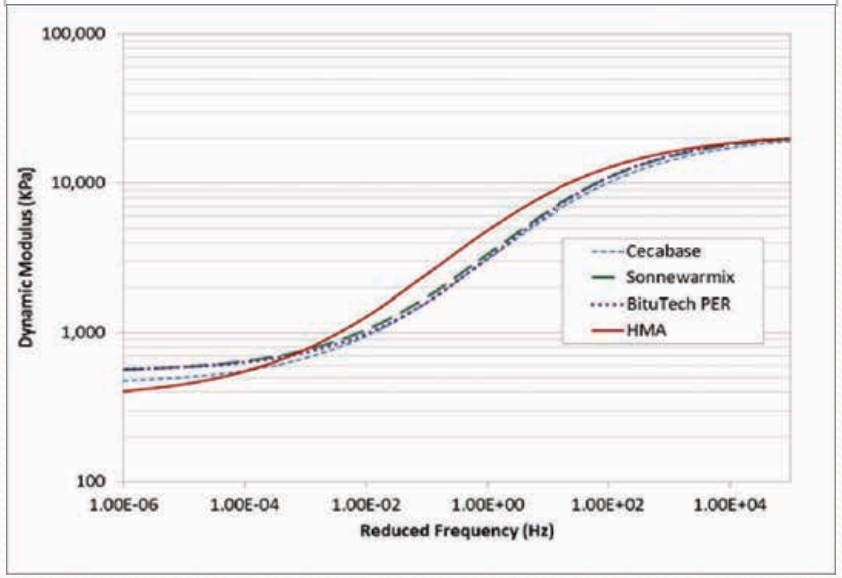
Dynamic Modulus (↓or =)

- AASHTO PP 61-10
- 11 of 13 comparisons have lower E* for WMA for at least one temperature and frequency







NCHRP 9-47 A-Engineering Properties Summary

- In place densities (=)
- Tensile Strength from cores (=)
- TSR (= or↓)
- Hamburg (= or ↓)
- FN (= or ↓)
- E* (= or ↓)

Field Performance Evaluation Procedure

- Three 200-foot sections per mix
- Three 6” dia. cores from in right wheelpath, and four 6” dia cores from in between wheelpaths
- Cores used to determine the in-place density indirect tensile strengths, specific gravity, gradation, asphalt content, and the true binder grade for each mix.

Field Performance-Existing Projects

Project	Mix	Rutting (mm)	Cracking (m)
St. Louis, MO (5years 5months)	HMA	2	191
	Sasobit	<1	333
	Evotherm ET	2	255
	Aspha min-Zeolite	2	399
Iron Mtn., MI (4years 9months)	HMA	1	1
	Sasobit	0	14
Silverthorne, CO (3years 2months)	HMA	6	3
	Advera	4	0
	Sasobit	6	1
	Evotherm DAT	6	1
Franklin, TN (3 years 5 months)	HMA	0	9
	Advera	<1	32
	Astec DBG	<1	18
	Evotherm DAT	0	1
	Sasobit	0	96
Graham, TX (2 years 6 months)	HMA	0	18
	Astec	0	25

Field Performance-New Projects

Project	Mix	Rutting (mm)	Cracking (m)
Walla Walla, WA	HMA	5	1
	Maxam Aquablack	0	0
Centreville, VA	HMA	3	1
	Astec DBG	3	1
Rapid River, MI	HMA	0	0
	Evotherm 3G	0	0
	Advera	0	0
Baker, MT	HMA	1	0
	Evotherm DAT	0	0
Munster, IN	HMA	0	4
	Gencor Foam	0	36
	Evotherm 3G	0	0
	Heritage Wax	0	0
Jeff. Co., FL,	HMA	3	0
	Terex Foam	3	0
Queens, NY	HMA	-	9
	Cecabase	<1	20
	SonneWarmix	-	5
	BituTech PER	-	5
Casagrande, AZ	HMA	3	NA
	Sasobit	0	NA

Summary-Engineering Properties

- Recovered binders from plant produced mixes– true binder grades show that WMA binders had aged slightly less than HMA binders
- Recovered binders from 1-2 year cores - true grades of HMA and WMA not substantially different, very little or no stiffening from time of construction
- TSR test - 82% of mixes passed the standard 0.8 TSR criterion - 6 mixes failed: four WMA and two HMA mixes
- FN results for WMA mixes lower than HMA (2/3 of the comparisons)

Summary-Engineering Properties

- FN criteria recommended in NCHRP Report 673 for HMA and NCHRP Report 691 for WMA (included now in AASHTO TP 79) seem appropriate for evaluating plant produced mixes and lab mixes
- Hamburg tests - 59% of WMA mixes had statistically equivalent rut depths than HMA mixes, other 41% of WMA mixes had greater rut depths
- Statistical analyses indicate that the dynamic moduli of WMA are lower than HMA mixtures for at least one temp. and frequency, for 2 projects results are equivalent

Summary Finding

- WMA sections have performed same as HMA sections with regard to rutting , none of the field projects had any evidence of moisture damage
- Little cracking was observed. Transverse cracking was the most common type of cracks. Of the projects with transverse cracking, WMA and HMA sections generally had similar amounts
- WMA did not appear to have effect on densities under traffic. This observation was confounded by the fact that many of the WMA test sections constructed in different lanes than the HMA sections

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