Warm Mix Asphalt

Technical Working Group Meeting

Marriott Hunt Valley Inn

Baltimore, MD

Dec. 12-13, 2007

Federal Highway Administration

Office of Pavement Technology

Warm Mix Asphalt Characterization

Binder Properties

Mixture Properties

Federal Highway Administration
Office of Pavement Technology

Acknowledgements

Matt Corrigan – Program Manager

Jagan Guddimettla – Mix Project Engineer
Satish Belagutti – Binder Project Engineer
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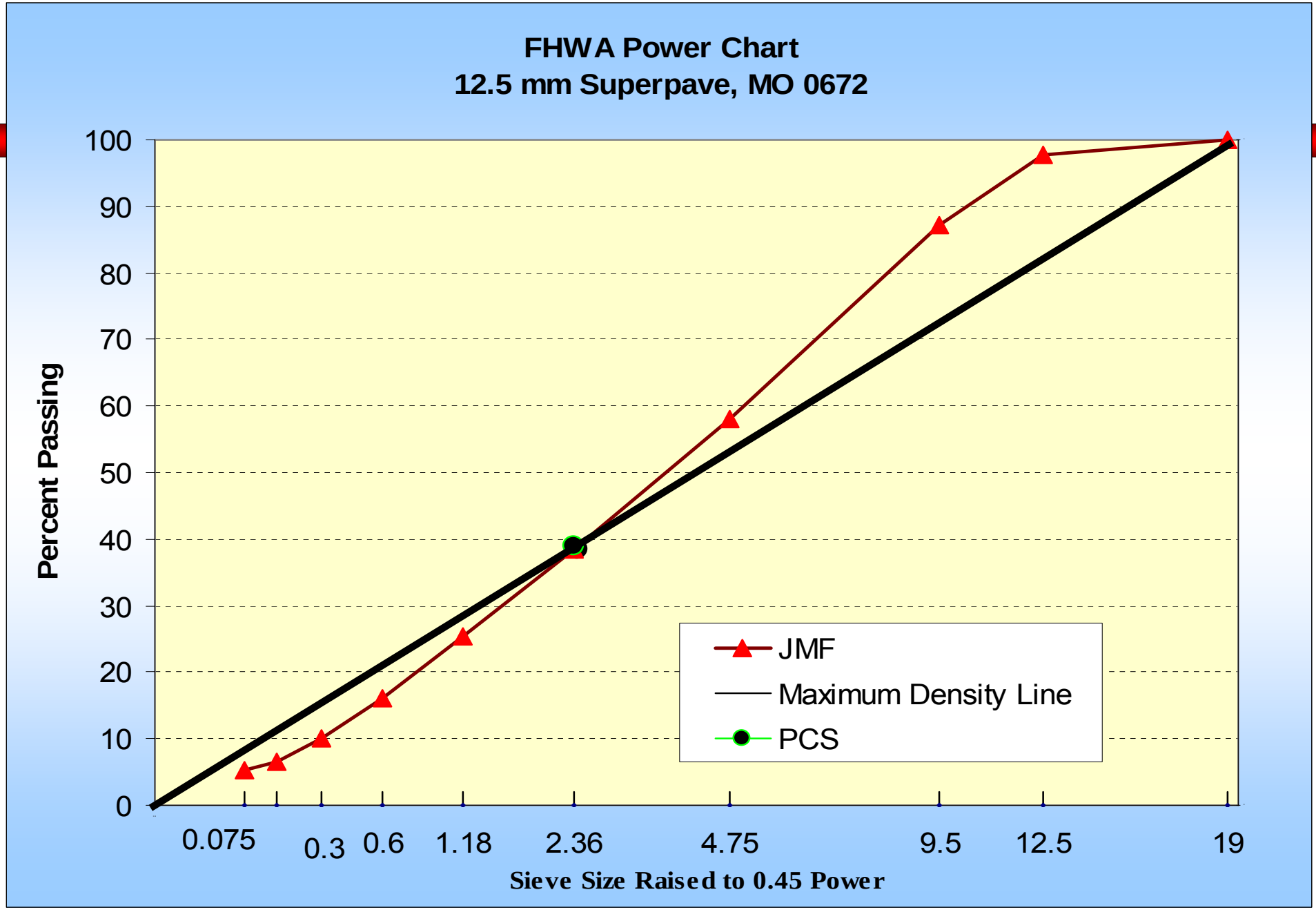
Justin Tesch – Mix Tech
Joshua Thompson – Mix Tech
David Heidler – Binder Tech
Darnel Jackson – Binder Tech

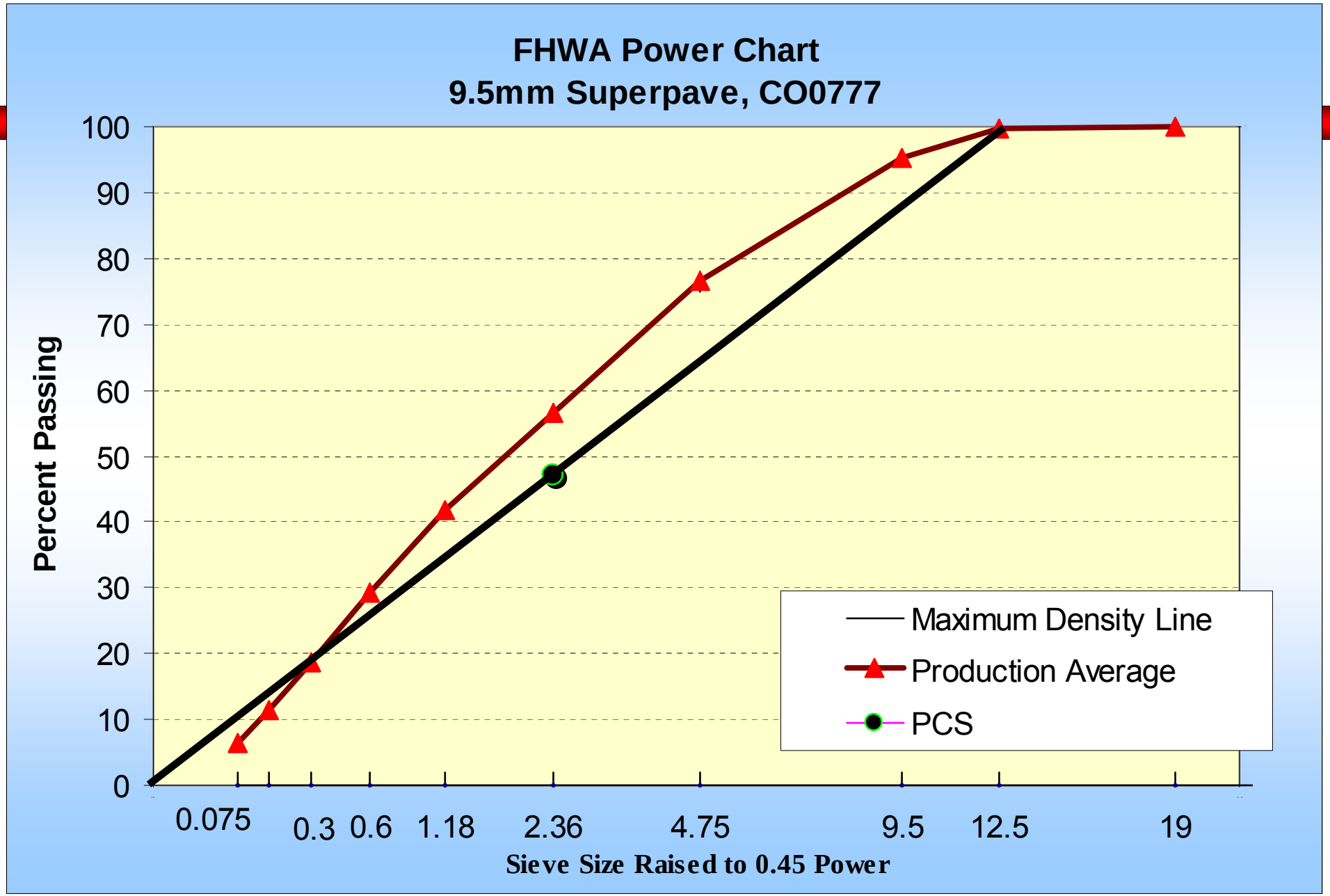
also:

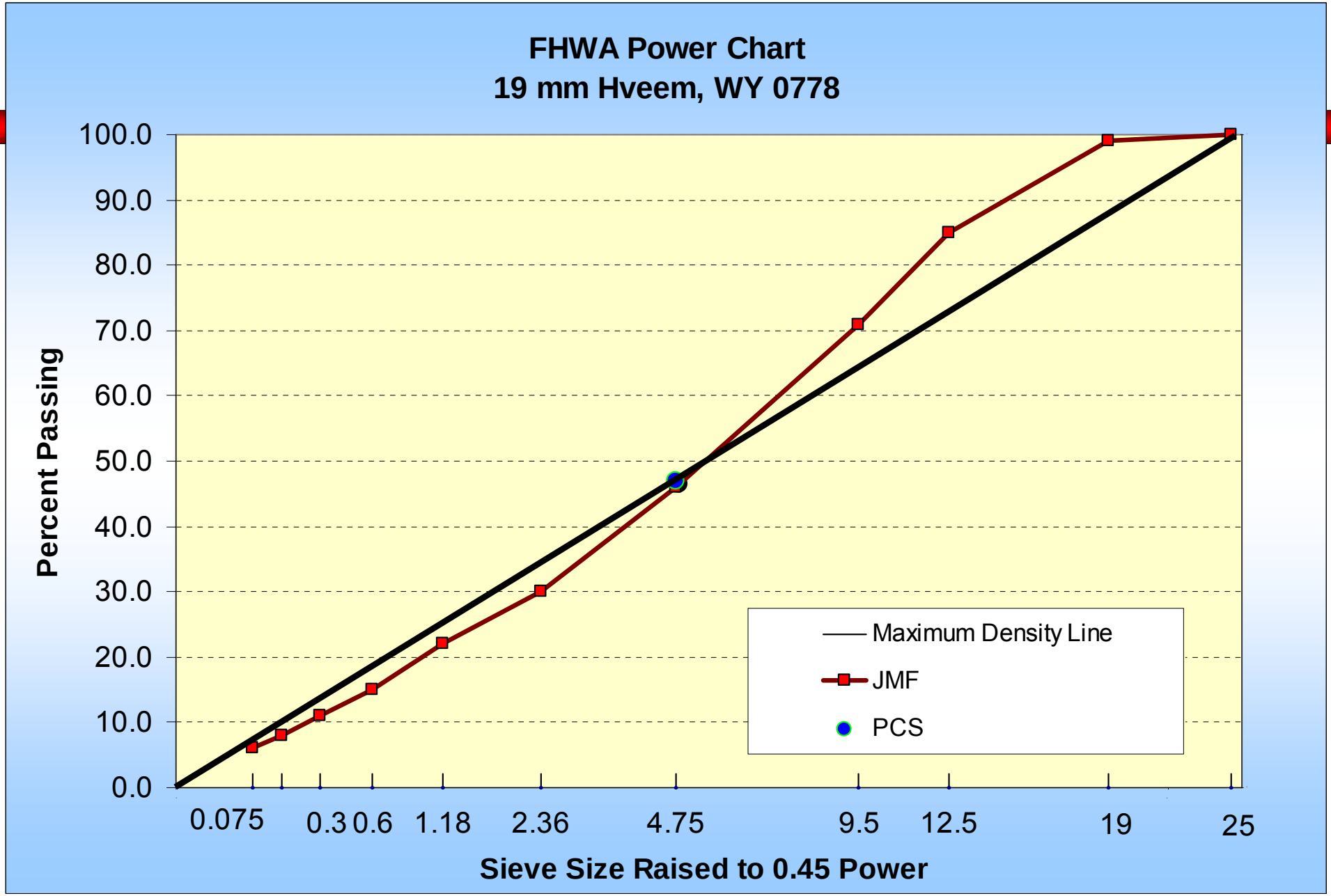
TFHRC Group
- Nelson Gibson
- Scott Parobeck
- Frank Davis

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
Percent Passing
100
90
80
70
60
50
40
30
20
10
0
0.075
0.3
0.6
1.18
2.36
4.75
9.5
12.5
19
Sieve Size Raised to 0.45 Power
JMF
Maximum Density Line
PCS


FHWA Power Chart
9.5mm Superpave, CO0777
Percent Passing
100
90
80
70
60
50
40
30
20
10
0
0.075
0.3
0.6
1.18
2.36
4.75
9.5
12.5
19
Sieve Size Raised to 0.45 Power
Maximum Density Line
Production Average
PCS


FHWA Power Chart
19 mm Hveem, WY 0778
Percent Passing
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0.075
0.3
0.6
1.18
2.36
4.75
9.5
12.5
19
25
Sieve Size Raised to 0.45 Power
Maximum Density Line
JMF
PCS

Binder Characterization

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

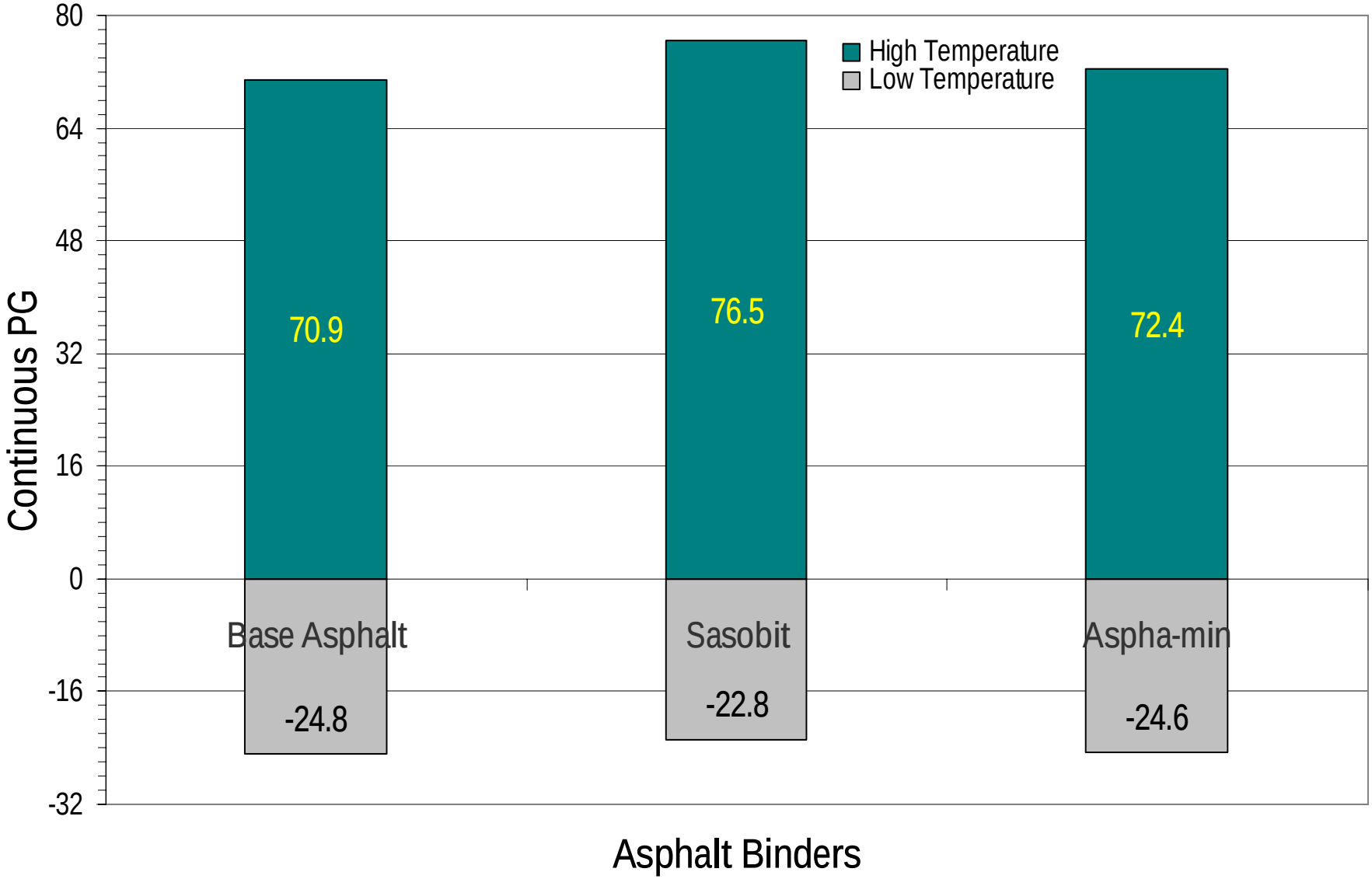
Study Approach

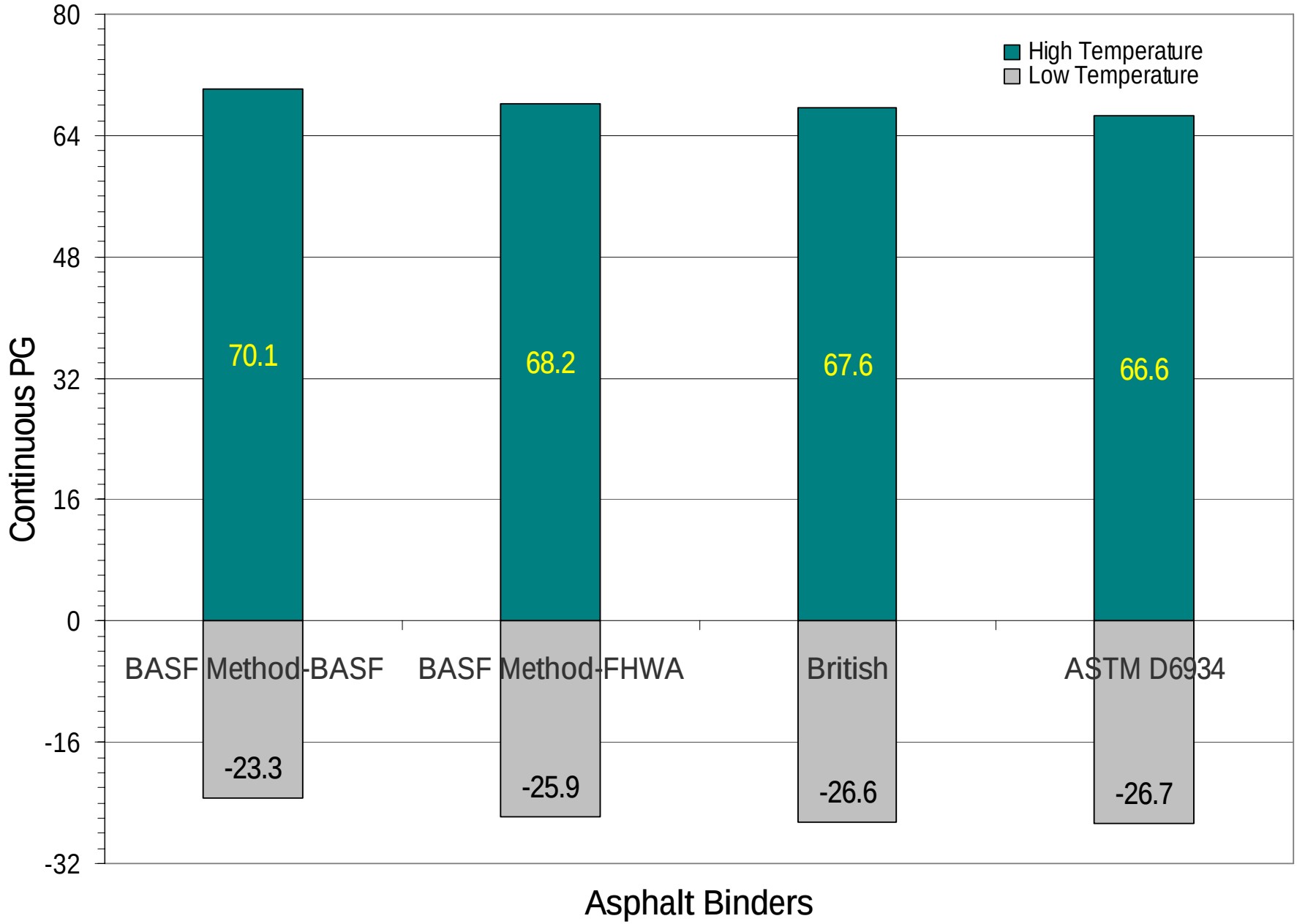
- Experiment Design
  - Base Asphalt PG 70-22
  - Base Asphalt + 1.5% Sasobit
  - Base Asphalt + 5.26% Aspha-Min
  - Evotherm – (emulsion)

Hall St, St. Louis, MO

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

Hall St, St. Louis, MO

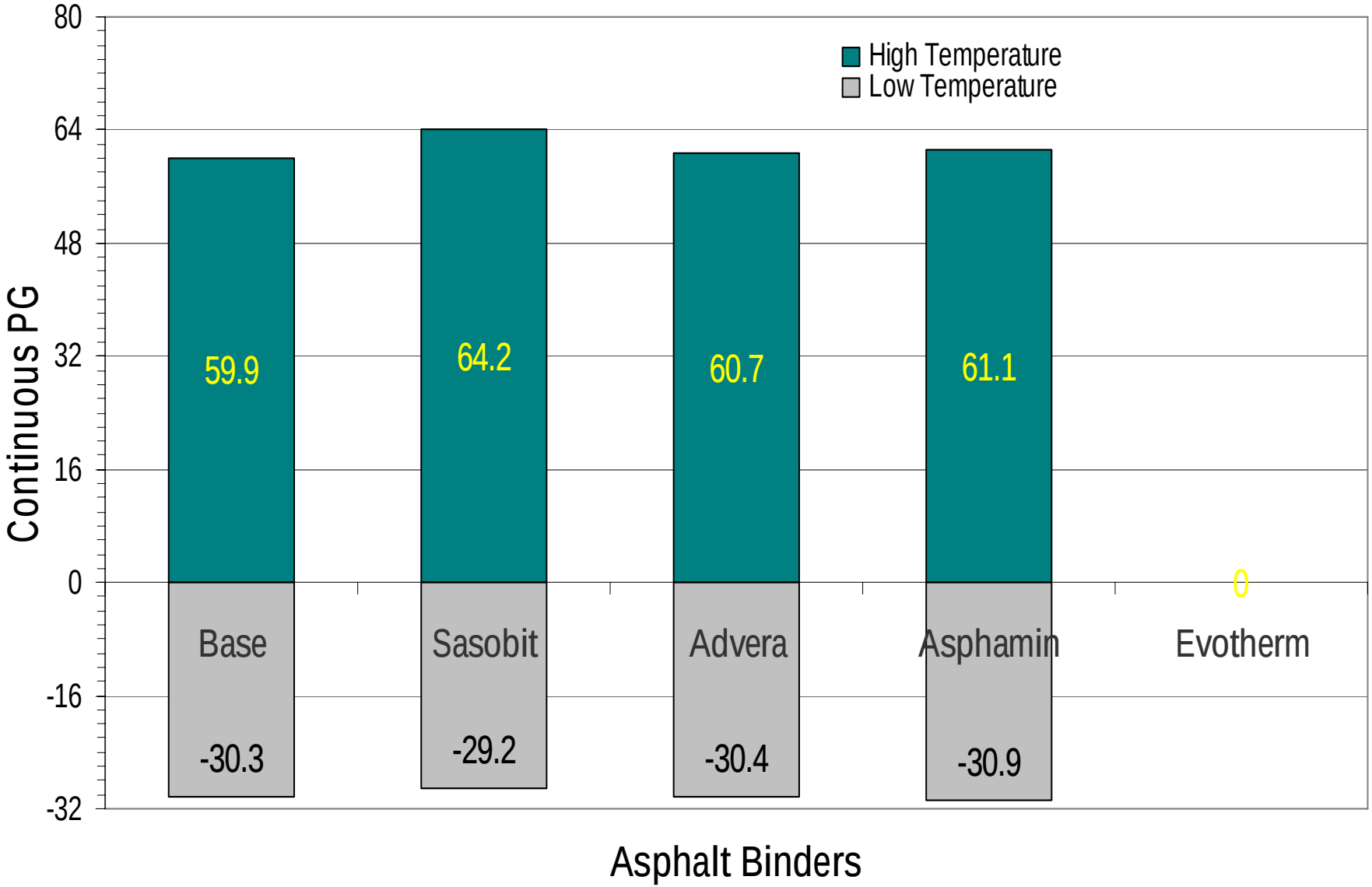



PG Comparison - Evotherm
80
64
48
32
16
0
-16
-32
Continuous PG
High Temperature
Low Temperature
70.1
68.2
67.6
66.6
-23.3
-25.9
-26.6
-26.7
BASF Method-BASF
BASF Method-FHWA
British
ASTM D6934
Asphalt Binders

I-70, Frisco, CO

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

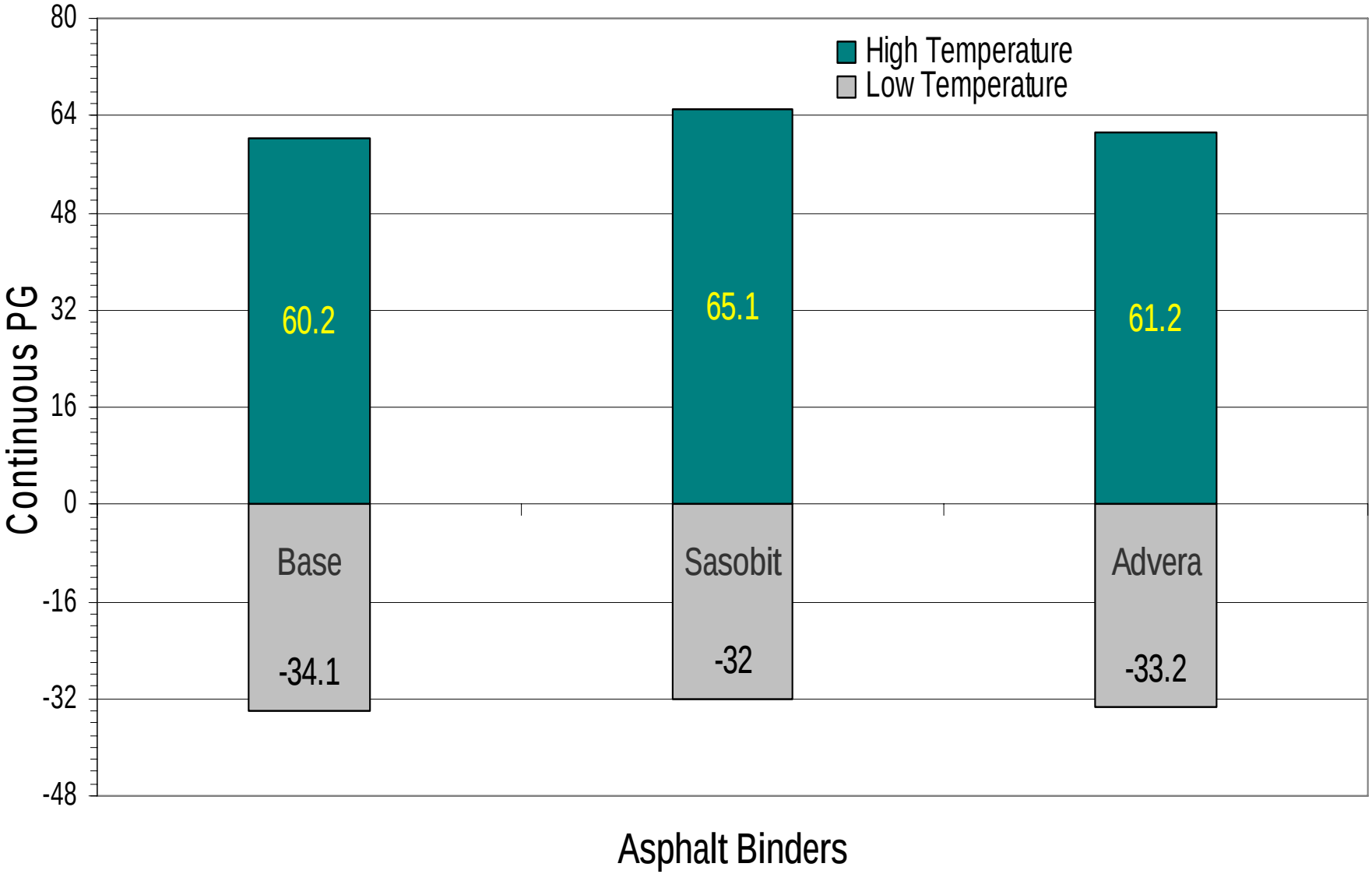
I-70, Frisco, CO



East Entrance Rd, Yellowstone, WY

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

Mixture Characterizations

Objectives

- 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 ≈ every 2hrs of production
  - Volumetric
    - Pb – Ignition
    - Gmm
    - Gmb
  - SPT; TSR; Hamburg

Sampling

- **DELAYED Testing**
  - **2-3 weeks after manufacture**
- Truck bed ≈ 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***

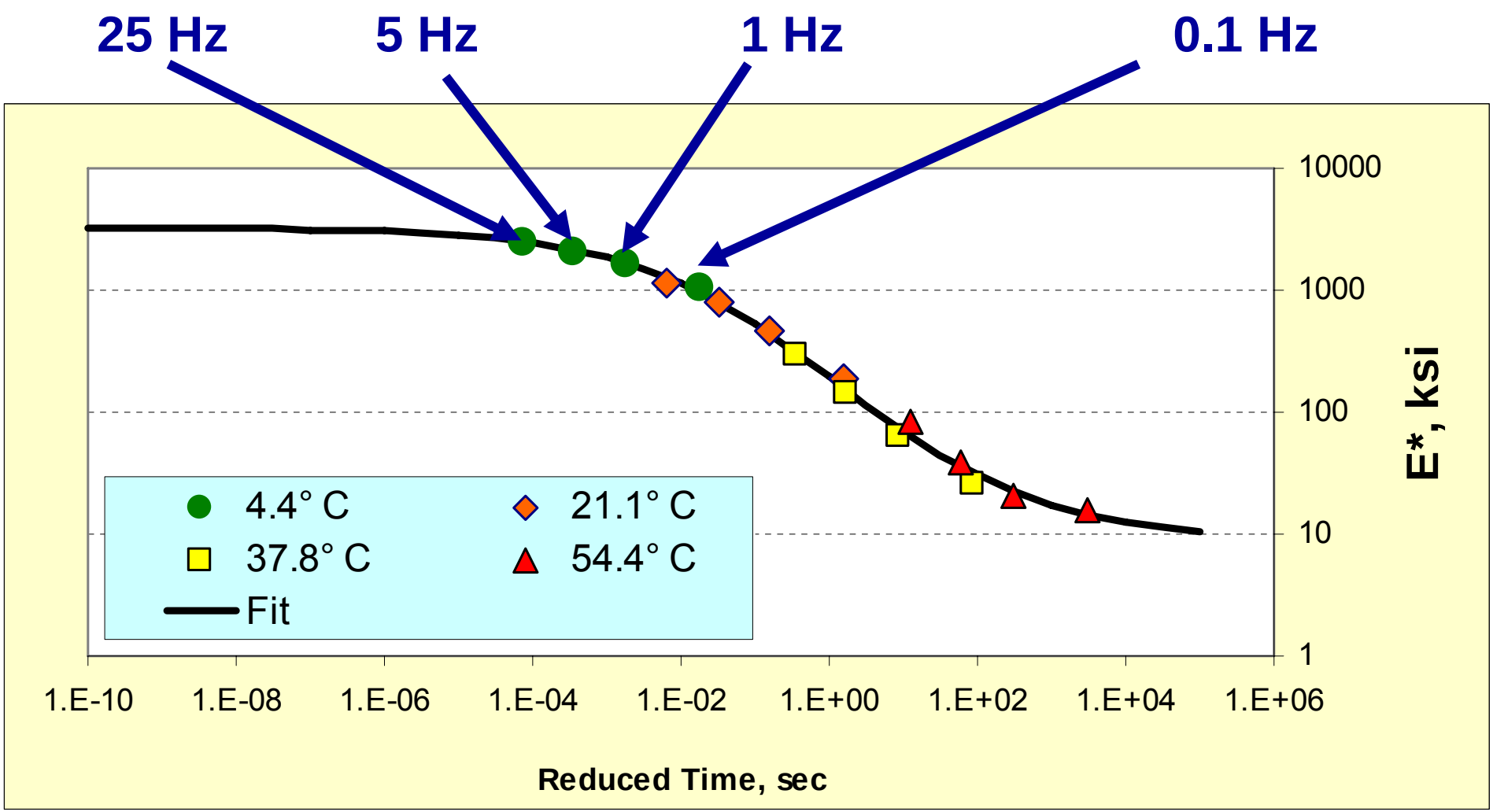
SGC

- **6 nights - *366* specimens**

Dynamic Modulus (E*)

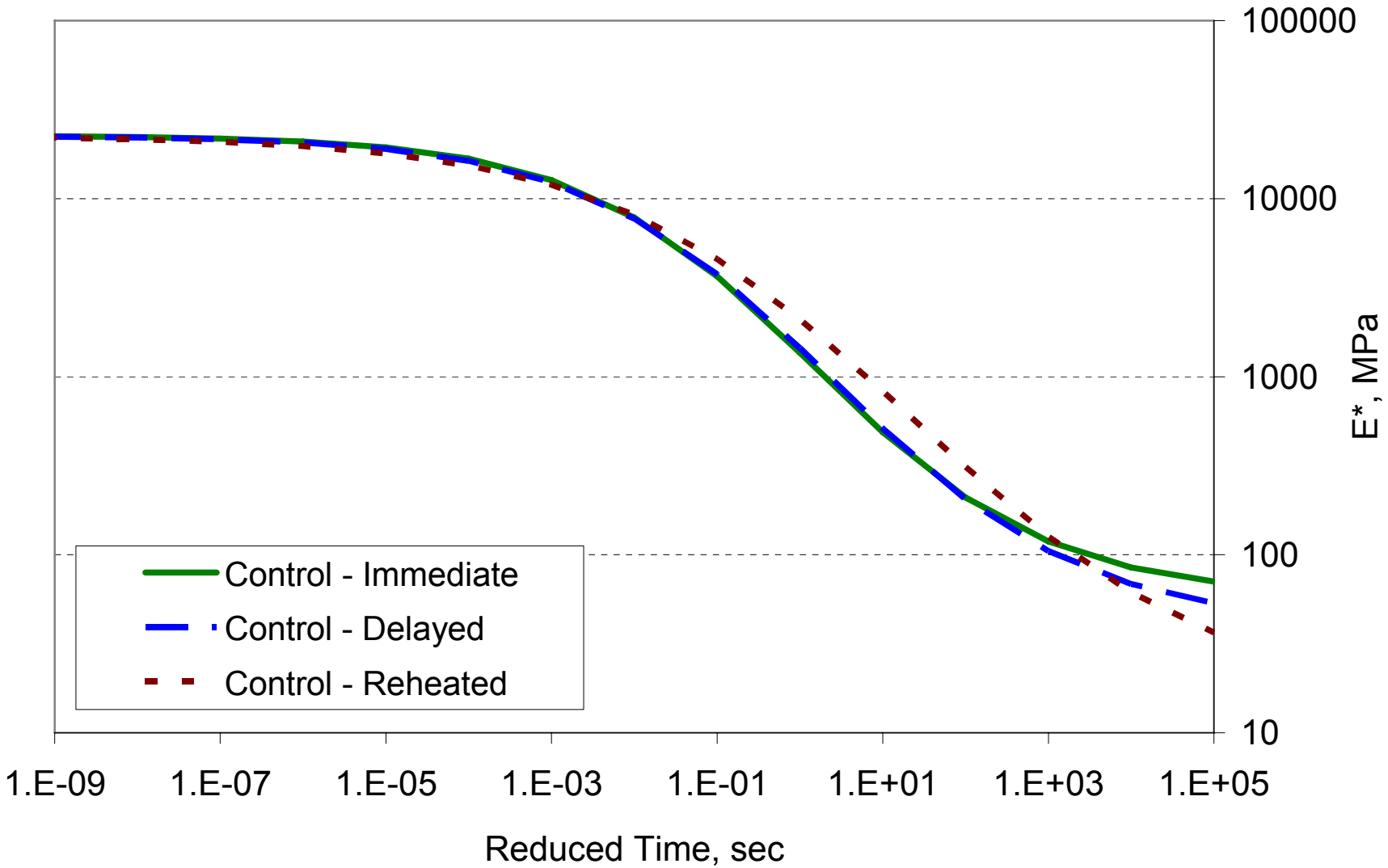
- Test Temperatures
  - **4.4º C** (40º F)
  - **21.1º C** (70º F)
  - **37.8º C** (100º F)
  - **54.4º C** (130º F)
- Frequency Sweep
  - **0.1, 0.5, 1, 5, 10, 25 Hz**

Master Curve – Arrenhius Fit



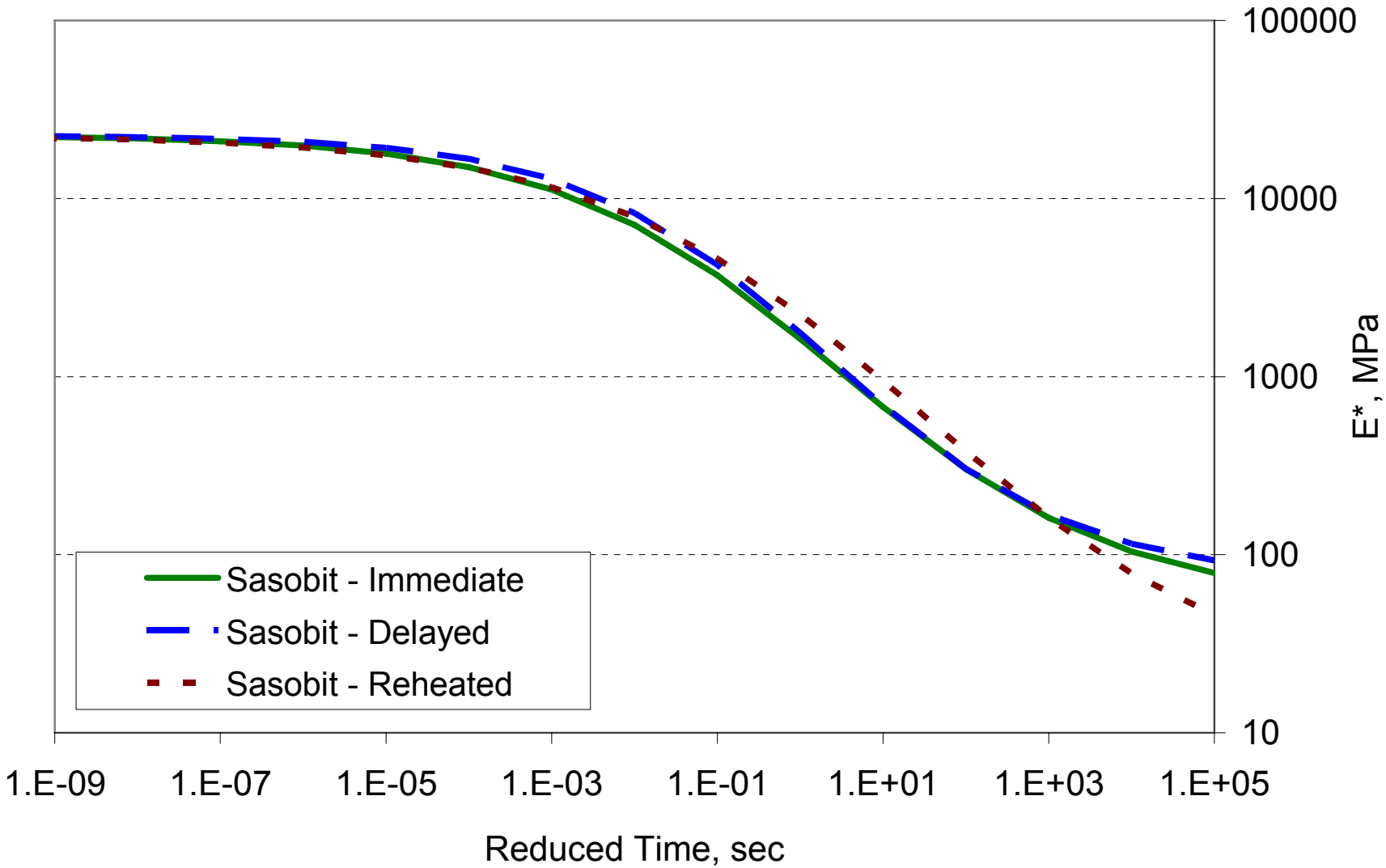
E* - Master Curve

Hall St, St. Louis, MO

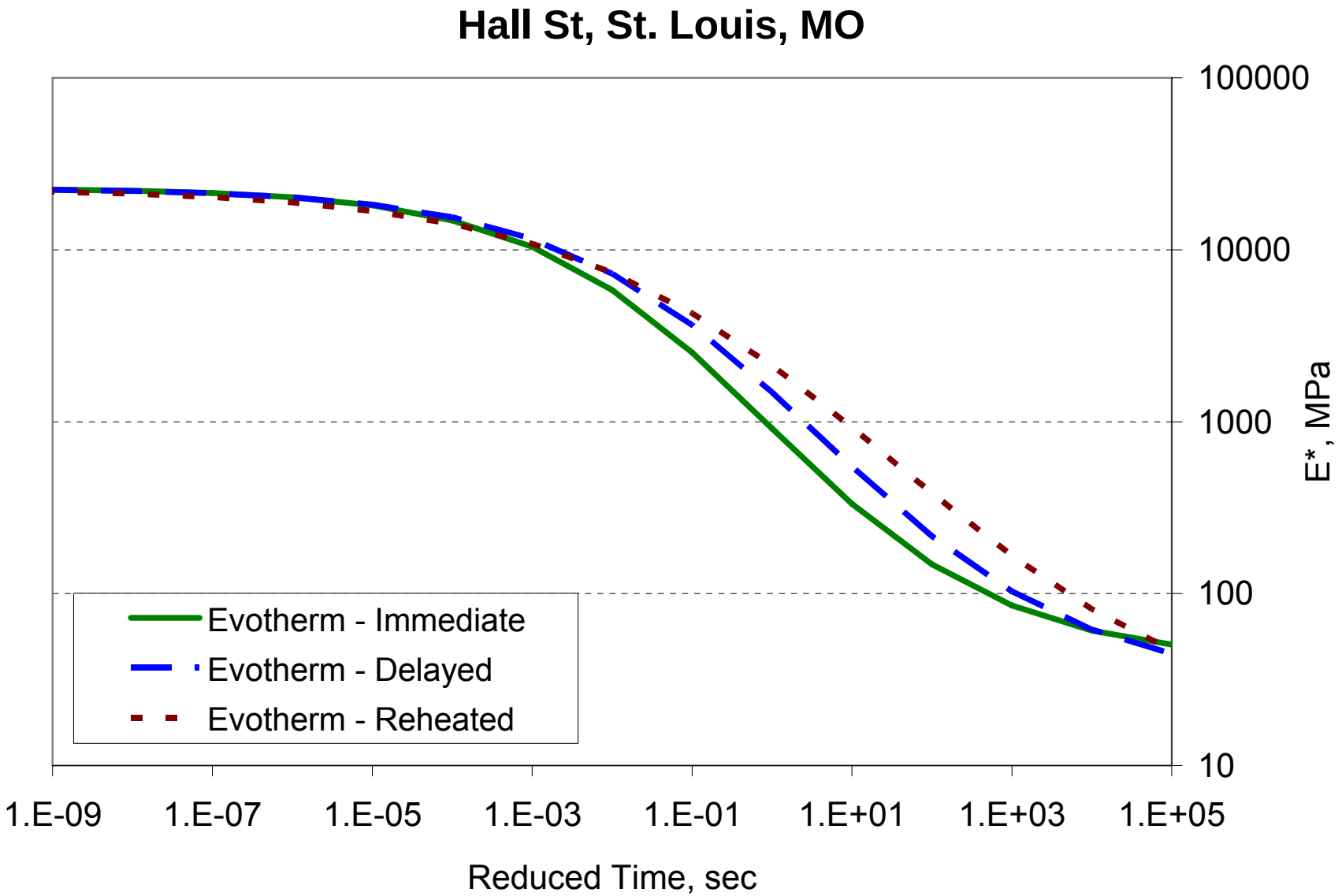


E* - Master Curve

Hall St, St. Louis, MO

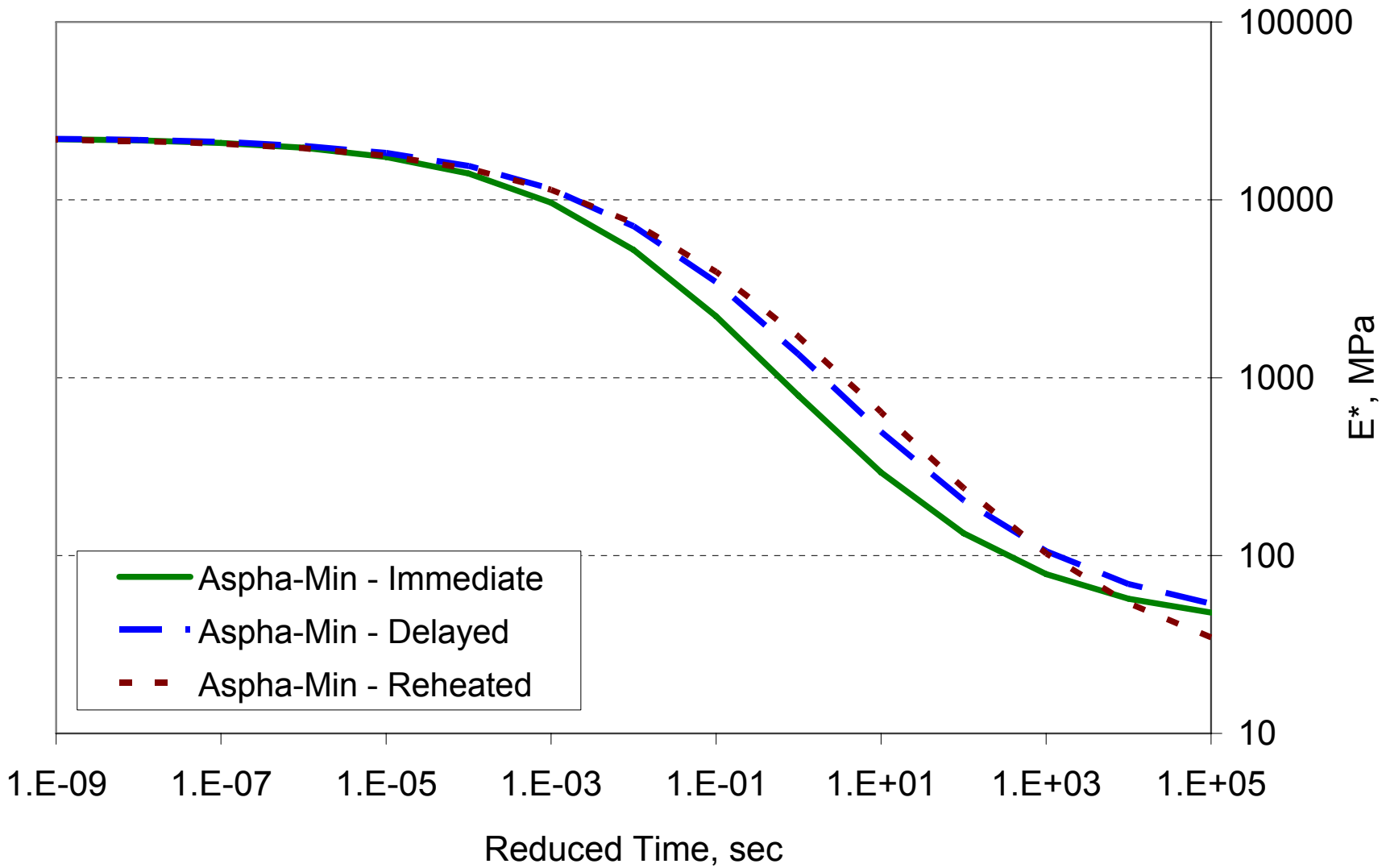


E* - Master Curve



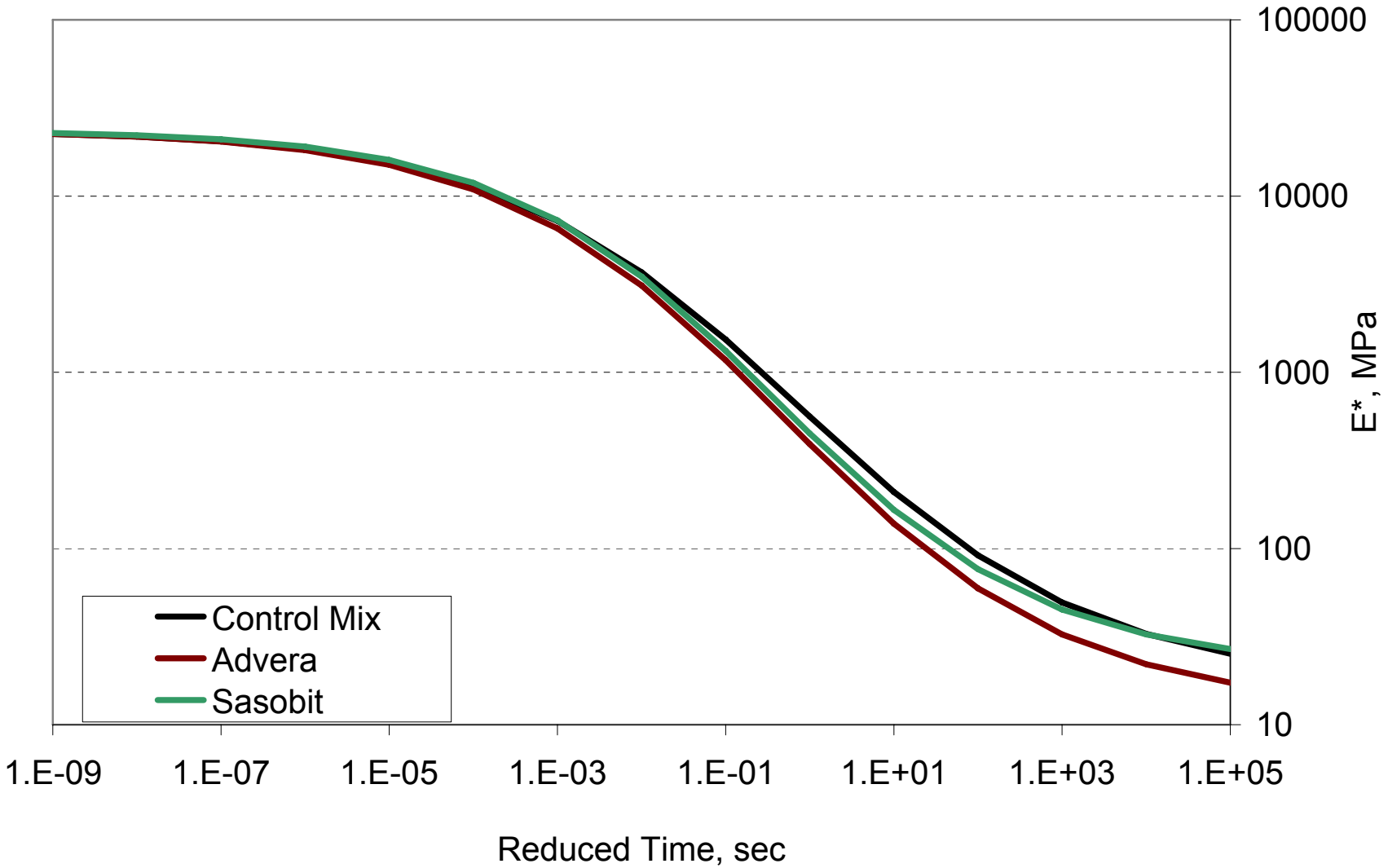
E* - Master Curve

Hall St, St. Louis, MO



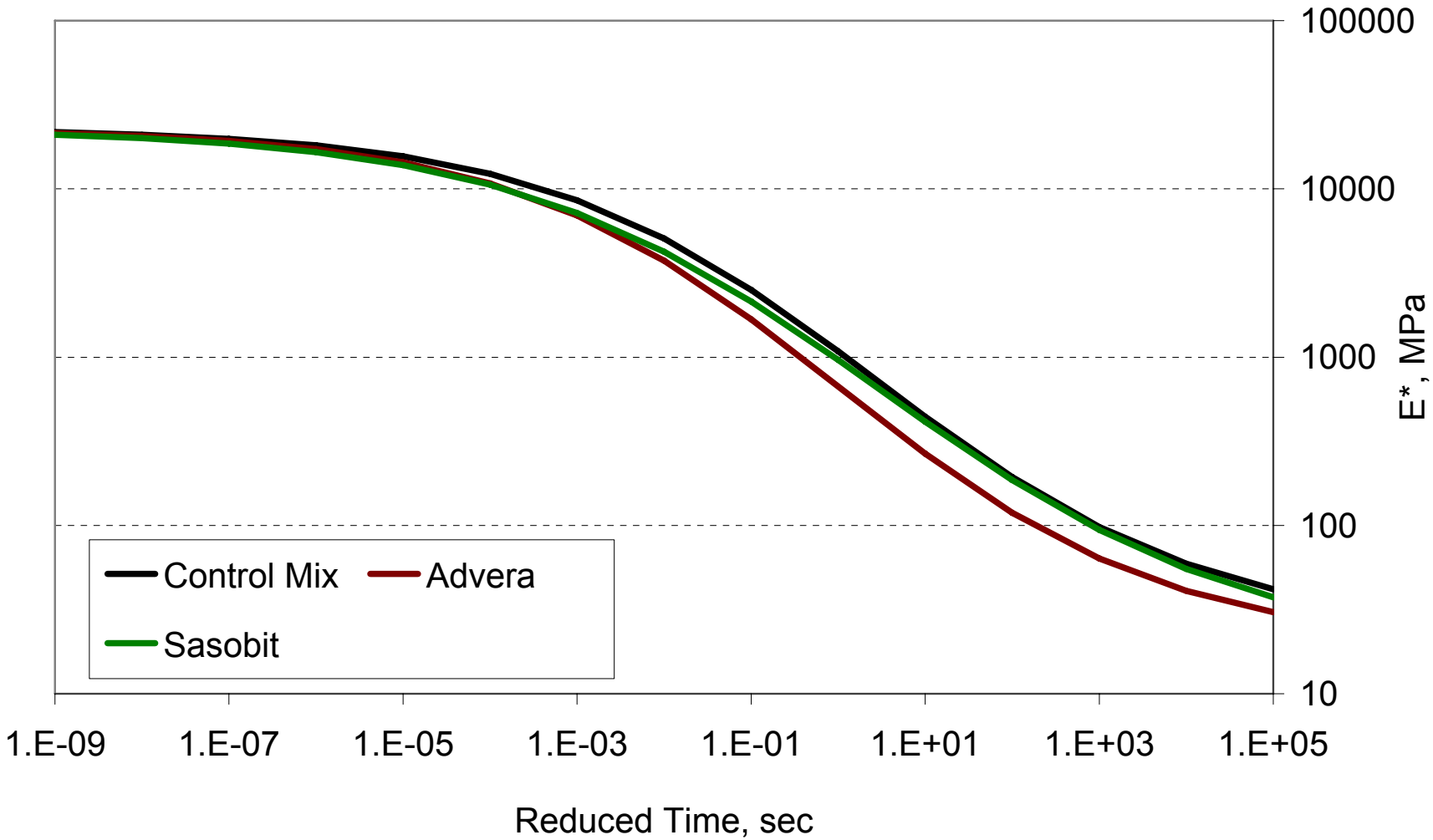
E* - Master Curve

I-70, Frisco, CO



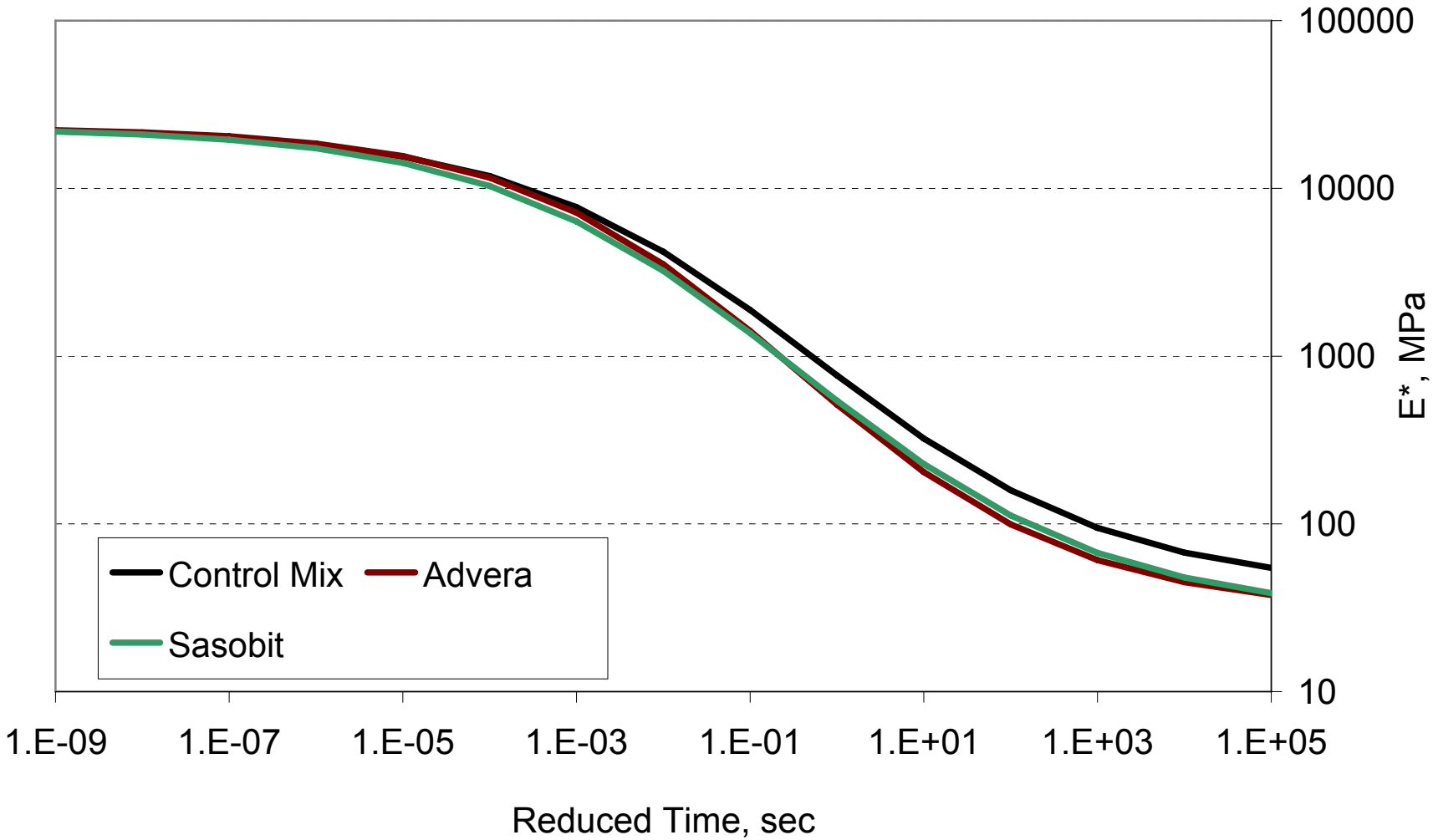
E* - Master Curve

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

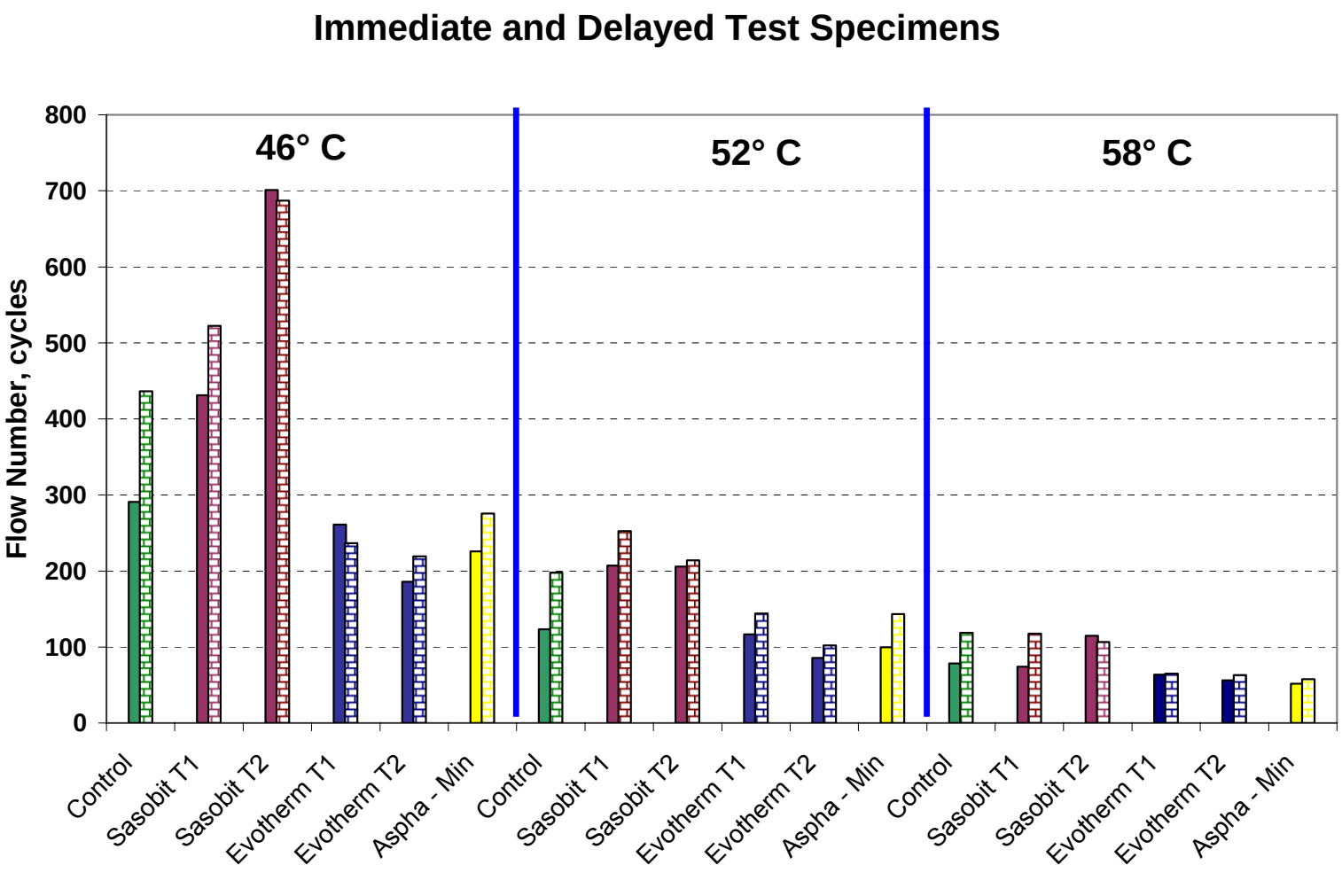
- **Test Temperatures**
  - LTTPBind, Version 3.1 Software
  - Site pavement temperature @ 50% Reliability
    - Pvmt Temp, ± 6° C

Flow Number, Fn

Hall Street, St. Louis, MO

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

Flow Number, Fn



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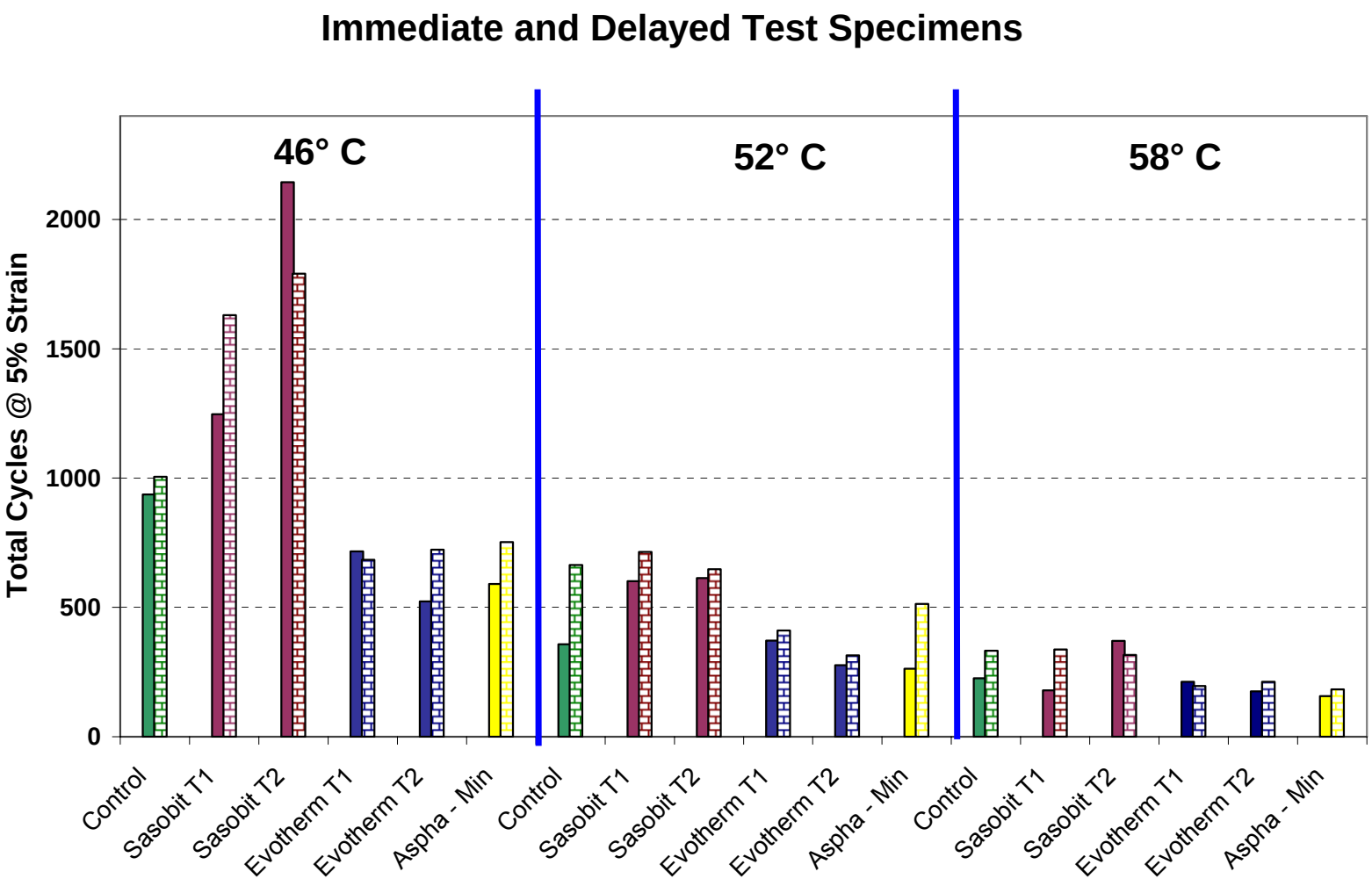
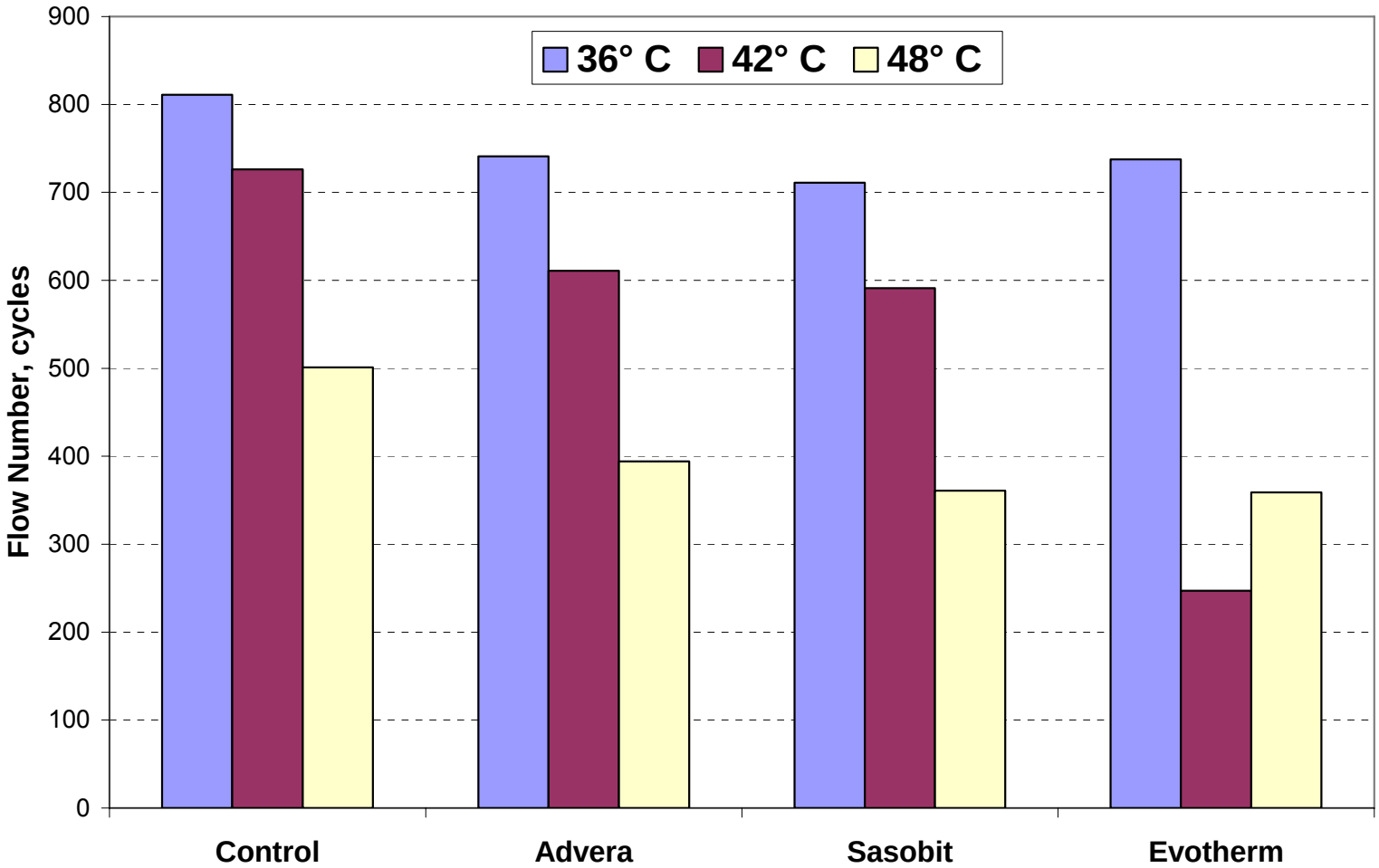


Flow Number, Fn

I-70 - Frisco, CO

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

Flow Number, Fn



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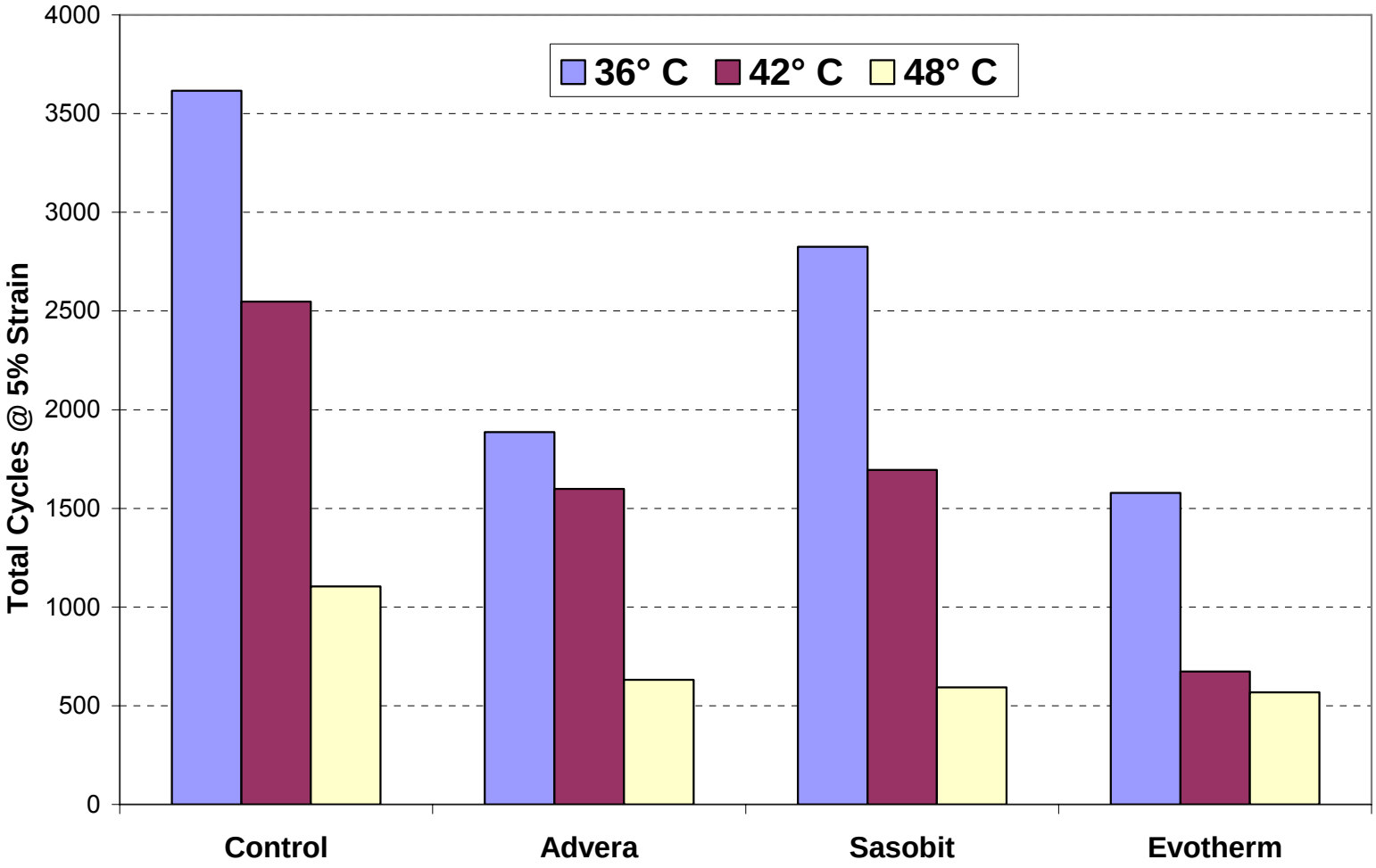


Flow Number, Fn

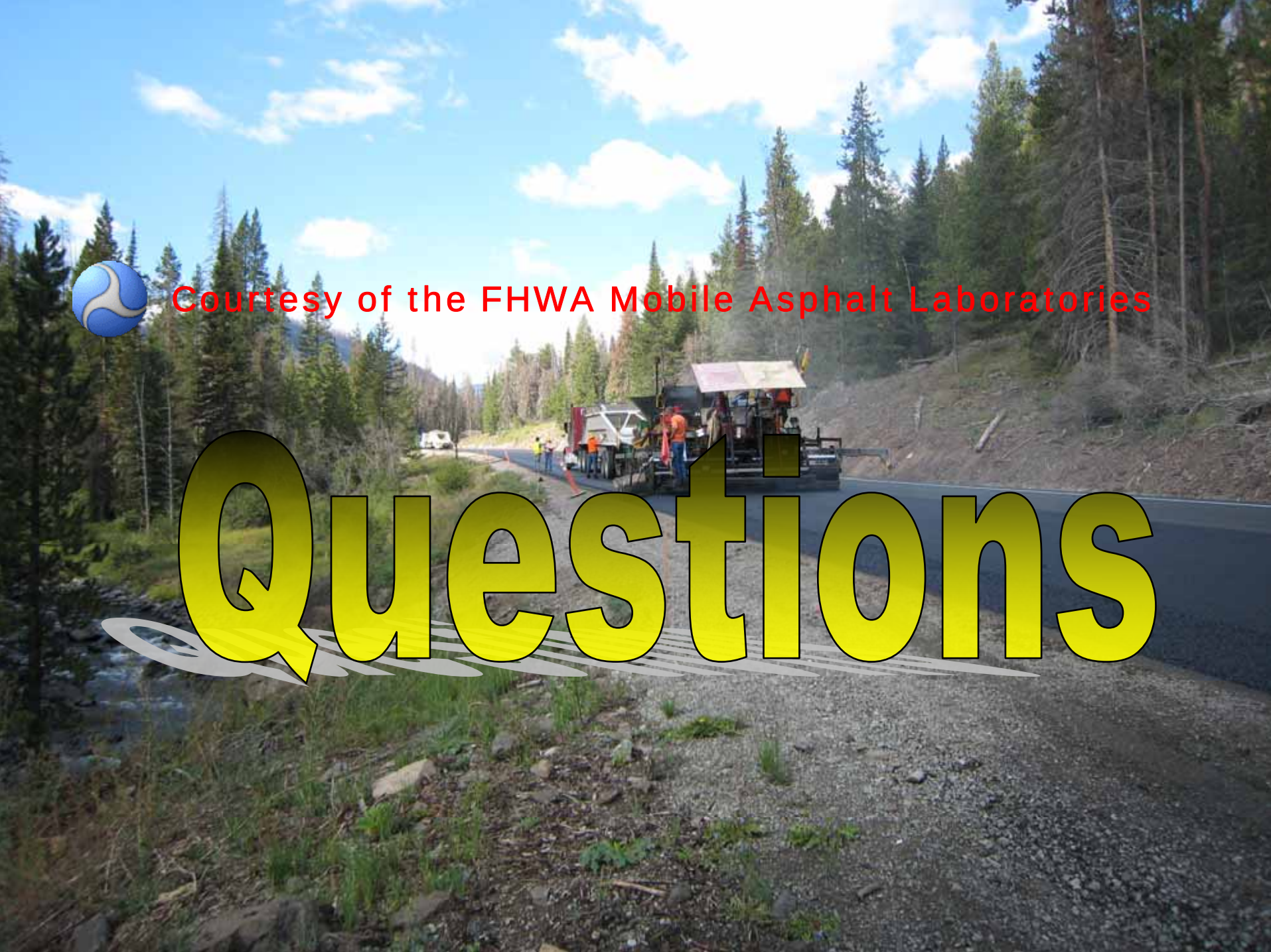
East Entrance Rd - Yellowstone, WY

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

Flow Number, Fn

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