U.S. Department of Transportation
Federal Highway Administration

National Center for Asphalt Technology
NCAT
at Auburn University

Office of Pavement Technology

Updates on High RAP Field Projects

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RAP ETG
October 28, 2008
Phoenix, AZ

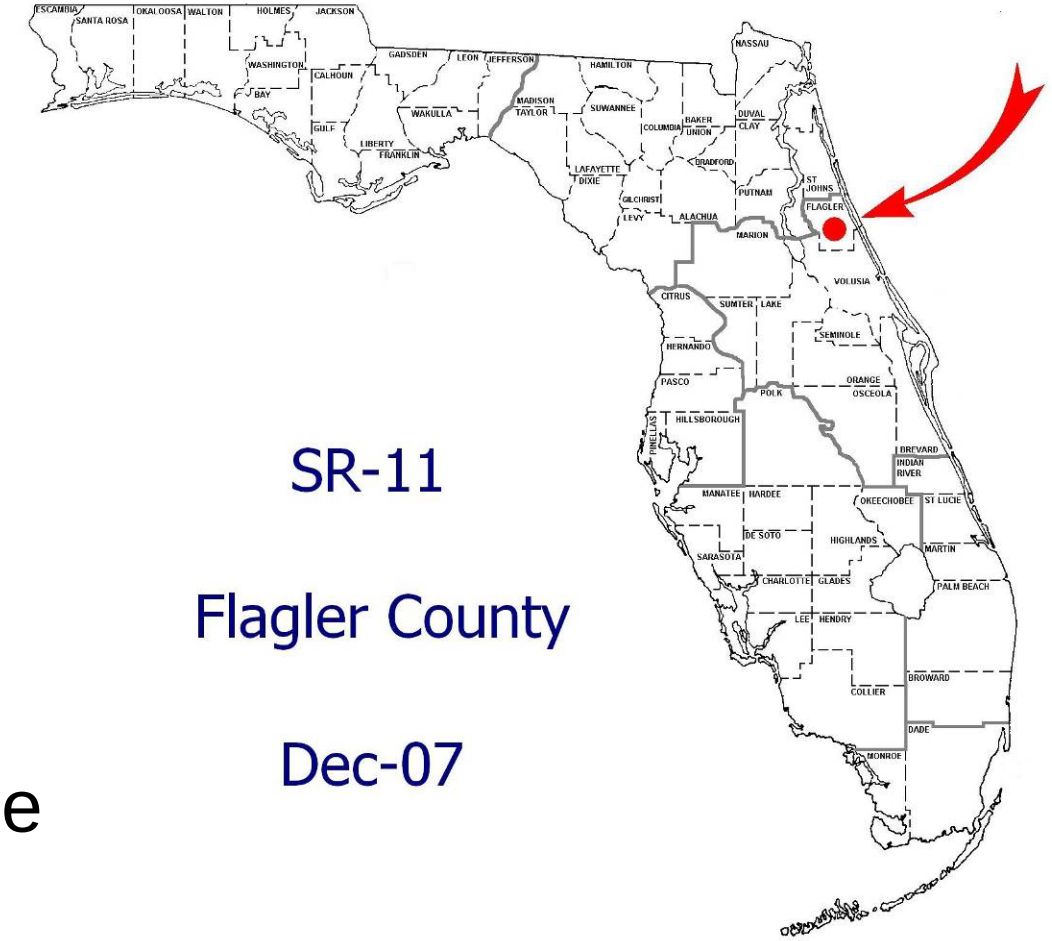
High RAP Field Projects to Date

State	Permitted Intermediate	Permitted Surface	RAP Percentage Used	Date of Paving
North Carolina*	20%	20%	**40%**	**September 2007**
South Carolina	15%	15%	**30% and 50%**	**October 2007**
Wisconsin	≥30%	20%	**25%**	**November 2007**
Florida*	≥30%	0%	**45%**	**December 2007**
Kansas	25%	25%	**30 – 40 %**	**May 2008**
Delaware	20%	10%	**30%**	**Summer 2008**

* Warm mix asphalt process

Project Information

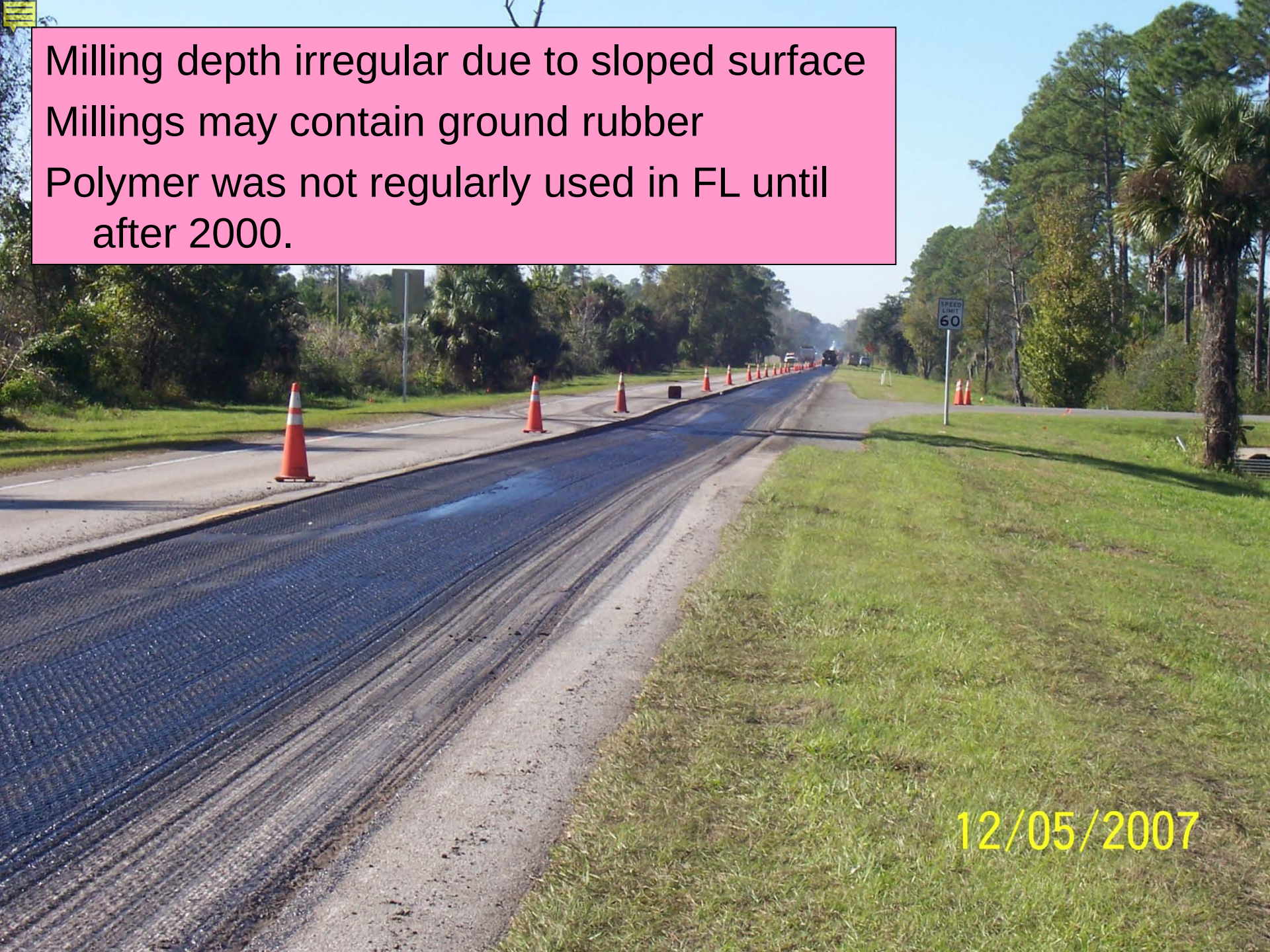
- Plant Location:
  Daytona Beach, FL
- Construction Site:
  Deland, FL (15 miles from plant)
- Two lane road
- Dates of paving:
  December 2007 – January 2008, daytime conditions



Job Mix Formula Information

Mix Type	Superpave 12.5 mm	
Mix Use	Structural	
Design Traffic Level	3 to <10 (1 x 10^6 ESAL's)	
Gyrations @ Ndes	75	
Total Binder Content	5.6 %	
RAP Binder	2.8 %	
Virgin Binder (RA 800)	2.8 %	
Antistrip	0.75 %	
	Control	**Warm Mix**
Mixing Temp	310^o F	270^o F
Compacting Temp	300^o F	260^o F

Pavement Layer Information



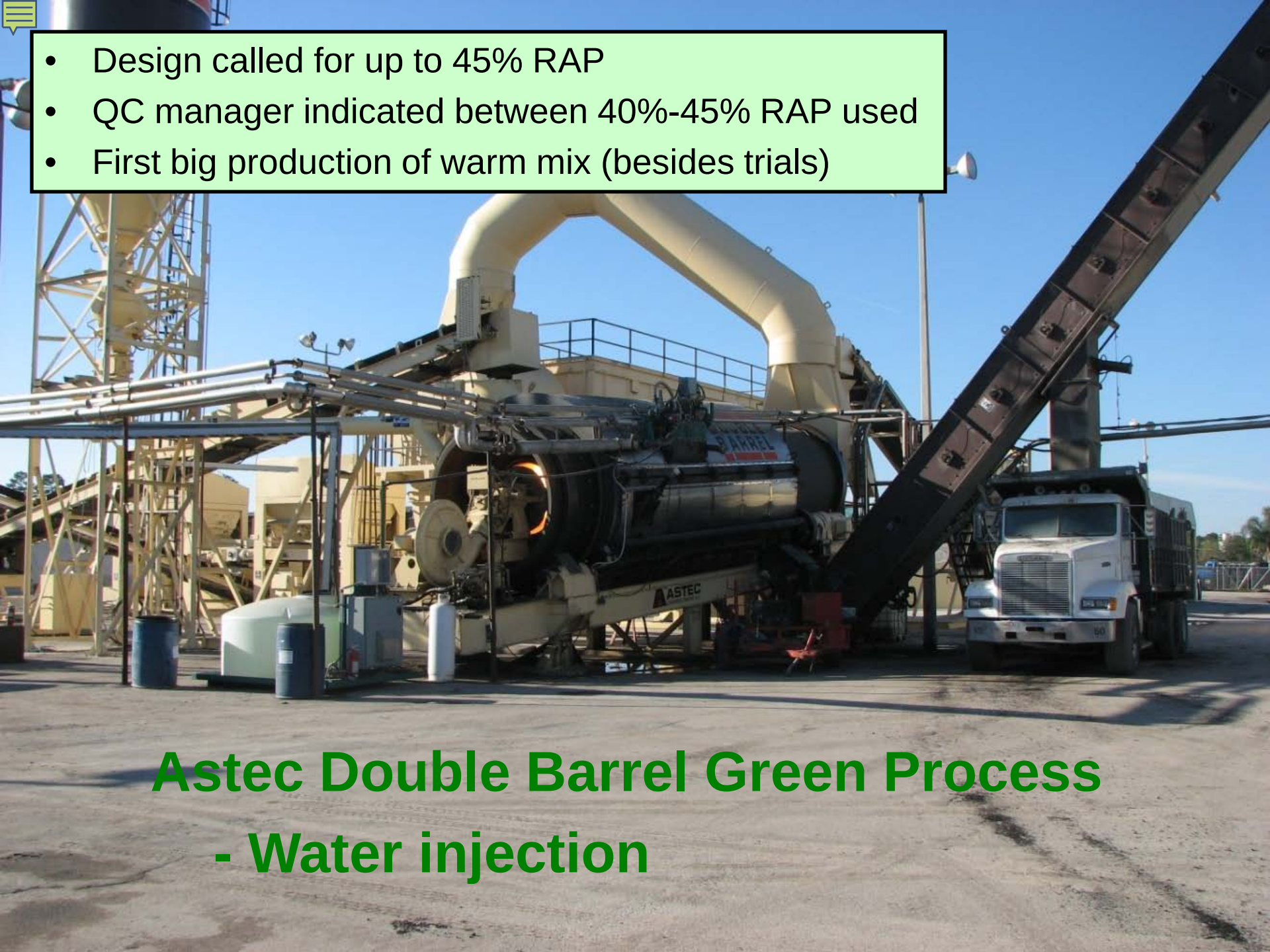
- Milling depth irregular due to sloped surface
- Millings may contain ground rubber
- Polymer was not regularly used in FL until after 2000.


Paving level with shoulder and then slopes up to crown about 2º for finished lift.
12/05/2007

Fractionated RAP

Coarse

Fine



- Design called for up to 45% RAP
- QC manager indicated between 40%-45% RAP used
- First big production of warm mix (besides trials)

Astec Double Barrel Green Process - Water injection

Results Summary

- FDOT Research Lab
  - Virgin and Recovered Binder Viscosity Results
  - Gradation
  - Volumetrics
  - Performance Testing (T 283 and APA)
- Contractor's Quality Control (QC)
  - Gradation
  - Volumetrics

- NCAT
  - Virgin and RAP PG
  - Gradation
  - Performance Testing
    - T 283
    - APA
    - Hamburg
    - IDT
    - Dynamic Modulus
    - Beam Fatigue
- FHWA MAMTL
  - Virgin and Recovered Binder PG
  - Performance Testing (AMPT)
    - Dynamic Modulus
    - Flow Number

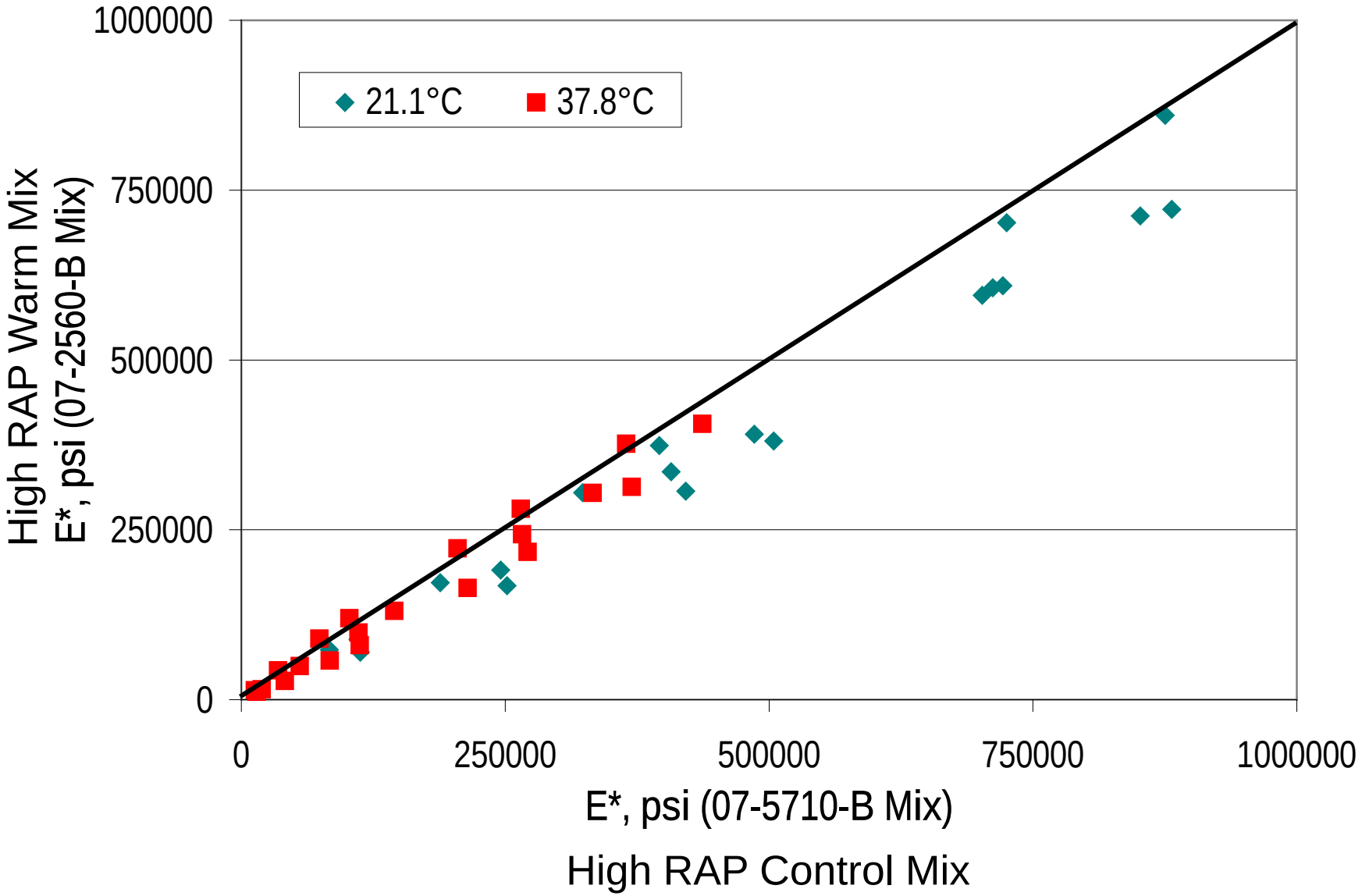
Performance Grade Results

Binder	M320-Table 1	M320 – Table 2	M320 - Continuous
Virgin Binder 1 NCAT	n/a	64-22	64.7-25
Virgin Binder 2 (RA 800) NCAT	n/a	52-28	57.5-29.1
Virgin Binder 2 (RA 800) FHWA	52-28	52-28	55.4-30.5
Warm Mix Hi RAP (FHWA)	52-16	52-22	57.2-27.3
Control Mix Hi RAP (FHWA)	64-16	64-16	68.4-19.2
Coarse RAP (NCAT)	n/a	82-16	82.9-17.2
Fine RAP (NCAT)	n/a	82-10	85.2-14.2

Mixture Performance Testing by FHWA

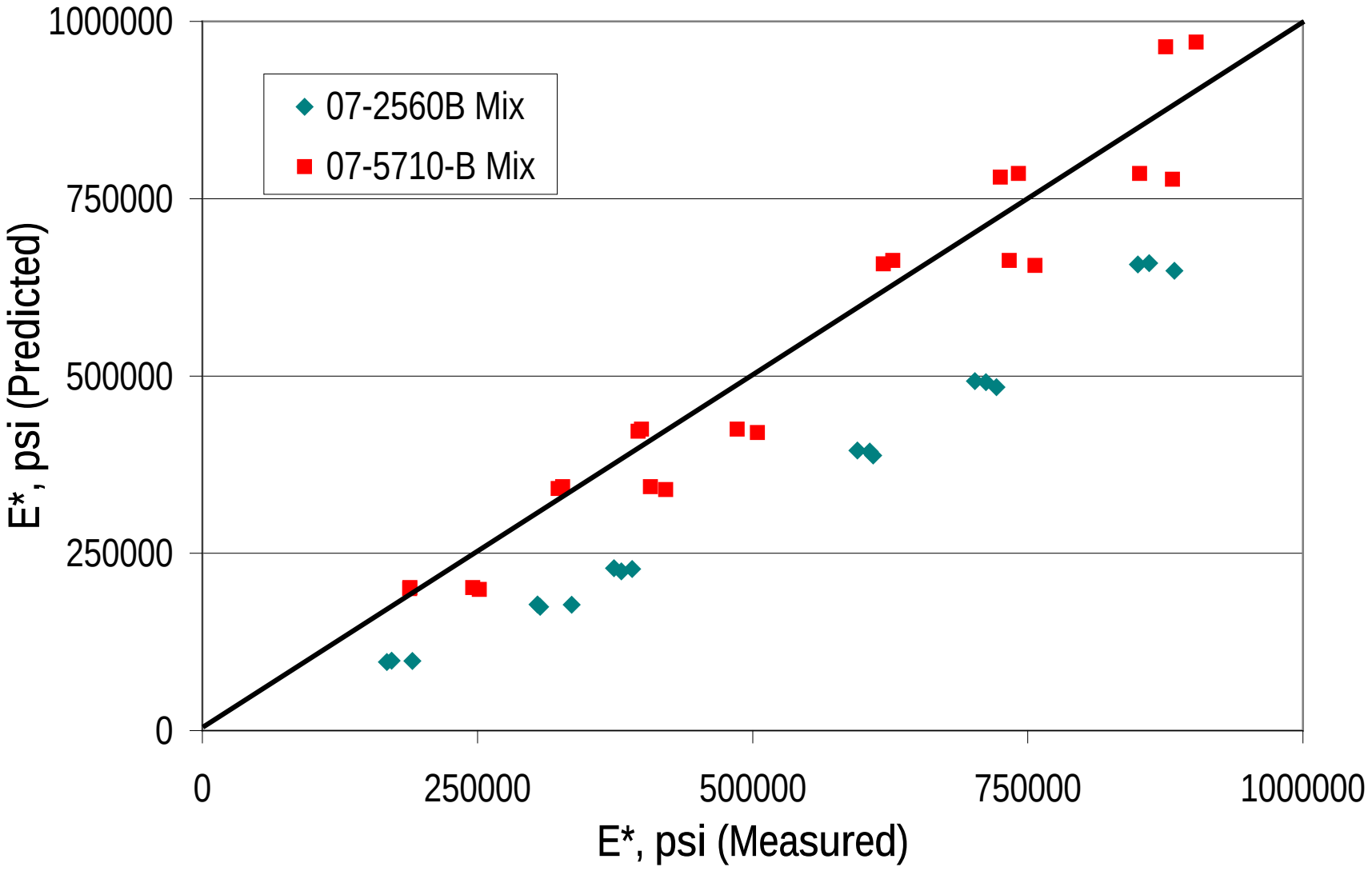
- **Asphalt Mix Performance Tester (AMPT)**
  - Dynamic Modulus (*E**) and Flow Number (Fn) were tested according to NCHRP 9-29 protocols.
  - Dynamic Modulus: Plant produced mix tested at 21.1º C (70º F) and 37.8º C (100º F).
  - Flow Number: Plant produced mix tested at 60º C (140º F).

Comparing Measured E* Values



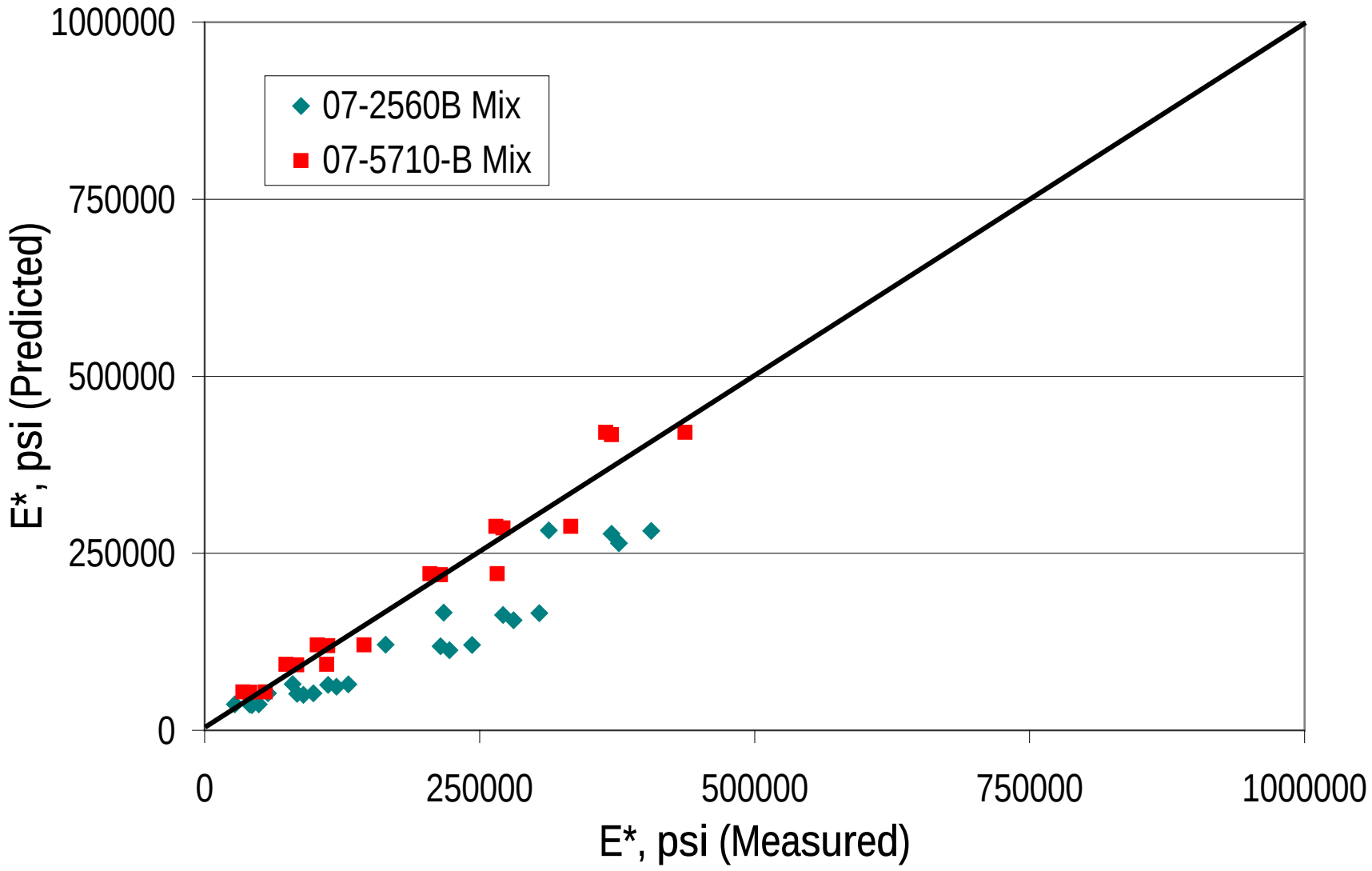
Predicted vs. Measured E* Values

(Hirsch Model at 21.1º C)



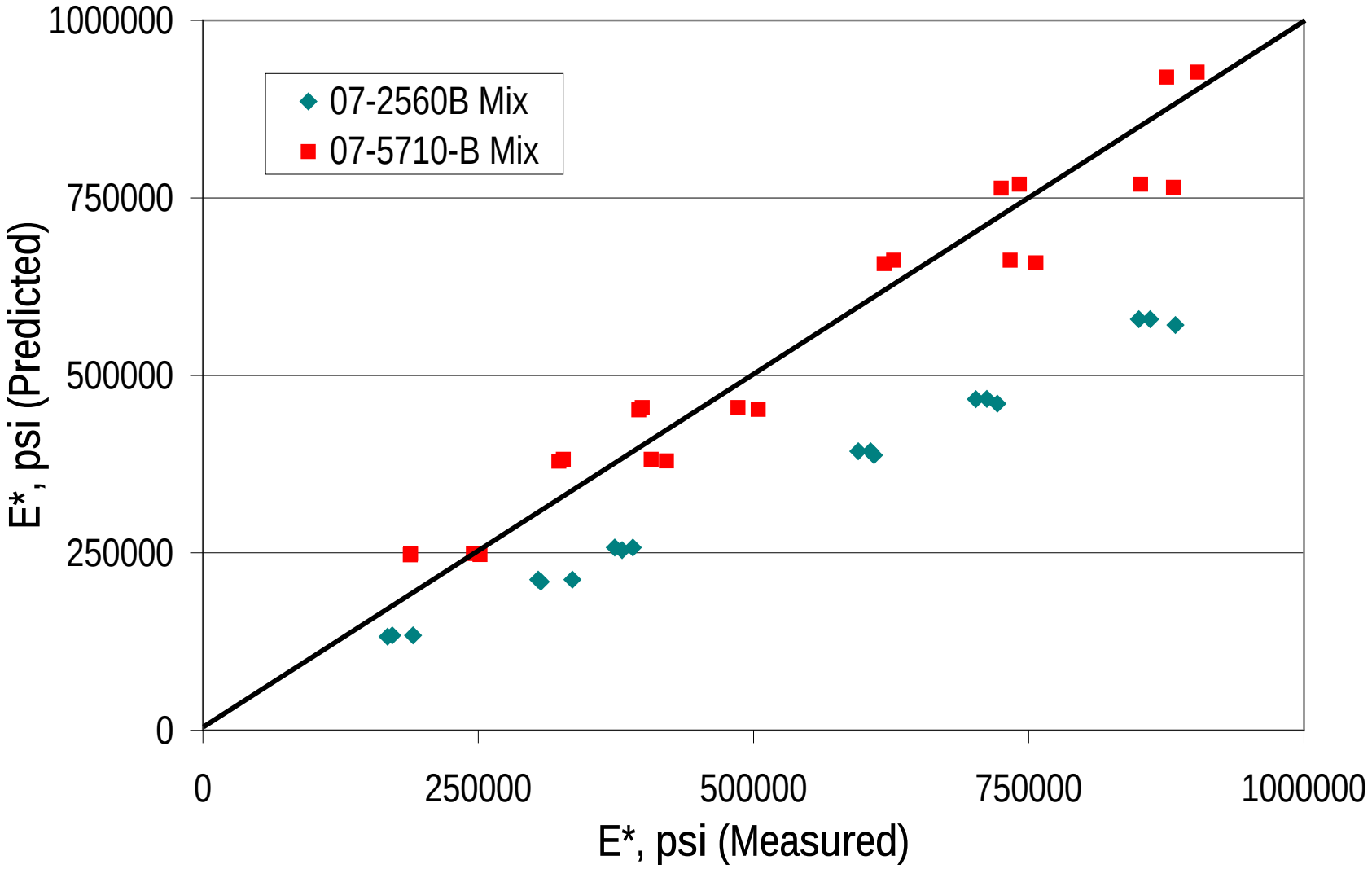
Predicted vs. Measured E* Values

(Hirsch Model at 37.8º C)



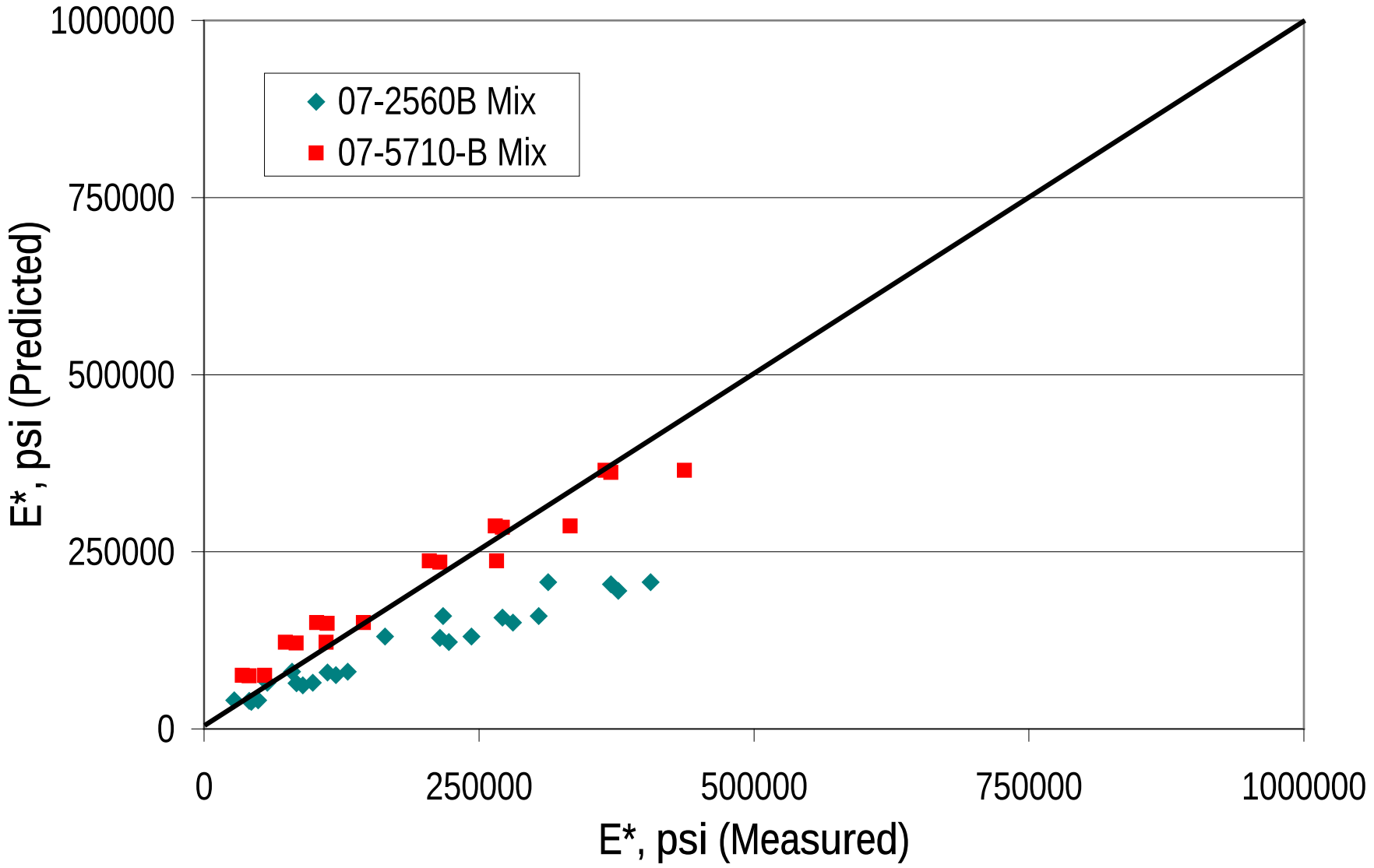
Predicted vs. Measured E* Values

(Witczak Model at 21.1º C)



Predicted vs. Measured E* Values

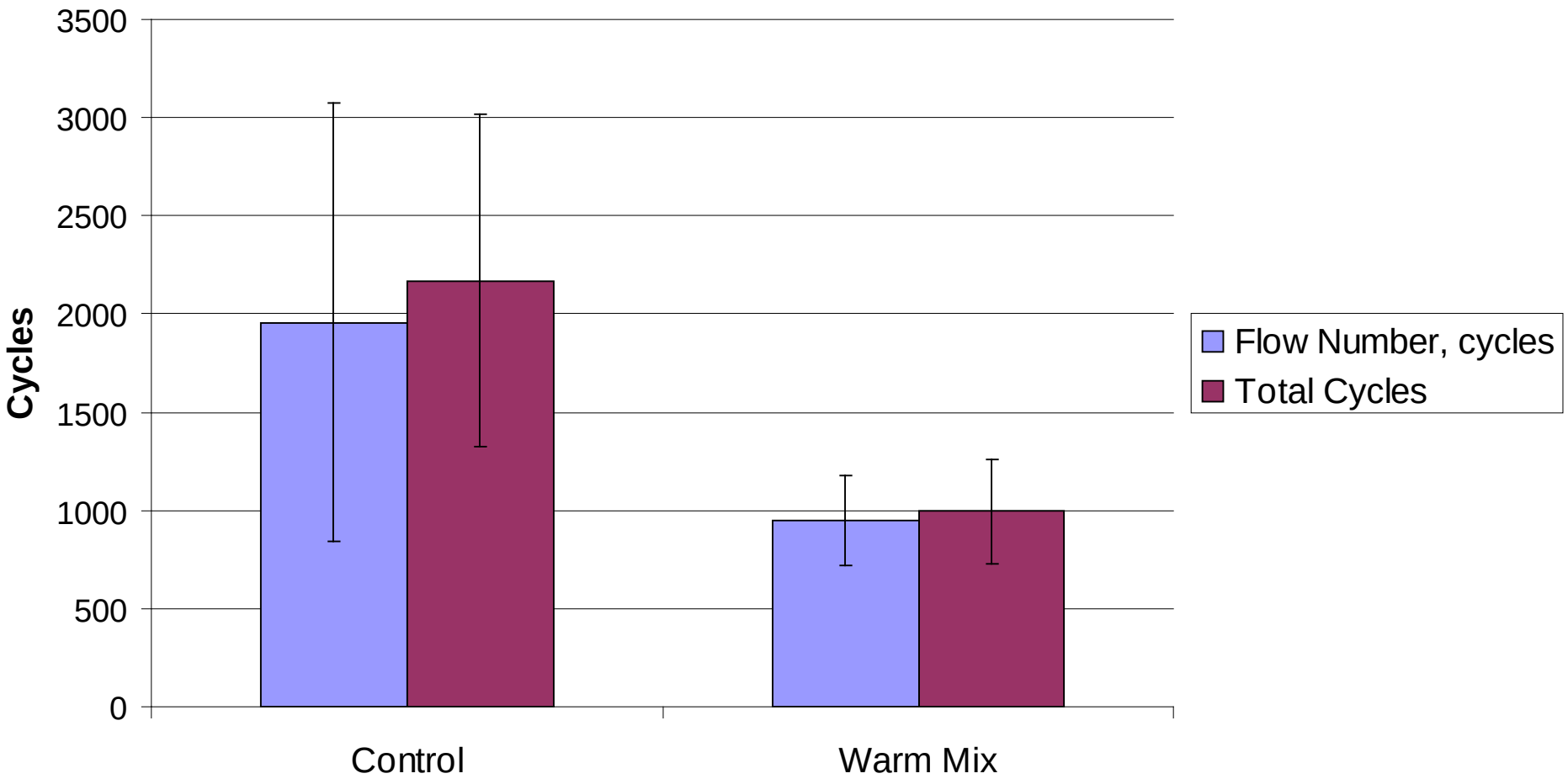
(Witczak Model at 37.8º C)



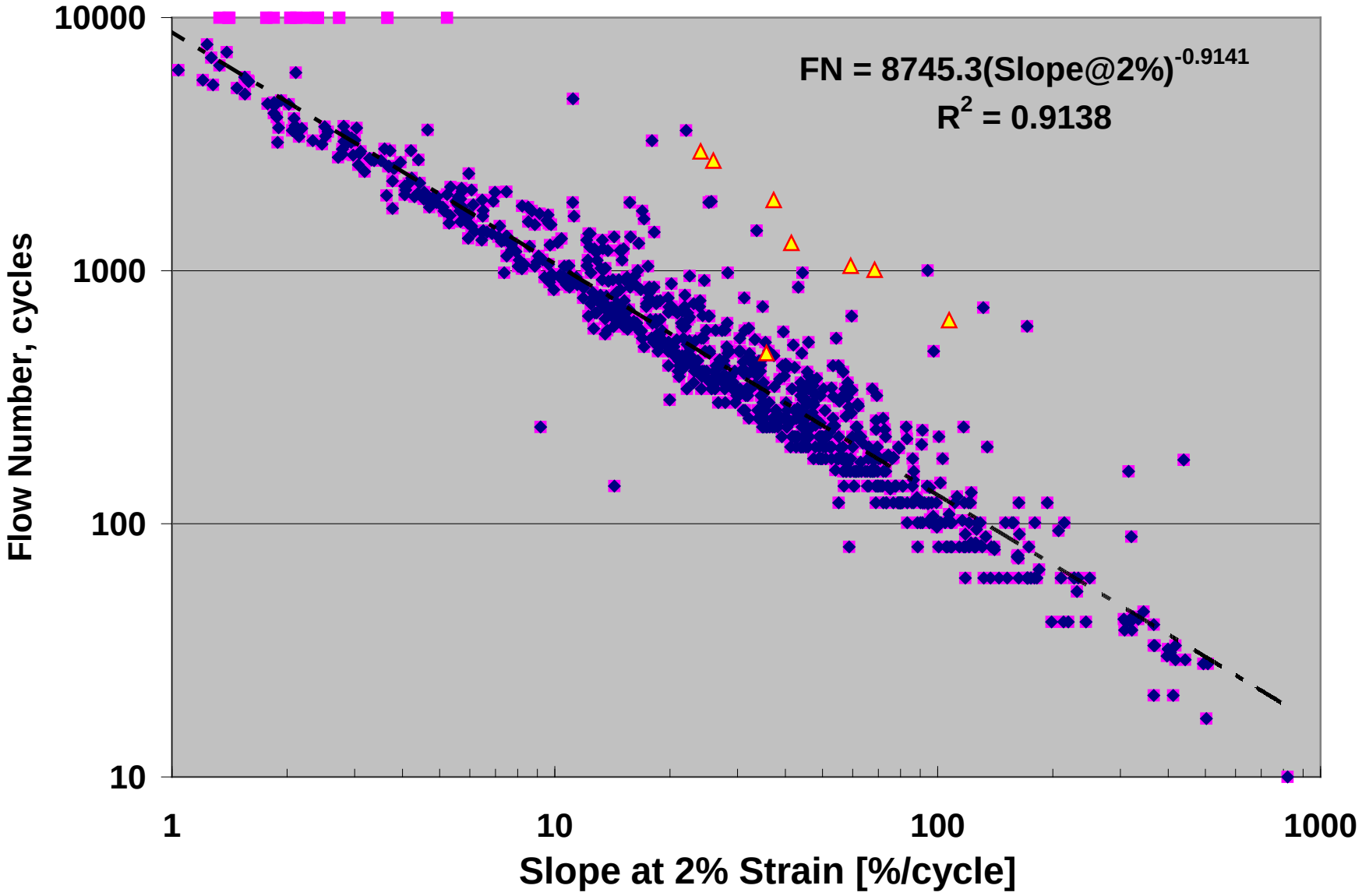
Flow Number (Fn)

- Determined using repeated load permanent deformation test
- Indicates rutting resistance
- Francken model used to predict Fn
- Steady State Slope and Slope at 2% Strain were found to be robust indicators of rust resistance.

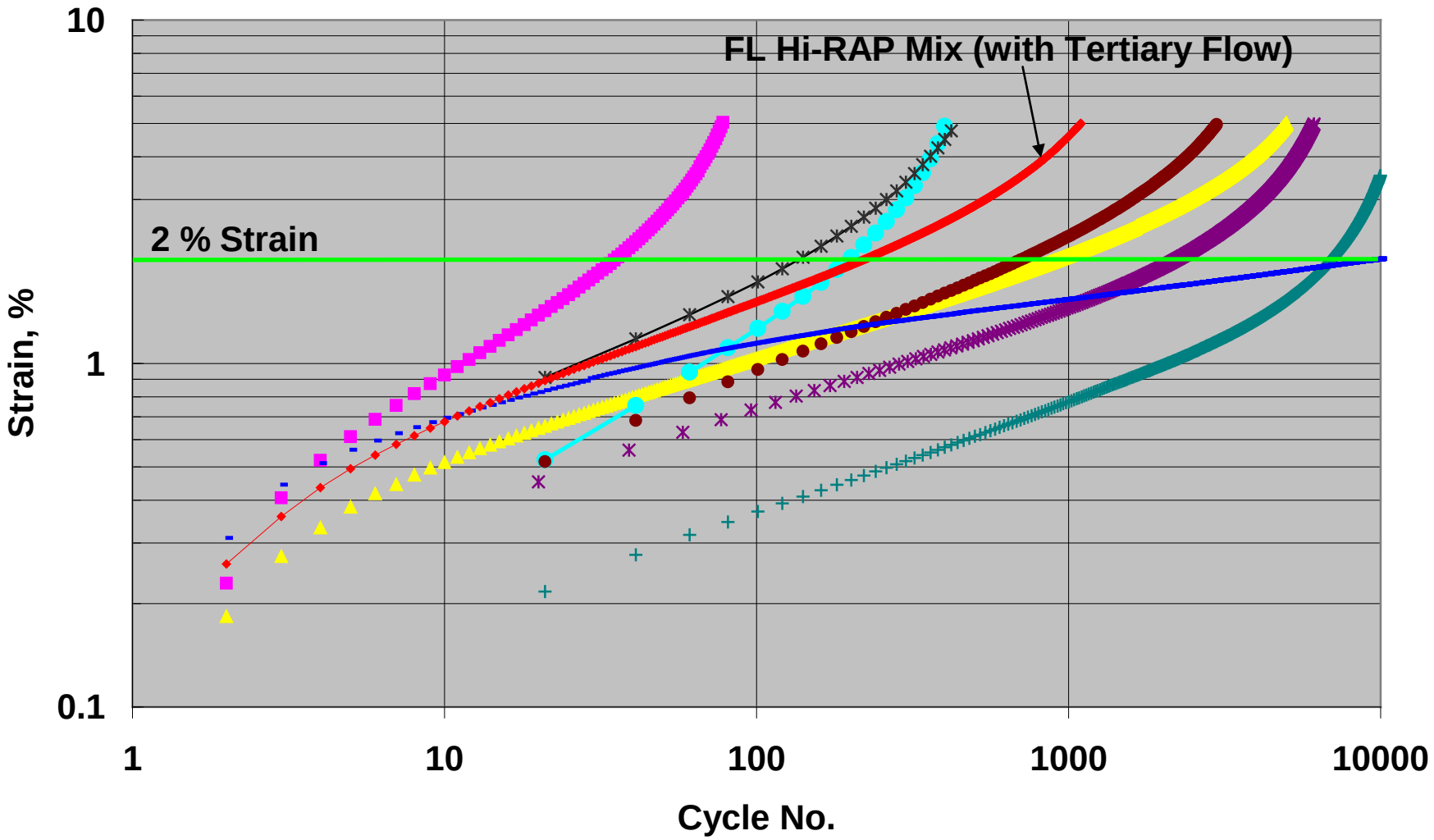
AMPT Flow Number Results for FL



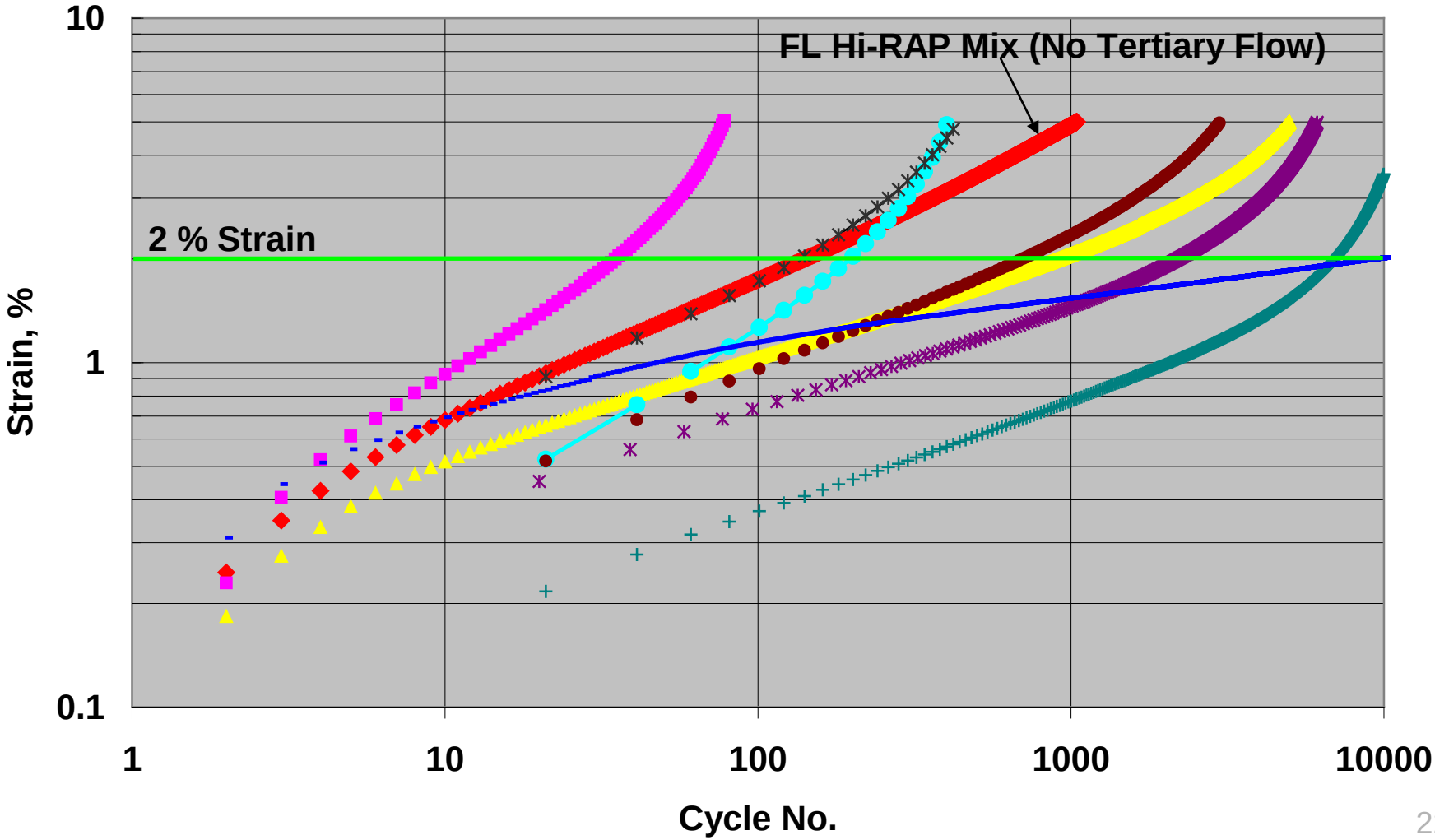
Flow Number vs. Slope at 2% Strain



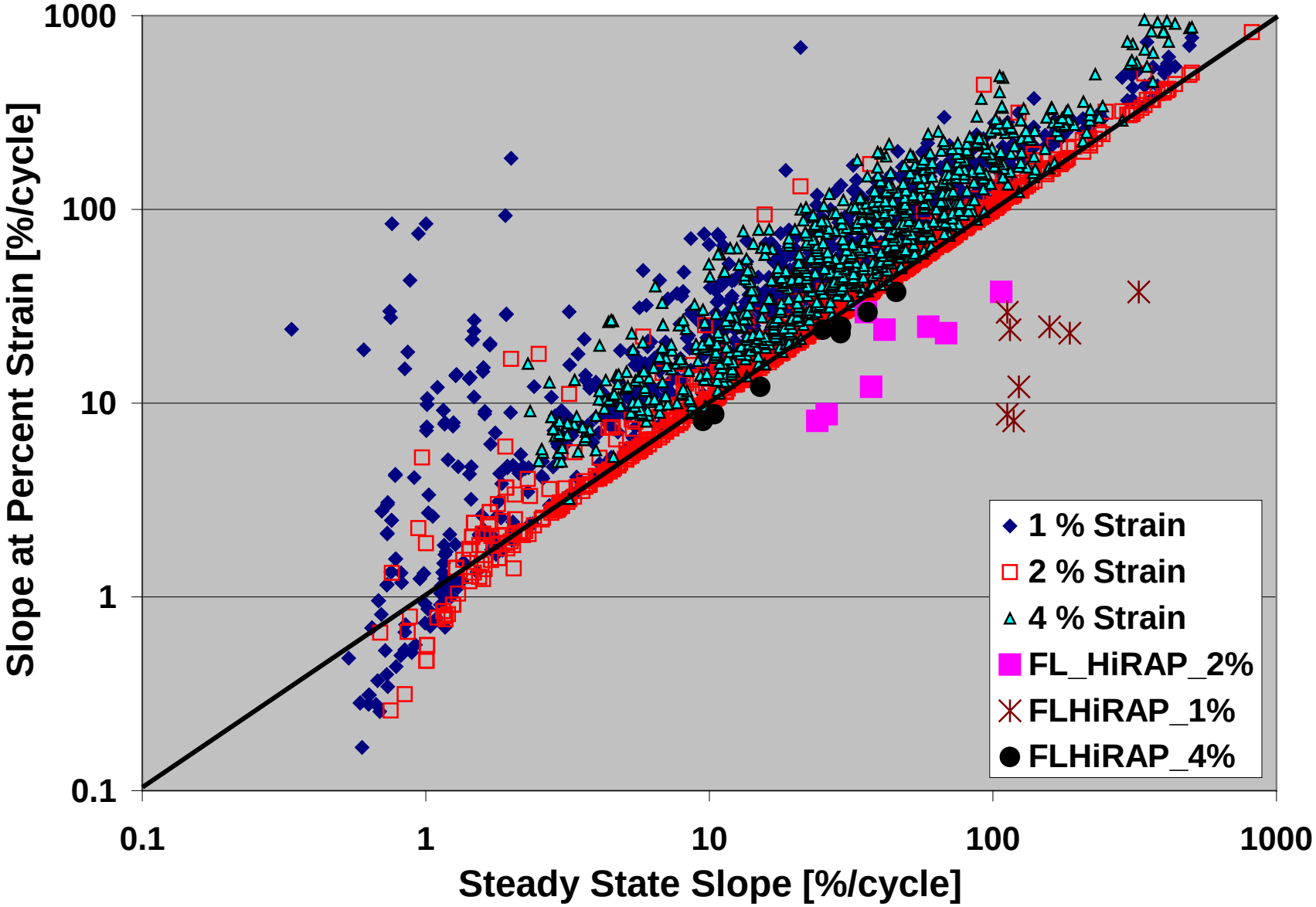
"Close" Data Point



"FAR" Data Point



Slope at % Strain vs. Steady State Slope



Summary for FL Performance Data

- E* predictive models input use recovered binder G* data (full blending) and do not account for lower effective binder content due to incomplete blending at lower temperature.
- PG grading, E*, and Fn results indicate that due to low plant temperatures (less aging), Warm Mix is less stiff.
- Flow Number
  - Didn’t test at high enough temperature
  - High RAP mixtures may not reach tertiary (consolidation) phase as quickly as regular/low RAP mixtures.

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Thank you! Questions?