

NJDOT High RAP (HRAP) Performance Based Specification

Thomas Bennert, Ph.D.

Center for Advanced Infrastructure and Transportation (CAIT)

Rutgers University

RUTGERS

Center for Advanced Infrastructure
and Transportation

Northeast Asphalt User Producer Group

Springfield, MA

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Presentation Outline

- Brief History of RAP Use in New Jersey
- Development of NJDOT HRAP Specification
 - Field Performance
 - New Jersey & Others
- HRAP 2.0
 - Construction 2024



History of RAP Use in NJ

History of RAP in NJ (Sheehy, 2008)

- Late 1970's, NJDOT started looking at the use of RAP.
- Route 130 Shoulder (1978)
 - Closed System – millings from Route 1
 - 50% RAP in Surface Course (Mix #4)
- Route 81 / Turnpike Interchange 13A (1981)
 - Dedicated Stockpile – tested and approved
 - 30% RAP in Surface Course (Mix I-4)

Batch Plant from Rt 130 Project



History of RAP in NJ (Sheehy, 2008)

- Industry had issues with “closed system” or dedicated stockpiles.
- 1983 Standard Specifications allow 10% RAP in Base and Intermediate Courses in an “open system”, meaning RAP from unknown source.
- On a job-to-job basis, allowance in contract for higher percentages in Base and Intermediate Courses if “closed system” used.
- Trial project in 1984 (Rt 40).
 - 10% RAP from unknown source in Surface Course

RT 40 After 10 Years



History of RAP in NJ (Sheehy, 2008)

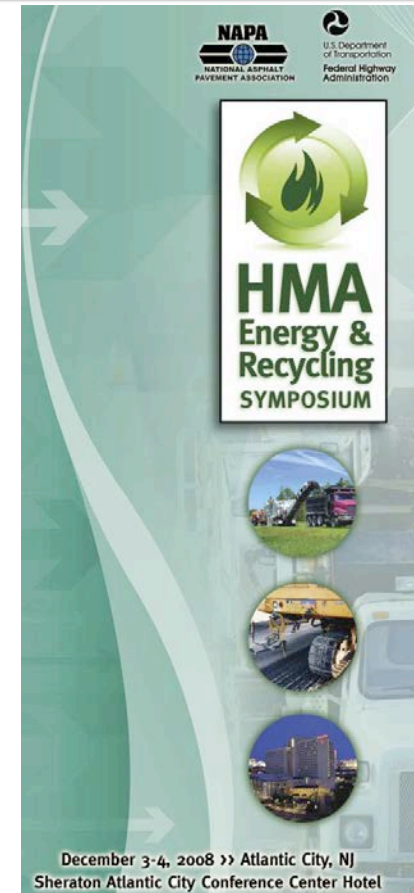
- Through 1980's continued to specify closed system for higher (over 10%) RAP in Base and Intermediate Course or for any RAP in Surface Course.
 - NJDOT took cores prior to project advertisement.
 - Tested – extraction & recovery.
 - Used blending charts to determine virgin asphalt grade.
- Very few projects used the closed system recycling due to logistics.

History of RAP in NJ (Sheehy, 2008)

- 1989 Standard Specifications (“Direct Substitution”)
 - 10% RAP from unknown source in Surface Course
 - 20% RAP from unknown source in Base and Intermediate Courses
- Continued job-to-job allowance for higher percentages of RAP in Base and Intermediate Courses for closed system.
 - NJDOT allowance for closed system based on visual assessment of the pavement to be milled.
 - Few projects actually used the higher percentages.
- In 1996 bumped up to 25% RAP in Base and Intermediate Course and in 2001 bumped up to 15% RAP in Surface Course
 - Based on national research

2008 - 25% RAP in Surface Course (Sheehy, 2008)

- Looking at 25% RAP in Surface Course.
 - Concerns about QC
 - Actual percent of asphalt binder in the RAP
 - Ignition oven correction factor may be a bigger question mark than we thought
- Based on Laboratory Testing – Simple Performance Test, Fatigue Test, Overlay Tester, and APA
 - More results expected over Winter 2009
- Industry working on addendum on to QC plans for higher percentages of RAP (i.e. 20 & 25%) in Surface Course.
 - 5 projects went out for bid and construction for 2009 season

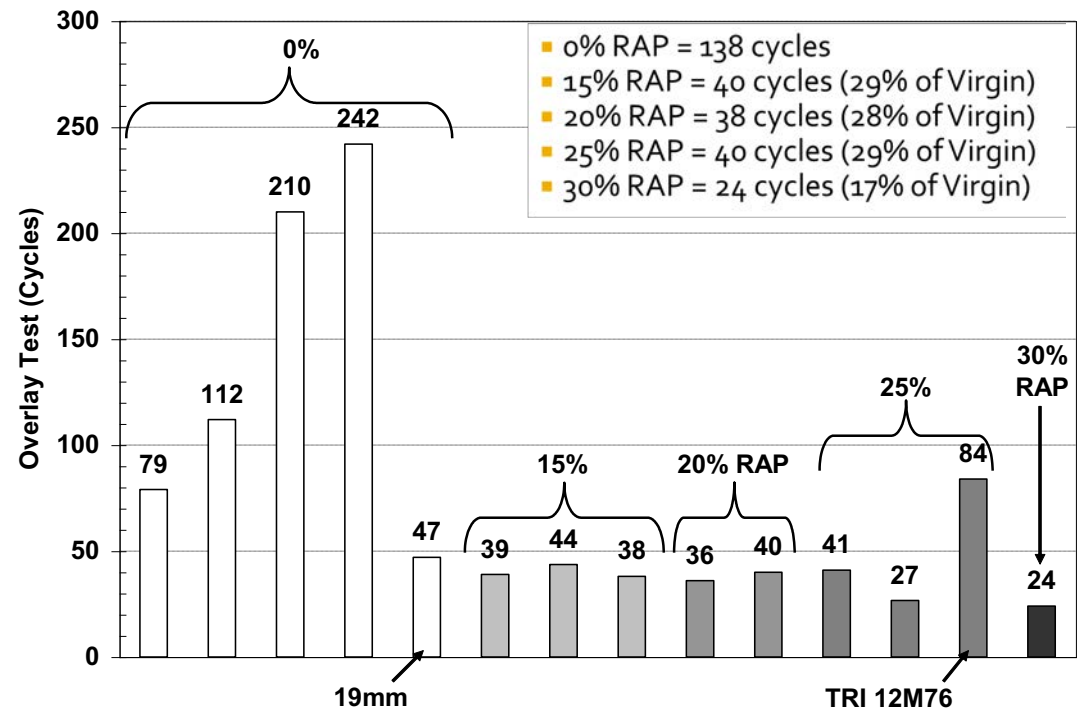


2009 NJDOT Higher RAP Projects (25% RAP Surface Course Mixes)

- Rt 206 – production and construction data met specifications
 - Holding water in 2011 – Maintenance 2012
- I-80 – issues with volumetrics throughout first half of project
 - Went back to 15% RAP
- I-78 – compaction issues resulted in high in-place air voids and poor ride
- South Jersey Maintenance Roadway Repair Contract (#1)
 - Could not get mix verified through plant
- South Jersey Maintenance Roadway Repair Contract (#2)
 - Only project not to report issues

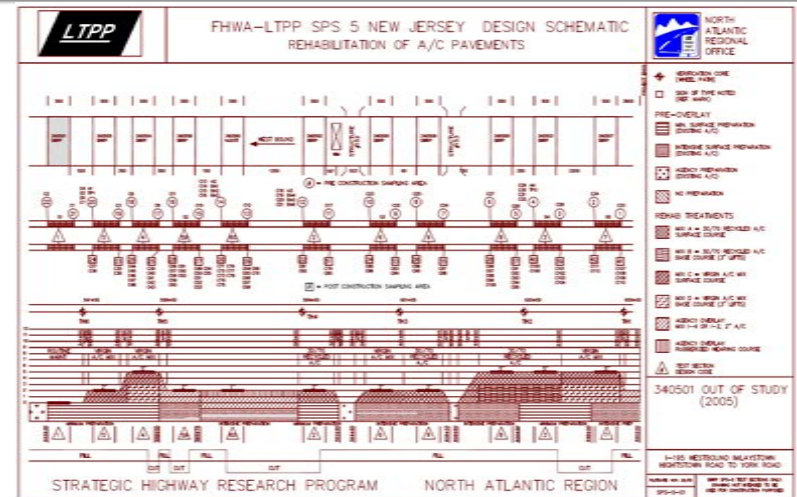
NJDOT 25% RAP Surface Course - 2009

- On average, 0% RAP had 3 times fatigue life!
- In general, the addition of RAP has a tendency to decrease the durability and fatigue cracking resistance of asphalt mixtures
 - Lower effective asphalt content
 - Aged/stiff RAP binder
 - Higher dust contents



FHWA LTPP SPS-5: NJ's 0% vs 30% RAP Sections

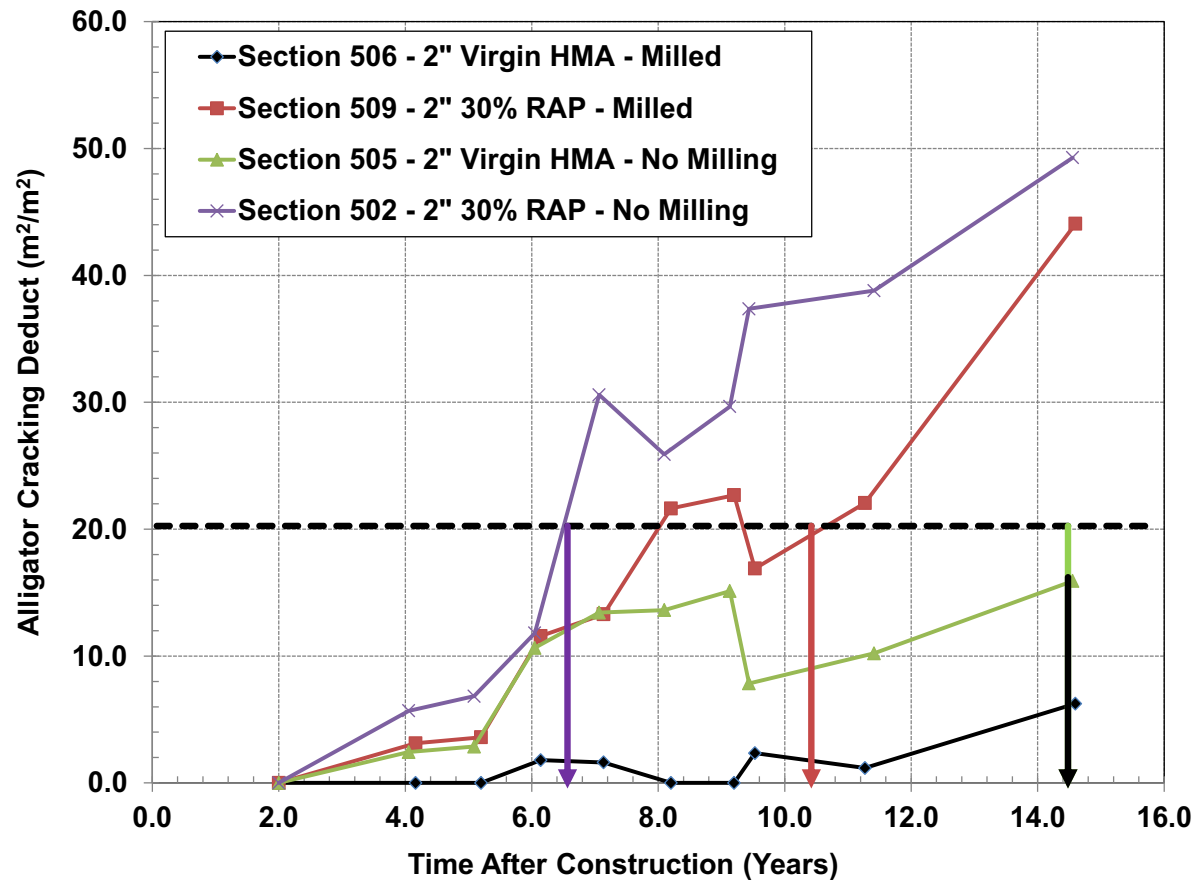
- SPS-5 (LTPP's Special Pavement Sections) used for the "Study of Rehabilitation of Asphalt Concrete Mixtures" – softer binder
 - 2-inch vs 5-inch thick overlays
 - Milled vs Unmilled surfaces
 - Virgin vs 30% RAP Mixtures
- NJ Constructed in 1994 – Out of Service in 2009
- Yearly distress survey
- Cores taken and tested prior to rehab, as well as retained loose mix from 1994 construction



Virgin Materials	PG Grade
AC-10	61.5-31.5 (58-28)
AC-20	65.9-23.9 (64-22)
RAP	100-1.4 (100-0)

Cores	Continuous PG Grade	
	Virgin Mixture	30% RAP Mixture
Top 2"	72.3-28.3 (70-28)	77.3-25.1 (76-22)
Bottom 3"	61.6-26.6 (58-22)	66.0-27.1 (64-22)

NJ SPS-5 Alligator Cracking



Comparing

Black vs Red (Milled)

Green vs Purple (Unmilled)

Load Associated Cracking

- 30% RAP cracking rate was 5 times faster than 0% RAP

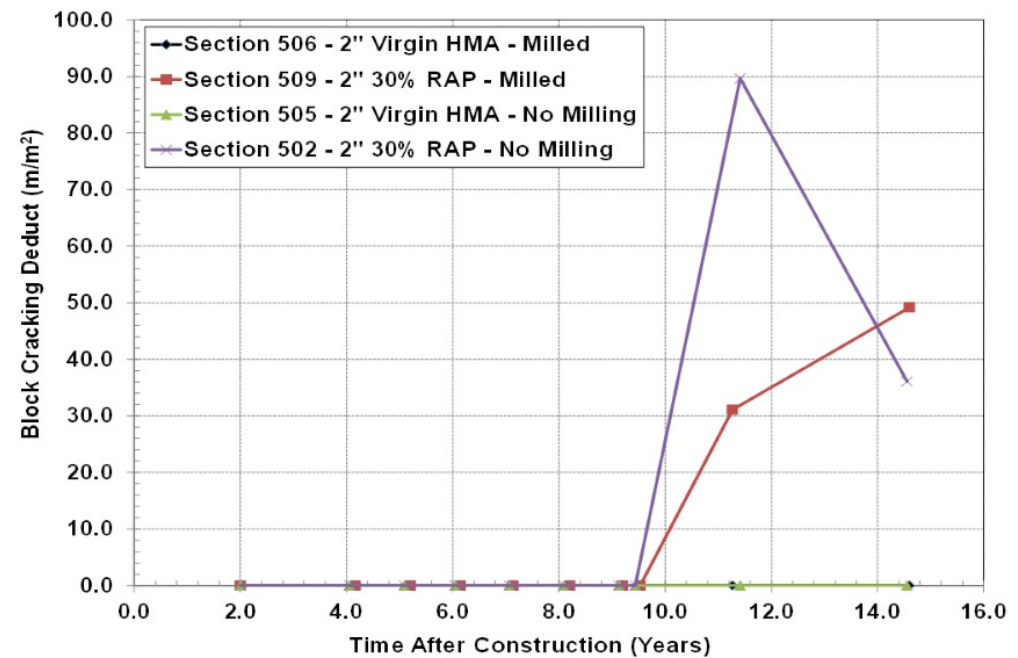
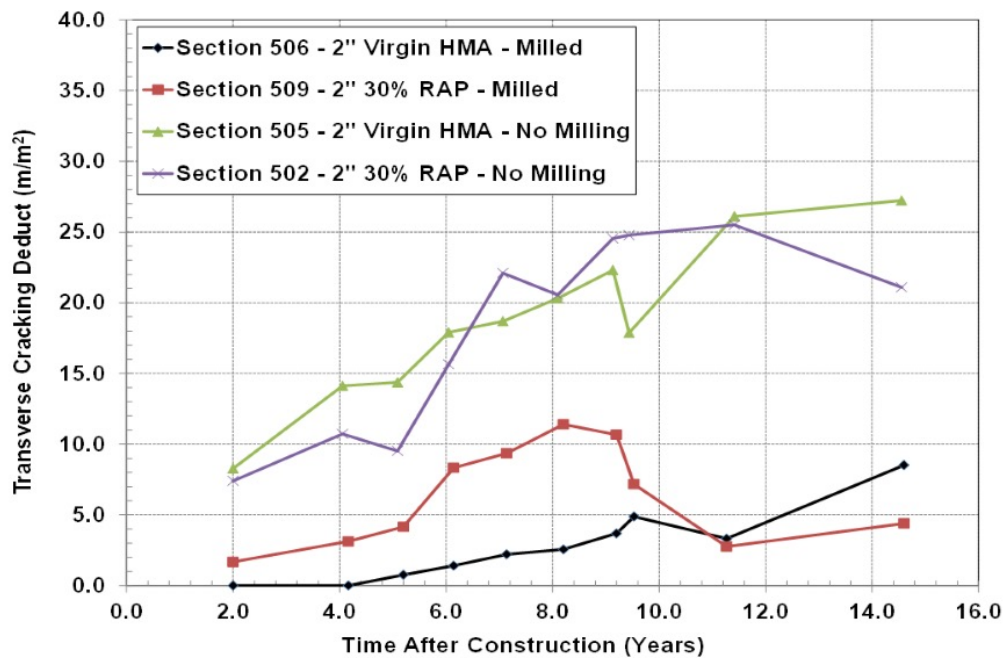
Milled Surface

- 30% RAP reduced life 5 yrs

Unmilled Surface

- 30% RAP reduced life 10 yrs

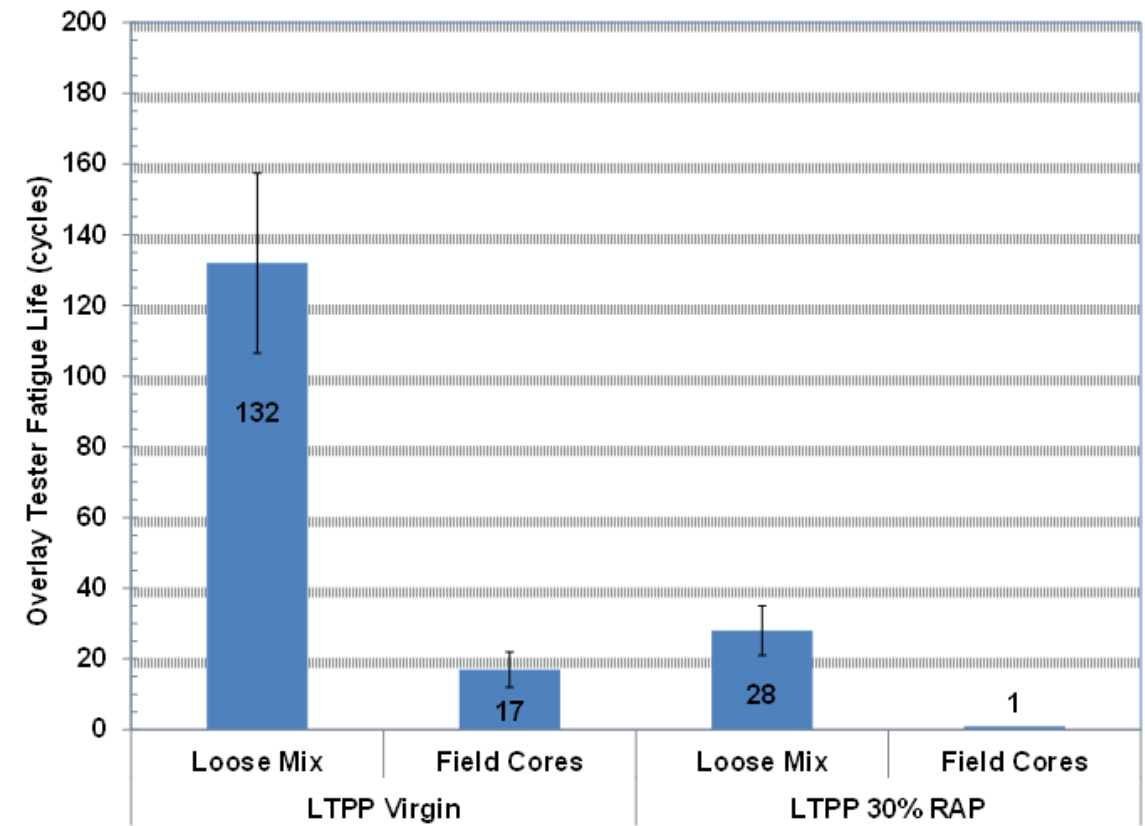
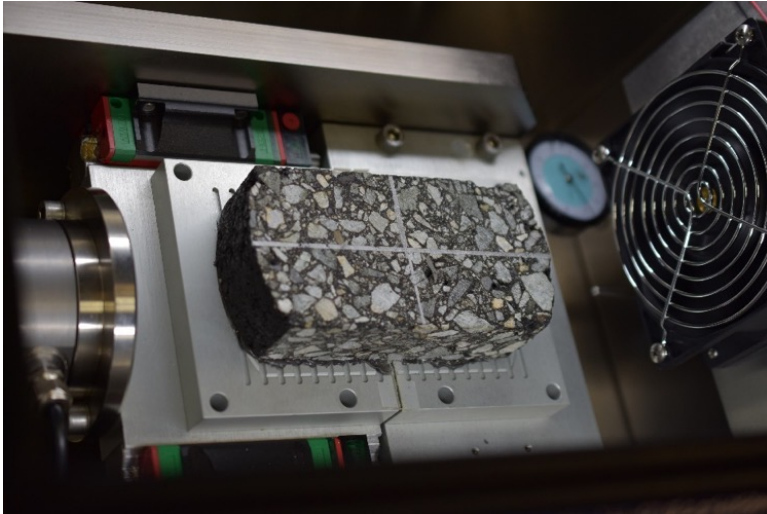
NJ SPS-5 Transverse Cracking



Transverse Cracking

- 30% RAP cracking rate was 50% faster than 0% RAP

Overlay Tester for NJ SPS-5



Back to the Drawing Board!

- In 2011, NJDOT held NJ asphalt industry to current specifications
 - 15% RAP in surface; 25% RAP in intermediate/base
- 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)
 - **New procedure would have performance test requirements that are based on asphalt mixtures with 0% RAP**

NJDOT HRAP Specification

NJDOT HRAP Specification – Basic Principle

- The supplier is not held to PG grade or max. RAP content
- Have to meet basic Superpave requirements
 - NJDOT increased VMA 1% over current specs
 - Could use softer binder, rejuvenators, WMA
- However, acceptance based on final mixture performance, based on database of typical “virgin” HMA
 - Suppliers not required to conduct extra & sophisticated testing on RAP if they choose not to – END RESULT SPEC

To overcome issues with lack of RAP binder blending – essentially increases the virgin binder content requirement

To overcome issues with workability/compaction and helps to counteract the increase in stiffness associated with the stiffer, RAP material

NJDOT HRAP - Volumetrics

Table 902.11.03-1 HMA HIGH RAP Requirements for Design

Compaction Levels	Required Density (% of Theoretical Max. Specific Gravity)		Voids in Mineral Aggregate (VMA) ² , % (minimum)					Voids Filled With Asphalt (VFA) %	Dust-to-Binder Ratio
	@N _{des} ¹	@N _{max}	Nominal Max. Aggregate Size, mm						
			25.0	19.0	12.5	9.5	4.75		
L	96.0	≤ 98.0	13.0	14.0	15.0	16.0	17.0	70 - 85	0.6 - 1.2
M	96.0	≤ 98.0	13.0	14.0	15.0	16.0	17.0	65 - 85	0.6 - 1.2

- As determined from the values for the maximum specific gravity of the mix and the bulk specific gravity of the compacted mixture. Maximum specific gravity of the mix is determined according to AASHTO T 209. Bulk specific gravity of the compacted mixture is determined according to AASHTO T 166. For verification, specimens must be between 95.0 and 97.0 percent of maximum specific gravity at N_{des}.
- For calculation of VMA, use bulk specific gravity of the combined aggregate including aggregate extracted from the RAP.

Table 902.11.04-1 HMA HIGH RAP Requirements for Control

Compaction Levels	Required Density (% of Theoretical Max. Specific Gravity)	Voids in Mineral Aggregate (VMA), % (minimum)					Dust-to-Binder Ratio
		Nominal Max. Aggregate Size, mm					
	@N _{des} ¹	25.0	19.0	12.5	9.5	4.75	
L, M	95.0 – 98.5	13.0	14.0	15.0	16.0	17.0	0.6 - 1.2

- As determined from the values for the maximum specific gravity of the mix and the bulk specific gravity of the compacted mixture. Maximum specific gravity of the mix is determined according to AASHTO T 209. Bulk specific gravity of compacted mixture is determined according to AASHTO T 166.

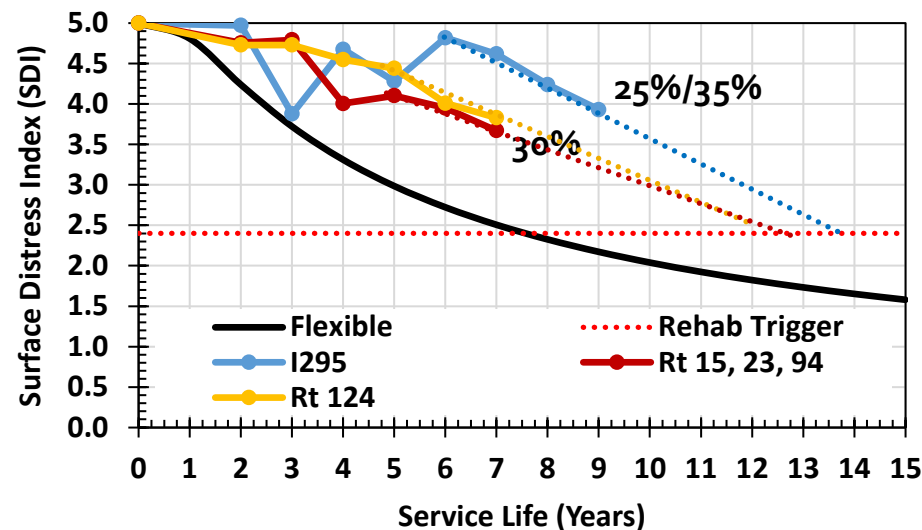
NJDOT HRAP - Performance

- 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)	> 200 cycles	> 275 cycles	> 100 cycles	> 150 cycles

High Recycled Asphalt Pavement (HRAP) Mixtures

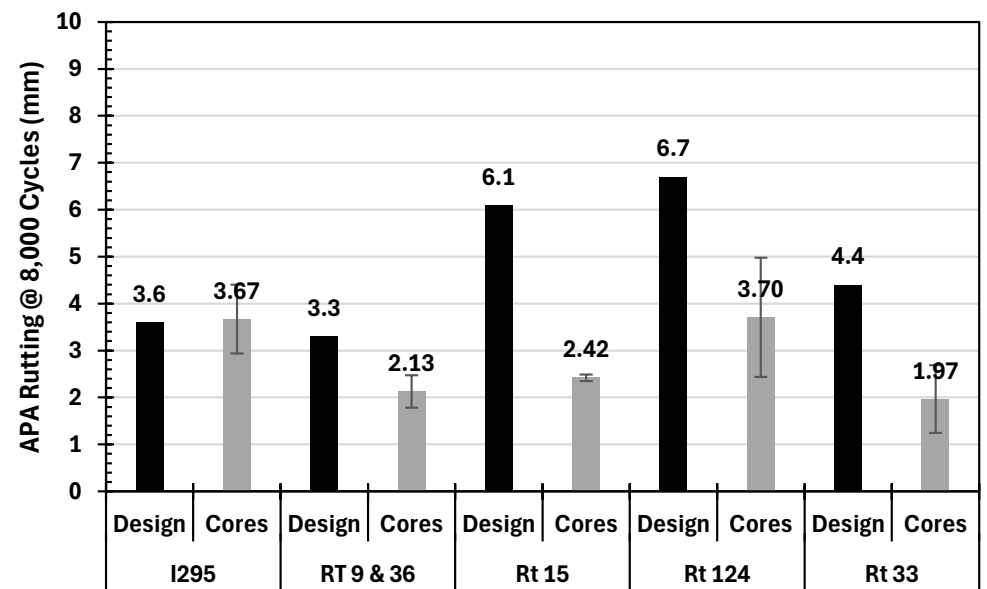
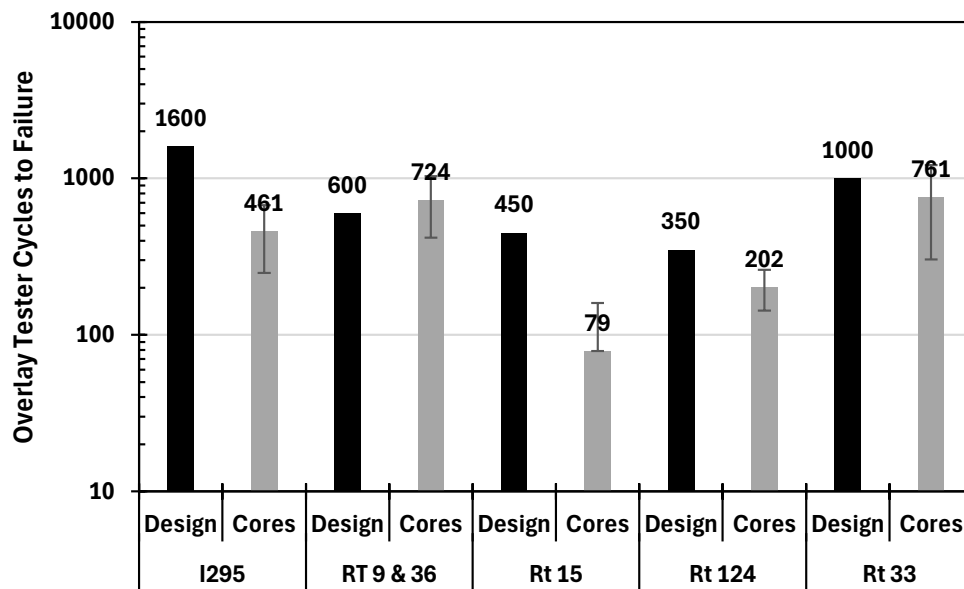
- Volumetric
 - Design AV = 4%
 - $N_{des} = 75$
 - VMA $\geq 14\%$
 - VFA 65 – 78%
 - RAP $\leq 15\%$
 - No performance test requirements



Only 3 projects with significant field performance, but projected 5 to 7 years benefit

- HRAP
 - Design AV = 4%
 - $N_{des} = 75$
 - VMA $\geq 1\%$ over Volumetric
 - VFA 65 – 85%
 - Unlimited RAP%
 - Modified binders, WMA, Recycling Agents
 - APA & OT Mix Testing

2024 Check on Mix Performance



NJDOT HRAP 2024
HRAP 2.0

NJDOT HRAP 2.0 (2024)

- Since 2015, no contractor/supplier came forward to request to utilize spec
 - Concern was regarding time requirement of test methods
- 2022 NJ Bill Proposed, *No. 4797*
 - “Increases percentage of RAP that can be used for local road projects.”
 - Up to 50% RAP in base/intermediate
 - Up to 35% RAP in surface
- Required NJDOT to rethink approach to high RAP contents

ASSEMBLY, No. 4797

STATE OF NEW JERSEY
220th LEGISLATURE

INTRODUCED OCTOBER 20, 2022

Sponsored by:
Assemblyman ROBERT J. KARABINCHAK
District 18 (Middlesex)
Assemblyman DANIEL R. BENSON
District 14 (Mercer and Middlesex)
Assemblyman ANTHONY S. VERRELLI
District 15 (Hunterdon and Mercer)

SYNOPSIS
Increases percentage of reclaimed asphalt pavement that can be used for local road projects.

CURRENT VERSION OF TEXT
As introduced.



(Sponsorship Updated As Of: 10/20/2022)

NJDOT HRAP 2.0

- Tier 1 – Volumetric
 - < 15% RAP in surface; < 25% RAP in intermediate/base
 - Direct substitution
- Tier 2 – IDT with Improved Volumetrics & Stockpiles
 - 15 to 20% RAP in surface; 25 to 35% RAP in intermediate/base
 - Designed for Local Aid
 - HT-IDT & IDEAL-CT at design, test strip and production – testing every 1400 tons
 - Increased VMA
 - RAP stockpile approval process
- Tier 3 – Existing HRAP with IDT & Stockpiles
 - Anything greater than Tier 2
 - Same at Tier 2 but requires Overlay Tester, IDEAL-CT, APA & HT-IDT during design and test strip

NJDOT HRAP 2.0

■ Stockpile Approval

- Developed to minimize production variability

Based on proposed methodology in NCHRP 9-33

Five random samples for stockpiles up to 10,000 tons

1 additional sample for every 2000 tons up to 25,000 ton max size

Tested for gradation and asphalt content AASHTO T30, T209, and T308

- Prior, no testing required of RAP

Maximum Allowable RAP and Binder Standard Deviations

RAP %	Binder Standard Deviation (maximum)
15%	0.5
20%	0.5
25%	0.5
30%	0.5
35%	0.5
40%	0.5
45%	0.5
50%	0.5

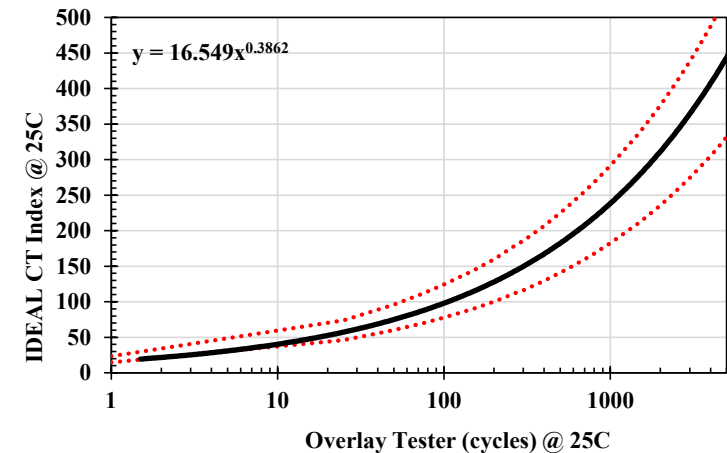
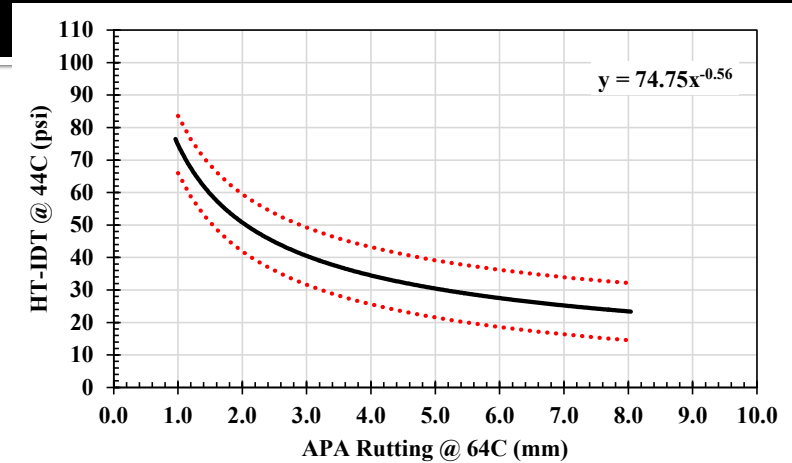
Maximum Allowable RAP and Binder Standard Deviations

RAP %	3/8" sieve Standard Deviation (maximum)	No. 4 sieve Standard Deviation (maximum)	No. 8/16 sieves Standard Deviation (maximum)	No. 30/50 sieves Standard Deviation (maximum)	No. 200 sieve Standard Deviation (maximum)
15%	9.5	8.2	7.0	5.6	3.5
20%	8.2	7.2	6.1	5.0	3.1
25%	7.2	6.4	5.5	4.5	2.8
30%	6.7	5.8	4.9	4.1	2.5
35%	6.1	5.3	4.5	3.8	2.4
40%	5.6	4.8	4.2	3.5	2.2
45%	5.2	4.5	3.9	3.2	2.0
50%	4.8	4.2	3.6	3.0	2.0

NJDOT HRAP 2.0

■ Performance Testing (BMD)

- Test specimens 6 to 7% AV
- Rutting (n = 132)
 - APA Rutting @ 64C \approx HT-IDT Strength @ 44C
- Fatigue Cracking (n = 185)
 - Overlay Tester @ 25C \approx IDEAL-CT Index @ 25C
- For 2024, if failing IDT tests, additional samples tested for Overlay Tester and APA



NJDOT HRAP 2.0

■ Performance Testing (BMD)

- Test specimens 6 to 7% AV
- Rutting (n = 132)
 - APA Rutting @ 64C ≈ HT-IDT Strength @ 44C
- Fatigue Cracking (n = 185)
 - Overlay Tester @ 25C ≈ IDEAL-CT Index @ 25C
- For 2024, if failing IDT tests, additional samples tested for Overlay Tester and APA

Table 902.16.03-2 Performance Testing Requirements for High RAP Pilot Project Design

Test	Requirement			
	Surface Course		Intermediate and Base Course	
	PG 64S-22	PG 64E-22	PG 64S-22	PG 64E-22
High Temperature IDT (psi) (ASTM D6931)	≥ 25	≥ 34	≥ 25	≥ 34
IDEAL-CT Index (ASTM D8225)	≥ 130	≥ 150	≥ 110	≥ 120

Table 902.16.04-2 Surface Course Performance Testing Pay Adjustments for High RAP Pilot Project

	Surface Course		PPA
	PG 64S-22	PG 64E-22	
High Temperature IDT (psi) (ASTM D6931)	t ≥ 25	t ≥ 34	0
	21 < t ≤ 25	25 < t ≤ 34	PG 64S-22: -(t-25)/0.08 PG 64E-22: -(t-34)/0.18
	t < 21	t < 25	-100 or Remove & Replace
IDEAL-CT Index (ASTM D8225)	t ≥ 130	t ≥ 150	0
	130 > t ≥ 120	150 > t ≥ 130	Surface PG 64S-22: -(t-130)/0.2 Surface PG 64E-22: -(t-150)/0.4
	t < 120	t < 130	-100 or Remove & Replace

NJDOT HRAP 2.0 – 2024 Projects

- 6 projects advertised for 2024 for HRAP (Tier 3)
 - 2 projects per NJDOT region (North, Central, South)
 - QC volumetric, constituent and performance testing
 - Additional materials sampled for more extensive testing
- Ex. I295, 19ME Intermediate

- ★ - Previous HRAP
- ★ - 2024 HRAP



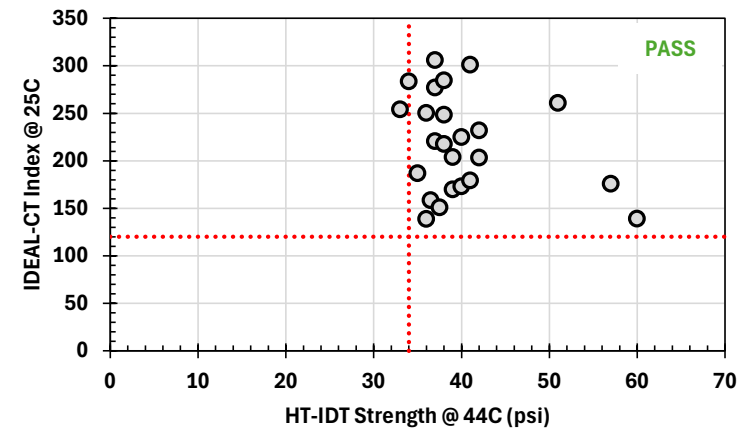
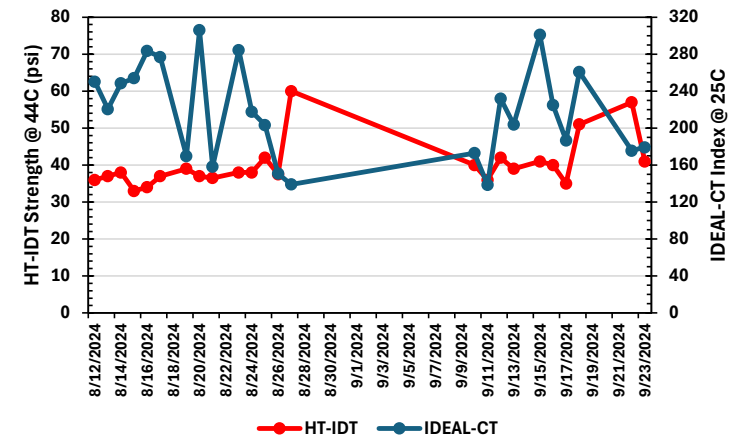
NJDOT HRAP 2.0 – 2024 Projects (I295)

- 35,000 tons surface course
 - 9.5 & 12.5mm (30% RAP)
- 50,000 tons intermediate course
 - 19mm, PG64E-22, 40% RAP
 - Fractioned RAP
 - Recycling agent @ 0.9% of mix
 - Total AC% = 4.8%
 - VMA = 14.2% (EABV = 10.2%)



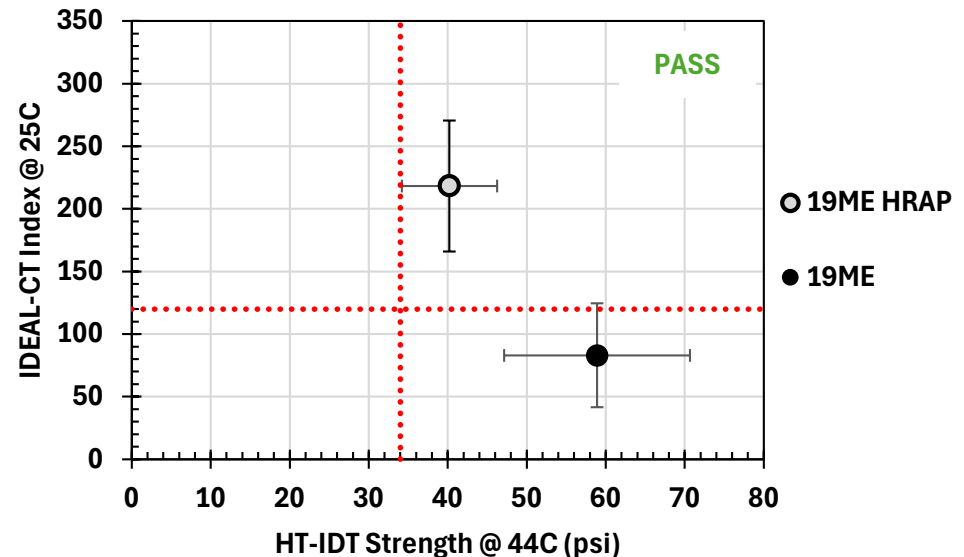
NJDOT HRAP 2.0 – 2024 Projects (I295)

- Majority of IDT performance tests met minimum requirements for 19ME
 - A few that did not, passed the APA & OT retest
- Reduction in Carbon Footprint
 - Assuming all production parameters identical
 - Saved approximately 225,000 kg CO₂eq on intermediate course alone



NJDOT HRAP – Final Thoughts

- A BMD approach was developed in 2009
 - Based on required performance to mirror 0% RAP mixes
 - Early success but needed to improve testing time
- Recent modification appears to be positive
 - 6 on-going projects in 2024
 - Additional projects proposed for 2025/2026
- Approach provides improved mixture performance with greater amounts of RAP



**As Ted Lasso reminded us..
"Be curious, not judgmental..."**



Thank you for your time!

Thomas Bennert, Ph.D.
Center for Advanced Infrastructure and Transportation (CAIT)
Rutgers University
bennert@soe.rutgers.edu
609-213-3312