NJDOT HRAP – Performance

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Presentation Overview

- I-295 Project (Constructed 2012)
- Factors to Consider HRAP Mixture Performance

NJDOT HRAP – I295

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

NJDOT HRAP – I295

- I295 SB – Milepost 11.26 to 14.48
- Project requirements
  - 9.5M76 HRAP Surface
    - APA < 4.0 mm
    - OT > 175 cycles
  - 12.5M64 HRAP Intermediate
    - APA < 7.0 mm
    - OT > 100 cycles

Mix Design Prep

- Fractionated RAP & Testing

Sample No.			Fine RAP		Coarse RAP	
Sieve Size			% Passing	% Passing	% Passing	% Passing
inch	mm		#1	#2	#3	#4
50.0	2	%	100	100	100	100
37.5	1 1/2	%	100	100	100	100
25.0	1	%	100	100	100	100
19.0	3/4	%	100	100	100	100
12.5	1/2	%	100	100	100	99.3
9.5	3/8	%	100	100	94.7	94.9
4.75	No. 4	%	94.7	95.3	40.5	44
2.36	No. 8	%	72.7	74.7	25.1	27.8
1.18	No. 16	%	58.7	59.3	22.3	24.2
0.600	No. 30	%	44.6	45.9	18.7	20.8
0.300	No. 50	%	25.8	26.3	12.6	13.6
0.150	No. 100	%				
0.075	No. 200	%	9.70	9.20	5.40	5.40
Asphalt		%	6.93	7.08	3.40	3.90

83.8-18.8 (29.1)
PG82-16

Mix Design

- Asphalt supplier ran multiple designs to meet the performance requirements – all initially failed
  - Due to lack of time, complete mixture design was thought not to be practical
    - Modified existing design to meet specification
  - Different binder grades – softer PG did not work!
    - Excessive rutting
  - Increase asphalt binder; back to “standard” binder
    - Fail fatigue cracking

Mixture Design Trials – Initial

Surface Course

PG Grade	NMAS	RAP %	OT (cycles)	APA Rut
76-22	9.5mm	20%	365	5.53mm
76-22	9.5mm	30%	129	4.37mm

Intermediate Course

PG Grade	NMAS	RAP %	OT (cycles)	APA Rut
58-28	12.5mm	30%	1442	9.28mm
58-28	12.5mm	40%	503	8.56mm

Mix Design Trials

- Mix Supplier contacted binder supplier to design a binder to help achieve desired mixture performance
  - Reminder – no PG grade specified
- Mix supplier resubmitted another 2 variations (each) at different RAP contents

Mixture Design Trials – Binder Modified

Surface Course

PG Grade	NMAS	RAP %	OT (cycles)	APA Rut
76 HRAP	9.5mm	25%	390	3.16mm
76 HRAP	9.5mm	30%	121	3.66mm

Intermediate Course

PG Grade	NMAS	RAP %	OT (cycles)	APA Rut
64 HRAP	12.5mm	35%	529	6.40mm
64 HRAP	12.5mm	40%	80	5.94mm

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

Plant Production

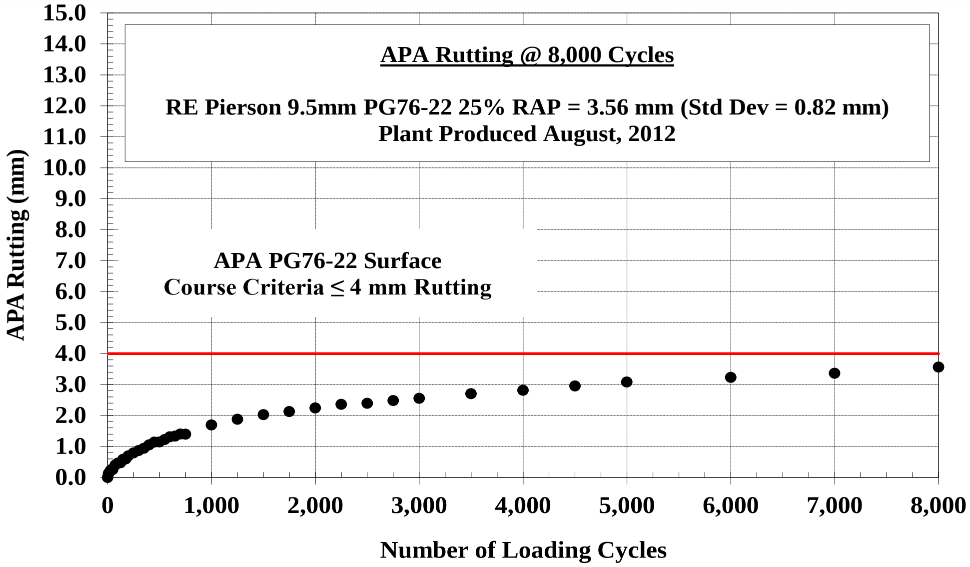
Plant Production

- Multiple RAP bins for fractionated RAP
- Separated RAP piles solely for project
- Remixing RAP piles while feeding bins

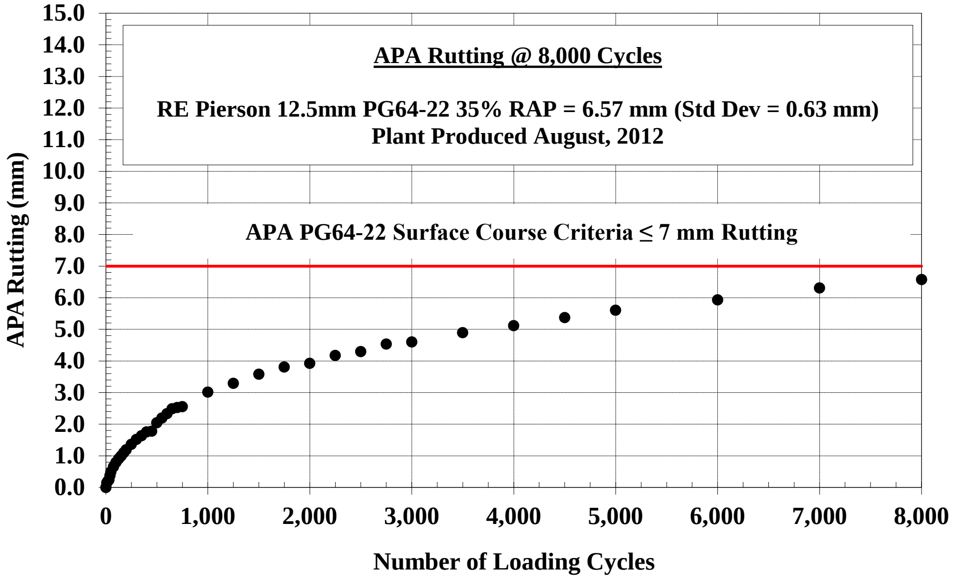
Plant Production

- Mix supplier utilized private job to work out any issues a week before construction
- Sampling conducted 150, 300, 450 tons
  - Recognized possible binder contamination in first 150 tons sampled – failed performance specs
    - Some mix may need to be discarded depending on plant set up
- Final project constructed in August 2012
  - 900 tons of 9.5M76 HRAP
  - 1700 tons of 12.5M64 HRAP

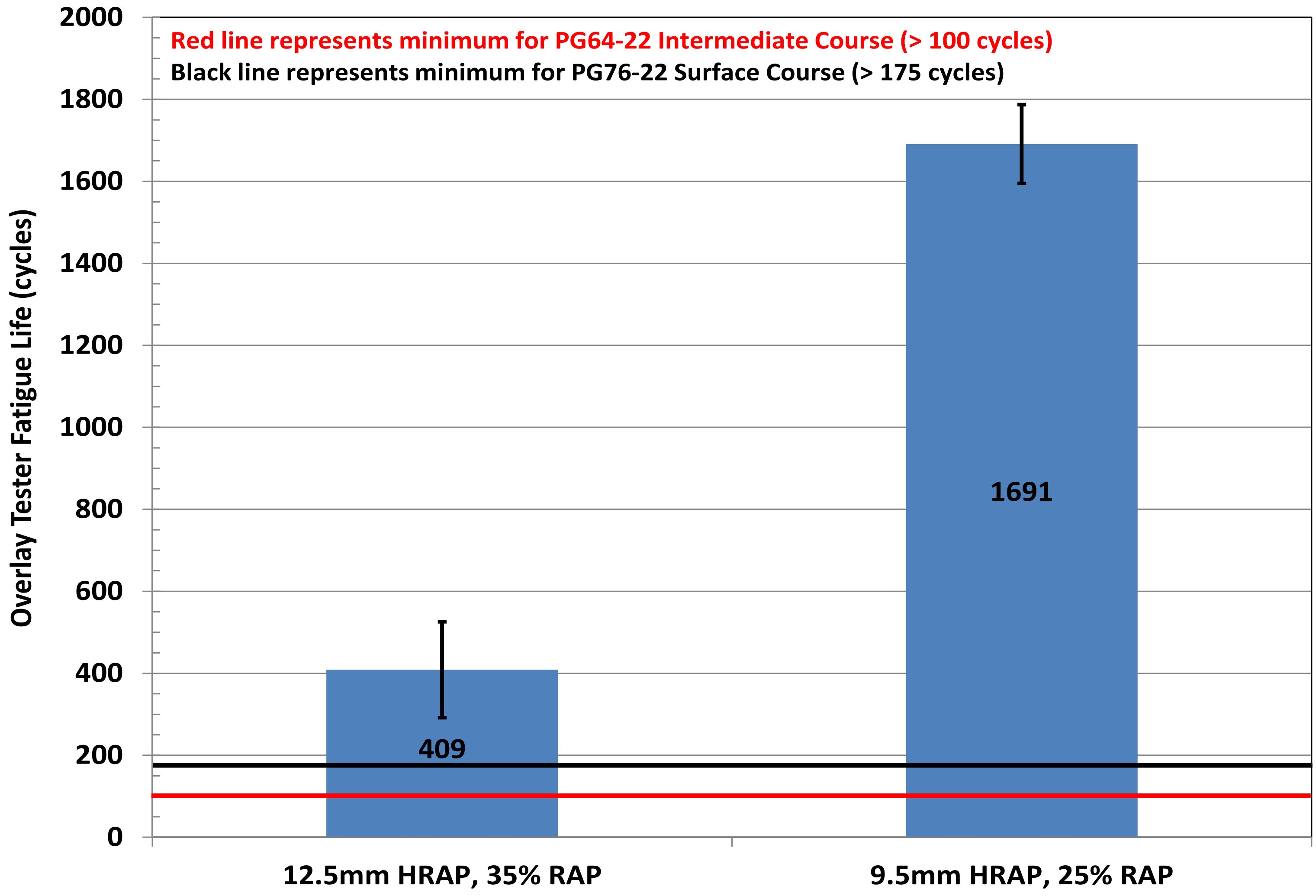
Ex. – 1st Lot APA Rutting Performance



64°C Test Temp.; 100psi Hose Pressure; 100 lb Load Load



Ex. – 1st Lot Overlay Tester



Final Product – October 2012

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Densities

- For plant production, NJDOT allowed lower air voids in gyratories than "normal" HMA
  - 95% to 98.5% of Gmm

- 9.5M76 HRAP Cores
  - Lot #1: Average = 7.4% air voids
  - Lot #2: Average = 5.9% air voids
- 12.5M64 HRAP Cores
  - Lot #1: Average = 4.6% air voids (Full bonus)
  - Lot #2: Average = 5.7% air voids (Full bonus)
  - Lot #3: Average = 6.5% air voids

IRI

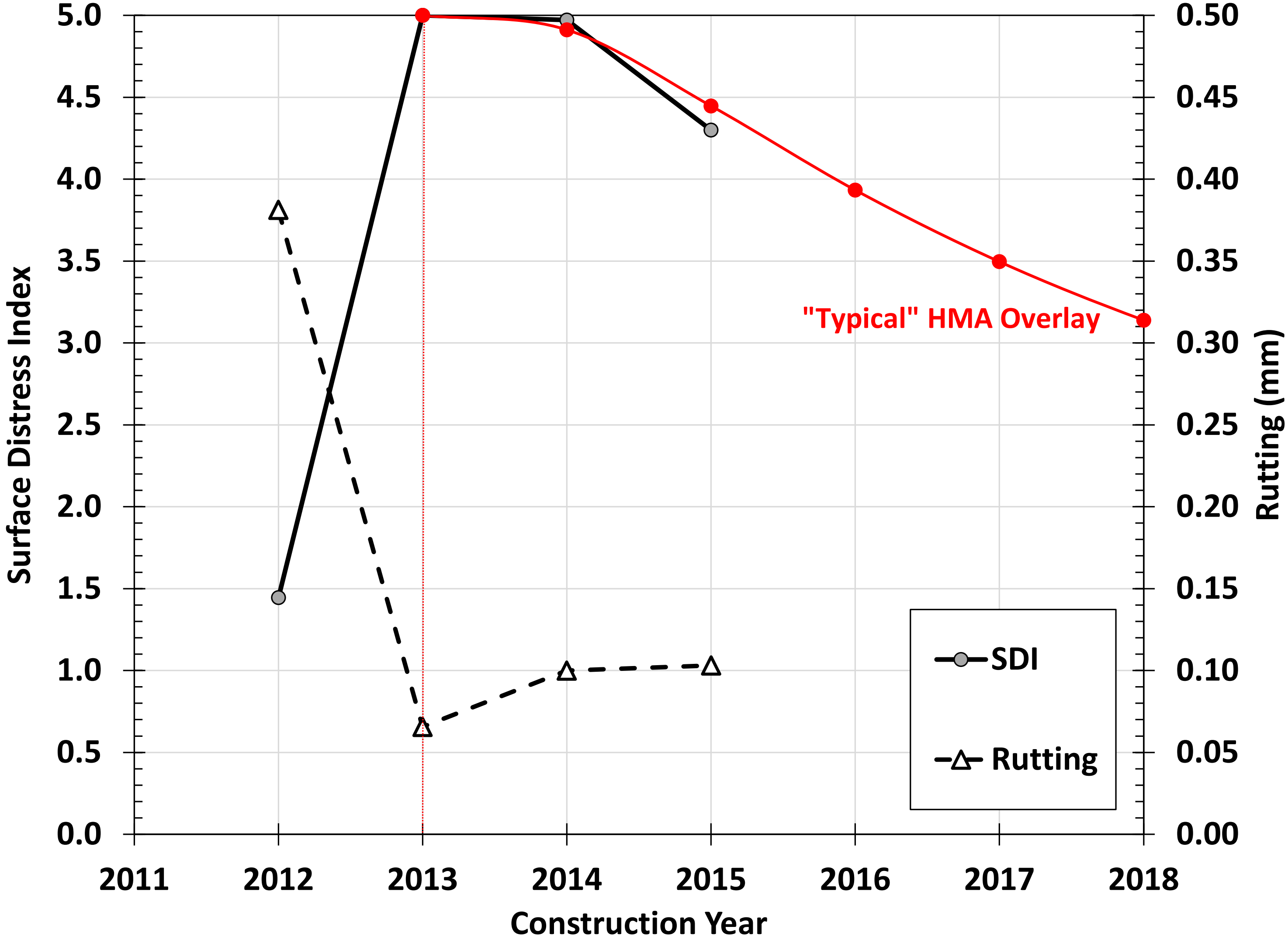
- 9.5M76 WMA
  - 11.54 – 11.26: Average = 57.8 in/mile
  - 13.93 – 11.54: Average = 37.7 in/mile
  - 14.39 – 13.93: Average = 76.9 in/mile

Ave = 57.5 in/mile

- 9.5M76 HRAP
  - 14.39 – 13.93: Average = 57.8 in/mile
  - 13.93 – 11.54: Average = 44.0 in/mile
  - 11.54 – 11.26: Average = 60.8 in/mile

Ave = 54.2 in/mile

Field Performance to Date



Designing and Producing HRAP for Performance

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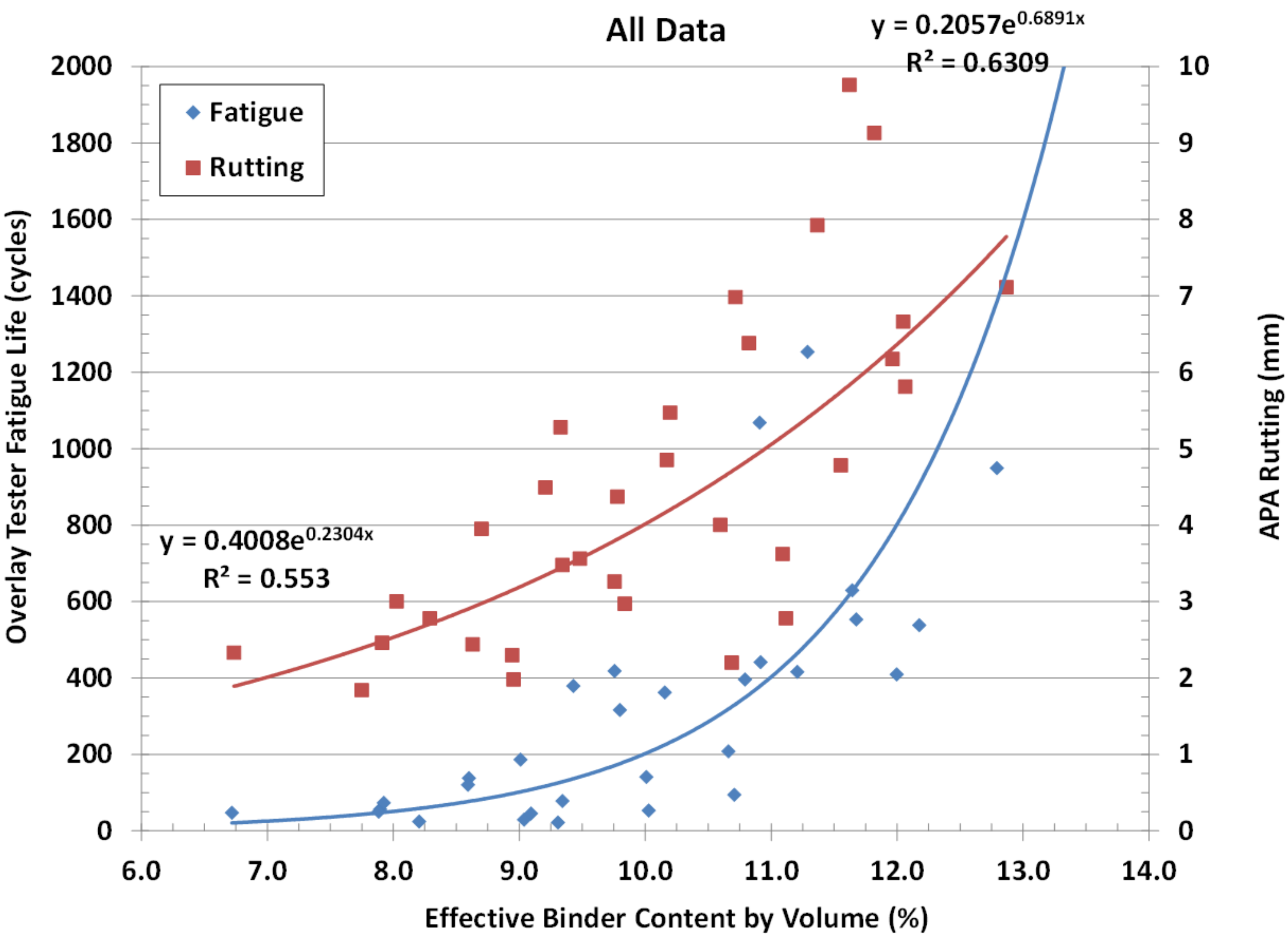
Increase Your Effective Asphalt Content

Effective Asphalt Content by Volume (VBE)

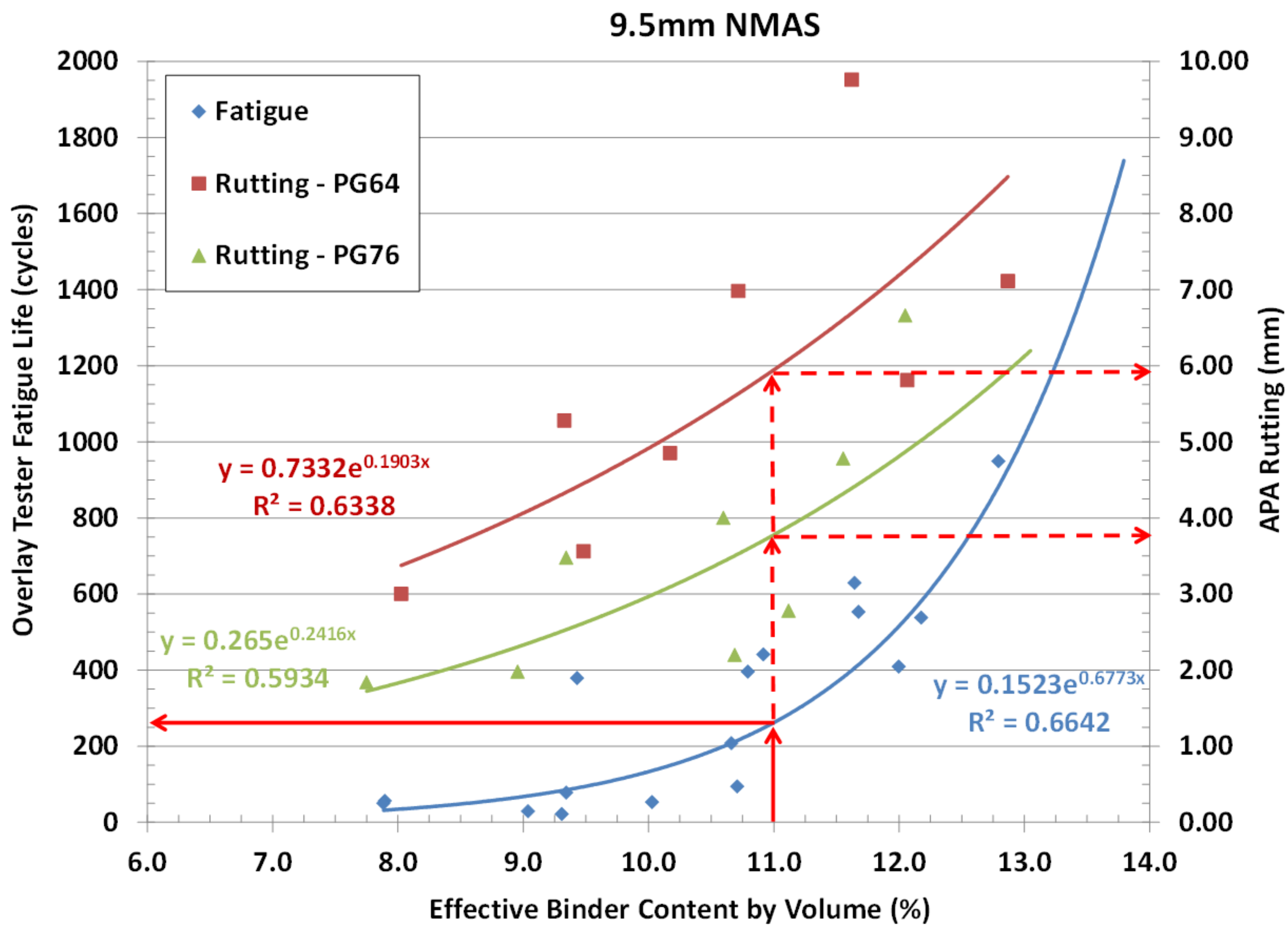
- For HRAP, Voids in Mineral Aggregate (VMA) increased 1% over typical NJDOT mixtures
  - Result: Increase Effective Asphalt Content by Volume (VBE) by 1%
  - VBE = VMA – Air Voids
- Example: 9.5 NMAS
  - Typical HMA: Design AV = 4%; Min. VMA = 15%; Min VBE = 11%
  - HRAP: Design AV = 4%; Min. VMA = 16%; Min VBE = 12%
- Fatigue/Durability of asphalt mixtures highly dependent on Effective Asphalt Content by Volume
  - NCHRP Projects 9-25/9-31

APA Rutting and Overlay Tester Fatigue vs Effective Asphalt Content by Volume

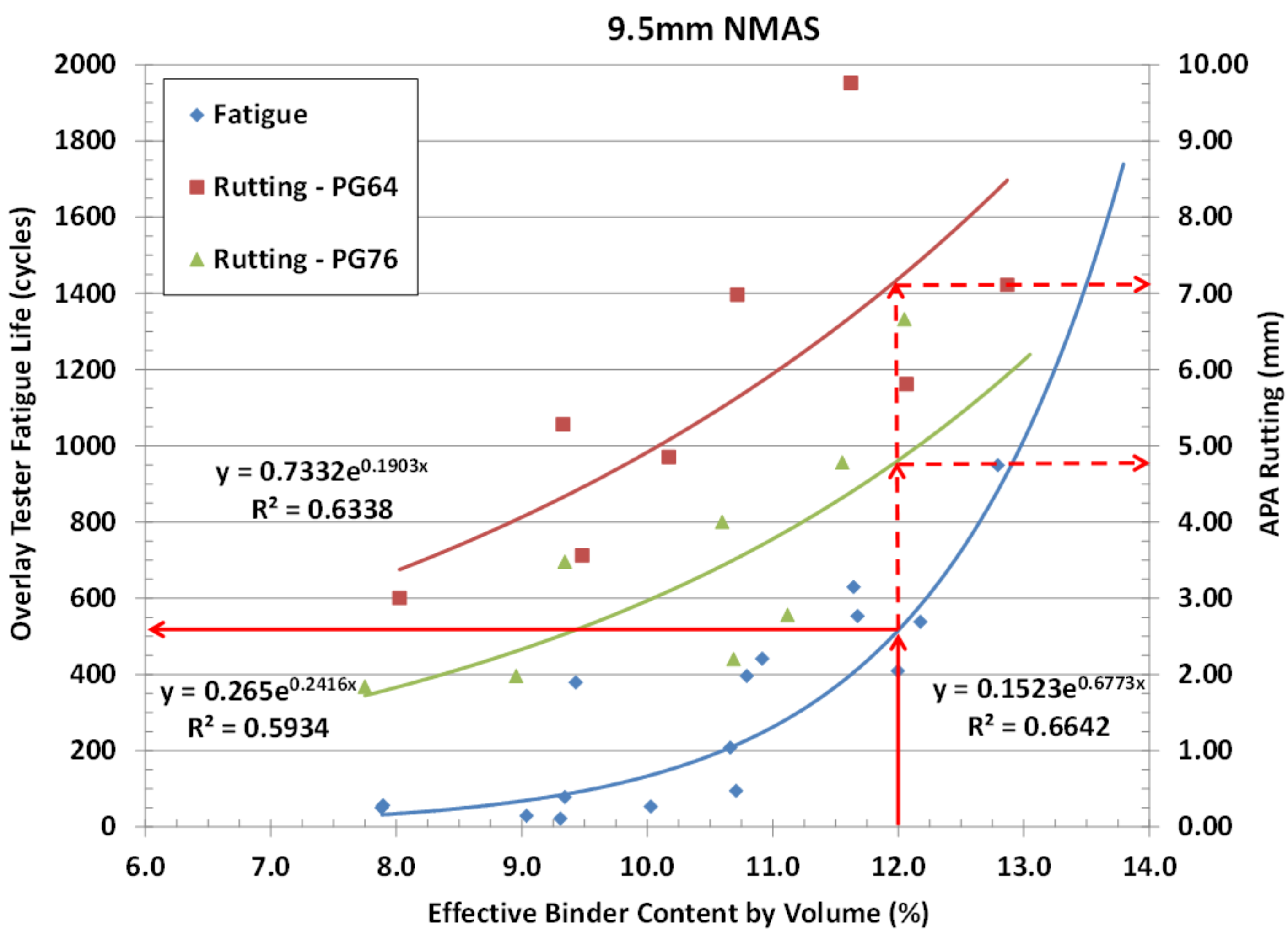
- 9.5 &12.5mm NMAS
- PG64-22 & PG76-22
- 2 aggregate sources
- 15% RAP



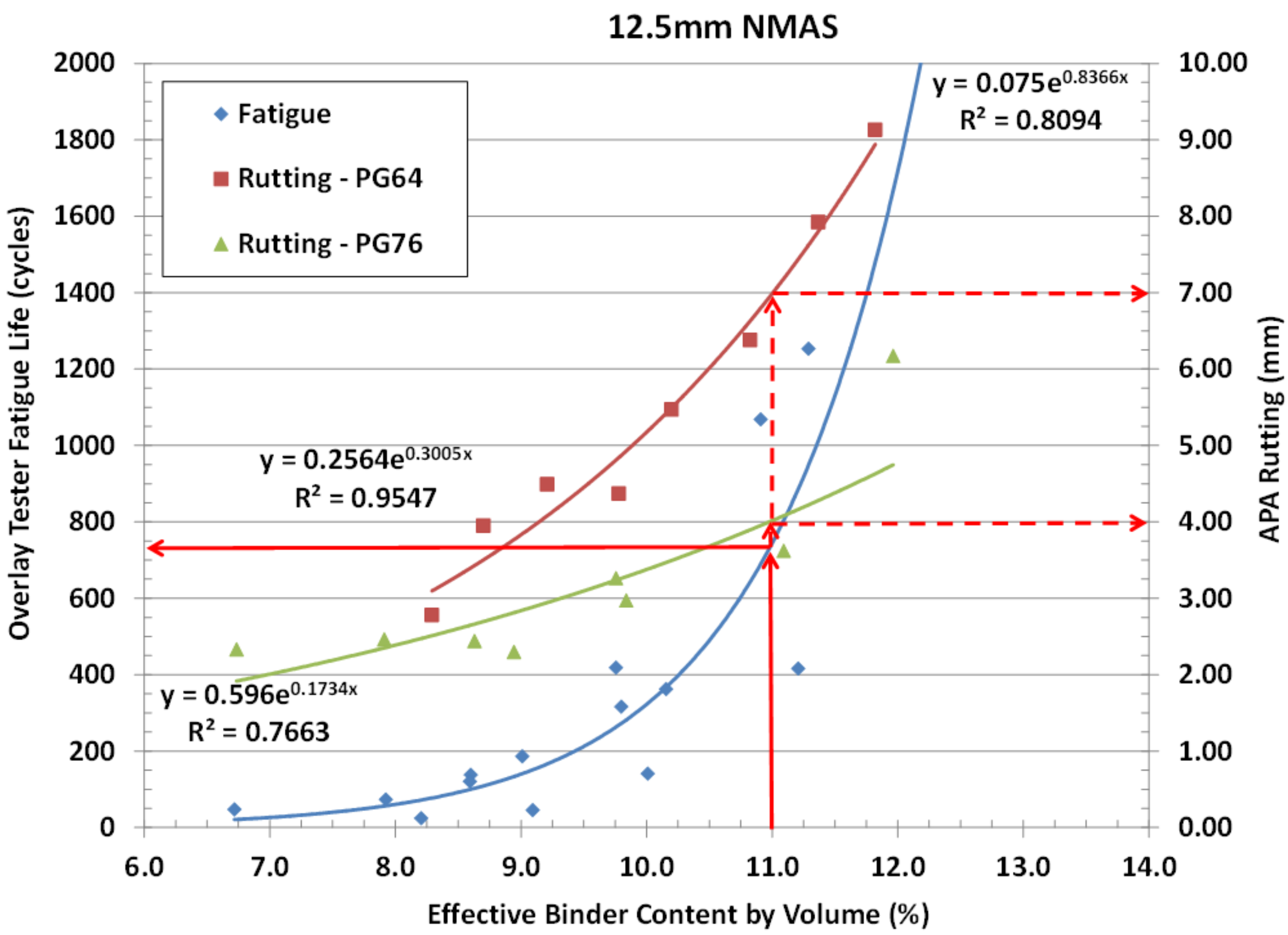
9.5 mm NMAS Mixtures – Current VMA Minimum



9.5 mm NMAS Mixtures – HRAP VMA Minimum



12.5 mm NMAS Mixtures – HRAP VMA Minimum



For HRAP: Increase Your Effective Asphalt Content by Volume (VBE)

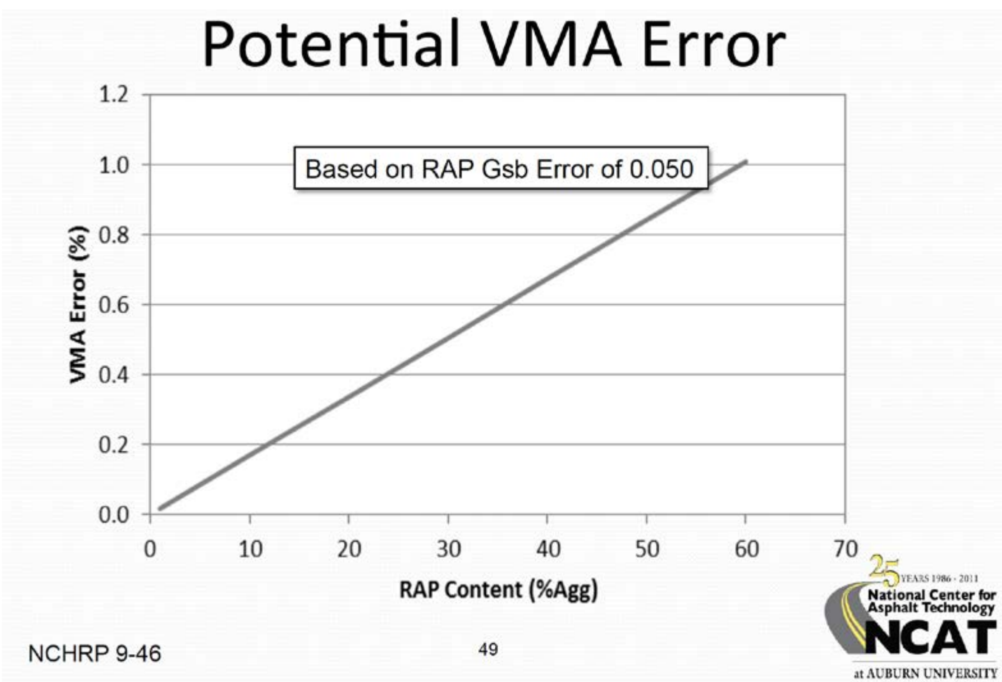
- VBE = VMA – Air Voids
- As VBE increases, additional effective asphalt in the asphalt mixtures
  - Improves durability
    - Fatigue resistance
    - Thicker films to reduce effects of oxidative aging
- Packing characteristics of aggregate skeleton directly influence VMA
  - Gradation
  - Aggregate surface texture
  - Aggregate shape
  - Reduce fine content
- Are we measuring Gsb correctly/accurately?

Designing and Producing HRAP for Performance

Are You Determining VMA Properly? Aggregate G_{sb} Impacts

Basic HMA Volumetrics

- VMA directly related to G_{sb} of aggregate blend
- When RAP used, do we really know the G_{sb}?



$$V_a = \left(1 - \frac{G_{mb}}{G_{mm}}\right)x100$$

$$VMA = \left(100 - \frac{G_{mb}P_s}{G_{sb}}\right)$$

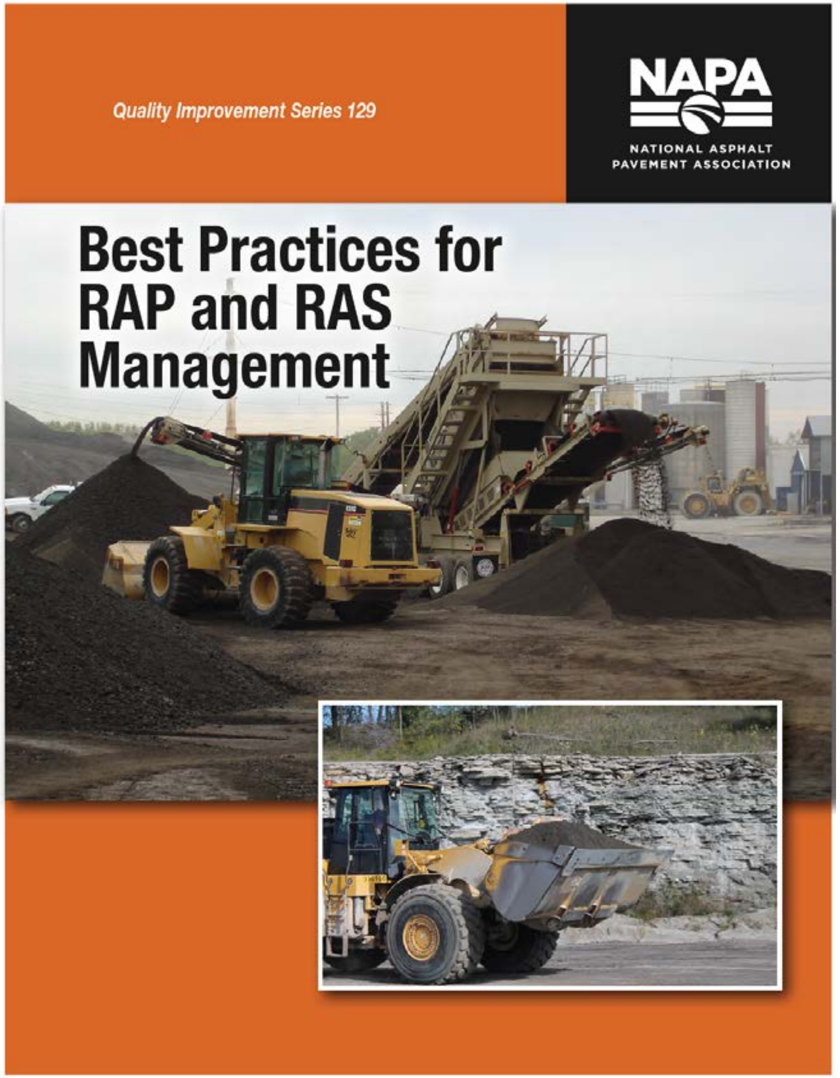
$$VFA = \left(\frac{VMA - V_a}{VMA}\right)x100$$

$$V_{be} = VMA - V_a$$

Determining G_{sb} for High RAP

- Option 1: Estimate G_{sb} from G_{mm} and P_{ba}
  - Determine G_{mm} of RAP sample
  - Calculate G_{se} using:

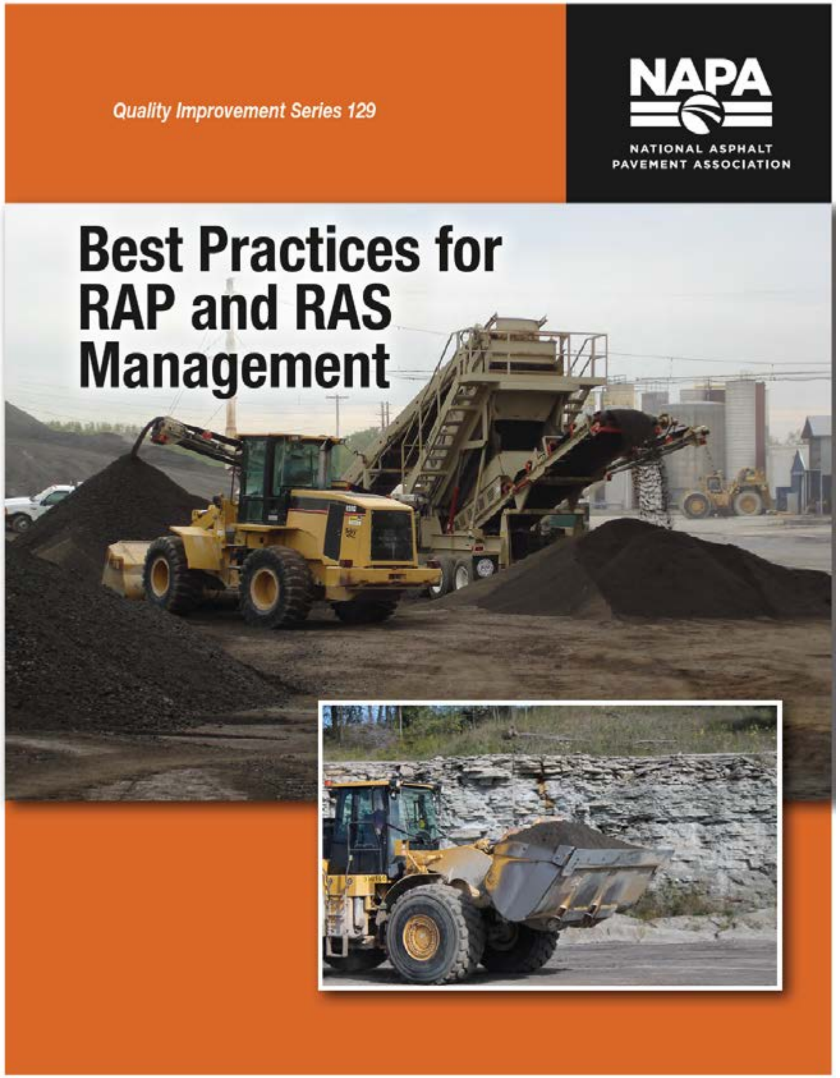
$$G_{se(RAP)} = \frac{100 - P_{b(RAP)}}{\dfrac{100}{G_{mm(RAP)}} - \dfrac{P_{b(RAP)}}{G_b}}$$



Determining G_{sb} for High RAP

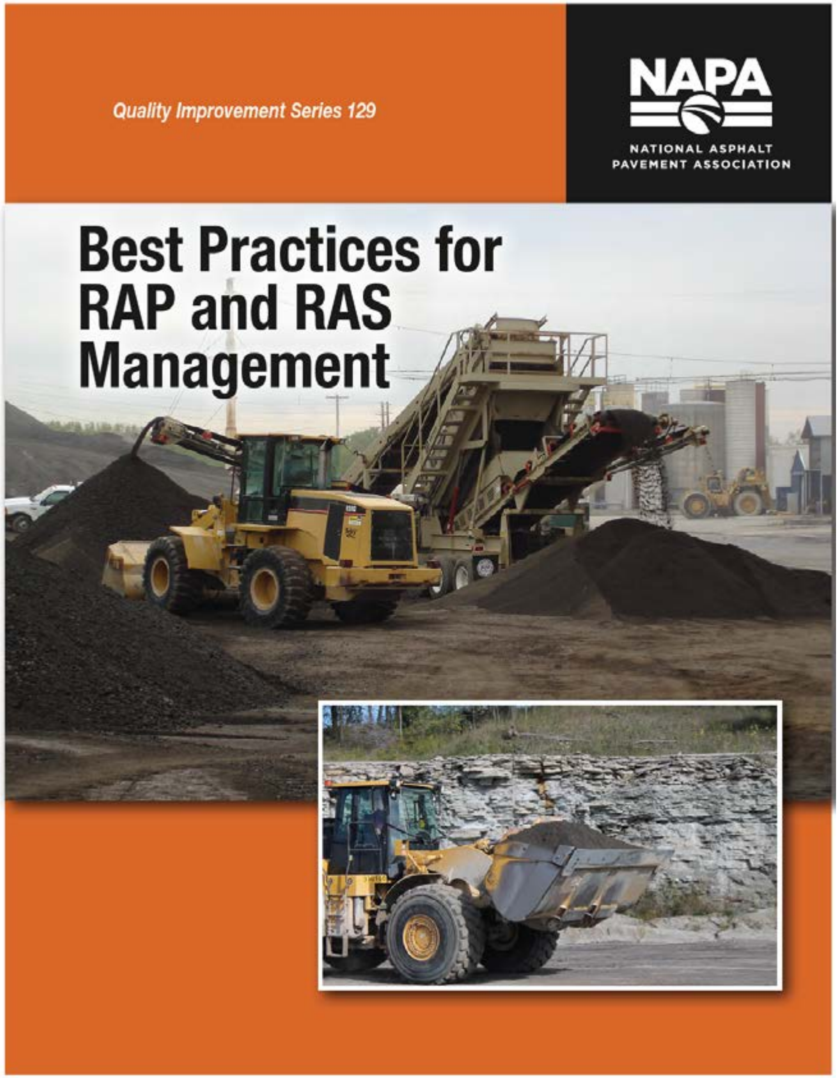
- Option 1: Estimate G_{sb} from G_{mm} and P_{ba}
  - Estimate absorbed binder, P_{ba}, based on historical values at plant
  - Calculate G_{sb} using:

$$G_{sb(RAP)} = \frac{G_{se(RAP)}}{\dfrac{P_{ba} \times G_{se(RAP)}}{100 \times G_b} + 1}$$



Determining G_{sb} for High RAP

- Option 2: Recover aggregate using solvent extraction or ignition, then conduct AASHTO T84 & T85



Designing and Producing HRAP for Performance

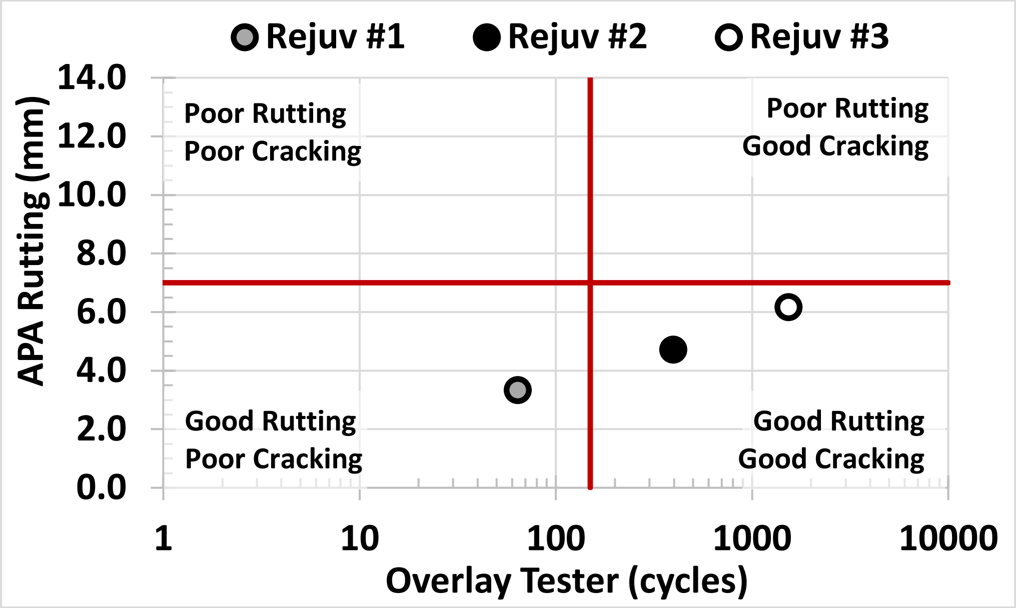
Try Using an Additive

Evaluate Different Additives

- HRAP specification allows for the use of different additives
  - Rejuvenators
  - WMA
  - Specialty designed asphalt binder
- See how additives work with YOUR MIX – not all additives are the same

APA and Overlay Tester Performance with Different Rejuvenators

- Not all additives created equal
  - Example: Rejuvenators
- Same mix; different rejuvenators
- Rejuvenator #1
  - Dosage rate too low/RAP content too high
- Rejuvenator #2
  - Optimized dosage rate for that RAP content
- Rejuvenator #3
  - Can reduce dosage rate, or try increasing RAP content



HRAP Performance Conclusions

- Increase the VBE
  - Reason for VMA increase in HRAP Spec
  - Increasing VBE will improve fatigue & durability
- Understand your mixture
  - RAP (binder properties; asphalt content; aggregate gravities)
  - Can you modify your aggregate blend to improve VMA
  - G_{sb} directly impacts VMA calculation!
- Rejuvenators available – but need to evaluate with YOUR MATERIALS
- Formulated asphalt binder
  - Specially formulating an asphalt binder for YOUR MATERIALS that will meet performance specifications

Thank you for your time!
Questions?

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