

Warm Mix Asphalt Technologies: Where are We?



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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!

Warm Mix Asphalt: Where are We?

- 2002 - NAPA Sponsored a study tour of WMA technologies in Europe
- 2003 - Potential suppliers (existing products) approached about funding research to evaluate WMA for U.S. Market
- 2004
 - Evaluation of first product completed
 - First trial sections placed
- 2005
 - Two more product evaluations completed
 - Numerous test sections completed

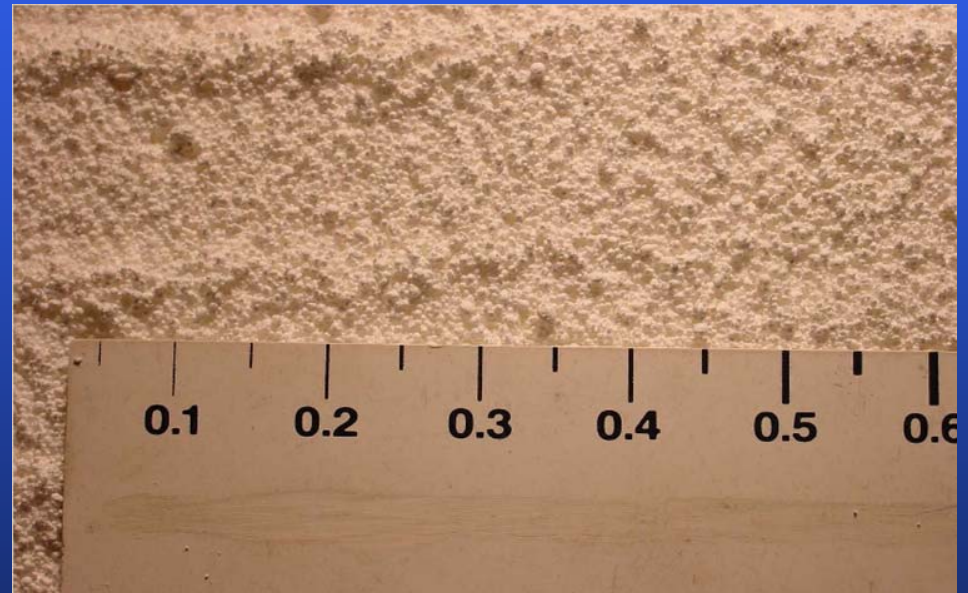
What are Warm Asphalt Mixes?

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
- New Products under development

Aspha-min® Zeolite

- When the Zeolite is heated, it gives up its internal moisture, approximately 21% by weight, microscopically foaming the asphalt
- Typically added at 0.3% by TWM



U.S. Drum Plant Addition of Aspha-min®

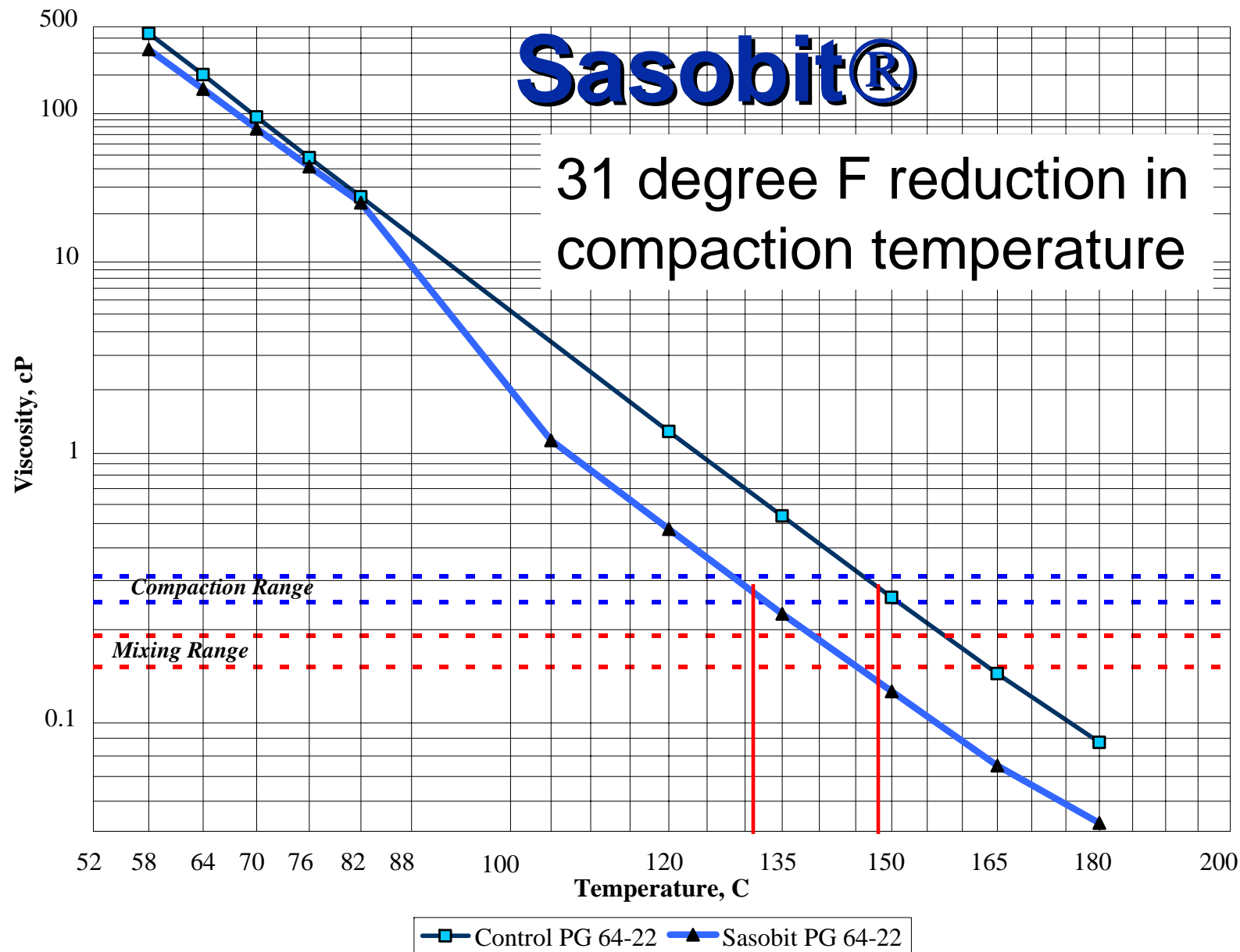


Sasobit®/Sasoflex

- 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



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, $G^*/\sin \delta$, kPa	1.015	1.815	1.790	2.689	1.290	1.461
RTFO DSR, $G^*/\sin \delta$, kPa	2.781	3.868	3.950	4.548	3.096	2.682
Test Temp., °C	19	25	25	28	31	31
PAV DSR, $G^*\sin\delta$, 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

Addition of Evotherm® from Tanker



Optional
in-line
addition
of latex

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

Product Evaluations

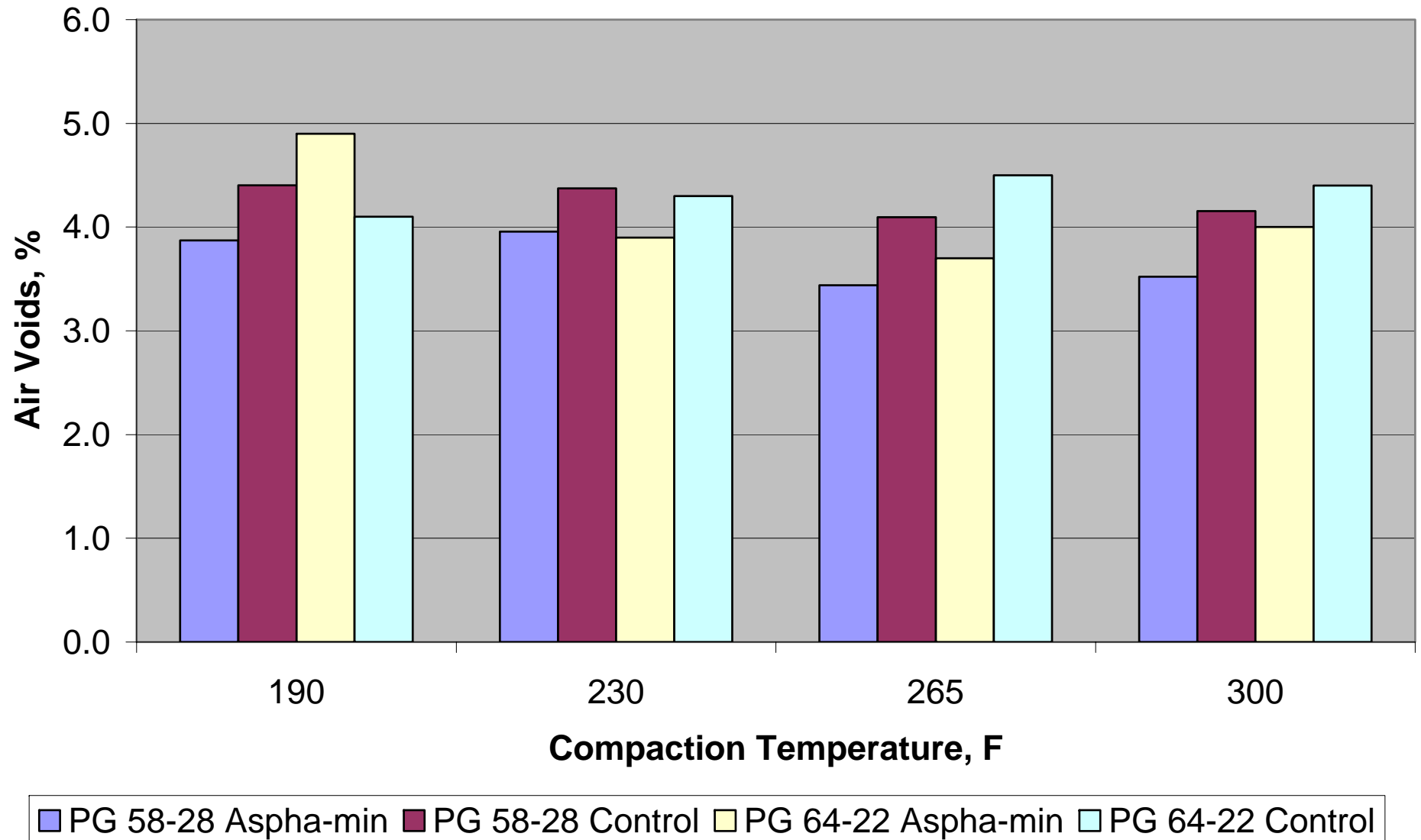
- Evaluate Warm Asphalt Technologies for U.S. Paving Practices
 - Compaction
 - Quick “turn-over” to traffic
 - Rutting
 - Resilient modulus (for pavement design)
 - Moisture damage
- Products Evaluated
 - Aspha-min zeolite
 - Sasobit
 - Evotherm

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



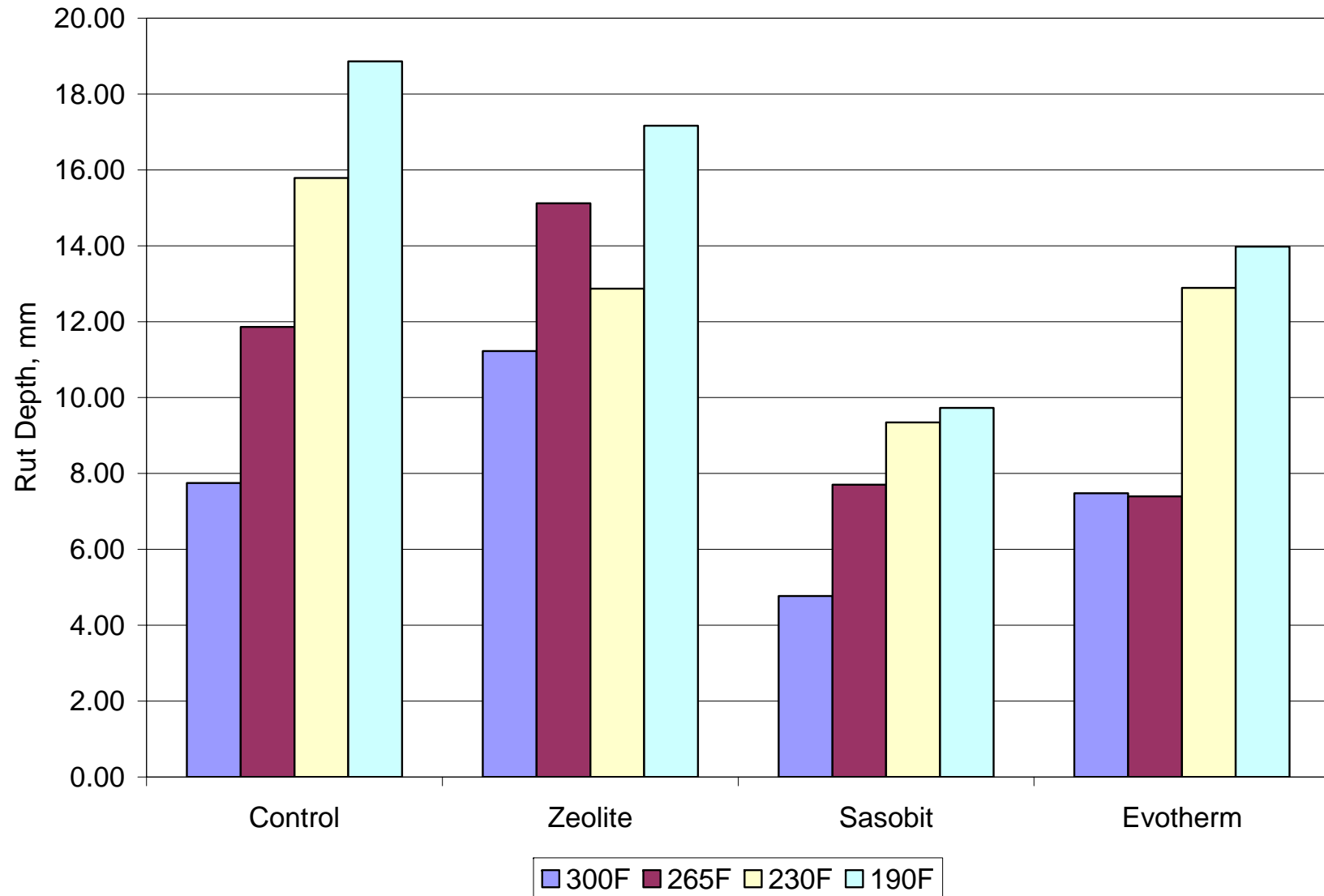
Limestone - SGC



Samples mixed 35F above compaction temperature

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)

Effect of Lower Production Temperatures on Binder Aging

- Compaction results for control mixture < 230F and APA results suggest reduced aging of binder
- Binder recoveries suggest mixing temperatures < 250 do not produce same aging as RTFO
- Care must be taken when recovering binder to avoid artificial aging
 - “Casting” used for Evotherm

Moisture Susceptibility

Simulating a Drum Plant



Failure Modes



Adhesive



Cohesive

Moisture Susceptibility

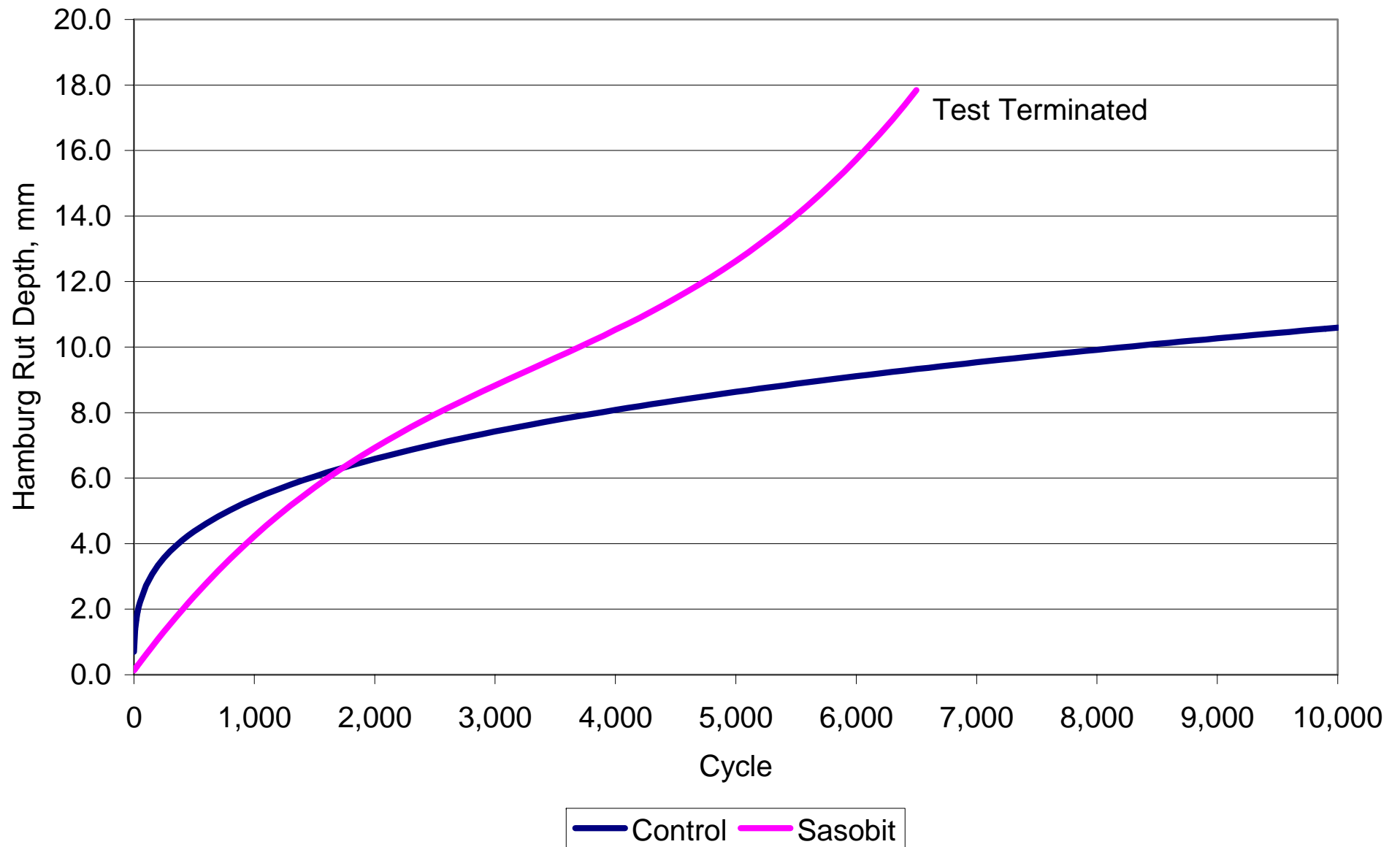
- All technologies evaluated to date and control have in some cases indicted moisture susceptibility
- Tests at “normal” temperatures have not indicted a problem
- TSR and Hamburg do not always agree, Hamburg sometimes indicates better performance
- Problems can be mitigated with anti-stripping agents.

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

PG 64-22 Granite



Granite Hamburg Stripping Inflection Point

Additive	SSD+ in Bucket Mixer at 250F	Bucket Mixer With Anti-Strip	Anti-Strip Agent
HMA	6500*	NA	0.75% LOF 6500
Zeolite	3975	8500*	1.5% Lime
Sasobit	3450	>10,000	0.4% Magnabond
Evotherm	>10,000	NA	Evotherm

* One of two samples did not have striping inflection point in 10,000 cycles

Field Sections

More than ten U.S. sections to date
World wide in dense-grade, SMA and OGFC

Seeing is Believing!

Orlando, FL - 2004

Hot Mix 314 F



138.1 pcf

Aspha-min Mix 254 F



138.5 pcf

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**

Addition of Evotherm® from Tanker



Optional
in-line
addition
of latex

Evotherm Wearing Course with Latex

Mix Produced 7:00 PM



Mix Loaded out 1:30 PM – next day

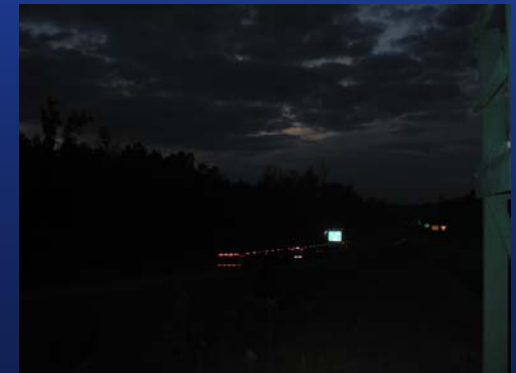


Mix held in
silo at 240F
overnight

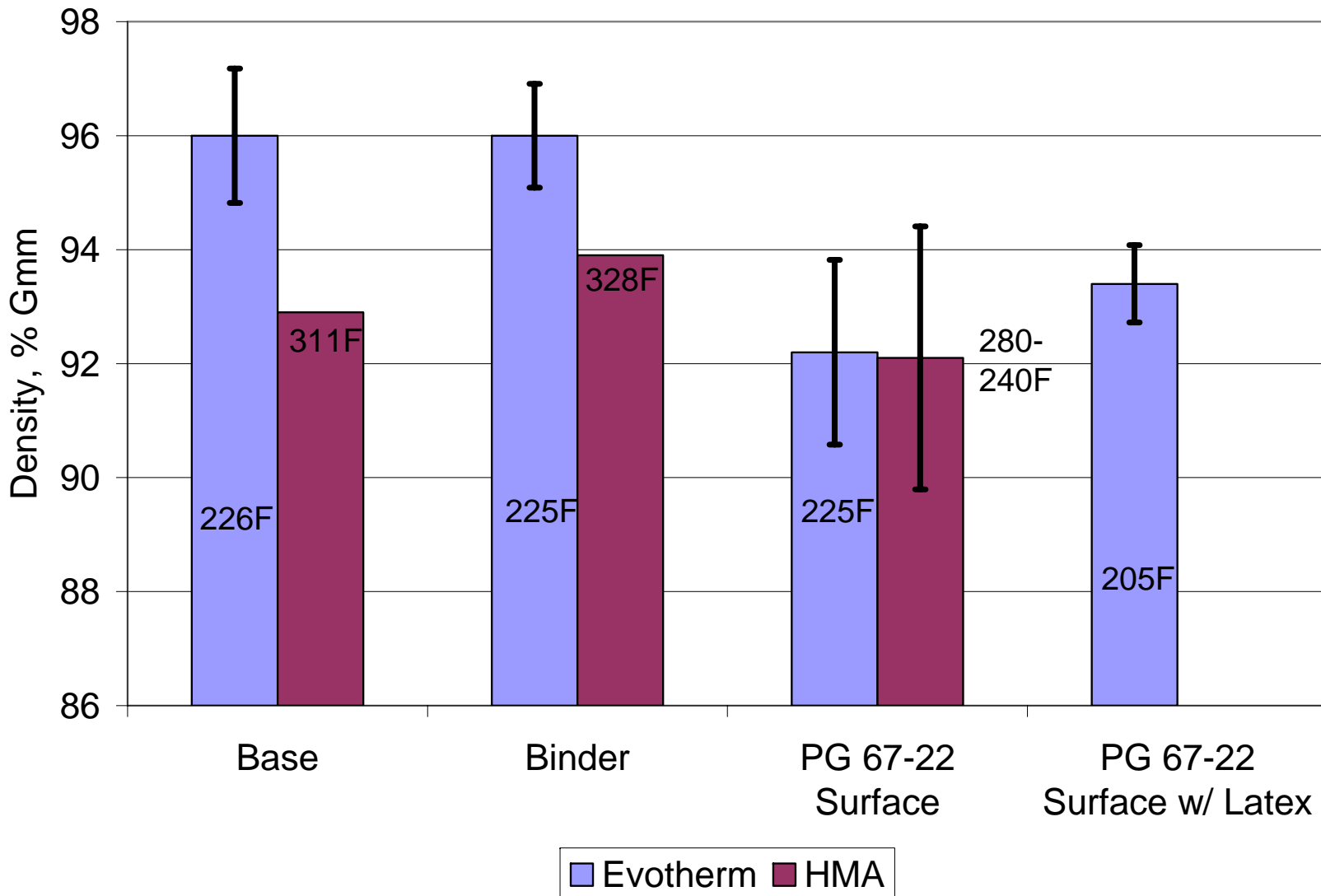
Mix Placed at 3:15 PM



Traffic Returned at 5:00 PM



Test Track Pavement Densities



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.

Recommendations

- At this time, determine optimum asphalt content without warm asphalt additive
- If mixing temperature is below 250 °F, consider using stiffer binder grade
- Conduct tensile strength ratio tests at anticipated production temperatures

Things We Need to Go Forward

- Larger trials
- A robust product evaluation protocol
- 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)
 - Address emissions and odor concerns in limited urban areas
- A future solution to changes in emissions or worker exposure requirements, *if necessary*

A photograph of a racetrack at sunset. The sky is filled with orange and pink clouds. A large, curved metal fence is on the left side of the track. A white truck is visible on the track in the distance. The word "Thanks!" is written in large, bold, black letters with a white outline, slanted upwards from left to right, across the center of the image.

Thanks!

