



RAP Update

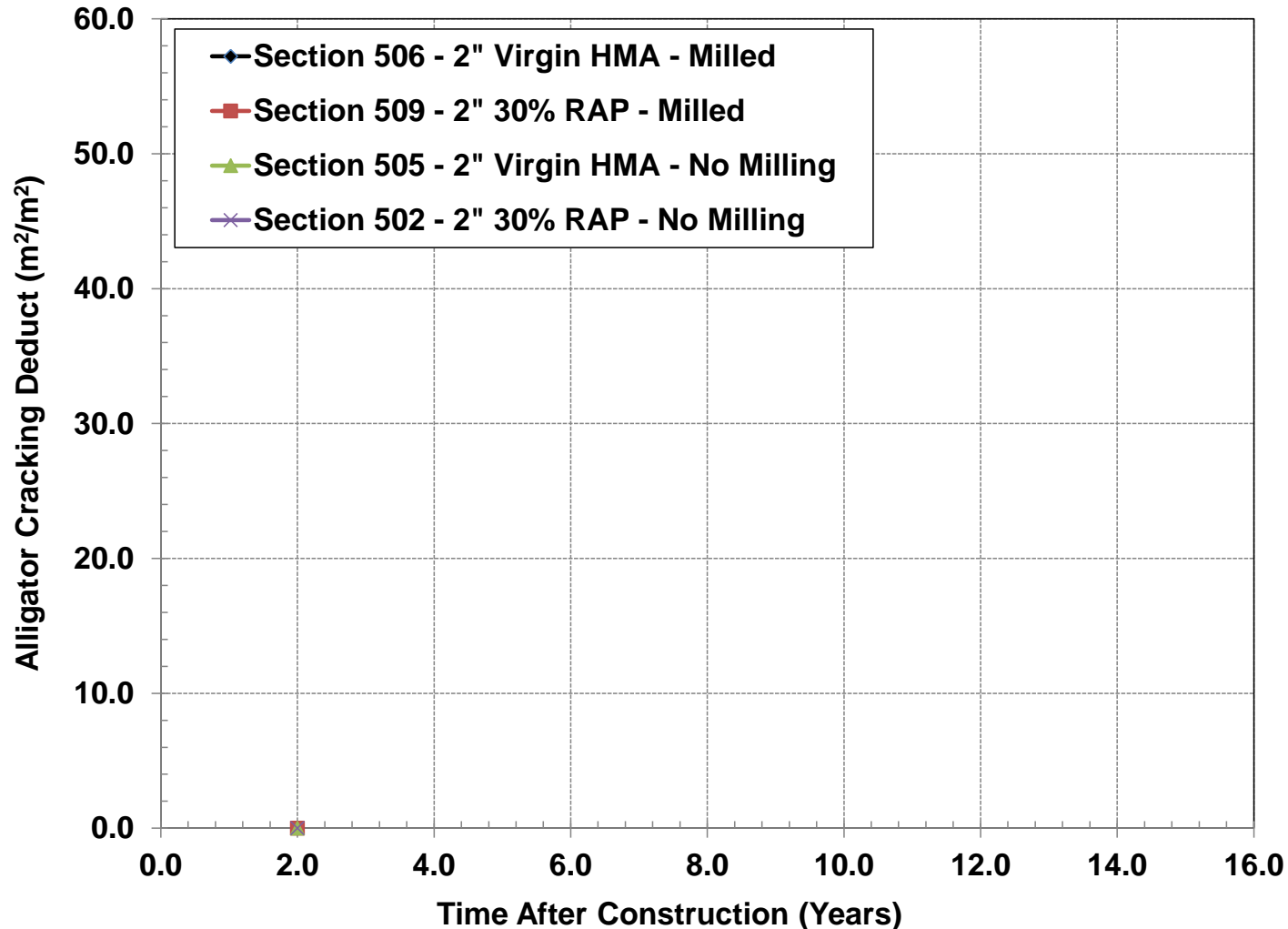
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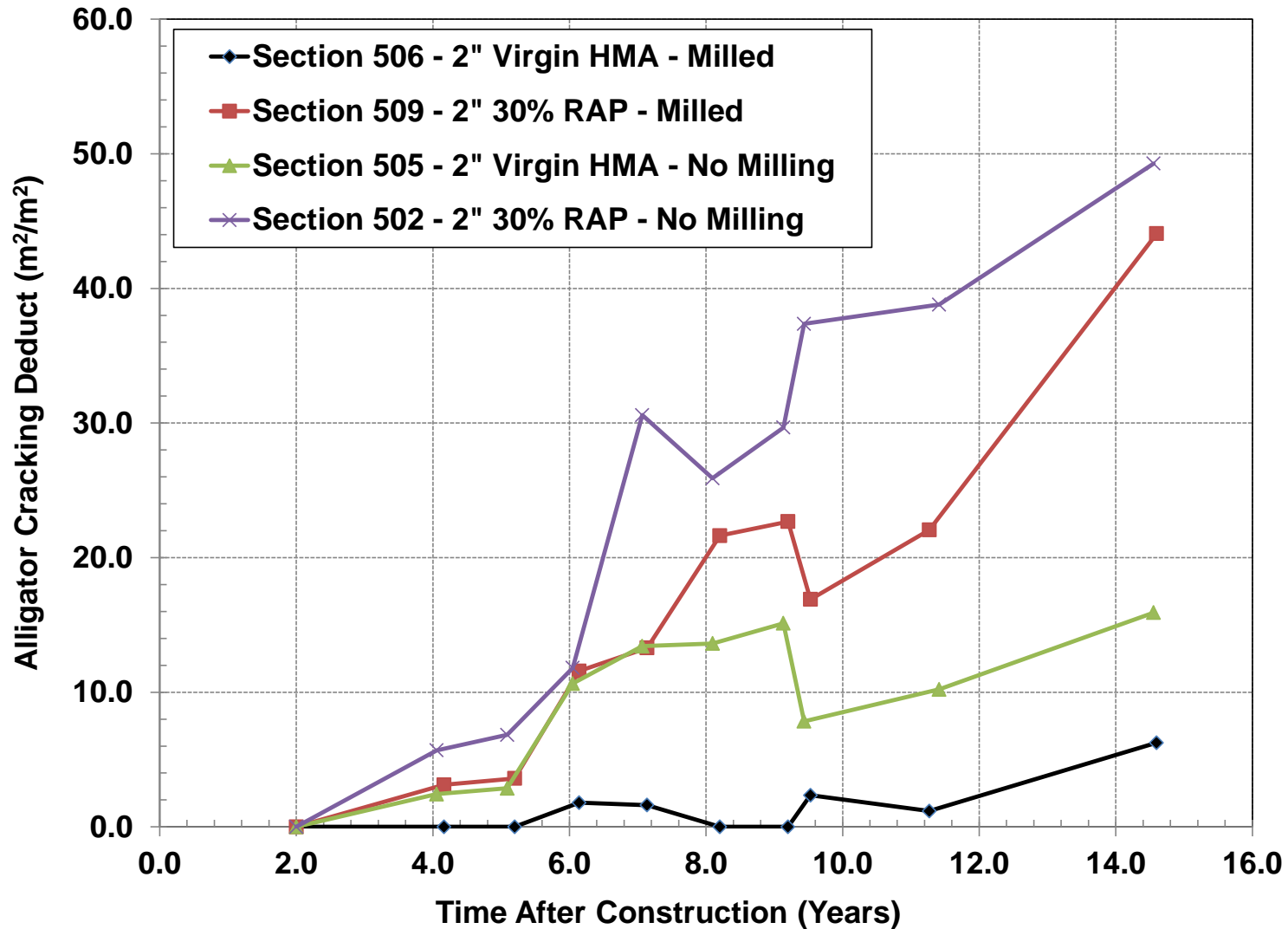
General Concerns with RAP Usage

- Higher binder stiffness
- Does blending between virgin and RAP binders occur?
- Incorrect asphalt content determination
- Primary concern by state agencies
 - Cracking
 - But what is the definition of “cracking” – two modes
 - Crack initiation – when a crack starts
 - More structurally dependent
 - Crack propagation – how a crack grows once it starts
 - More material dependent

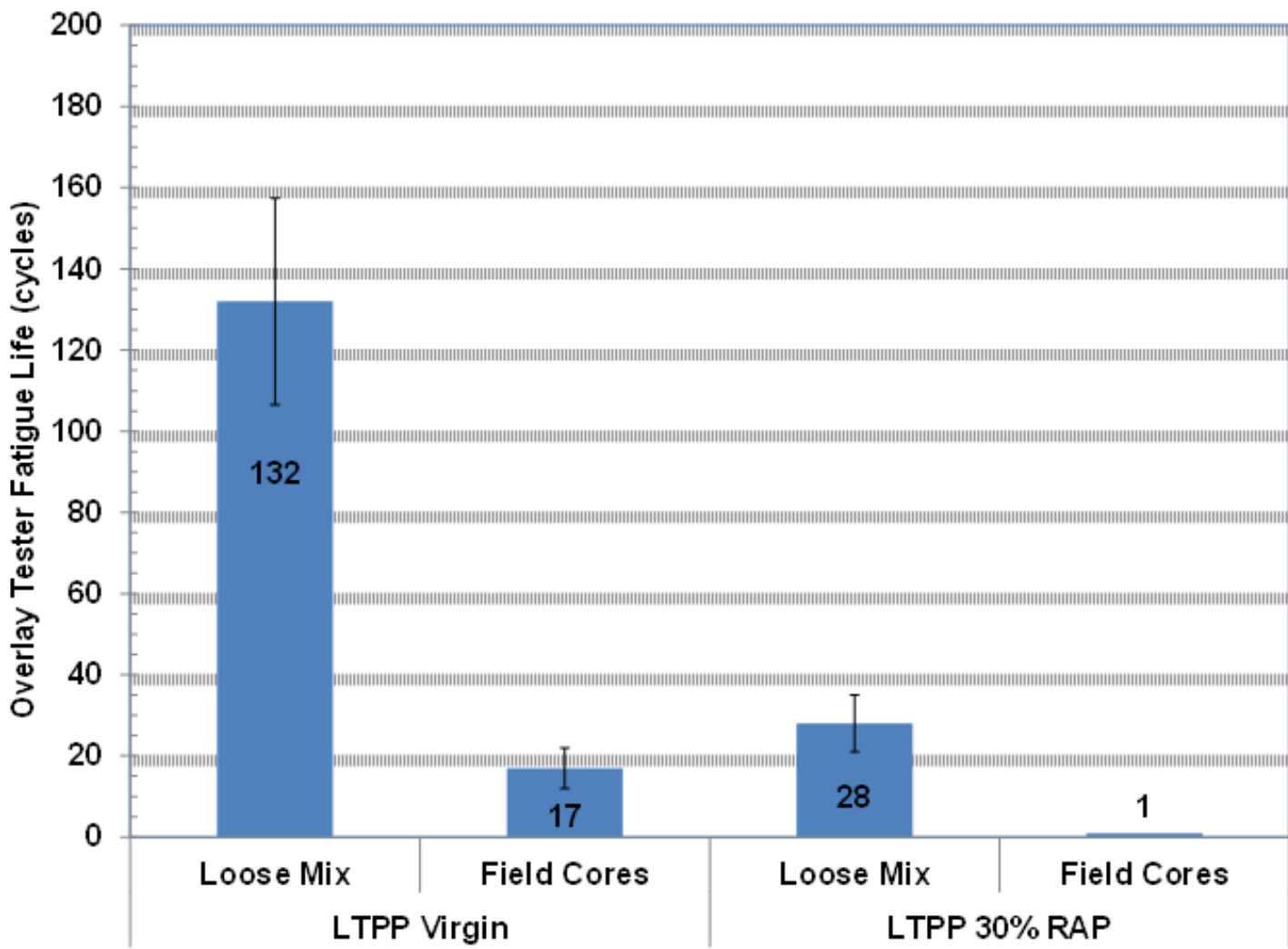
Example: NJ SPS-5 Alligator Cracking - Initiation



Example: NJ SPS-5 Alligator Cracking – Final (Propagation)



Example: NJ SPS-5 Alligator Cracking – Overlay Tester Results



HIGHER BINDER STIFFNESS

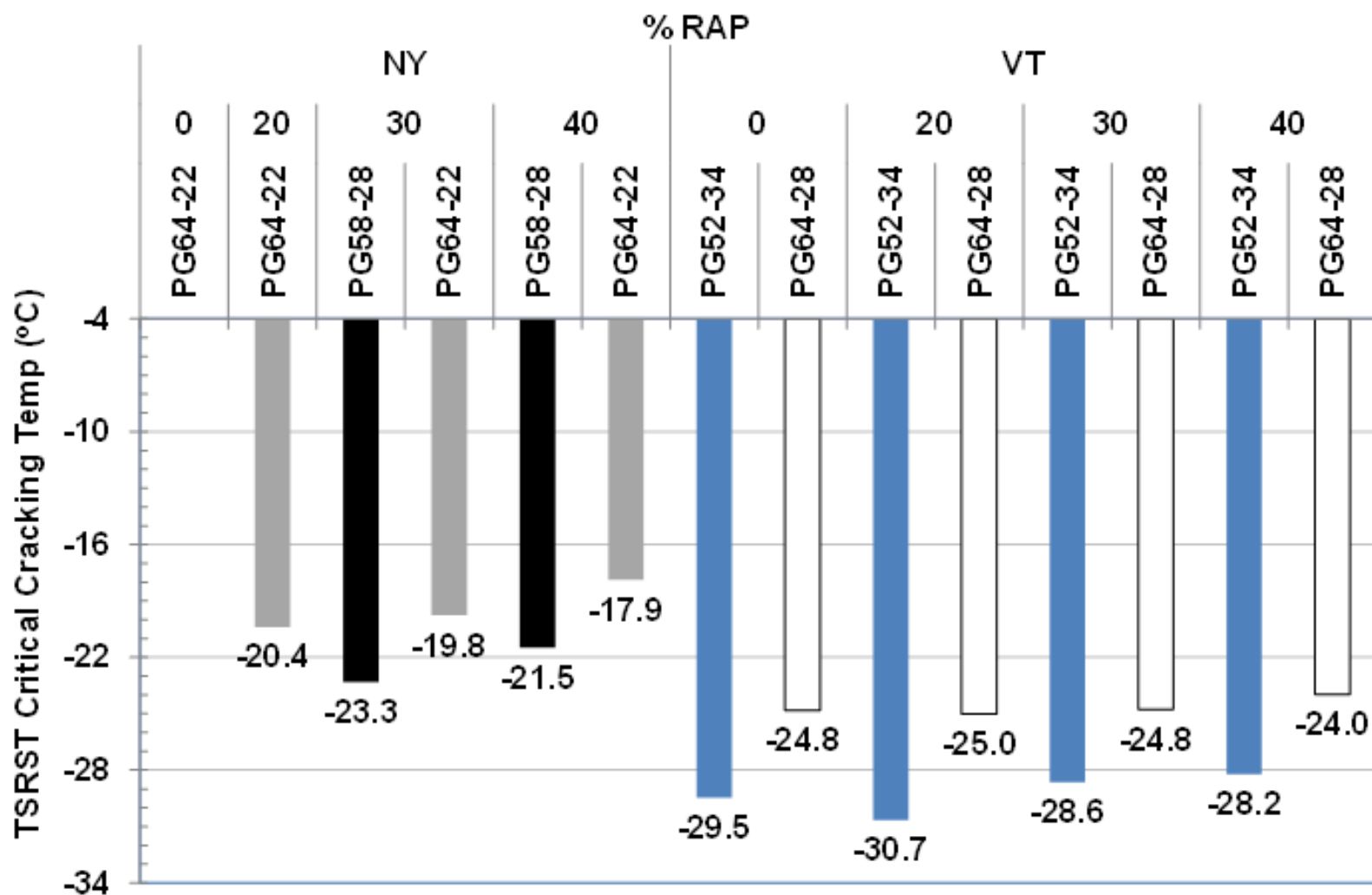
Higher Binder Stiffness (Warmer PG Grades)

- On average – for every 10% RAP added:
 - High temperature PG grade increases 2°C
 - Low temperature PG grade increases 1.5°C
- Use of softer grade generally used to offset
- Can the use of rejuvenators help?

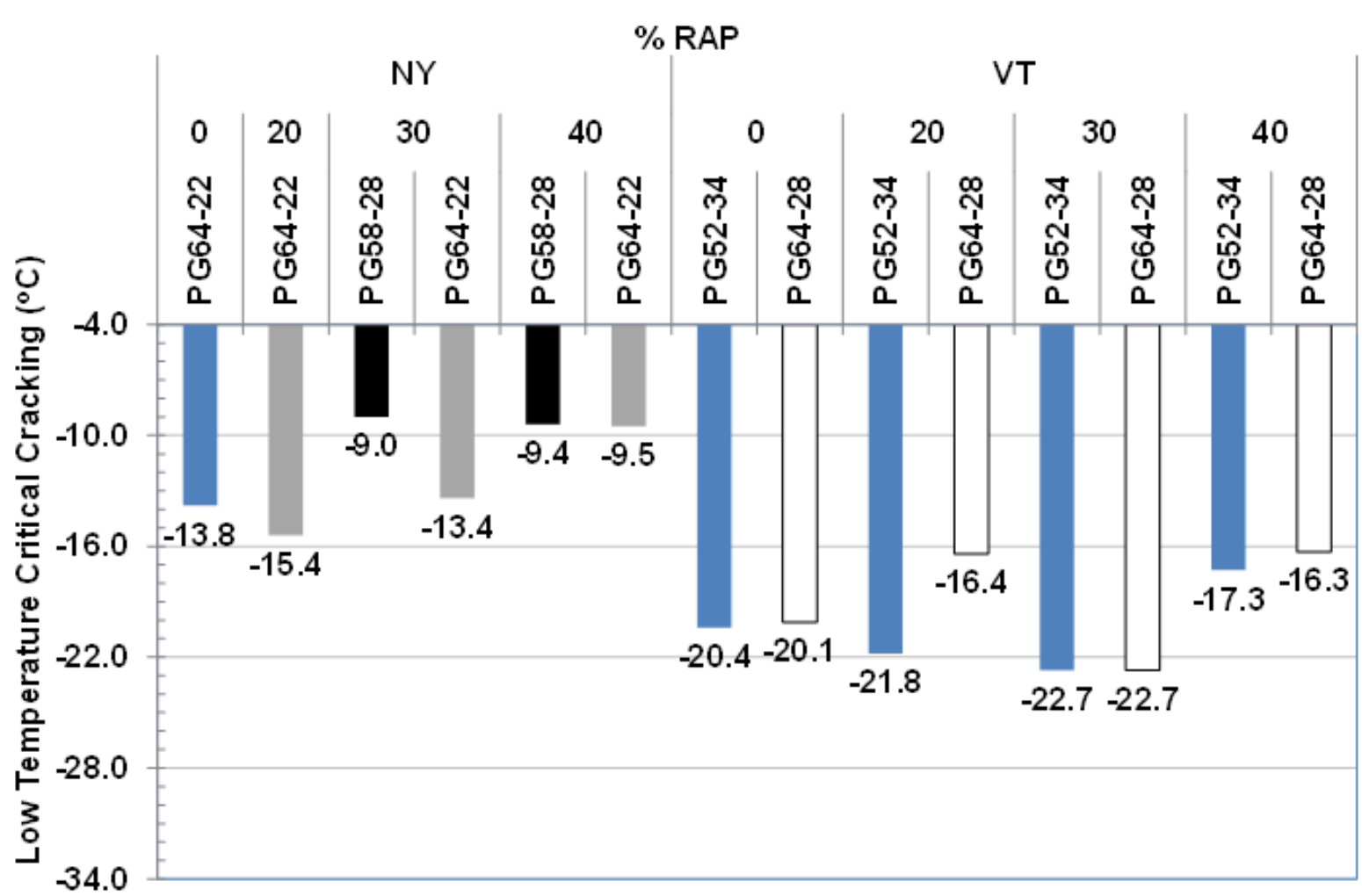
Soft Binder Grade – Conclusions for Northeast High RAP Pooled Fund Study

- 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
 - Especially at RAP contents greater than 20%
- 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

Low Temperature Cracking - TSRST



Low Temperature – IDT TCMModel

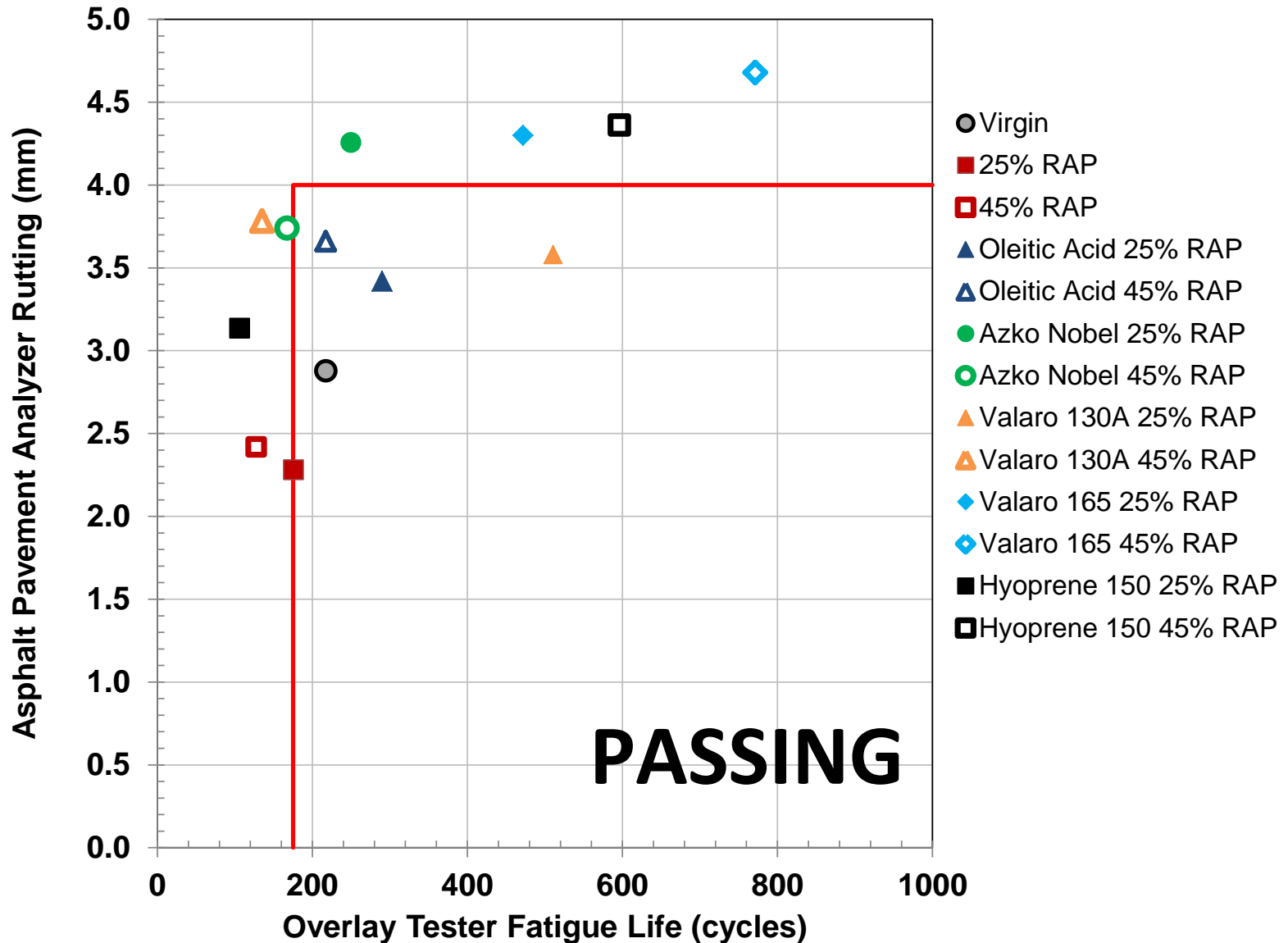


NJDOT Rejuvenator Study - Conclusions

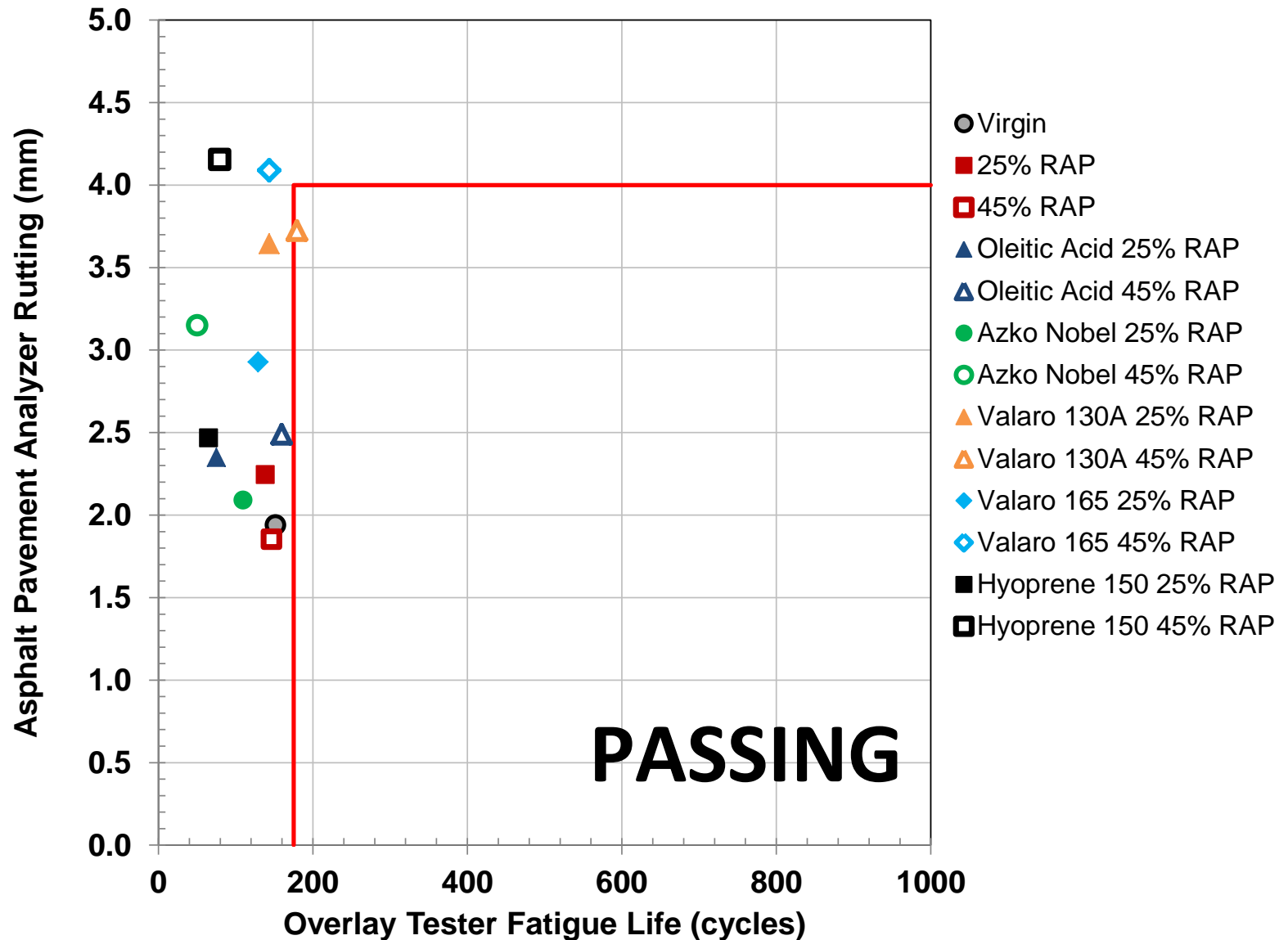
- Rheological verification of rejuvenating (binder only) but mixtures showed mixed results
- There appears some rejuvenators help in improving performance
 - Dosage rate should be a function of total binder contribution and RAP binder properties specific to the project/plant
- Conditioning time did not improve fatigue performance
 - Some rejuvenators maybe volatilizing during this period
- Improved results may be attainable by improving point of entry to allow more time for rejuvenator to co-mingle with recycled binder

Rejuvenator/Binder Type	RAP Content (%)	Aging Condition	Continuous PG Grade Results		
			High Temp (°C)	Low Temp (°C)	Final PG Grade
PG76-22 (No Rejuvenator)	0%	2 Hr	88.2	-21.8	88-16
	25%	2 Hr	89.0	-24.0	88-22
	45%	2 Hr	92.7	-22.3	88-22
	0%	6 Hr	101.0	-18.6	100-16
	25%	6 Hr	91.5	-22.0	88-22
	45%	6 Hr	89.1	-22.4	88-22
Valaro 130	25%	2 Hr	82.8	-25.7	82-22
	45%	2 Hr	78.4	-29.6	76-28
	25%	6 Hr	81.8	-26.5	76-22
	45%	6 Hr	83.0	-26.2	82-22
Valaro 165	25%	2 Hr	79.4	-28.9	76-28
	45%	2 Hr	80.1	-30.3	76-28
	25%	6 Hr	81.5	-27.5	76-22
	45%	6 Hr	77.3	-30.2	76-28
Hyprene	25%	2 Hr	83.4	-26.3	82-22
	45%	2 Hr	81.1	-27.0	76-22
	25%	6 Hr	88.6	-24.5	88-22
	45%	6 Hr	82.7	-25.8	82-22
Oleitic Acid	25%	2 Hr	85.2	-27.2	82-22
	45%	2 Hr	82.7	-27.5	82-22
	25%	6 Hr	84.7	-24.8	82-22
	45%	6 Hr	87.1	-26.8	82-22
Akzo Nobel	25%	2 Hr	82.9	-26.6	82-22
	45%	2 Hr	79.7	-25.9	76-22
	25%	6 Hr	82.1	-26.2	82-22
	45%	6 Hr	84.4	-24.5	82-22

“Balancing Performance” – 2 Hr Aging



“Balancing Performance” – 6 Hr Aging

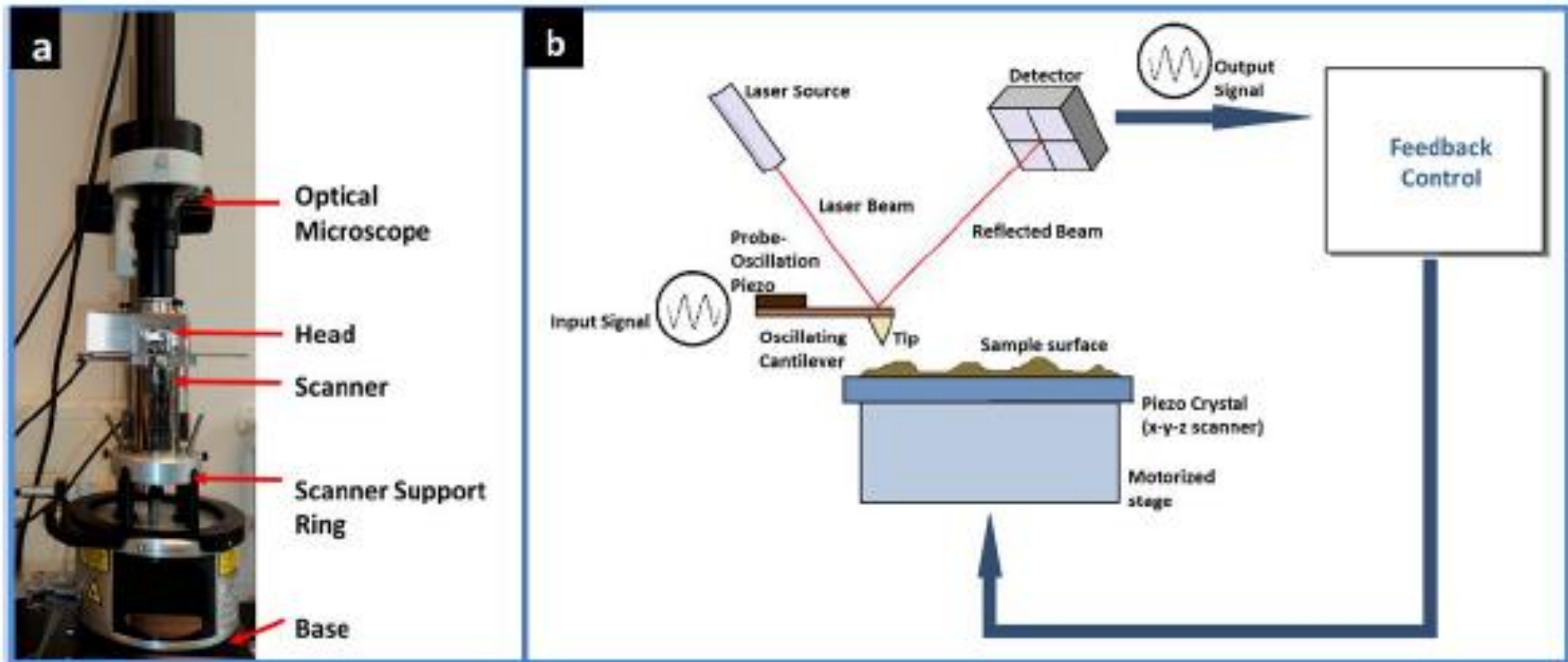


BLENDING OF RAP AND VIRGIN BINDERS

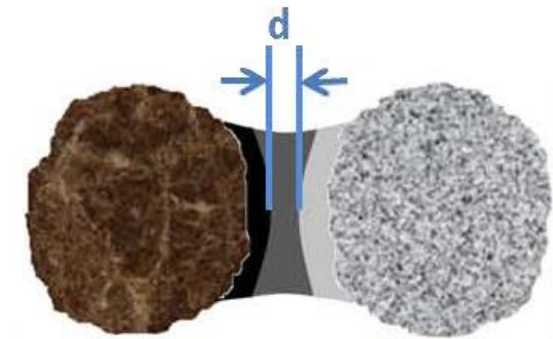
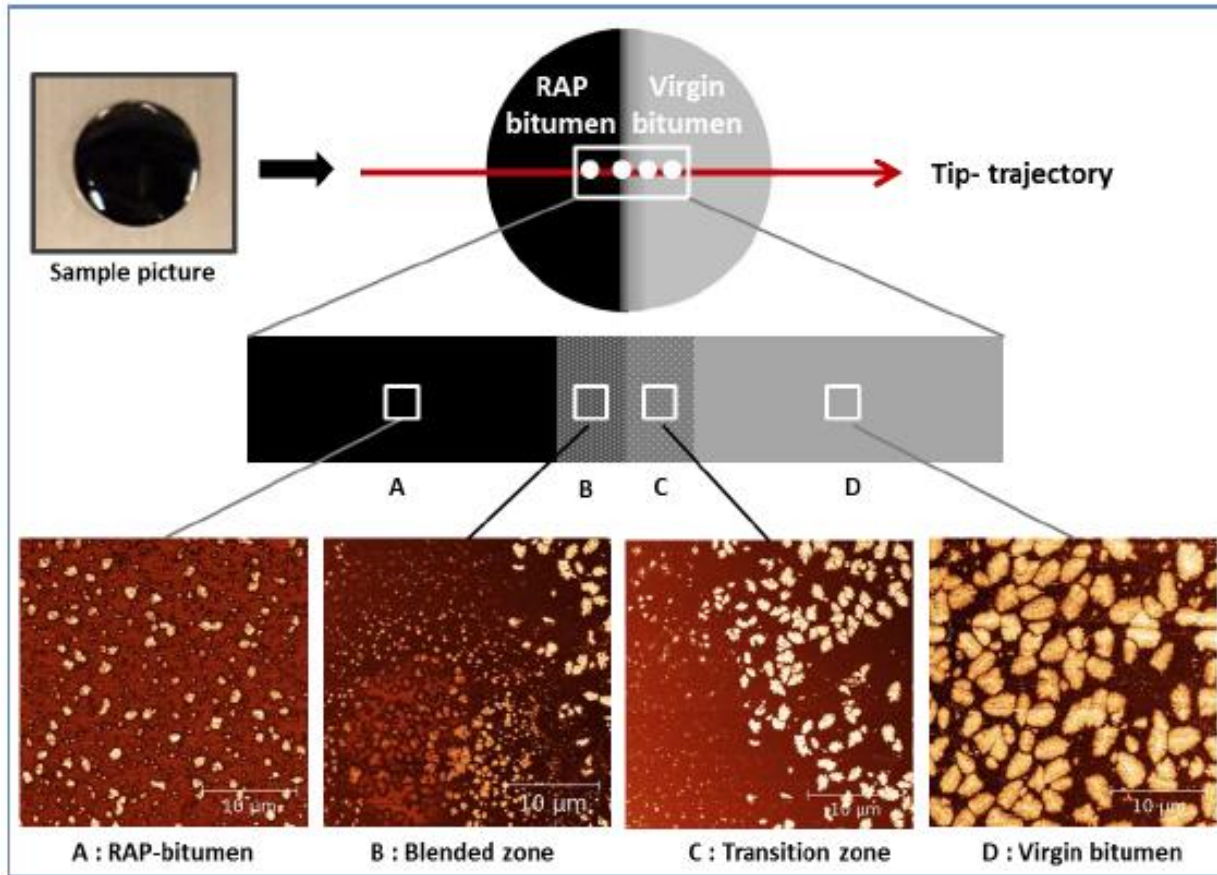
Blending?

- Does blending occur between RAP and virgin binder? If so, how much?
- Too much influences degree of blending
 - Production and materials
- Scientific proof of blending?

Atomic Force Microscopy (AFM) – used to probe the change in microstructural properties



Blending occurring in small zone (after 24 hrs)



Is the RAP binder mobilized during mixing?



HMA MIX PARAMETERS

1. 12.5 mm Superpave™ mix with Florida Limestone
2. Mix: 75% virgin aggregate + 25% RAP.
 - RAP treated as a graded stockpile
3. Three RAP Types:
 - RAP 1: Absolute Viscosity $\approx 1.25 \times 10^6$ Poise, % Binder = 4.6%
 - Commercial 50K+ tons
 - RAP 2: Absolute Viscosity < 60,000 Poise, % Binder = 4.1%
 - 'Fresh' Pavement Millings
 - RAP 3: Lab Prepared: 95% JMF virgin aggregate blend + 5% PG 64-22 binder.



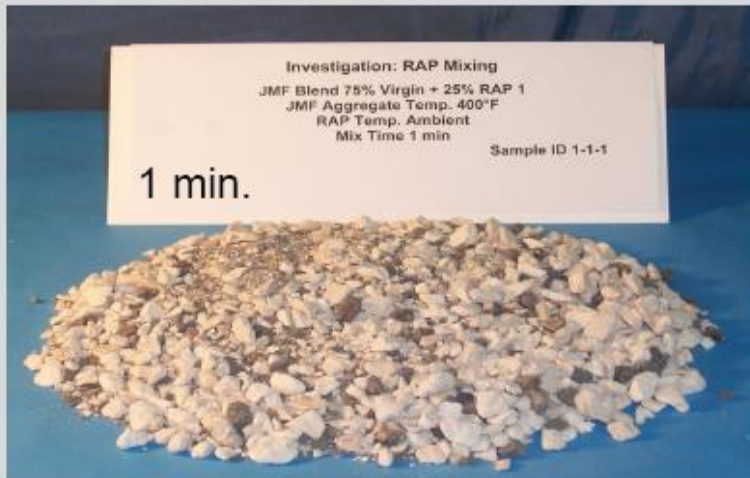
Virgin JMF Aggregate & Three RAPs





Effect of Mixing Time on the Mix

(400°F Virgin + RAP-1 @ ambient)





Effect of Mixing Time on the Mix

(800°F Virgin + RAP-1 @ ambient)



RAP #1, Preheated to 375F, Mixed for 10 minutes





Effect of Mixing Time on the Mix

(400°F Virgin + RAP-2 @ ambient)





Effect of Mixing Time on the Mix

(800°F Virgin + RAP-2 @ ambient)





Effect of Mixing Time on the Mix

(400°F Virgin + **RAP-3 @ ambient**)





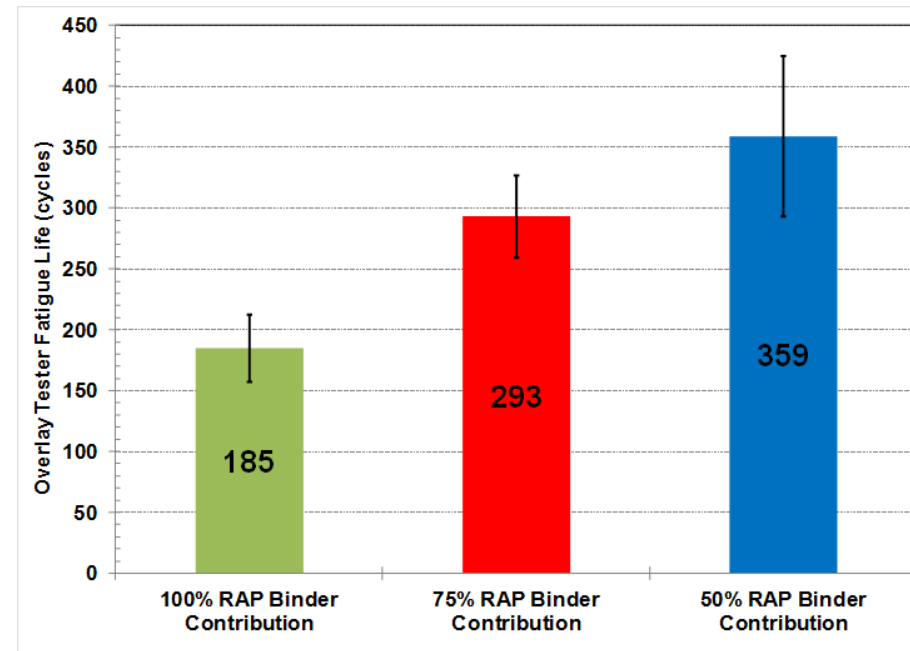
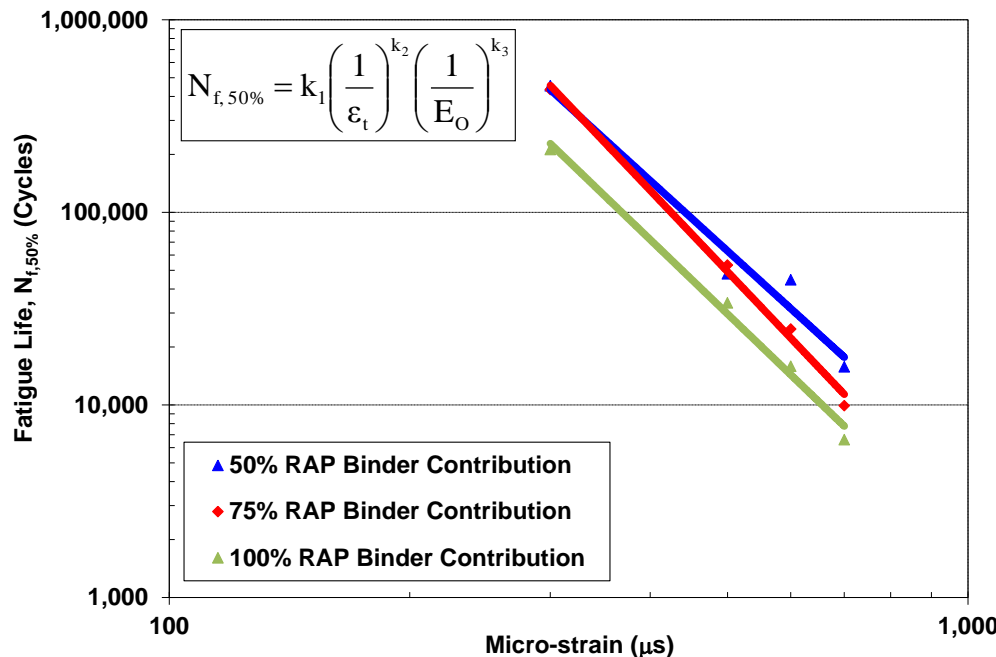
Effect of Mixing Time on the Mix

(800°F Virgin + RAP-3 @ ambient)



Degree of Blending

- New York State looking at the influence of different degrees of blending by limiting the amount of RAP binder credited to total asphalt content
 - Reducing % contribution requires additional virgin AC, which increases effective asphalt content



INCORRECT ASPHALT CONTENT DETERMINATIONS

What is my RAP binder content?

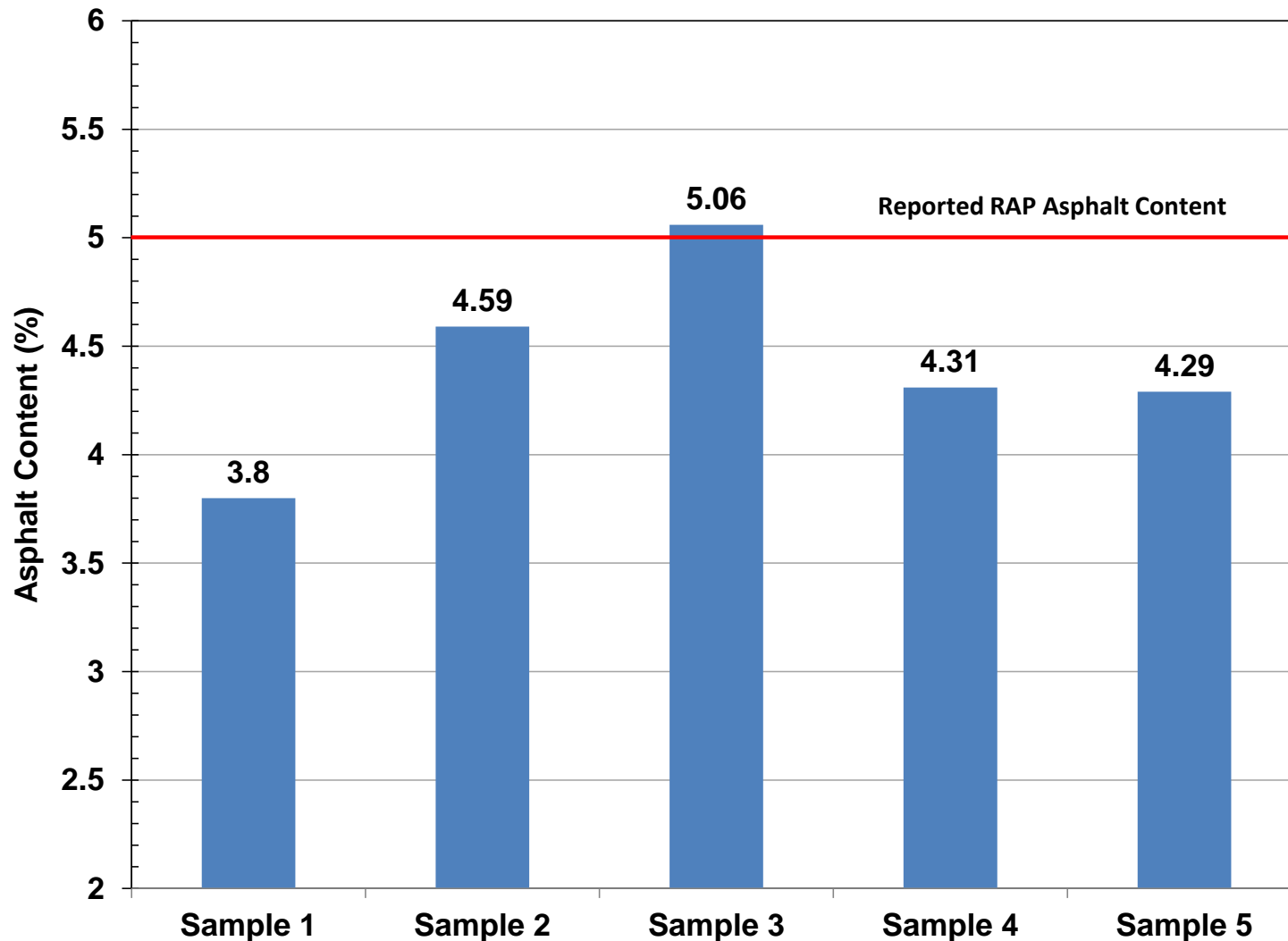
- Industry's current practice is to use the Ignition Oven to determine RAP binder content
- Unfortunately, Correction Factor is assumed based on “typical” results at plant
- As RAP content increases, results in greater degree of under-asphalting
- Also, need to move to “Binder Replacement”.
Current NJ practice is RAP % by total weight
 - What if mix calls for 5.5% asphalt content but RAP binder content is 4.5%?

Collected PANYNJ Data – RAP AC%

	<u>Extracted</u>	<u>Ignition</u>	<u>Diff. (or Correction Factor)</u>
Plant #1	5.75%	6.99%	-1.24%
Plant #2	4.62%	5.31%	-0.69%
Plant #3	5.27%	6.17%	-0.90%
Plant #4	4.38%	5.46%	-1.08%
Plant #5	5.43%	6.25%	<u>-0.82%</u>

Average = -0.88%

NJ Plant (One Plant) – Stockpile Variability

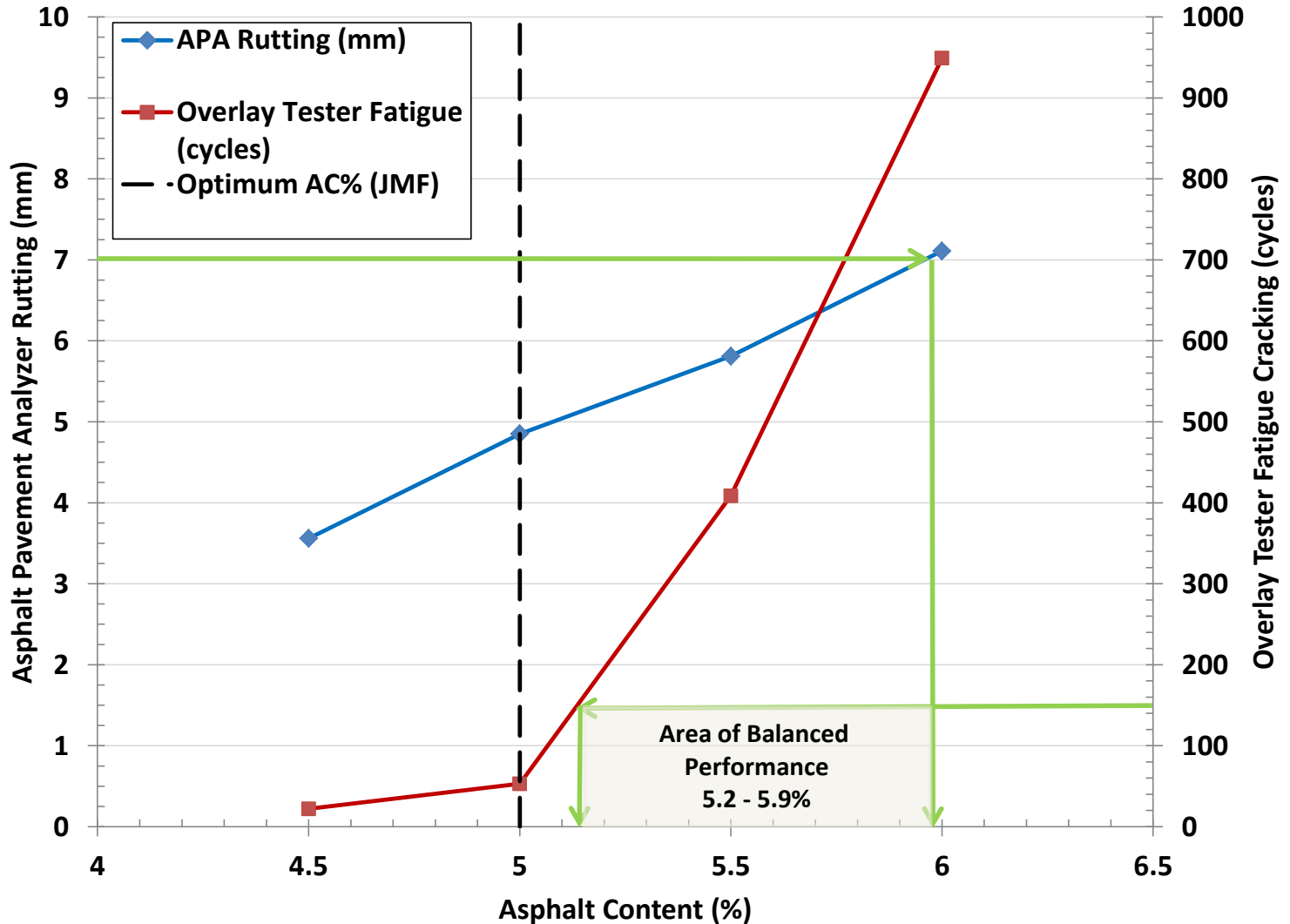


DESIGNING FOR PERFORMANCE

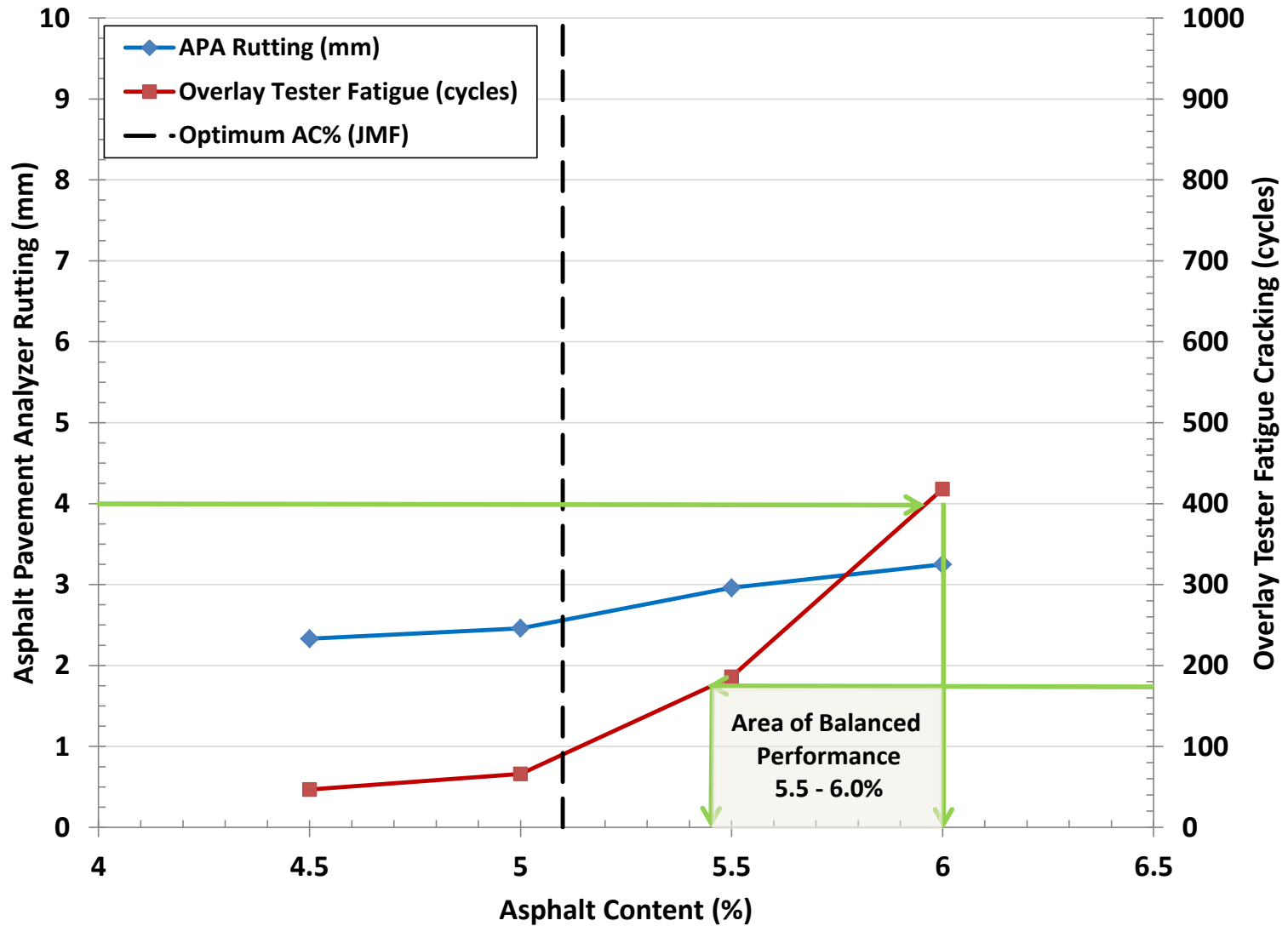
Designing RAP Mixtures to Performance

- New NJDOT High RAP (HRAP) specification allows suppliers to use as much RAP as they want, as long as the resultant mixture performs to established criteria.
- Can use:
 - Rejuvenators, WMA, increase asphalt contents, specialized binders, etc.
 - As long as the final mixture meets HRAP specification
 - Sometimes, a little more binder is all that is needed....

Supplier #1 – 9.5M64



Supplier #2 – 12.5M76



More RAP...

- When looking to utilize higher RAP
 - Know what you have for RAP
 - Stiffness, binder grade, asphalt content (solvent extraction)
 - Rejuvenators show promise but concerns with volatilizing during excessive hold times
 - Conducting research on long-term performance
 - Full mobilizing and blending of RAP binder not occurring
 - State agencies looking into limiting RAP binder contribution to total binder content
 - Results in increased effective asphalt contents
 - High RAP mixtures can be designed to perform. Takes a little work, but can be accomplished

Thank you for your time!

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