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# Warm Mix Asphalt



Technical Working Group Meeting

Marriott Hunt Valley Inn

Baltimore, MD

Dec. 12-13, 2007

Federal Highway Administration  
*Office of Pavement Technology*



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# Warm Mix Asphalt Characterization

**Binder Properties**

**Mixture Properties**



# Acknowledgements

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Matt Corrigan – Program Manager

Jagan Guddimettla – Mix Project Engineer

Satish Belagutti – Binder Project Engineer

Raj Dongré – DLS, Inc

Justin Tesch – Mix Tech

Joshua Thompson – Mix Tech

David Heidler – Binder Tech

Darnel Jackson – Binder Tech

also:

TFHRC Group

Nelson Gibson

Scott Parobeck

Frank Davis



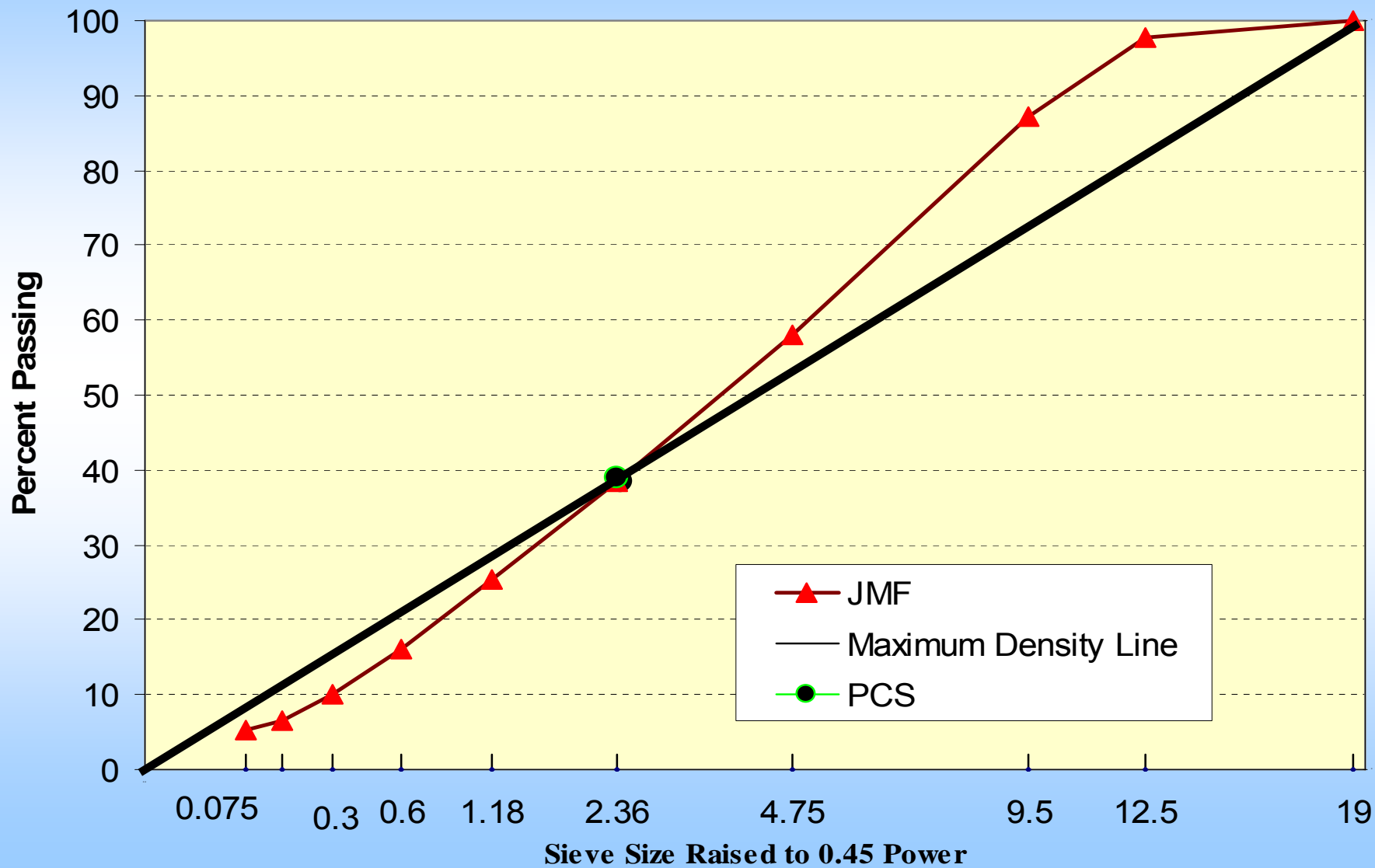
# Projects

Warm Mix Asphalt Projects				
Location	Mix Design	Lab Compaction Level, gyrations	Base Binder Grade	Technologies
Hall St, St. Louis, MO	12.5mm Superpave	100	PG 70-22	Aspha-Min Evotherm Sasobit
I-70 w of Eisenhower Tunnel, Frisco, CO	9.5mm Superpave	75	PG 58-28	Advera Evotherm Sasobit
E Entrance Rd, Yellowstone National Park, WY	19mm Hveem	75	PG 58-34	Advera Sasobit



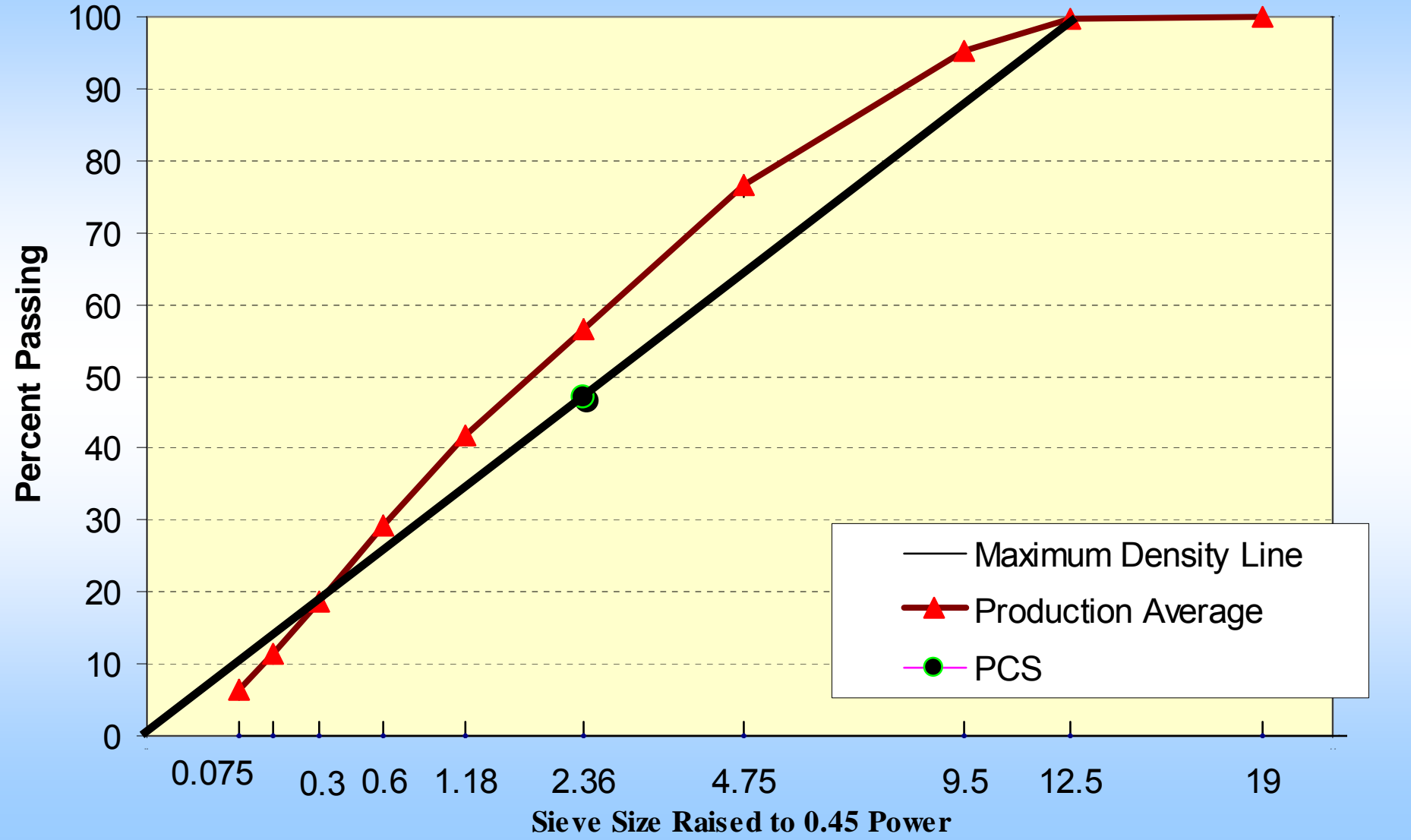
# FHWA Power Chart

## 12.5 mm Superpave, MO 0672



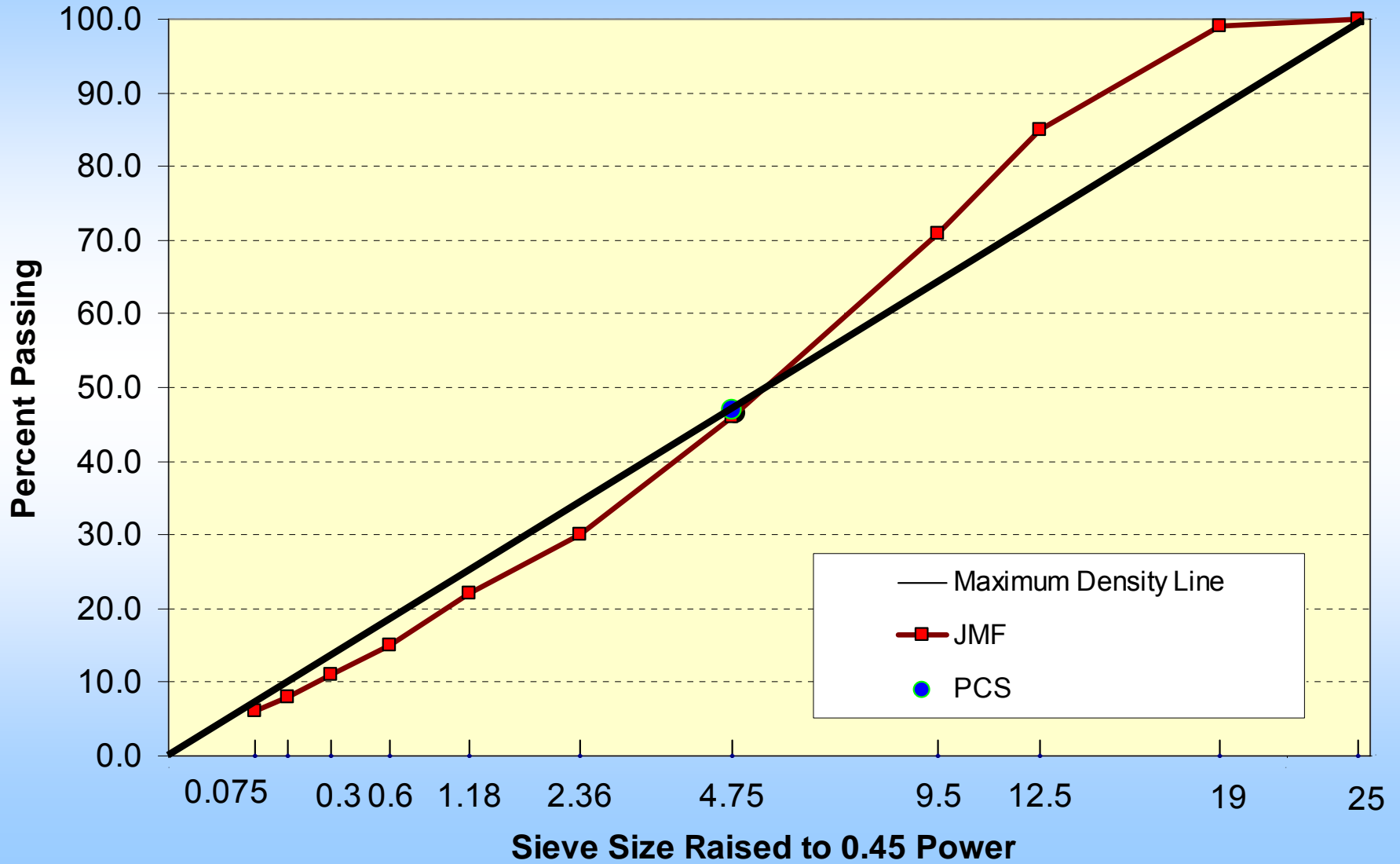
# FHWA Power Chart

## 9.5mm Superpave, CO0777



# FHWA Power Chart

## 19 mm Hveem, WY 0778



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# Binder Characterization



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# Objective

- Evaluate the effects of three Warm Mix process namely Sasobit, Aspha-Min and Evotherm on M320-Table 2 Performance Grade
- To Compare the Performance Grades of Warm Mix processes with the base asphalt used in preparing warm mix asphalts



# Study Approach

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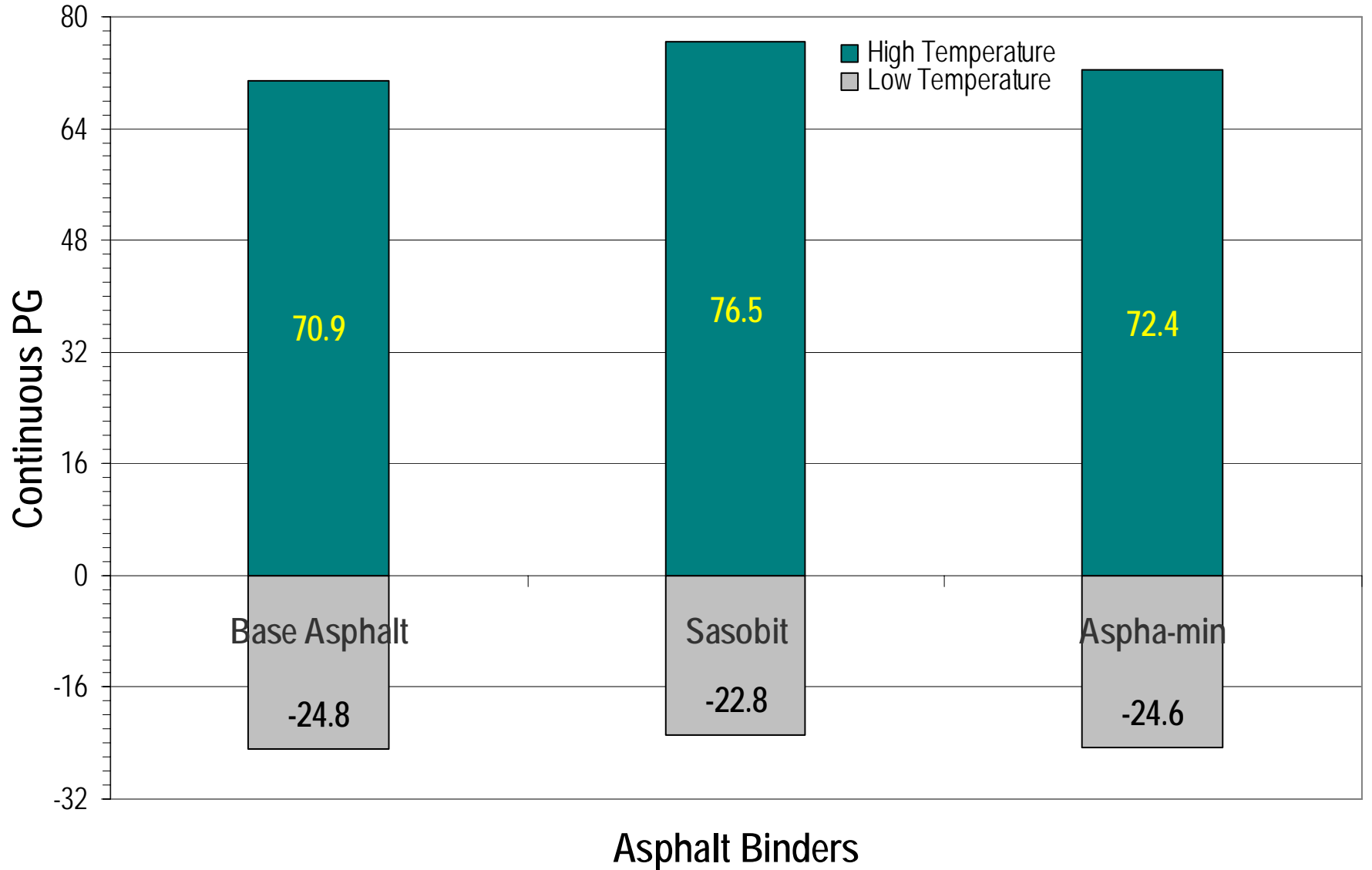
- Experiment Design
  - Base Asphalt PG 70-22
  - Base Asphalt + 1.5% Sasobit
  - Base Asphalt + 5.26% Aspha-Min
  - Evotherm – (emulsion)



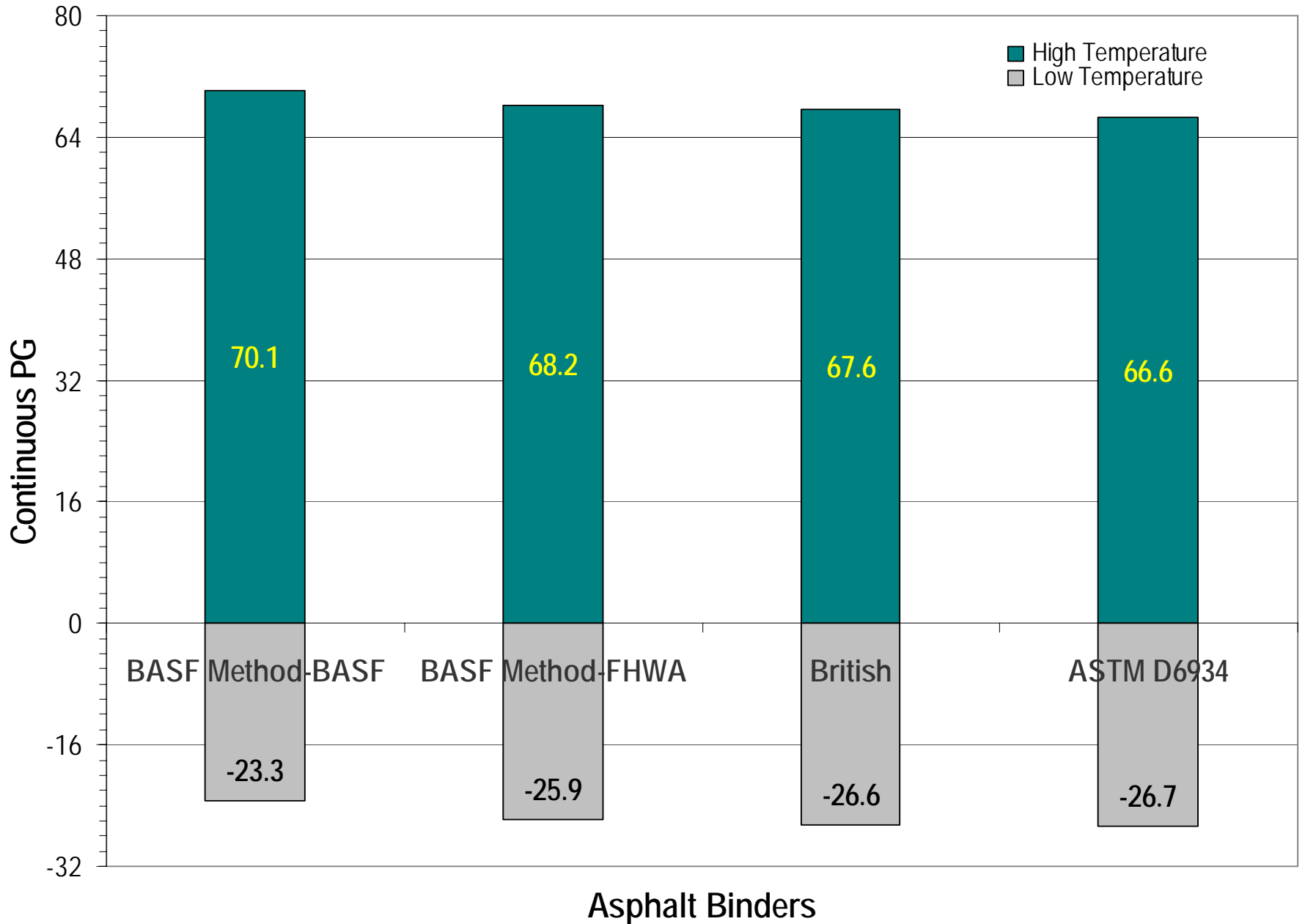
# Hall St, St. Louis, MO

	<b>M320 Continuous Performance Grade</b>	<b>M320, Table 2 Performance Grade</b>	<b>Additive Rate, by wt of binder</b>
<b>Base</b>	<b>70.9 – 24.8</b>	<b>70 - 22</b>	
<b>Sasobit</b>	<b>76.5 – 22.8</b>	<b>76 - 22</b>	1.5%
<b>Aspha-Min</b>	<b>72.4 – 24.6</b>	<b>70 - 22</b>	5.26%
<b>Evotherm - recovered (ASTM D 6934)</b>	<b>66.6 – 26.7</b>	<b>64 - 22</b>	

# Hall St, St. Louis, MO



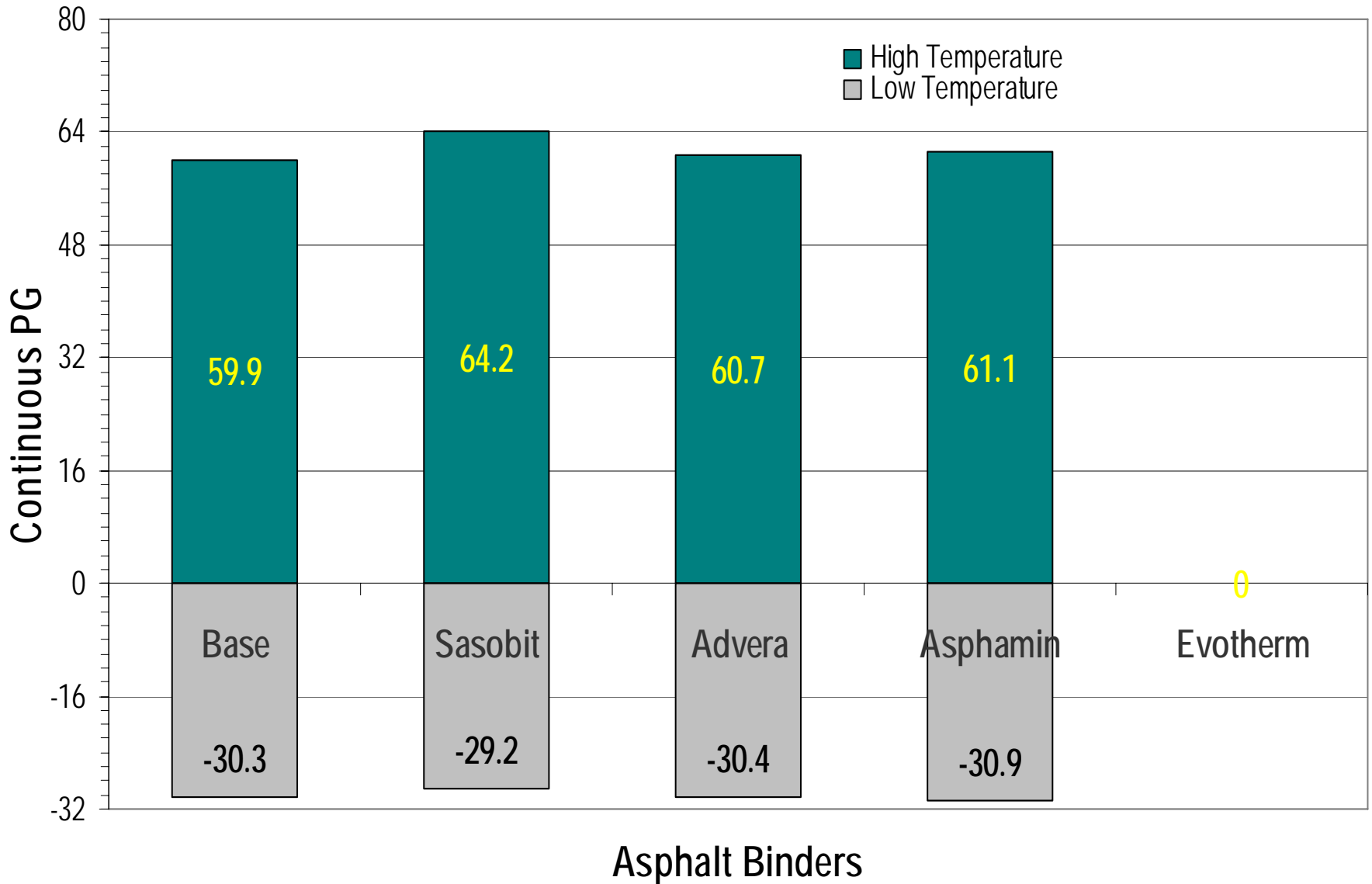
# PG Comparison - Evotherm



# I-70, Frisco, CO

	M320 Continuous Performance Grade	M320, Table 2 Performance Grade	Additive Rate, by wt of binder
Base	<b>59.9 – 30.3</b>	<b>58 – 28</b>	
Sasobit	<b>64.2 – 29.2</b>	<b>64 – 22</b>	1.5%
Aspha-Min	<b>61.1 – 30.9</b>	<b>58 – 28</b>	
Advera	<b>60.7 – 30.4</b>	<b>58 - 28</b>	4.33%
Evotherm	<b>NO DATA</b>		

# I-70, Frisco, CO

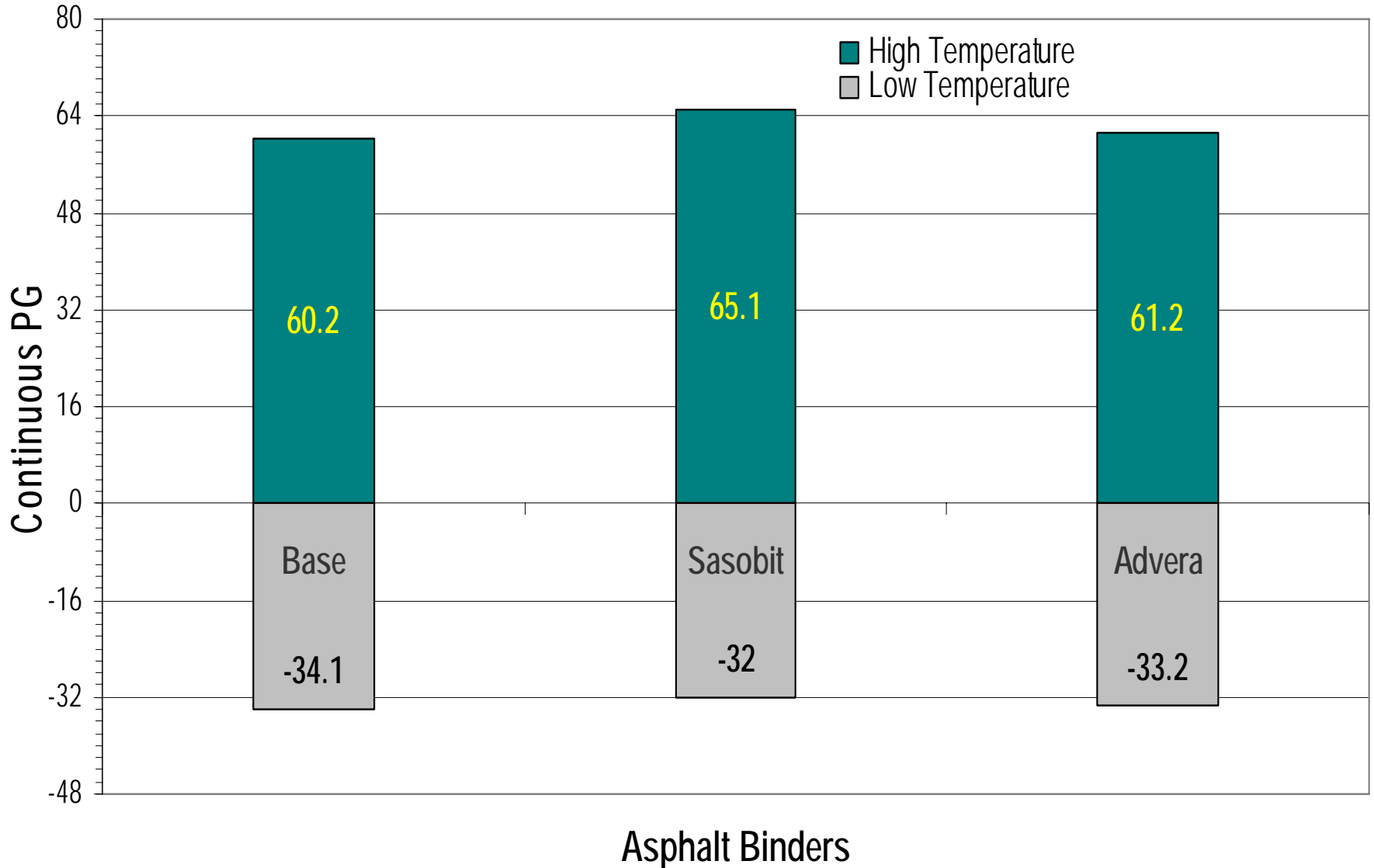


# East Entrance Rd, Yellowstone, WY

	<b>M320 Continuous Performance Grade</b>	<b>M320, Table 2 Performance Grade</b>	<b>Additive Rate, by wt of binder</b>
<b>Base</b>	<b>60.2 – 34.1</b>	<b>58 – 28</b>	
<b>Sasobit</b>	<b>65.1 – 32.0</b>	<b>64 – 28</b>	1.5%
<b>Advera</b>	<b>61.2 – 33.2</b>	<b>58 – 28</b>	5.2%



# East Ent Rd, Yellowstone, CO



# Findings

- Sasobit – increase of 1 high temp grade
- Aspha-Min - no impact on PG grade
- Evotherm - recovered at BASF, no effect on the PG
- Evotherm - recovered from the stored emulsion was reduced by one grade



# Findings

- Emulsion recovery processes had no effect on the PG. The PGs from all three recovery methods were found to be the same.
- ASTM D6934 was found to be the quickest and easiest process to recover the Evotherm residue from emulsion.



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# Mixture Characterizations



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# Objectives

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- When should performance specimens be tested
- What are the effects of reheating on performance test properties
- Approach
  - Immediate Testing
  - Delayed Testing
  - Reheated Testing



# St. Louis Paving Schedule

- Control (12.5mm PG 70-22) – 5/17/06
- Sasobit – 5/18/06
- Sasobit – 5/19/06
- Evotherm – 5/22/06
- Evotherm – 5/23/06
- Aspha-Min – 5/25/06



# Sampling

- **IMMEDIATE Testing**
  - Next day after manufacture
- Truck bed  $\approx$  every 2hrs of production
  - Volumetric
    - Pb – Ignition
    - Gmm
    - Gmb
  - SPT; TSR; Hamburg



# Sampling

- **DELAYED Testing**
  - 2-3 weeks after manufacture
- Truck bed  $\approx$  every 2 hrs of production
  - Volumetric
    - Pb – Ignition
    - Gmm
    - Gmb
  - SPT; TSR; Hamburg



# Sampling

- **REHEATED (TFHRC)**
- 1~2 tons
  - 15 – 5 gallon buckets
  - SPT; TSR; Hamburg
- ***Nelson Gibson - TFHRC***



# SGC

- **6 nights - 366** specimens



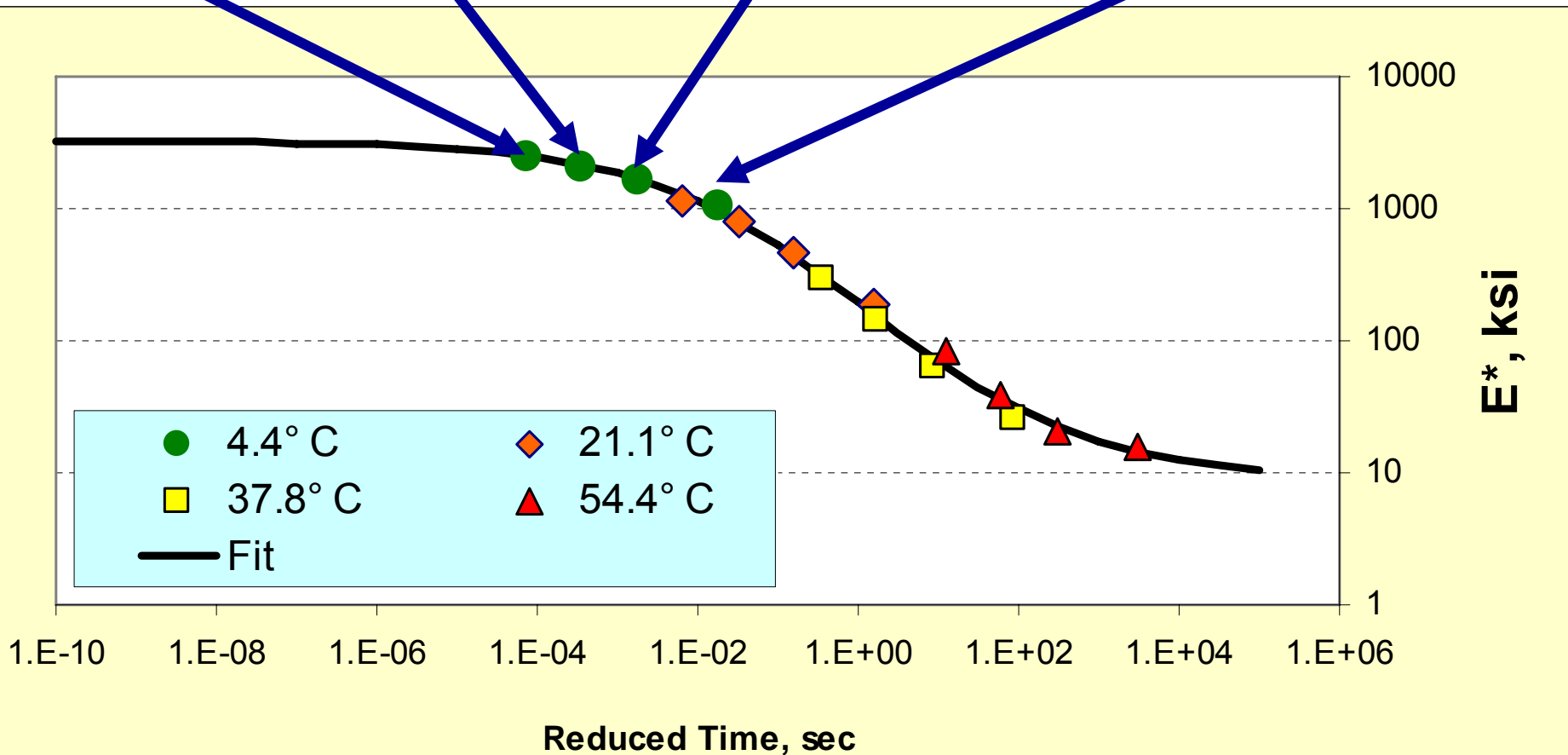
# Dynamic Modulus ( $E^*$ )

- Test Temperatures
  - **4.4° C** (40° F)
  - **21.1° C** (70° F)
  - **37.8° C** (100° F)
  - **54.4° C** (130° F)
- Frequency Sweep
  - **0.1, 0.5, 1, 5, 10, 25 Hz**



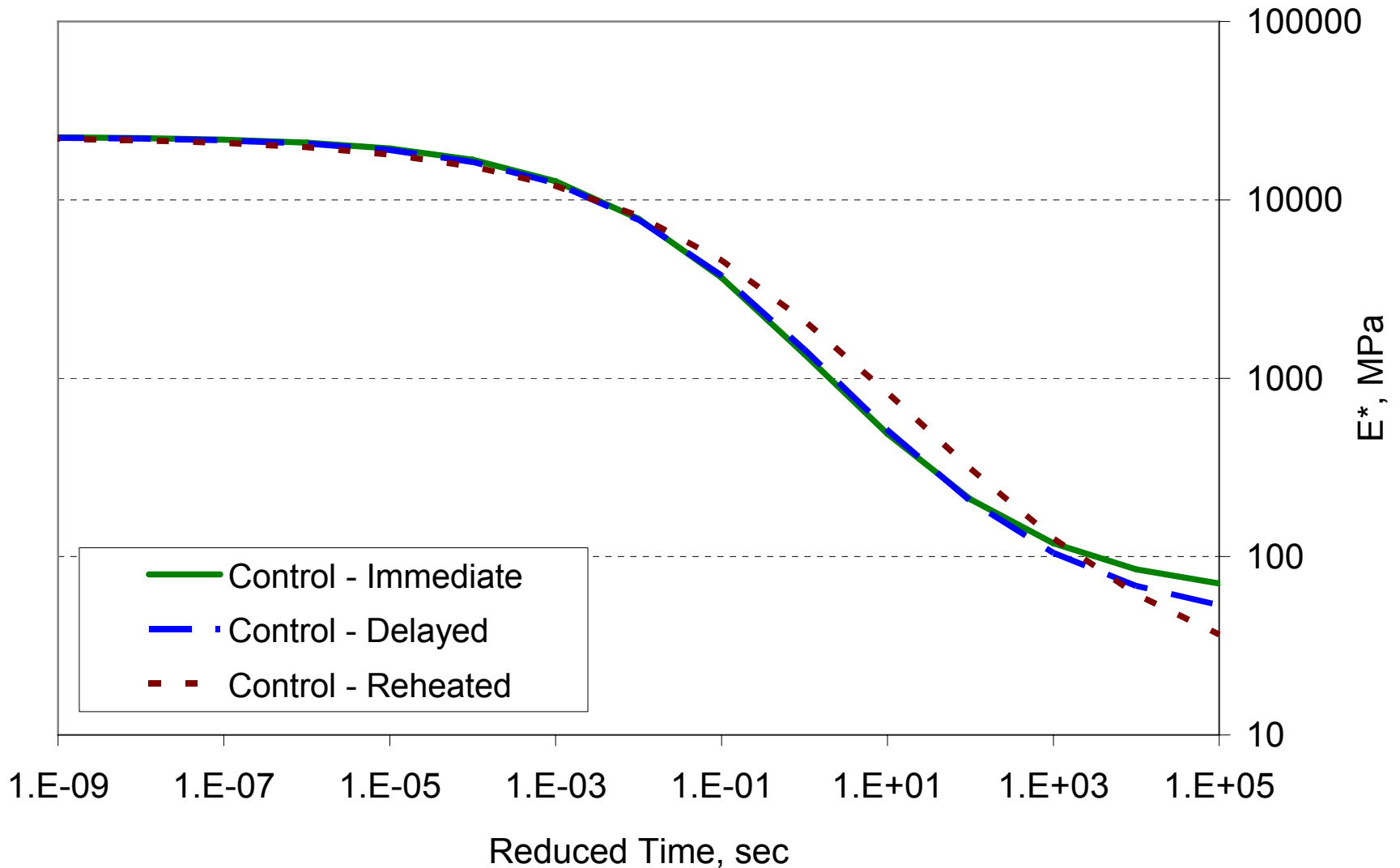
# Master Curve – Arrhenius Fit

25 Hz      5 Hz      1 Hz      0.1 Hz



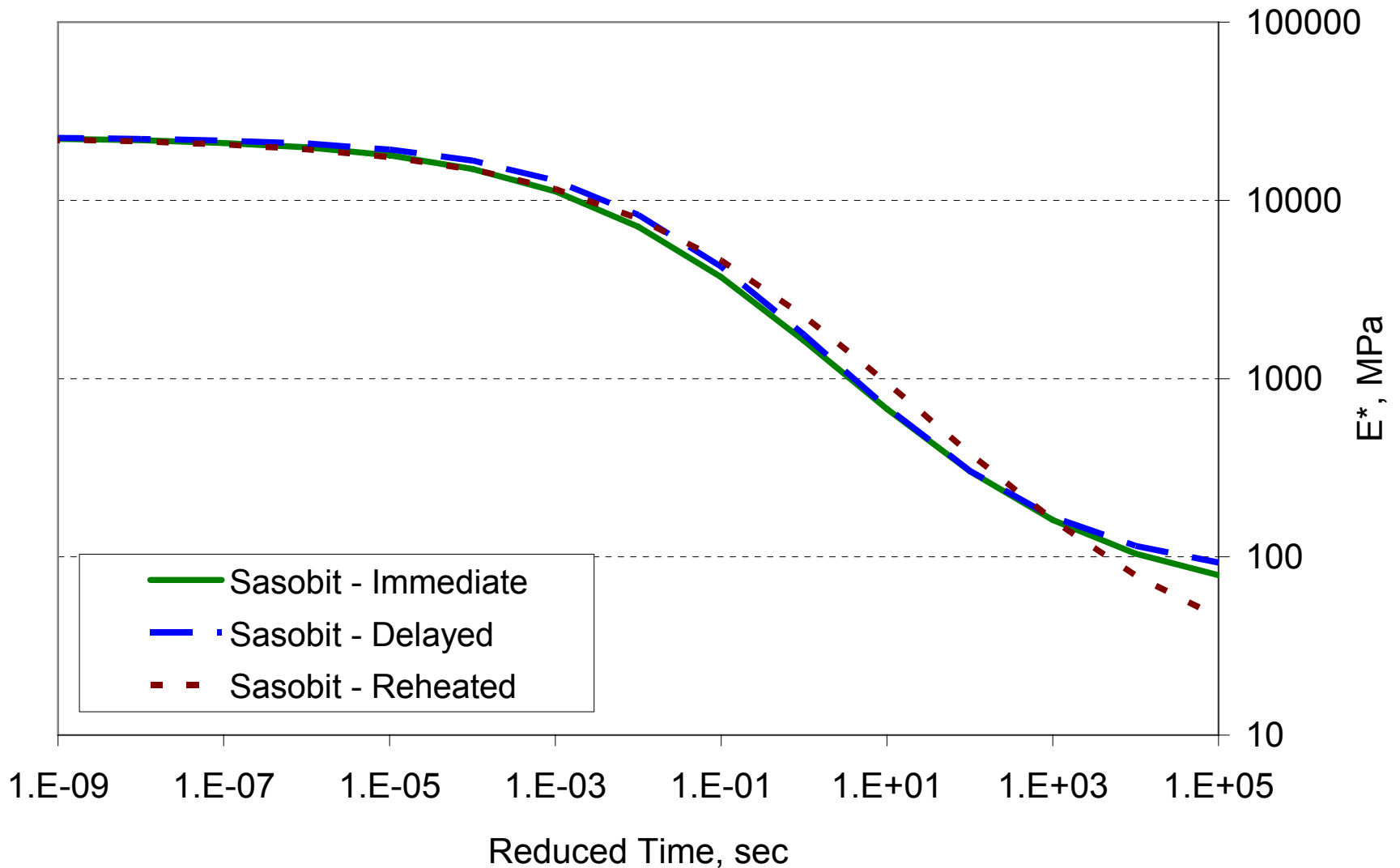
# E\* - Master Curve

Hall St, St. Louis, MO



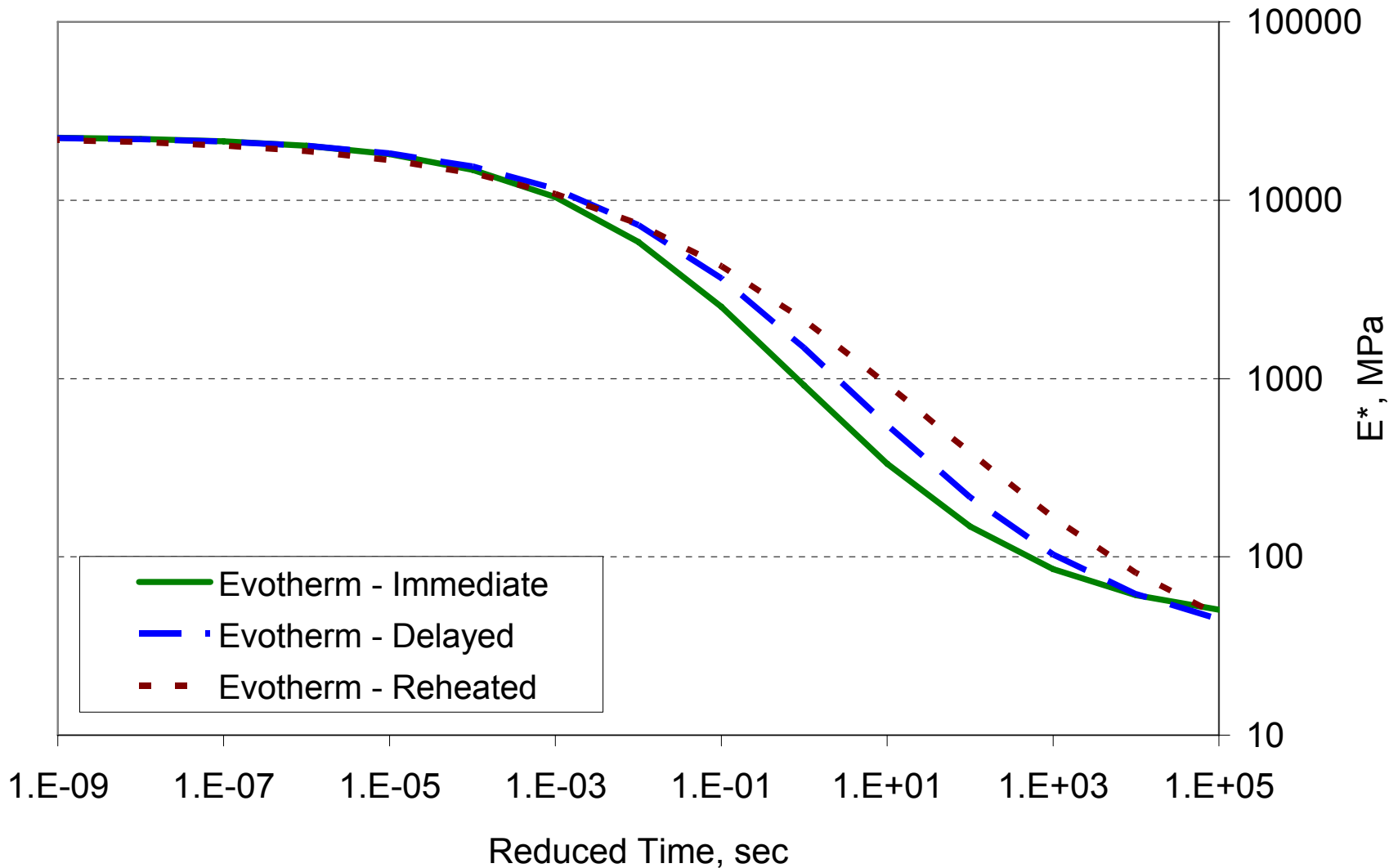
# E\* - Master Curve

Hall St, St. Louis, MO



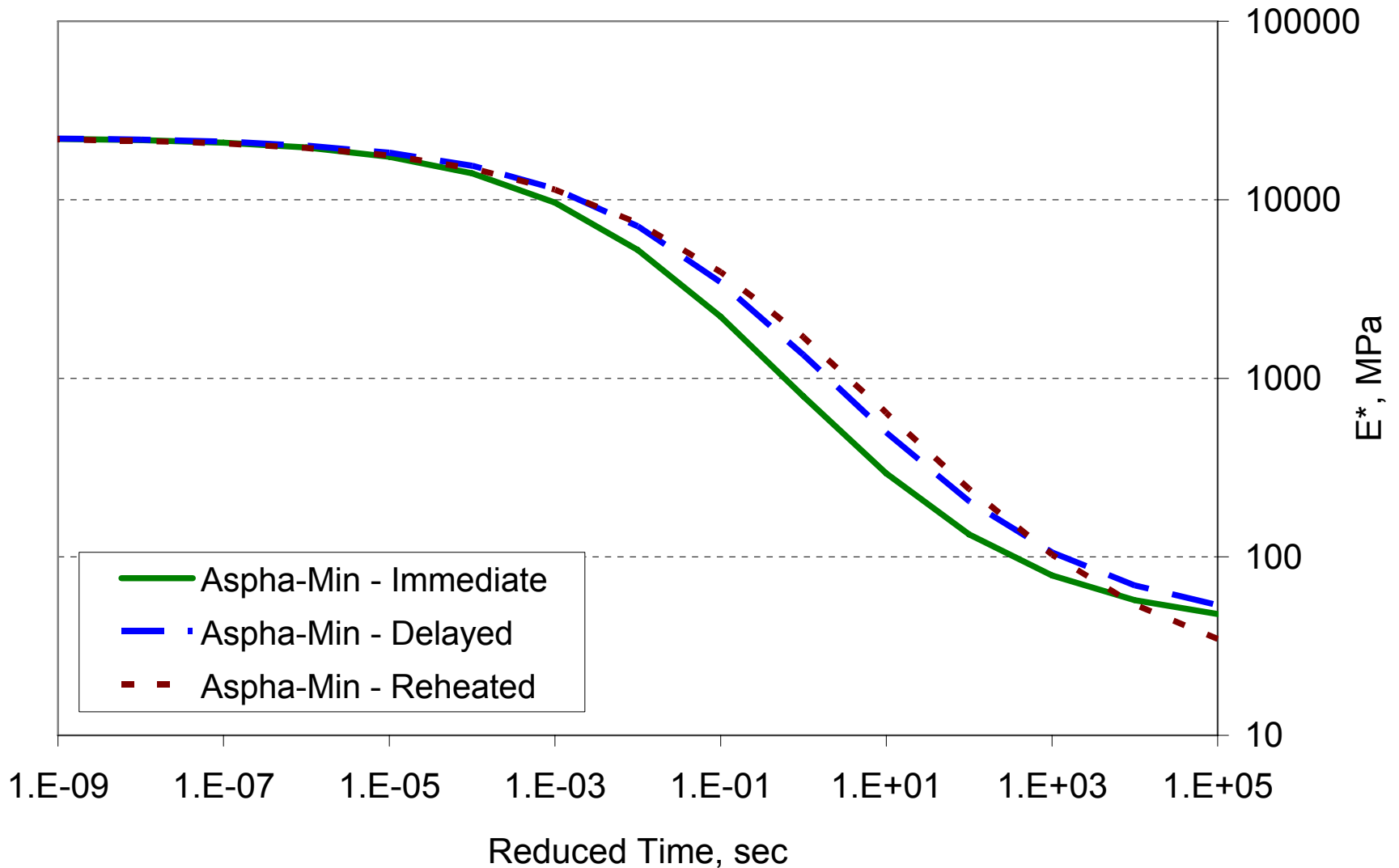
# E\* - Master Curve

Hall St, St. Louis, MO



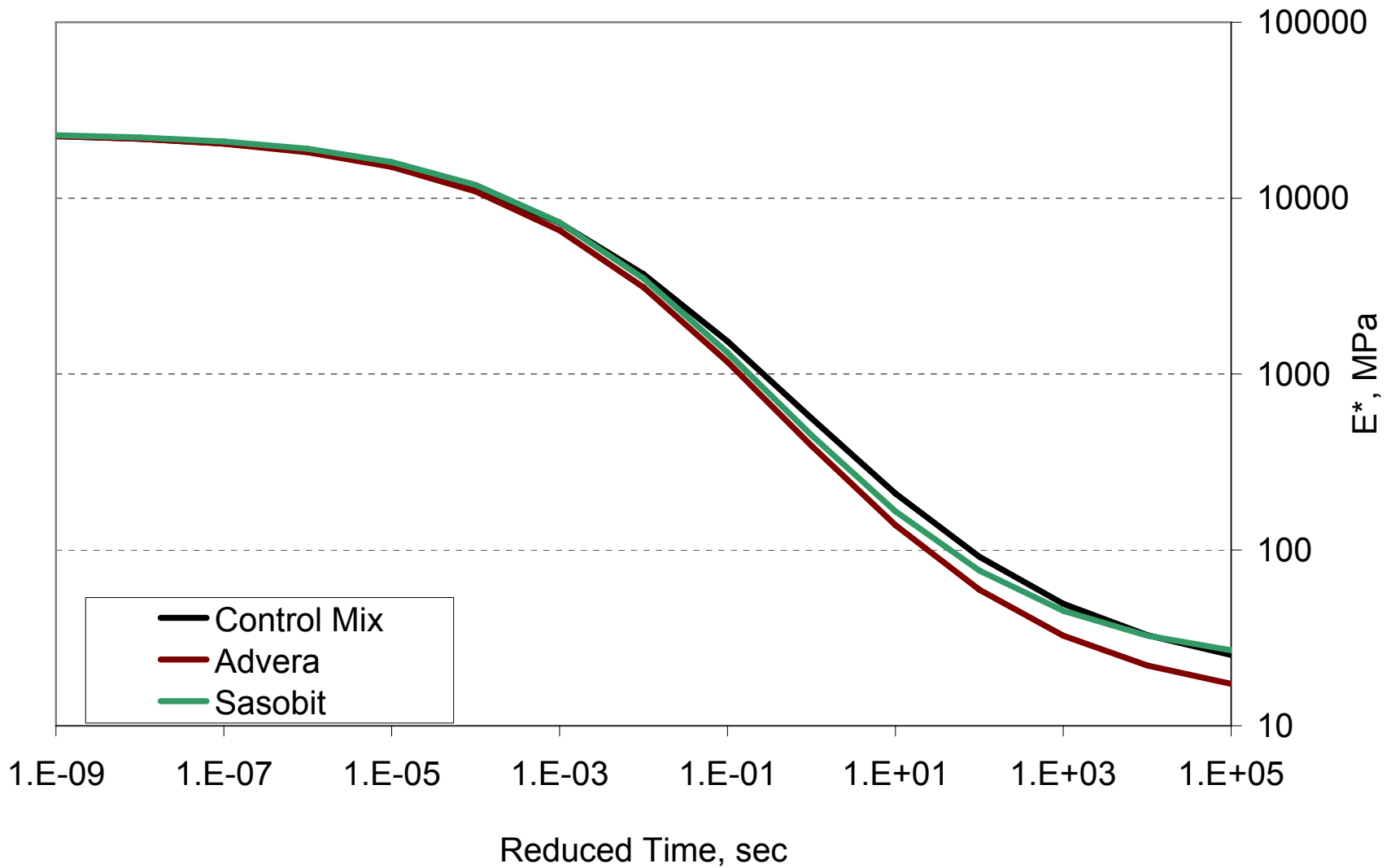
# E\* - Master Curve

Hall St, St. Louis, MO



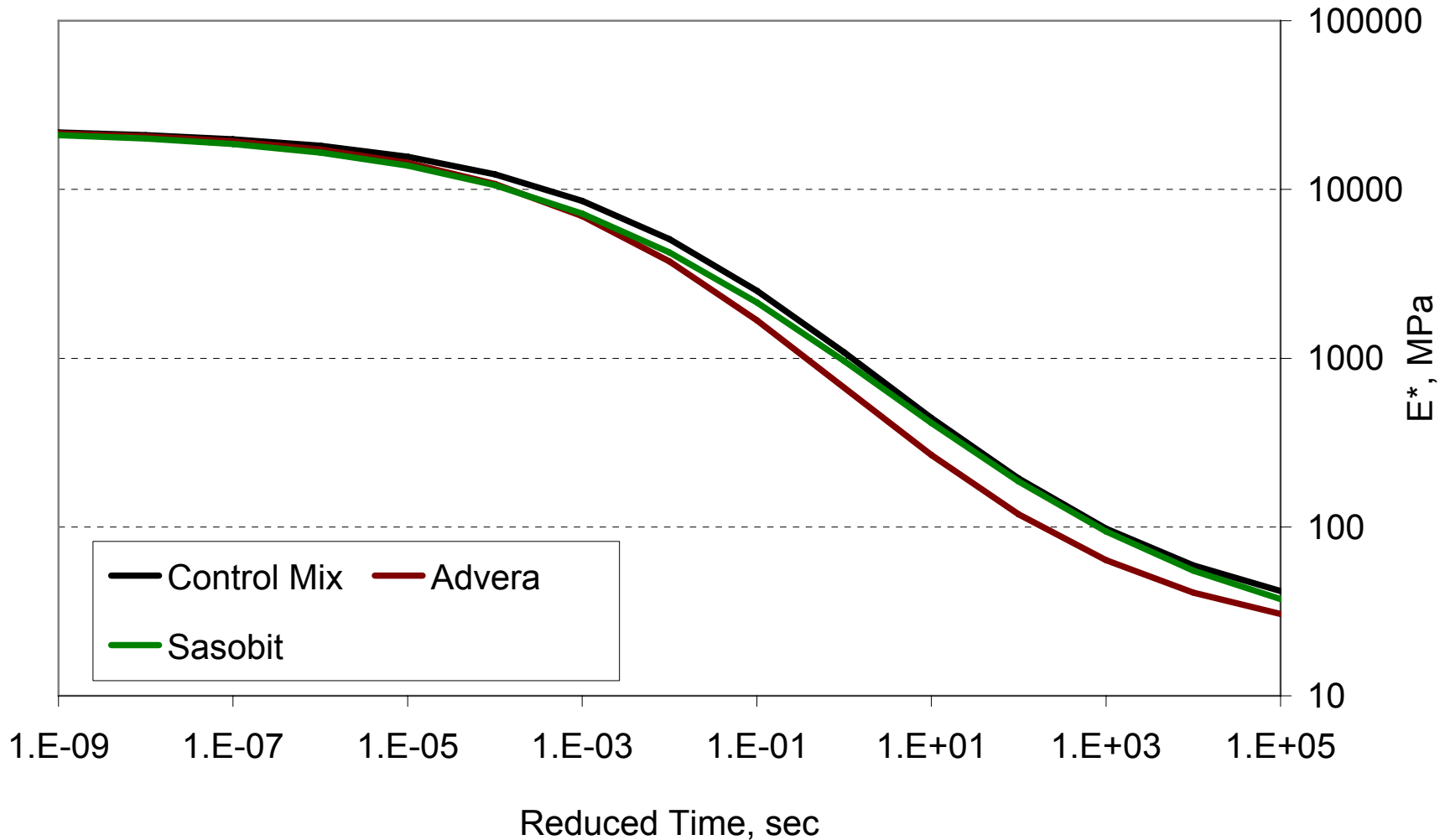
# E\* - Master Curve

I-70, Frisco, CO



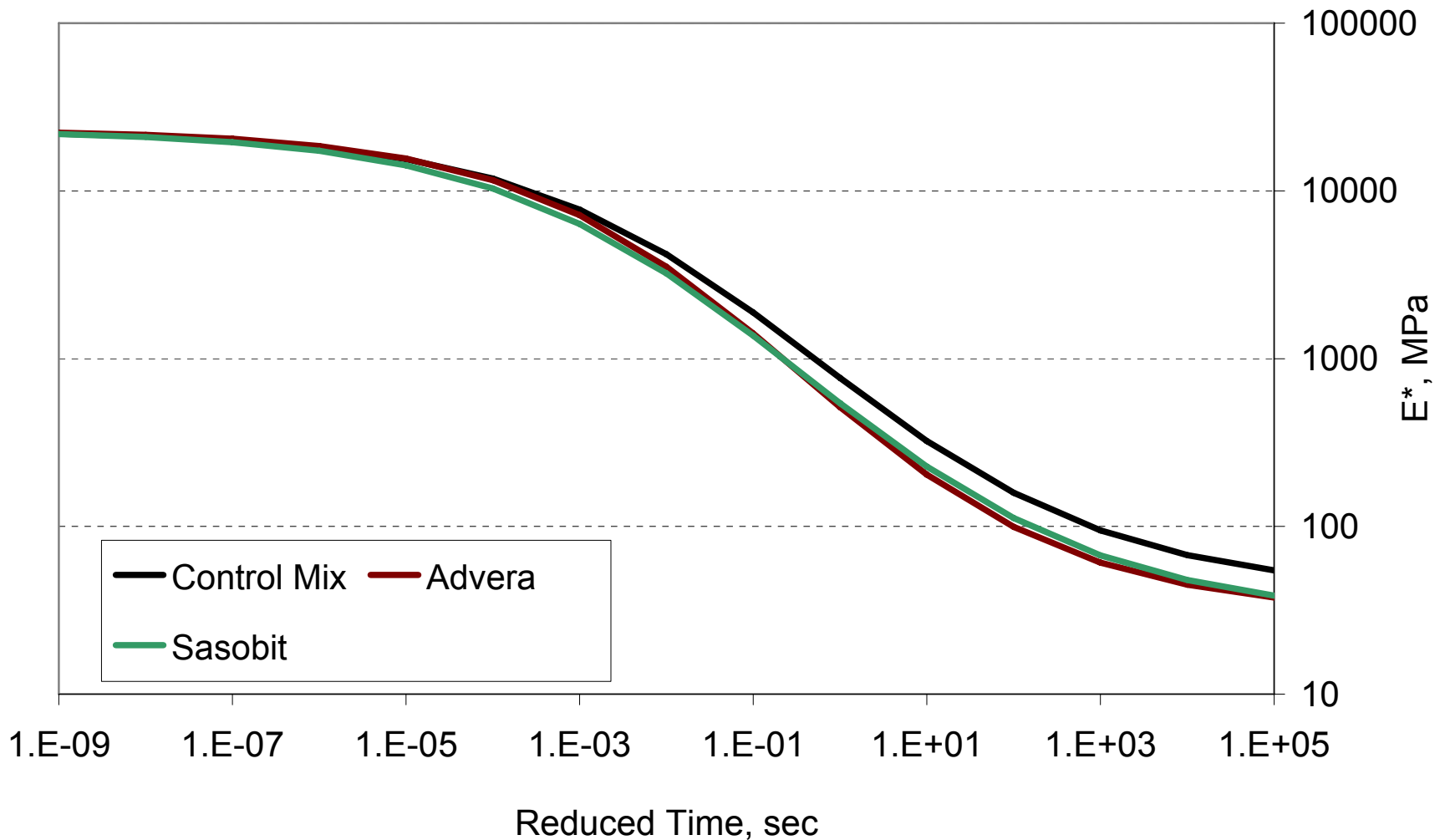
# E\* - Master Curve

E. Entrance Rd, Yellowstone, WY  
Pb - 5.3%, Mix Design Replication



# E\* - Master Curve

E. Entrance Rd, Yellowstone, WY  
Average WMA Production



# Flow Number, Fn

- **Test Temperatures**
  - LTTPBind, Version 3.1 Software
  - Site pavement temperature @ 50% Reliability
    - Pvmt Temp,  $\pm 6^{\circ}$  C



# Flow Number, Fn

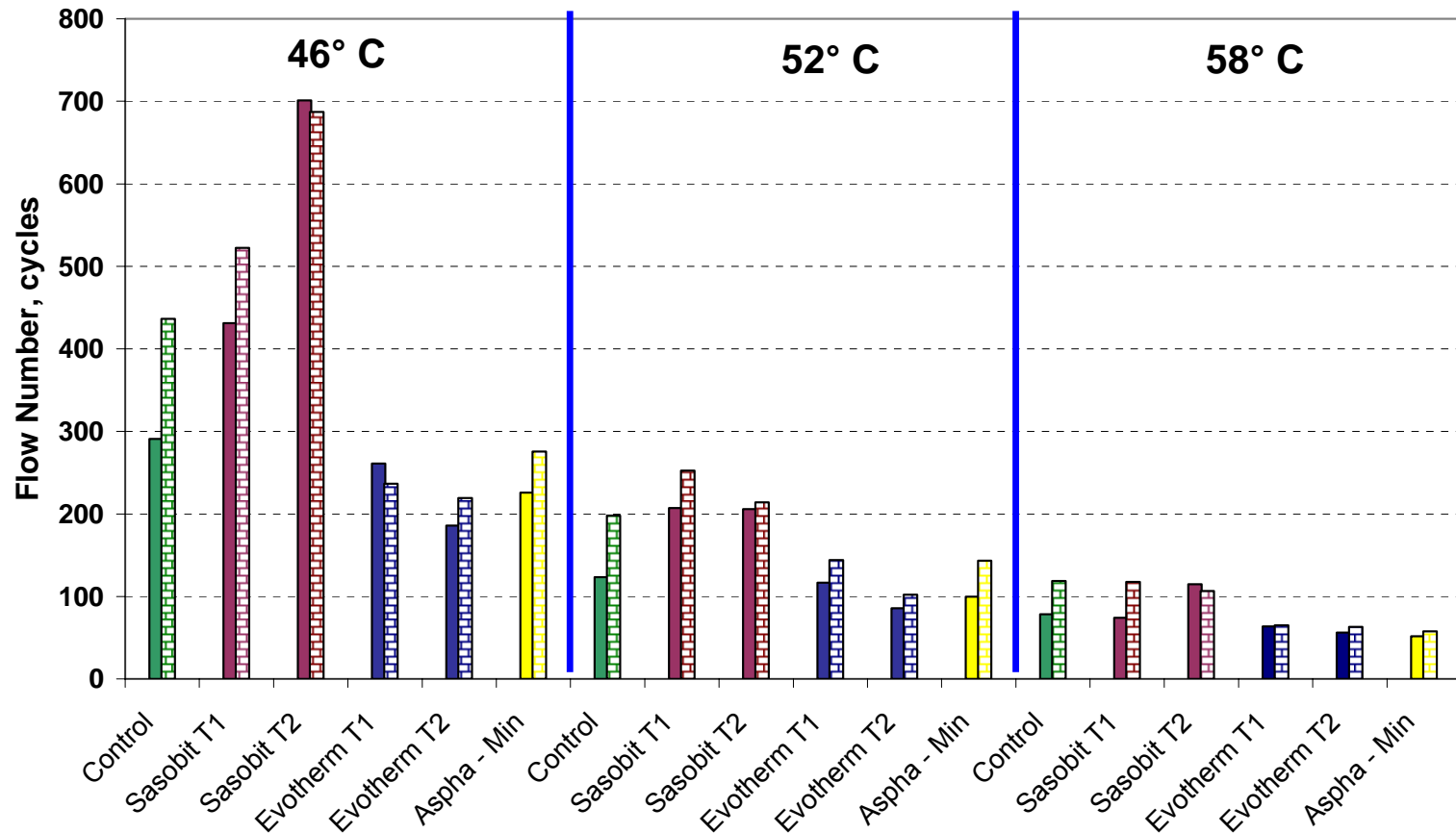
Hall Street, St. Louis, MO

- Test Temperatures
  - **46° C** (115° F)
  - **52° C** (126° F)
  - **58° C** (136° F)
- Loading
  - **600 kPa** – Deviator Stress
  - **0 kPa** – Confining Pressure



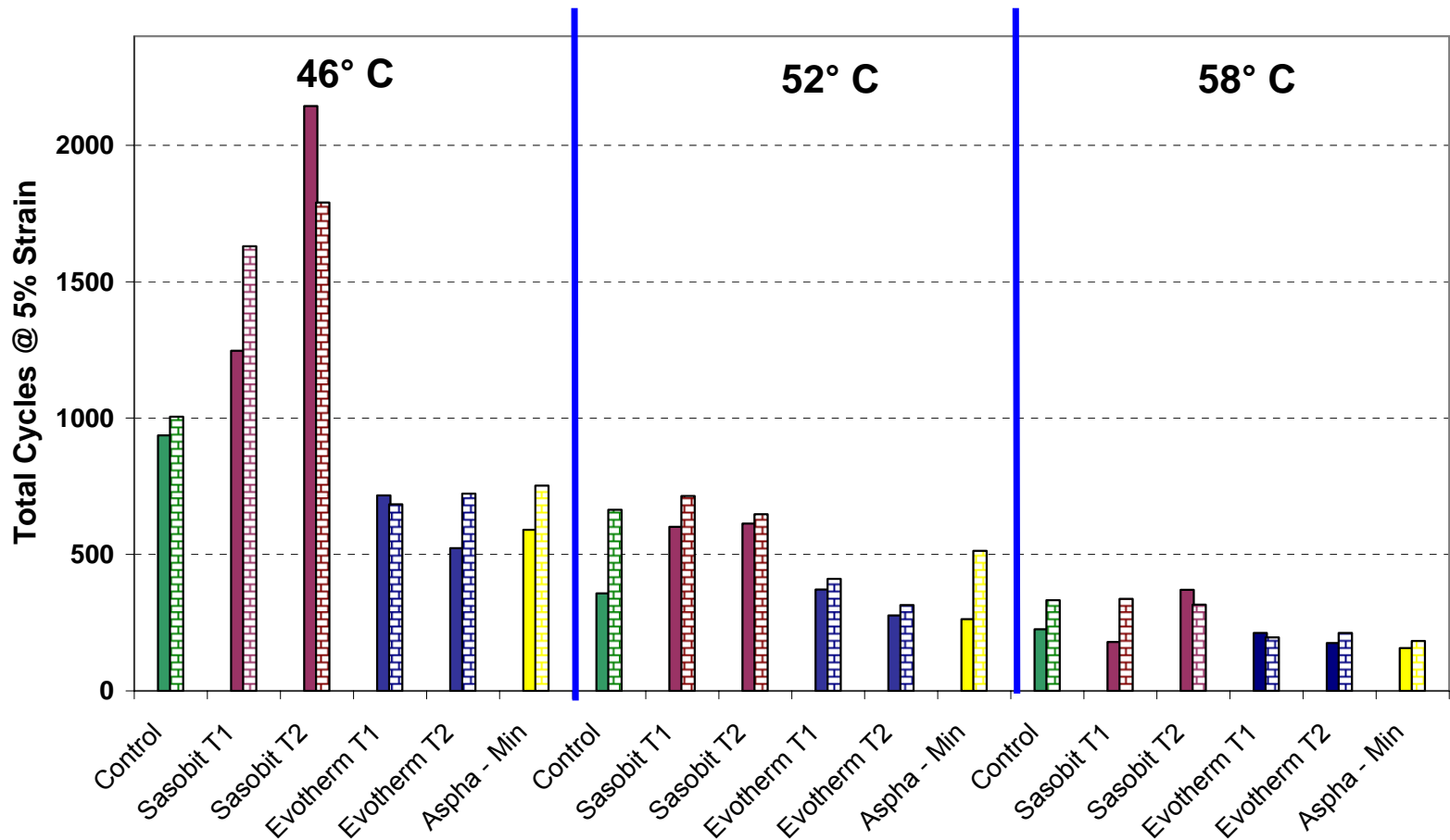
# Flow Number, Fn

Immediate and Delayed Test Specimens



# Flow Number, Fn

## Immediate and Delayed Test Specimens



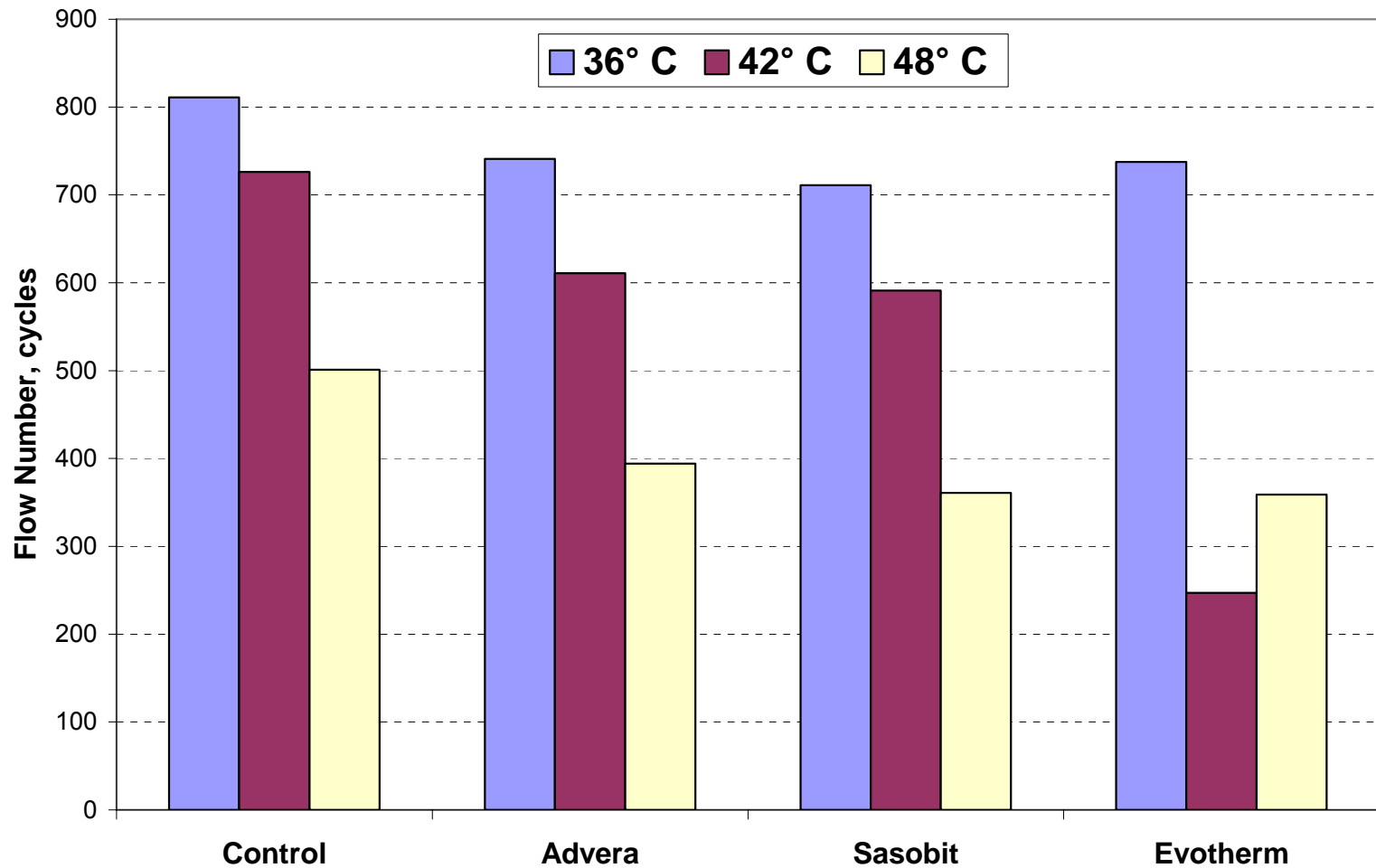
# Flow Number, Fn

## I-70 - Frisco, CO

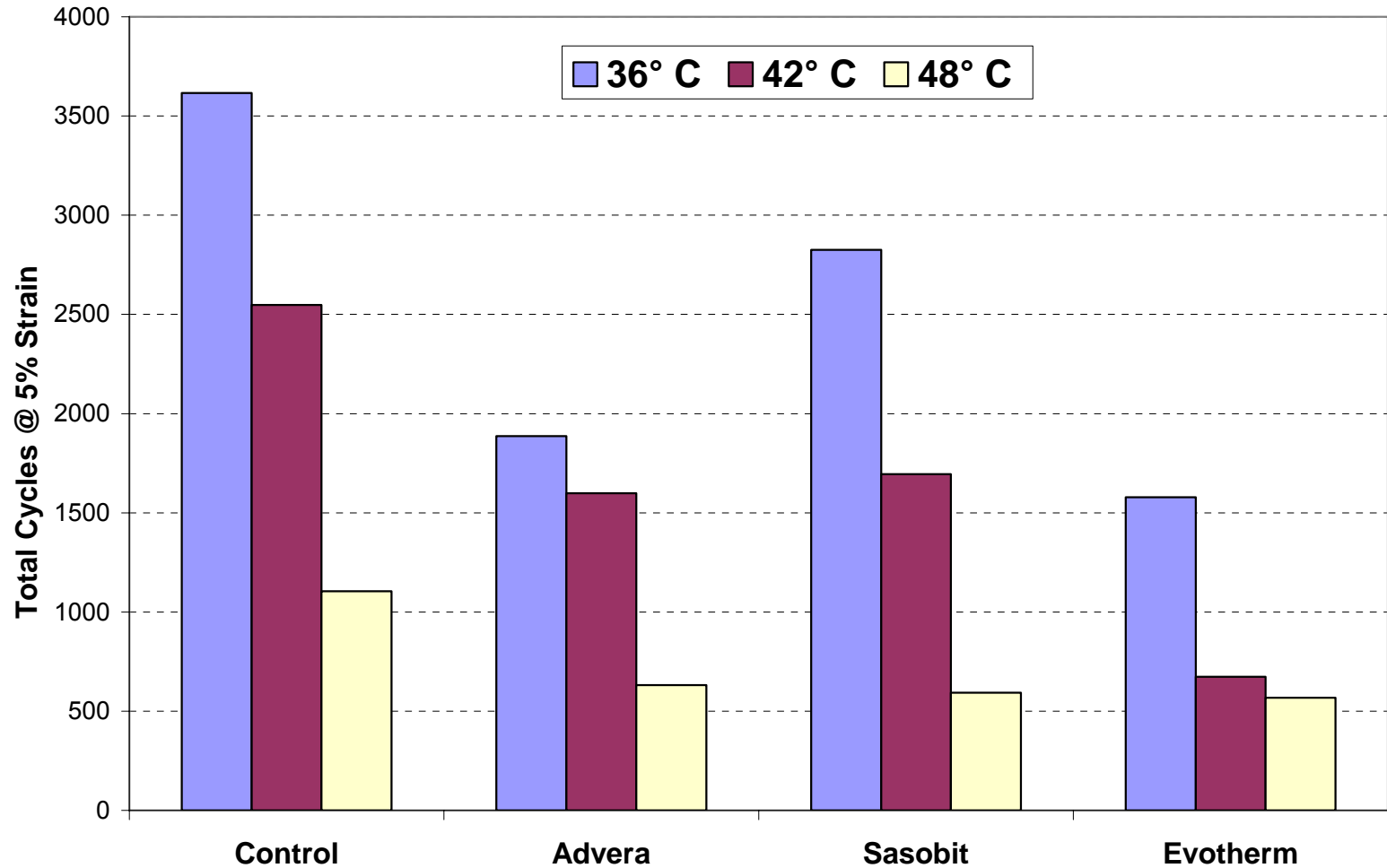
- Test Temperatures
  - **36° C** (97° F)
  - **42° C** (108° F)
  - **48° C** (118° F)
- Loading
  - **689 kPa** (100 psi) – Deviator Stress
  - **69 kPa** (10 psi) – Confining Pressure



# Flow Number, Fn



# Flow Number, Fn



# Flow Number, Fn

East Entrance Rd - Yellowstone, WY

- Test Temperatures
  - **46° C** (115° F)
  - **52° C** (126° F)
  - **58° C** (136° F)
- Loading
  - **689 kPa** (100 psi) – Deviator Stress
  - **69 kPa** (10 psi) – Confining Pressure



# Flow Number, Fn

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# Findings

- **Immediate vs Delayed Testing**
  - **Evotherm & Aspha-Min**
    - Performance testing - delayed after specimen manufacture
  - **Sasobit**
    - Performance testing can be conducted immediately after specimen manufacture





Courtesy of the FHWA Mobile Asphalt Laboratories

# Questions

