Development and Use of "Fiberless" SMA in the United States

Richard Steger, P.E.
Ingevity

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Agenda

- Acknowledgments
- Design of SMA
- Issues with Fibers
- Fiberless SMA
  - Concept
  - Design Techniques
  - Lab & Field Mix Performance Data

Acknowledgements

- Rutgers University (CAIT) – Presentation Prep
  - Tom Bennert
- NJ DOT
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- Associated Asphalt
  - Ron Corun
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- Ingevity - VA RT 29 Project cores/testing
  - Bryan Pecht, Dominic Barilla, Pete Truncale, Bill Criqui, Jason Bausano

Stone Matrix Asphalt (SMA)

- Gap graded aggregate blends with cubical shaped aggregate
- Mastic of polymer-modified asphalt binder, mineral filler and fibers
- When produced and placed correctly, known for outstanding performance

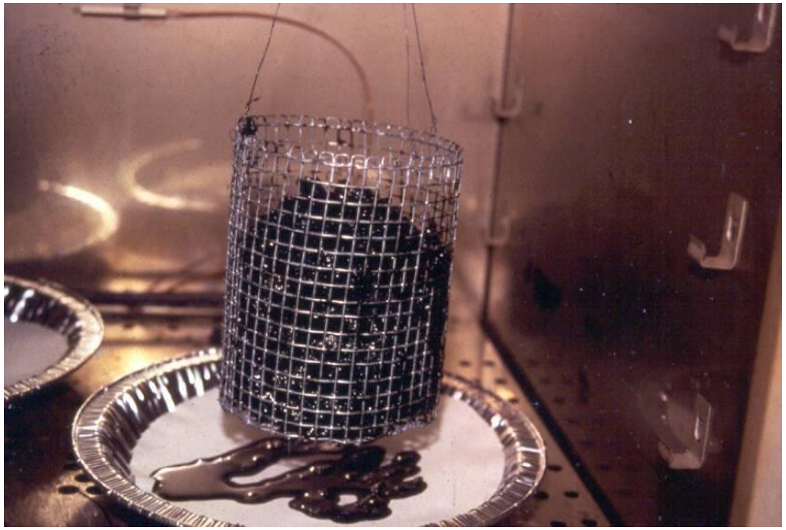
Dr. Ray Brown (NCAT Report 425, 1999)

"***SMA is a simple idea***. Find a hard, durable, quality stone, fracture it into roughly cubical shape and of a size consistent with the proposed layer thickness, and then glue the stones together with a durable, moisture-resistant mortar of just the right quantity to give stone-to-stone contact among the coarse aggregate particles. ***For the asphalt technologist, the trick is getting the various parameters right***."

Design of SMA Mixes

Design of SMA Mixes

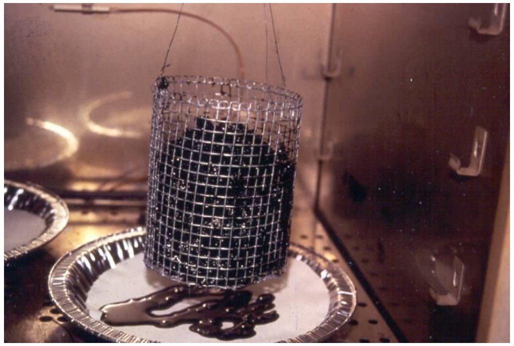
- Due to high asphalt contents, a potential for "draindown" of binder exists
  - Defined as liquid binder running off aggregate surface
  - Results in "fat spots" and segregated areas of high and low binder content



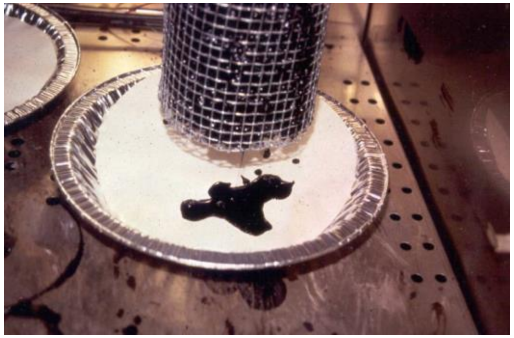
Design of SMA Mixes

- To help reduce the potential of draindown, polymer-modified asphalt (PMA) and fibers used with SMA
  - PMA results in better adhesion to aggregate at higher temps than Neat binders (generally higher viscosity)
  - Fibers increase stiffness of mastic by increasing surface area

Neat



PMA



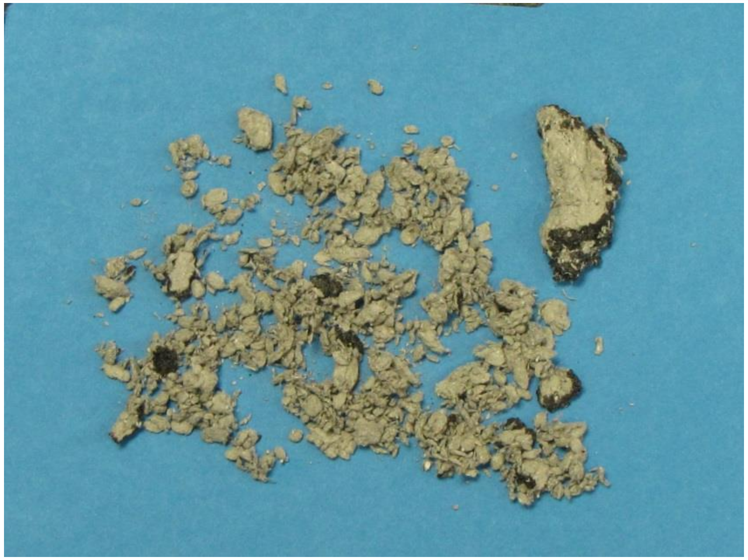
PMA + Fibers

Issues with Fibers

- Cost – fibers and rental equipment
- Fibers need to be separated or "fluffed" prior to addition or clumping can occur
- Metering required and should have "sight glass" to ensure fibers flowing
- Fibers must be included in ignition oven correction factor determination
  - Impossible to separate AC and Fiber changes during production from ignition oven testing

Example of Fiber Issue: "Fiber Ball" in New Jersey SMA

- Found in pavement surface during visual inspection after placement
- Possibly due to the "feeding system" at the asphalt plant



Fiberless SMA Concept & Design

Fiberless SMA Concept

- Fibers used to increase viscosity of mastic (binder+ fines + fibers)
  - Increasing mastic viscosity will make it stick better to aggregate and resist draindown
- Using higher viscosity binder can help increase mastic viscosity
  - As temperature decreases, binder viscosity increases
- Reducing mixture temp will create compaction issues
  - Must couple mixture temp reduction with WMA additive
  - **WMA technology that does not influence binder viscosity**

Fiberless SMA "Mixture Design"

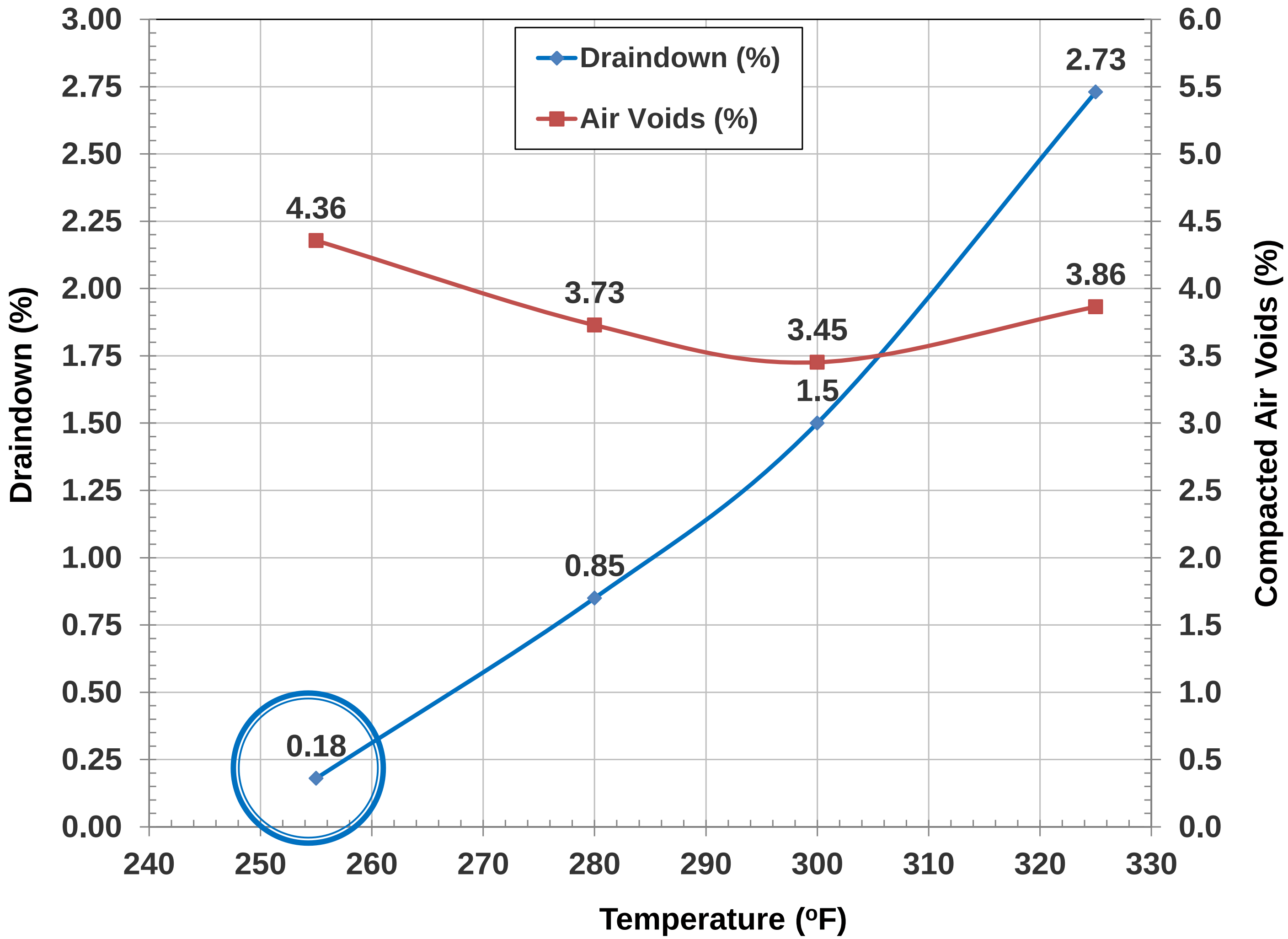
- General methodology
  - Use existing SMA design with fibers as starting point
    - (i.e. – asphalt content, aggregate blend)
  - Determine Draindown (AASHTO T305) & compacted air voids after reducing mixture temperature
    - Example: 325, 300, 280, 255°F
    - Design: Aggregates heated 10°F higher than compaction temp – compaction temperature used for specific binder grade
  - Compare draindown and compacted air voids
  - Examine mixing process to ensure coating is taking place (AASHTO T195, Degree of Particle Coating)
  - Make mix component adjustments if necessary
    - In general, have found for every 0.1% of cellulose fibers removed, asphalt plant will need to remove same amount of asphalt binder

Design Example #1 – "Sometimes It All Goes Right"

- Determine Optimal Temperature for Fiberless SMA in MD
  - 12.5 mm NMAS SMA
  - 6.5% Asphalt Content
    - PG76-22
  - 0.3% Cellulose Fibers
  - 0.04% Draindown at Design
    - Specification < 0.3%

Washed Gradation		
Screen		% Pass
2"	50.00	100
1 ½"	37.50	100
1"	25.00	100
¾"	19.00	100
½"	12.50	96
3/8"	9.50	80
#4	4.75	34
#8	2.36	21
#16	1.18	17
#30	0.600	15
#50	0.300	13
#100	0.150	12
#200	0.075	9.3

Design Example #1: Compacted Air Voids vs Draindown



Design Example #1 - Results

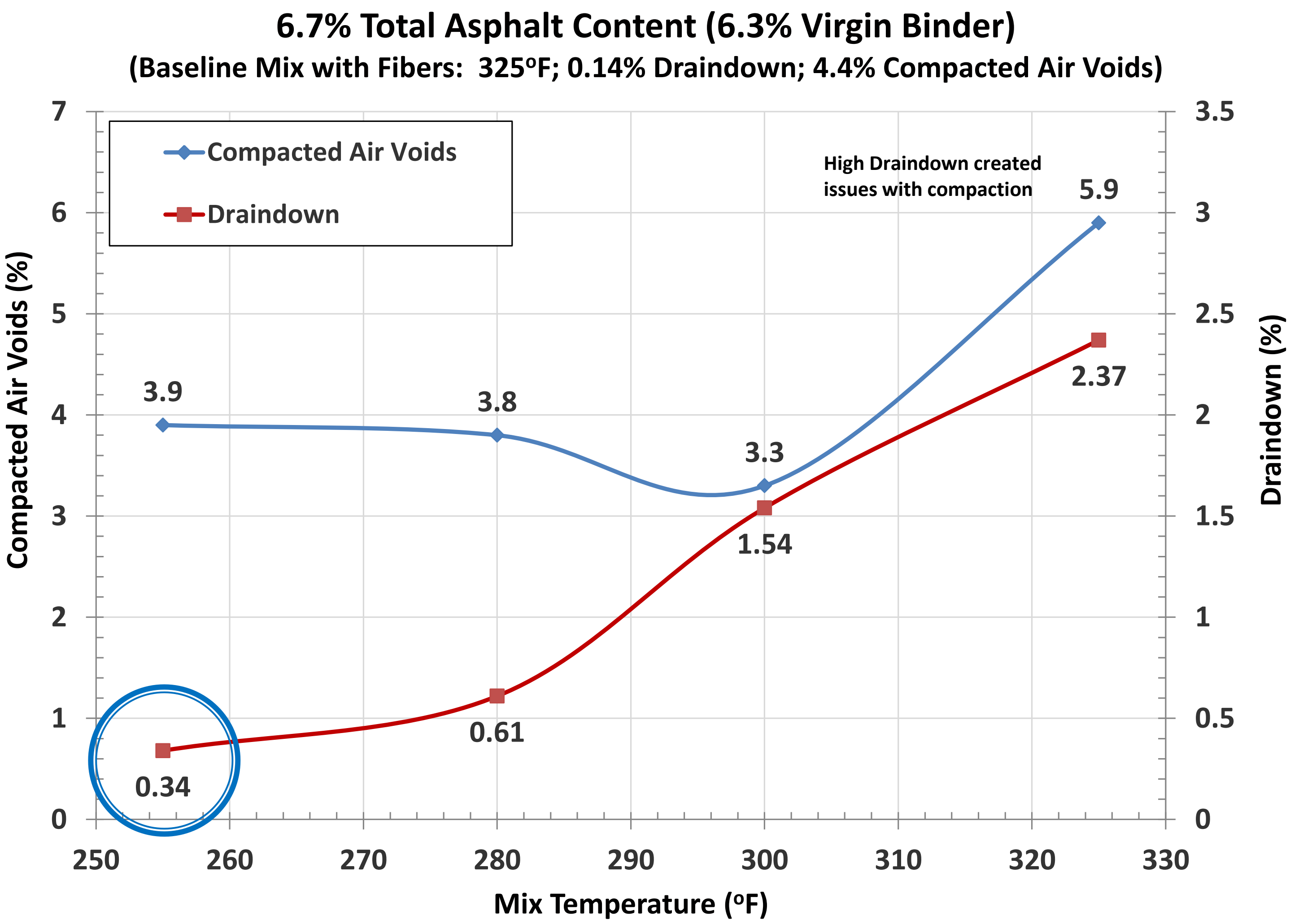
- Final Result
  - Optimal temp range for mixture between 255 and 265ºF.
  - In that range;
    - Air voids slightly above 4%
    - Draindown around 0.2 to 0.25% (specification is 0.3%)
    - All aggregates coated after mixing
- Final production
  - Maintained asphalt content and slight increase filler content
    - Increased filler to help close up air voids and reduce draindown
    - Contractor and agency extremely happy with final product

Design Example #2 – "Sometimes You Need a Few Trials"

- Determine Optimal Temperature Range for Fiberless SMA in VA
  - 12.5mm NMAS SMA
  - 6.7% Total Asphalt Content
    - PG76-22
  - 15% RAP
    - 0.4% Total Binder Weight Contribution
  - 0.3% Cellulose Fibers
  - 0.14% draindown

Washed Gradation		
Screen		% Pass
2"	50.00	100
1 ½"	37.50	100
1"	25.00	100
¾"	19.00	100
½"	12.50	95
3/8"	9.50	75
#4	4.75	30
#8	2.36	19
#16	1.18	14
#30	0.600	13
#50	0.300	12
#100	0.150	11
#200	0.075	8.5

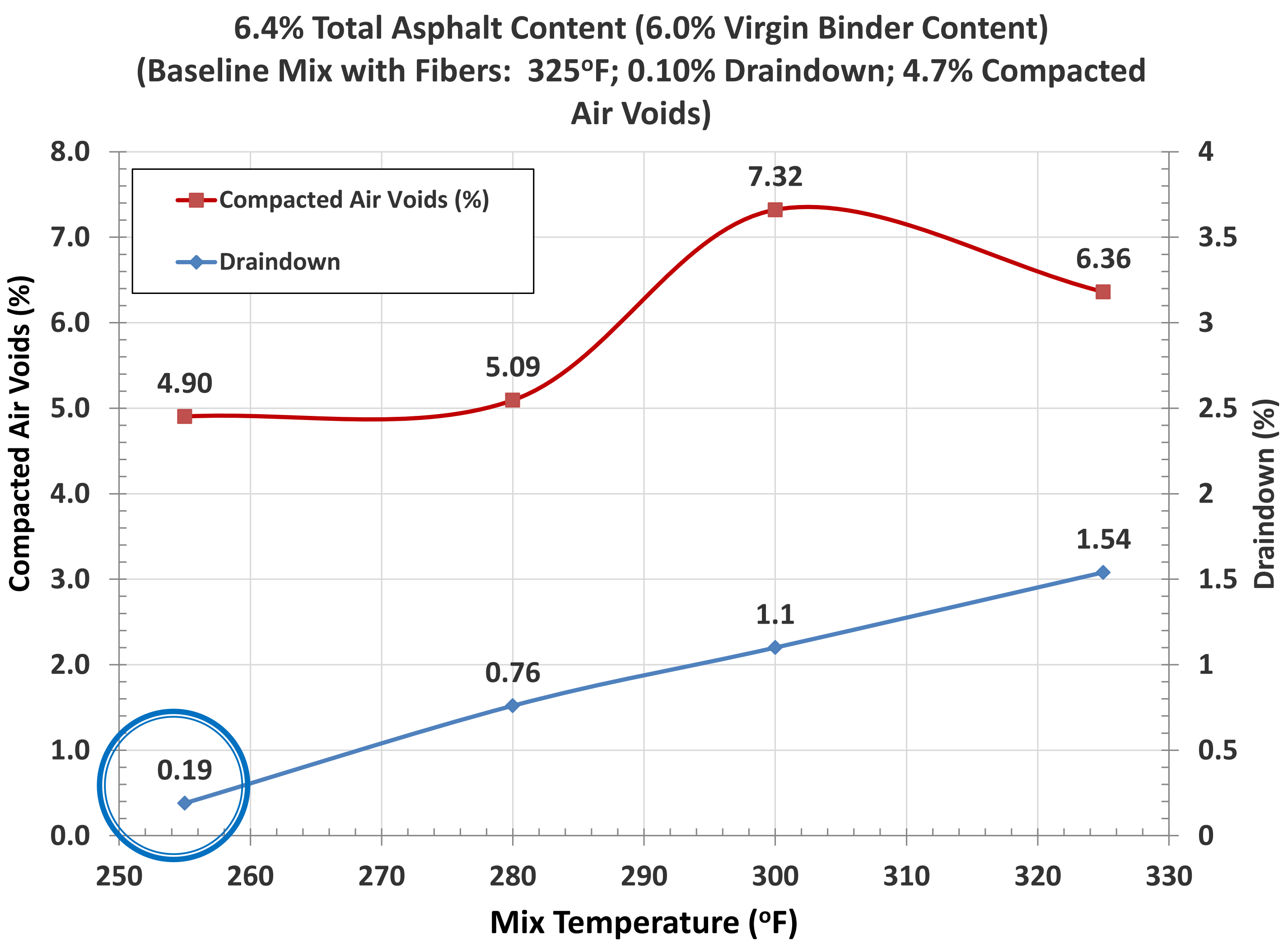
Design Example #2 – Compacted Air Voids vs Draindown



Design Example #2 – "Sometimes You Need a Few Trials"

- 1st Trial Results
  - Testing at lower temps showed that air voids were slightly low and draindown was still above specification
    - Coating easily met at all temperatures
  - For this particular mix, the elimination of fibers is creating an slightly over-asphalted mix
  - For Trial #2, asphalt content was reduced 0.3% (same % as original fibers) and testing was again conducted

Design Example #2 – 2nd Trial Results



Design Example #2 – Finals Results

- For the Design Example #2 SMA, eliminating fibers created an over-asphalted condition
  - Fibers creating surface area – taking up additional asphalt
- 2^{nd} trial showed a reduction of 0.3% asphalt was required to maintain draindown
- Supplier also slightly increased dust to help tighten up air voids

Fiberless SMA Field and Laboratory Performance

Project #1 – New Jersey, Route 1 SB

- First project to look at fiberless SMA with WMA (2009)
- Location: Rt 1, SB in New Jersey (MP 6.5 to 7.8)
  - Rt 1 NB constructed with conventional SMA
- Trap Rock aggregate
- 12.5mm SMA
  - 6.4% AC content-Same w/o fibers
  - PG76-22
  - 0.3% cellulose fibers

Washed Gradation		
Screen		% Pass
2"	50.00	100
1 ½"	37.50	100
1"	25.00	100
¾"	19.00	100
½"	12.50	94
3/8"	9.50	63
#4	4.75	28.2
#8	2.36	19.8
#200	0.075	8.8

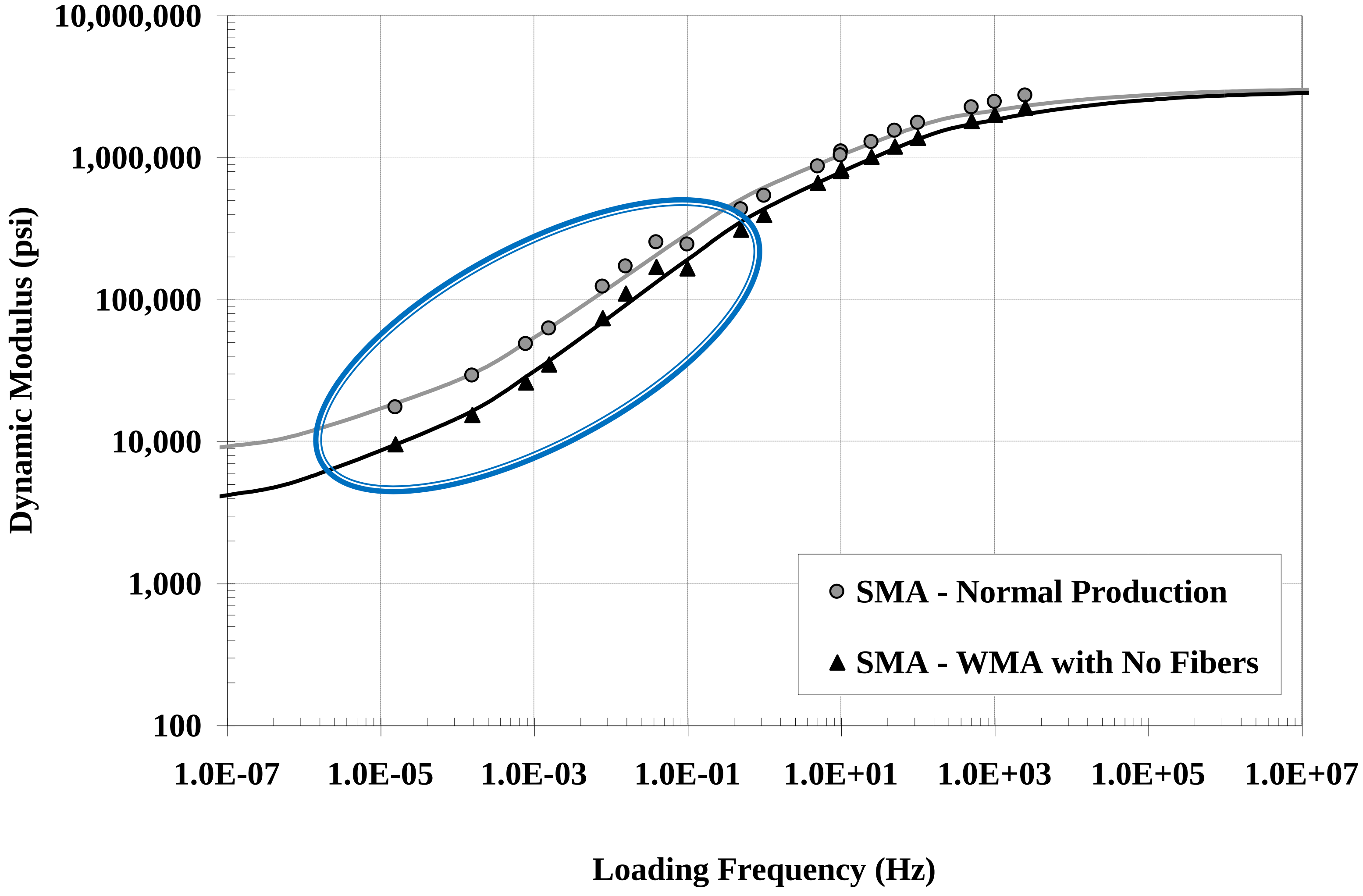
Project #1 –NJ, Rt. 1 SB

- Air voids ranged between 3.8% to 4.4%
- Aggregate coating no issue

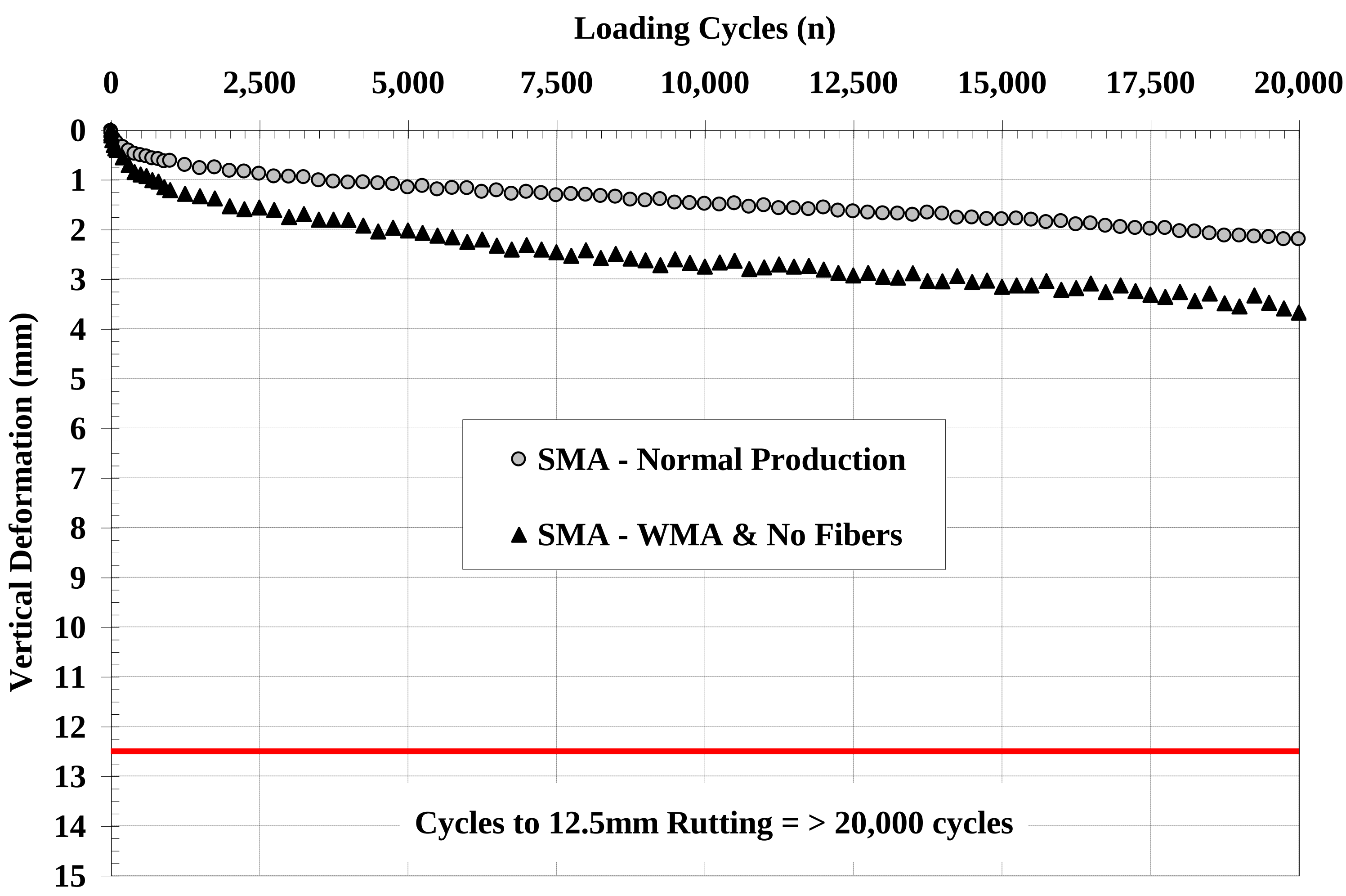
Mixture ID	Temperature (F)		Percent Draindown
	Mixing	Testing	
Normal SMA	325	325	0.08
WMA SMA #1 (No Fibers)	325	325	0.19
WMA SMA #2 (No Fibers)	290	290	0.08
WMA SMA #3 (No Fibers)	255	255	0.06

Supplier did own assessment of compacted air voids

NJ Rt 1 - Dynamic Modulus for Mixture Stiffness



NJ Rt 1 – Wet Hamburg Wheel Tracking for Stripping & Rutting Potential



NJ Rt 1 - Overlay Tester for Fatigue Cracking Potential

SMA - WMA with No Fibers			
Sample ID	Temp (F)	Displacement (inches)	Fatigue Life (cycles)
# 1	77 F	0.025"	10,472
# 2			27,855
# 3			16,255
Average (Trimmed Mean) =			**18,194**

SMA - Normal Production			
Sample ID	Temp (F)	Displacement (inches)	Fatigue Life (cycles)
# 1	77 F	0.025"	2,126
# 2			2,425
# 3			1,458
Average (Trimmed Mean) =			**2,003**

Project #1 – New Jersey

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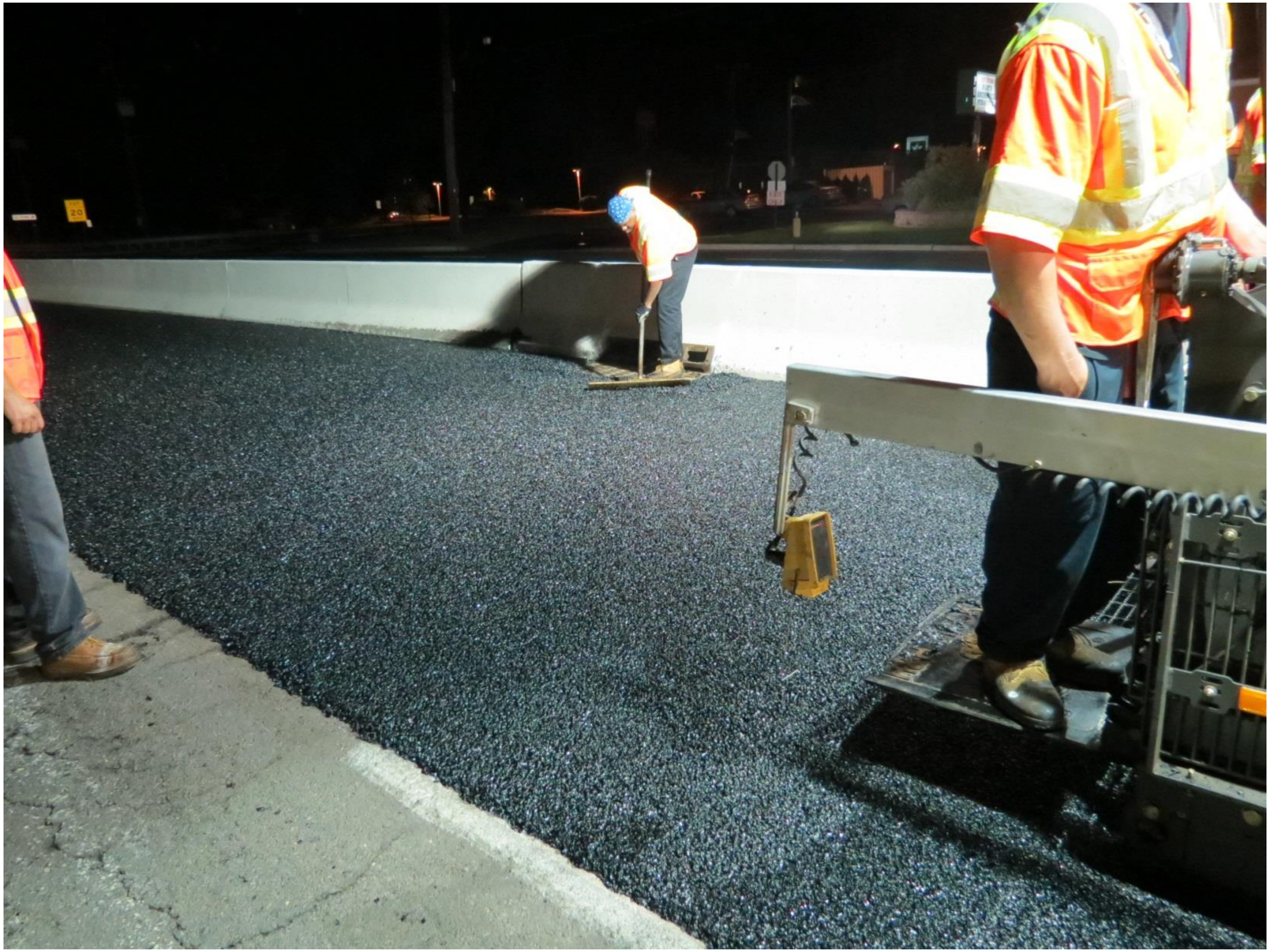


NJ, Rt 1 SB – Final Field Density

- Field Core Density
  - Conventional SMA Density = 5.13% air voids
    - Produced over 315F
  - WMA SMA Density = 5.12% air voids
    - Produced under 280F
  - Both mixtures were identical with regard to density

Fiberless using WMA SMA Project #1 – New Jersey Rt 1 Southbound

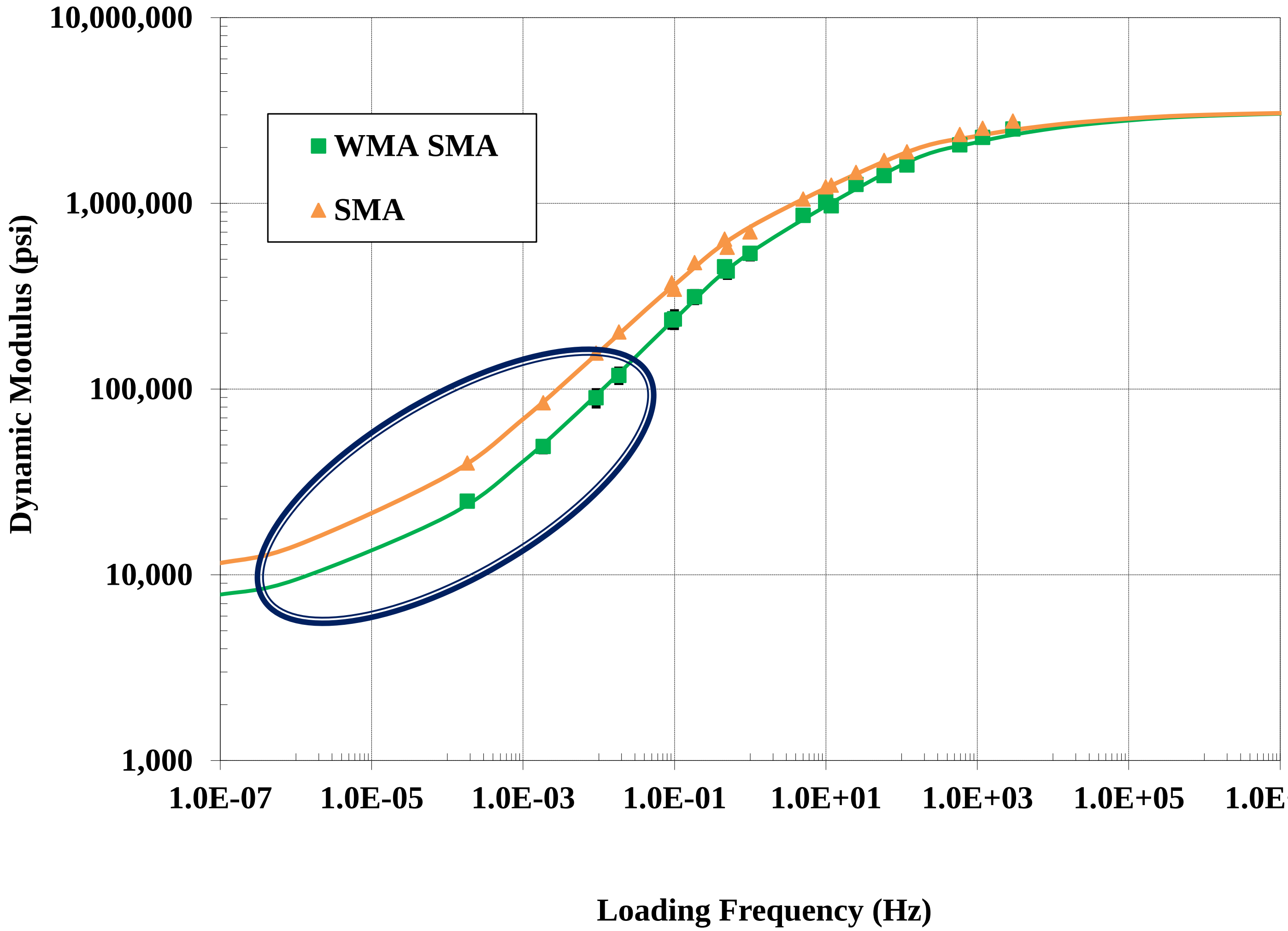
- For initial pilot, reduction in production temp successfully reduced draindown when fibers eliminated
  - Produced @ 275 to 285°F
  - 1st Roller Pass @ 270 to 280°F
- Field densities of with and without fibers statistically equal
- Mixture performance looked good
  - Lower production temps not aging binder as normal
    - Stiffness slightly lower
    - Large increase in fatigue resistance (higher effective AC?)

One Complaint!

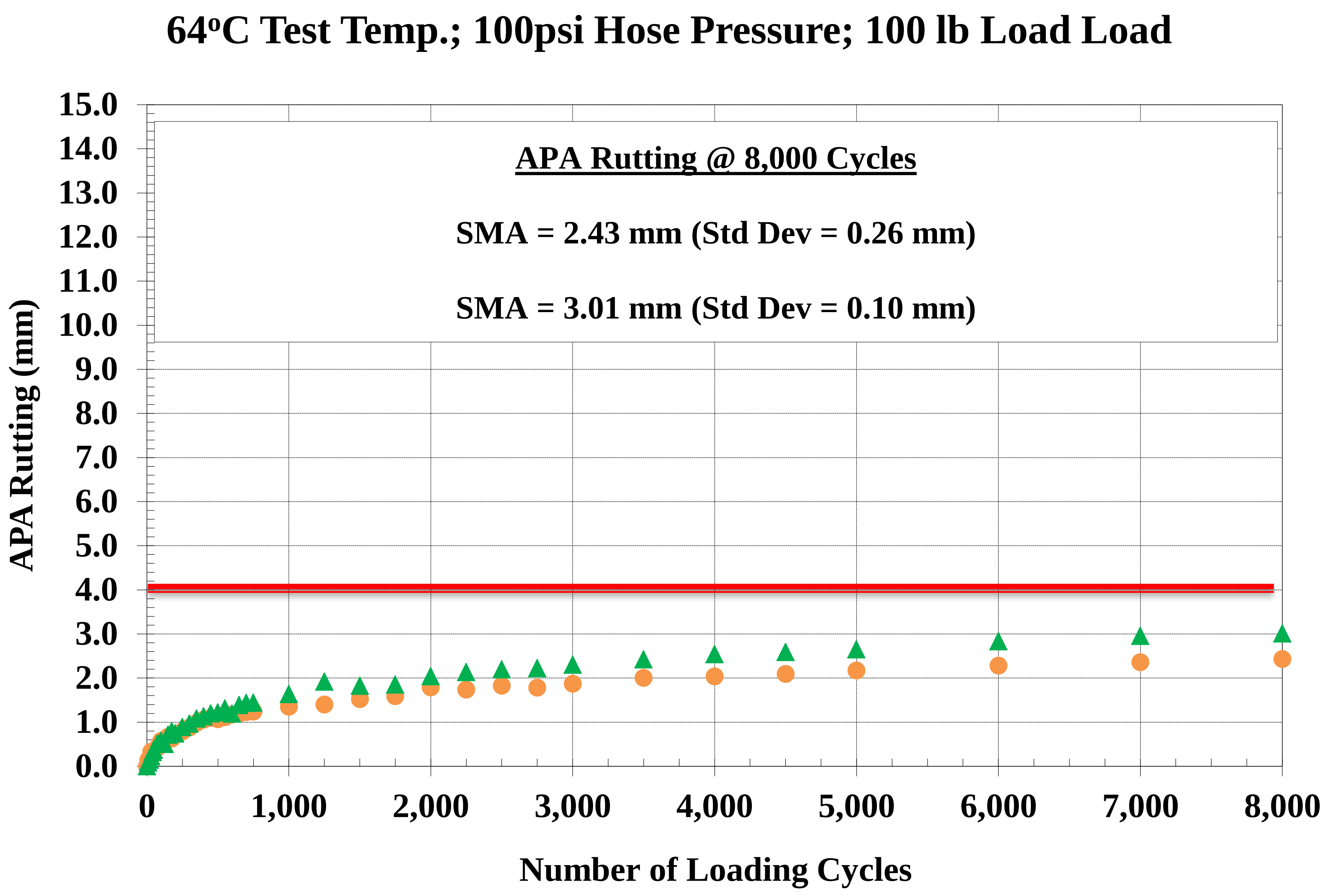
Project #2 – New Jersey

- Fiberless SMA (2012) – NB Rt 1
  - Approximately MP 28.5 to 32.1
- Supplier conducted draindown and compaction on own
  - AC% = 6.1%; no fibers; PG76-22 asphalt binder, 0.6% WMA
- Produced @ 275 to 285F
- 1st Roller Pass @ 270 to 280F
  - Average of 5% air voids in the field
- Rutgers received loose mix to evaluate/compare general performance properties

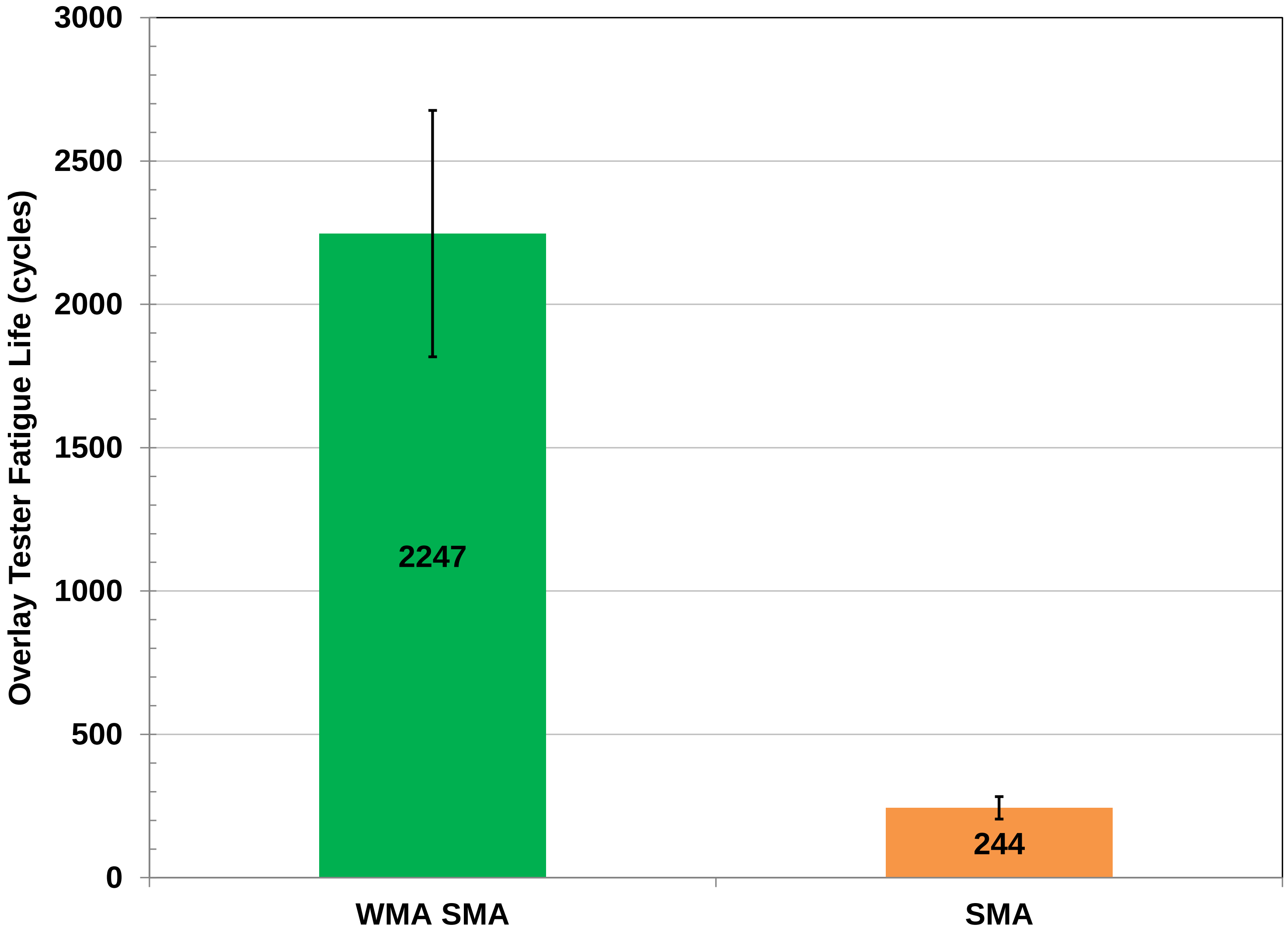
Project #2 – NJ – Mixture Stiffness



Project #2 – NJ - Rutting Resistance



Project #2 – NJ – Fatigue Resistance



Project #2 – New Jersey

- Mixture performance between SMA and WMA-SMA similar
  - Decreased production temps results in slightly less stiff WMA fiberless mixture
  - Eliminating fibers and reducing temps results in superior fatigue resistance
- Properly designed SMA with PMA and stone-on-stone contact (assuming quality stone) should not rut

Supplier and Contractor Comments/Opinions

Supplier Opinions – Wayne Byard, Trap Rock Industries, NJ

- Produced 1st Fiberless SMA and 4 to 5 projects since
  - Mix Design
    - Able to reduce asphalt binder content by 0.4% while still improving fatigue properties. Reduction in binder more than paid for addition of WMA additive
    - Fiberless eliminated the need for purchasing, delivering, stockpiling and protecting fibers – no rental costs
    - Can take an order of SMA one day and start producing the next
  - No plant modifications necessary
  - Field/Compaction
    - Workability (hand work) and compaction excellent, even as low as 265F in the northeast
    - Ship 1st load or two at normal temp to heat up MTV and paver, then go back to warm mix temps
    - No issues with material sticking to truck bodies

Supplier Opinions – Tilcon Mt. Hope, NJ

- Produced two Fiberless SMA projects
  - Mix Design
    - Reduced asphalt content by 0.4% - lab testing at Rutgers showed good fatigue cracking performance
    - Saved costs on both no fibers and reduced asphalt content
  - No plant modifications necessary during production
    - Production 280 to 290F with PG76-22 compared to > 325F
  - Field/Compaction
    - Better workability than conventional SMA
    - Truck bodies clean
    - Compaction still as low as 170F – densities better than 94% Gmm

VA Route 29 Fiberless SMA Trial Paved in 2013

Field Core Evaluation

VA Route 29 Project Overview

- VDOT and Superior Paving constructed a fiberless SMA as a trial
- 1,100 tons of fiberless SMA in the SB (left) lane
- Volumetric properties were in specification; no issues with density or drain down issues
- Superior lowered plant temps by ~50°F by adding WMA when removing fibers
- Plant production 285°F - 290F
- Roadway production 275°F - 280°F
- When using WMA and no fibers:
  - lower cost per mix ton
  - increased plant production
  - reduced mixing time

Mix Designs

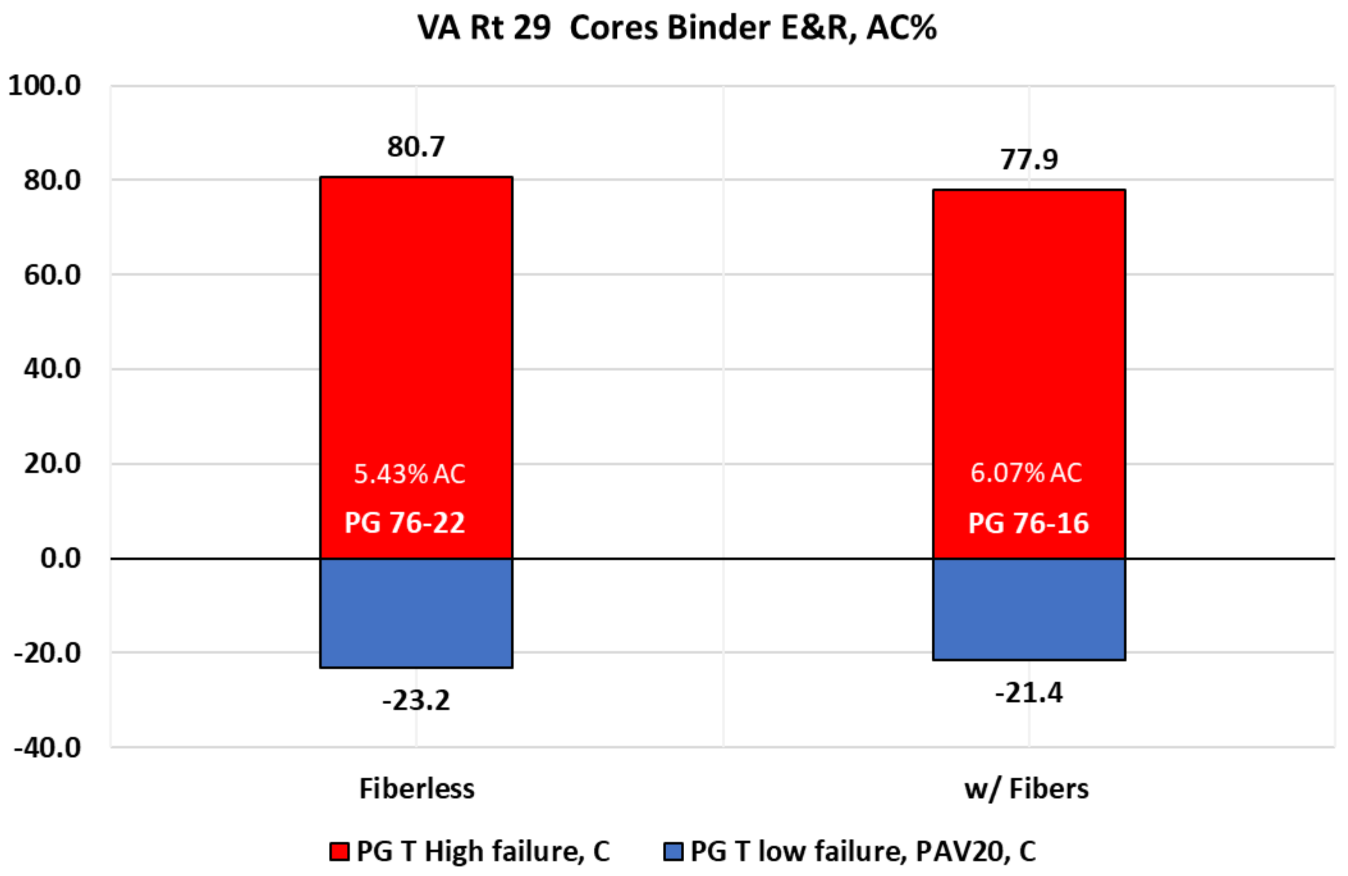
FIBERLESS

- 15% RAP
- 9.6% P200
- 6.0% AC
- PG 76-22
- 0.6% WMA

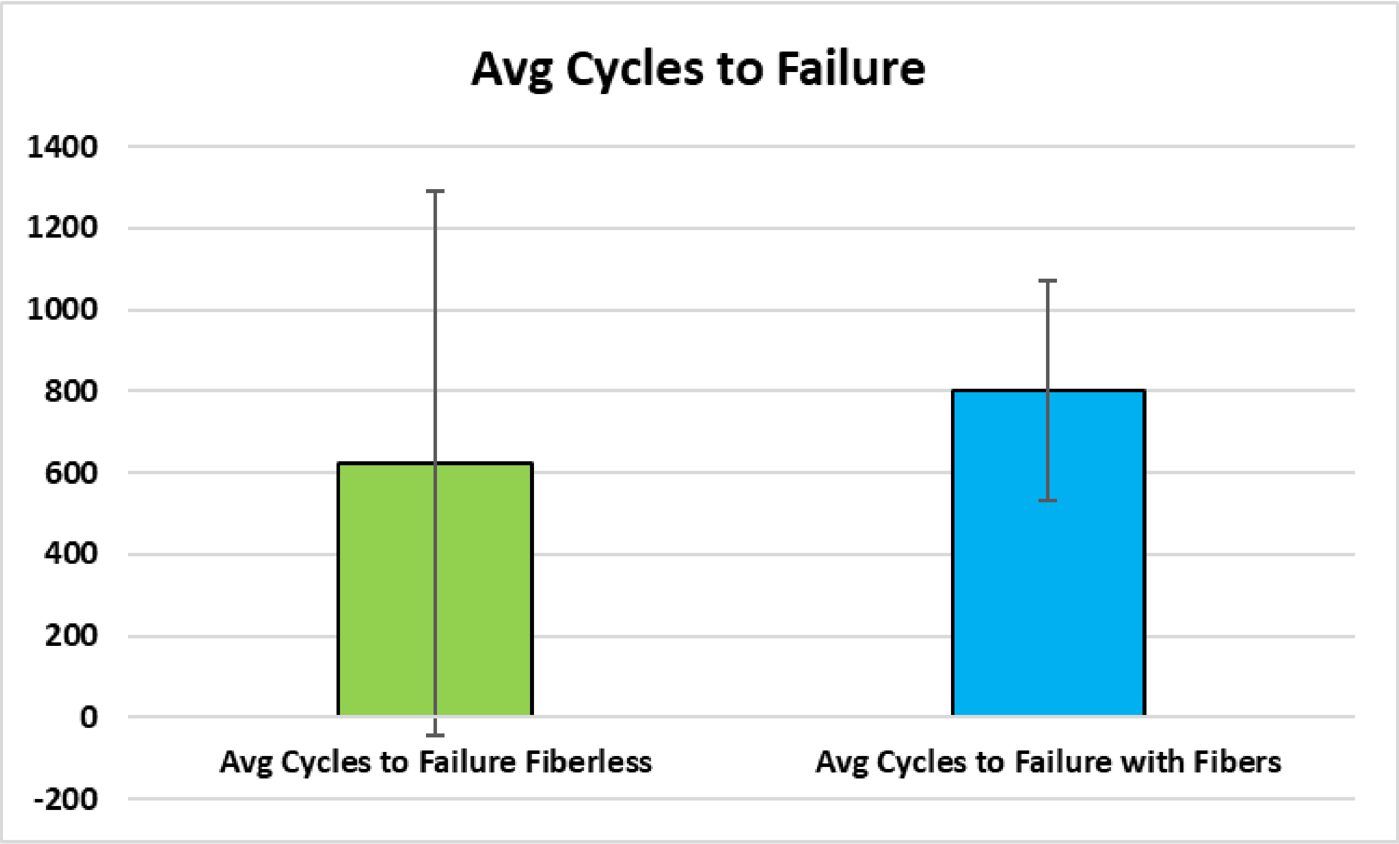
CONVENTIONAL

- 12% RAP
- 9.5% P200
- 6.3% AC
- PG 76-22
- 0.3% Cellulose Fibers
- 0.3% LAS

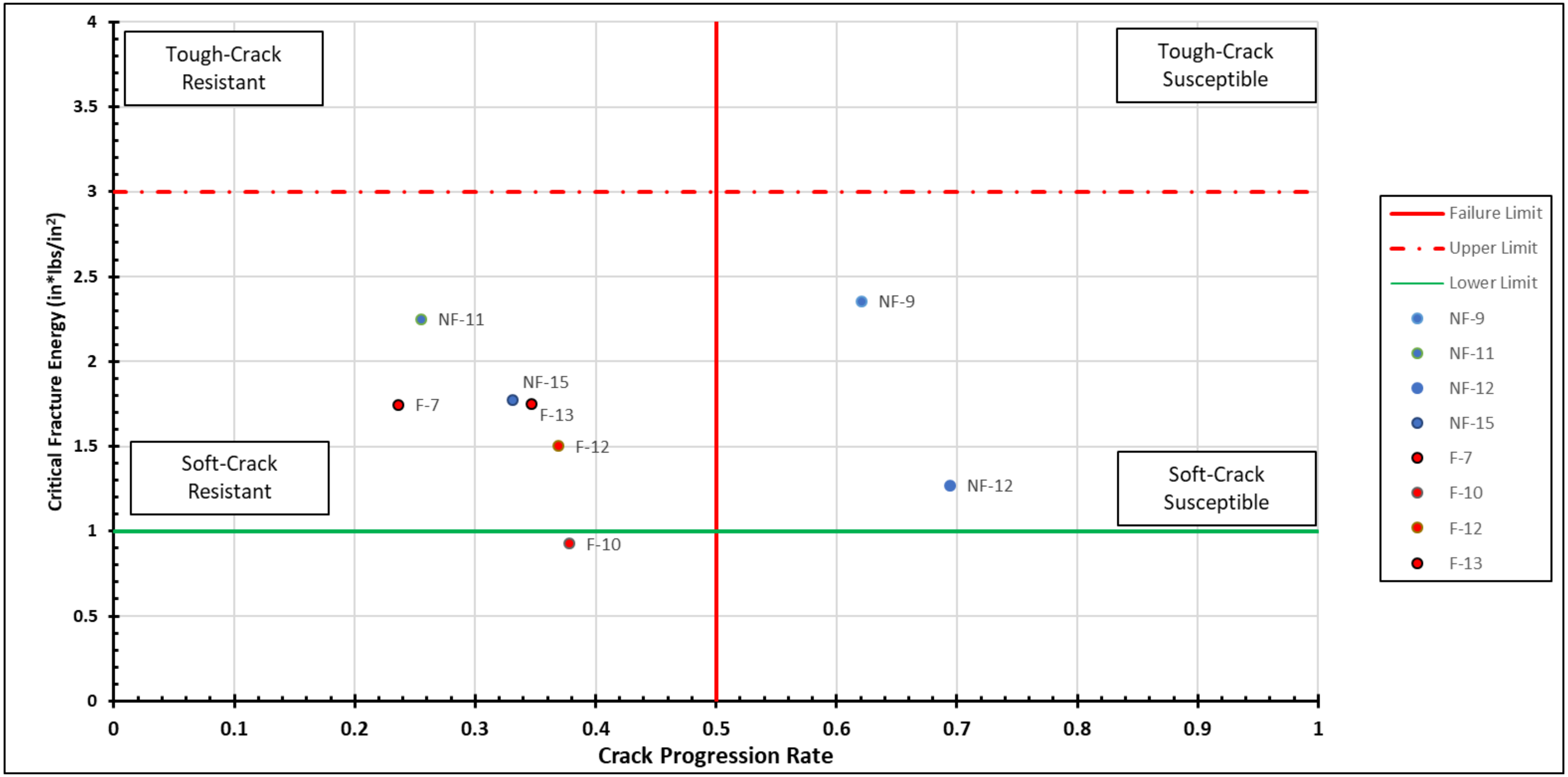
Road Core E&R Binder Grade, %AC



Overlay Test TEX-248-F



Overlay Test TEX-248-F (all data)



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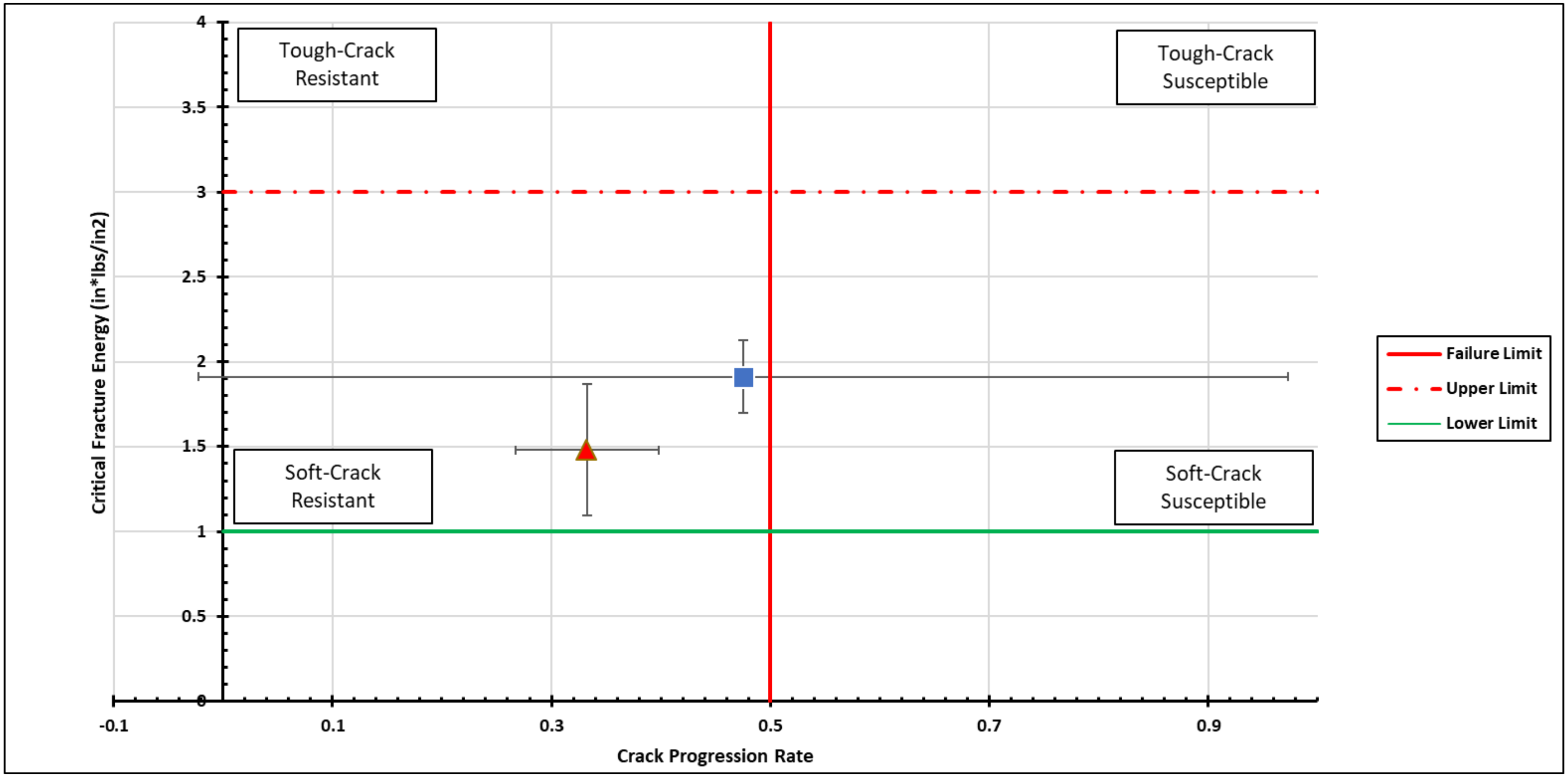
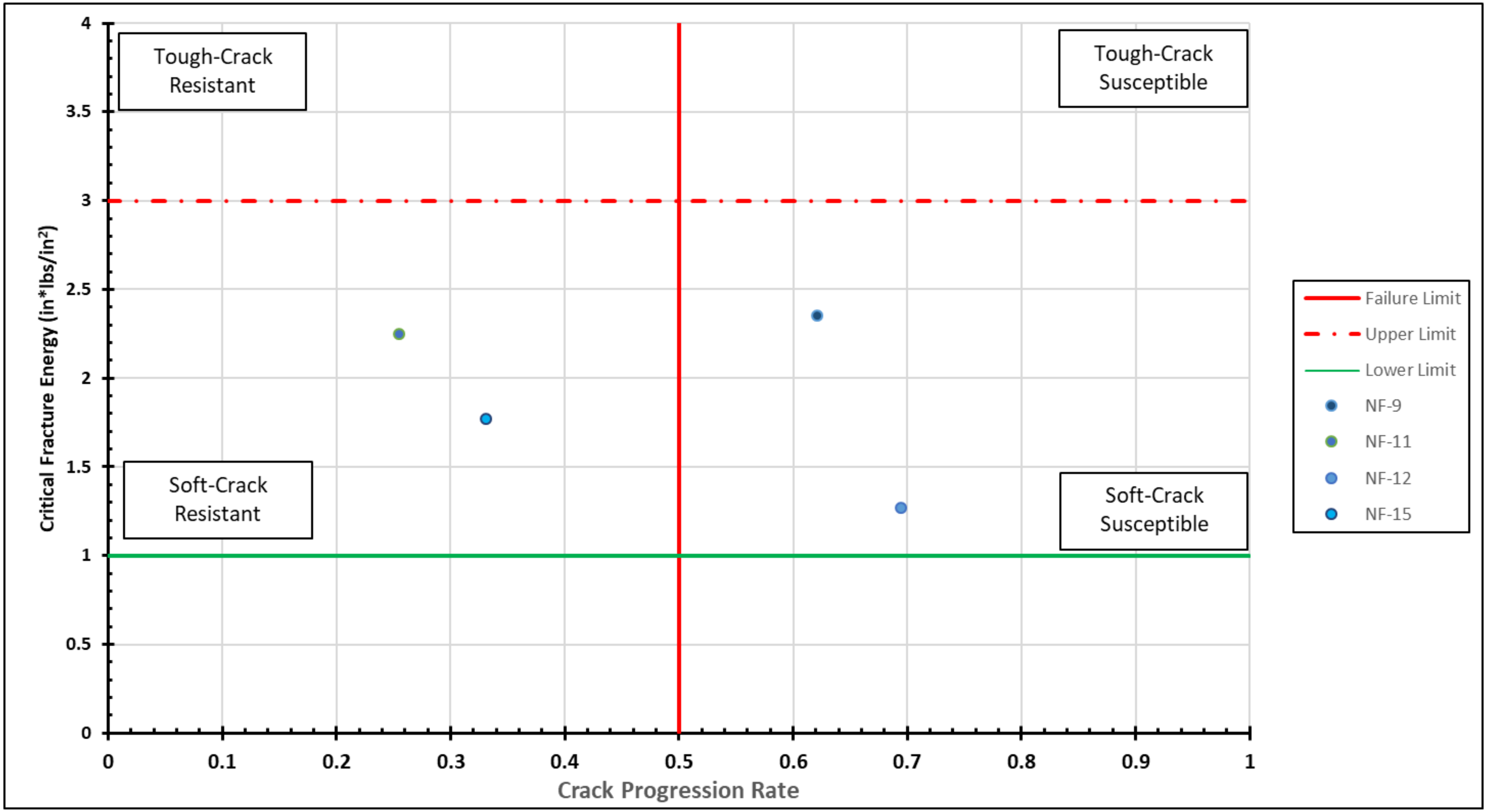
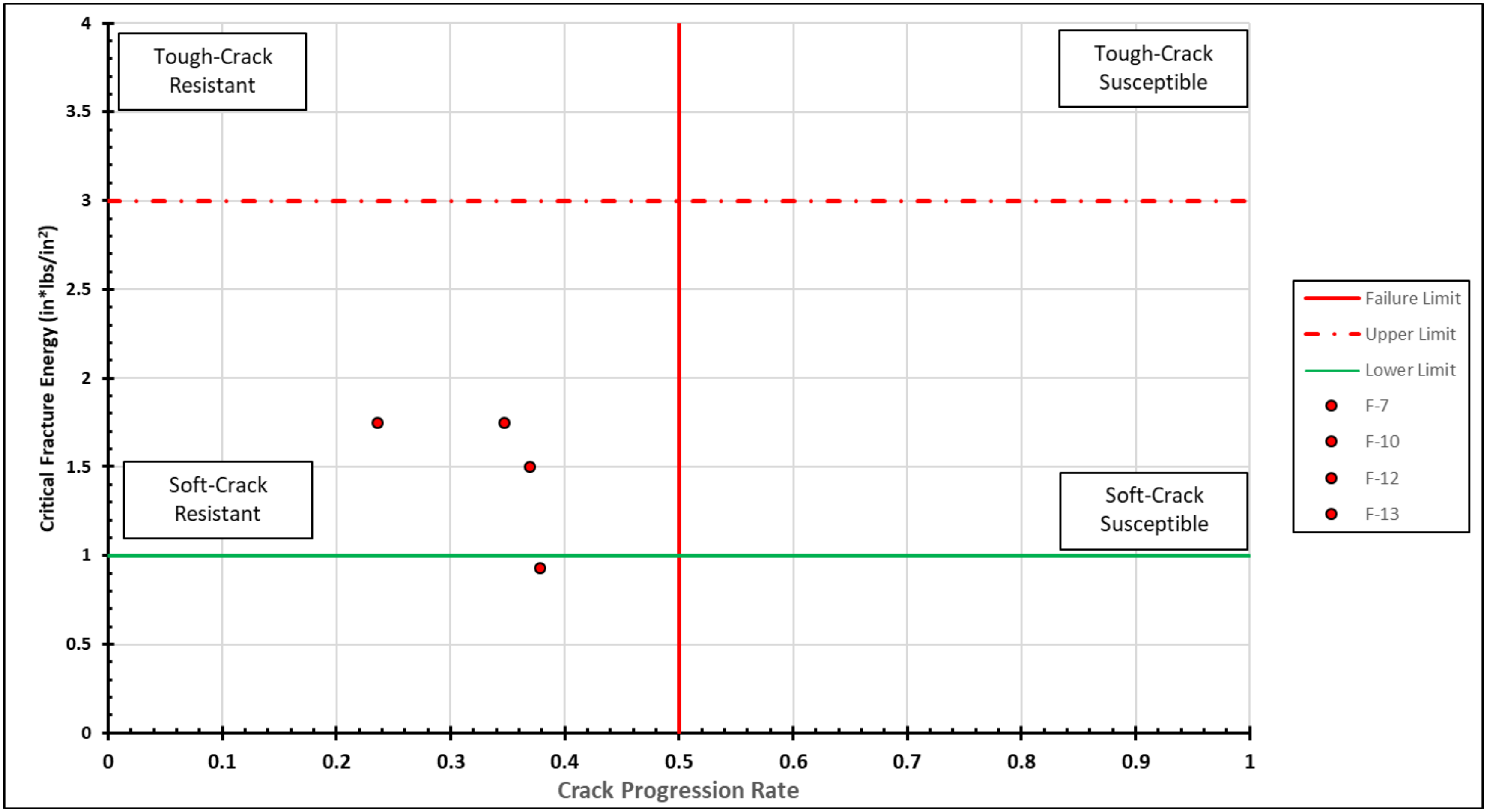


Overlay Test TEX-248-F (Fiber-less)



Overlay Test TEX-248-F (with Fibers)



Questions?