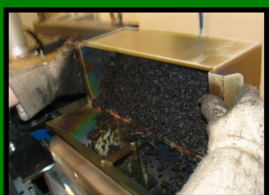
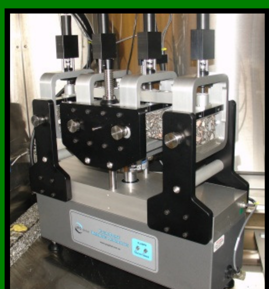
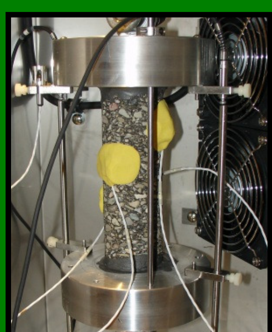
Innovative Research in Asphalt Pavements







Performance Characteristics of Two High Performance Wearing Course Mixtures

Dr. Walaa S. Mogawer, PE, F.ASCE

Director - Highway Sustainability Research Center

Professor of Civil & Environmental Engineering

University of Massachusetts

North Eastern States' Materials Engineers Association

Portsmouth, NH

October 23rd, 2013 ♦ 9:10 AM

Background

2011 Highways for LIFE Construction Projects

NHDOT Auburn-Candia Resurfacing Project

U.S. Department of Transportation
Federal Highway Administration
HIGHWAYS FOR LIFE

The New Hampshire Department of Transportation is proposing to include six innovations in the Auburn-Candia Project to extend the life of the pavement and reduce the necessary frequency for resurfacing. The innovations include: 40% RAP content, WMA, asphalt-rubber wearing surface mixture, high-polymer modified asphalt wearing surface with1% total reused binder.

Auburn-Candia Project – Mixtures

Wearing Course Mixtures

- 12.5 mm Asphalt Rubber Gap Graded (ARGG)

- 9.5mm High Polymer Mixture

Base Course Mixtures

- 12.5mm + 35% RAP Mixture

- 19.0mm + 20% RAP Mixture

Auburn-Candia Project – Cross Section

← Westbound

Wearing Course	12.5mm ARGG	9.5mm High Polymer	9.5mm High Polymer
Base Course	12.5mm + 35% RAP	12.5mm + 35% RAP	19.0mm + 20% RAP

Eastbound →

Wearing Course	12.5mm ARGG	9.5mm High Polymer	9.5mm High Polymer
Base Course	12.5mm + 35% RAP	12.5mm + 35% RAP	19.0mm + 20% RAP

Wearing Course Mixtures

	ARGG	High Polymer Mixture
NMAS	12.5 mm	9.5 mm
Design Gyrations	75	75
Percent RAP in Mixture	7.5%	16.0%
Percent Binder in RAP	5.70%	5.70%
Optimum Binder Content	7.60%	6.50%
Percent Virgin Binder Added	7.14%	5.53%
Total Replaced Binder	0.46%	0.97%
Asphalt Binder	Asphalt Rubber Binder	PG70-34 HiMA

Base Course Mixtures

	12.5 mm + 35% RAP	19.0mm + 20% RAP (Control)
NMAS	12.5 mm	19.0 mm
Design Gyrations	75	75
Percent RAP in Mixture	32.9%	19.1%
Percent Binder in RAP	5.90%	4.40%
Optimum Binder Content	5.50%	4.90%
Percent Virgin Binder Added	3.54%	4.02%
Total Replaced Binder	2.08%	0.88%
Virgin Binder	PG52-34 + Evotherm	PG64-28

Testing Plan

1. RAP Stockpile Material & RAP Binder Characterization

2. Base Course Mixtures
   - Production Testing (Plant Produced)

3. Wearing Course Mixtures
   - *Required* Pre-Production Testing (Lab Produced)
   - *Informational* Pre-Production Testing
   - Production Testing (Plant Produced)

RAP Characterization

Test	Applicable Method
Binder Content	AASHTO T164 (Centrifuge)
Extraction and Recovery of RAP Binder	AASHTO T319 (Rotovap)
Determine Performance Grade of Extracted Binder	AASHTO R29 - Section 6.0
Recovered RAP Aggregate Gradation	AASHTO T11 & AASHTO T27
Specific Gravity of Recovered RAP Aggregates	AASHTO T84 & T85
Maximum Theoretical Specific Gravity of RAP	AASHTO T209

Base Course Mixture - Production

Property	Test Method
Mix Cracking	Beam Fatigue
Mix Cracking	Overlay Test -TXDOT Test Designation Tex-248-F
Dynamic Modulus of Mix	Asphalt Mix Performance Tester (AMPT) AASHTO TP 79
Flow Number of Mix	Asphalt Mix Performance Tester (AMPT) AASHTO TP 79
Mix Rutting	Hamburg Wheel Tracking Device AASHTO T 324
Low Temperature Cracking Susceptibility	Thermal Stress Restrained Specimen Test (TSRST) AASHTO TP 10

ARGG Wearing Course – Pre-Production

Required	
Property	**Test Method**
Mix Cracking	Overlay Test -TXDOT Test Designation Tex-248-F
Mix Rutting	Hamburg Wheel Tracking Device AASHTO T 324
Informational	
Thermal Cracking Temperature of the Asphalt Rubber Binder	Asphalt Binder Cracking Device (ABCD) AASHTO TP 92
Low Temperature Cracking Susceptibility	Thermal Stress Restrained Specimen Test (TSRST) AASHTO TP 10
Resistance to Permanent Binder Deformation	Multiple Stress Creep Recovery (MSCR) Test AASHTO TP 70

ARGG Wearing Course – Production

Property	Test Method
Mix Cracking	Beam Fatigue
Mix Cracking	Overlay Test -TXDOT Test Designation Tex-248-F
Dynamic Modulus of Mix	Asphalt Mix Performance Tester (AMPT) AASHTO TP 79
Flow Number of Mix	Asphalt Mix Performance Tester (AMPT) AASHTO TP 79
Mix Rutting	Hamburg Wheel Tracking Device AASHTO T 324
Low Temperature Cracking Susceptibility	Thermal Stress Restrained Specimen Test (TSRST) AASHTO TP 10

Polymer Wearing Course – Pre-Production

Required	
Property	**Test Method**
Thermal Cracking Temperature of Extracted Binder from the Mixture	Critical Cracking Temperature AASHTO M 320 Table 2
Dynamic Modulus of Mix	Asphalt Mix Performance Tester (AMPT) AASHTO TP 79
Flow Number of Mix	Asphalt Mix Performance Tester (AMPT) AASHTO TP 79
Mix Rutting	Hamburg Wheel Tracking Device AASHTO T 324

Polymer Wearing Course – Pre-Production

Informational	
Property	**Test Method**
Thermal Cracking Temperature of the Modified Asphalt Binder	Asphalt Binder Cracking Device (ABCD) AASHTO TP 92
Thermal Cracking Temperature of Extracted/Recovered Binder from the Mixture	Asphalt Binder Cracking Device (ABCD) AASHTO TP 92
Thermal Cracking Temperature of Modified Asphalt Binder	Critical Cracking Temperature AASHTO M 320 Table 2
High Temperature Properties of Modified Binder	AASHTO M 320 Table 2
High Temperature Properties of Extracted/Recovered Binder from the Mixture	AASHTO M 320 Table 2
Resistance to Permanent Binder Deformation	Multiple Stress Creep Recovery (MSCR) test AASHTO TP 70
Mix Cracking	Overlay Test -TXDOT Test Designation Tex-248-F
Low Temperature Cracking Susceptibility	Thermal Stress Restrained Specimen Test (TSRST) AASHTO TP 10

Polymer Wearing Course – Production

Property	Test Method
Thermal Cracking Temperature of the Modified Asphalt Binder	Asphalt Binder Cracking Device (ABCD) AASHTO TP 92
Thermal Cracking Temperature of Extracted Binder from the Mixture	Asphalt Binder Cracking Device (ABCD) AASHTO TP 92
Thermal Cracking Temperature of Modified Asphalt Binder	Critical Cracking Temperature AASHTO M 320 Table 2
Thermal Cracking Temperature of Extracted/Recovered Binder from the Mixture	Critical Cracking Temperature AASHTO M 320 Table 2
High Temperature Properties of Modified Binder	AASHTO M 320 Table 2
High Temperature Properties of Extracted/Recovered Binder from the Mixture	AASHTO M 320 Table 2
Resistance to Permanent Binder Deformation	Multiple Stress Creep Recovery (MSCR) test AASHTO TP 70

Polymer Wearing Course – Production

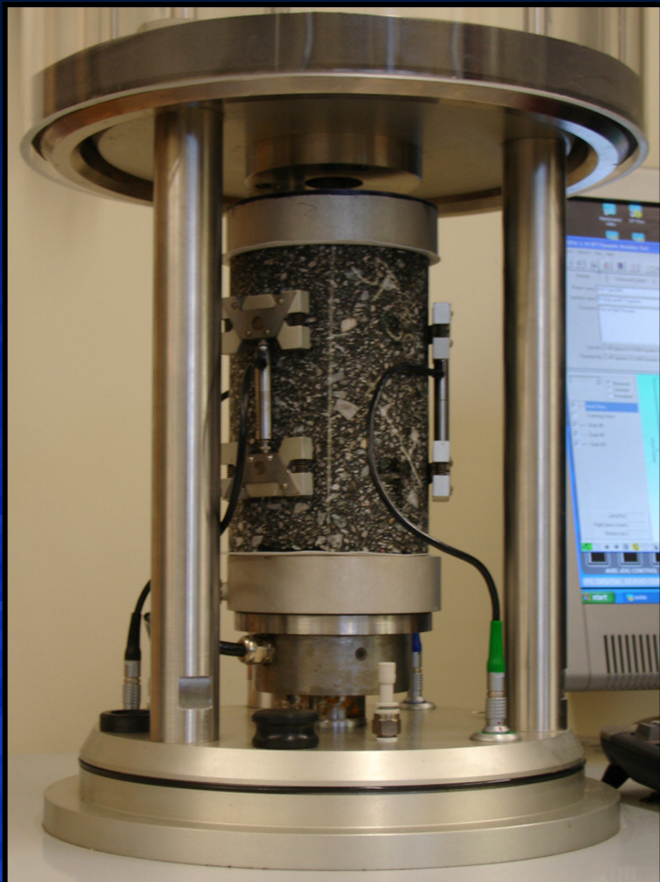
Property	Test Method
Mix Cracking	Beam Fatigue
Mix Cracking	Overlay Test -TXDOT Test Designation Tex-248-F
Dynamic Modulus of Mix	Asphalt Mix Performance Tester (AMPT) AASHTO TP 79
Flow Number of Mix	Asphalt Mix Performance Tester (AMPT) AASHTO TP 79
Mix Rutting	Hamburg Wheel Tracking Device AASHTO T 324
Low Temperature Cracking Susceptibility	Thermal Stress Restrained Specimen Test (TSRST) AASHTO TP 10

Preliminary Testing Results

Binder Testing

	Asphalt Rubber Pre-Production	PG70-34 HiMA (7.5% SBS) Pre-Production	PG70-34 HiMA (7.5% SBS) Production
Continuous Grade	85.2-33.1	77.9-39.1	73.5-39.5
PG Grade	PG82-28	PG76-34	PG70-34
MSCR Jnr @ 0.1	0.279	0.243	Ongoing
MSCR Jnr @ 3.2	0.259	0.369	Ongoing

Mixture Stiffness - Dynamic Modulus



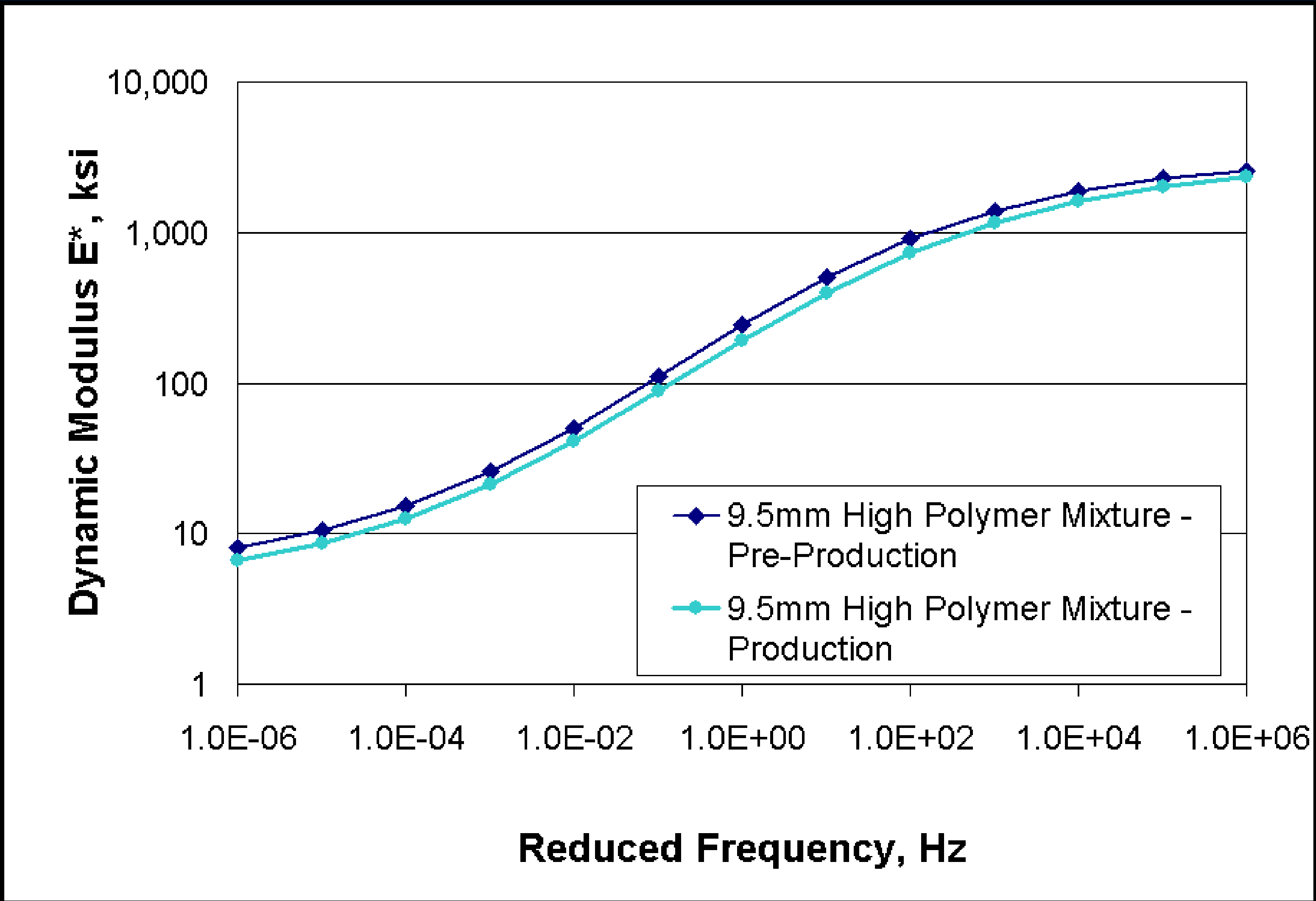
AASHTO TP79 in Asphalt Mixture Performance Tester (AMPT)

Conducted to compare mixture stiffness. Also needed for DARWIN M-E design and prediction of distress.

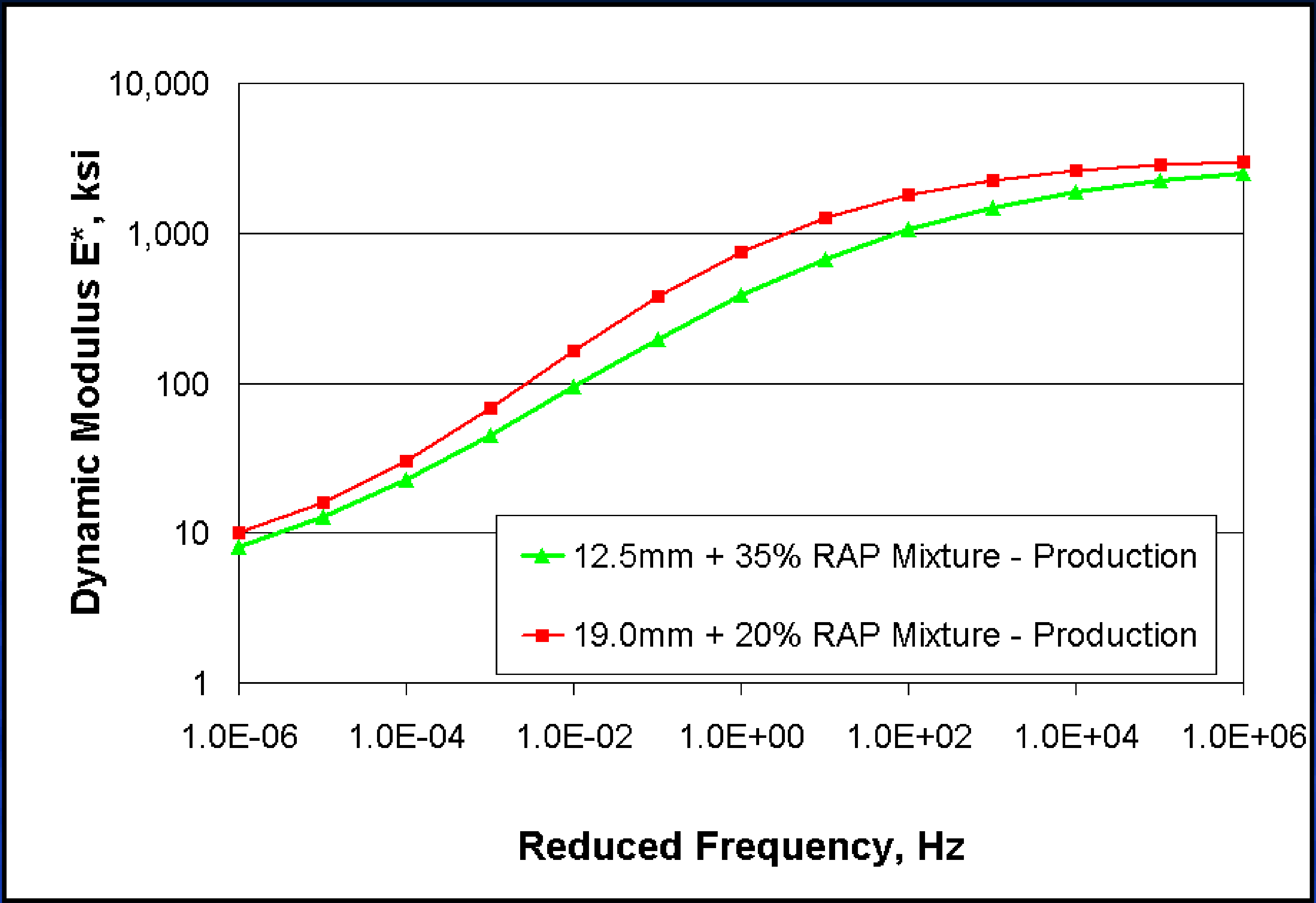
Temperature	Frequency
4°C	10 Hz, 1Hz, 0.1Hz
20°C	10 Hz, 1Hz, 0.1Hz
30-40°C	10 Hz, 1Hz, 0.1Hz, 0.01Hz

Specimens were fabricated at a target air void level of 7.0 ± 1.0%.

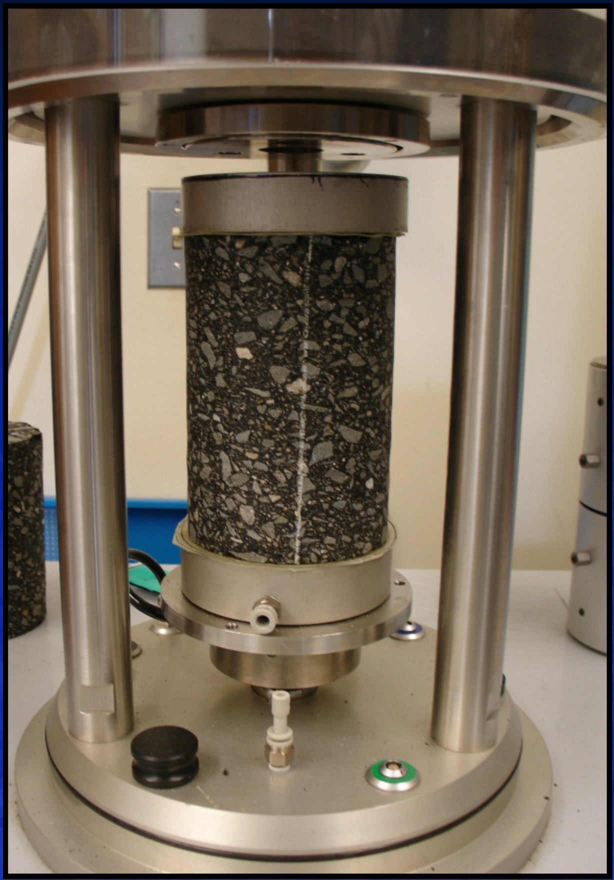
Mixture Stiffness - Dynamic Modulus



Mixture Stiffness - Dynamic Modulus



Mixture Rutting - Flow Number



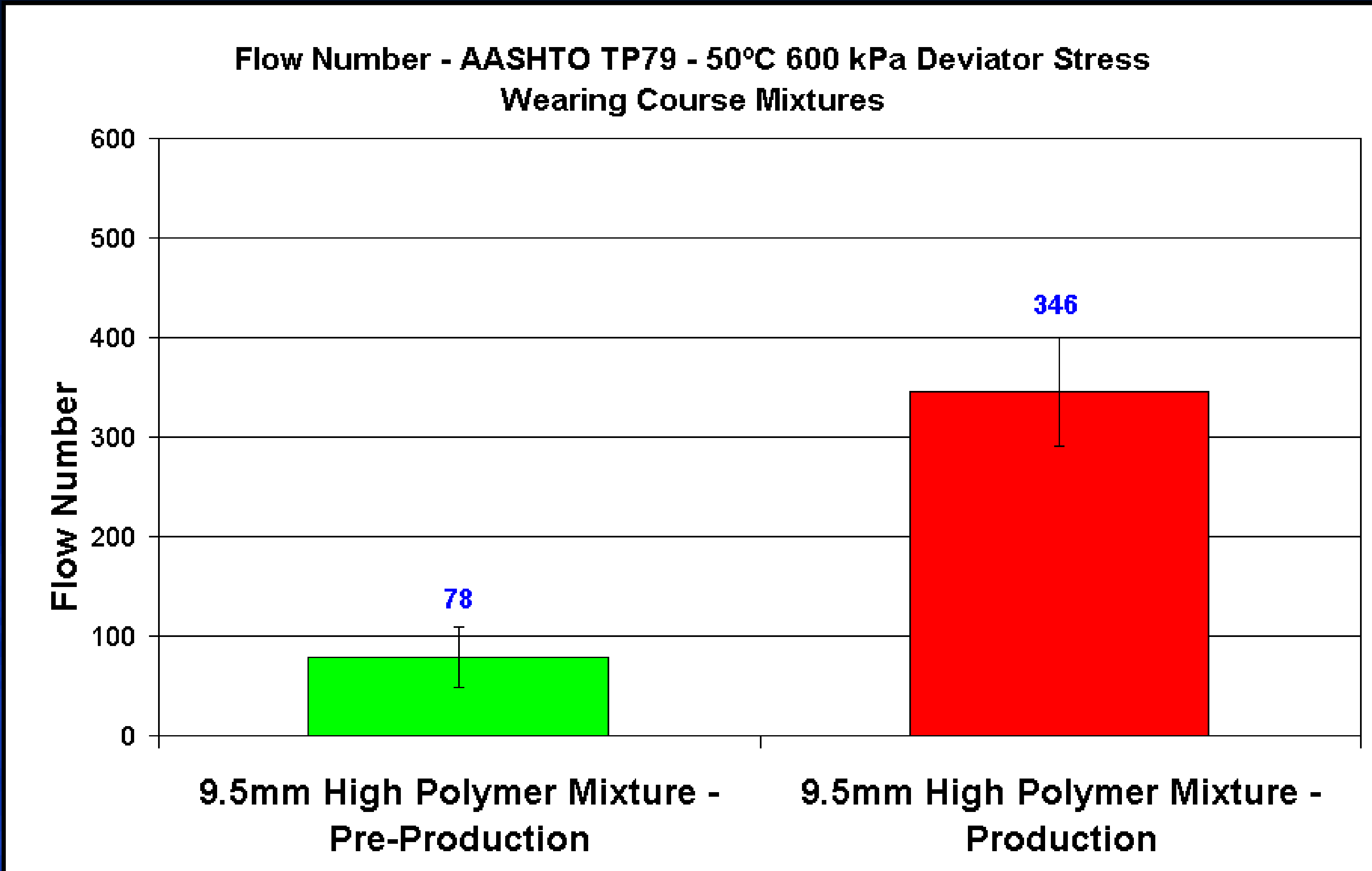
AASHTO TP79 in AMPT

Conducted to determine mixture rutting potential.

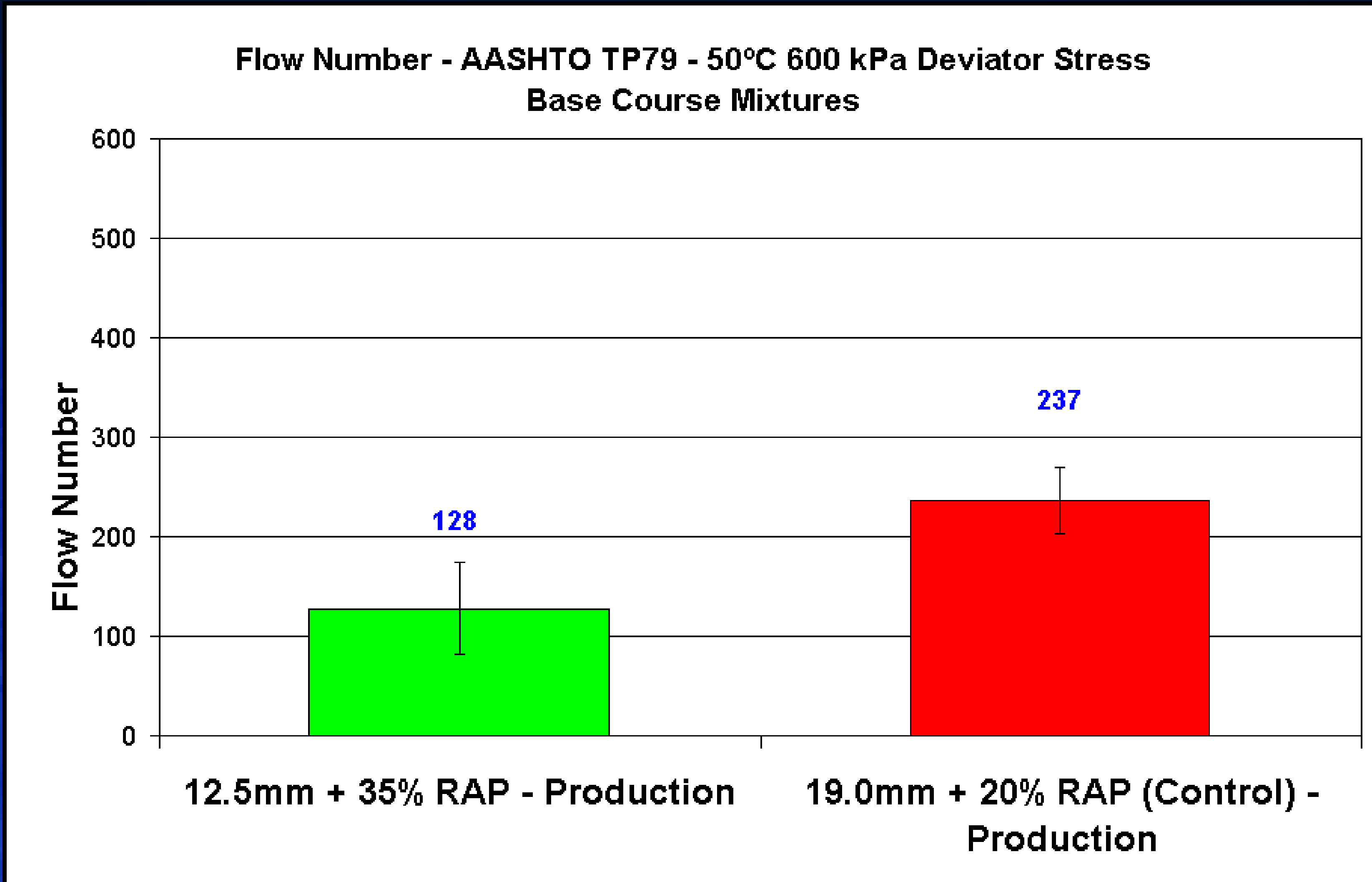
Temperature	Deviator Stress
50°C	600kPA

Specimens were fabricated at a target air void level of 7.0 ± 1.0%.

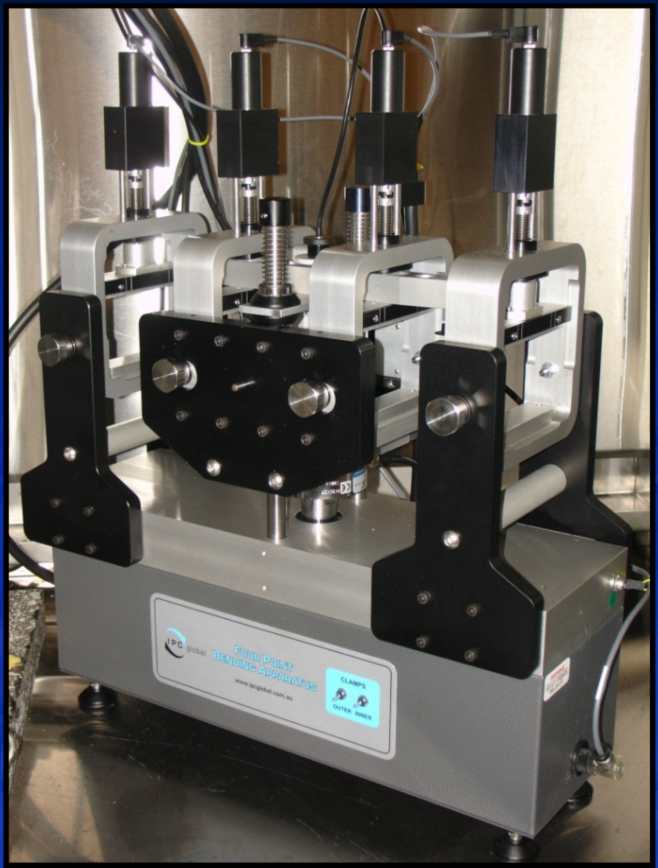
Mixture Rutting - Flow Number



Mixture Rutting - Flow Number



Fatigue – Four Point Bending Beam

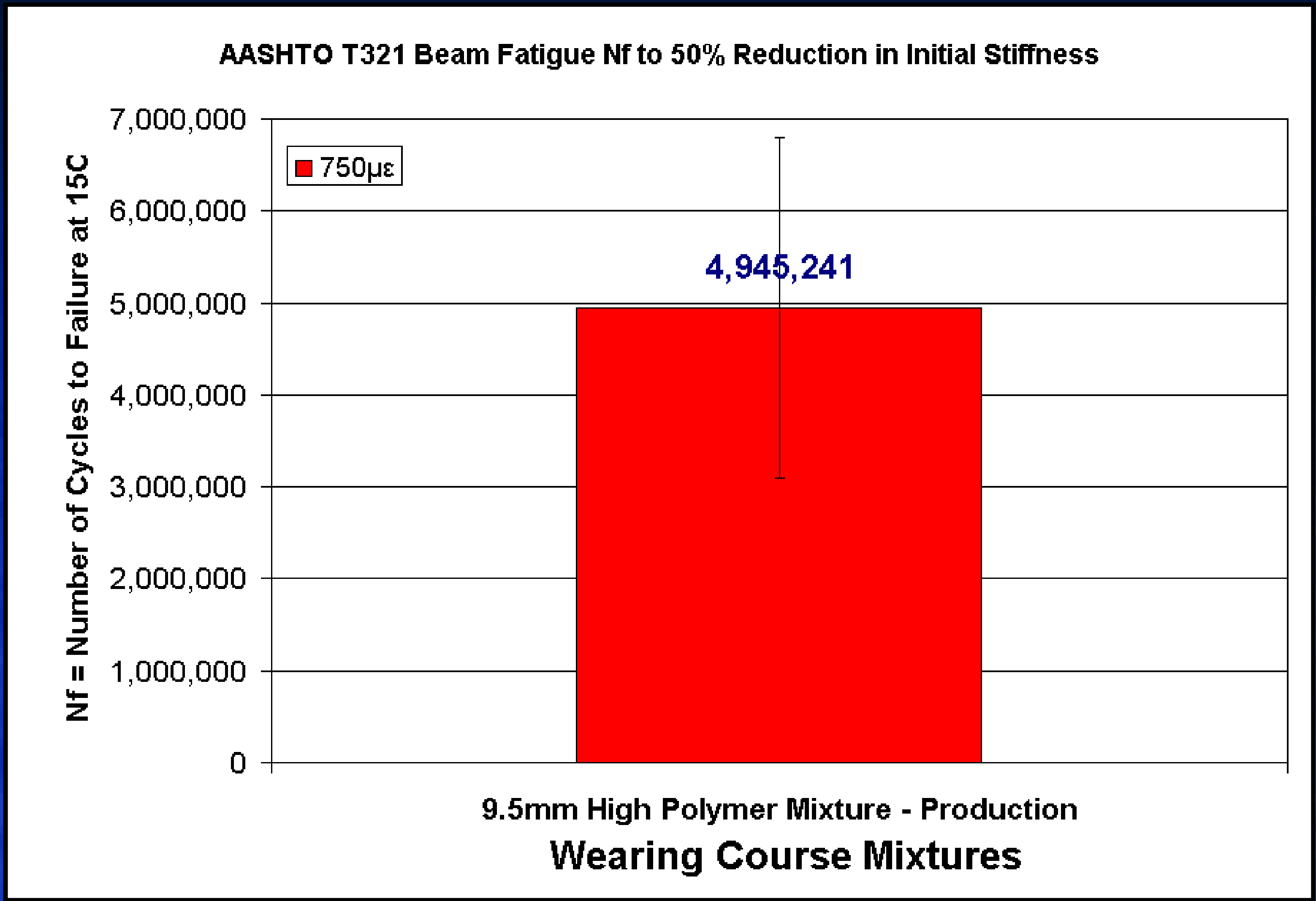


Testing in Accordance with AASHTO T321

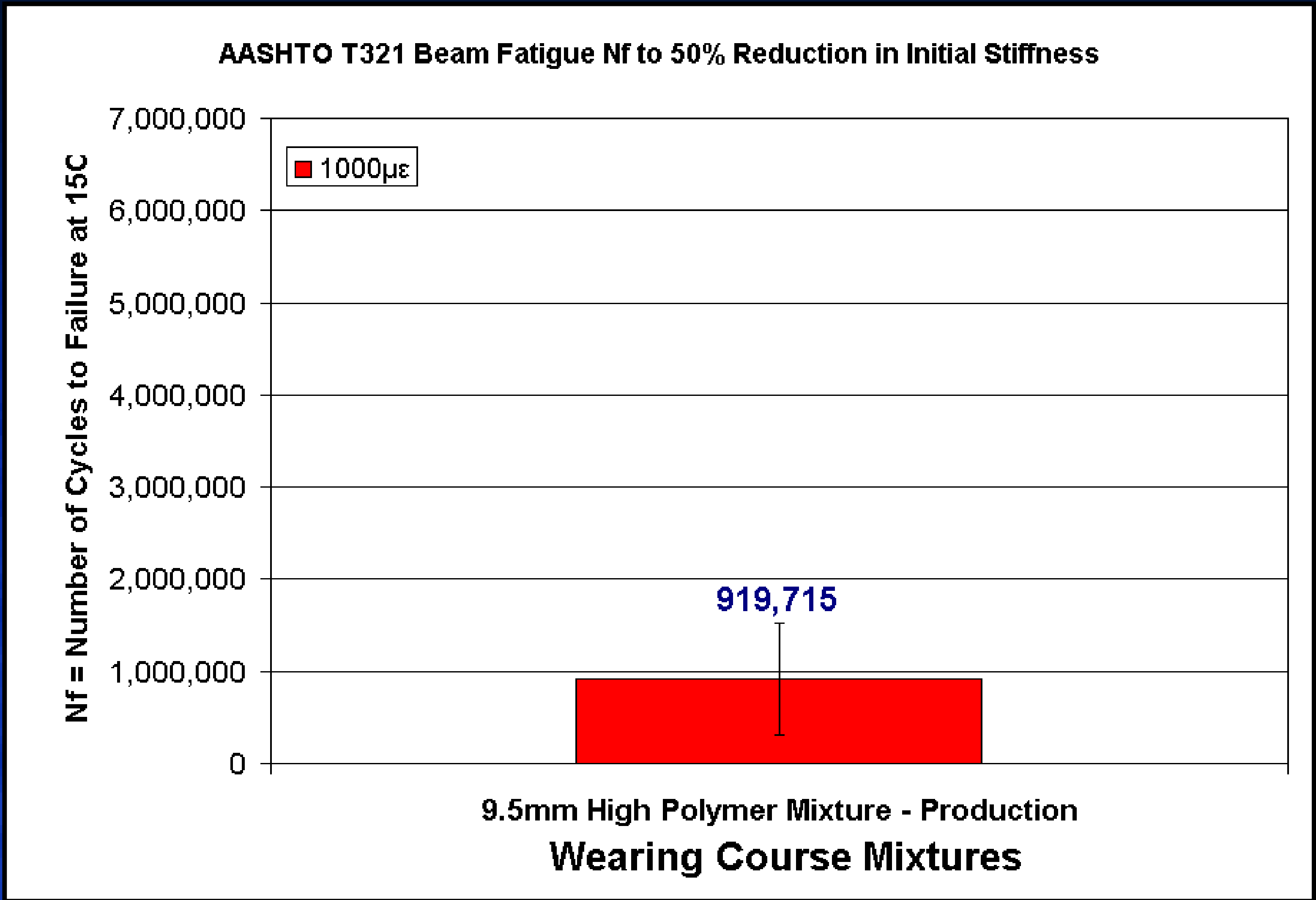
- Specimens were fabricated at a target air void level of 7.0 ± 1.0%
- Testing conducted in strain control mode
- Loading Frequency = 10Hz
- Failure Criteria = 50% reduction in initial stiffness per AASHTO T321 method

Temperature	Strain Levels
15°C (59°F)	Variable Based on Mixture Type: 250με, 500με, 750με or 1000με

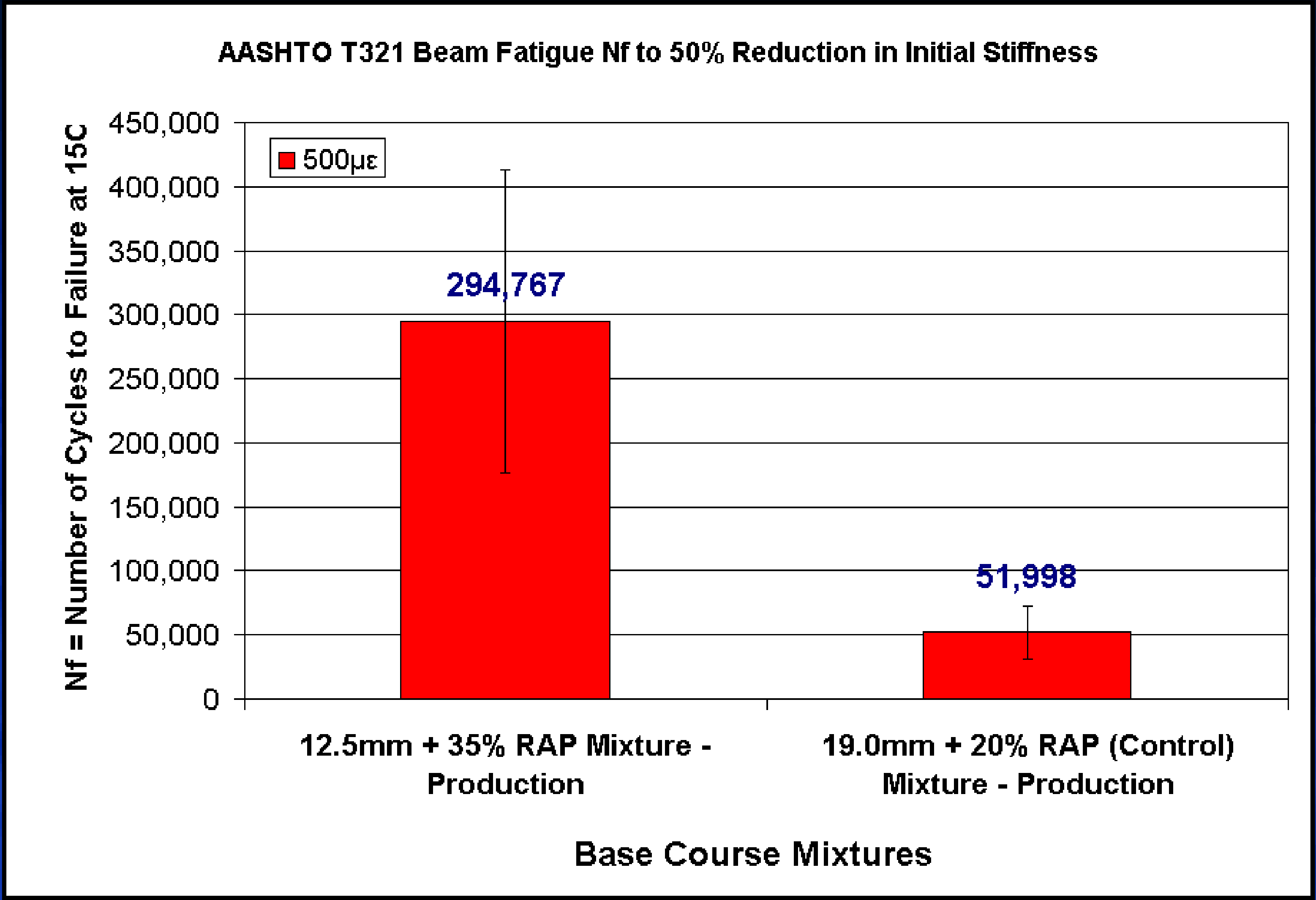
Fatigue – Four Point Bending Beam



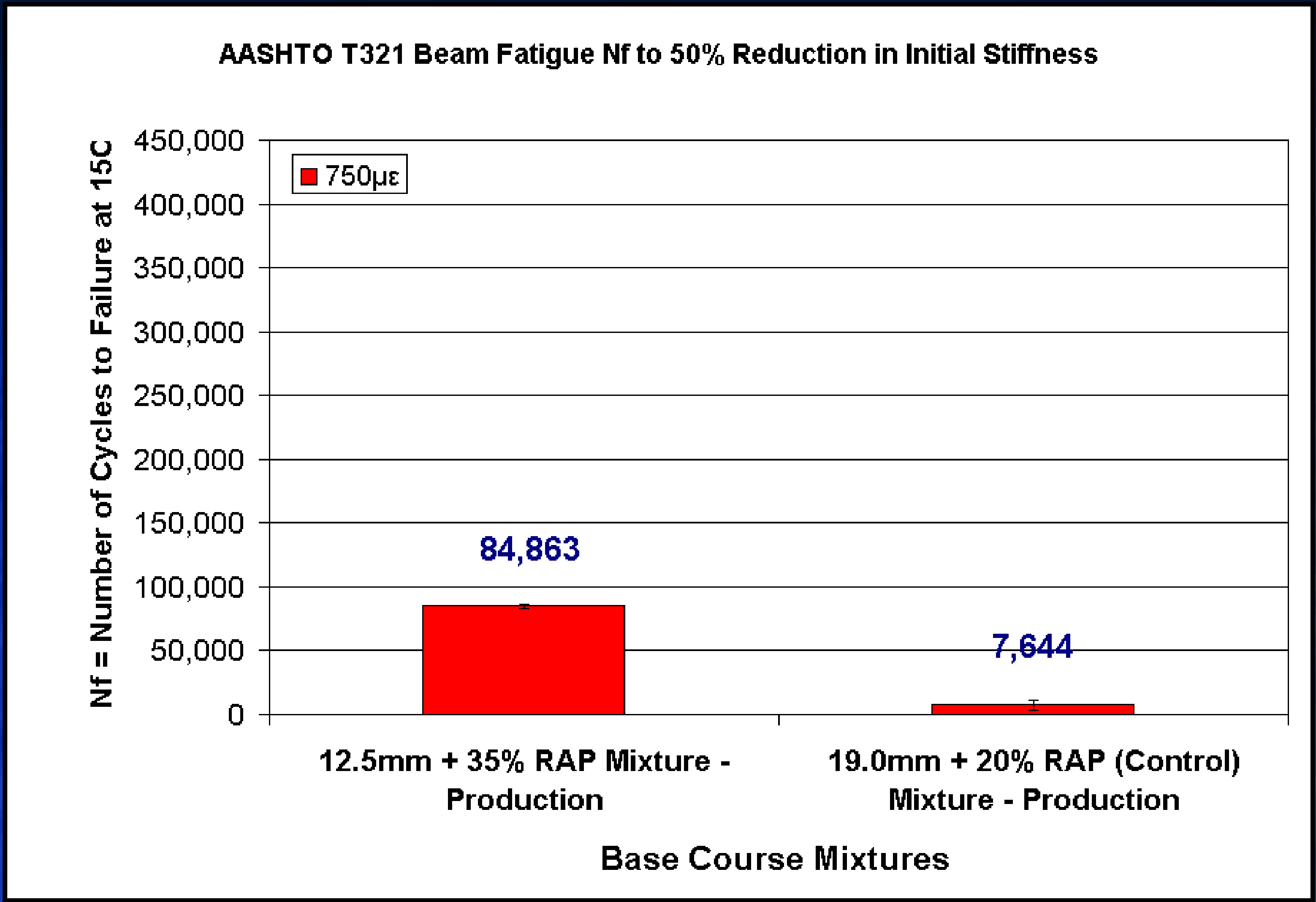
Fatigue – Four Point Bending Beam



Fatigue – Four Point Bending Beam



Fatigue – Four Point Bending Beam



Reflective Cracking - Overlay Tester

- Test Temperature = 15ºC (59ºF)
- Test Termination at 1,200 cycles or 93% Load reduction
- Testing in accordance with Tex-248-F

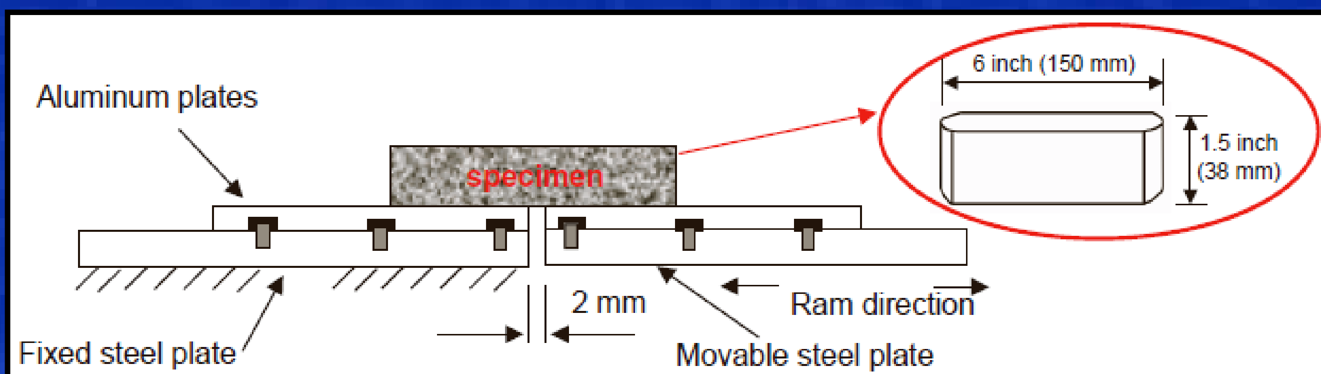
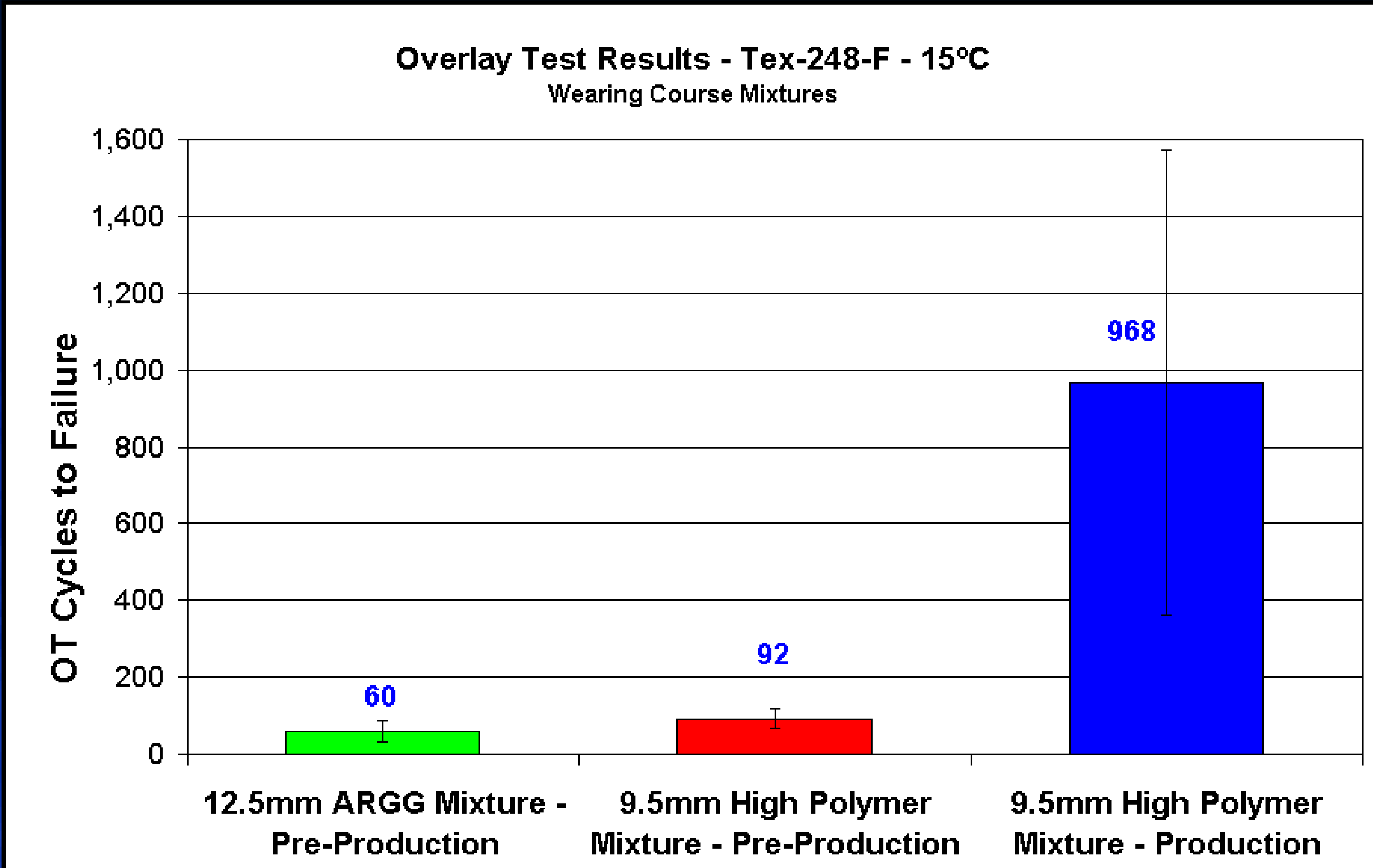
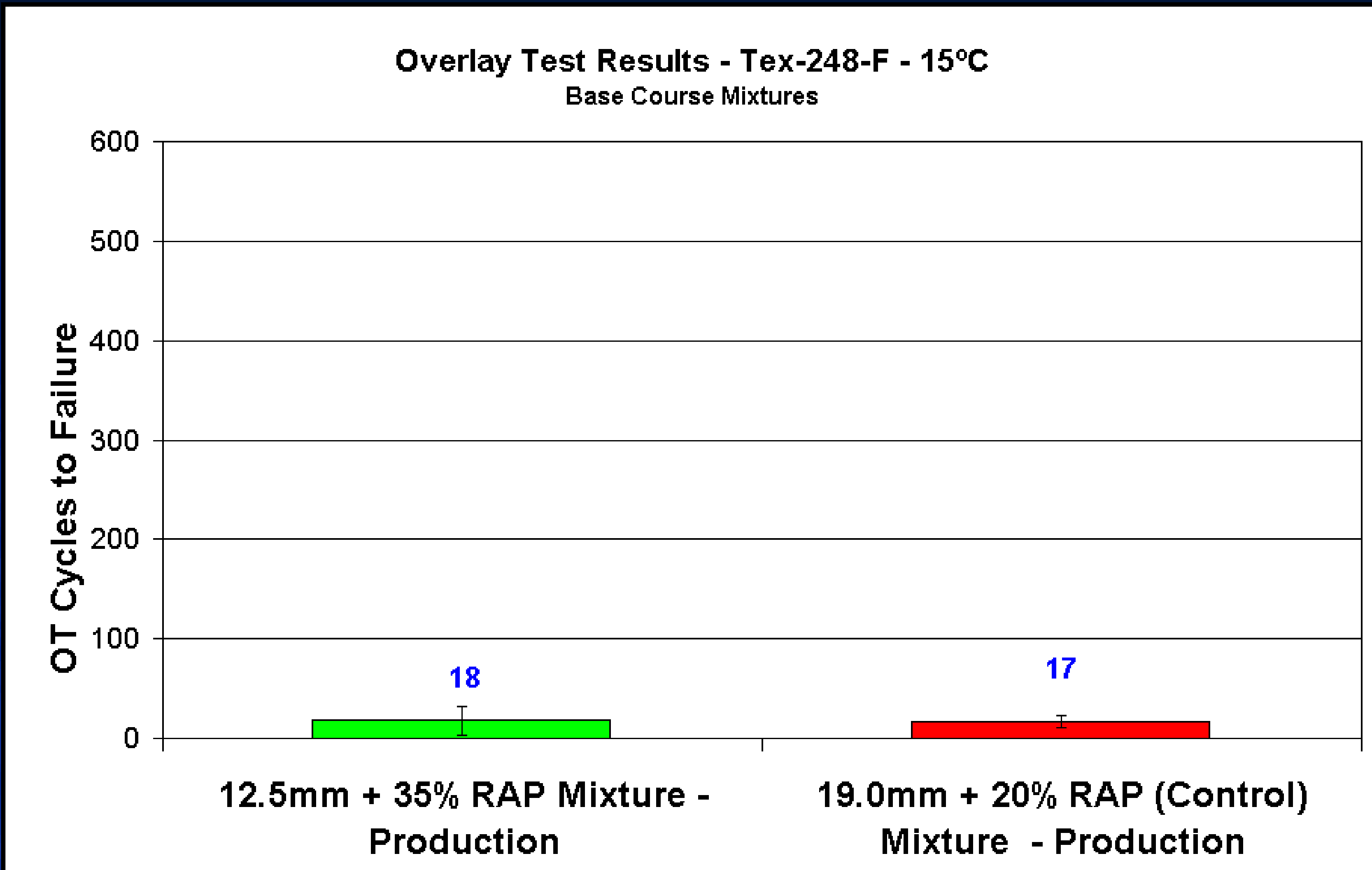


Diagram from: Zhou et al. "Overlay Tester: Simple Performance Test for Fatigue Cracking" Transportation Research Record: Journal of the Transportation Research Board, No. 2001, Transportation Research Board of the National Academies, Washington, D.C., 2007, pp. 1–8.

Reflective Cracking - Overlay Tester



Reflective Cracking - Overlay Tester

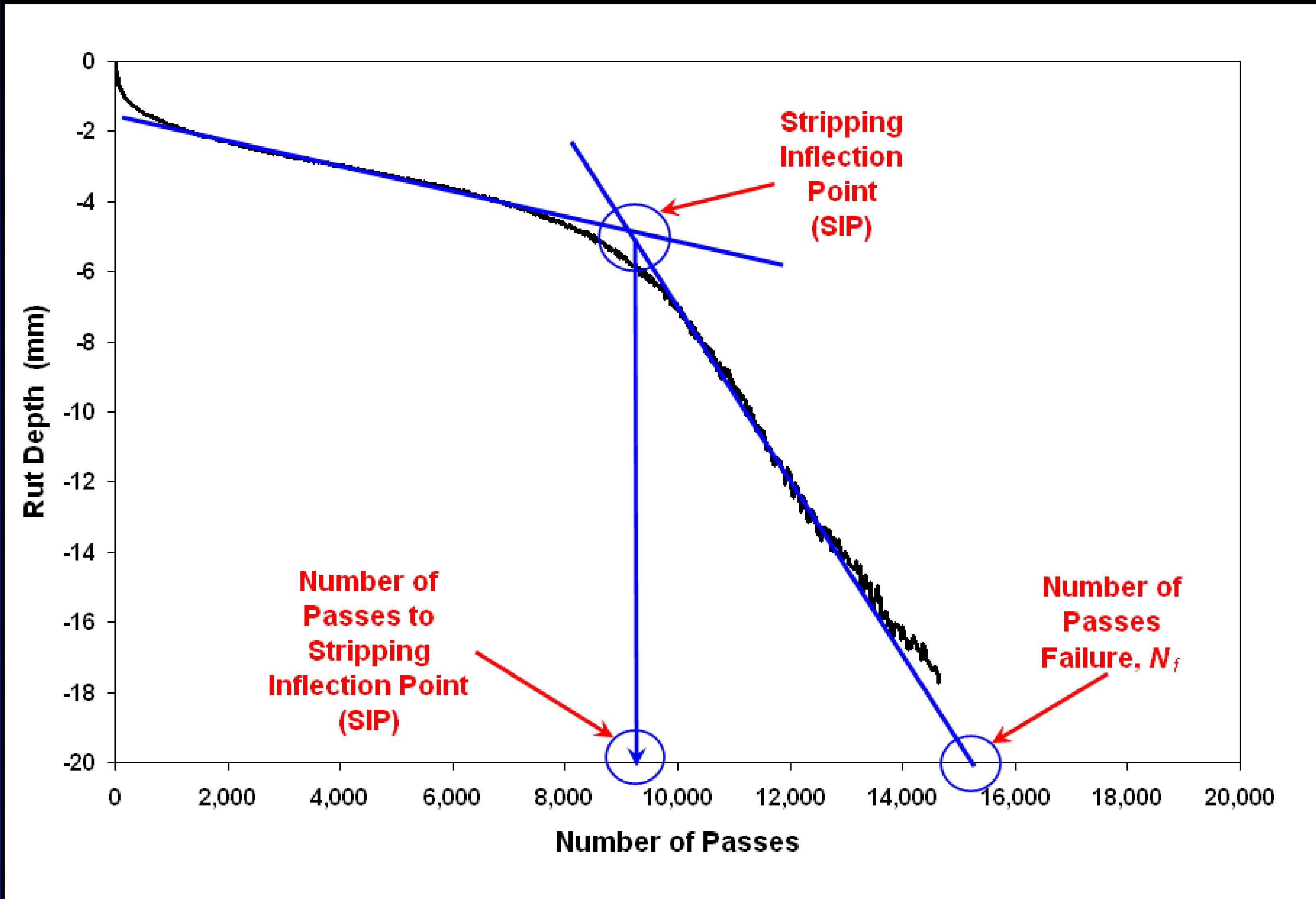


Rutting/Moisture Susceptibility - Hamburg Wheel Tracking Device (HWTD)

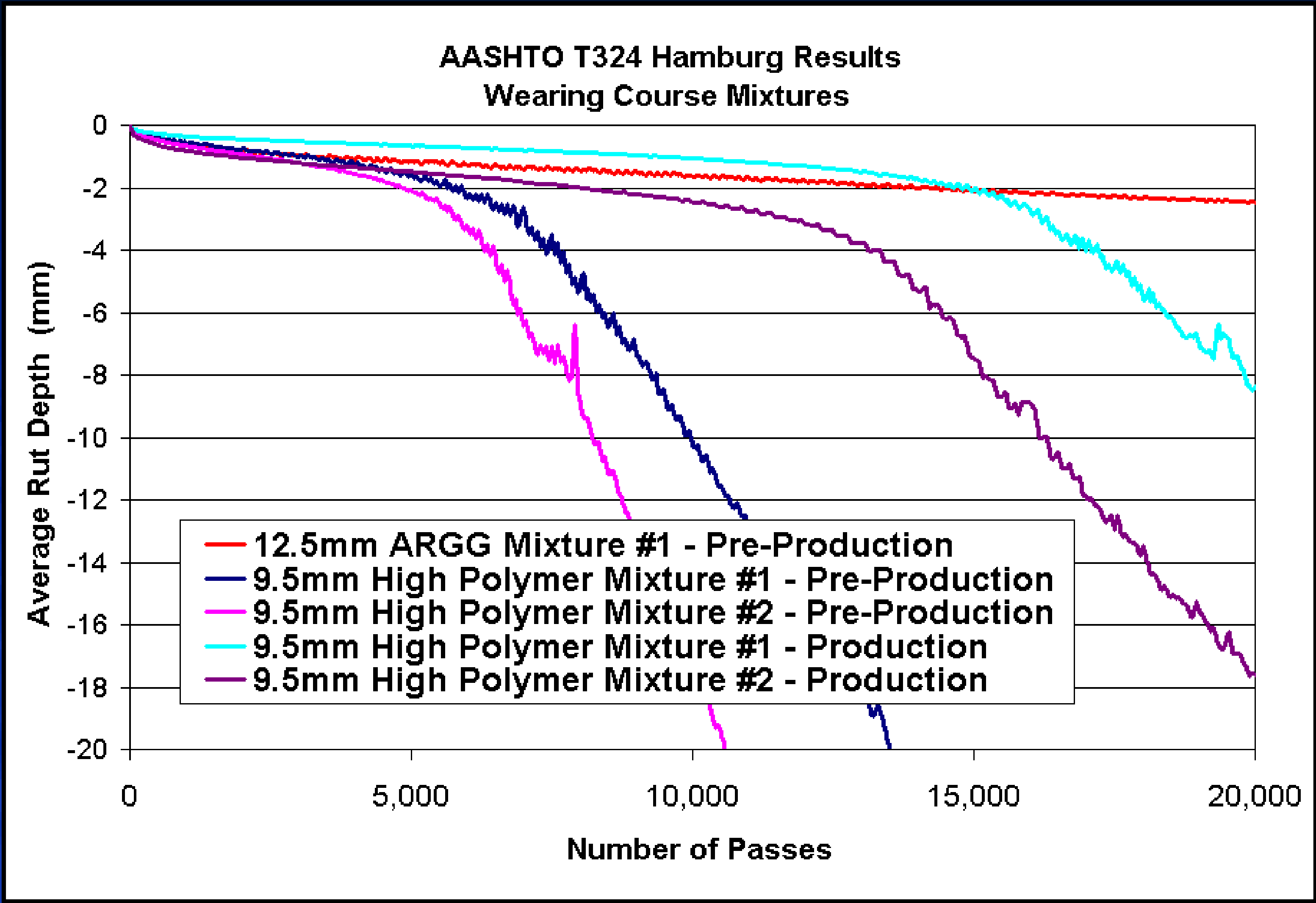
- HWTD testing conducted in accordance with AASHTO T324

- Water temperature of 50ºC (122ºF) during testing
- Test duration of 20,000 cycles

Stripping Inflection Point (SIP)



Rutting/Moisture Susceptibility - HWTD



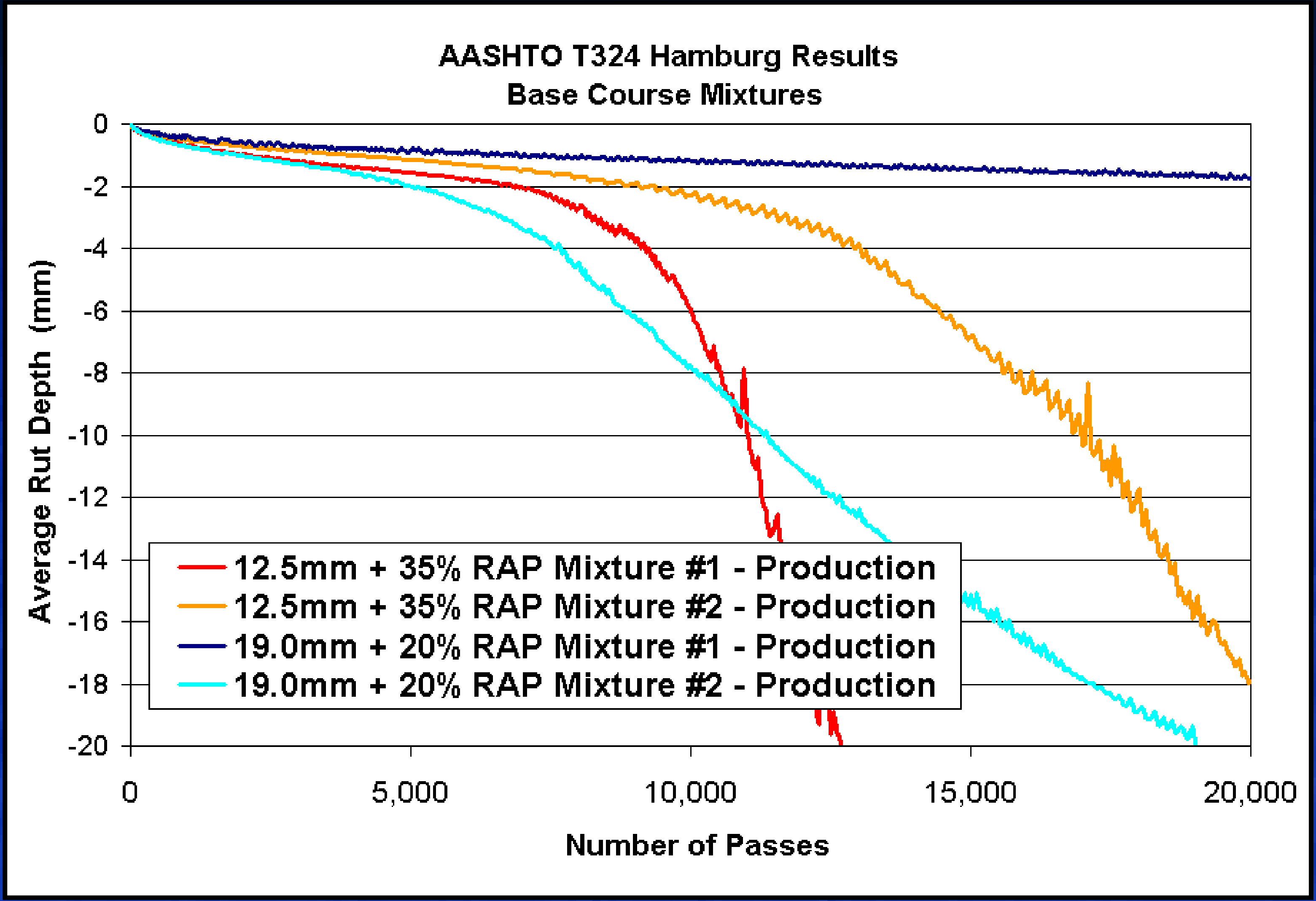
Rutting/Moisture Susceptibility - HWTD

Mixture	Stripping Inflection Point	Average Rut Depth at 10,000 Passes (mm)	Average Rut Depth at 20,000 Passes (mm)
12.5mm ARGG Mixture #1 - Pre-Production	NONE	1.7	2.5
9.5mm High Polymer Mixture #1 – Pre-Production	6,600	9.8	20.1*
9.5mm High Polymer Mixture #2 – Pre-Production	5,880	17.1	20.0*
9.5mm High Polymer Mixture #1 – Production	15,400	1.1	8.4
9.5mm High Polymer Mixture #2 – Production	12,800	2.5	17.6

NONE = Mixture passed 20,000 cycle test with no SIP.

* Testing ended before 20,000 cycles due to maximum rut depth exceeding 20mm.

Rutting/Moisture Susceptibility - HWTD

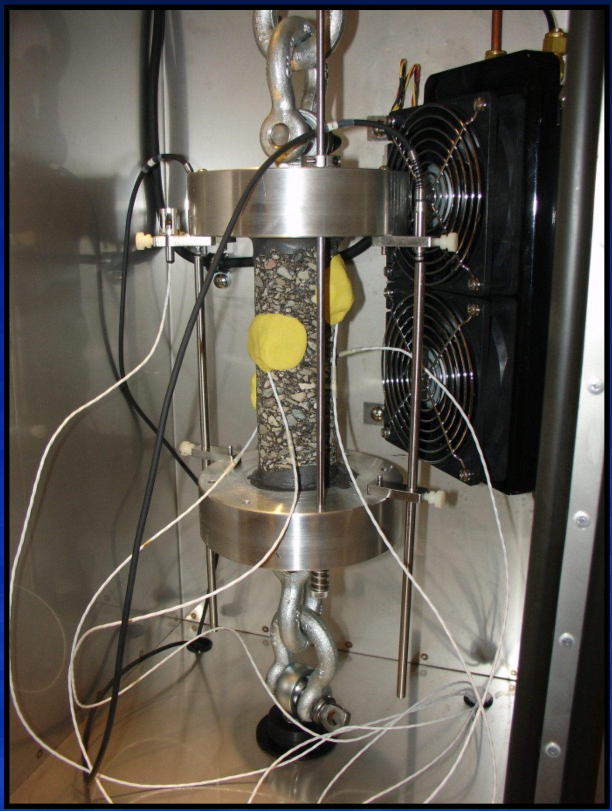


Rutting/Moisture Susceptibility - HWTD

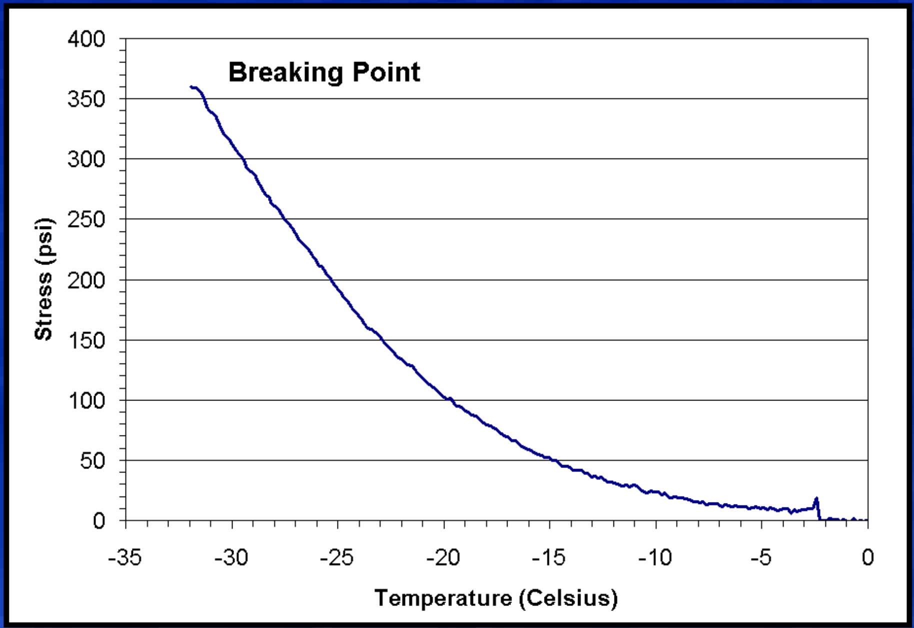
Mixture	Stripping Inflection Point	Average Rut Depth at 10,000 Passes (mm)	Average Rut Depth at 20,000 Passes (mm)
12.5mm + 35% RAP Mixture #1 - Production	9,350	5.9	20.1*
12.5mm + 35% RAP Mixture #2 - Production	12,500	2.3	18.0
19.0mm + 20% RAP Mixture #1 - Production	NONE	1.2	1.8
19.0mm + 20% RAP Mixture #1 - Production	6,750	7.8	20.0*

NONE = Mixture passed 20,000 cycle test with no SIP.
* Testing ended before 20,000 cycles due to maximum rut depth exceeding 20mm.

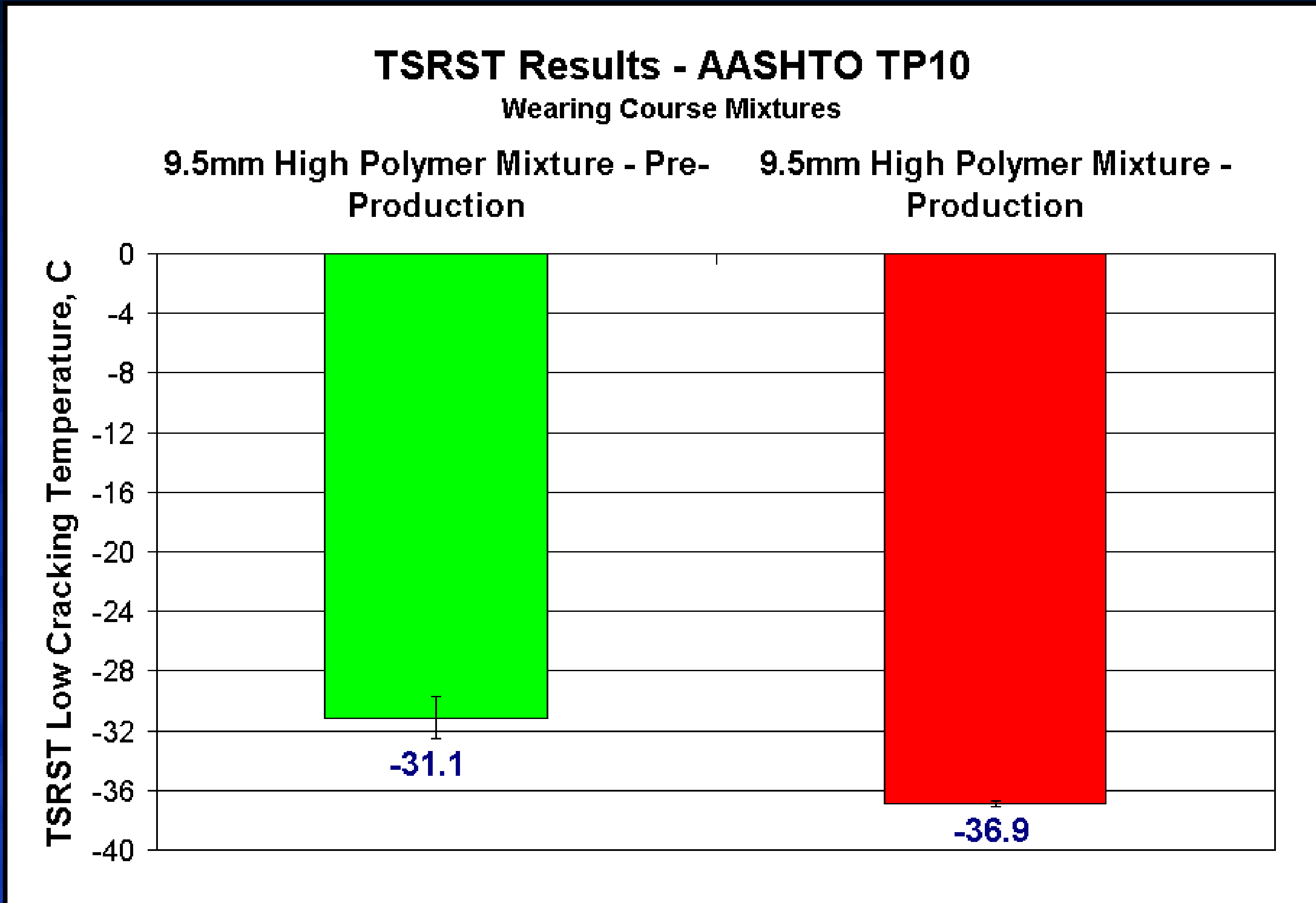
Mixture Low Temperature Cracking - TSRST



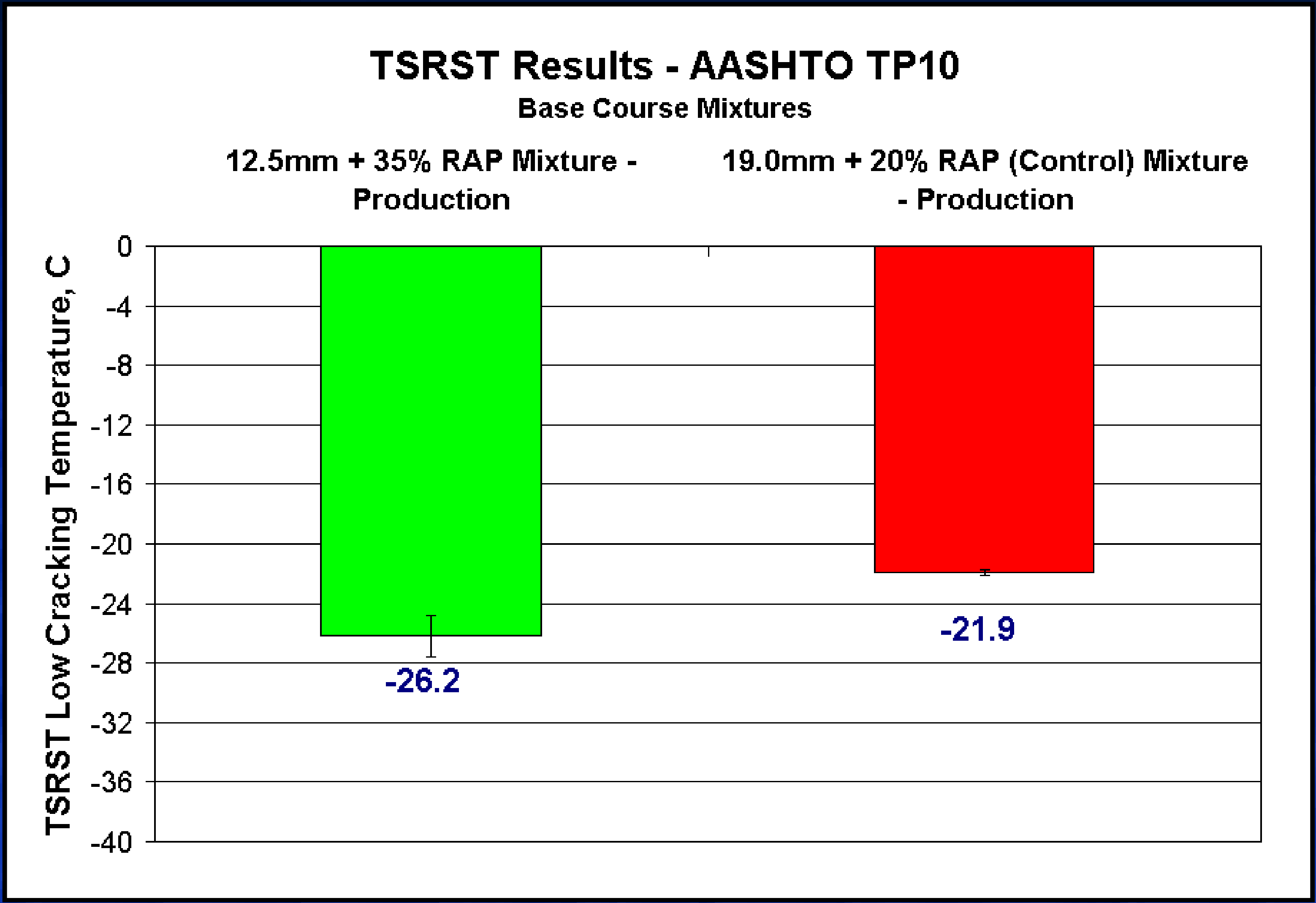
- Cooling Rate of -10ºC/hour
- Testing in accordance with AASHTO TP10-93



Mixture Low Temp. Cracking - TSRST



Mixture Low Temp. Cracking - TSRST



Discussion of Preliminary Results

- The 12.5 mm base mixture with higher RAP content and higher binder content performed better in fatigue and thermal cracking than the 19.0 mm base mixture with lower RAP content and lower binder content.

- Field performance will be monitored to correlate laboratory observations to field performance.

Acknowledgements

The following people have been instrumental in completing the research presented here:

- Alexander Austerman, P.E. (HSRC/UMass)

-Alan Rawson (NHDOT)

-Denis Boisvert (NHDOT)

-Mary Wescott (Pike Industries Inc.)

Thank You!