Evaluation of Warm Asphalt Technologies

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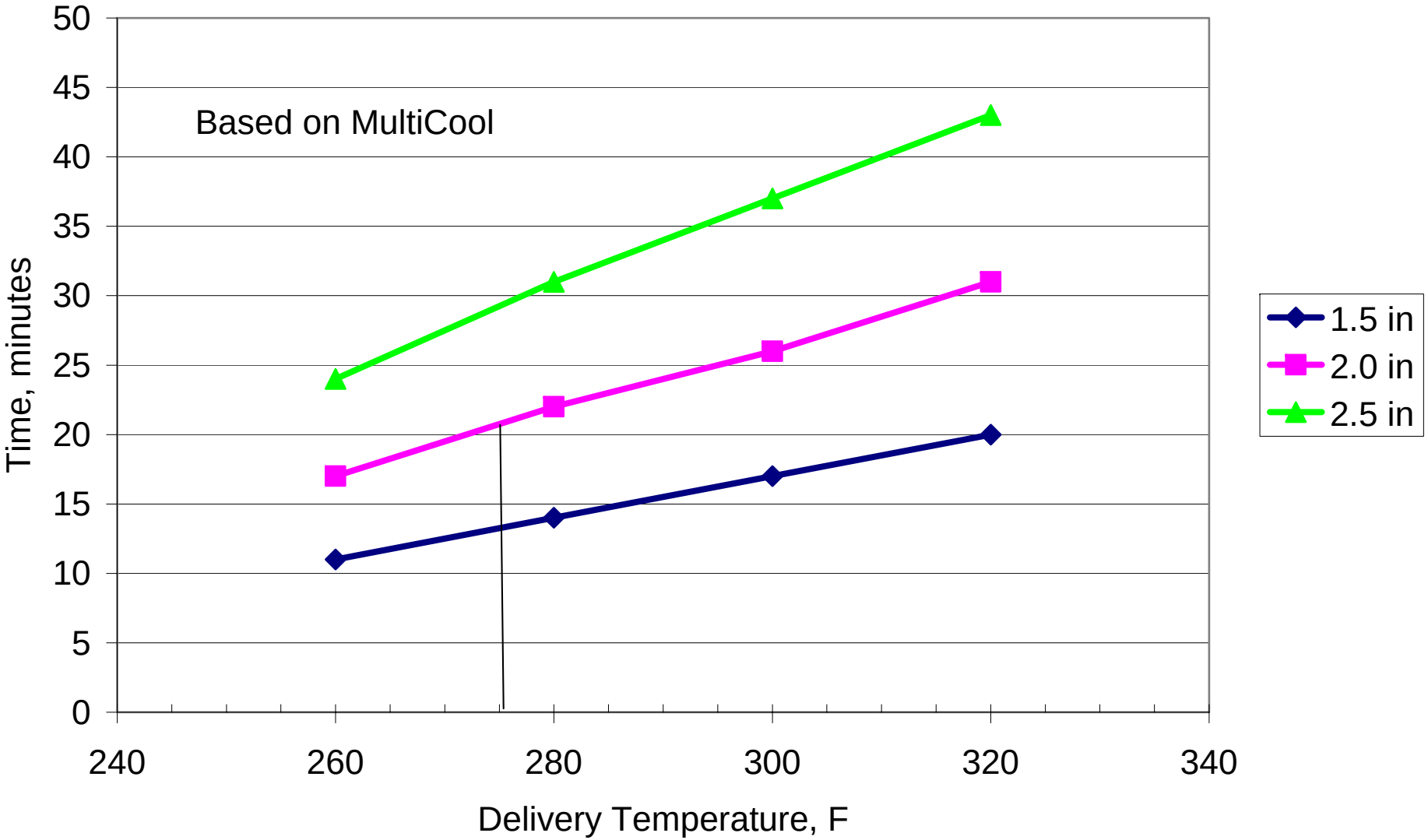
We Can Reduce Temperatures Today with No Additives

- Pre-Superpave – typical compaction temperature 275 °F
- Place Thicker Lifts – NCHRP 9-27
  - 3 x NMAS for fine graded
  - 4 x NMAS for coarse graded
- Tarp Trucks
- Drier Aggregate – pave under stockpiles

Time Available for Compaction



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

Comparison of Visible Emissions

Courtesy of Shell/Kolo Veidekke

What are Warm Asphalt Mixes?

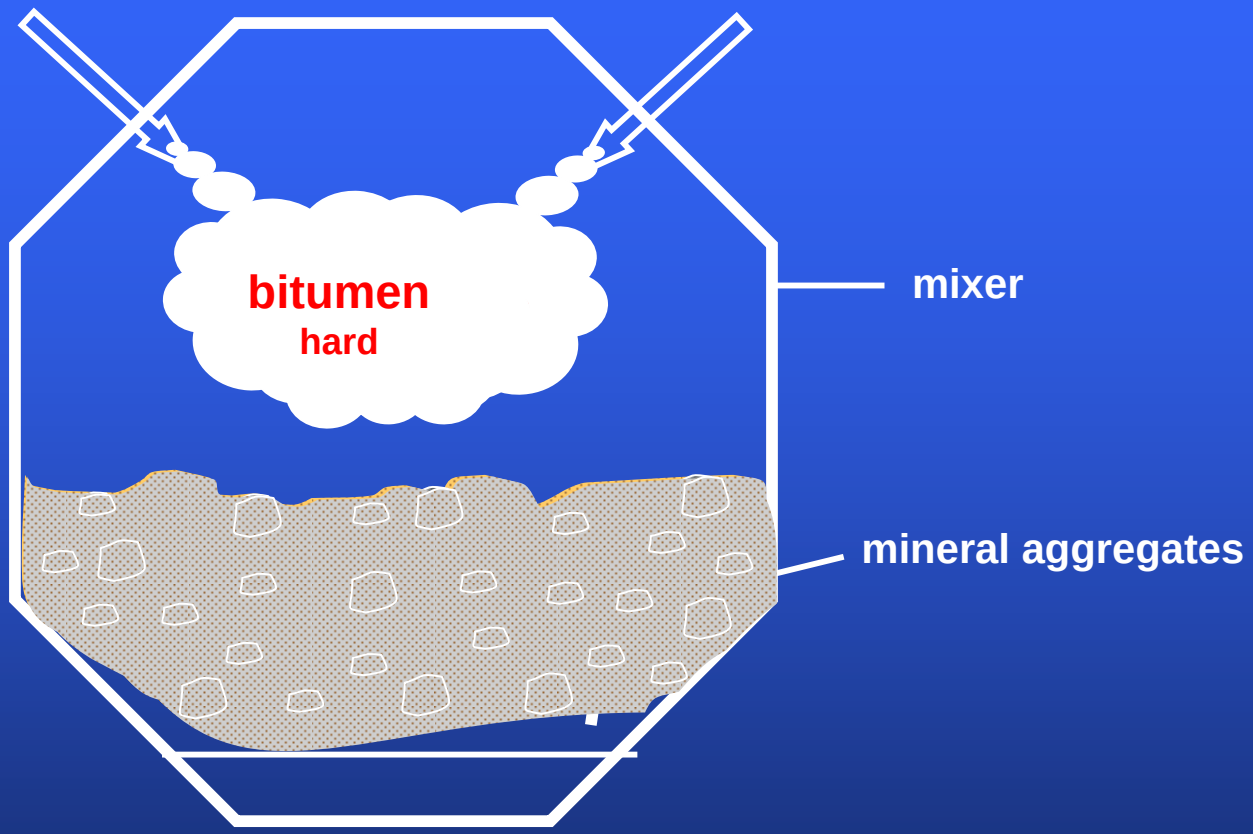
Several process have been developed to improve mixture workability allowing lower production and laydown temperatures

- WAM Foam – Shell/Kolo Veidekke
- Zeolite – Eurovia/Hubbard Construction
- Sasobit – Sasol Int./Moore and Munger
- Evotherm - MeadWetvaco

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

Two phase bitumen mixing method



Courtesy IFTA GmbH

WAM Foam Installation in Hot Mix Asphalt Plant

Courtesy of Shell/Kolo Veidekke

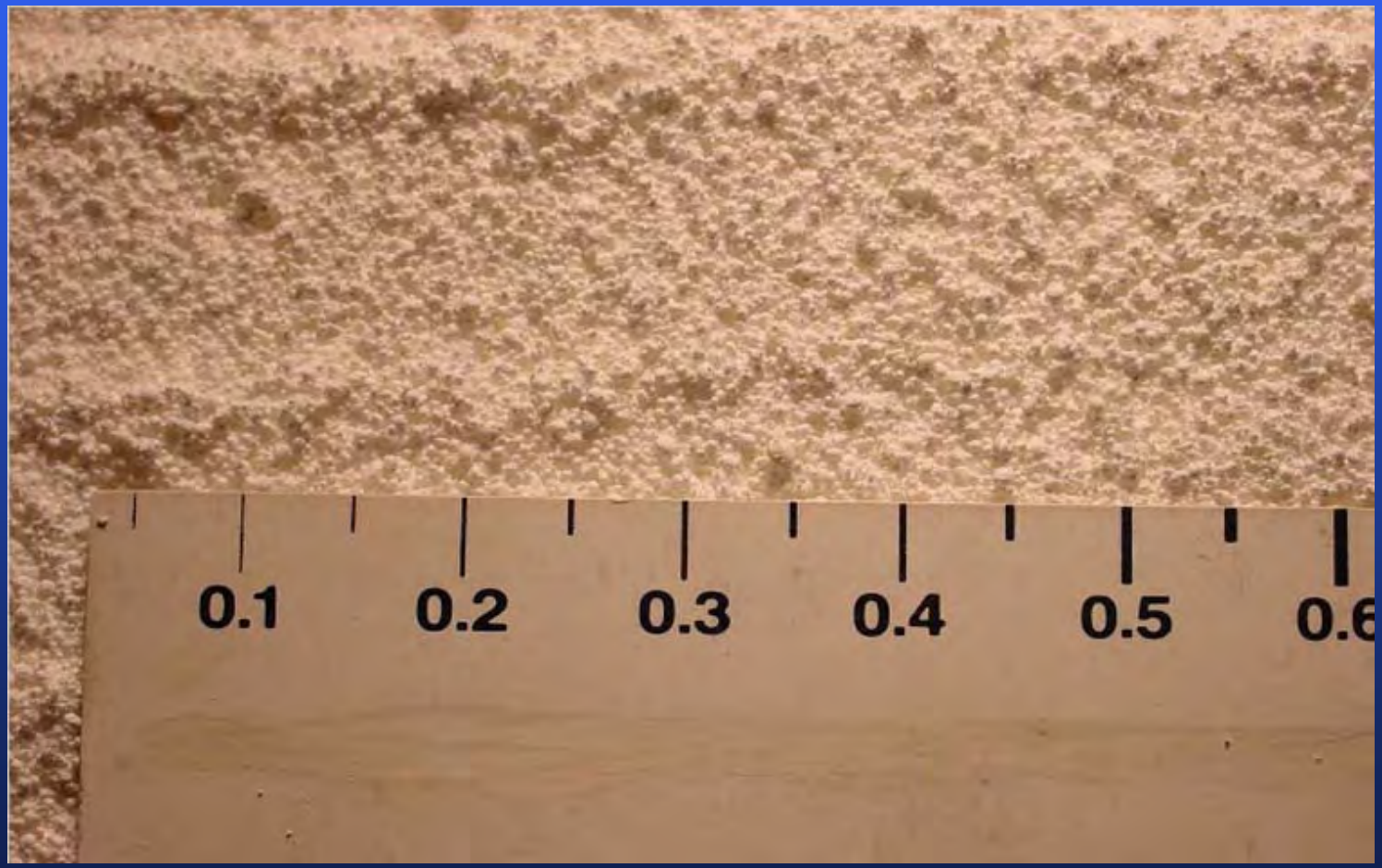
Zeolite

- Zeolites are crystalline hydrated aluminum silicates
- aspha-min®, is a special Zeolite added to the hot mix asphalt in the temperature range of 100 to 200 °C (212 to 392 °F)
- When the Zeolite is heated, it gives up its internal moisture, approximately 21% by weight, microscopically foaming the asphalt

Addition of aspha-min®

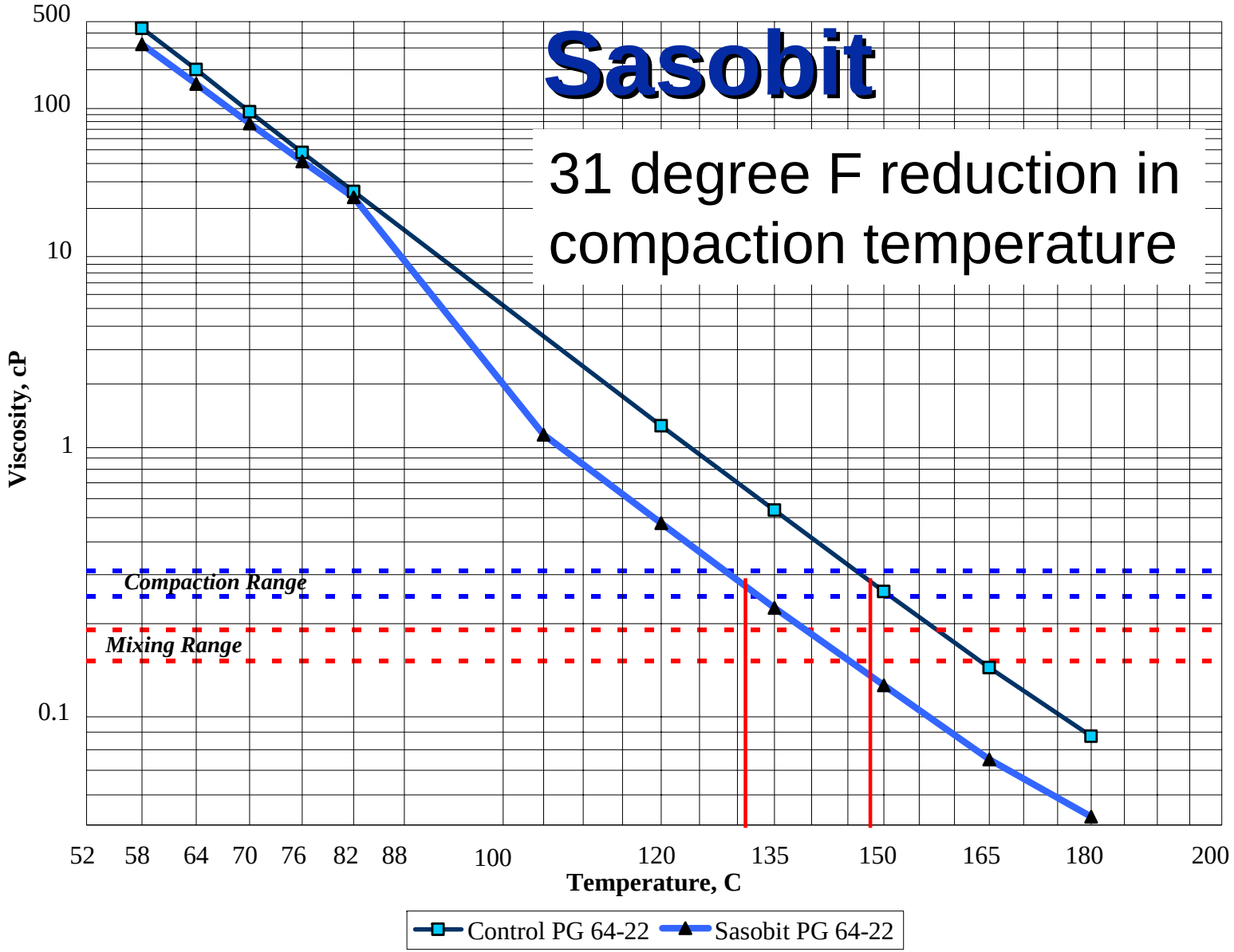
- Aspha-min is typically added at an addition rate of 0.3% by weight of mix
- Expected to increase mix cost by approximately $1.50 per ton
- Can be added to the mineral filler or fed separately
- Can be added directly into the pugmill of a batch plant, or
- Can be blown into a drum plant using a specially built feeder

Granulated aspha-min®



Sasobit/Sasoflex

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

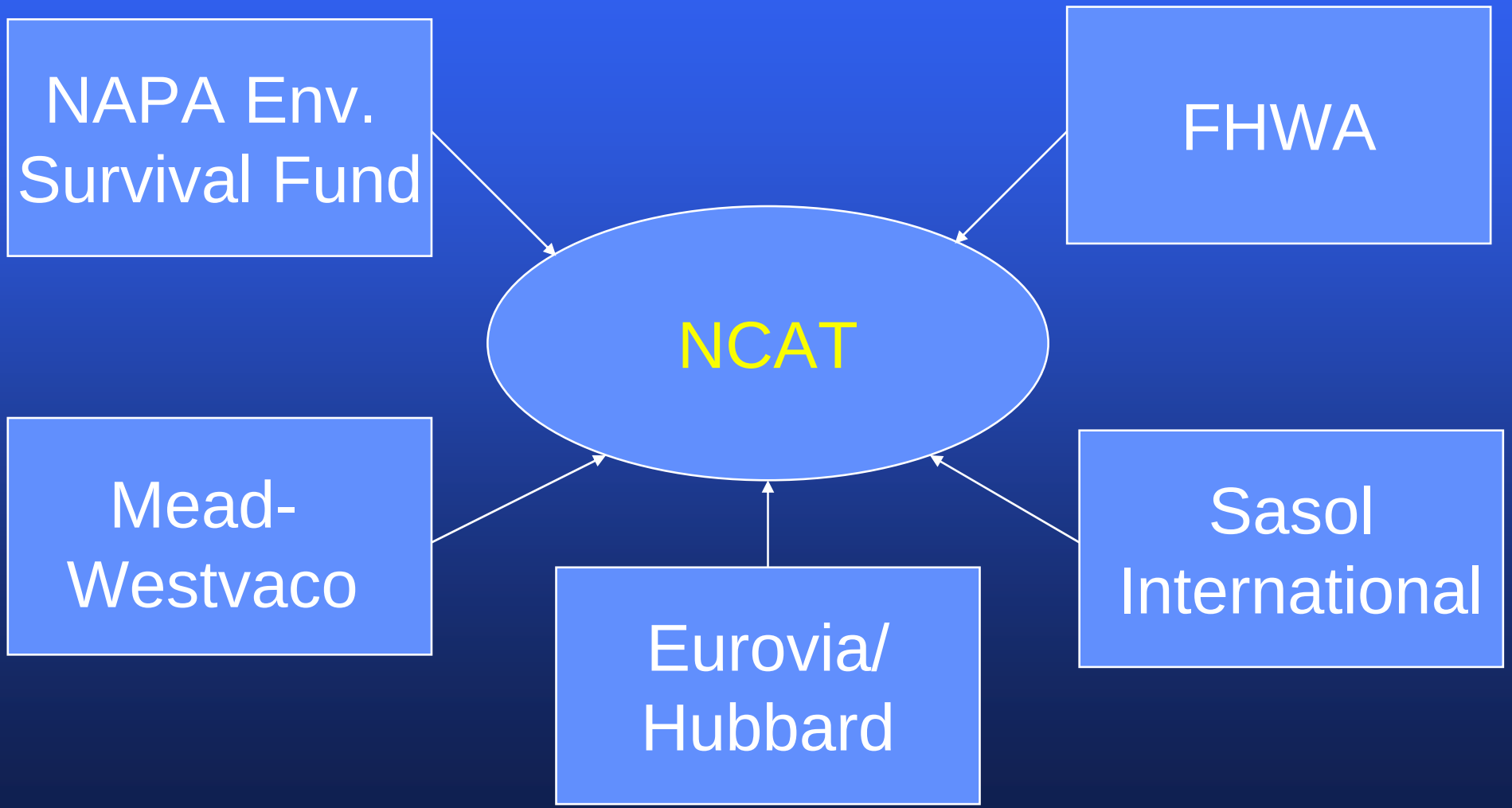

Sasobit
31 degree F reduction in compaction temperature
Viscosity, cP
500
100
10
1
0.1
Compaction Range
Mixing Range
52
58
64
70
76
82
88
100
120
135
150
165
180
200
Temperature, C
Control PG 64-22
Sasobit PG 64-22

Sasobit

Evotherm

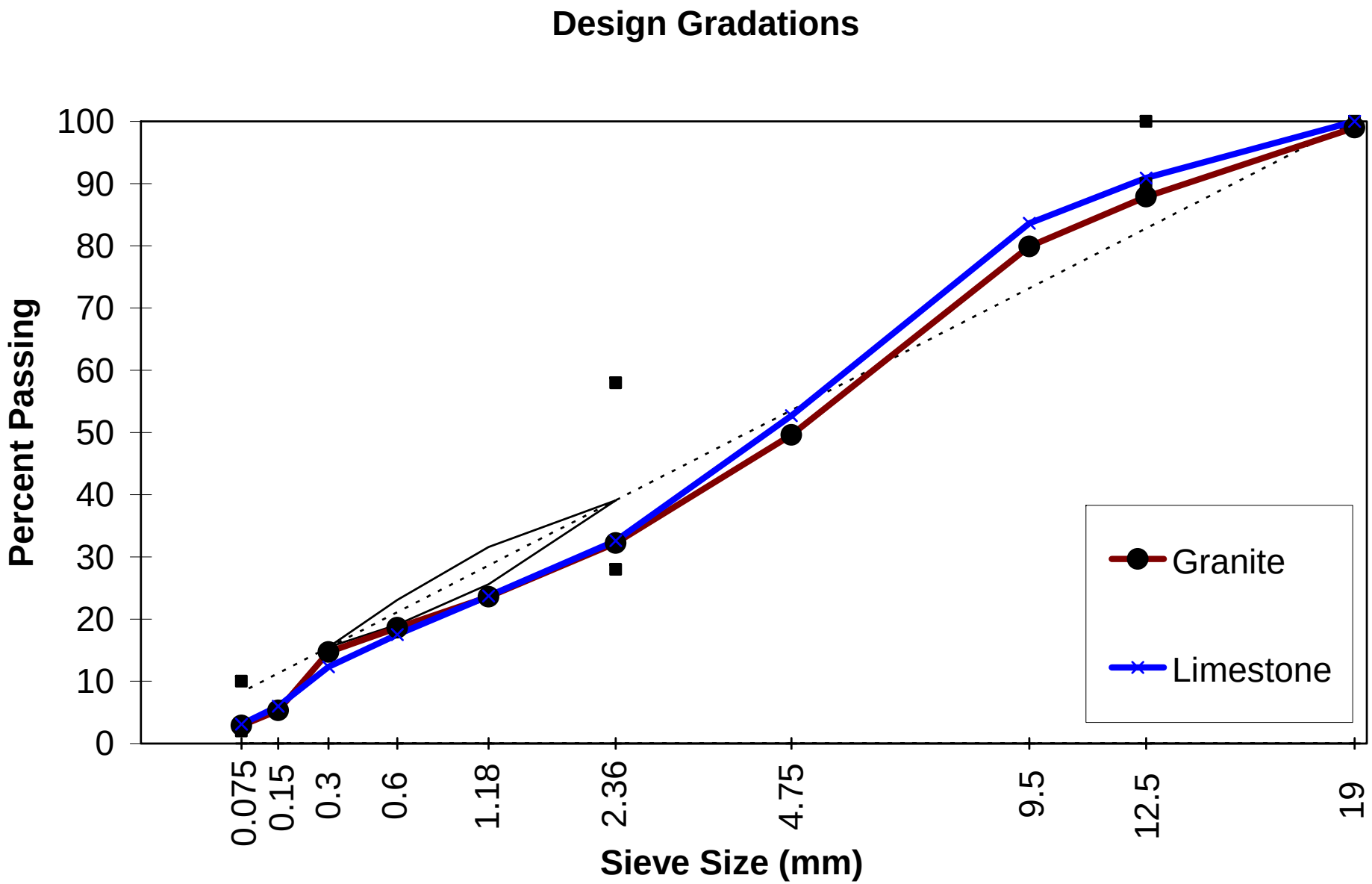
- Emulsion – approximately 70% binder residue
- Includes adhesion promoters (e.g. anti-stripping agents)
- Storage at 80 °C (176 °F)
- Some steam liberated upon mixing

Project Partners (To Date)



Study Objectives

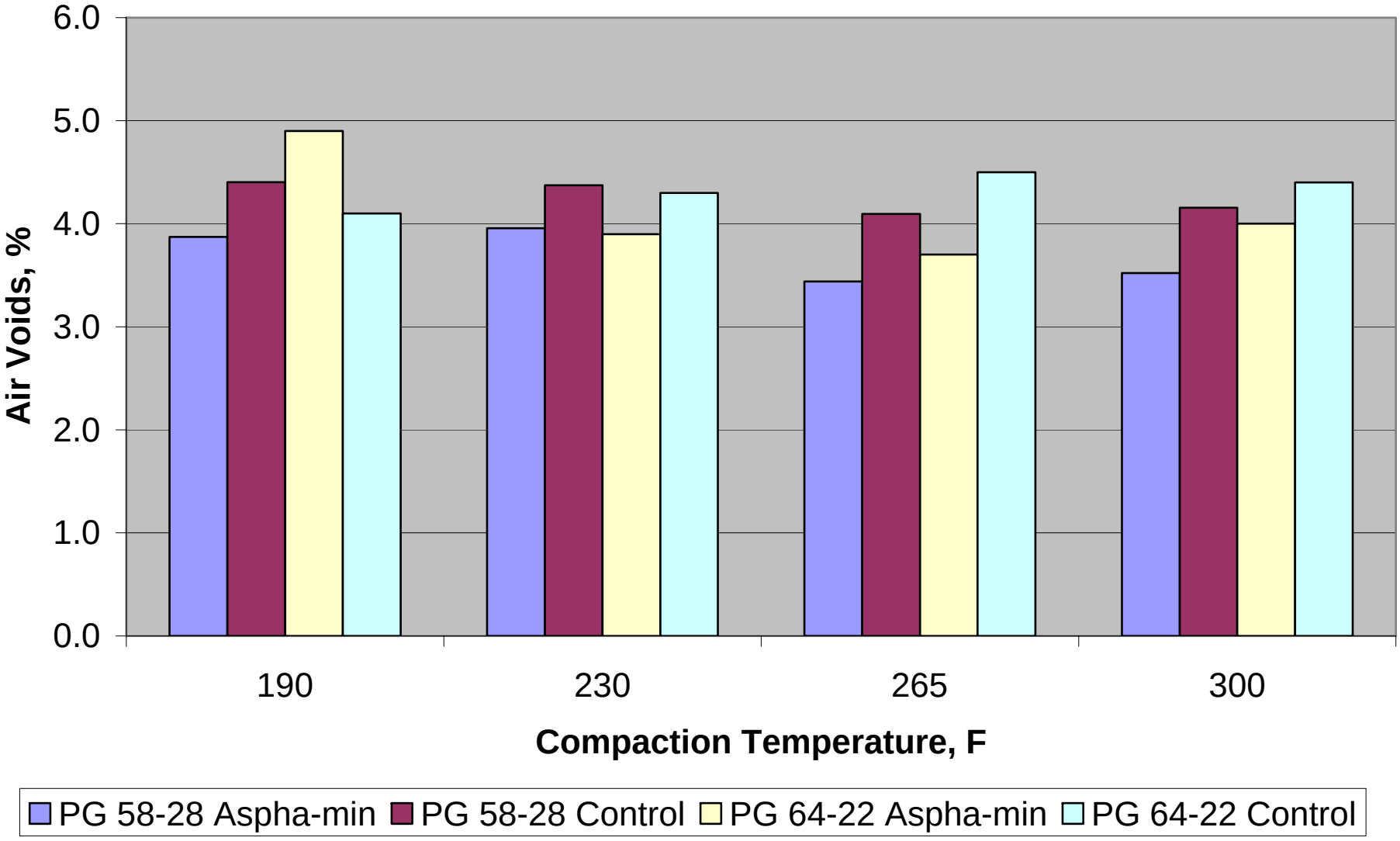
- Evaluate Warm Asphalt Technologies for U.S. Paving Practices
  - High production
  - Rapid Turn-over to traffic
- Potential Concerns
  - “Curing” Time
  - Increased Potential for Moisture Damage
  - Binder effects

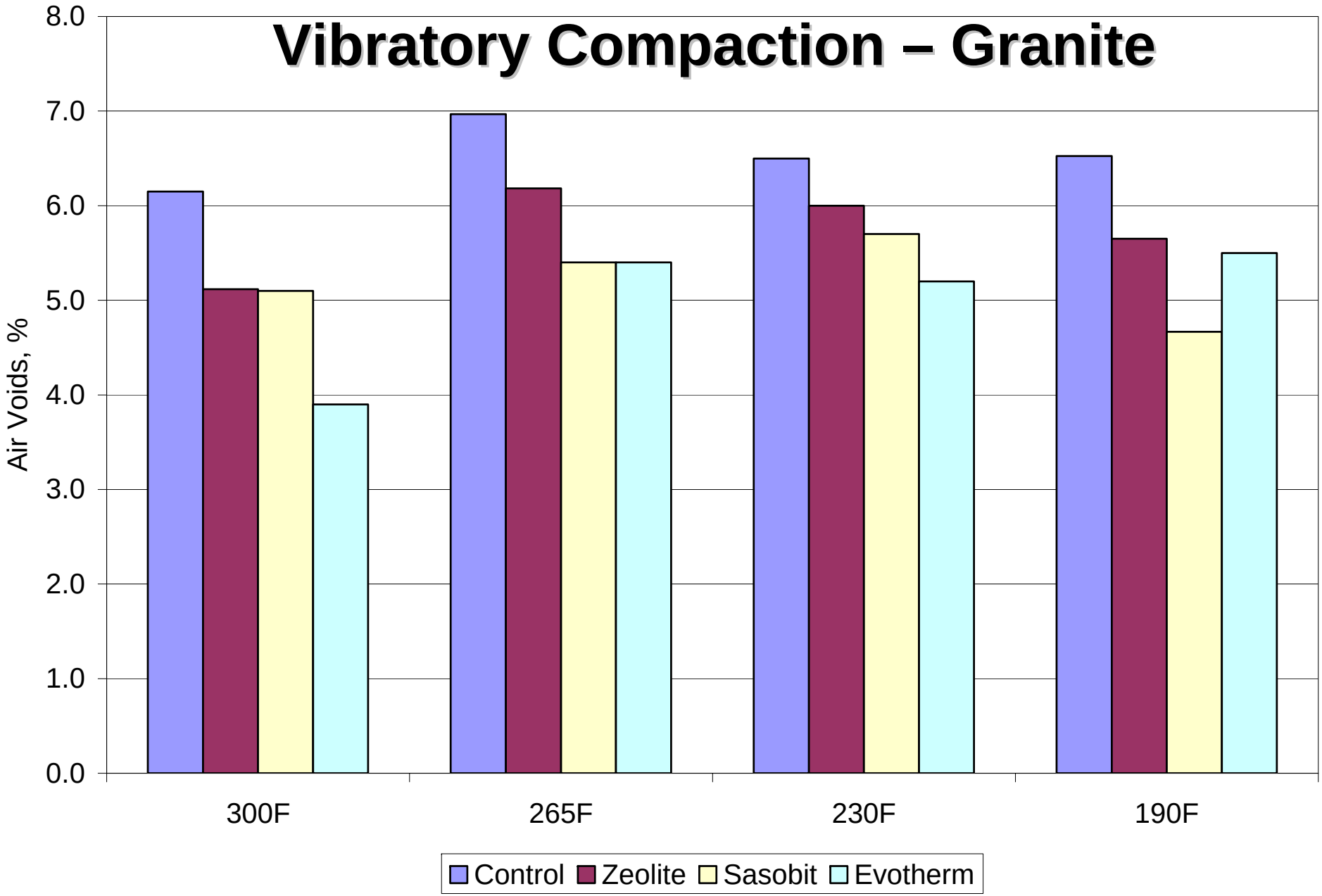

Design Gradations
Percent Passing
100
90
80
70
60
50
40
30
20
10
0
0.075
0.15
0.3
0.6
1.18
2.36
4.75
9.5
12.5
19
Sieve Size (mm)
Granite
Limestone

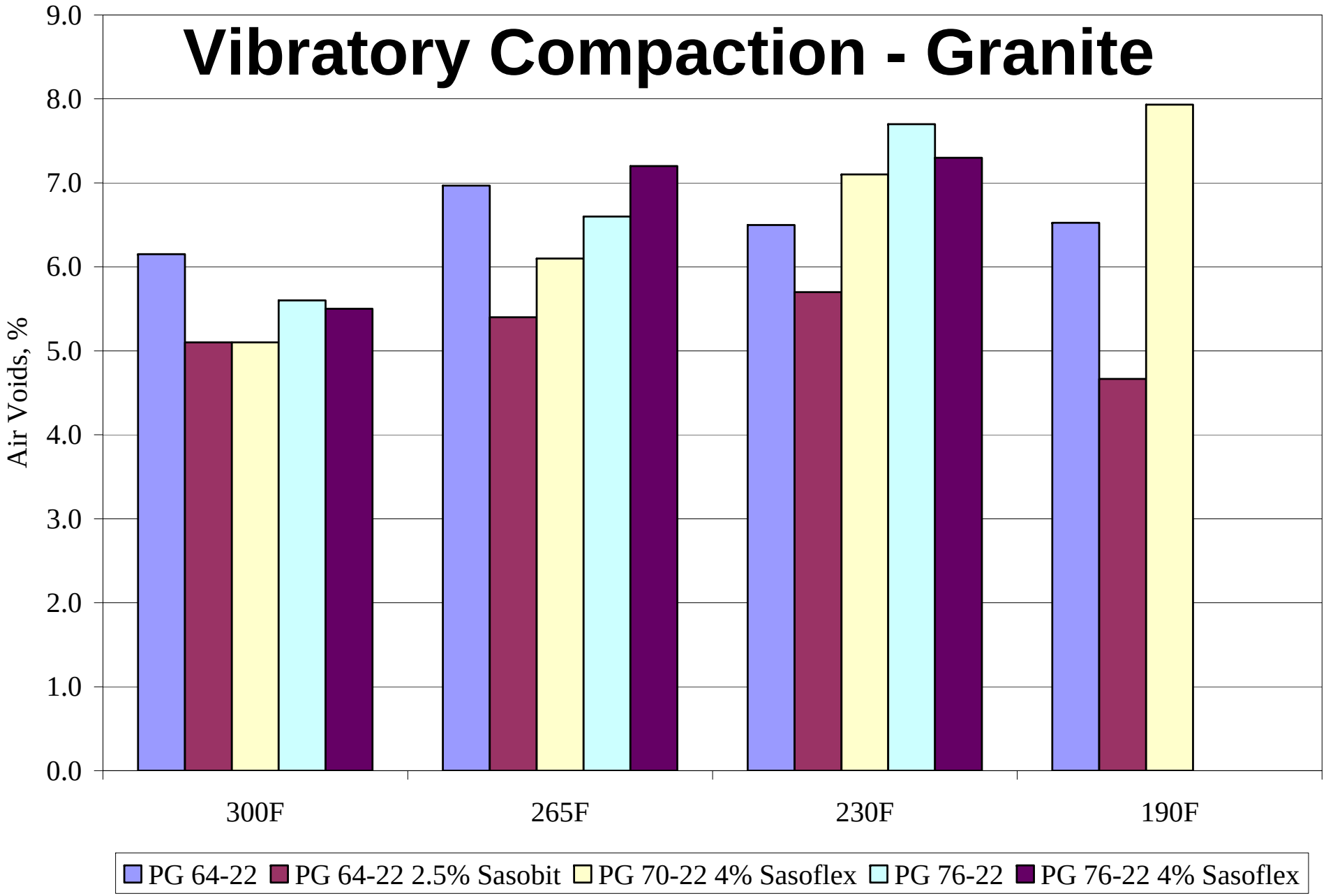
How Do You Measure Compaction in Lab?

- 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




Vibratory Compaction – Granite
Air Voids, %
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
300F
265F
230F
190F
Control
Zeolite
Sasobit
Evotherm


Vibratory Compaction - Granite
Air Voids, %
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
300F
265F
230F
190F
PG 64-22
PG 64-22 2.5% Sasobit
PG 70-22 4% Sasoflex
PG 76-22
PG 76-22 4% Sasoflex

Summary of Laboratory Compaction

- Aspha-min Evotherm and Sasobit improved compaction with both the SGC and vibratory compactor. For PG 64-22:
  - Evotherm reduced air voids 1.5%
  - Sasobit reduced air voids 0.9%
  - Aspha-min reduced air voids 0.8%
- Warm asphalt additive may reduce design asphalt content

German Autobahn Paving

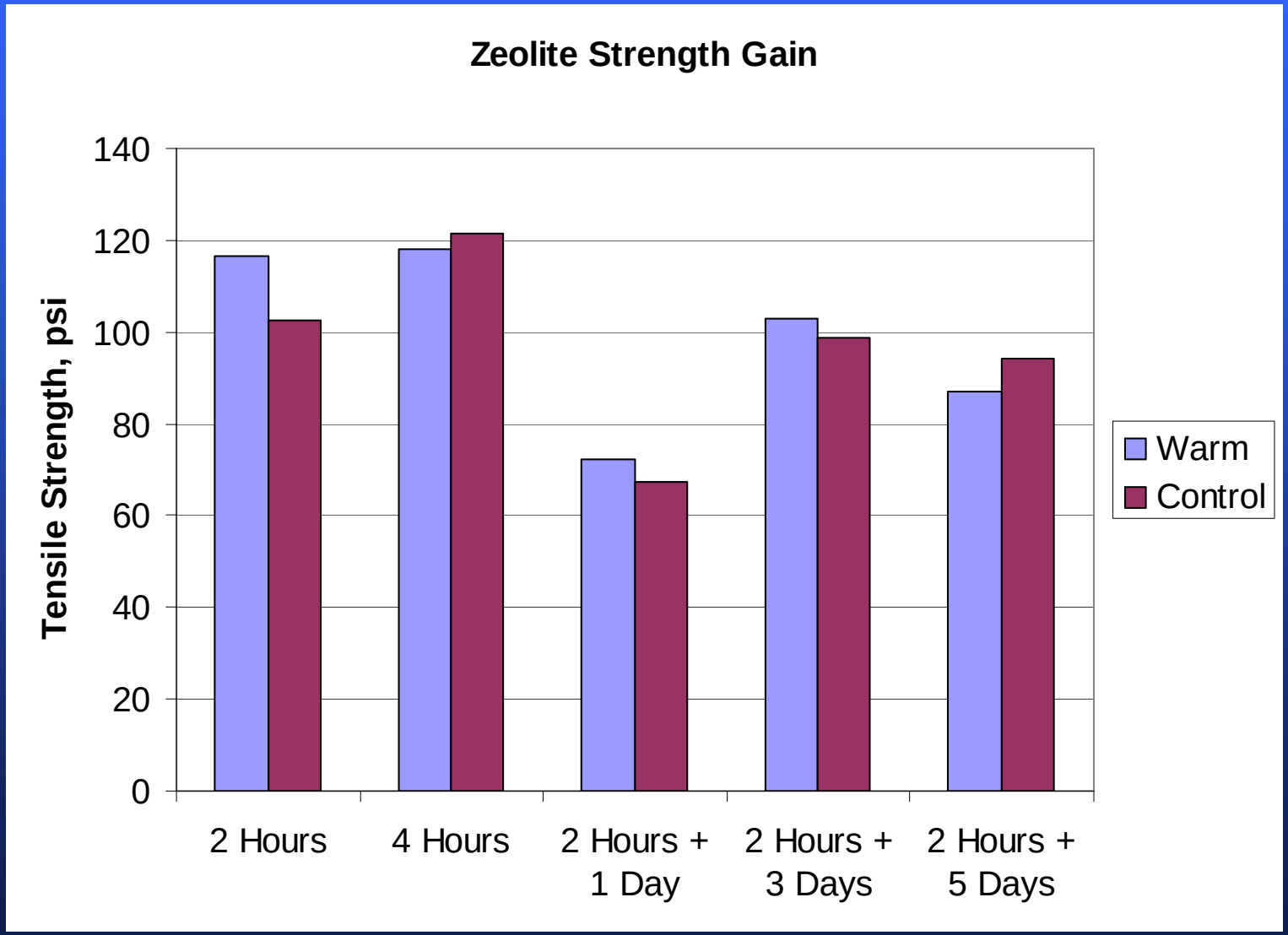
Cure Time – Early Concern

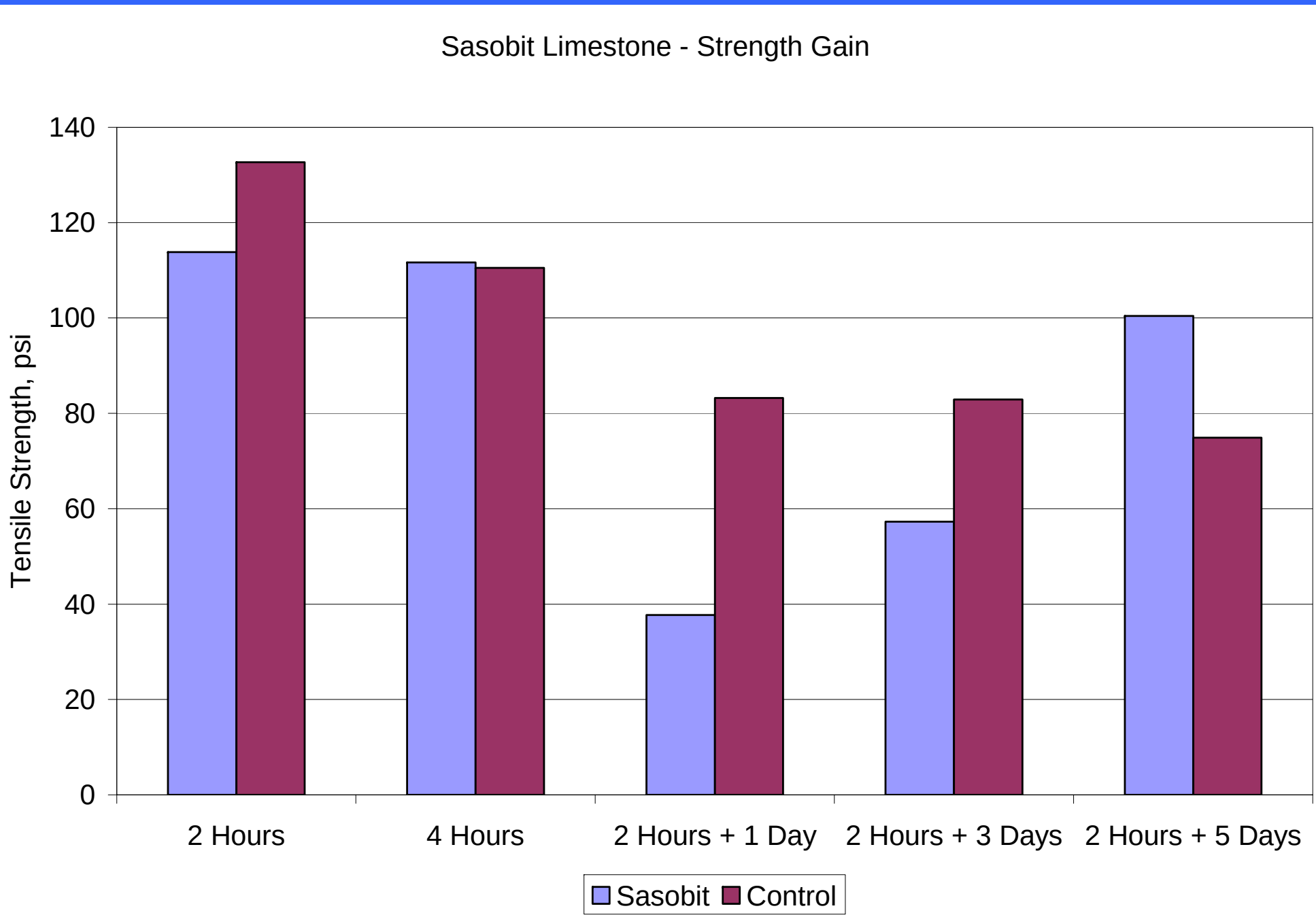
- In Germany, traffic may not be immediately returned to traffic
- When does Warm asphalt's workability end?
- Will pavements rut if traffic allowed on an hour or so after placement?

European Cure Time Experience

- Sasobit being used for repaving Frankfurt Airport.
  - Placing 24 inches of HMA in 7.5 hour window (approx. 1,500 tons)
  - Opening to jet aircraft at 85 C (185 F)
- WAM Foam Paving SMA on ring road around Oslo Norway – Night work opened for rush hour traffic

Strength Gain Experiment

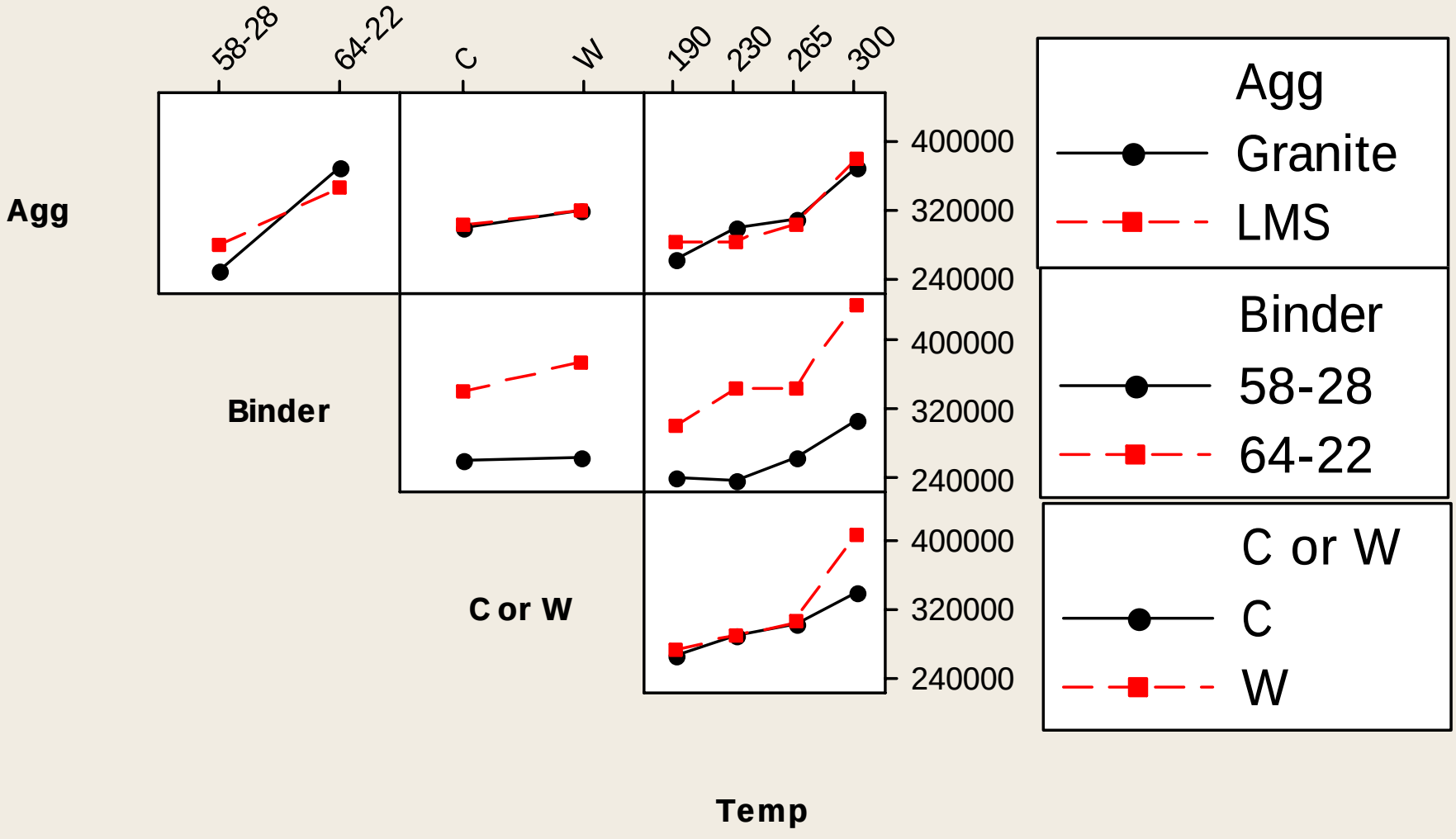



Sasobit Limestone - Strength Gain
Tensile Strength, psi
140
120
100
80
60
40
20
0
2 Hours
4 Hours
2 Hours + 1 Day
2 Hours + 3 Days
2 Hours + 5 Days
Sasobit
Control

Resilient Modulus

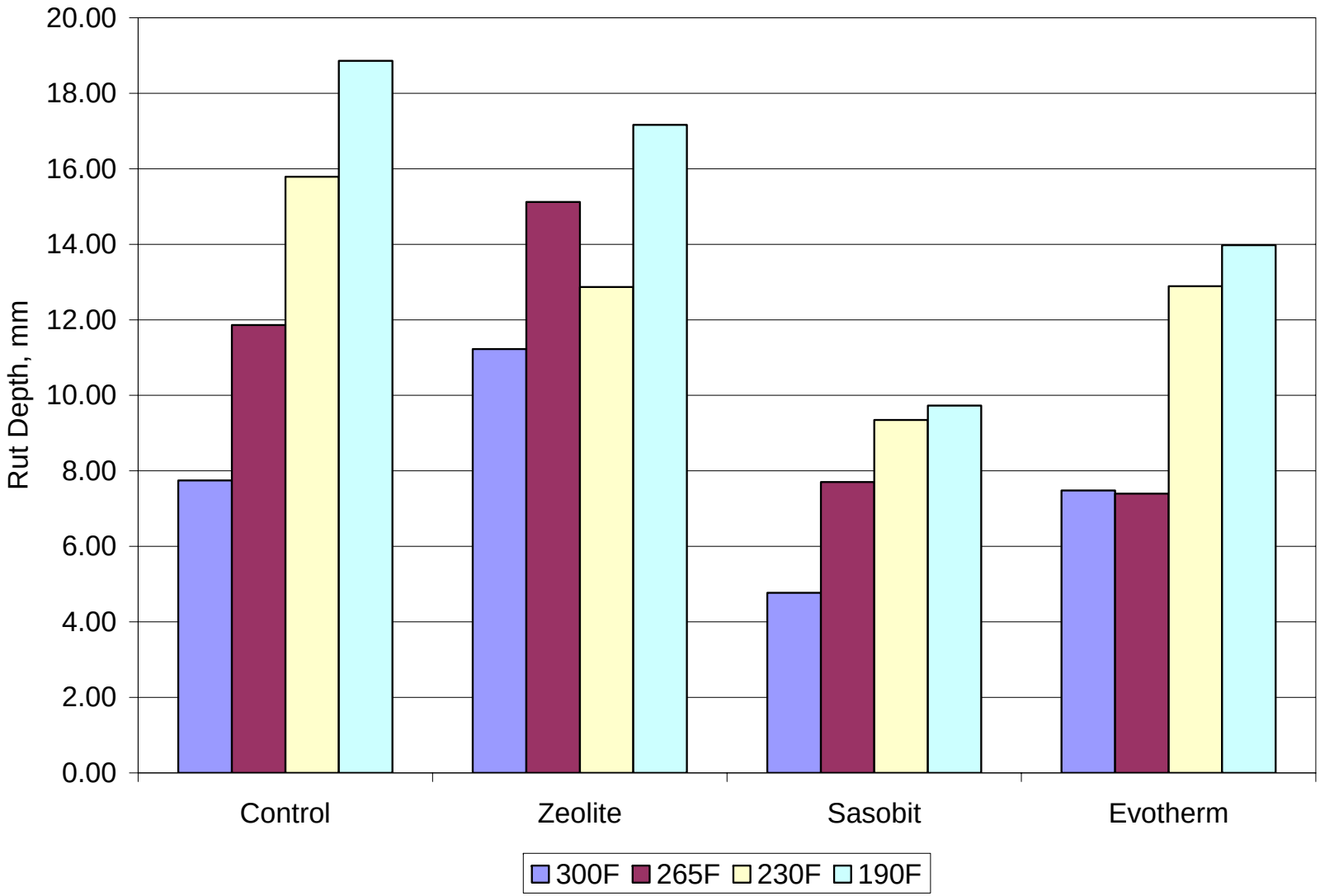
Would the use of Warm Asphalt effect pavement thickness design?

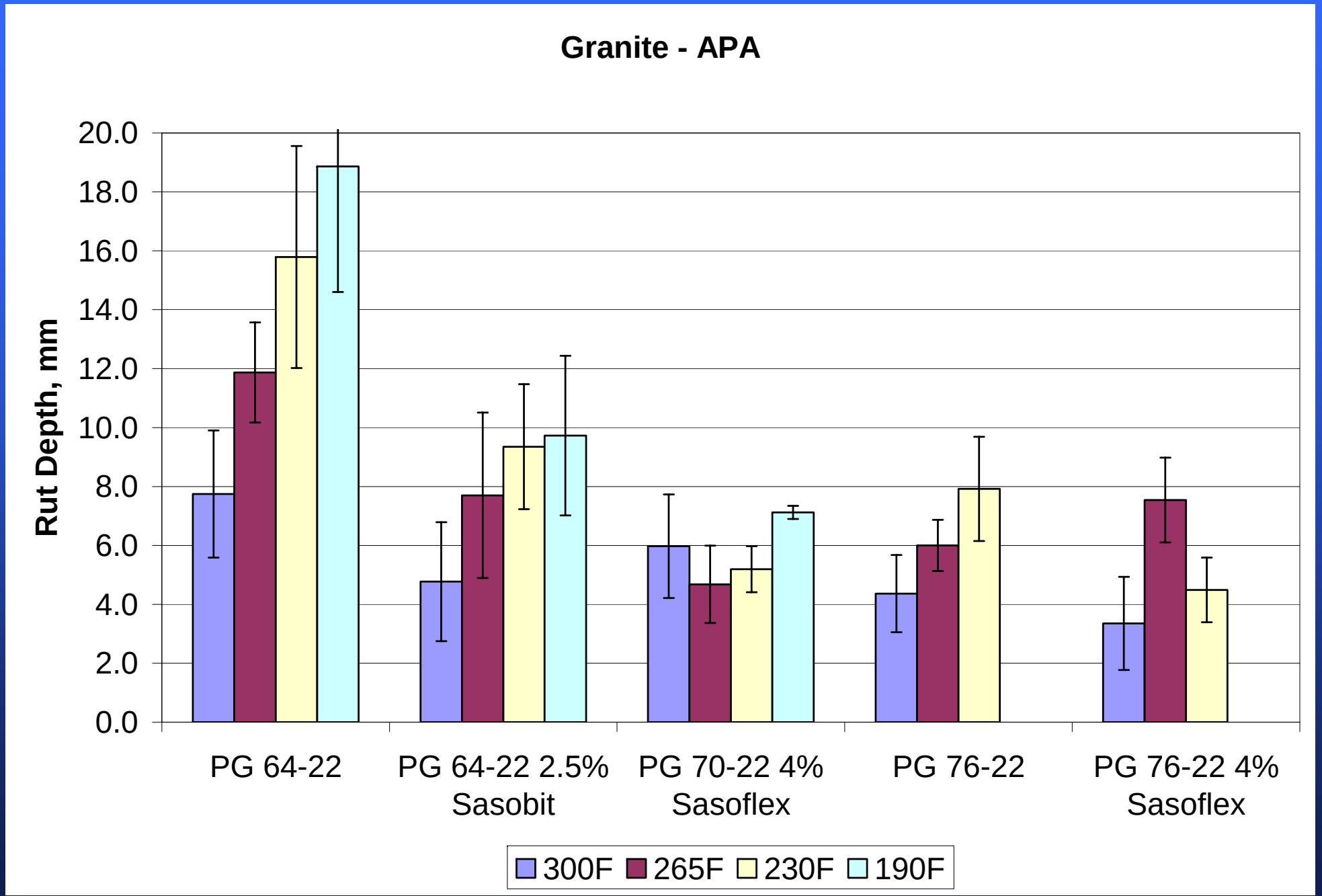
Interaction Plot for Resilient Modulus



APA Rut Testing

APA Rut Depth for PG 64-22 - Granite




Granite - APA
Rut Depth, mm
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
PG 64-22
PG 64-22 2.5% Sasobit
PG 70-22 4% Sasoflex
PG 76-22
PG 76-22 4% Sasoflex
300F
265F
230F
190F

Summary of Stiffness and Permanent Deformation

- No evidence of required “cure time” based on indirect tensile strength after various aging periods
- Statistical Analysis indicated that the inclusion of warm asphalt additives did not effect modulus or APA rut depth
  - Decreased temperature did decrease modulus and increase rut depth. This may be related to decreased aging of the binder
  - Higher density generally resulted in higher modulus

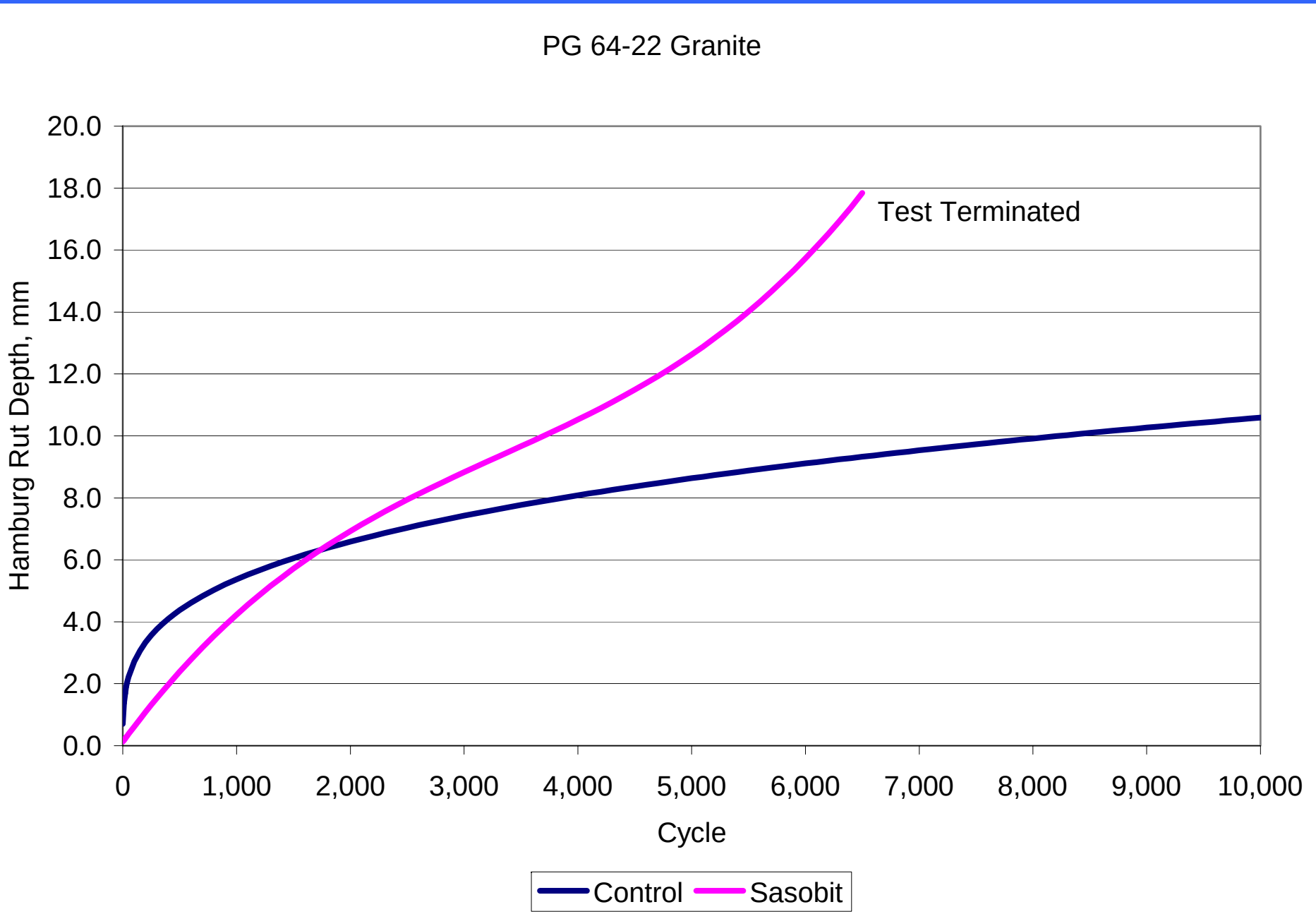
Moisture Susceptibility

Simulating a Drum Plant

Failure Modes

Adhesive

Cohesive


PG 64-22 Granite
Hamburg Rut Depth, mm
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
Cycle
Test Terminated
Control
Sasobit

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.

Field Sections

Laydown of Polymer Modified Warm Asphalt with Zeolite at 250 F

94% Gmm
55 F Air Temp.

4 passes of Rubber Tire,

followed by 4 vibratory passes, followed by static finish roller

U.S. Drum Plant Addition of Aspha-min

Seeing is Believing!

Hot Mix 314 F

138.1 pcf

Aspha-min Mix 254 F

138.5 pcf

Evotherm Field Trial
Near Indianapolis, IN
July 2005


Milestone
ENTRANCE


207.5


INGERSOLL-RAND
DD-90


163

MD SMA Sasobit Trial
Capital Beltway

Summary

- Three warm asphalt processes used in Europe for up to 6 years
- Allow compaction at lower temperatures
- SGC not sensitive to compaction temperature
- Data indicates warm asphalt additive could reduce optimum asphalt content
- Minimum temperature to which compaction is improved is dependent upon technology – ranges from 265 to less than 190 °F

Summary

- Rutting susceptibility of warm asphalt mixtures similar to hot mix produced at the same temperature
  - Some technologies improve rutting susceptibility
  - Rutting tends to increase with reduced production temperatures due to decreased aging of the binder
  - May need to use a stiffer binder below mixing temperatures of 275 °F
- Lower production temperatures may increase potential for moisture damage due to incomplete drying of the aggregate
  - Certain technologies may increase moisture susceptibility
  - Moisture susceptibility can be mitigated with appropriate additives

Recommendations

- At this time, determine optimum asphalt content without warm asphalt additive
- If mixing temperature is below 275 °F, consider using stiffer binder grade
- Conduct Tensile Strength Ratio Tests at anticipated production temperatures
- Consider use of Hamburg wheel tracking test in lieu of TSR

A Word About Cost

- Most additives, warm asphalt or other, are expected to increase the price of the HMA
- Some processes or additives may require plant/production modifications
- It is not anticipated that the fuel savings will totally offset these costs
- This project is a look ahead to make sure that we can continue paving, even in non-attainment areas

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