Evaluation of Warm Asphalt Technologies

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NCAT
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Why Warm Asphalt?

Research by Stroup-Gardiner and Lange at AU
Indicates increased emissions with increased temp.

Why Warm Asphalt?

- Reduce production and laydown temperatures
- Reduce emissions
- Reduce energy costs
- Reduce aging of binder
- Other Possible Benefits:
  - Cool weather paving (extend season)
  - Compaction aid for stiff mixes

While achieving the same or better density!

What is Warm Mix Asphalt?

Several process have been developed to improve mixture workability allowing lower production and laydown temperatures

- – WAM Foam – Shell/Kolo Veidekke
- – Zeolite – Eurovia/Hubbard Construction
- – Sasobit – Sasol Int./Moore and Munger
- – Evotherm – MeadWestvaco
- – Low Energy Asphalt - Fairco
- – New Products under development

WAM-Foam

- Two Phase addition of asphalt
  - Aggregate coated with “soft” asphalt
  - Hard asphalt foamed to mix with pre-coated aggregate
  - Soft asphalt controls minimum placement temperature
  - Material placed as low as 80 C (176 F), 50 – 60 C (90 – 108 F) reduction
  - Requires plant modification for foaming, estimated at $50,000 - $70,000. No additional costs thereafter
  - Special asphalt feeds may be required

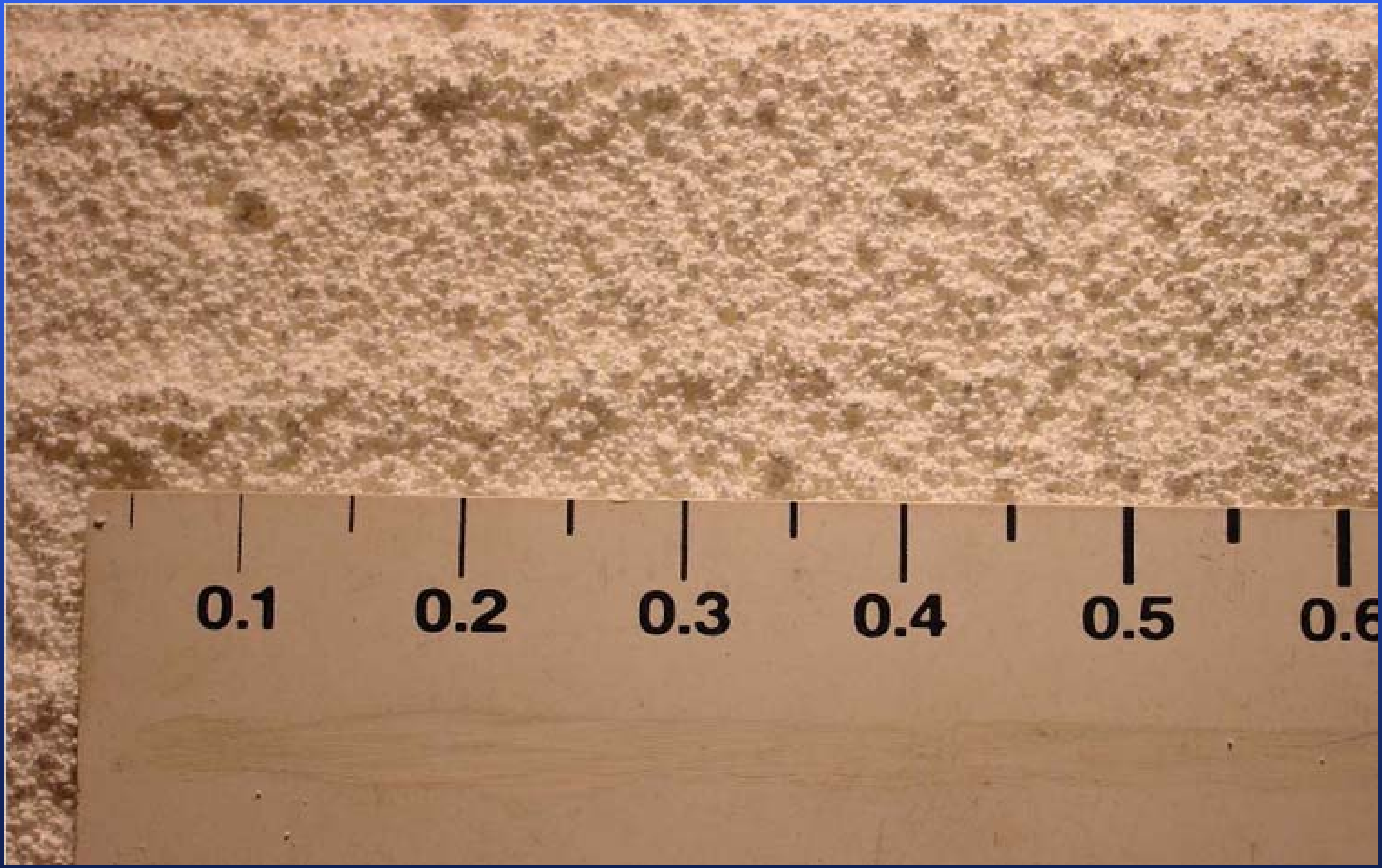
WAM Foam Installation in Hot Mix Asphalt Plant

Courtesy of Shell/Kolo Veidekke

Zeolite

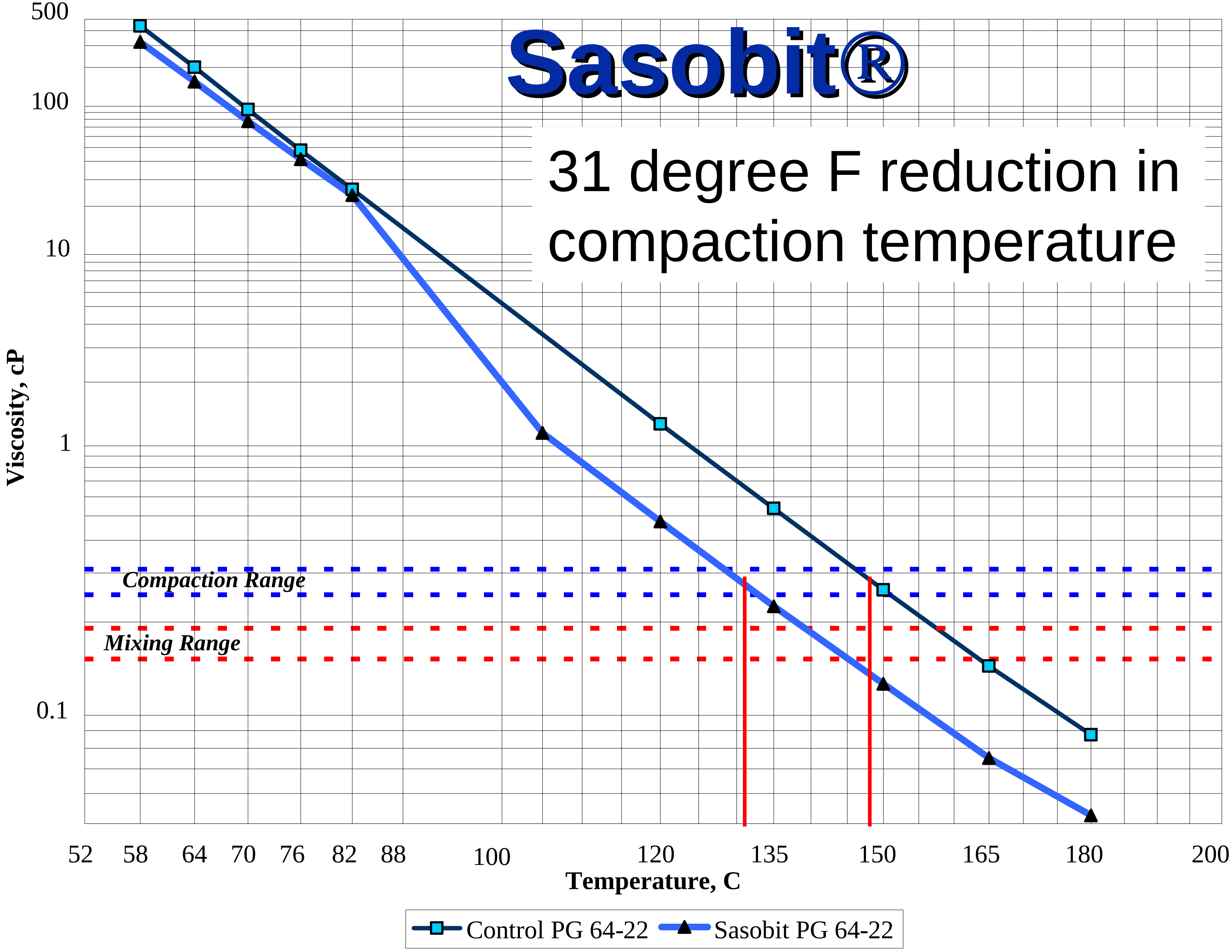
- Zeolites are crystalline hydrated aluminum silicates
- When the Zeolite is heated, it gives up its internal moisture, approximately 21% by weight, microscopically foaming the asphalt
- Aspha-min is typically added at 0.3% by TWM

Granulated aspha-min®



Sasobit®/Sasoflex

- Fischer-Tropsch synthetic waxes – Sasobit
  - Produced from gasification of coal or natural gas feed stocks
  - Added to binder or directly into mix
  - Can incorporate an SBS modifier using special cross-linking agent (Sasoflex)
  - Does not require high-shear blending
  - May negatively impact low temperature properties



Sasobit®
31 degree F reduction in compaction temperature
500
100
10
1
0.1
Viscosity, cP
Compaction Range
Mixing Range
52
58
64
70
76
82
88
100
120
135
150
165
180
200
Temperature, C
Control PG 64-22
Sasobit PG 64-22

Sasobit Binder Tests

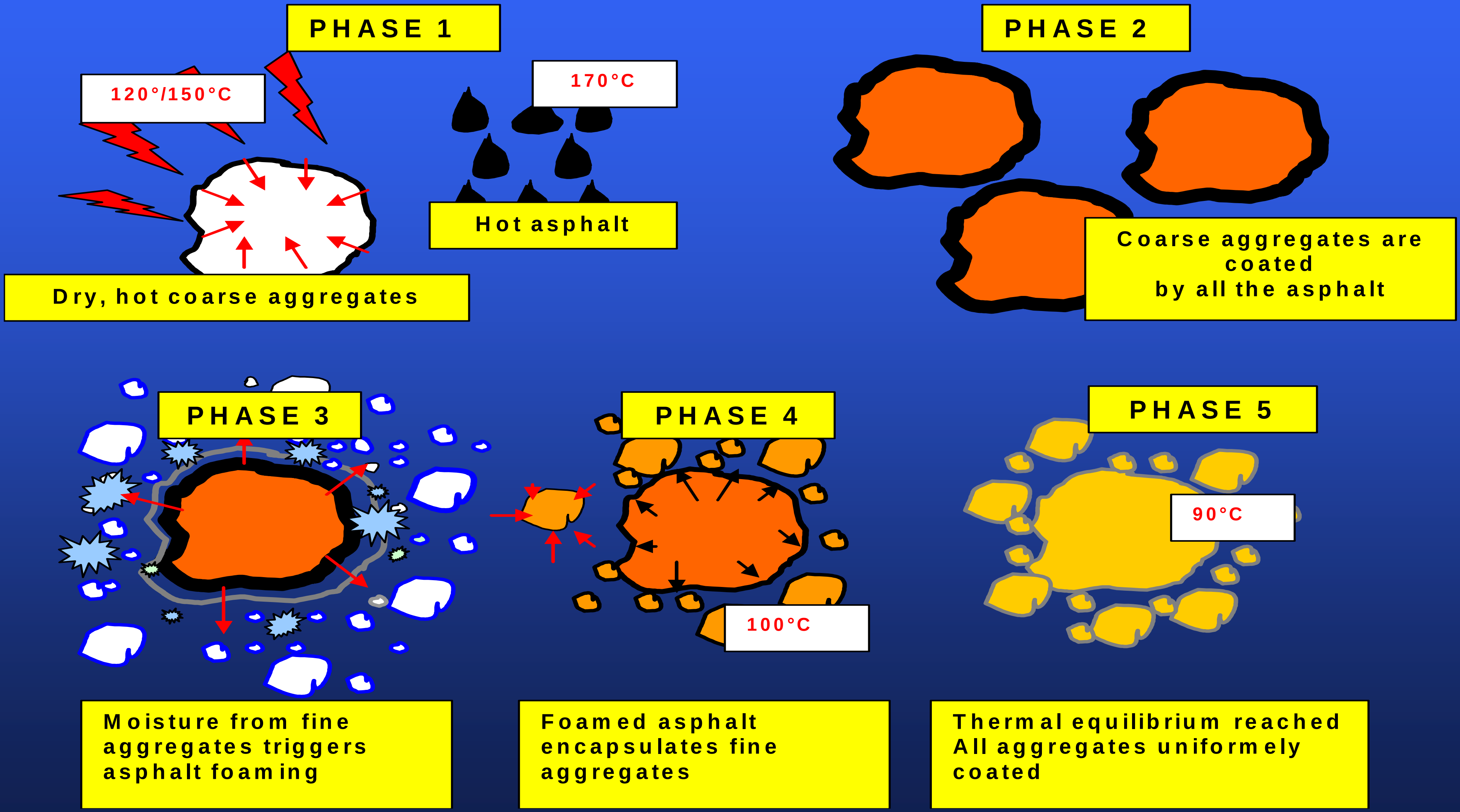
Test	PG 58-28 Base	PG 64-22 Control	PG 64-22 Sasobit®	PG 70-22 Sasoflex	PG 76-22	PG 76-22 Sasoflex
Modifier	None	None	2.5% Sasobit®	4% Sasoflex	None	4% Sasoflex
Test Temp., °C	58	64	64	70	76	76
Original DSR, G*/sin δ, kPa	1.015	1.815	1.790	2.689	1.290	1.461
RTFO DSR, G*/sin δ, kPa	2.781	3.868	3.950	4.548	3.096	2.682
Test Temp., °C	19	25	25	28	31	31
PAV DSR. G*sinδ, kPa	4138	3554	2906	2448	1059	2635
Test Temp., °C	-18	-12	-12	-12	-12	-12
BBR Creep Stiffness (S), MPa	248	208	164	153	165	251
BBR m-value	0.316	0.317	0.306	0.328	0.315	0.292

Sasobit®

Evotherm®

- Emulsion – approximately 70% binder residue
- Chemical package provides mixing, coating, workability, compaction and adhesion (e.g. anti-stripping agents)
- Some steam liberated upon mixing

L.E.A's sequential mixing



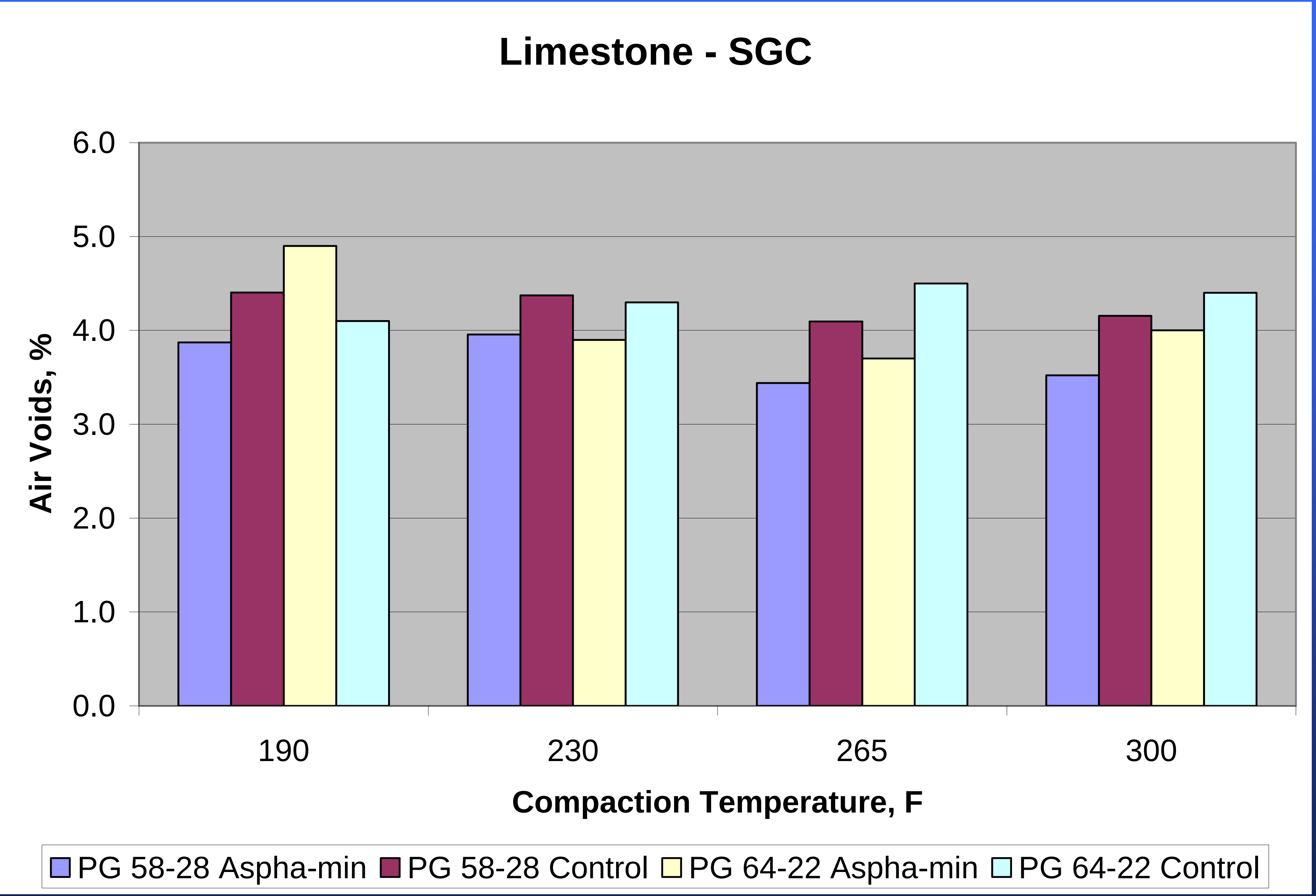
Courtesy of Fairco

Product Evaluations

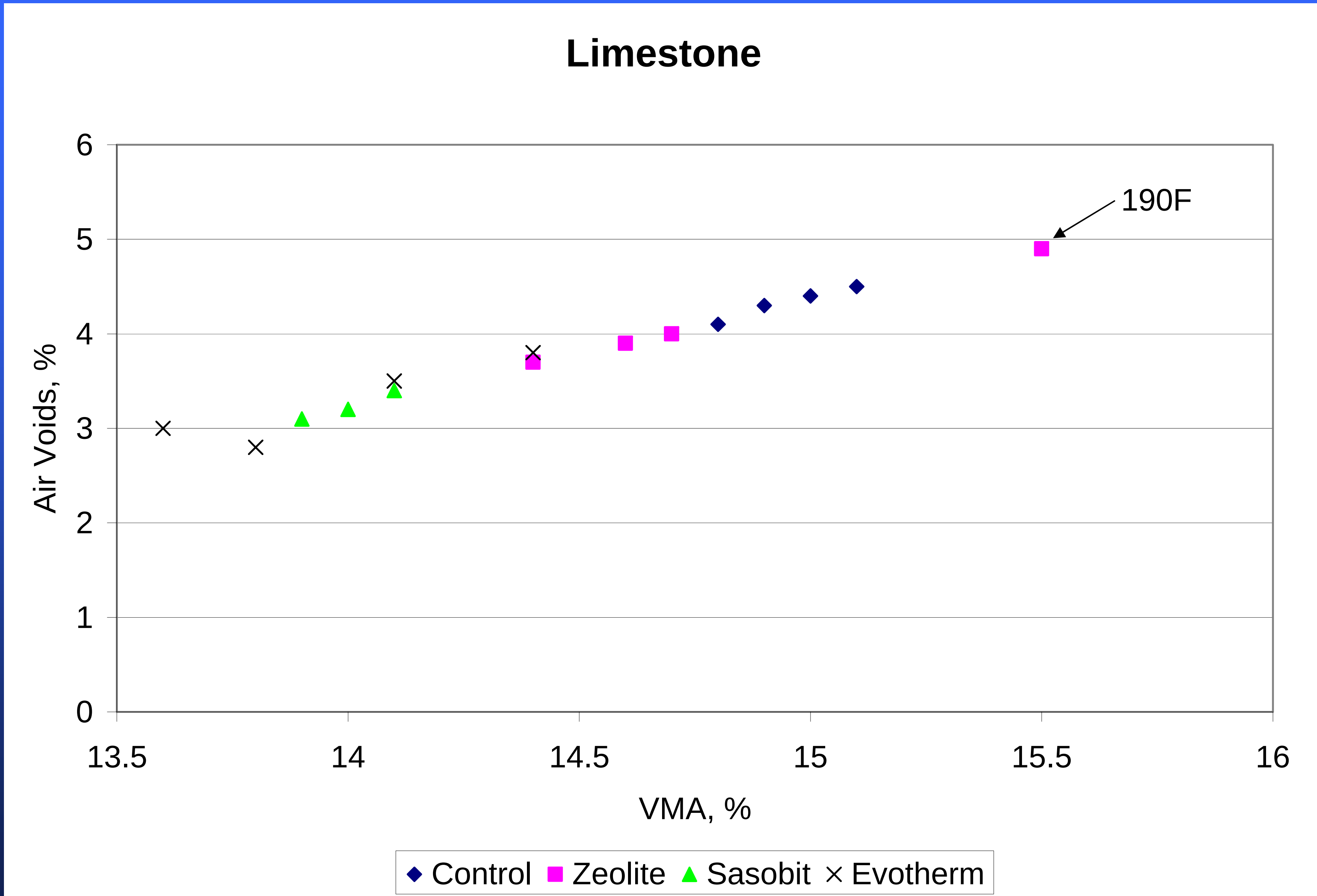
- Evaluate Warm Asphalt Technologies for U.S. Paving Practices
  - Compaction
  - Quick “turn-over” to traffic
  - Rutting
  - Resilient modulus (for pavement design)
  - Moisture damage
- Products Evaluated
  - Aspha-min zeolite
  - Sasobit
  - Evotherm

How Do You Measure Compaction in Lab?

- Superpave gyratory compactor is not sensitive to reduced temperature – control mix produces the same voids
- Field Compaction, Marshall and Vibratory (PTI) Compaction sensitive to temperature/workability changes



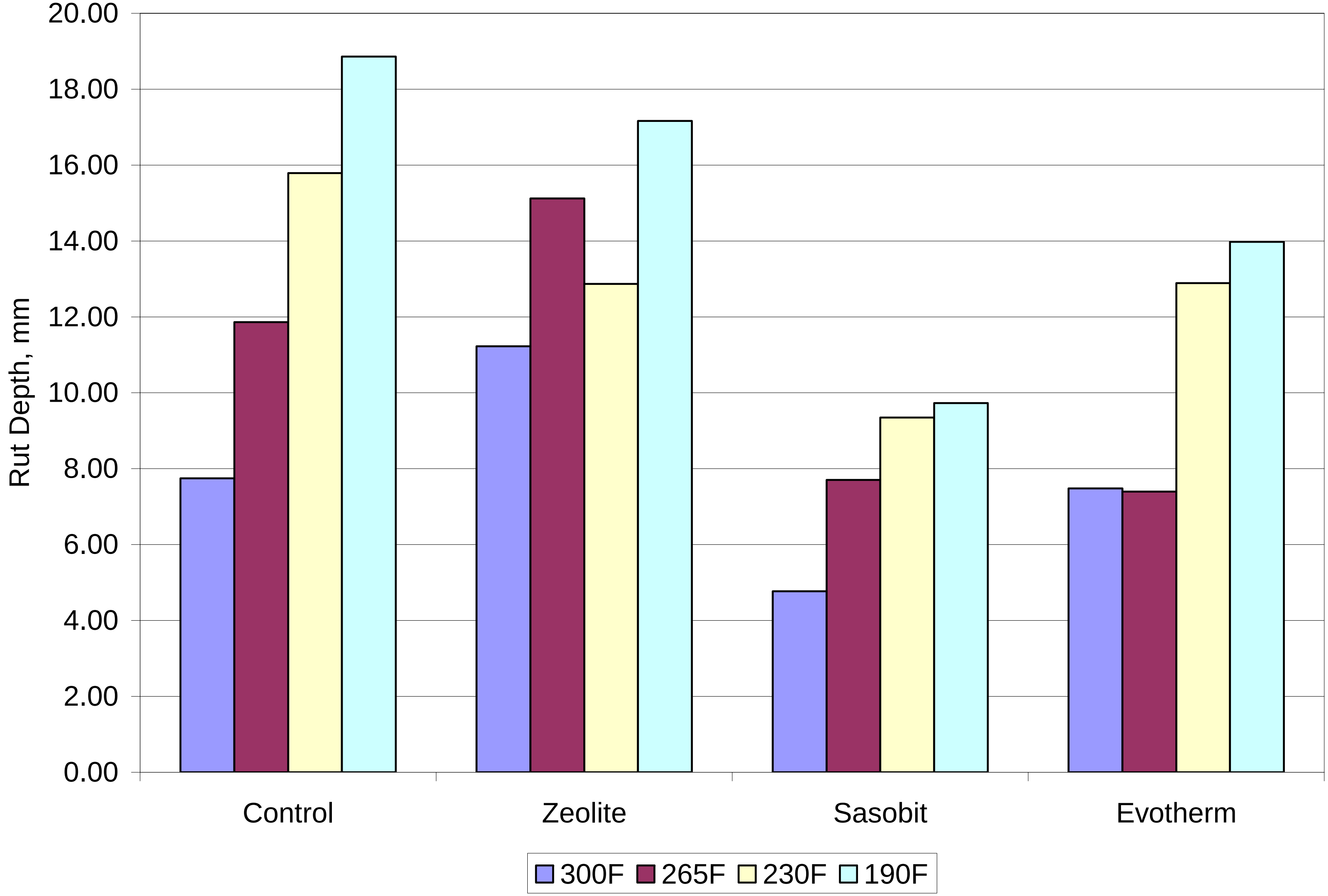
Samples mixed 35F above compaction temperature



Limestone
190F
Air Voids, %
VMA, %
0
1
2
3
4
5
6
13.5
14
14.5
15
15.5
16
Control
Zeolite
Sasobit
Evotherm

APA Rut Testing

APA Rut Depth for PG 64-22 - Granite



Comparison of Additives to Hot Mix Produced at 300F

	Air Voids		Resilient Modulus		APA Rutting	
	265	230	265	230	265	230
None	= (0.8895)	= (0.1161)	= (0.9695)	= (0.9969)	= (0.3071)	< (0.0002)
Zeolite	= (0.2250)	> (0.0122)	= (0.9968)	= (0.9391)	< (0.0025)	< (0.0420)
Sasobit	> (0.0006)	> (0.0059)	= (1.0000)	= (0.8911)	= (0.9926)	= (0.9752)
Evotherm	> (0.0000)	> (0.0001)	= (0.9801)	= (0.9987)	= (0.9833)	< (0.0087)

Moisture Susceptibility

Simulating a Drum Plant

Failure Modes

Adhesive

Cohesive

Granite TSR

Additive	Dry Aggregate 300F	SSD+ in Bucket Mixer at 250F	Bucket Mixer With Anti-Strip	Anti-Strip Agent
HMA	0.97	1.16	0.86	0.75% LOF 6500
Zeolite	0.81	0.67	0.87	1.5% Lime
Sasobit	0.68 (250F)	0.71	0.94*	0.4% Magnabond
Evotherm	NA	0.96	NA	

* Dry Strength 17.5 psi, wet strength 16.5 psi

Field Sections

More than ten U.S. sections to date

World wide in dense-grade, SMA and OGFC

MD SMA Sasobit Trial
Capital Beltway - 2005

OGFC with Sasobit
Beijing, China - 2005

- Breakdown - 95°C (203°F)
- Finish - 75°C (167°F)

Courtesy of Don Watson

Evotherm Test Sections
November 2005

	N2	N1	E9
	← 9.5 mm NMAS →		
1”	HMA Control PG 67-22	Evotherm PG 67-22 + 3% Latex	Evotherm PG 67-22
2”	19.0 mm NMAS w/ Evotherm PG 67-22		
2”	19.0 mm NMAS w/ Evotherm PG 67-22		

N_{design} = 80 for all mixes

Evotherm Wearing Course with Latex

Mix Produced 7:00 PM

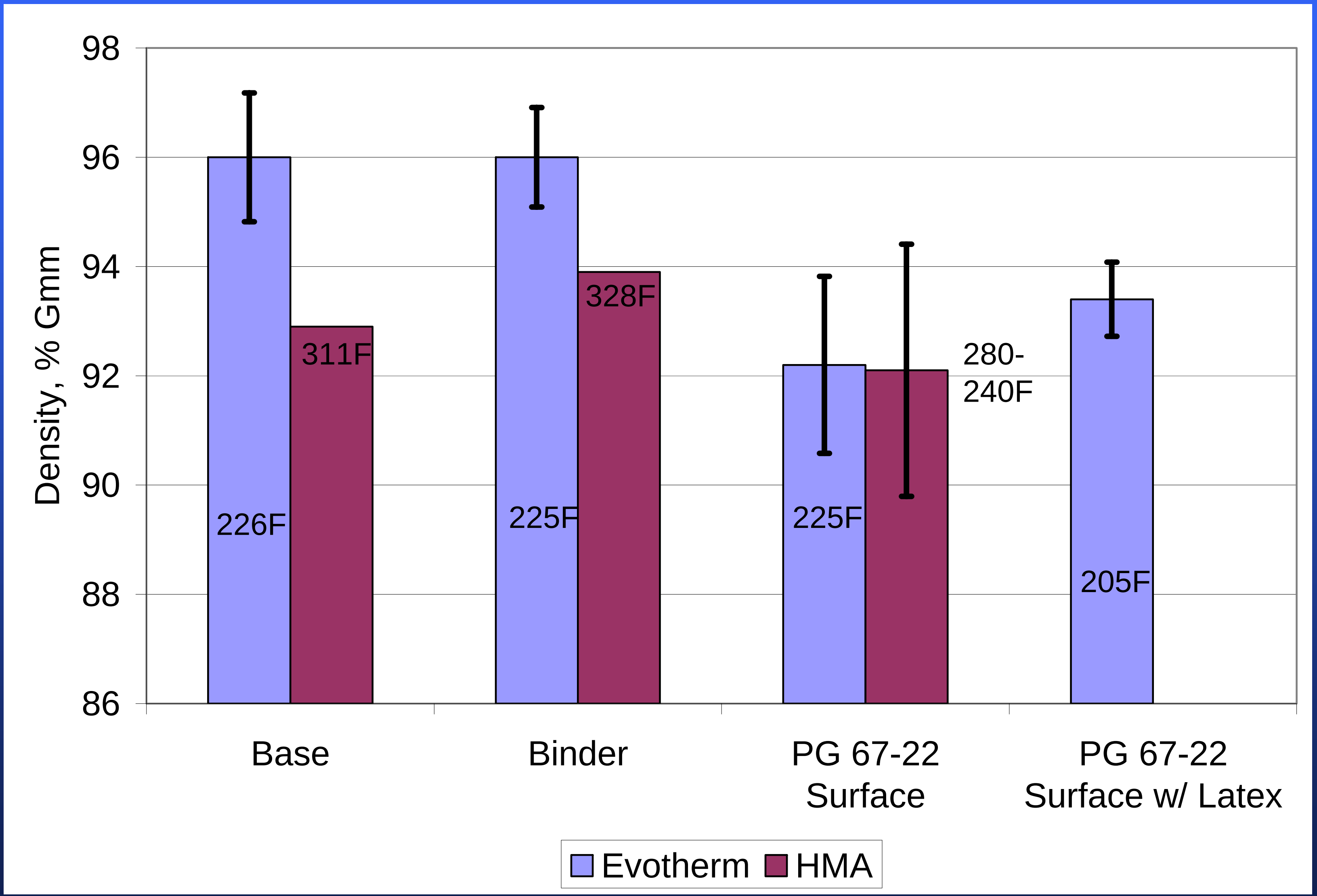
Mix held in silo at 240F overnight

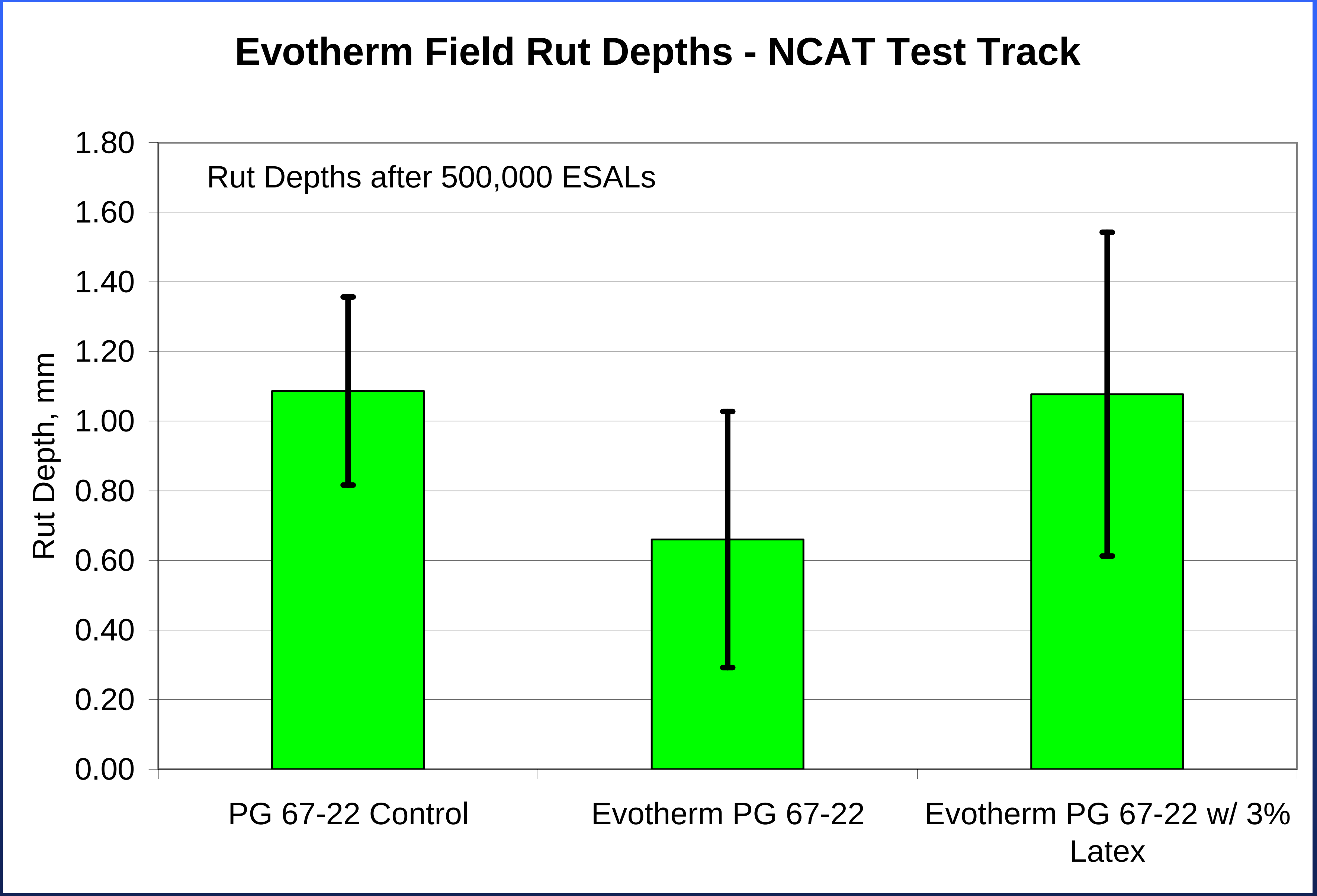
Mix Loaded out 1:30 PM – next day

Mix Placed at 3:15 PM

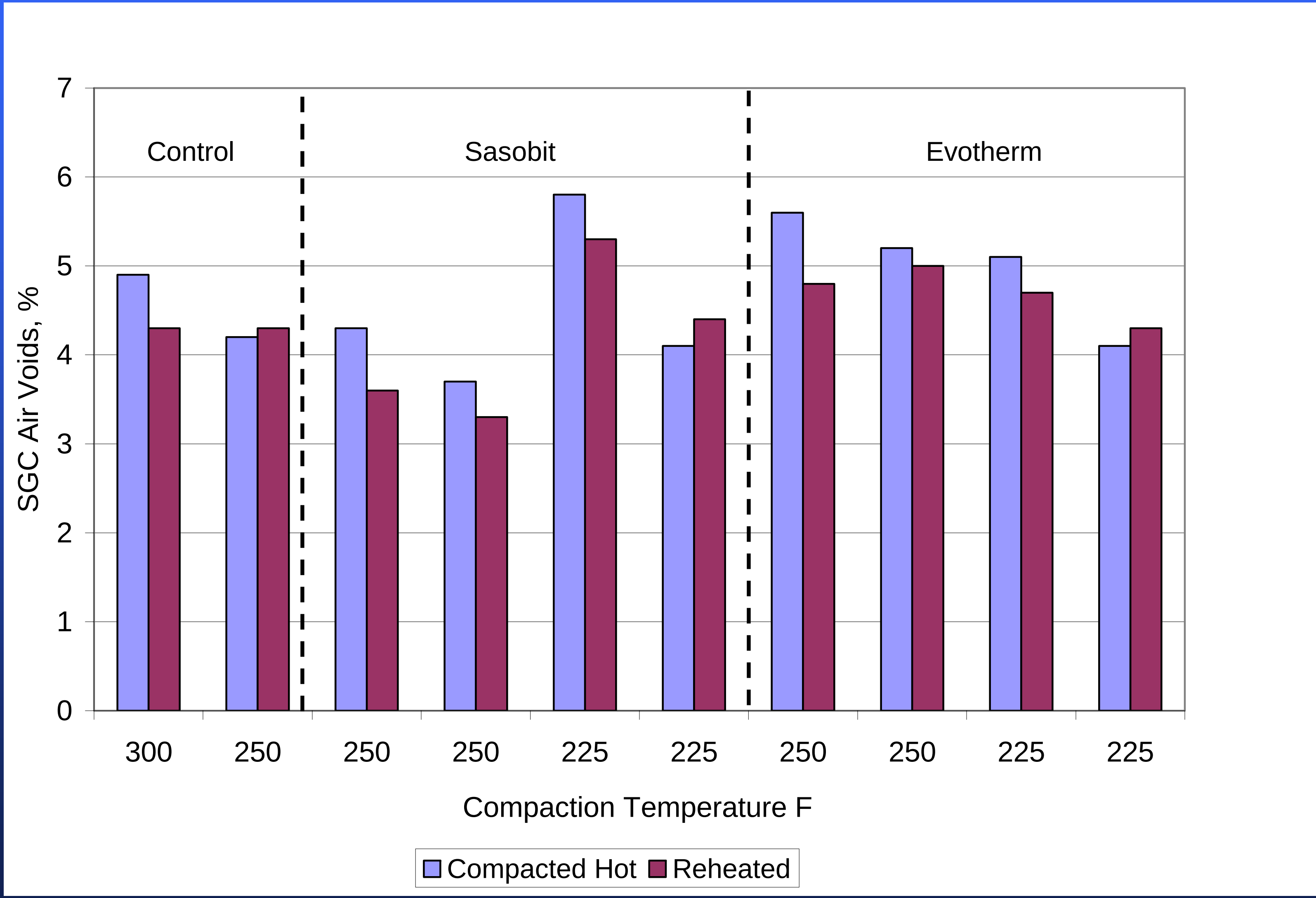
Traffic Returned at 5:00 PM

Evotherm Test Track Pavement Densities



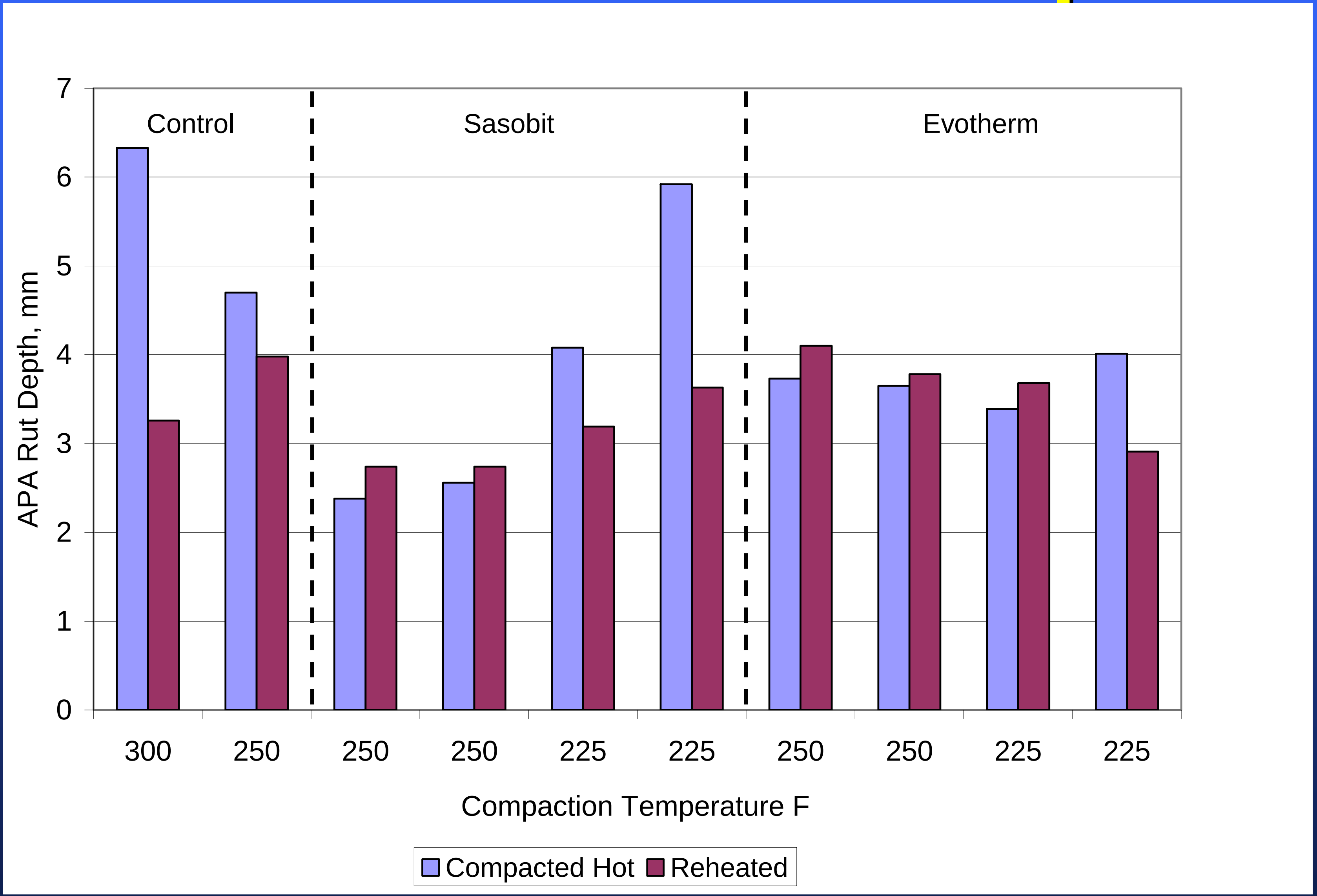

Evotherm Field Rut Depths - NCAT Test Track
Rut Depths after 500,000 ESALs
Rut Depth, mm
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
PG 67-22 Control
Evotherm PG 67-22
Evotherm PG 67-22 w/ 3% Latex

Missouri N_{design} VTM



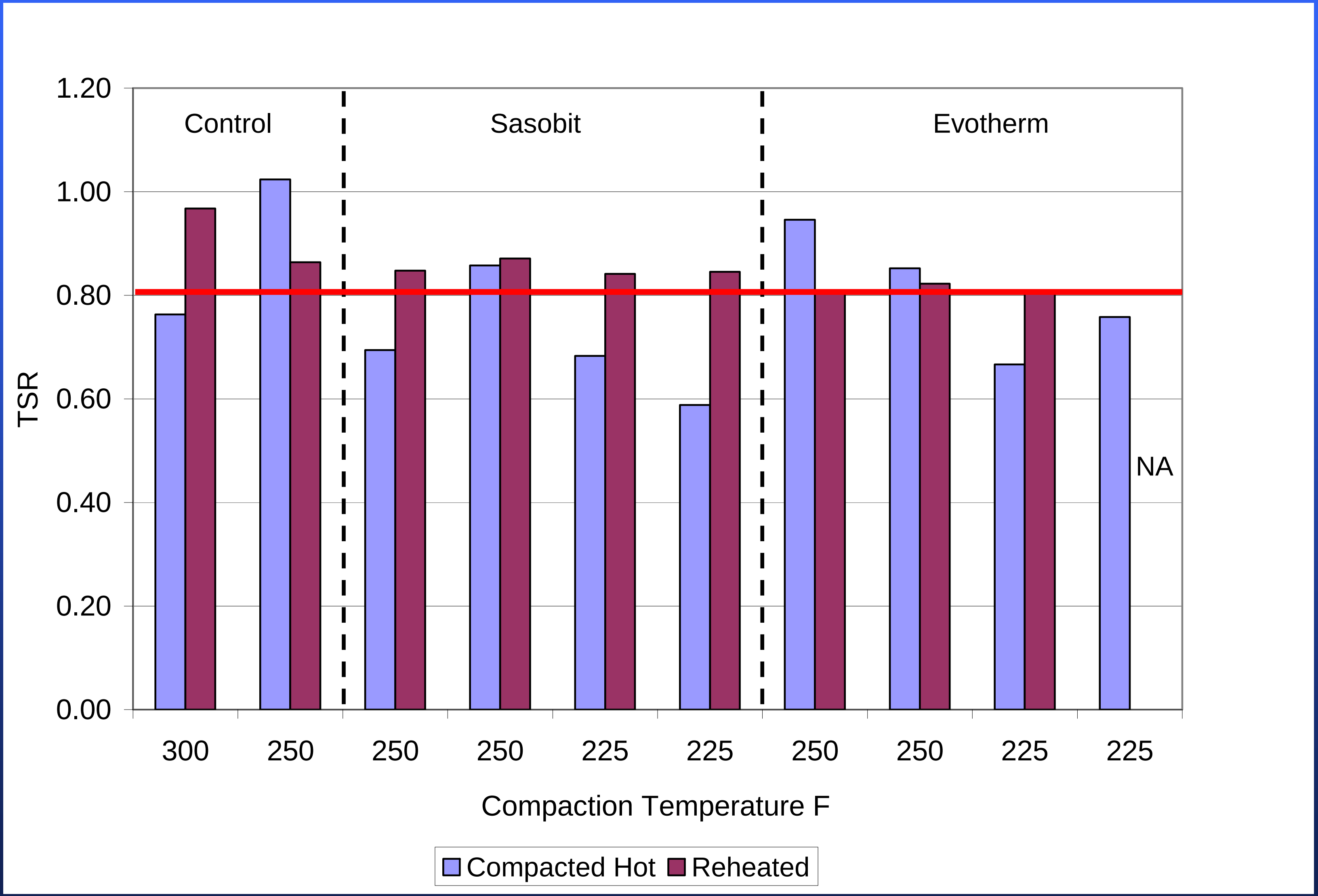
Average of six samples

Missouri APA Rut Depth



Average of six samples

Missouri TSR



Average of six samples

What Have We Learned?

- WMA additives improve compaction, both in the lab and in the field
- In the lab, rutting increases with lower temperatures – may not translate to the field
- Moisture, trapped in the aggregates and introduced into the mix, still a concern. Long-term affects unclear. Can mitigate effect in lab.

Things We Need to Go Forward

- Larger trials – Ongoing!
- A robust product evaluation protocol – Draft Developed!
- Better understanding of effect on rutting and moisture damage – Lab vs. Field
- Procedures for mix design and QC/QA (Do they need to be different?)
- A way for Agencies to specify
  - Temperature reduction?
  - Binder grade?

Vision?

- Started with: Is it possible? – Yes!
- Tool for the toolbox
  - Compaction aid for stiff mixes
  - Extend paving season (cold weather)
  - Allow longer haul distances
  - Address emissions and odor concerns in limited urban areas
- A future solution to changes in emissions or worker exposure requirements, *if necessary*

Thanks!

For More Information:

www.ncat.us

NCAT 05-04 Aspha-min

NCAT 05-06 Sasobit

NCAT 06-02 Evotherm

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