WMA Research at NCAT

Andrea Kvasnak

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at Auburn University

FHWA WMA

FHWA WMA Projects

- Compacted on site
  - Nashville, TN
  - Graham, TX
  - Bridgeport, TX
  - Royal, NE
  - Iron Mountain, MI
  - Brownsburg, IN
  - Kimbolton, OH
  - San Antonio, TX
  - St. Louis, MO
  - Milwaukee, WI

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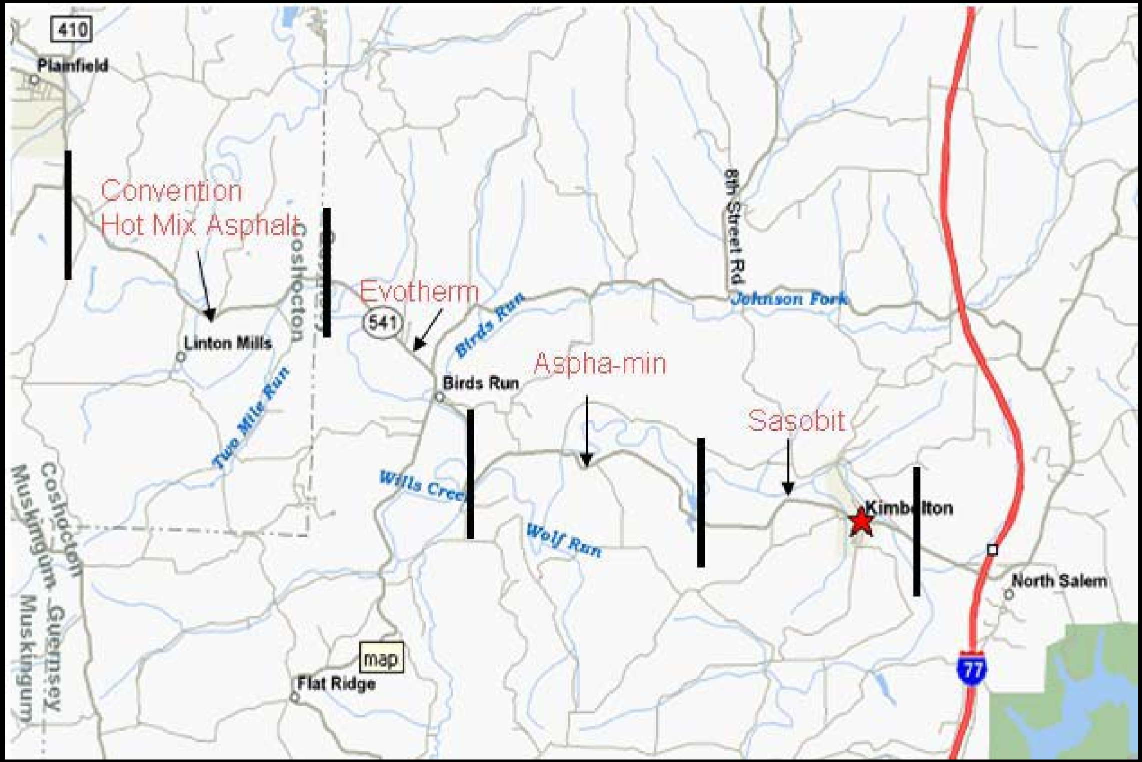
Kimbolton, OH

- SR 541
- 2-lane highway
- Constructed September 2006
- Aspha-min, Evotherm ET, and Sasobit
  – ~3 mi each
- Limestone
- PG 70-22



Kimbolton, OH Construction

- Approximately 23 mile haul
- Issues with material sticking to truck bed
- Some dragging behind the screed

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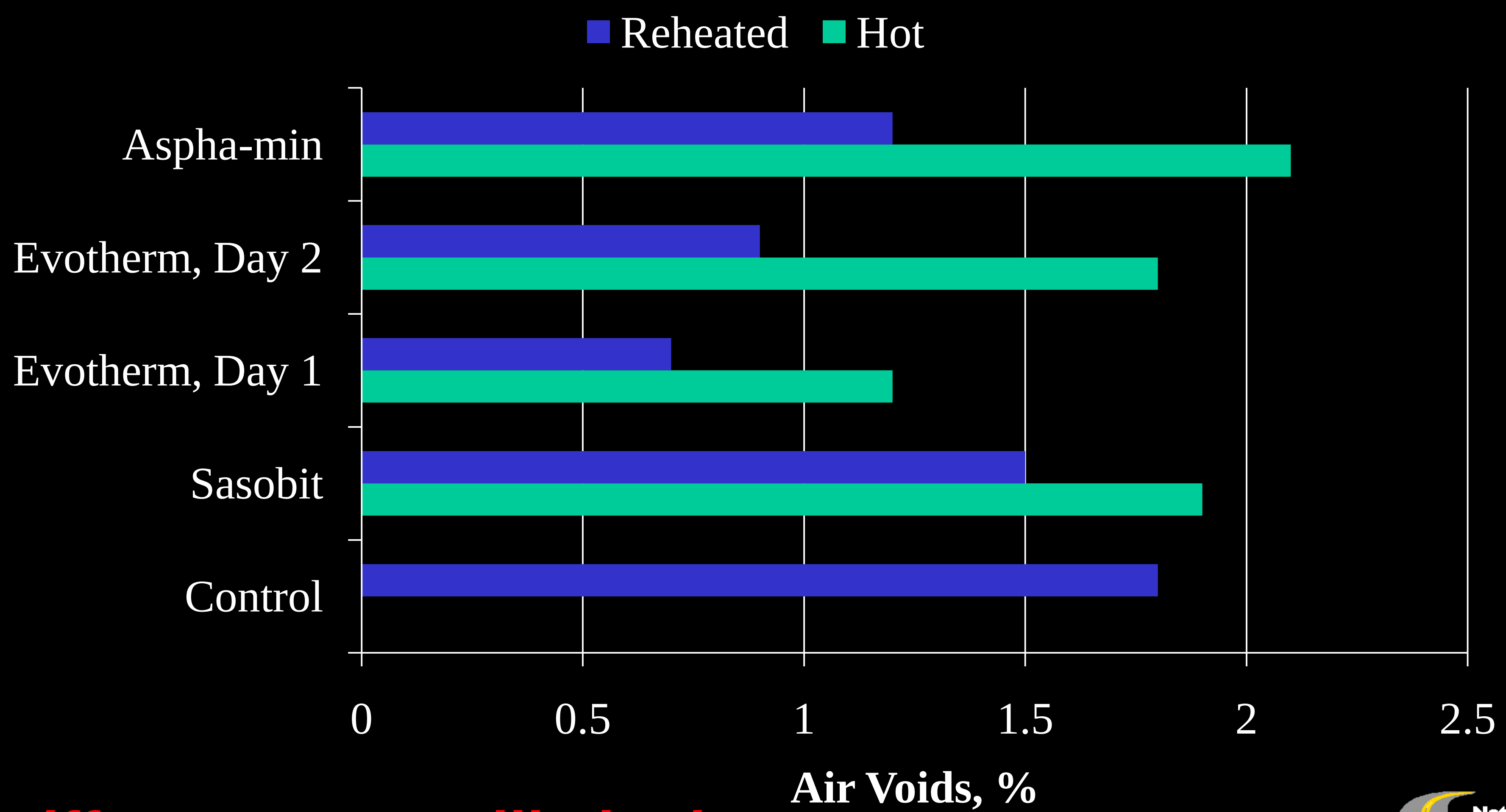
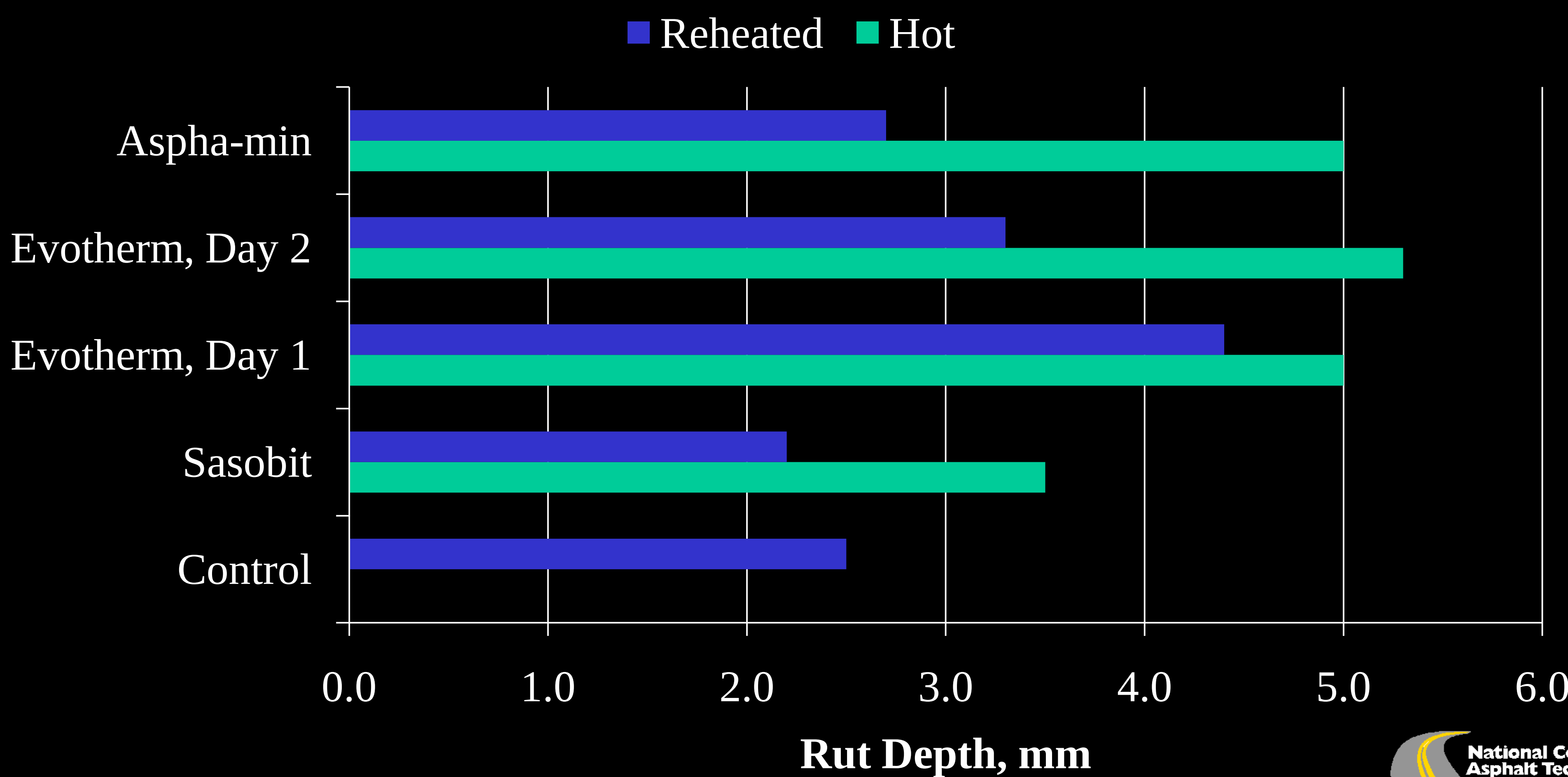
Kimbolton, OH
Hot vs. Reheated



Difference most likely due to different compactors

Kimbolton, OH
APA



Hot rutted more than reheated

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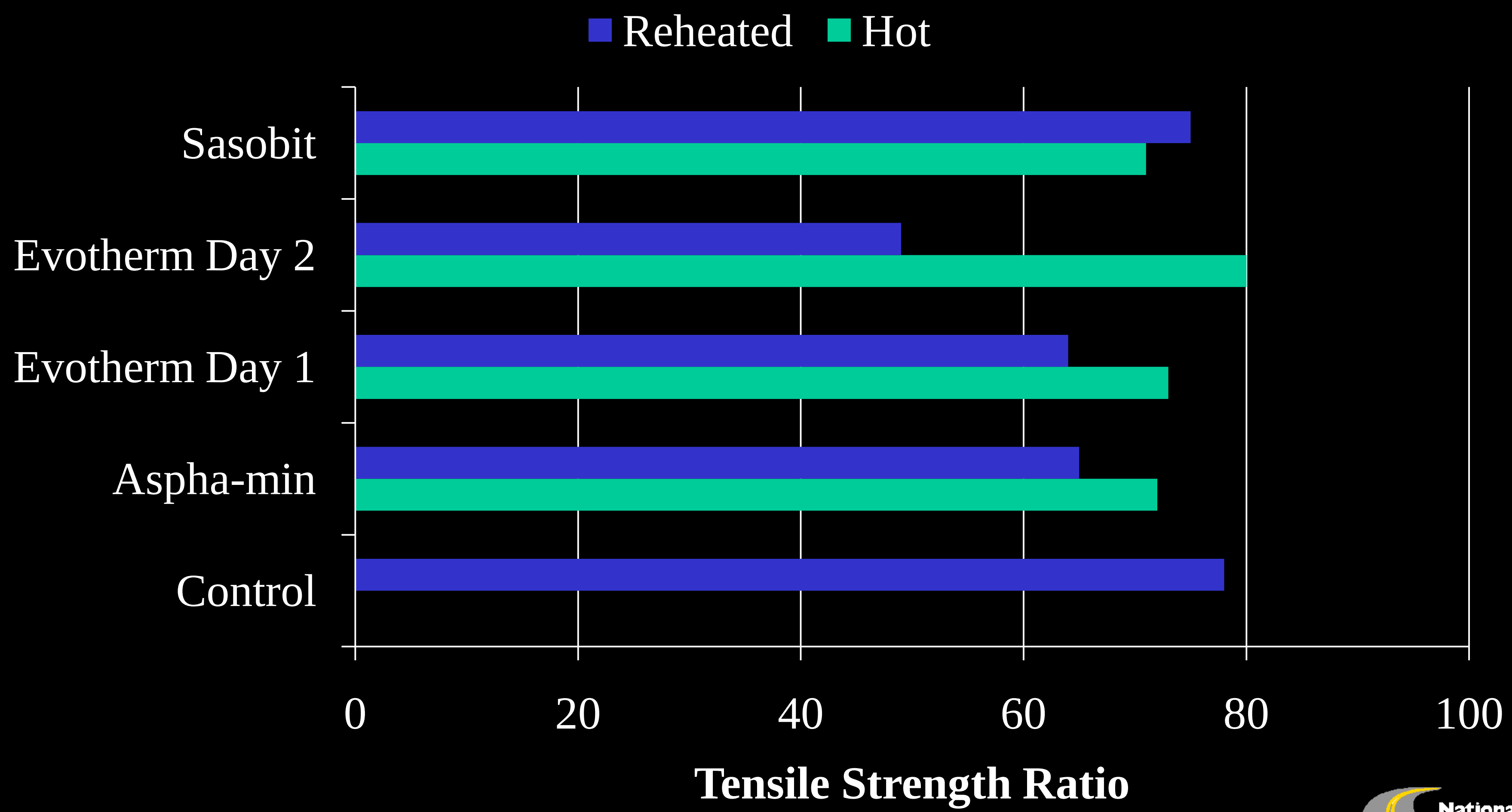
Kimbolton, OH
Moisture Susceptibility

- WMA typically have lower ITS than control
- Reheating increased ITS
- Some cases TSR improved and in some cases not

Kimbolton, OH
TSR



Almost all WMA and HMA failed TSR criterion

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Kimbolton, OH
Hamburg

- Majority of WMA stripping inflection points exceeded

- WMA had a higher rutting rate

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Kimbolton, OH
Emissions Data

	Control	Evotherm™	Aspha-min®	Sasobit®
Date	8/30/2006	9/7/2006	9/11/2006	9/16/2006
Production Rate, TPH	165	167	168	167
Fuel	Natural Gas	Natural Gas	Natural Gas	Natural Gas
Calculated Stack Moisture, %	22.3	29.5	24.4	24.8
Carbon Dioxide, %	3.5	4.2 (+ 20.0%)	2.8 (- 20.0%)	2.0 (- 42.9%)
Oxygen, %	15.7	15.0	15.8	15.7
Sulfur Dioxide, lbs/hr	0.24	0.37	0.04	0.04
Nitric Oxide, lbs/hr	5.2	5.1 (- 1.9%)	3.6 (- 30.8%)	4.1 (- 21.2%)
Carbon Monoxide, lbs/hr	63.1	50.3 (- 20.3%)	24.0 (- 62.0%)	23.2 (- 63.2%)
VOC, lbs/hr (USEPA Method 25A)	7.8	20.2 (+159%)	2.9 (- 62.8%)	3.8 (- 51.3%)

Reduced emissions for Sasobit and Aspha-min

Kimbolton, OH
Industrial Hygiene

Mixture	Total Particulate, mg/m³	Percent Reduction, Total Particulate	BSM, mg/m³	Percent Reduction, BSM
Control	1.25		1.05	
Evotherm™	0.29	77	0.29	72
Sasobit®	0.33	74	0.21	80
Aspha-min®	0.41	67	0.20	81

WMA reduced total particulates

WMA reduced benzene soluble matter

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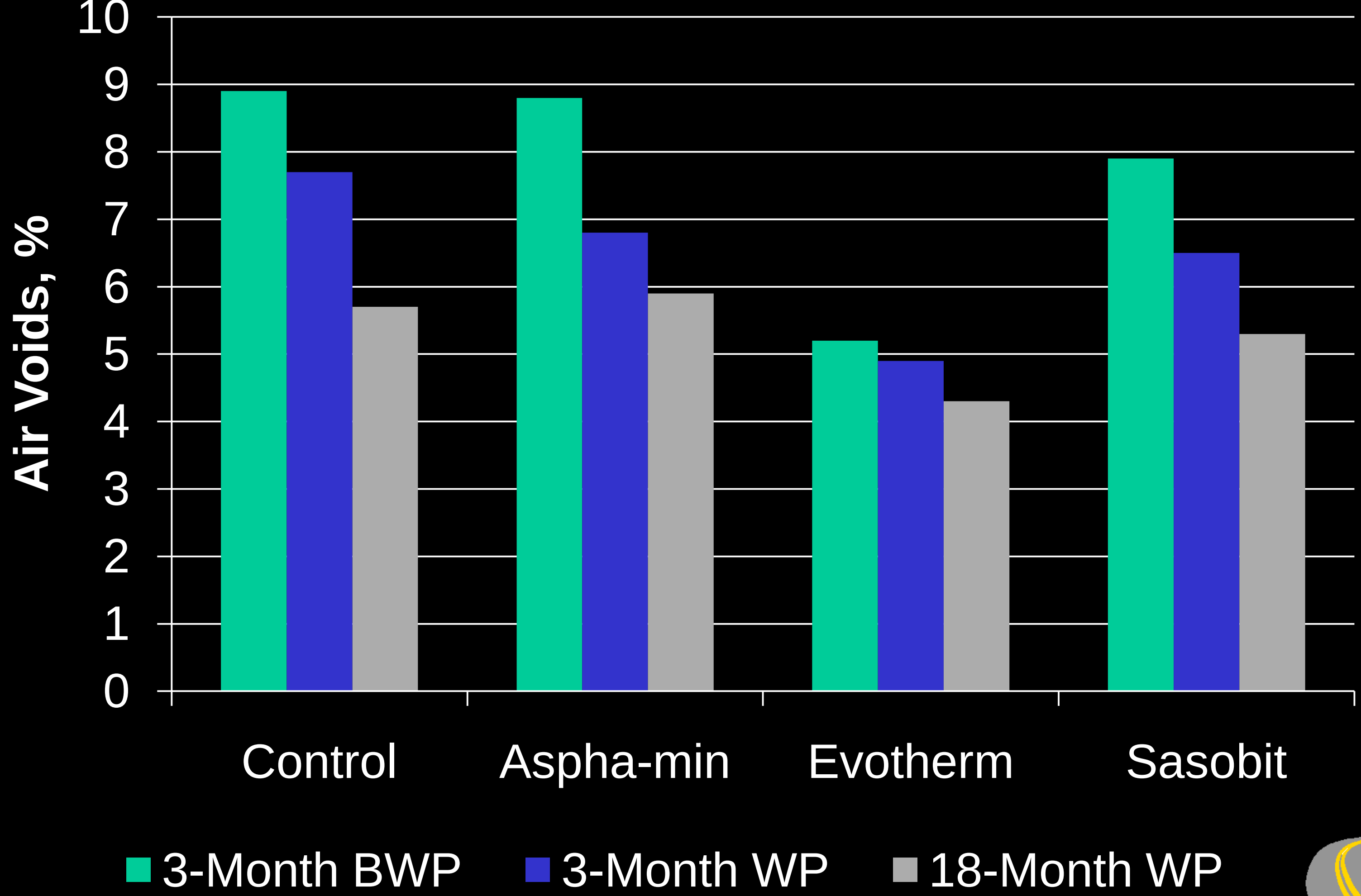
Kimbolton, OH
In-Place Densities



Courtesy of Ohio DOT

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Milwaukee, WI

- State Highway 100
  - Ryan Rd
- 3 million ESAL mix
- Sasobit and Evotherm ET
- Gravel
- PG 64-28

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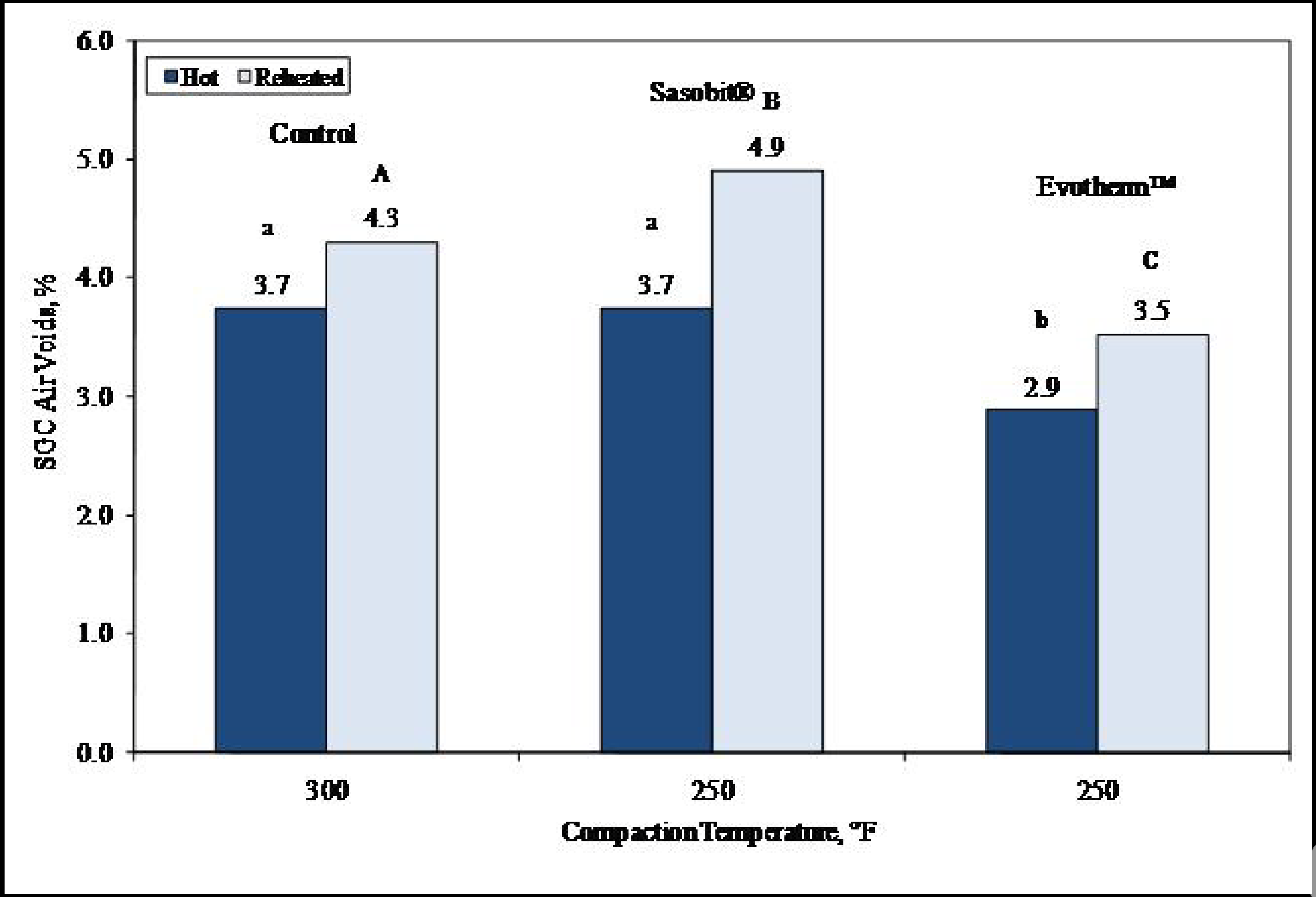
Milwaukee, WI
Hot vs. Reheated



Reheated had higher air voids

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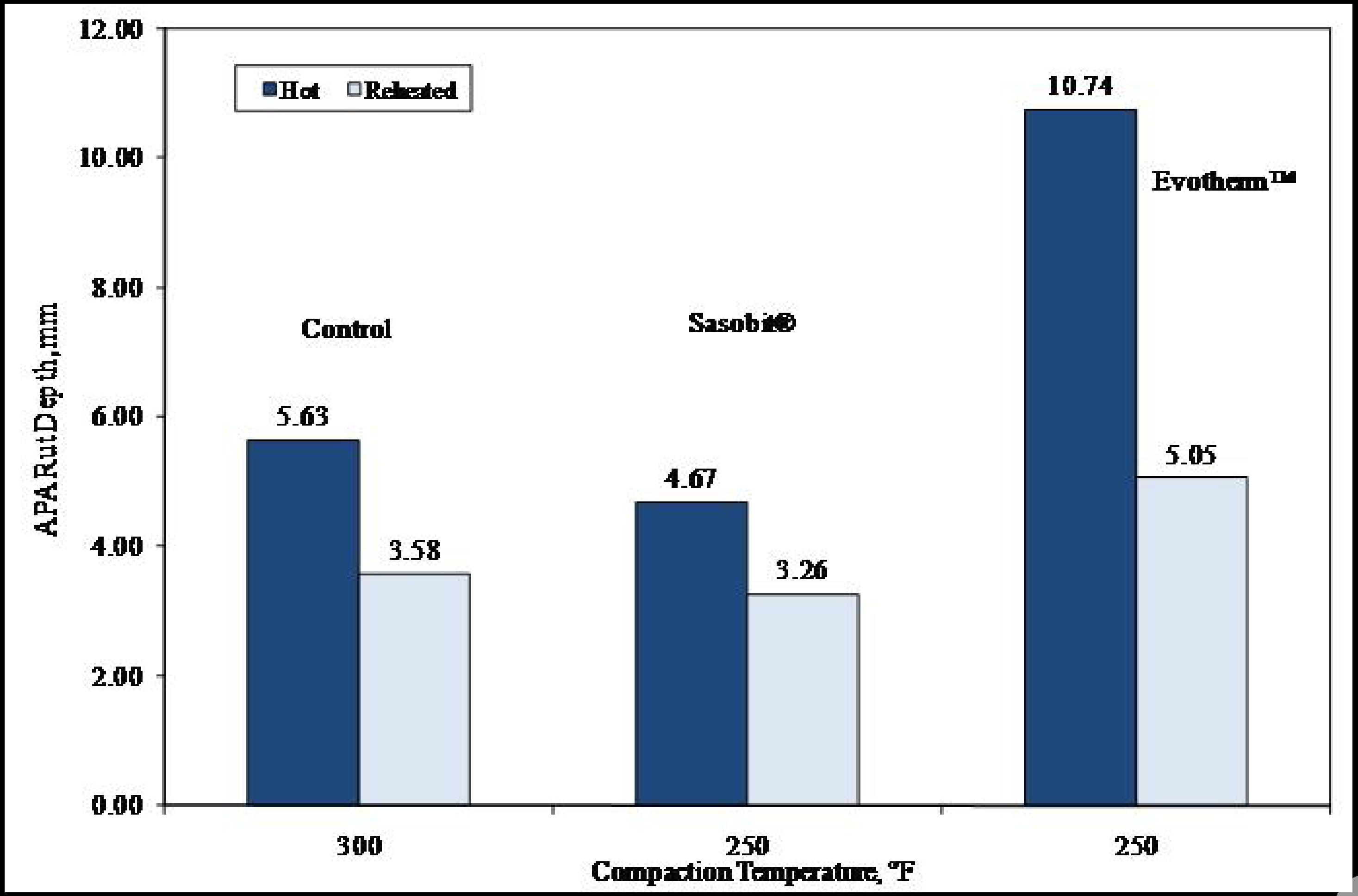
Milwaukee, WI
APA



Sasobit < HMA < Evotherm

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Milwaukee, WI
Moisture Susceptibility

Mix Type	Compaction Temperature, °F	Indirect Tensile Strength		TSR, %
		Unsaturated, psi	Saturated, psi	
Control	300	109.6	103.2	94
Sasobit®	250	118.7	109.6	92
Evotherm™	250	47.9	46.0	96

Mix Type	Compaction Temperature, °F	Indirect Tensile Strength		TSR, %
		Unsaturated, psi	Saturated, psi	
Control	300	140.2	126.8	90
Sasobit®	250	120.2	98.4	82
Evotherm™	250	72.1	45.7	63

Reheating typically improved ITS, but TSRs went down

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Milwaukee, WI
Hamburg

Mix Type	Avg. VTM, %	Stripping Inflection Point, cycles	Rutting Rate, mm/hr	Total Rutting @ 10,000 cycles, mm
Control	7.1	> 10,000	1.311	5.202
Sasobit®	7.0	9050*	0.605	2.401
Evotherm™	7.3	3450	5.574	22.118

WMA SIPs < HMA SIPs

Sasobit RR< HMA RR < Evotherm RR

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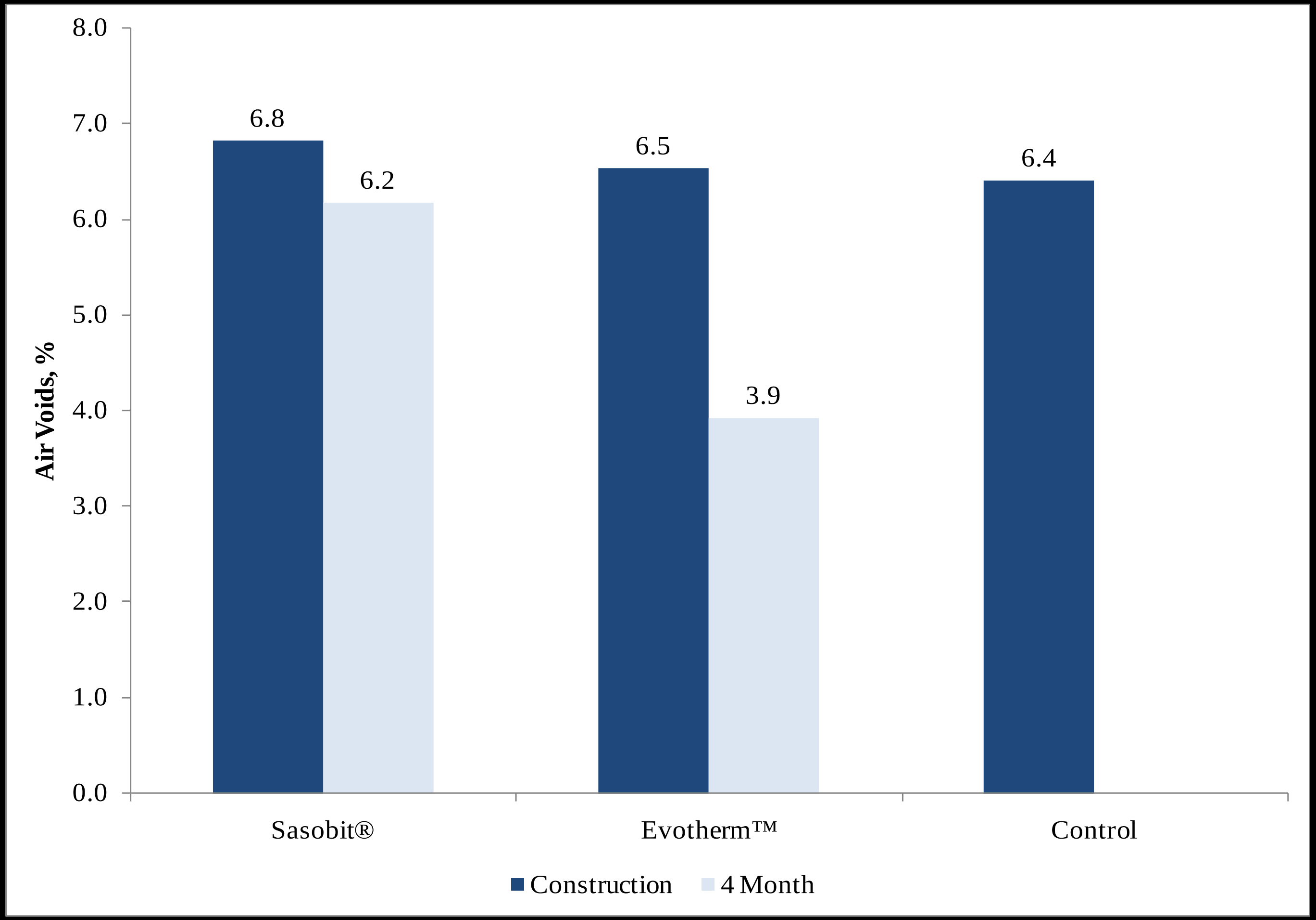
Milwaukee, MI Emissions Data

Emission	Avg. WMA	Avg. HMA	Reduction, %	Increase, %
NOx, lb/ton	0.058	0.068	14.0	
VOC, lb/ton	0.097	0.024		313.0
CO2, lb/ton	50.4	53.0	5.0	
Fuel Usage, gal/ton	1.79	1.98	9.0	

Milwaukee, WI
In-Place Densities



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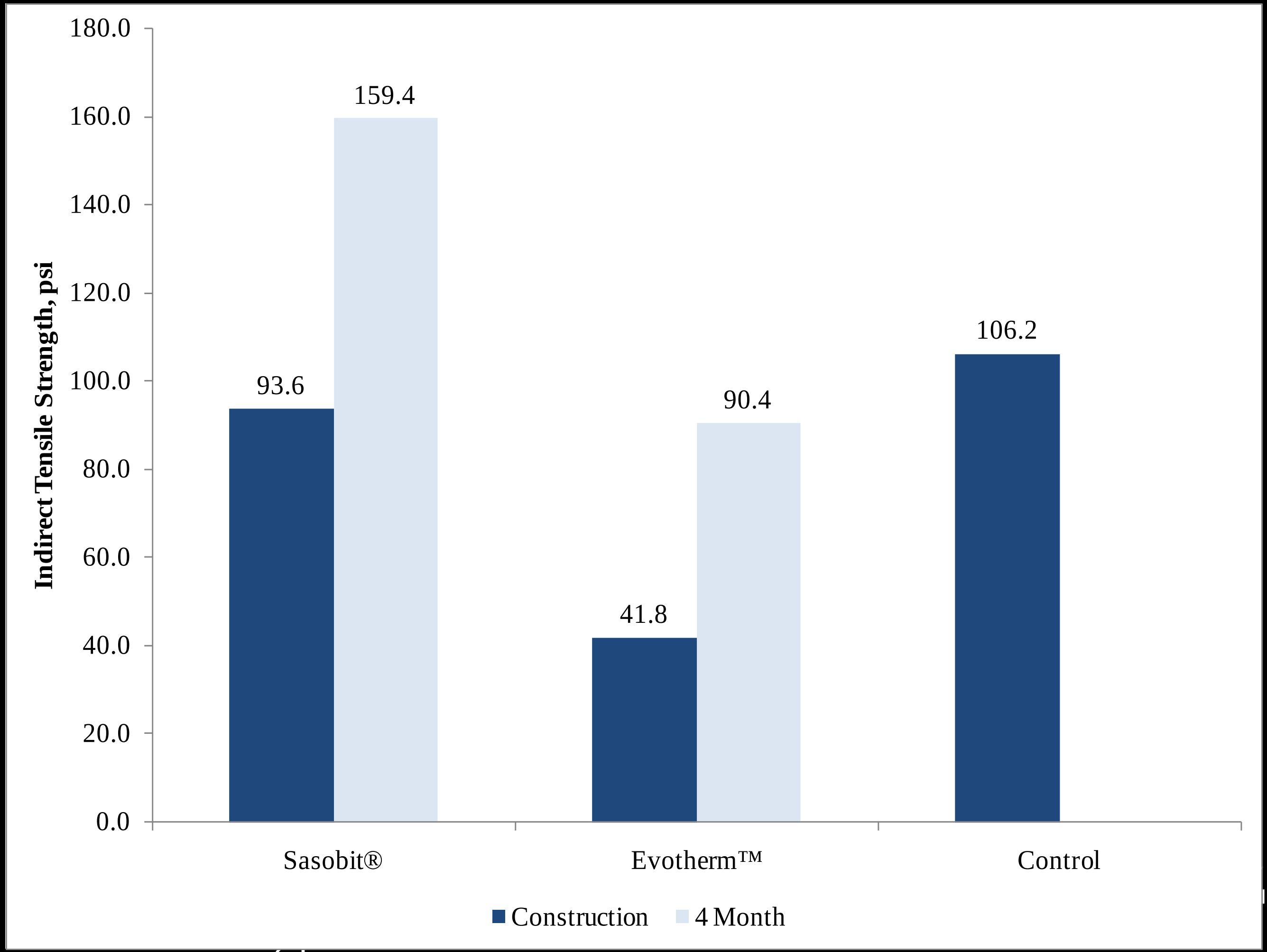
Milwaukee, WI
Core Tensile Strengths

ITS increases with time



St. Louis, MO

- Aspha-min, Evotherm ET, Sasobit
- Limestone and porphyry
- 10% RAP
- PG 70-22

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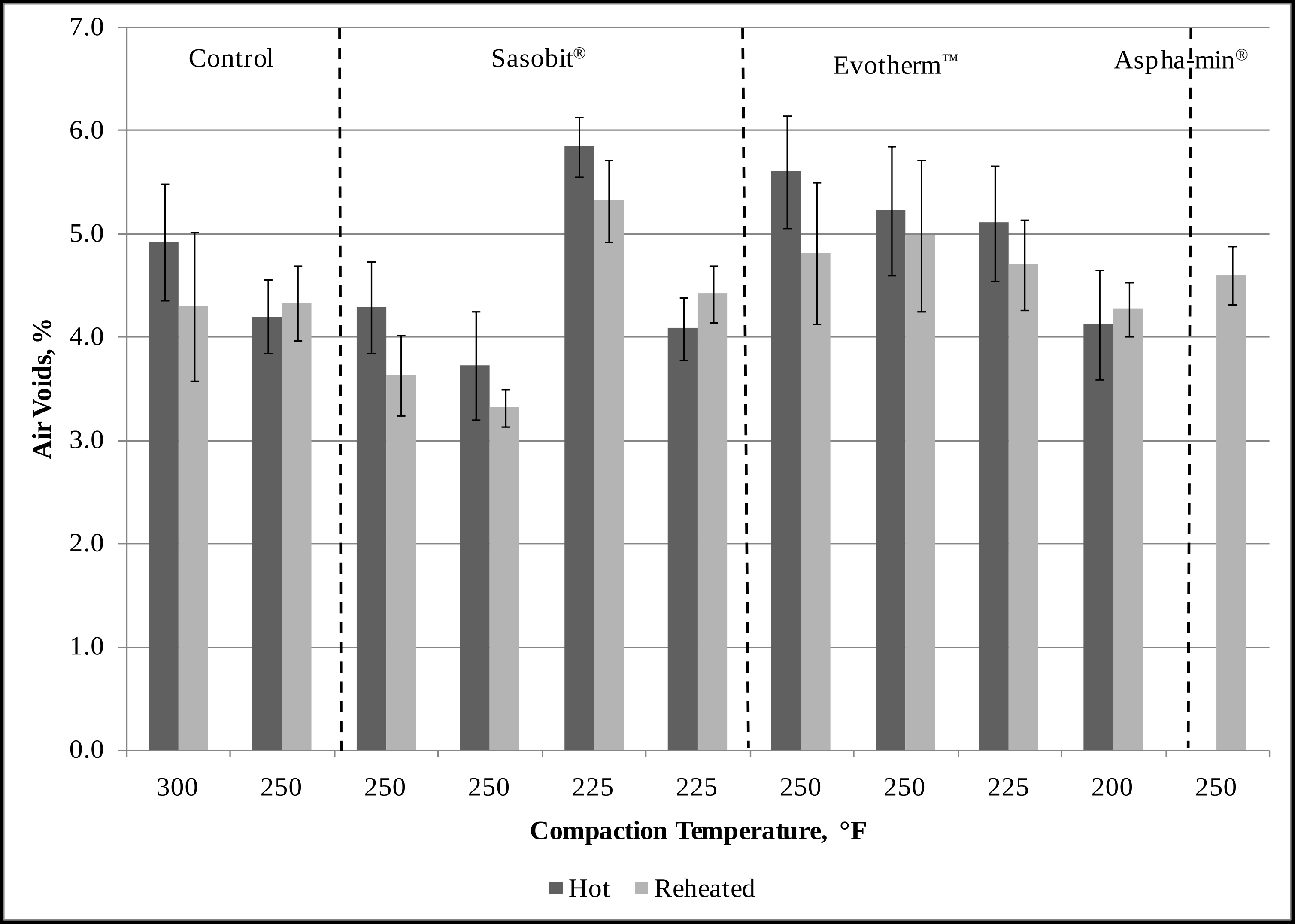
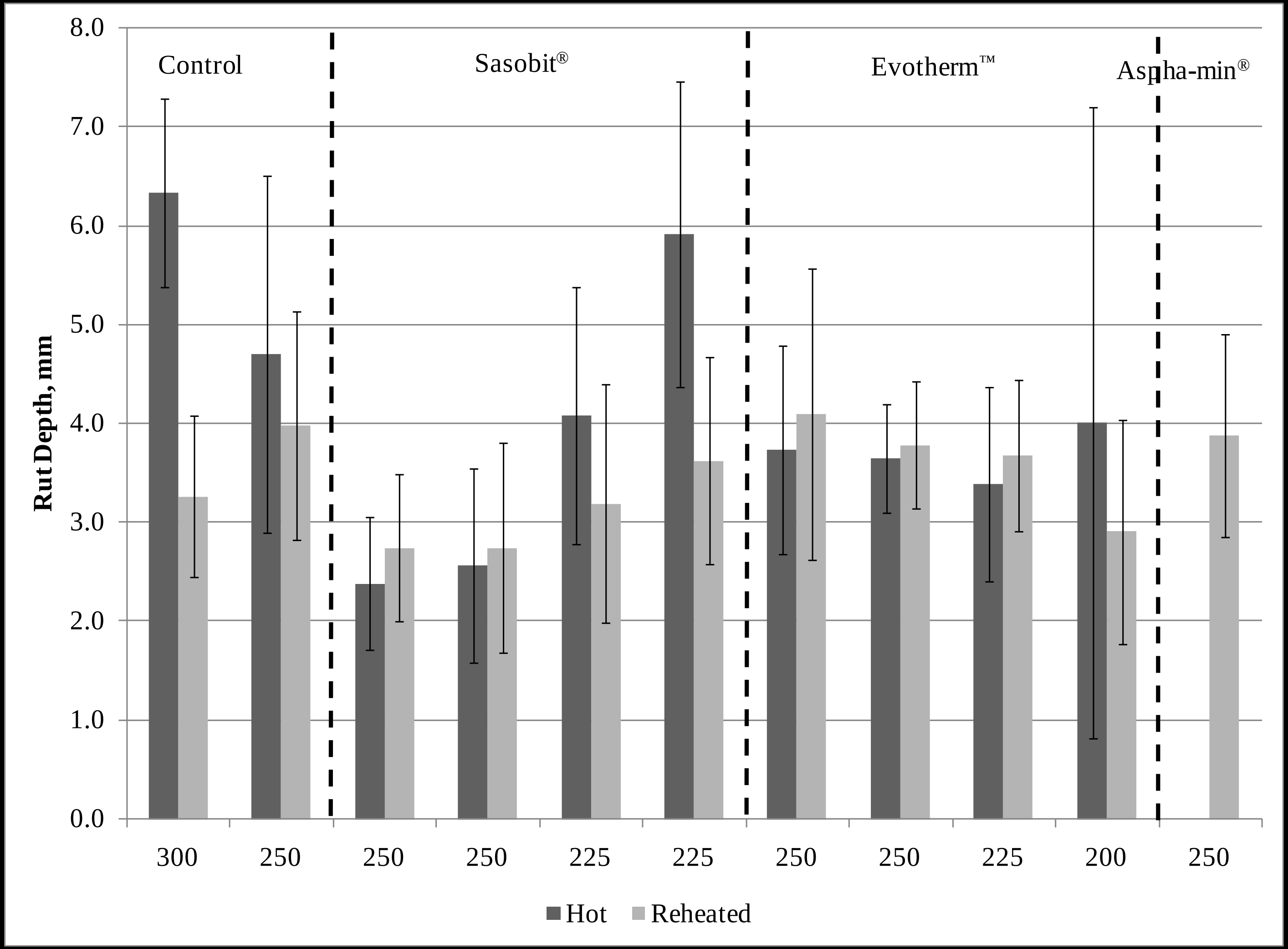
St. Louis, MO
Hot vs. Reheated



Most cases lower air voids for reheated

St. Louis, MO
APA



Some cases worse rutting with reheated

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St. Louis, MO
Moisture Susceptibility

- Improved indirect tensile strengths with reheating
  - TSRs tended to improve
- Lower ITS for lower mixing temperatures

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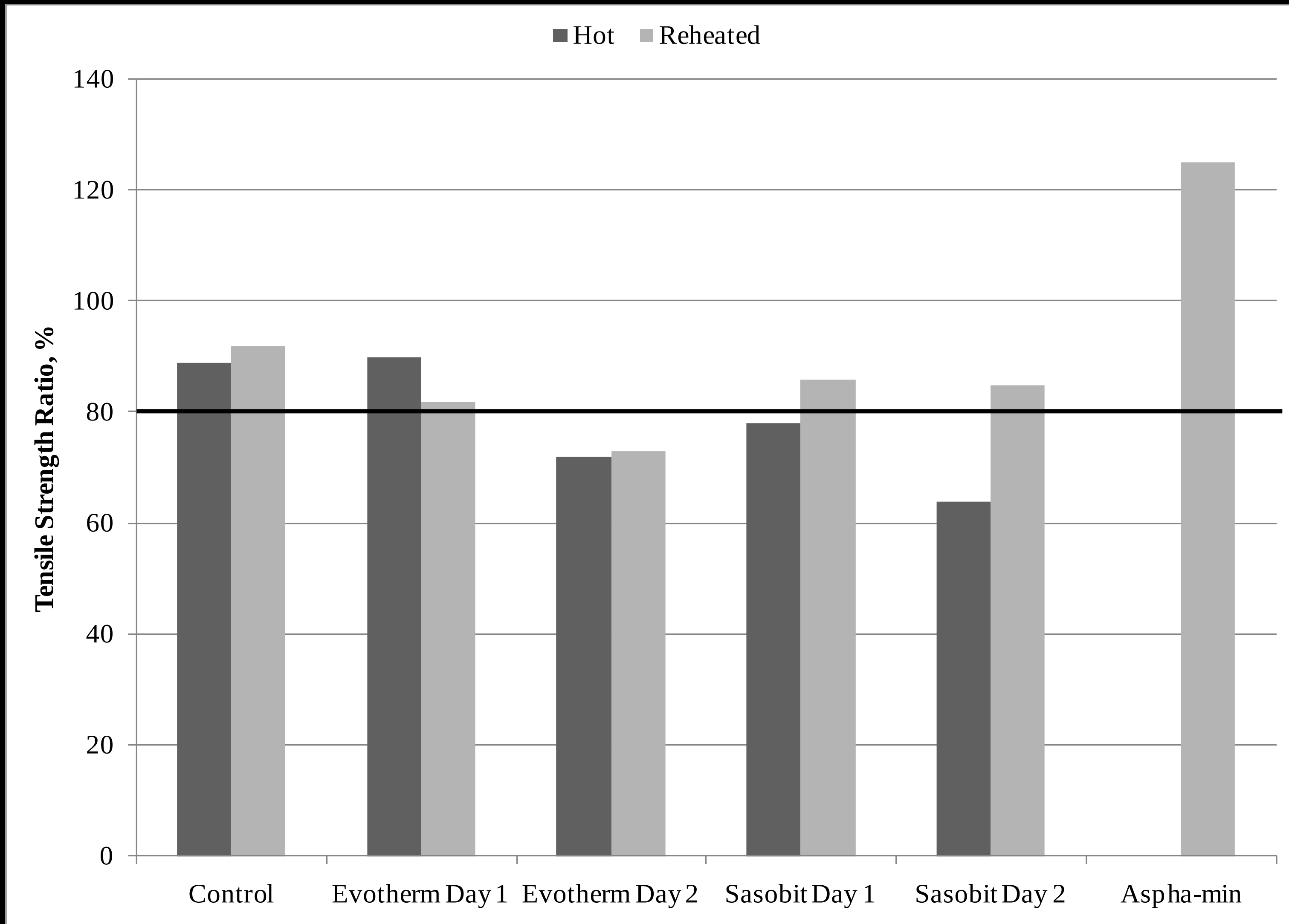
St. Louis, MO
TSR Results



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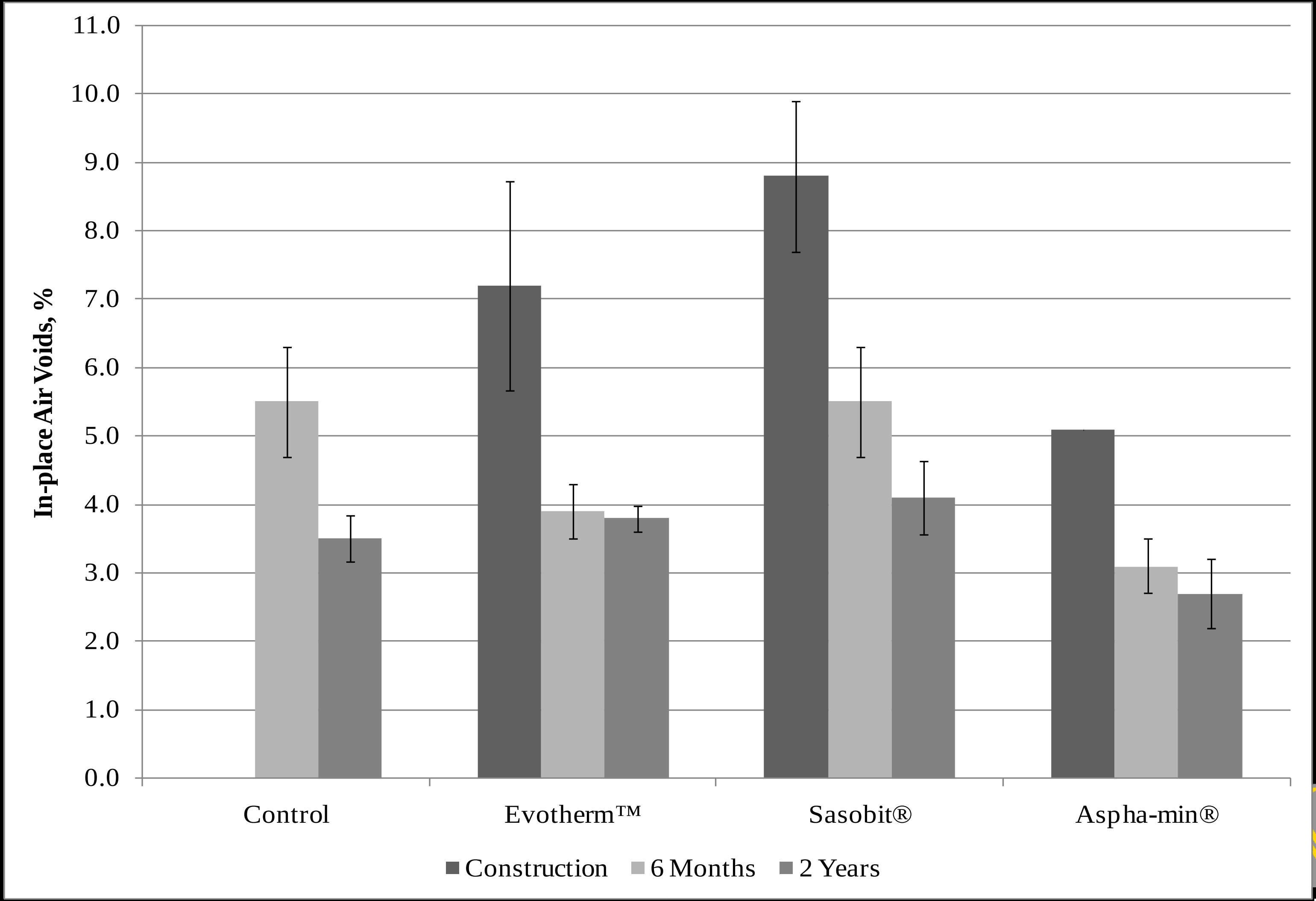
St. Louis, MO
Hamburg Data

- All had SIPs greater than 5,000 cycles
  - Sasobit and control most similar
- Mixing temperature did effect SIPs
- All rut depths less than 6 mm

St. Louis, MO
In-Place Air Voids



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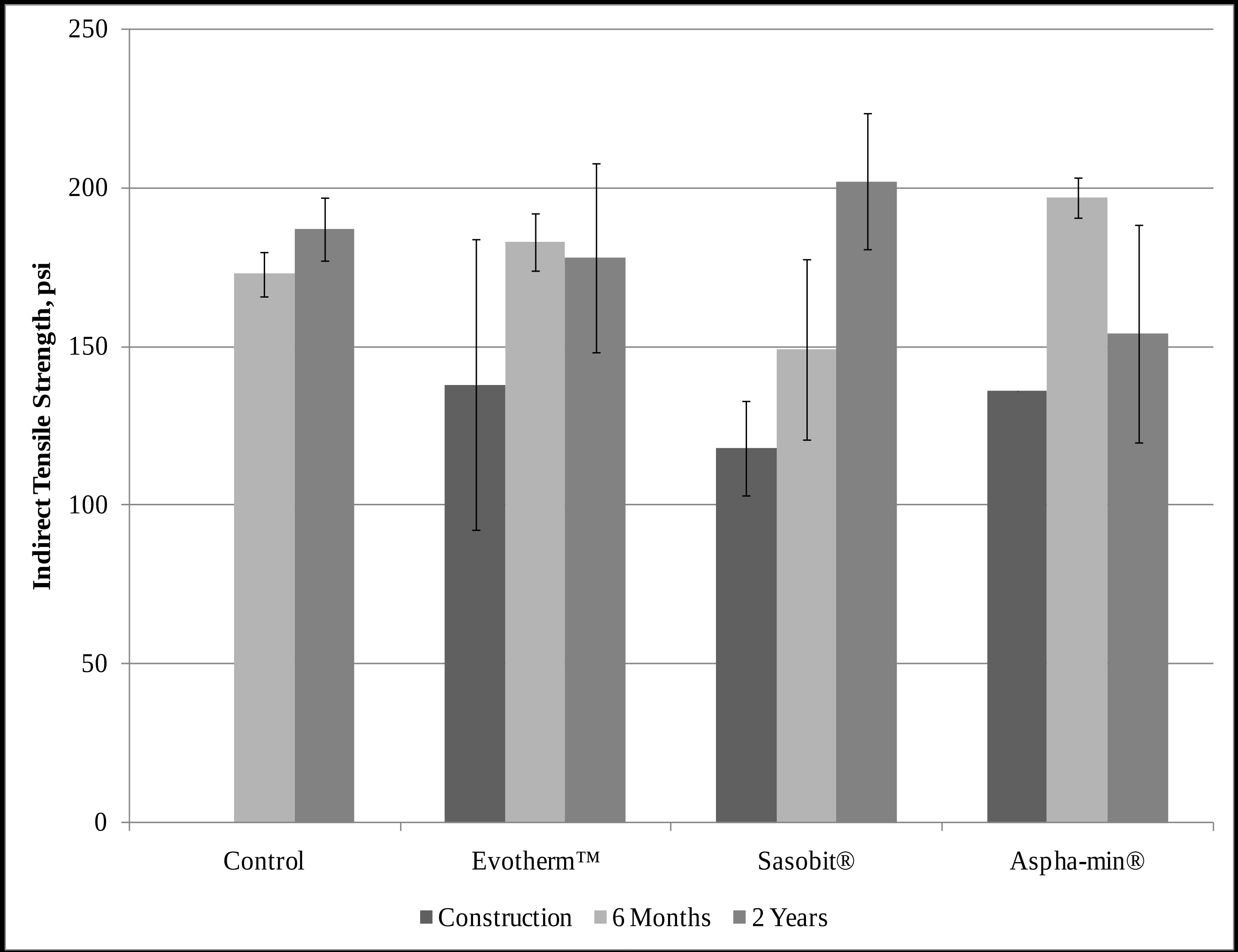
St. Louis
Core Indirect Tensile Strengths



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St. Louis, MO
Field Performance at 26 Months

Test Section	6 Months Rut Depth, mm	26 Months Rut Depth, mm
Control	0.4	0.5
Evotherm™	1.1	1.1
Sasobit®	0.8	0.8
Aspha-min®	0.3	0.5

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Iron Mountain, MI

- State Highway MI 95
- Basalt
- PG 58-34
- Sasobit

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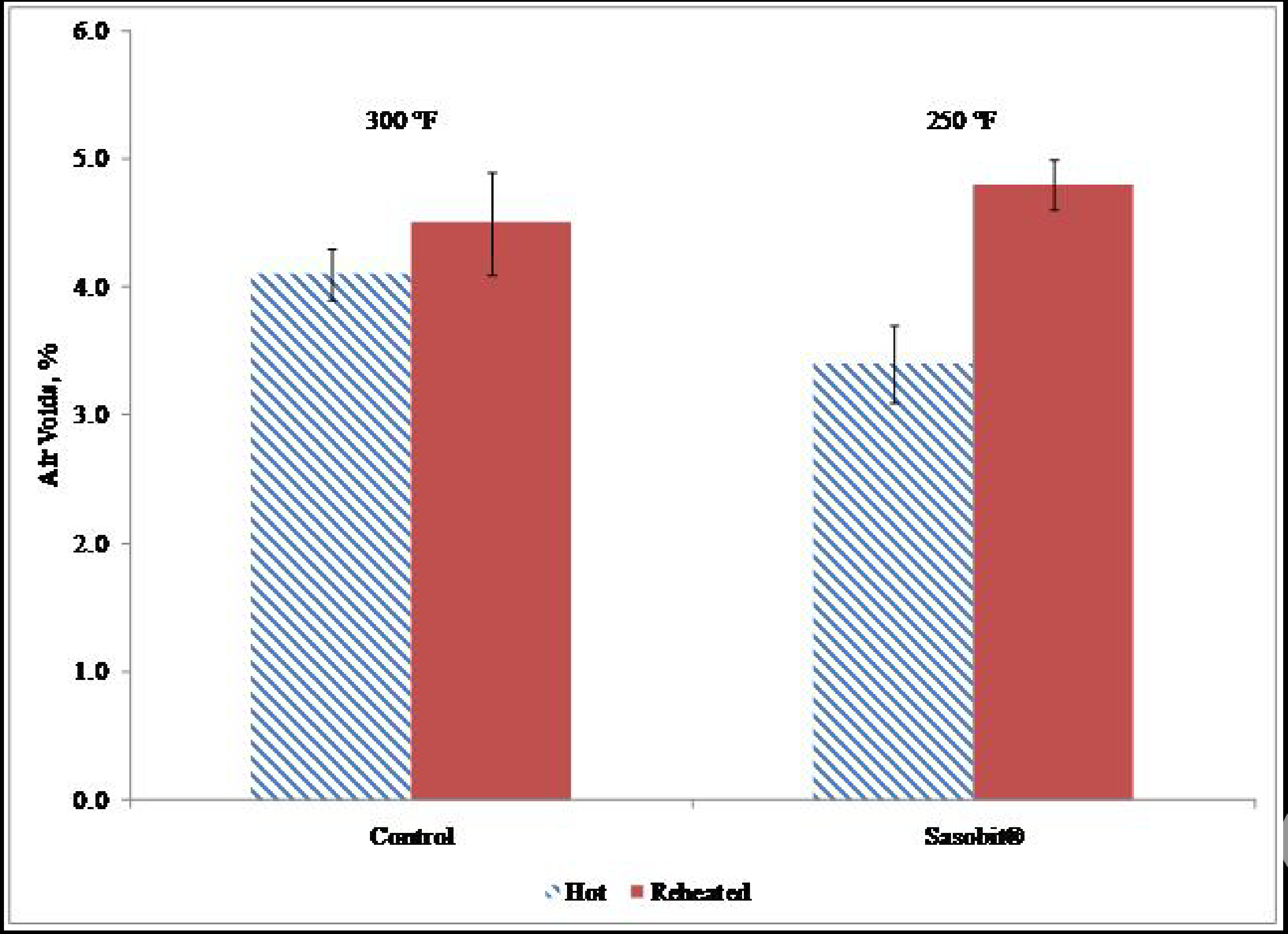
Iron Mountain, MI
Hot vs. Reheated



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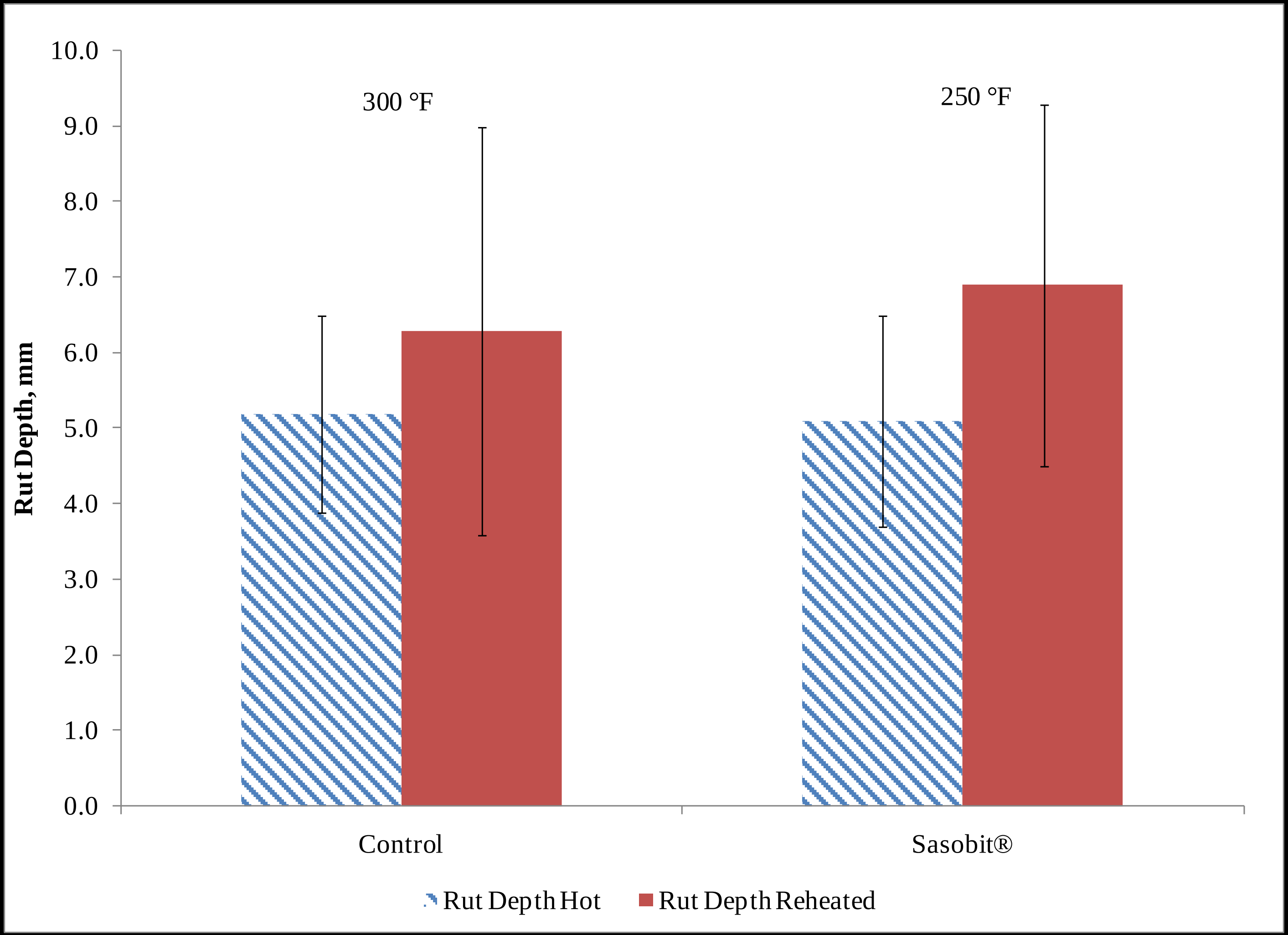
Iron Mountain, MI
APA



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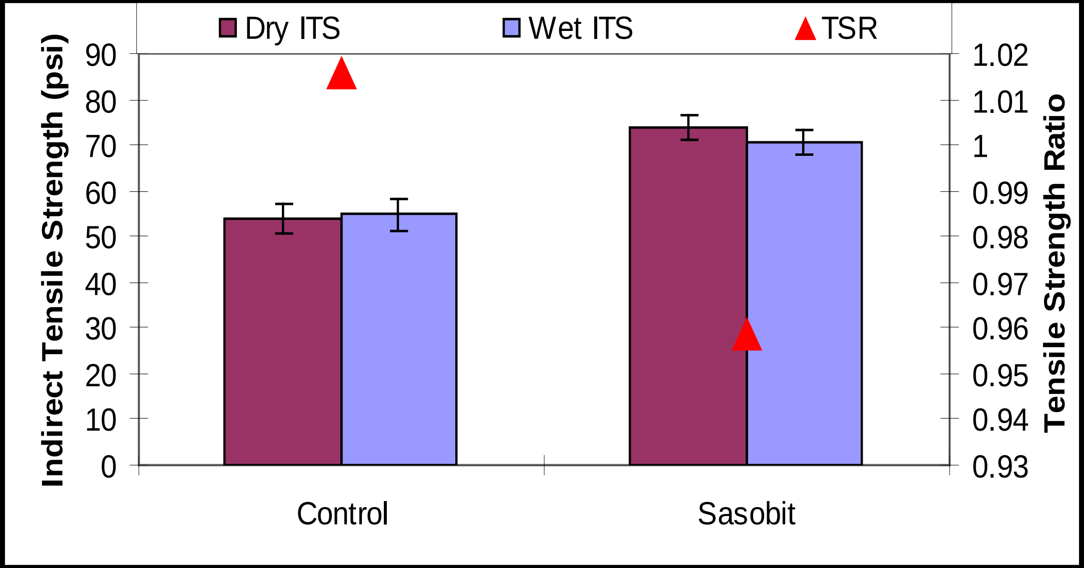
Iron Mountain, MI
Moisture Susceptibility

Mix Type	Sample #	Compaction Temperature, °F	Indirect Tensile Strength Unsaturated, psi	Saturated, psi	TSR
Control	1	300	53.9	54.8	1.02
Sasobit®	1	250	73.6	70.6	0.96



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Iron Mountain, MI
Hamburg

Mix Type	Stripping Inflection Point, cycles	Rutting Rate, mm/hr	Total Rutting @ 5,000 cycles, mm	Total Rutting @ 10,000 cycles, mm
Control	3,500	5.18	10.26	20.53
Sasobit®	5,200	4.82	9.57	19.13

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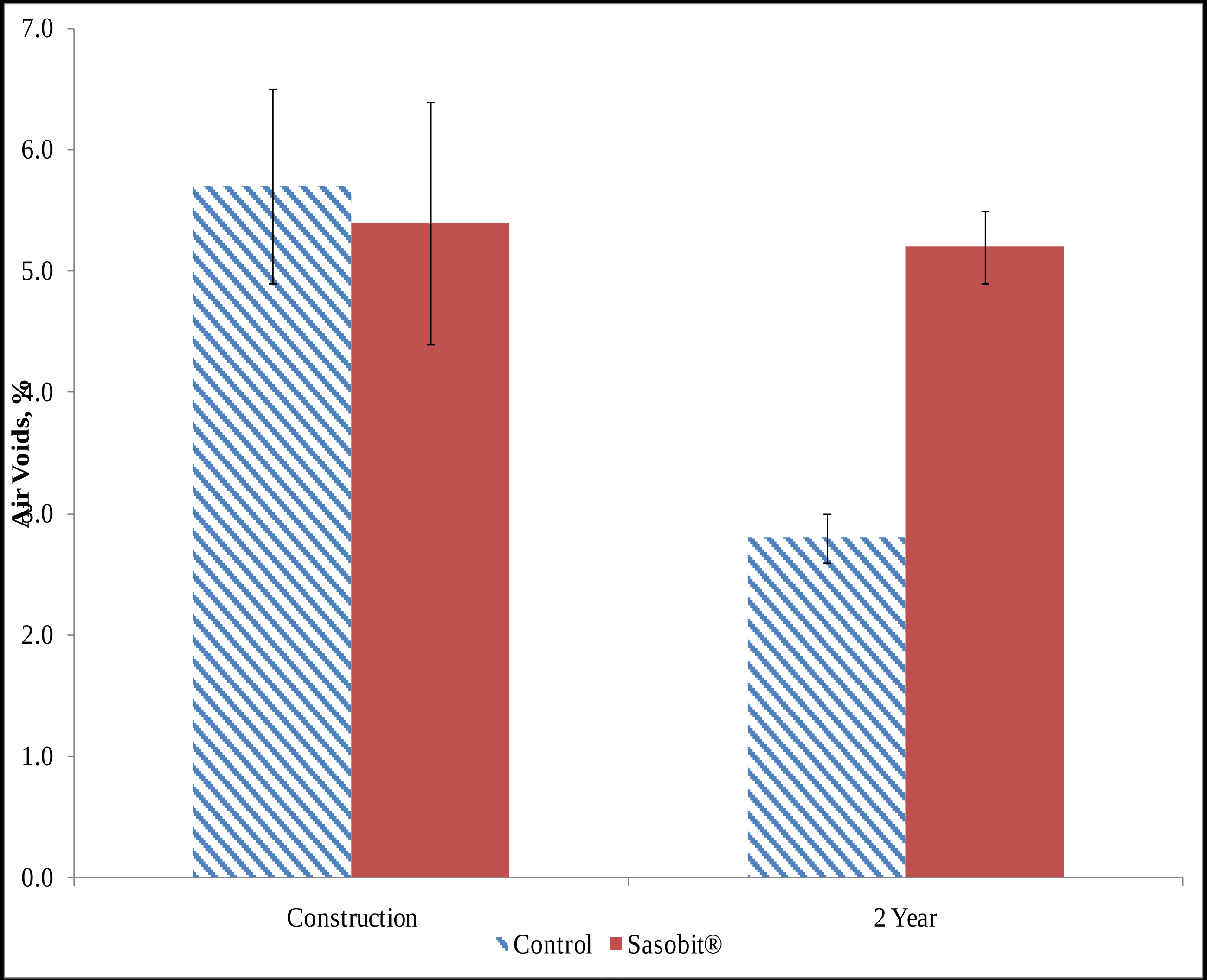
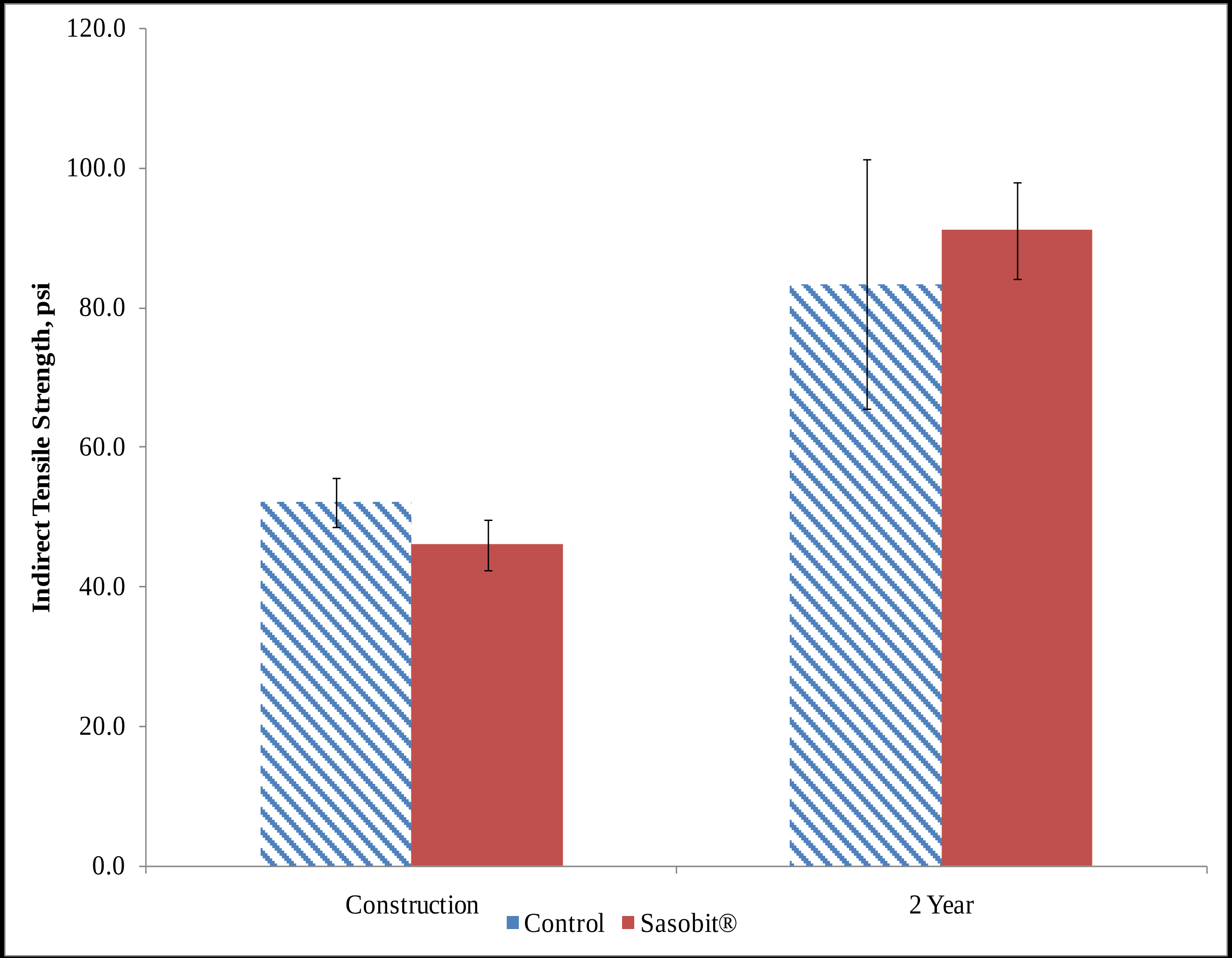
Iron Mountain, MI
In-Place Densities



Iron Mountain, MI
Core Indirect Tensile Strengths



What are we seeing for trends?

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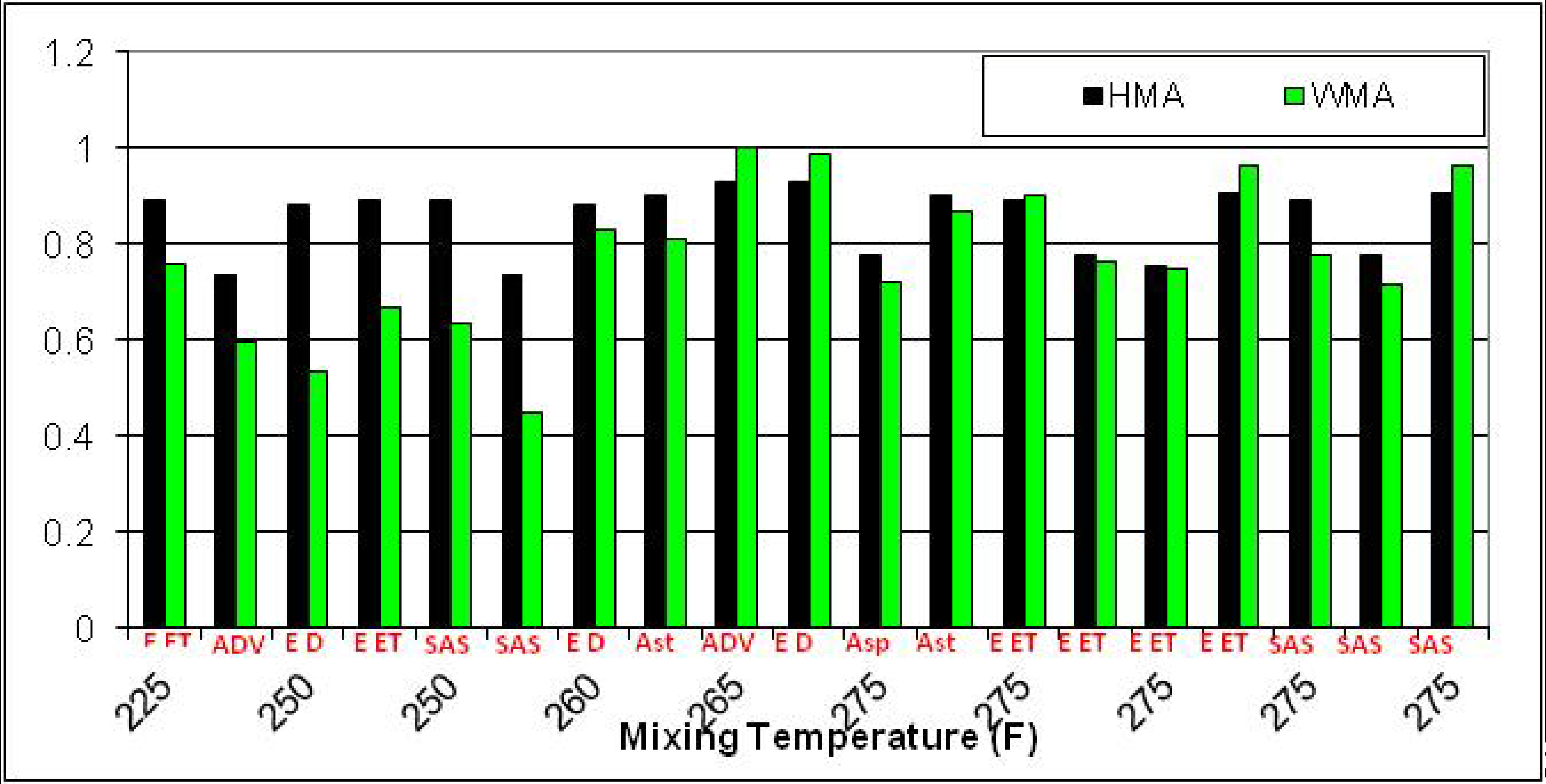
TSR



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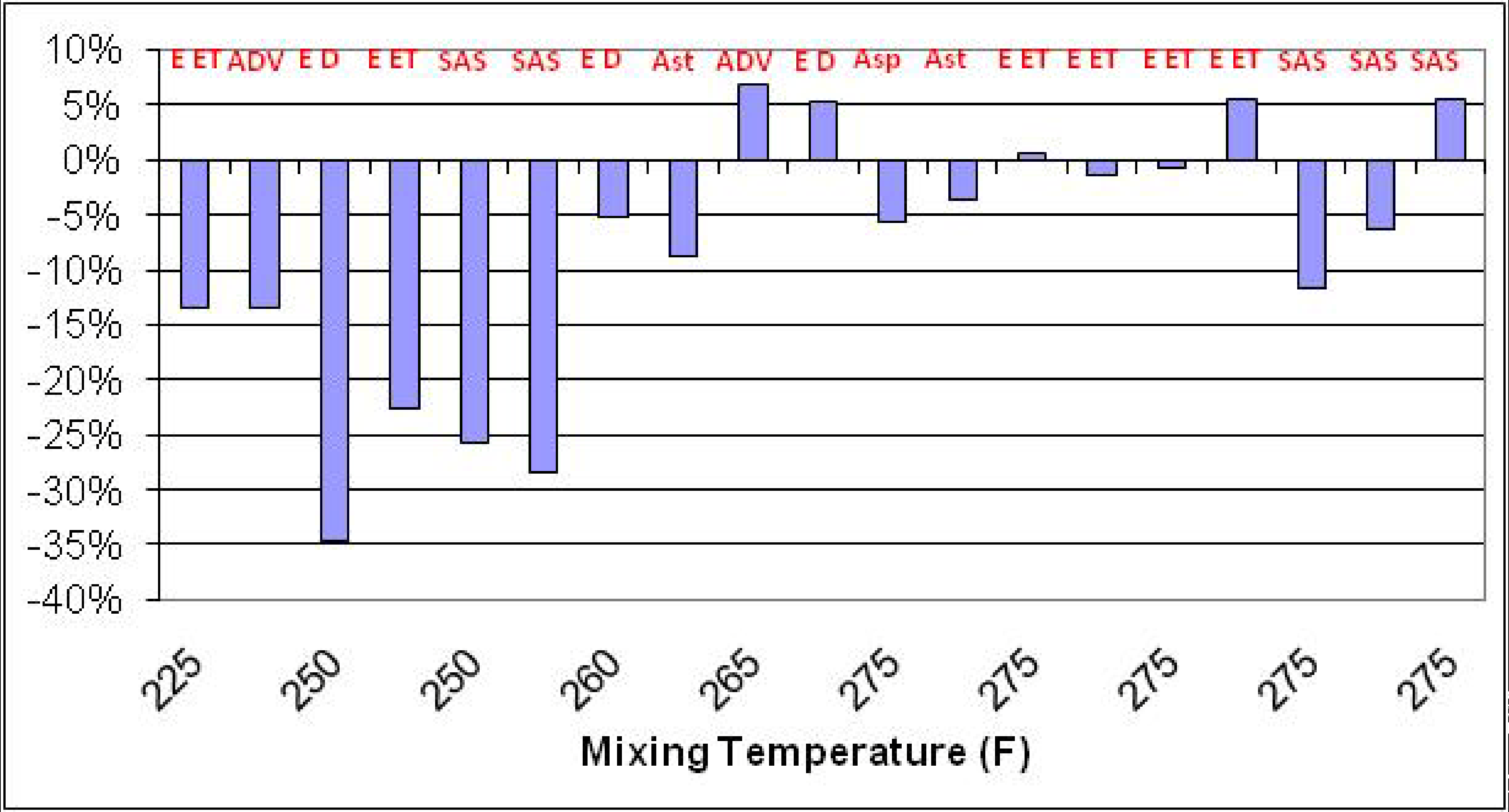
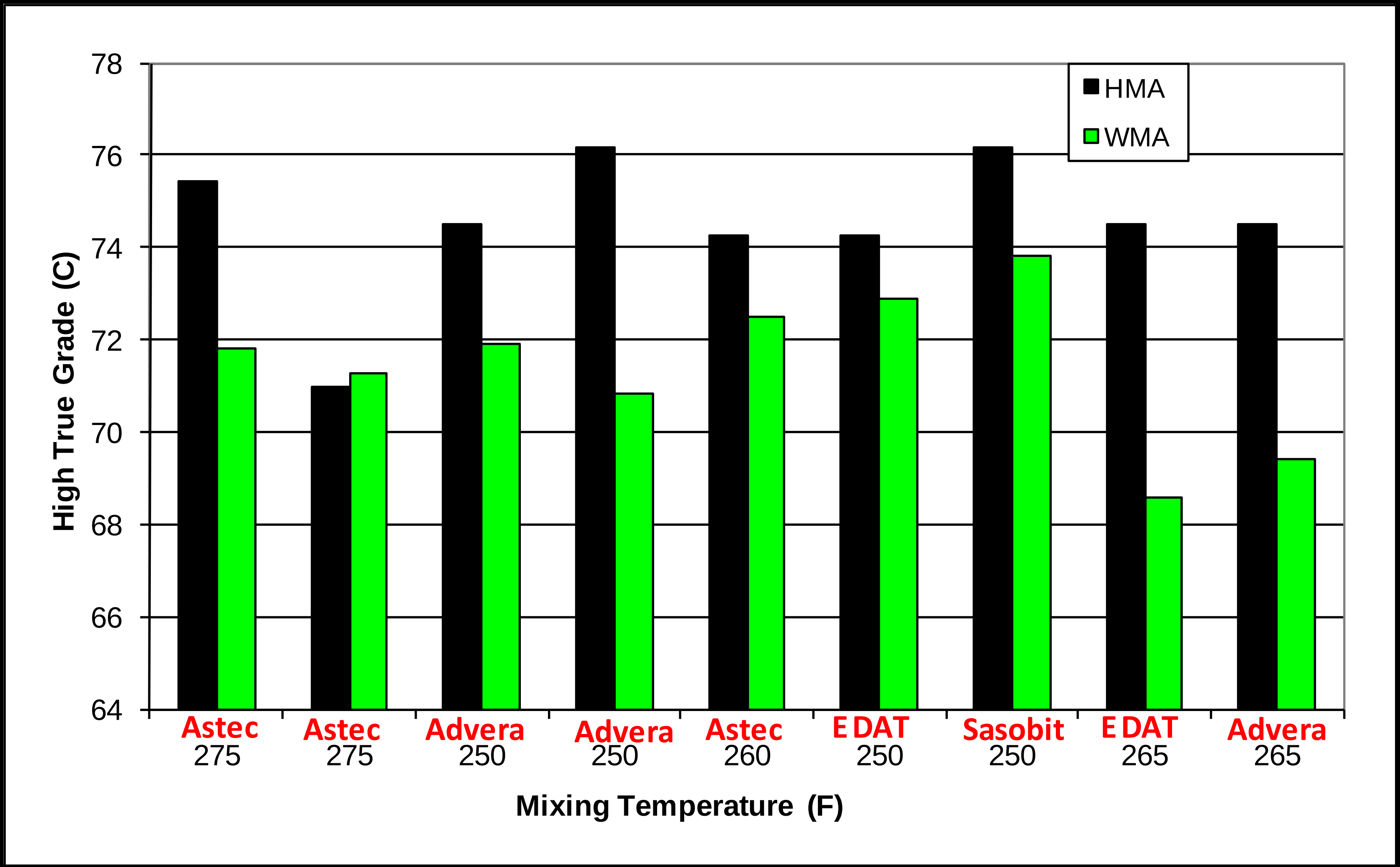
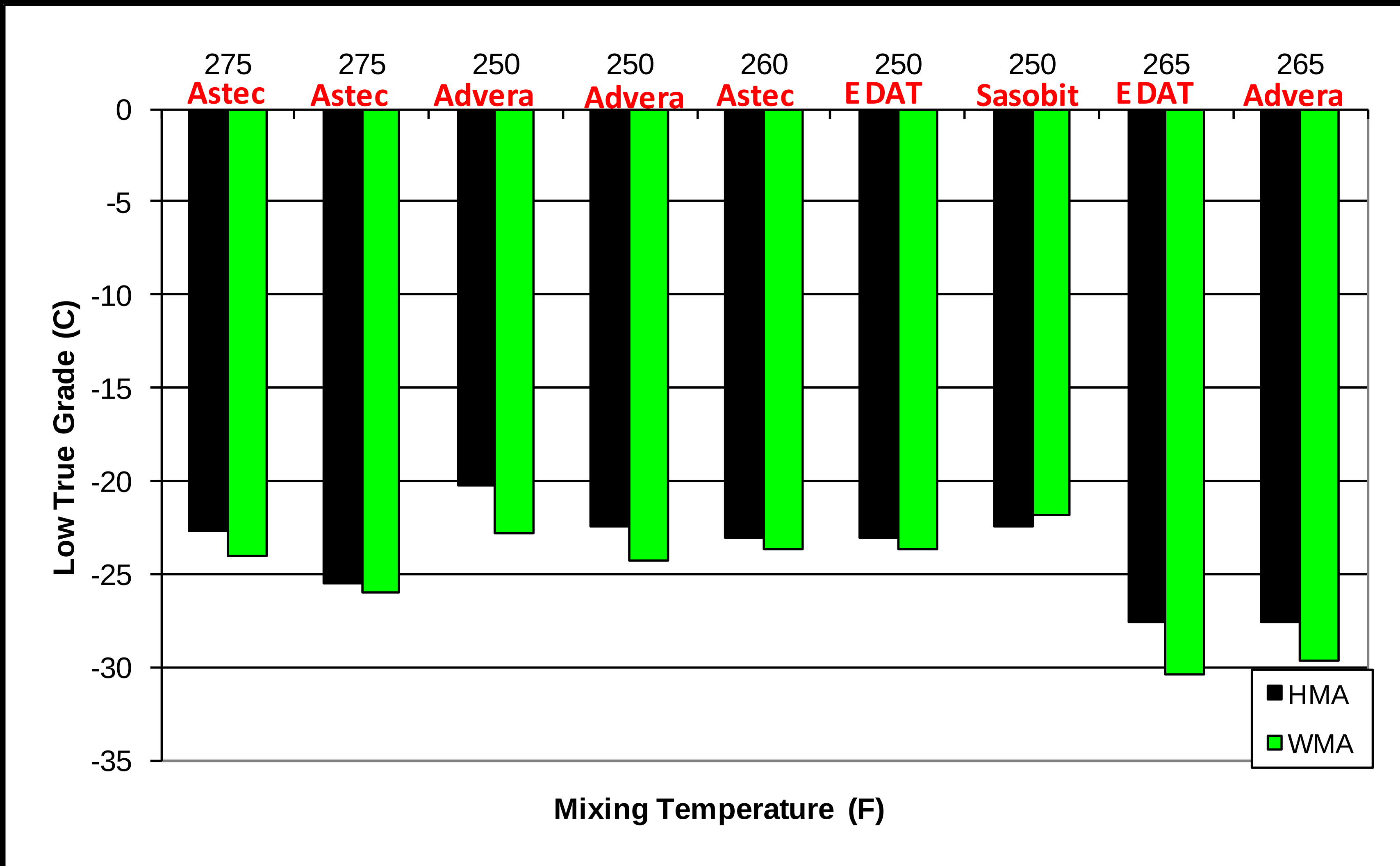
TSR Differences



High Performance Grade



Low Performance Grade



Additional Lab Testing

- Loaded wheel testers
  - WMA usually less but often still acceptable
    - Sasobit and Aspha-min (sometimes) exception
- Dynamic modulus
  - WMA often less stiff
    - Except Sasobit
- Low Temperature testing
  - No real difference

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Construction

- Lower production rates
- Less smoke
- Good joints
  - Is this due to WMA, crew, combination
- Good and bad densities
  - Problems with densities when HMA also has problems

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NCAT Test Track

2009 Cycle

- Group Experiment
  - WMA, RAP, and Porous Friction Course
  - Full depth reconstruction
  - Similar agg. gradation and eff. asphalt
- Constructed ended in August 2009
- Trafficking began August 2009

www.pavetrack.com

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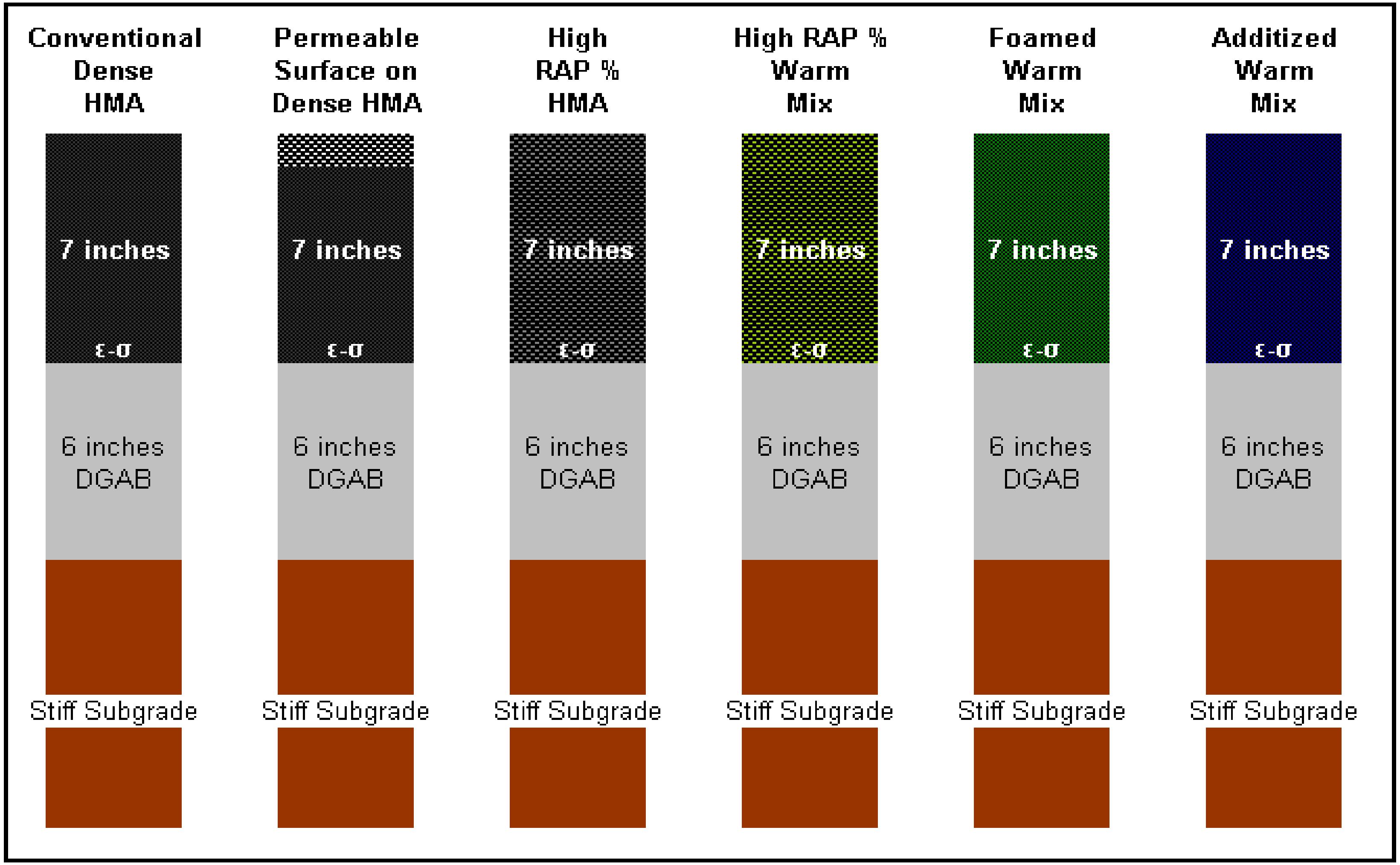
2009 Test Track Group Experiment



Virgin WMA

- S9
  - Control for group experiment
- S10
  - WMA Water Injection System
  - Same mix as S9
- S11
  - WMA Chemical Package
  - Same mix as S9

Virgin WMA Build Up

9.5mm PG 76-22
19.0mm PG 76-22
19.0mm PG 67-22

High RAP and WMA

- N10:
  - Similar gradation and effective asphalt to S9
  - 50% RAP HMA
    - Fractionated RAP
- N11:
  - Same gradation as N10
  - 50% RAP WMA
  - Water injection system

High RAP WMA Build Up

_9.5mm PG 67-22_

_19.0mm PG 67-22_

_19.0mm PG 67-22_

TSR and APA Testing

- Control had higher TSR than WMA
- Reheated specimens all passed TSR
- Most hot specimens passed TSR
- APA rutting greater for WMA sections than control
  - All rut depth measurements less than 6 mm

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WMA Certification

Survey

- Sent survey out to state agencies
- 31 responses
- Many states responded that they would use results from an NCAT study to approve
  - Remaining results were maybe, dependent upon finalized test selected

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What aggregate properties should be considered when selecting a mix for the WMA technology evaluation?

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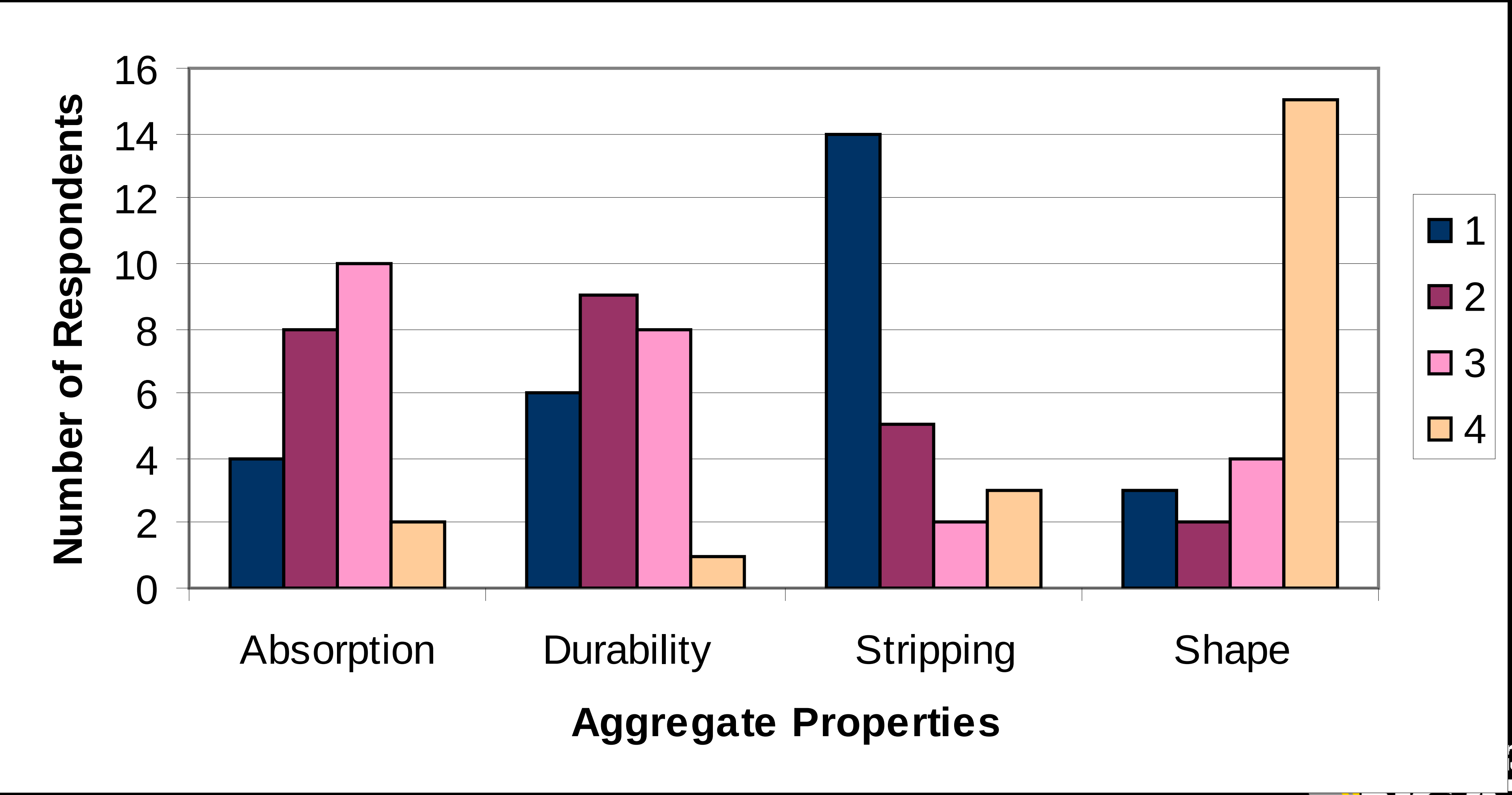
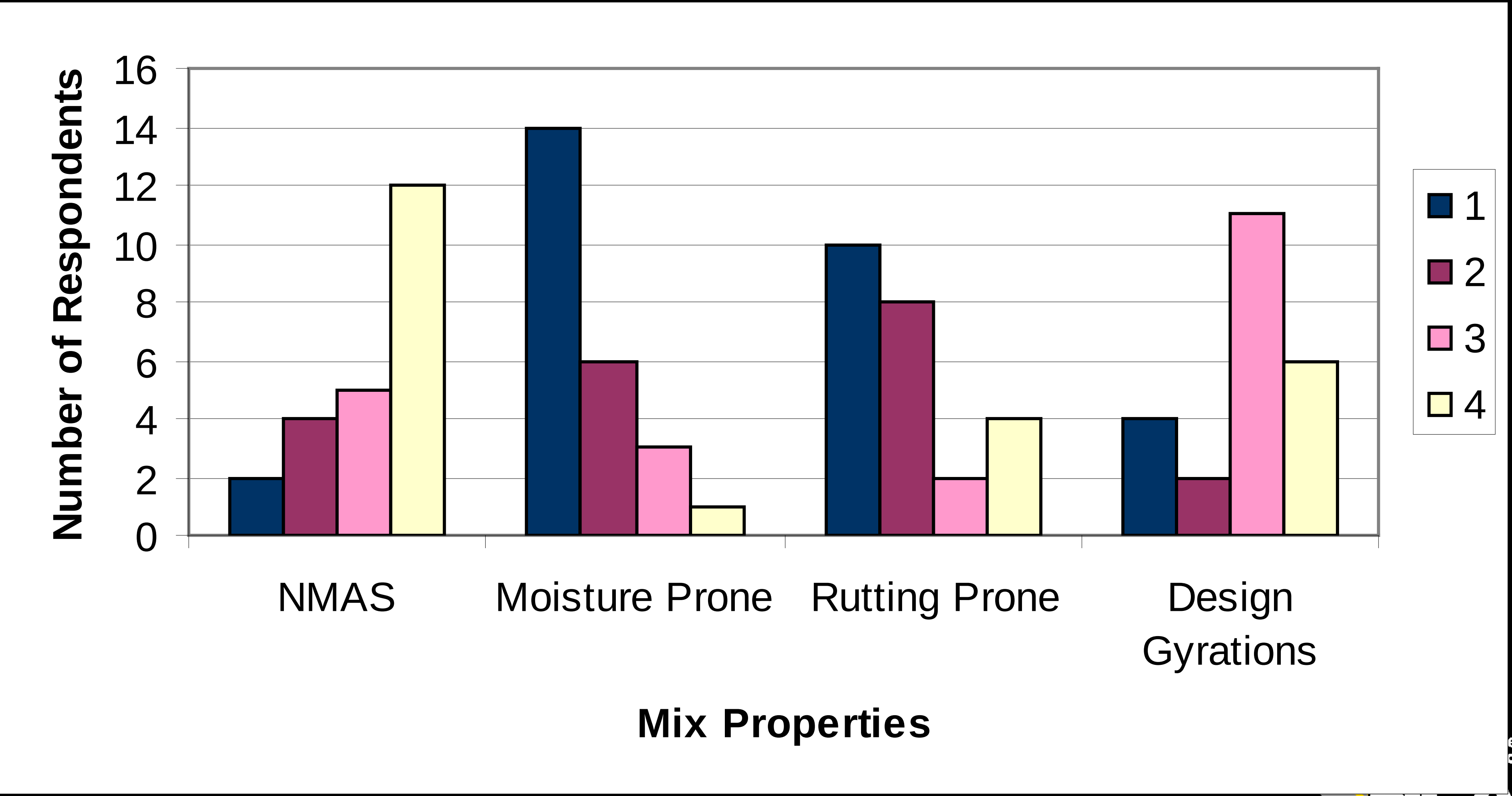
Aggregate Properties



What mix properties should be considered when selecting a mix for the WMA technology evaluation?

Mix Properties



What short term field performance results would your state require for a WMA technology to be approved?

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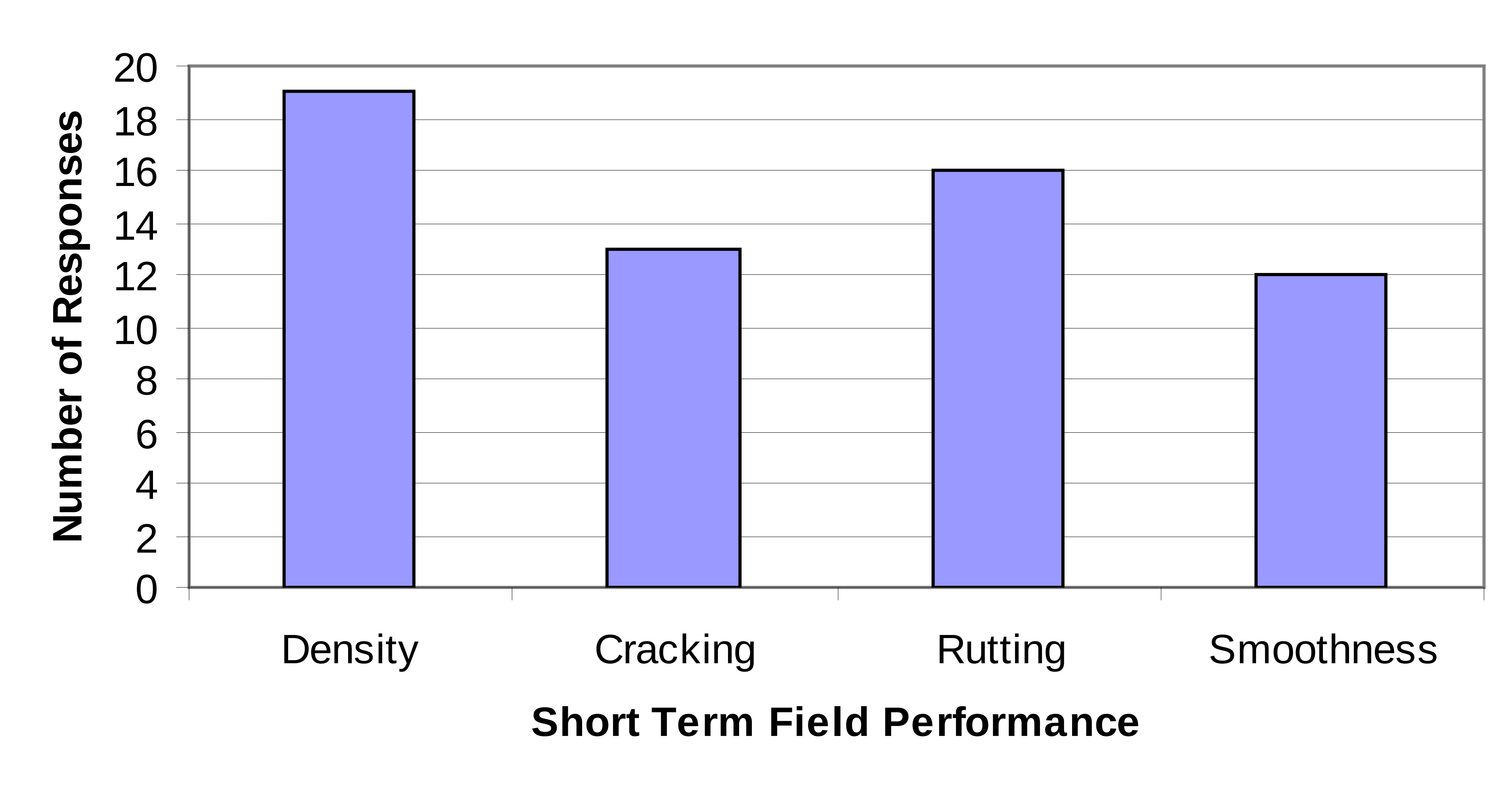
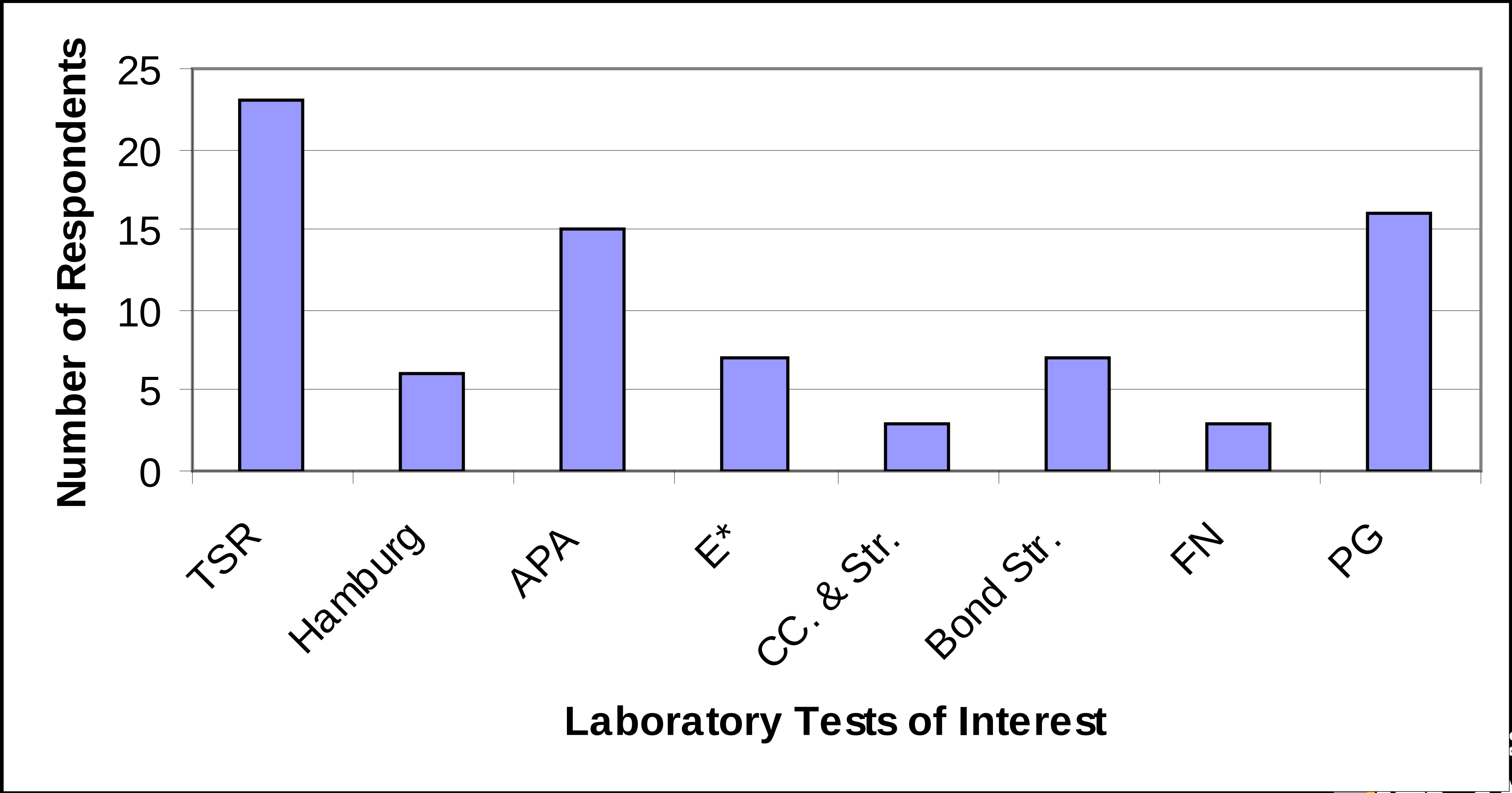
Short Term Field Performance



What laboratory testing results would your state require for a WMA technology to be approved?

Laboratory Testing



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Plan

- Develop mix design
- Produce mix at test track
- Compare WMA section to HMA section
  - After 1 year of trafficking
- Sample plant produced mix for laboratory testing

State Supported

- Need State Support

- States agree to use information when approving a WMA technology
  - Does not require that this be the only way for approval in a state

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Support Letters

- Arizona
- Colorado
- Delaware
- Florida
- Indiana
- New Hampshire
- South Carolina
- Texas
- Washington

More to Come….

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First Round

- First round of certification about to start
  - Shell Thiopave and two other WMA technologies working on contract
  - Four other WMA technologies considering participation
- Target end date to commit is March 1, 2010
- Target construction date is April 2010

First Round Participants

- Shell Thiopave
- Two others initiated contract stage
  - Once there is consent to reveal their participation it will be revealed

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Mix Design

- Mix design from a Georgia Contractor
  - 9.5 mm
  - Coarse graded
  - PG 64-22
- Predominant aggregate is lithia springs granite
- Mix design needs to be verified at NCAT

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Construction

- One control HMA will be constructed with each WMA Certification cycle

- Document construction
  - Plant modifications
  - Production changes
  - Placement temperatures
  - Compaction process

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Data Collected	Equipment
Plant Modifications	N/A
WMA Technology Cost	N/A
Materials Information	N/A
Target Mixing Temperature	N/A
Aggregate Moisture Content	Oven and a can
Mix Moisture Content	Oven and a can
Production Rate	N/A
Discharge Temperature	Temperature gun or thermal couple
Haul Distance	GPS
Delivery Temperature	Temperature gun and a temperature probe
Temperature Behind the Screed	Temperature gun
Cooling Rate	Temperature gun and a watch
Weather	N/A
Lift Thickness	N/A
Roller Pattern	N/A
Densities from Cores	Coring rig
Mean Texture Depth	Sand

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Plant Mix Testing

Test	Method
Moisture Susceptibility	AASHTO T 283
Moisture Susceptibility and Rutting	AASHTO T 324
Moisture Susceptibility and Rutting of Aged WMA (loose mix aged 4 hours at 275 F)	AASHTO T 324
Moisture Susceptibility	TEX-530-C
Rutting	AASHTO TP 63
Permanent Deformation	Flow Number in accordance with FHWA's mobile laboratory
Thermal Cracking Resistance	AASHTO T 322
Bond Strength	ALDOT 430
Stiffness	AASHTO TP 62
Cracking Potential	TEX-248
Binder Performance Grade (Complex Shear Modulus, Phase Angle, Viscosity, Flexural Stiffness)	AASHTO R 29

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Timeline

- 0-2nd months mix design verification
- 3rd month construction
- 4th-16th month trafficking, field monitoring, and mix testing
  – Laboratory report on mix tests completed as interim report
- 17th-18th month report writing

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First Round

- First round of certification about start
- Process of selecting material suppliers
- WMA manufacturers interested in the first round need to contact NCAT

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QUESTIONS

ank0004@auburn.edu

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