NEAUPG

High RAP Mixtures – Strategies and Their Implementation in the Northeast

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- Jo Sias-Daniel, UNH
- Walaa Mogawer, UMass – Dartmouth
- FHWA Pooled Fund Participants – *High RAP Mixtures in the Northeast*
- Eileen Sheehy, Materials Bureau of NJDOT
- Robert Blight and Susan Gresavage, NJDOT Pavement Design and Management
- Zoeb Zavery, Materials Bureau, NYSDOT

Pooled Fund Study Work Effort

- Ultimate Goal: Responsibly producing and placing higher recycled asphalt content mixtures that will perform well
- On-going FHWA Pooled Fund study to evaluate plant produced higher RAP mixtures
  - Survey to state and industry (separate surveys)
  - Laboratory evaluation of plant produced mixtures of varying RAP percentages (0 to 40%)
    - Field evaluation of those placed
  - Last phase, controlled laboratory expert

Northeast Pooled Fund - Survey

- Asked State DOT's in Northeast biggest concerns with higher RAP contents;
  - All concerned with cracking
  - Some concerned with quality control
- Asked State DOT's how they believed higher RAP contents should be adopted ("Strategy");
  - Use of softer asphalt binder to offset stiffer RAP
  - Limiting amount of RAP binder credited to total asphalt content
  - Adopt performance-based acceptance for final mixture

High RAP Content
Strategy #1 – Softer Binder Grade

Softer PG Grade for Higher RAP

- Came from recommendations of NCHRP Report 452 (McDaniel and Anderson, 2001)

Recommended Virgin Asphalt Binder Grade	Percent (%) RAP
No change in binder selection	< 15
Select virgin binder grade one grade softer than normal	15 – 25
Follow recommendations from blending charts	> 25

- Recent work by NCAT on NCHRP Project 9-46 suggests using "binder replacement" instead of by total weight. Also suggests adjustments only needed above 25%

Advantages/Disadvantages

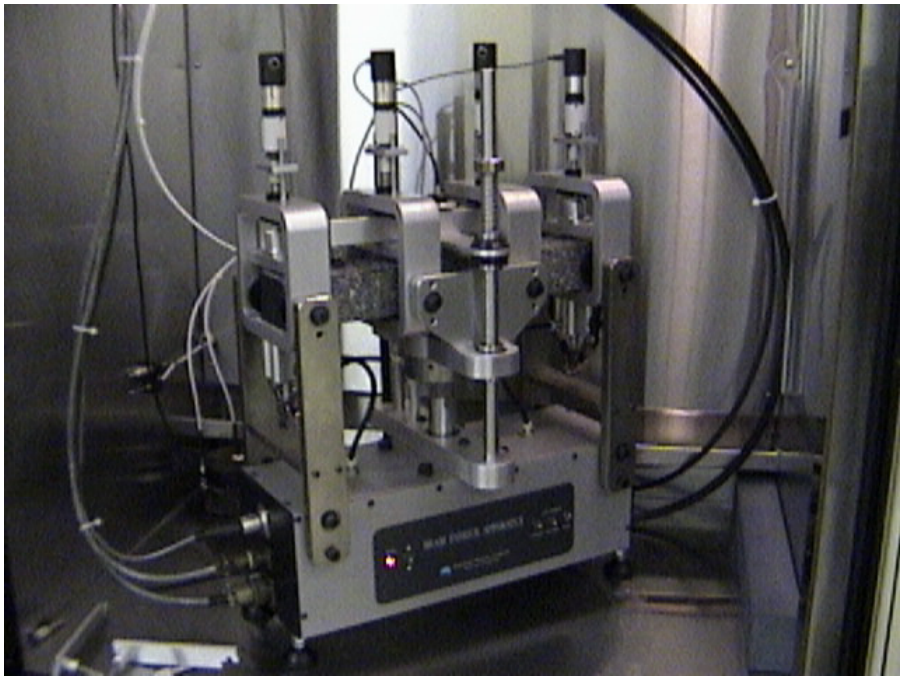
- Advantages
  - Easiest Strategy to implement
  - A simple change at the asphalt plant – no volumetric redesign required pending approval from state agency
- Disadvantages
  - Supply of grade may be limited in area
  - May not address issue of "under-asphalted" if exists
  - Blending charts may be required, which utilizes solvent extraction

Northeast Pooled Fund Study

- Mixtures evaluated in Phase I of study looked at the influence of softer binder grade
  - Callanan, NY (PG64-22 and PG58-28)
  - Williston, VT (PG64-28 and PG52-34)
- Intermediate Cracking
  - Flexural Fatigue (Crack Initiation)
  - Overlay Tester (Crack Propagation)
- Low Temperature Cracking
  - TSRST
  - Critical Cracking Analysis using TCModel – same as MEPDG

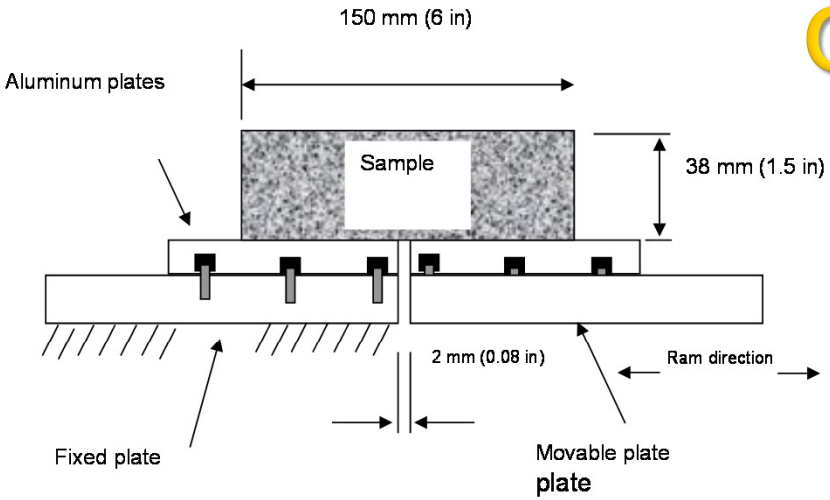
Crack Initiation Test

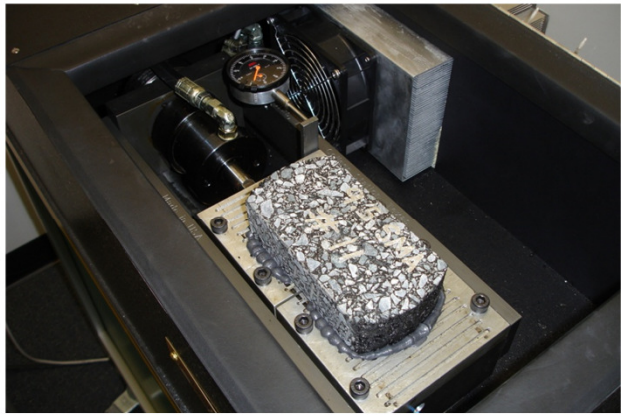
- Flexural Beam Device, AASHTO T321
- Test mixes ability to withstand repeated bending
- Run at different strain levels to determine fatigue life vs applied strain curve

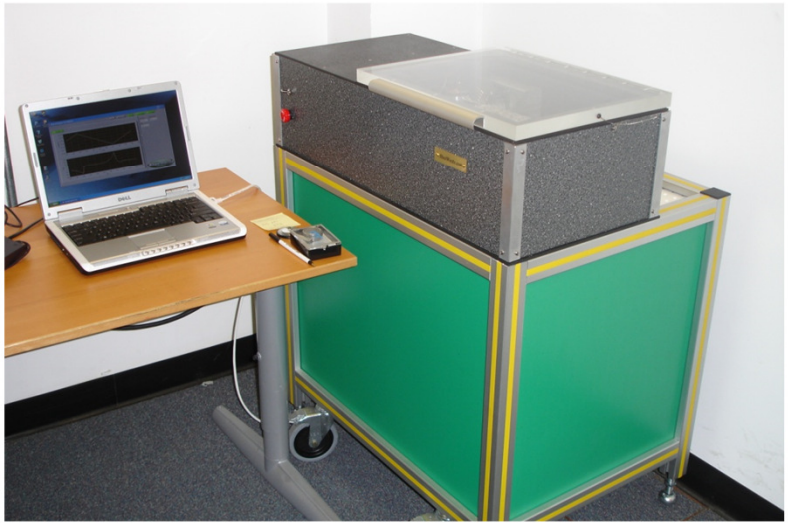


Crack Propagation

Overlay Tester







- Sample size: 6″ long by 3″ wide by 1.5″ high
- Loading: Continuously triangular displacement 5 sec loading and 5 sec unloading
- Definition of failure
  - Discontinuity in Load vs Displacement curve

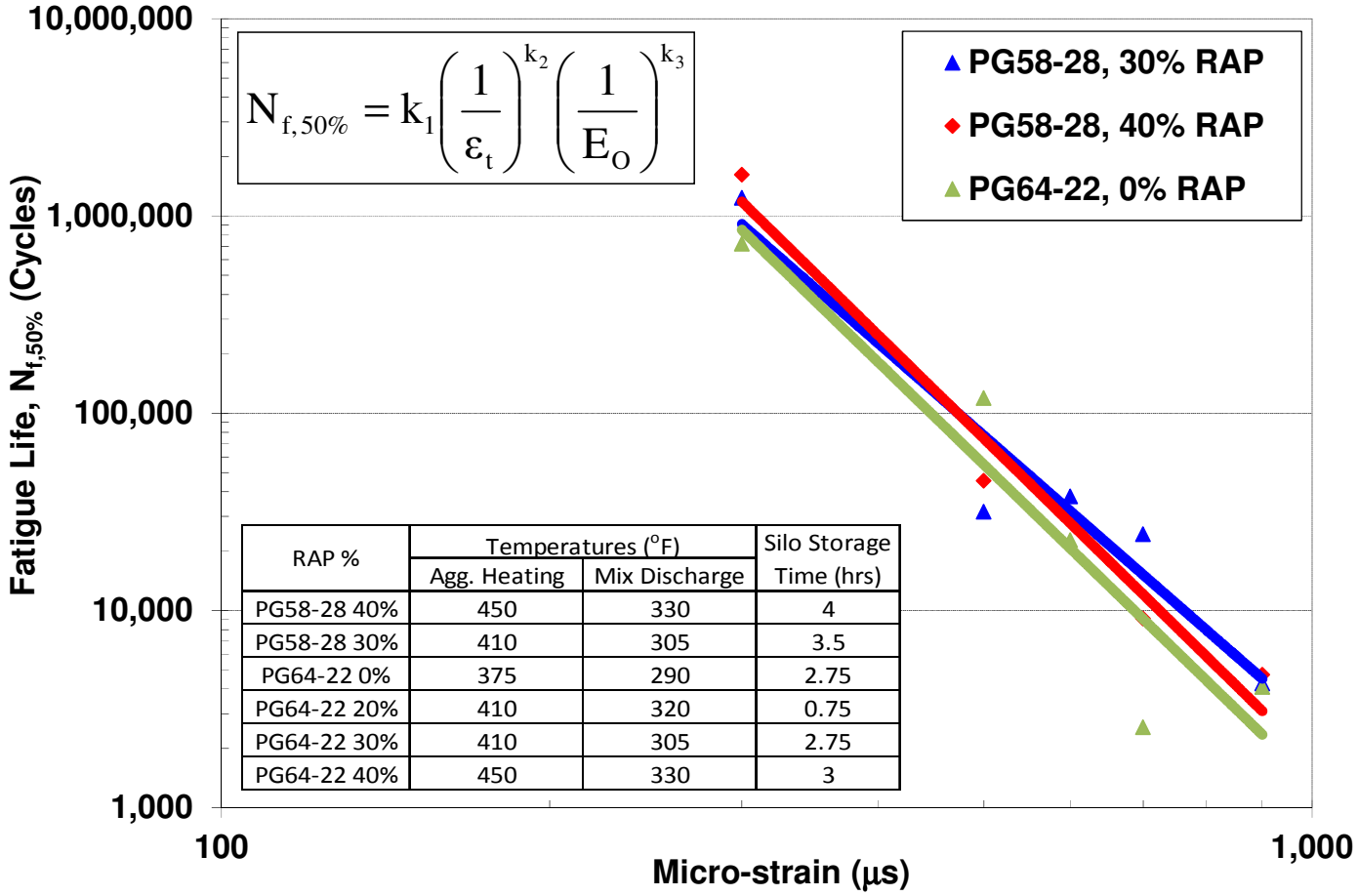
New York Mixtures

- Plant Produced Mixtures (Drum Plant & Silo Stored)
- PG58-28 and PG64-22 base binder
- RAP Contents
  - 0, 20, 30, 40% by weight of mixture (PG64-22)
  - 30, 40% by weight of mixture (PG58-28)

New York Mixtures

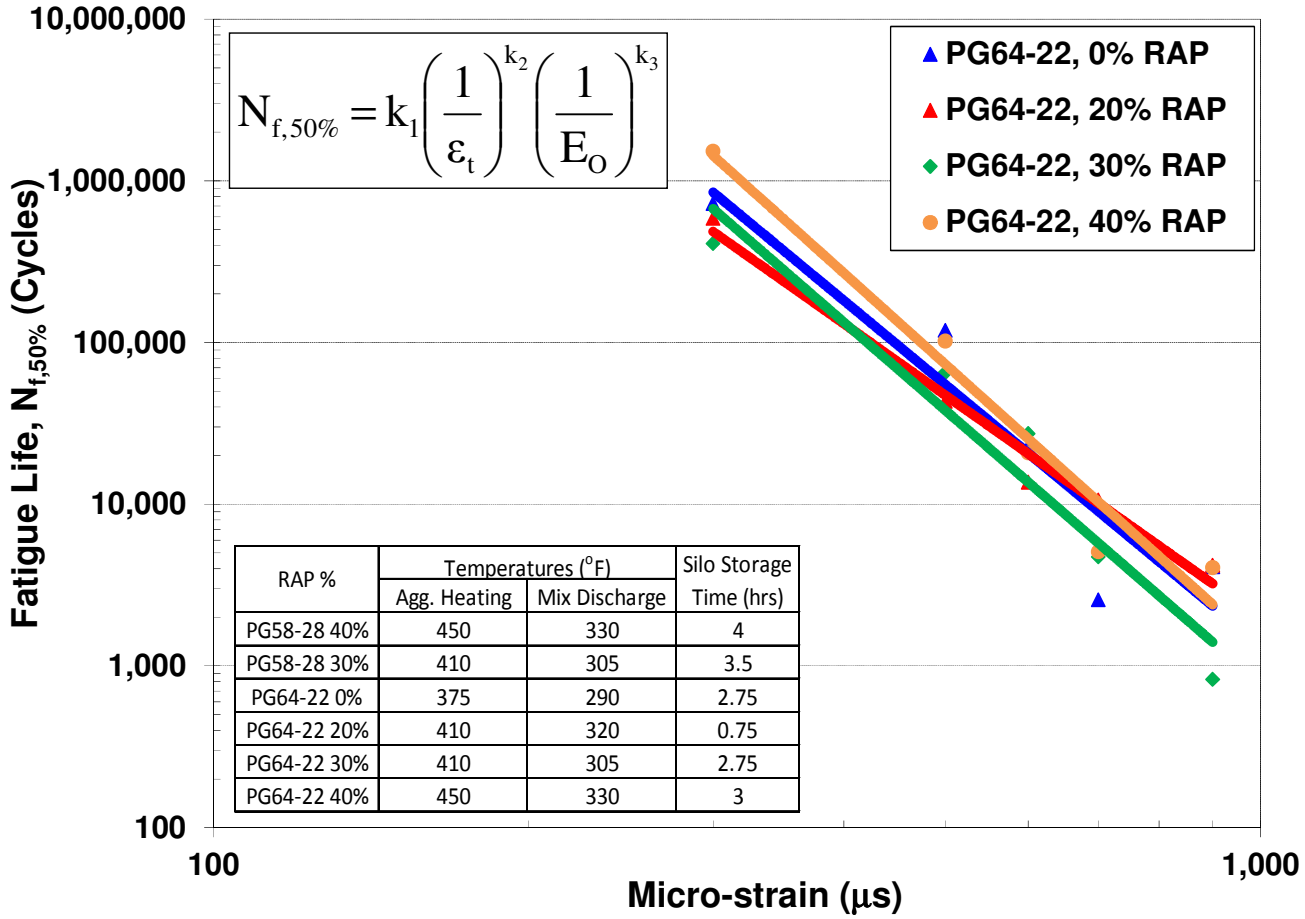
- From extracted/recovered binder (PG64-22)
  - 0% RAP: PG75.5-22.2; AC% = 5.0%
  - 20% RAP: PG78.3-21.8; AC%=5.2%
  - 30% RAP: PG78.4-19.9; AC%=5.5%
  - 40% RAP: PG80.9-17.6; AC%=5.1%
- From extracted/recovered binder (PG58-28)
  - 30% RAP: PG72.1-26.5; AC%=5.0%
  - 40% RAP: PG81.7-22.0; AC%=4.9%

New York Mixtures – Beam Fatigue



RAP %	Temperatures (°F)		Silo Storage Time (hrs)
	Agg. Heating	Mix Discharge	
PG58-28 40%	450	330	4
PG58-28 30%	410	305	3.5
PG64-22 0%	375	290	2.75
PG64-22 20%	410	320	0.75
PG64-22 30%	410	305	2.75
PG64-22 40%	450	330	3

New York Mixtures – Beam Fatigue



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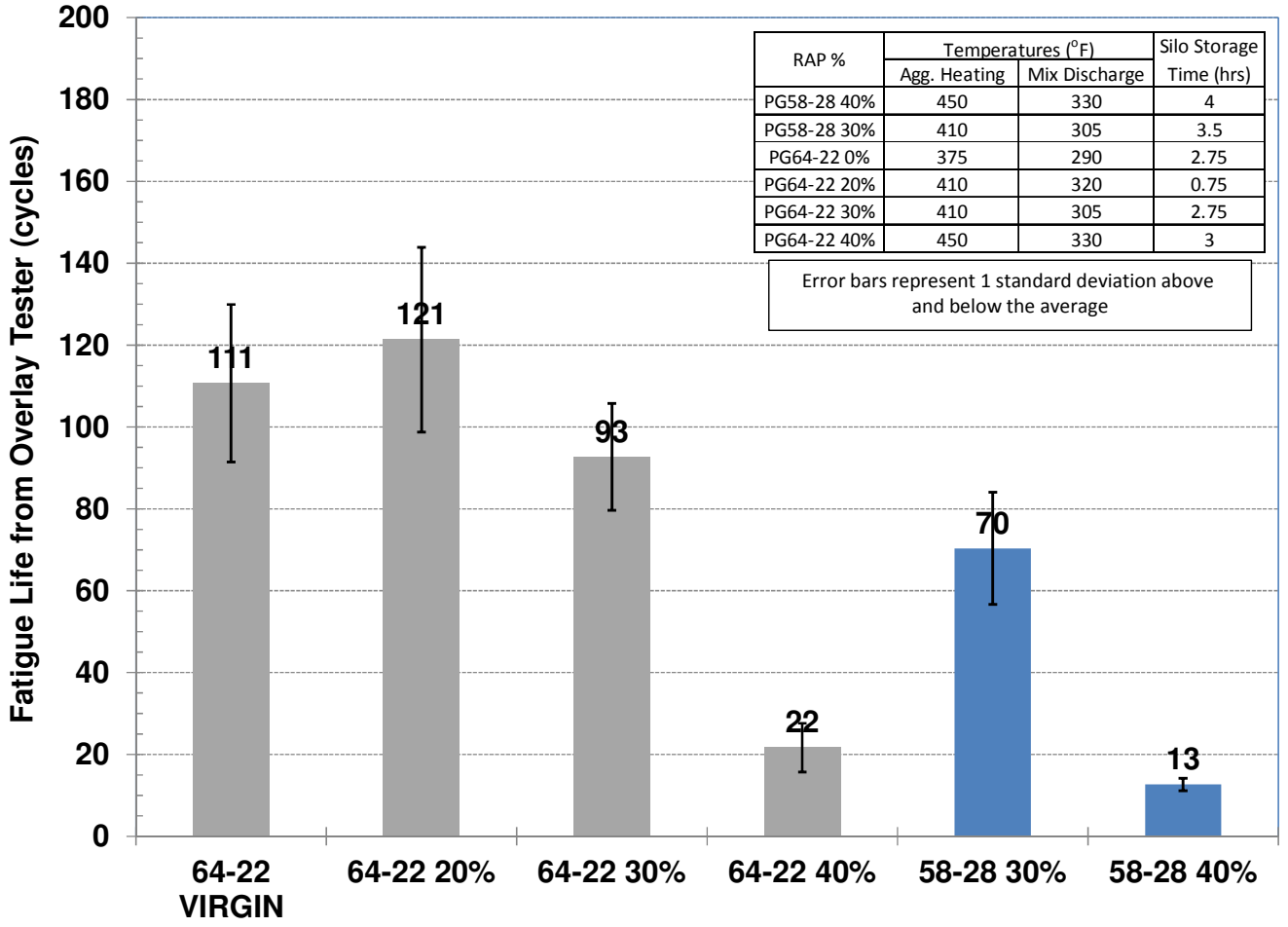
New York Mixtures – Overlay Tester



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PG64-22 20%	410	320	0.75
PG64-22 30%	410	305	2.75
PG64-22 40%	450	330	3

Error bars represent 1 standard deviation above and below the average

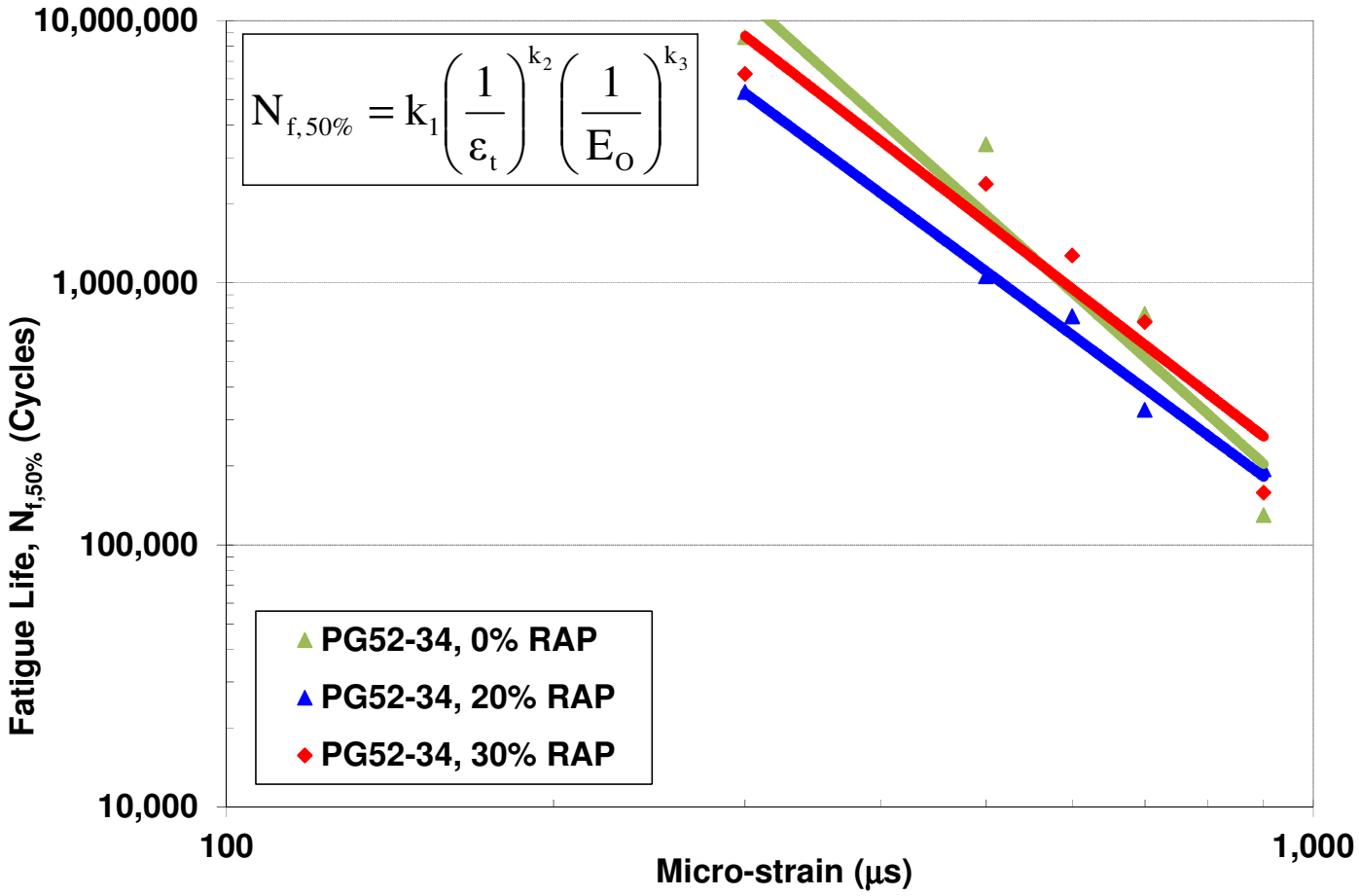
Vermont Mixtures

- Plant Produced Mixtures (Batch Plant)
- PG52-34 and PG64-28 base binder
- RAP Contents
  - 0, 20, 30, 40% by weight of mixture (PG64-28)
  - 0, 20, 30, 40% by weight of mixture (PG52-34)

Vermont Mixtures

- From extracted/recovered binder (PG52-34)
  - 0% RAP: PG65.4-28.3; AC% =6.6 %
  - 20% RAP: PG68.3-28.1; AC%=6.3%
  - 30% RAP: PG71.4-26.3; AC%=6.1%
  - 40% RAP: PG68.6-21.0; AC%=6.1%
- From extracted/recovered binder (PG64-28)
  - 0% RAP: PG67.4-30.2; AC%=5.8%
  - 20% RAP: PG69.6-27.0; AC%=5.5%
  - 30% RAP: PG74.7-23.0; AC%=5.3%
  - 40% RAP: PG78-24.9; AC%=6.0%

Vermont Mixtures – Beam Fatigue



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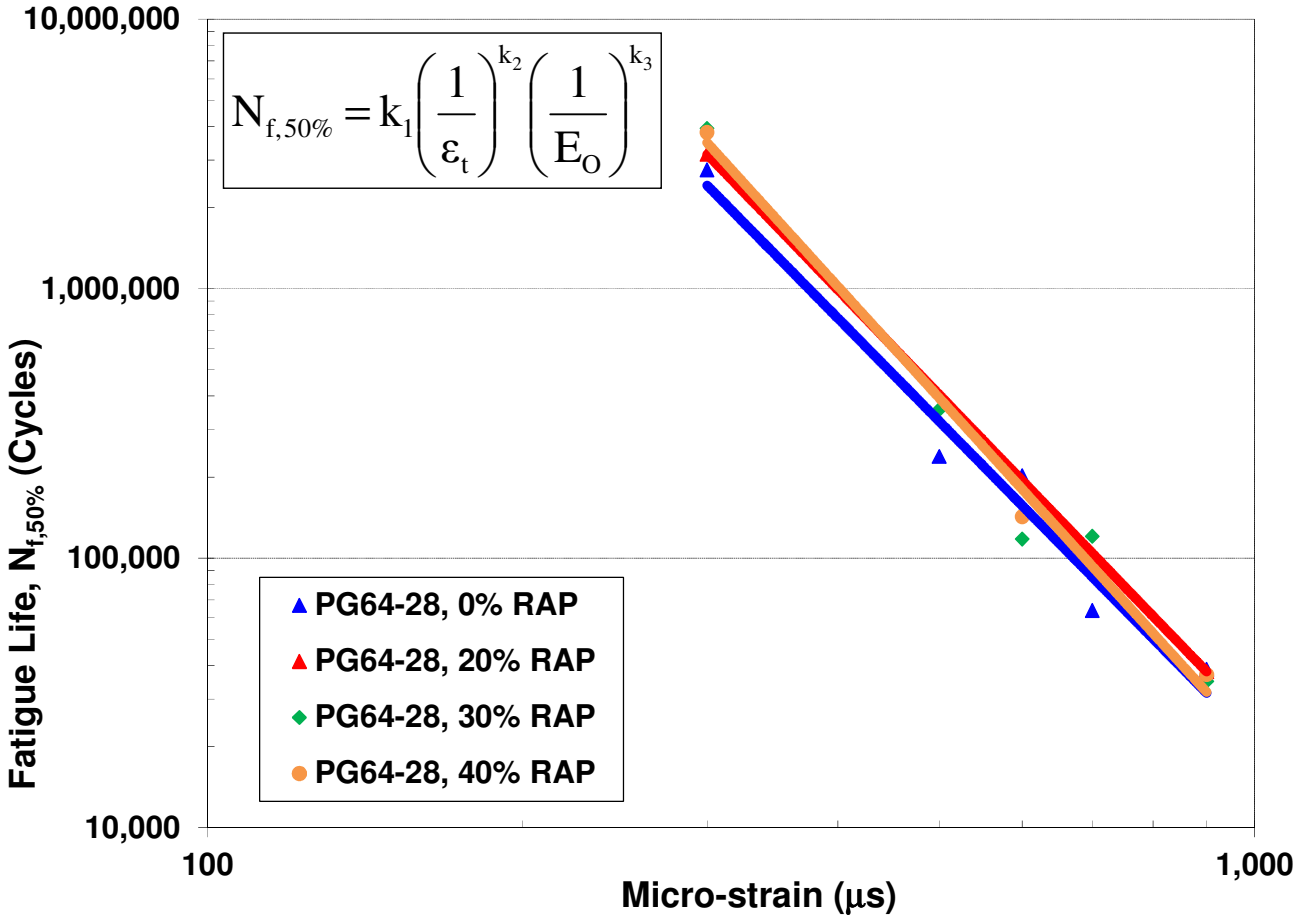
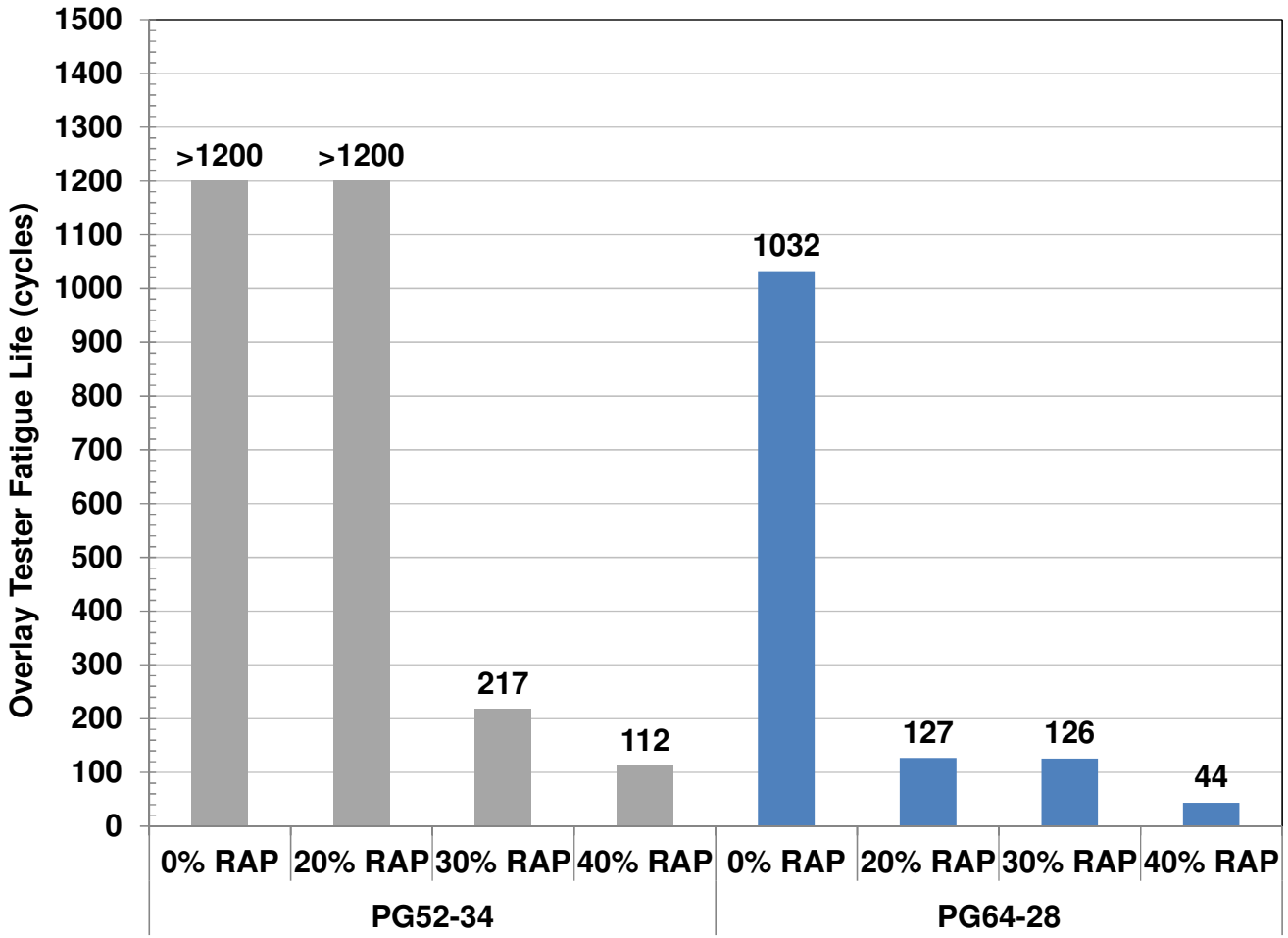
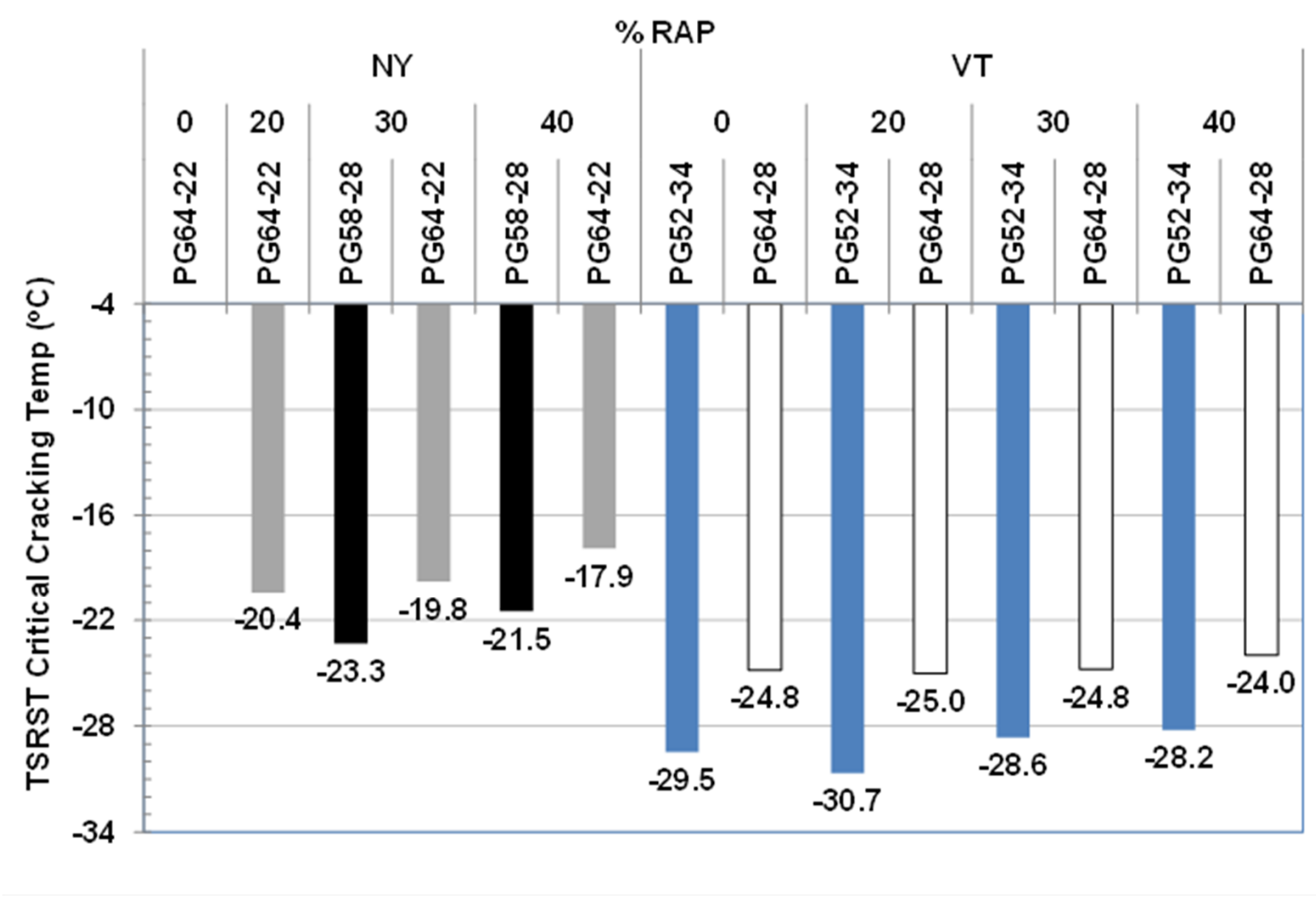


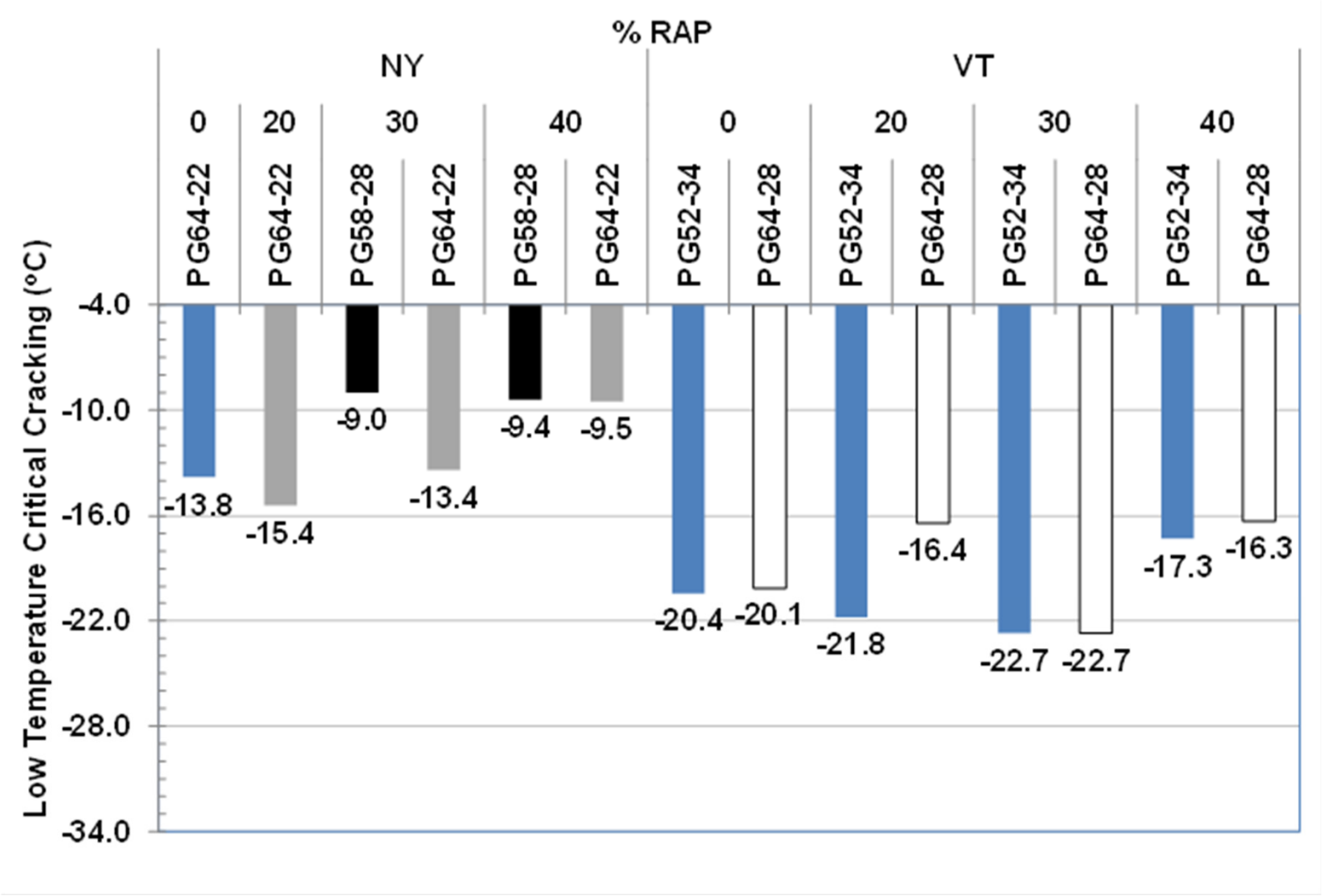
Vermont Mixtures – Overlay Tester



Low Temperature Cracking - TSRST



Low Temperature – IDT TCModel



Soft Binder Grade - Conclusions

- Resulted in slightly better low temperature cracking performance
  - Improvement not the full PG grade as in the drop
  - Less of improvement in critical cracking than TSRST
- Softer binder did not always improve the crack propagation performance in the Overlay Tester
- Softer binder showed mixed results for crack initiation in Flexural Beam Fatigue
- May indicate production and mixture parameters may negate or minimize effectiveness of softer grade

High RAP Content

Strategy #2 – Limiting RAP Binder Contribution

Advantages/Disadvantages

- Advantages
  - Immediately addresses issue of lack of potential blending/non-mobilized RAP binder
  - Increases effective asphalt content of the mix
  - No binder grade change required
- Disadvantages
  - Would require slight adjustment in the mix. Same adjustment to increase VMA
    - Limit natural sand/add more angular sand
    - Reduce dust content
    - Gradation more "gap-graded"

NYSDOT Binder Credit Study

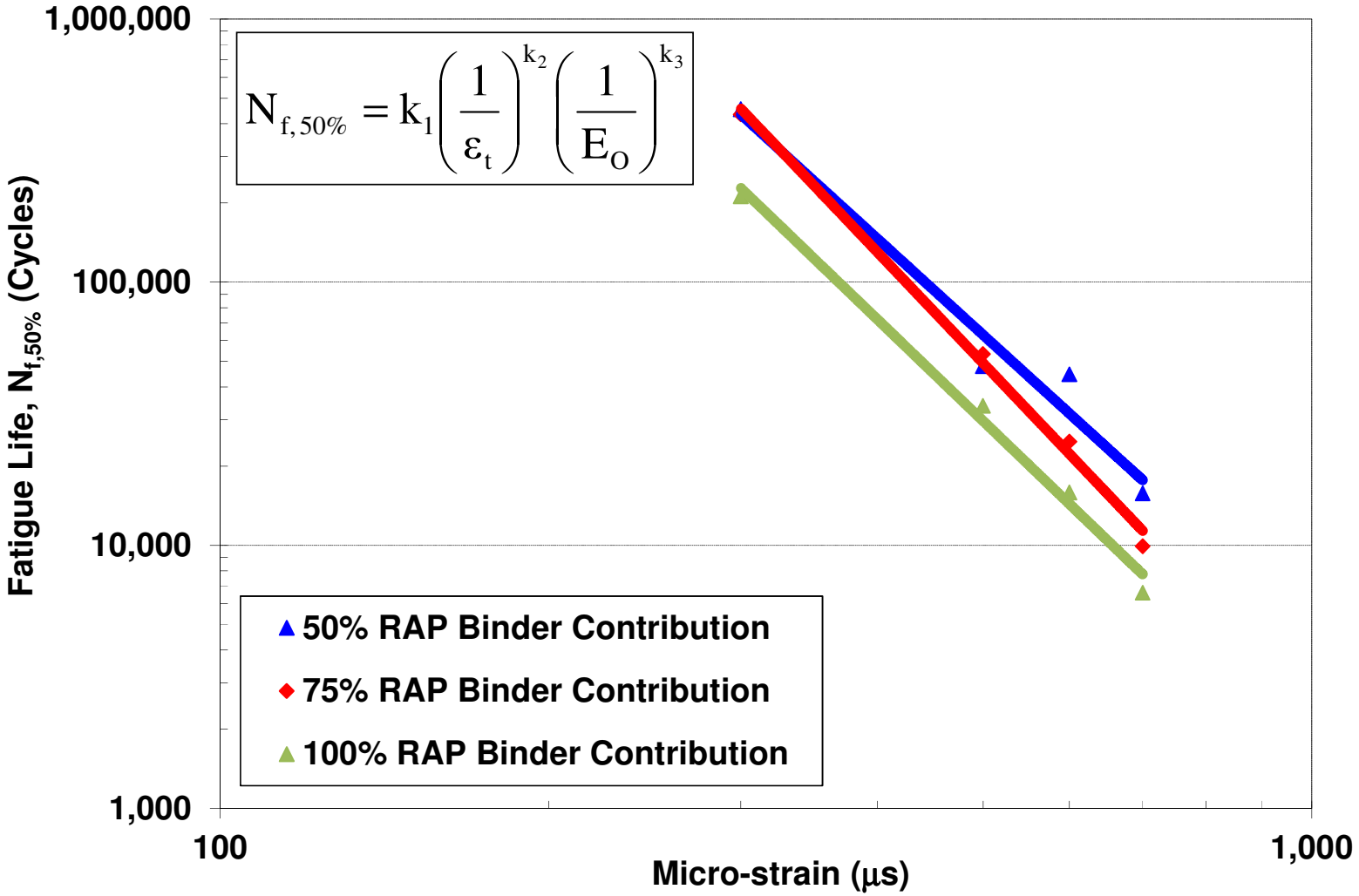
- Looked at changing the allowable asphalt binder credited to the total binder content from RAP
  - Based on the assumption that not all of the RAP binder mobilizes and blends with the virgin binder
- Arbitrarily selected as 100, 75, and 50% of RAP Binder credited to total binder content
  - Asphalt supplier required to modify mixture (gradation) to allow additional virgin binder

NYSDOT Binder Credit Study

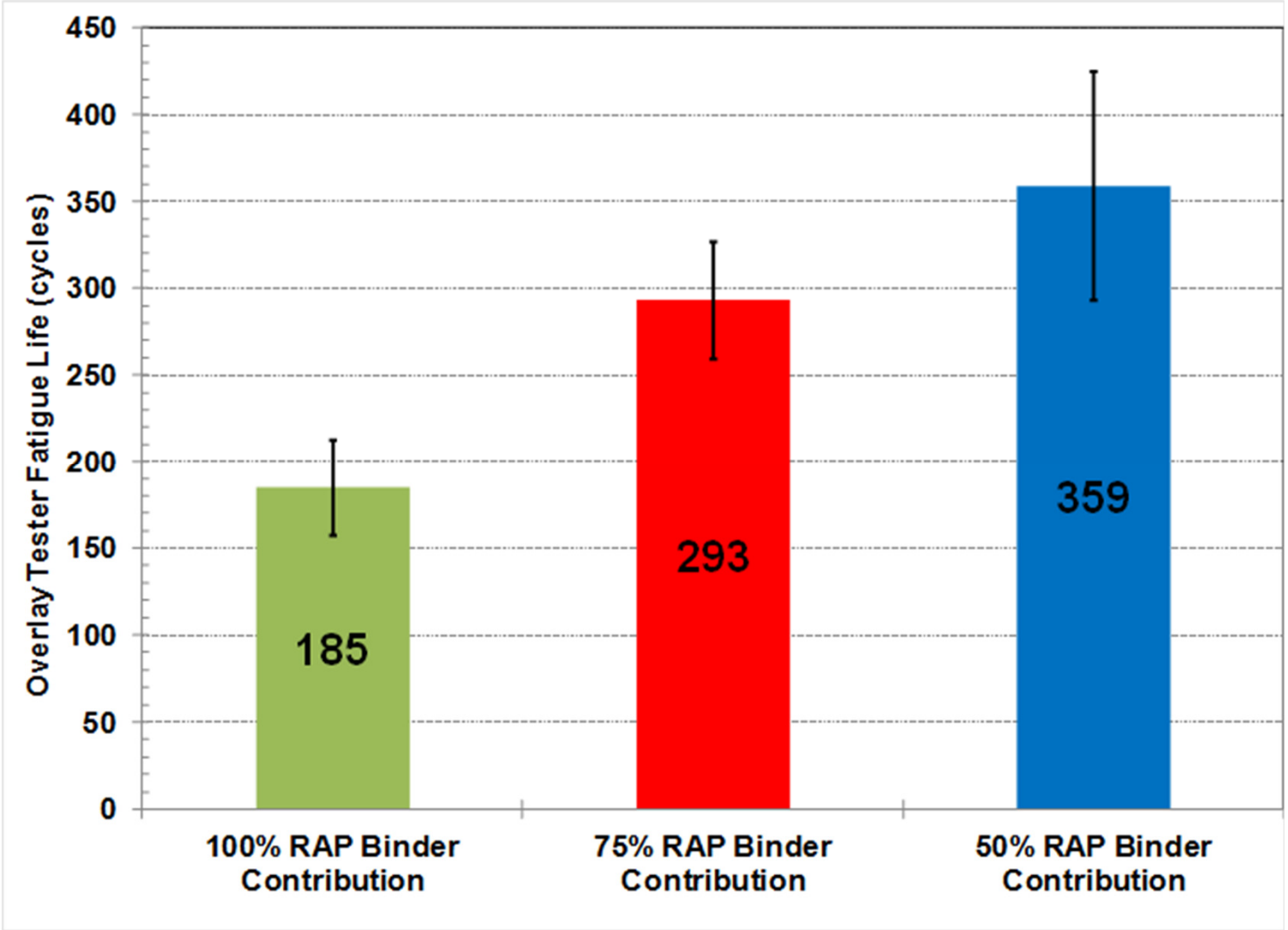
- 100% RAP Contribution: 5.3% AC
- 75% RAP Contribution: 5.6% AC
- 50% RAP Contribution: 5.8% AC

Property	RAP Binder Contribution		
	100%	75%	50%
High Temp Grade (^{o}C)	80.1	76.6	78.6
Low Temp Grade (^{o}C)	-23.6	-24.3	-23.6
Intemediate Temp Grade (^{o}C)	25.3	24.0	25.7
Resultant PG Grade	PG76-22	PG76-22	PG76-22
J_{nr} @ 64^{o}C (1/kPa)	0.471	0.698	0.504
% Recovery @ 64^{o}C (%)	15.8	11.3	15.3
Recovered Asphalt Content (%)	5.29	5.59	5.73

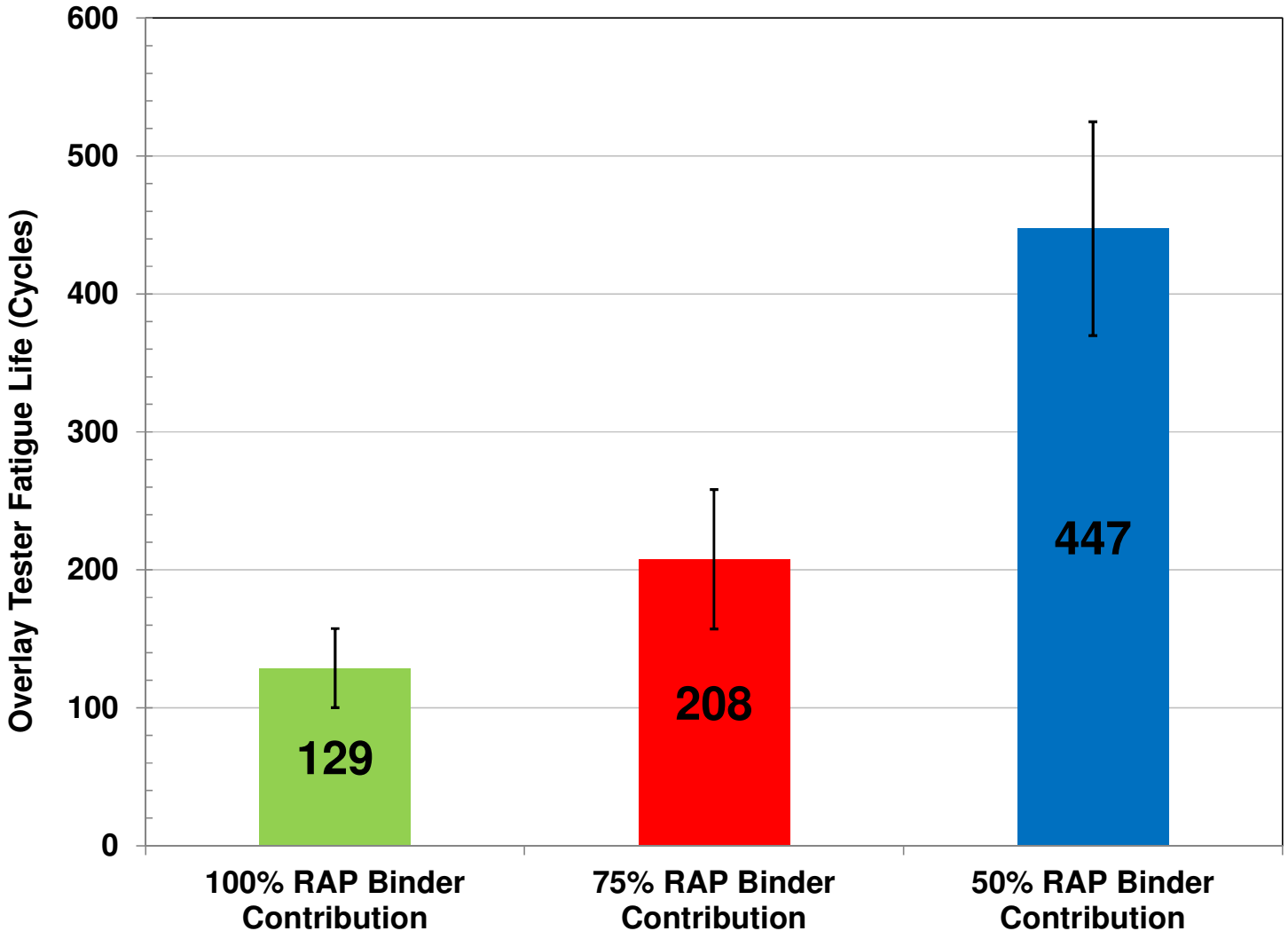
NYSDOT Binder Credit – Beam Fatigue



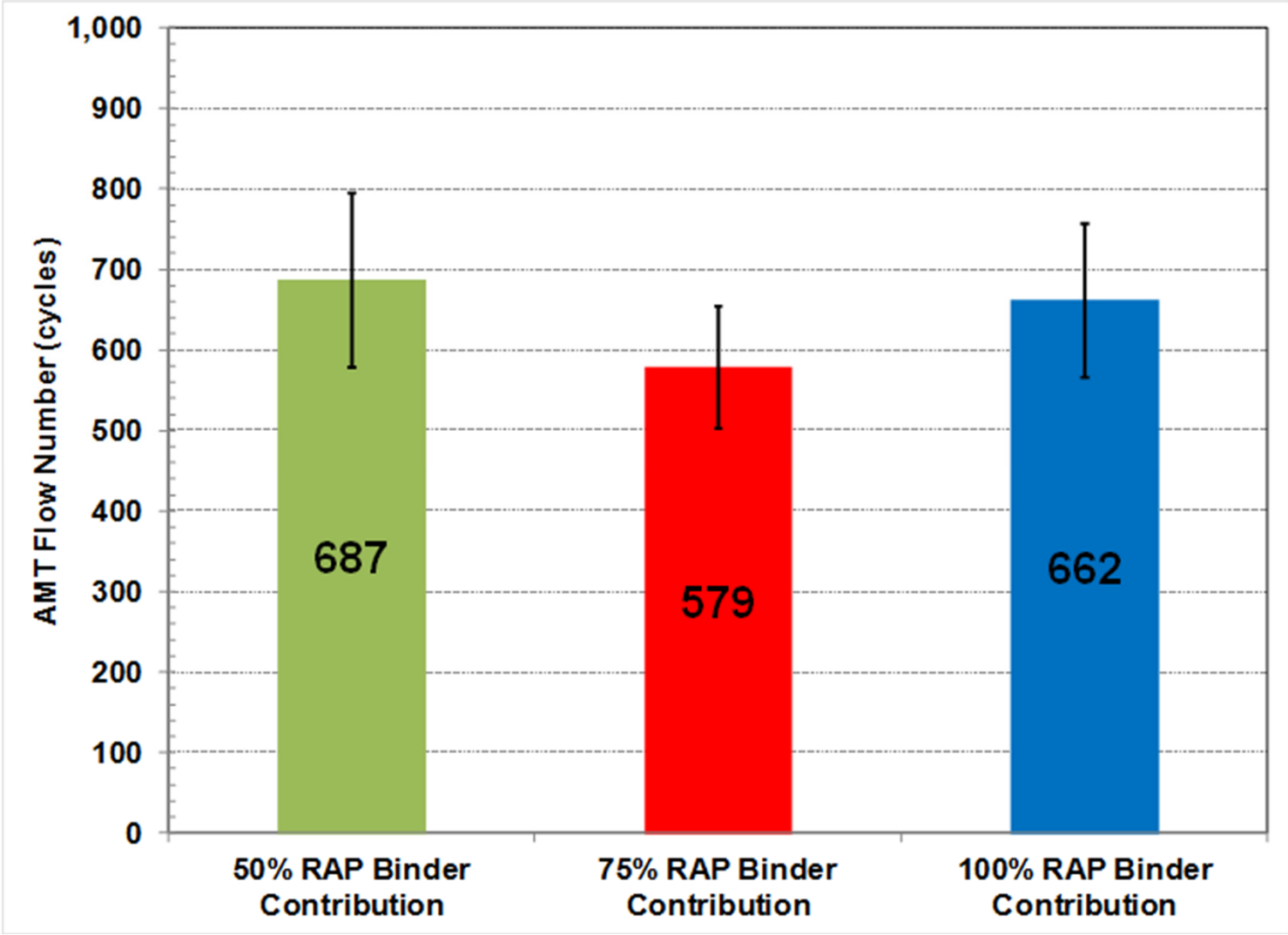
NYSDOT Binder Credit – Overlay Tester



NYSDOT Binder Credit – Overlay Tester on 1 Year Old Cores



NYSDOT Binder Credit – Rutting Check



NYSDOT Binder Contribution – Field Survey

- Immediately after placement and in the first year, field engineers commented "100% Contribution section not a dark as other sections."
  - 2 Years later, 100% and 75% look similar
- No cracking or rutting to date in any of the sections

RAP Binder Credit - Conclusions

- As RAP Binder Credit decreased, fatigue resistance increased
  - Occurred in both modes (crack initiation and crack propagation)
  - Not enough material to conduct low temperature testing
- Rutting was not issue based on AMPT Flow Number
- NYSDOT continuing to evaluate field performance
- Question is: what is the appropriate % RAP Credit?

High RAP Content

Strategy #3 – Performance Based Specification for Final Mixture

Advantages/Disadvantages

- Disadvantages
  - Most complex of 3 presented
  - Most likely requires mix redesign and possibly asphalt binder not common to region
  - Laboratory equipment for performance testing
  - Establishment of criteria
- Advantages
  - Provides state agency high level of assurance the mixture should perform to level of expectations

NJDOT High RAP (HRAP) Specification

- In winter 2012, Rutgers and NJDOT worked to develop a Performance-Based High RAP (HRAP) specification
  - Utilized database of performance testing results to establish performance requirements for both rutting (Asphalt Pavement Analyzer) and cracking (Overlay Tester)

NJDOT HRAP – Basic Principle

- The supplier is not held to PG grade, max. RAP content, etc.
  - Have to meet basic Superpave requirements
  - NJDOT increased VMA 1% over current specs
  - Could use softer binder, rejuvenators, WMA, etc.
- However, acceptance based on final mixture performance, based on database of typical "virgin" HMA

NJDOT HRAP

- Minimum of 20% RAP in Surface Course
- Minimum of 30% RAP in Intermediate/Base
- Lab design and plant produced material must meet rutting (APA) and cracking (Overlay Tester) requirements

Table 902.11.03-2 Performance Testing Requirements for HMA HIGH RAP Design				
Test	Requirement			
	Surface Course		Intermediate Course	
	PG 64-22	PG 76-22	PG 64-22	PG 76-22
APA @ 8,000 loading cycles (AASHTO T 340)	< 7 mm	< 4 mm	< 7 mm	< 4 mm
Overlay Tester (NJDOT B-10)	> 150 cycles	> 175 cycles	> 100 cycles	> 125 cycles

NJDOT HRAP – I295

- I295 SB – Milepost 11.26 to 14.48
- Contractor
  - Arawak Paving
- Supplier
  - R.E. Pierson
- Asphalt liquid
  - NuStar Refining

Final HRAP Mix Designs

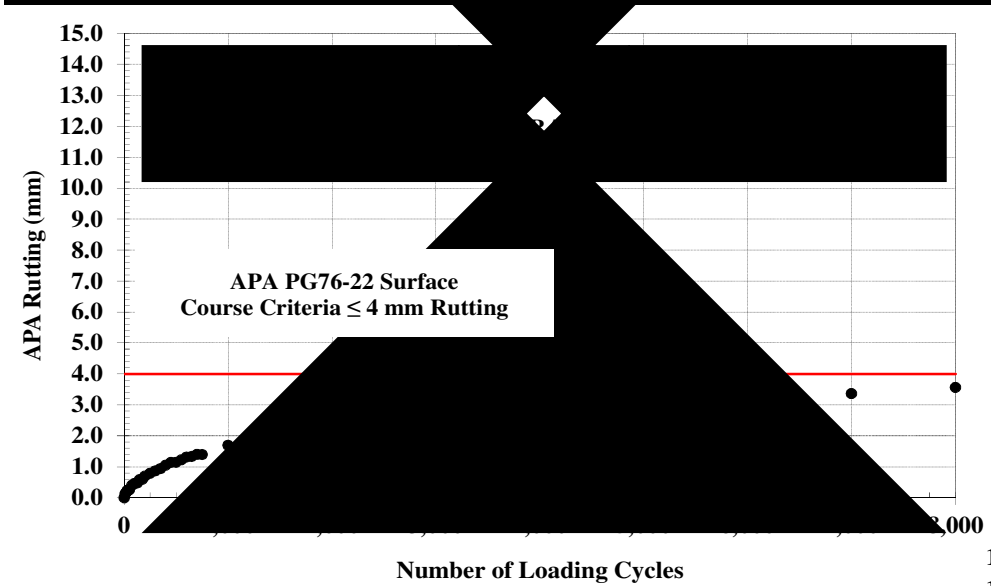
9.5M76 (SURFACE COURSE)

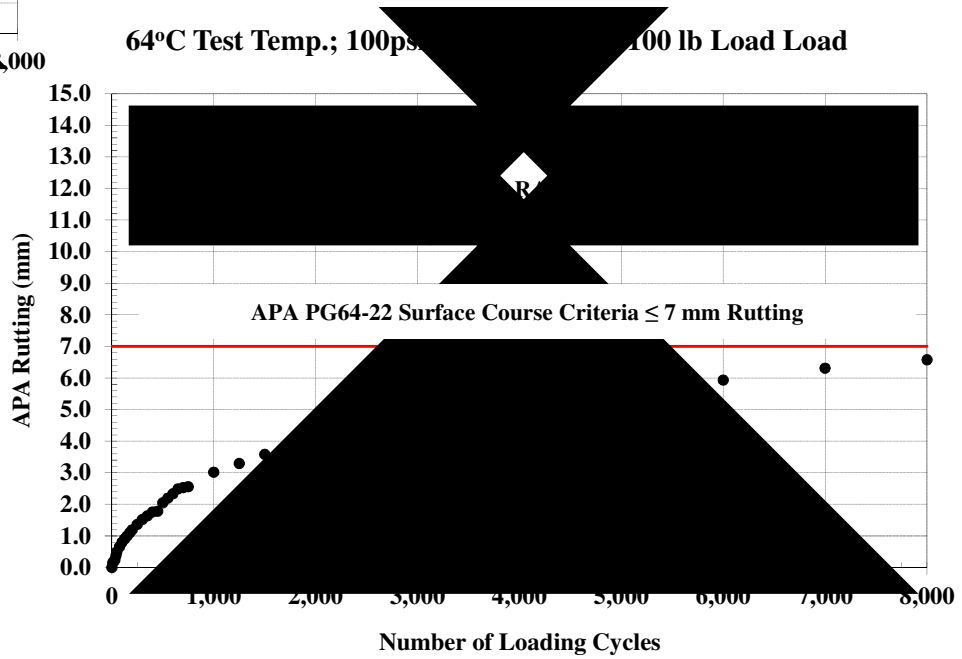
- 25% RAP
- 6.0% Total AC
  - 27.4% Binder Replacement
- PG70-22 (74.6-26.99)
- 25% Fine RAP Fraction Only

12.5M64 (INTERMED. COURSE)

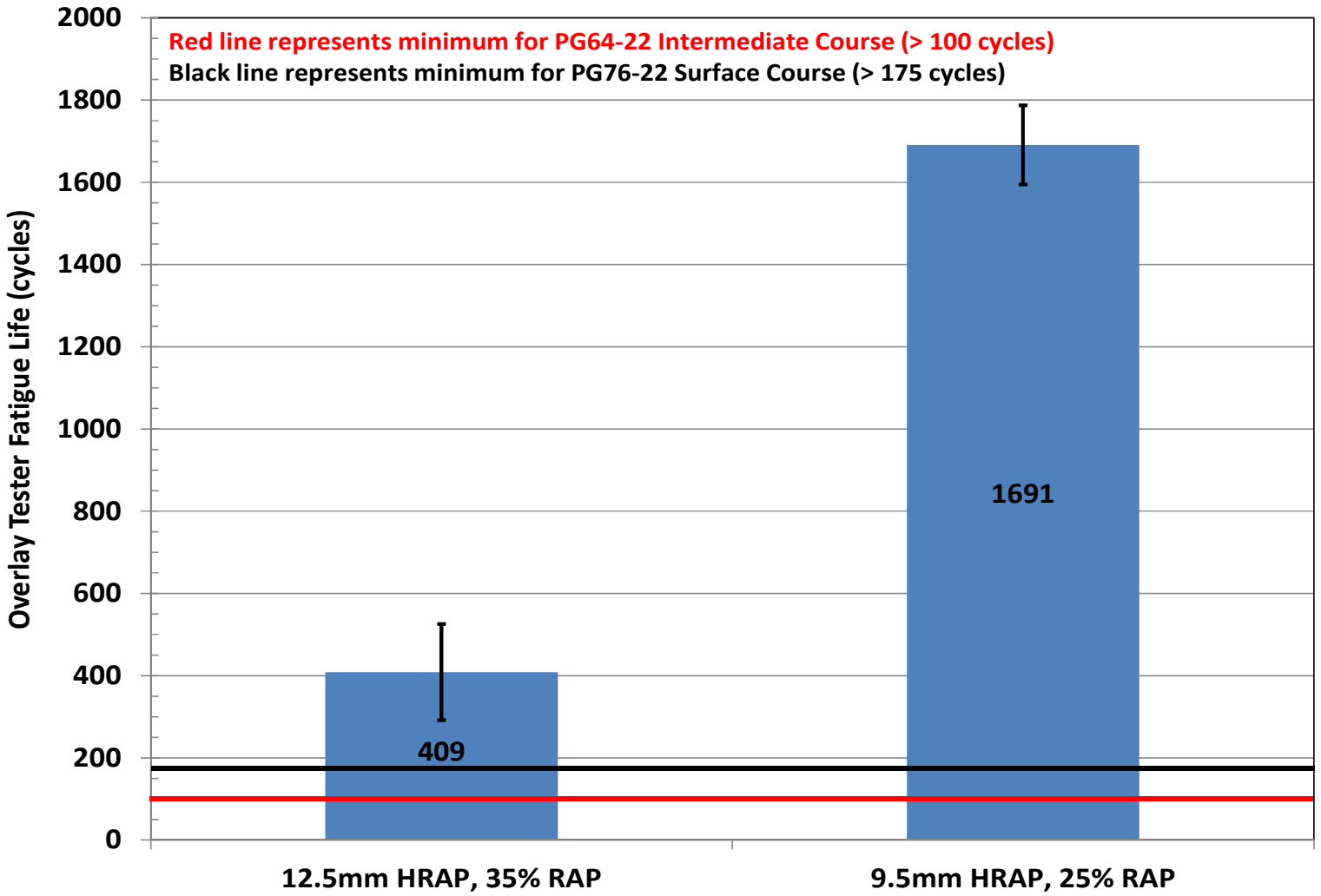
- 35% RAP
- 5.8% Total AC
  - 29.7% Binder Replacement
- PG64-28 (64.8-28.29)
- 17.5% Fine RAP/ 17.5% Coarse RAP

APA Rutting Performance





Overlay Tester



Final Product

Performance-Based Spec Conclusions

- A learning curve for supplier (binder and mixture)
  - Collaboration between academia, agency and industry helped make successful
- Mix supplier felt better control fractionating RAP. Believe could have increased RAP % if had more time to experiment in lab
- NJDOT looking for additional projects and will continue evaluating field performance.

Final Comments

- There are Strategies out there to help utilize more RAP
  - From easy to complex
- Not all will provide same degree of assurance
- Supplier needs to know there materials (RAP) and which Strategy makes the most sense
  - What the agency is looking for
  - What is cost effective for the Contractor


Thank you for your time!
Questions?
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