

Research on More Environmentally Friendly Asphalt Pavements in NJ

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

October 2024



Acknowledgements

- NJDOT
 - Robert Blight, Narinder Kohli, Nusrat Morshed, William Kettleson
 - Ed Inman, Stevenson Ganthier, Mark Gillece, Ryan Rathbun, Ed Colligan, *Eileen Sheehy, Robert Sauber*
- PANYNJ
 - Darius Pezeshki, John Tetar
- Rutgers Asphalt Lab/CAIT Staff
 - Michael Boxer, Richard Chui, Christopher Ericson, Edwin Haas, Shelby Maigis, Jake Tulanowski, Hao Wang, Edward Wass Jr.
- Industry
 - *Frank Fee, Ron Corun, Mike Worden, Wayne Byard, Mike Jopko*

Getting Back to Basics

- Need to get back to basics, AASHTO P₁



The image shows the cover of a book titled "Standard Specifications for Transportation MATERIALS and Methods of Sampling and Testing and AASHTO Provisional Standards 2024 | 44th Edition". The cover is dark red with a grid of the word "MATERIALS" in white and yellow text. A photograph shows a person's hand holding a tray of white aggregate material. The text "NOW AVAILABLE!" is in yellow. The AASHTO logo is in the bottom right corner.

MATERIALS MATERIALS
ATERIALS MATERIALS
TERIALS MATERIALS
ERIALS MATERIALS
RIALS MATERIALS
IALS MATERIALS
ALS MATERIALS
LS MATERIALS
S MATERIALS
MATERIALS
ATERIALS
TERIALS
ERIALS
R

NOW AVAILABLE!

Standard Specifications for Transportation
MATERIALS
and Methods of Sampling and Testing
and AASHTO Provisional Standards
2024 | 44th Edition

AASHTO

Getting Back to Basics

- Need to get back to basics, AASHTO P₁
 - *Standard Practice of Applying Common Sense to Transportation Engineering Problems and Issues*



“Sustainability”

■ Sustainability ≠ Recycling

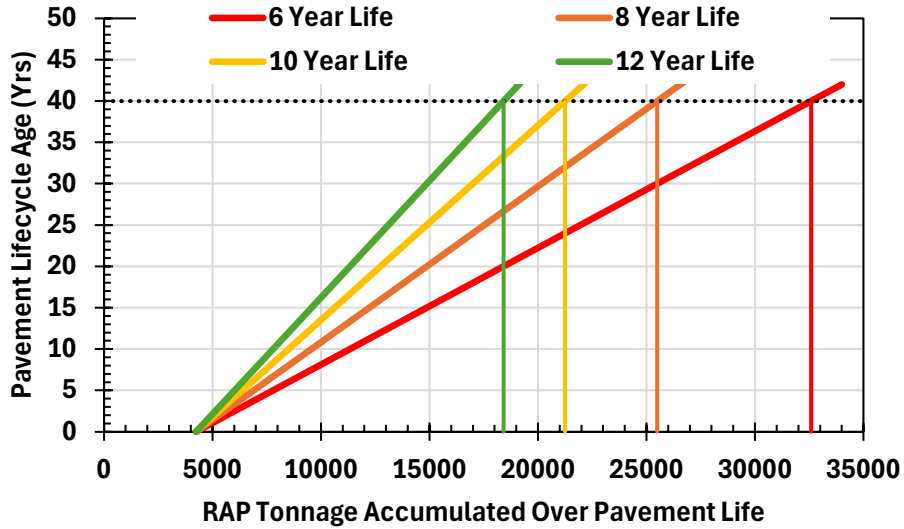
- Sustainability is the concept of maintaining something at a certain rate for a period of time (i.e. – resources, infrastructure, etc) – a social goal over a long period of time!
 - Longer pavement life will equate to lower RAP production and lower Global Warming Potential (GWP) over the life cycle of the pavement

■ Example:

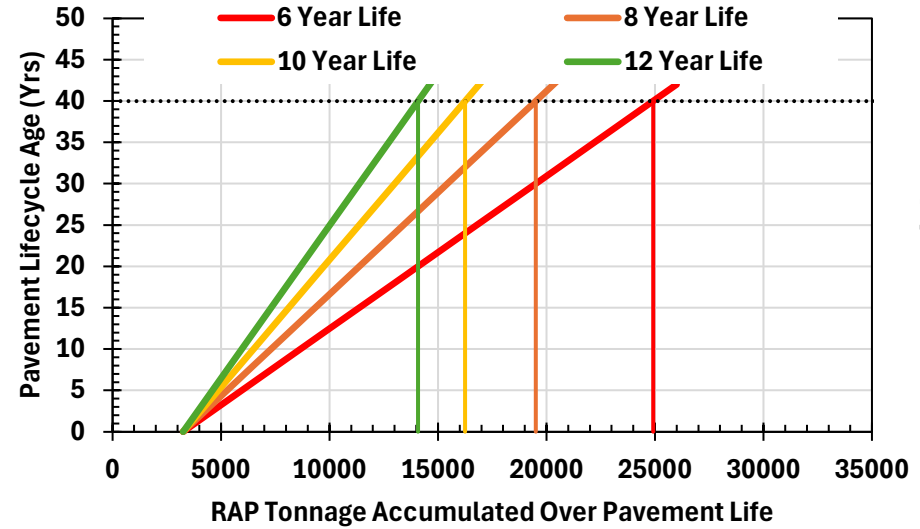
- 5000 ton paving project
 - Assuming all production and construction practices the same
 - Except changing RAP contents (assuming direct substitution – no other changes/additives)
 - Within the context of **40 year life cycle** before pavement needs to be reconstructed
- From NAPA EPD website, NJ is rather consistent with RAP EPD impact
 - For every 1% RAP, 0.3 to 0.4 kg CO₂ eq per ton of HMA
 - Ex. – NJ Asphalt Supplier:
 - 15% RAP = 54.37 kg eqCO₂ per ton HMA
 - 25 % RAP = 50.38 kg eqCO₂ per ton HMA

Impact of Pavement Life on RAP Production

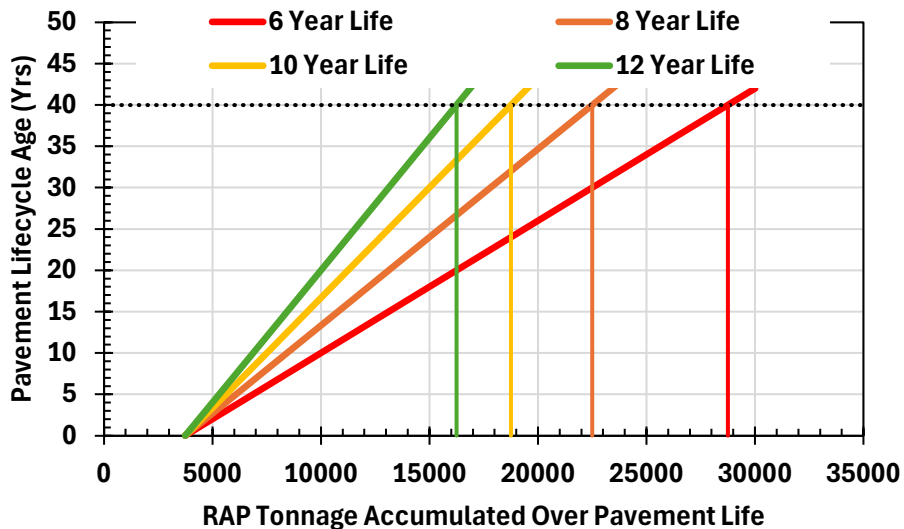
15% RAP



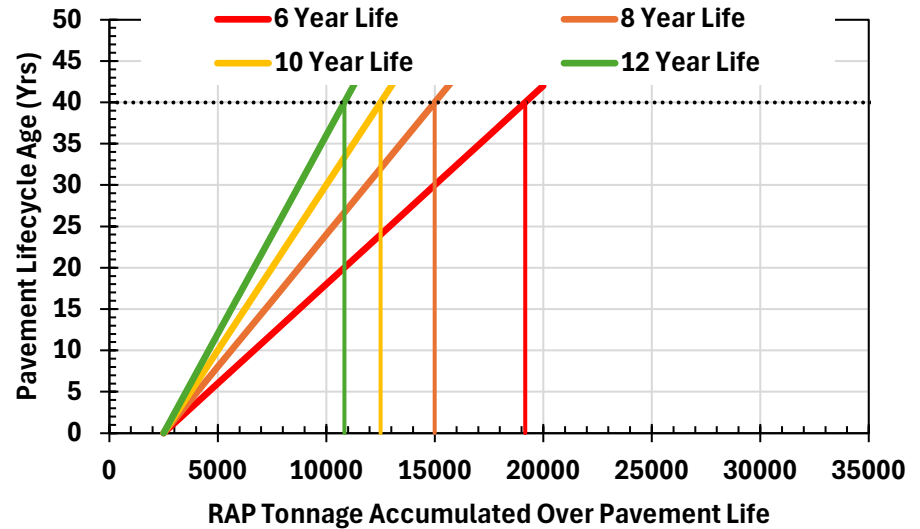
35% RAP



25% RAP

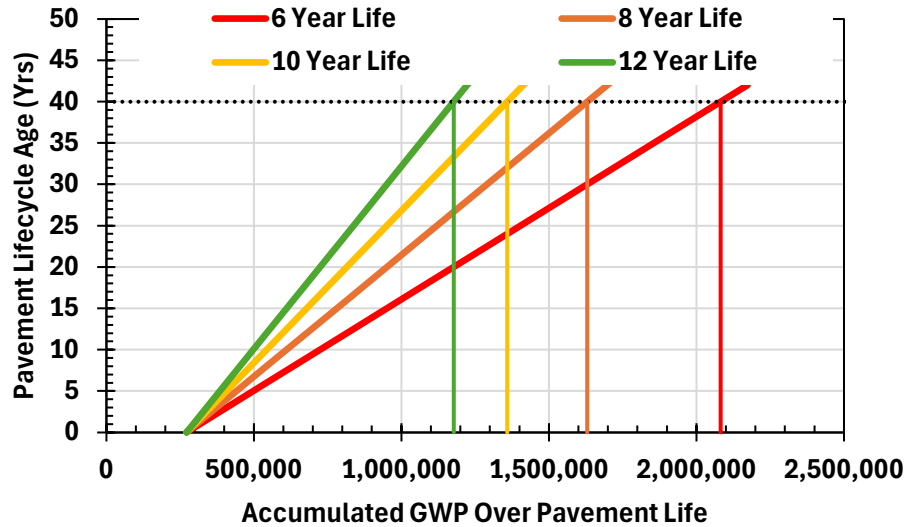


50% RAP

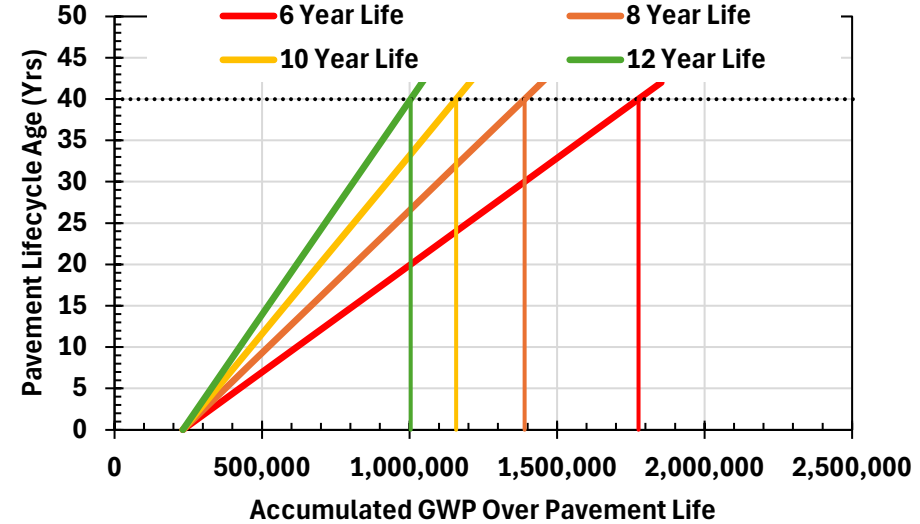


Impact of Pavement Life on GWP Production

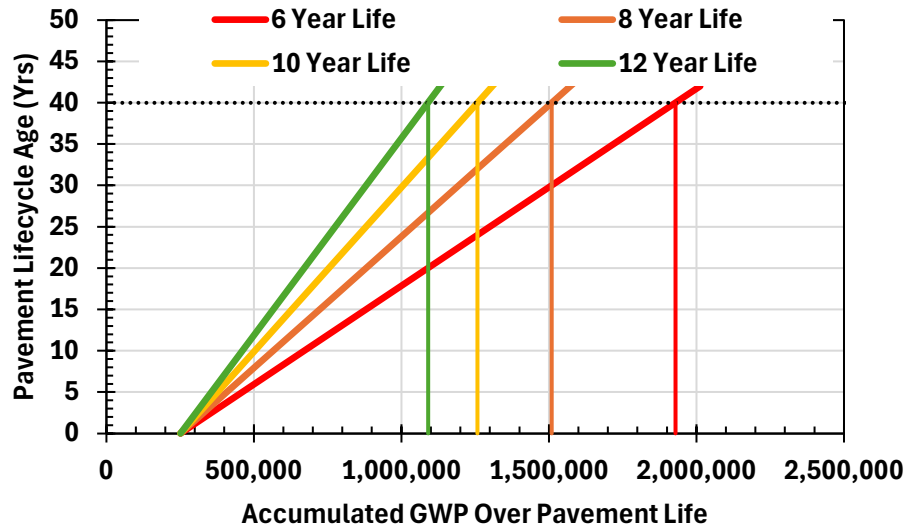
15% RAP



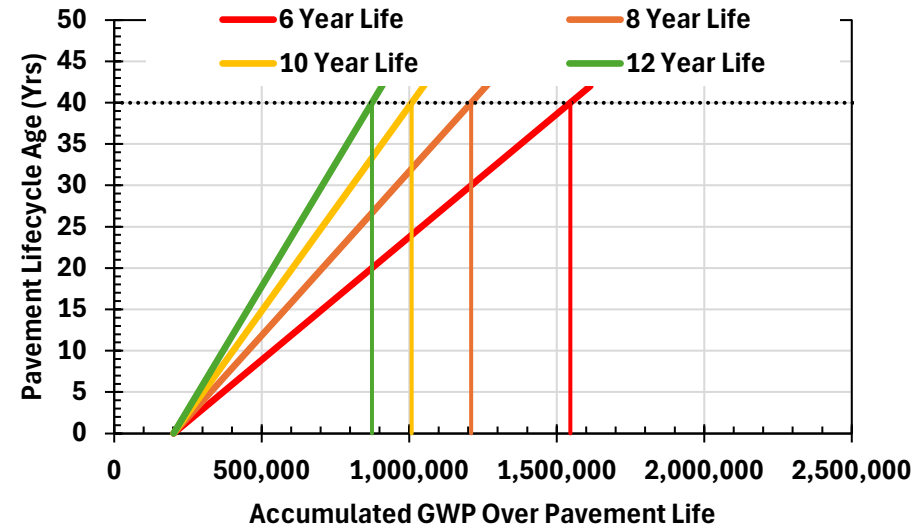
35% RAP



25% RAP



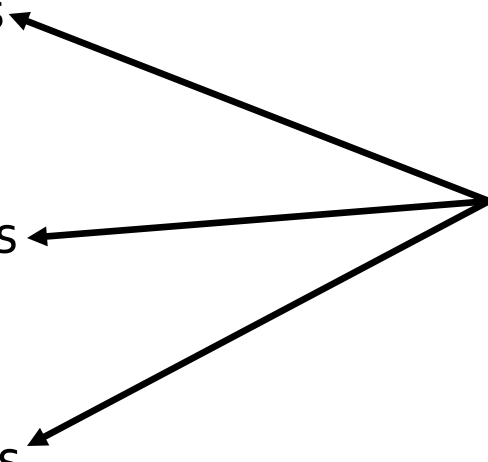
50% RAP



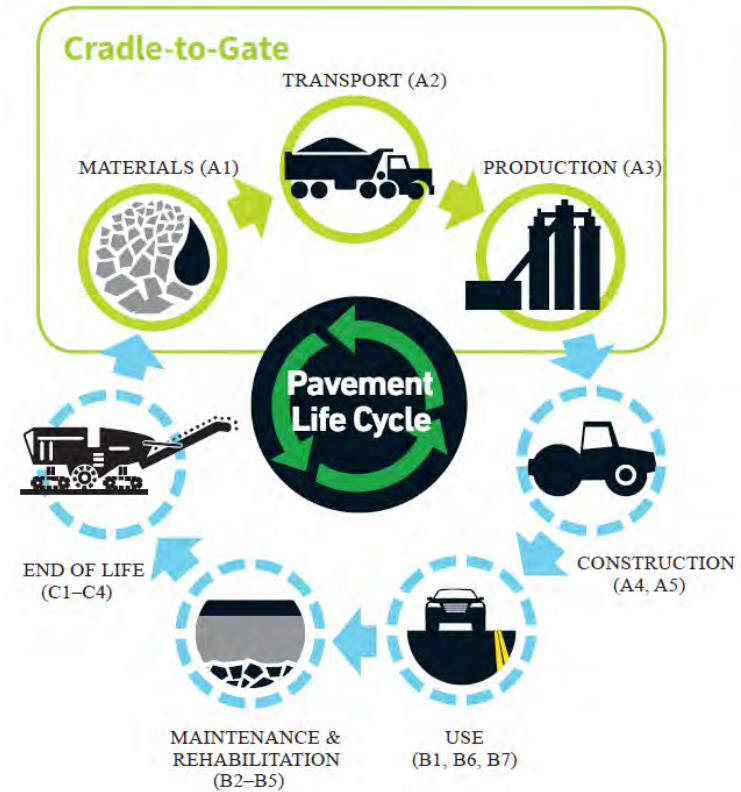
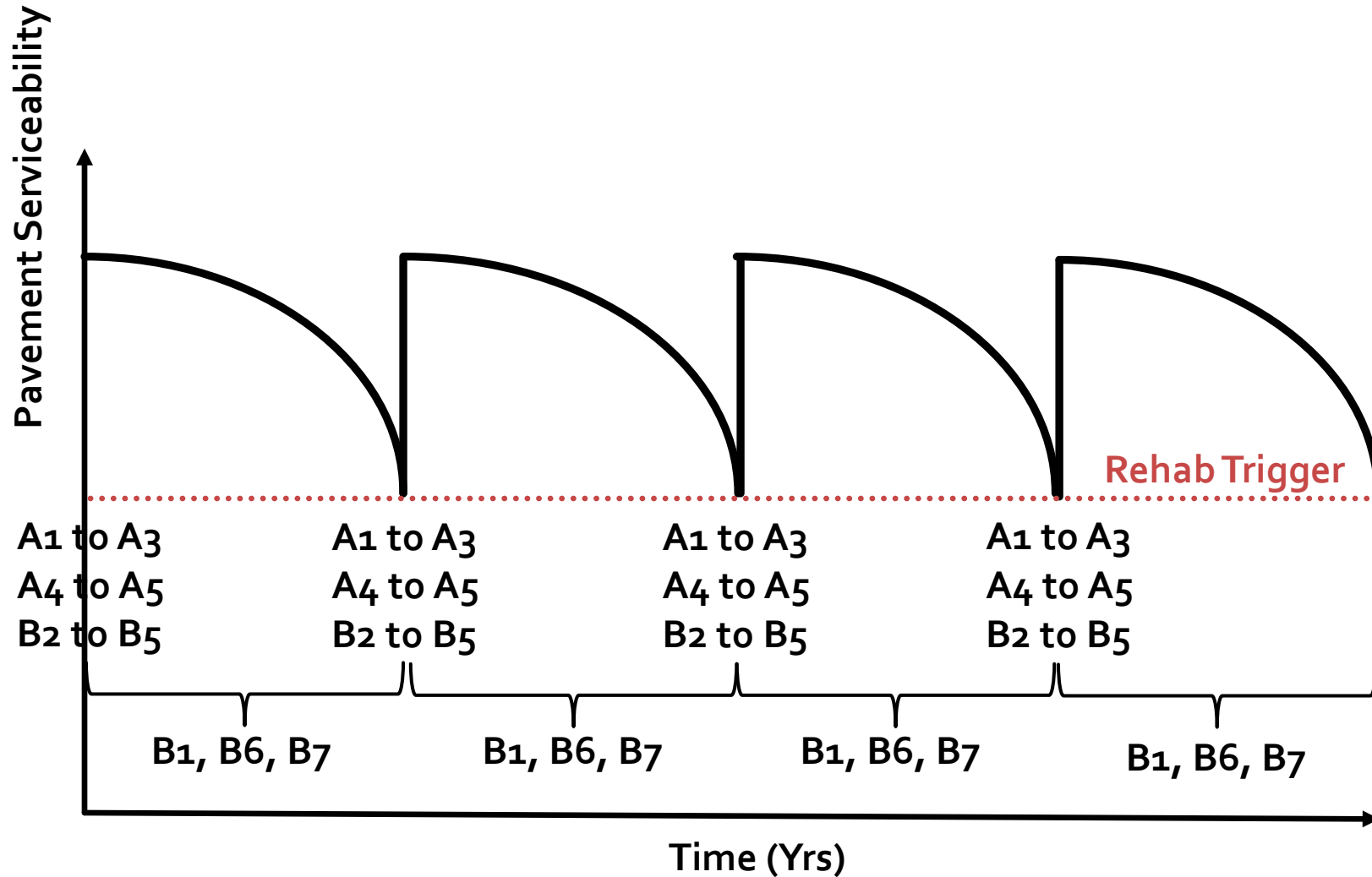
Impact of Pavement Life on GWP Production

- Extending the pavement life is actually more critical than increasing RAP content with respect to RAP & GWP production
 - 15% RAP, 12 Year
 - 18,416 tons of RAP produced in 40 Years
 - 1,177,150 kg of CO₂eq produced in 40 Years
 - 25% RAP, 10 Year
 - 18,875 tons of RAP produced in 40 Years
 - 1,258,250 kg of CO₂eq produced in 40 Years
 - 50% RAP, 6 Year
 - 19,166 tons of RAP produced in 40 Years
 - 1,545,983 kg of CO₂eq produced in 40 Years
- In essence, the more times the road needs a rehabilitation, you will be generating more RAP and GWP!

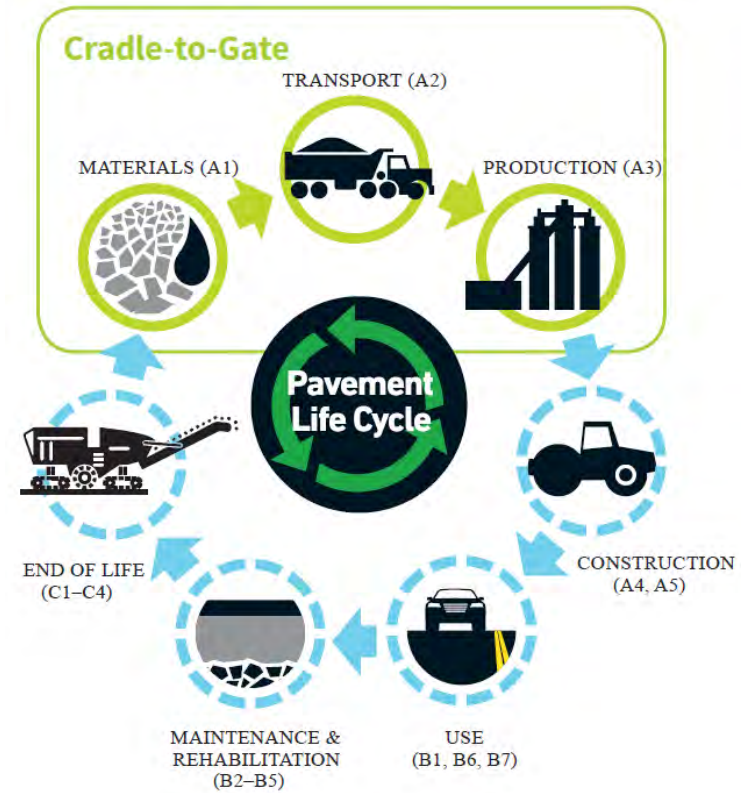
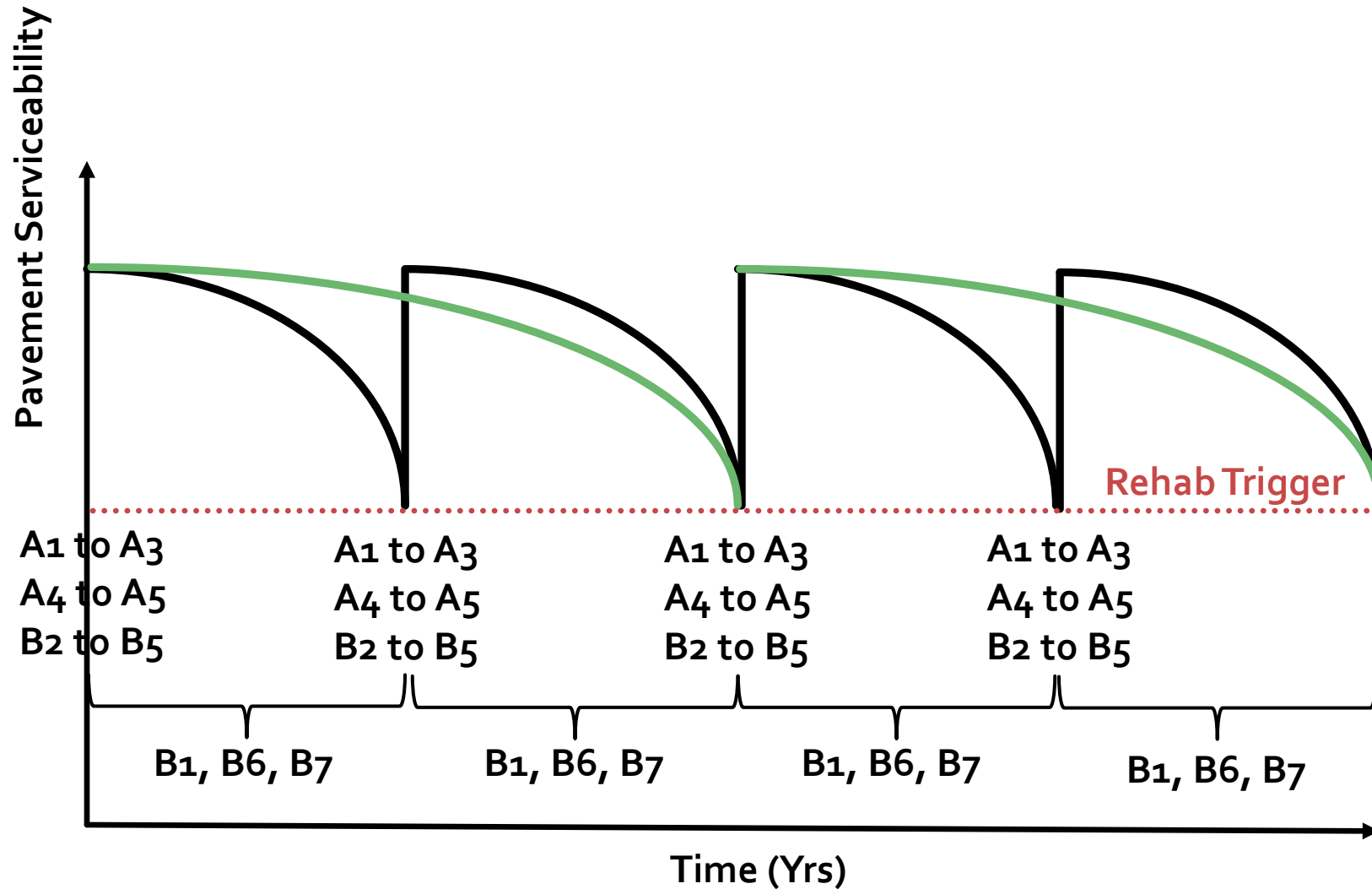
Just based on production!
Does not consider extra GWP
generated during additional
construction/trucking operations
from additional rehabilitation needs



Pavement Life Cycle

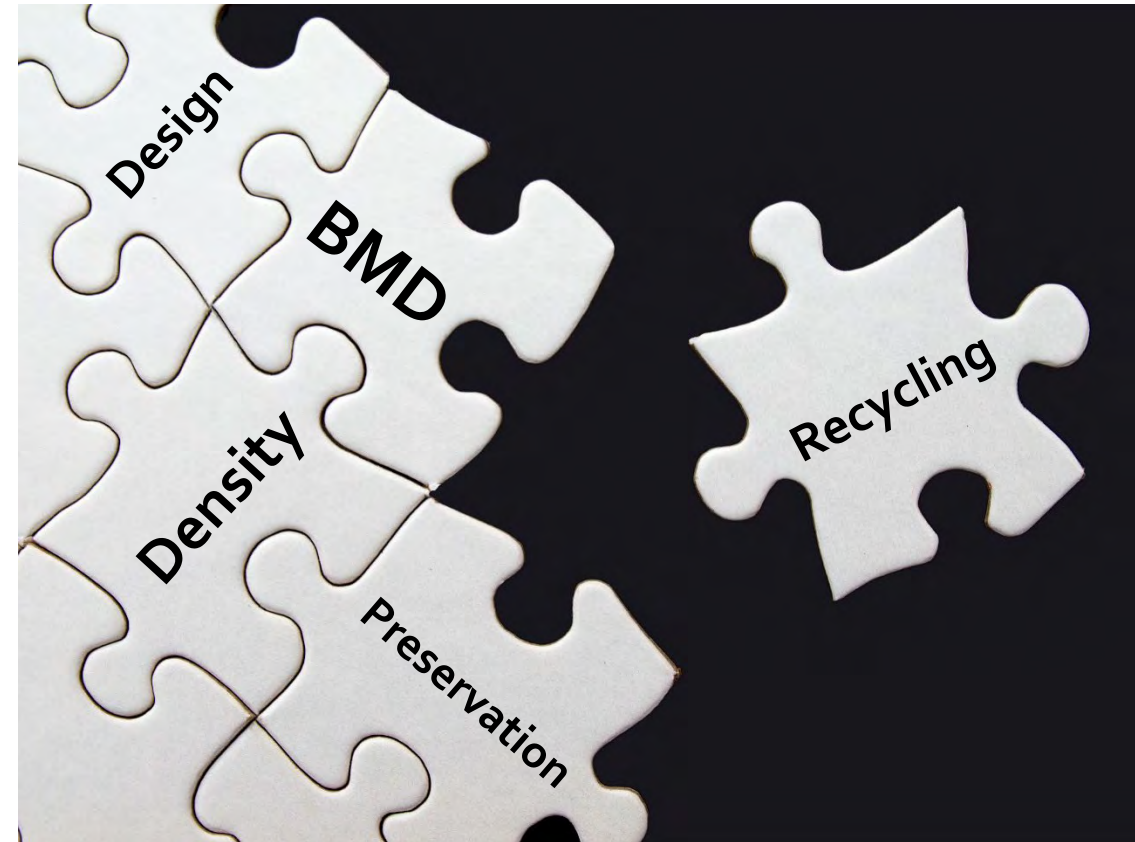


Pavement Life Cycle



Environmentally Friendly Pavements

- Materials
 - Recycled materials
 - Performance-based design (BMD)
 - HiMA
 - Anti-oxidants for asphalt
 - Synthetic binders
- Design
 - PAVEMENT-ME
 - Perpetual pavements
 - Pavement Preservation
- Construction
 - Impact of air voids/compaction
 - Bonding of pavement layers

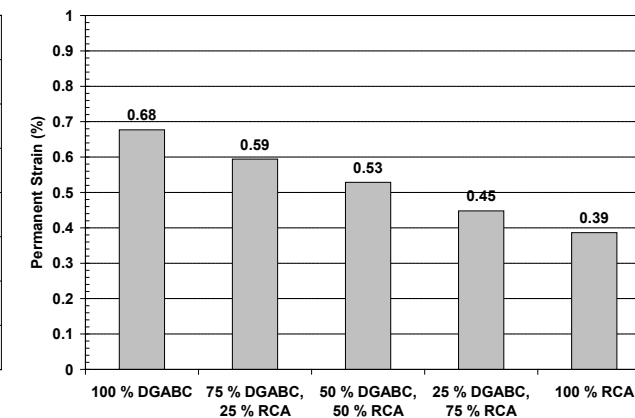
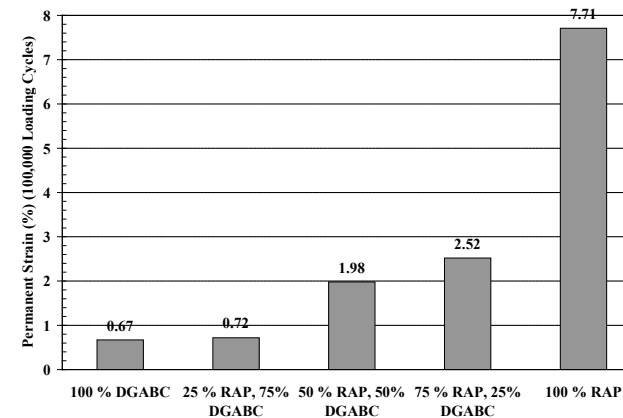
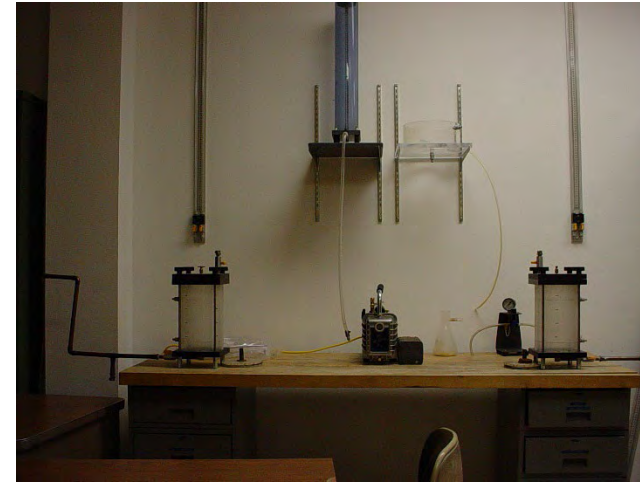


Environmentally Friendly Pavements

Materials

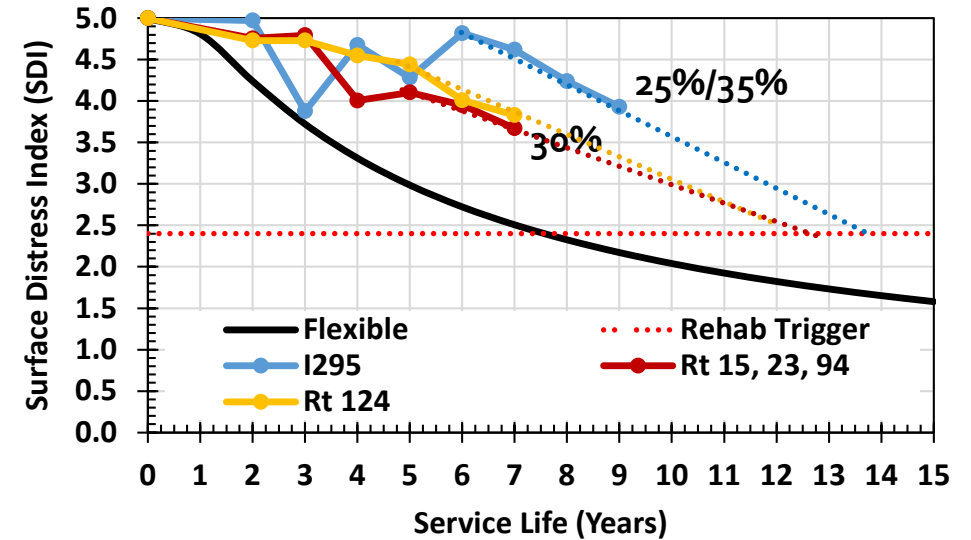
Recycled Materials – Base Aggregate

- NJDOT allows recycled concrete aggregate, RCA (100% replacement) and RAP (50% replacement) in substitution of dense graded aggregate base course (DGABC)
 - RCA base aggregate material of choice

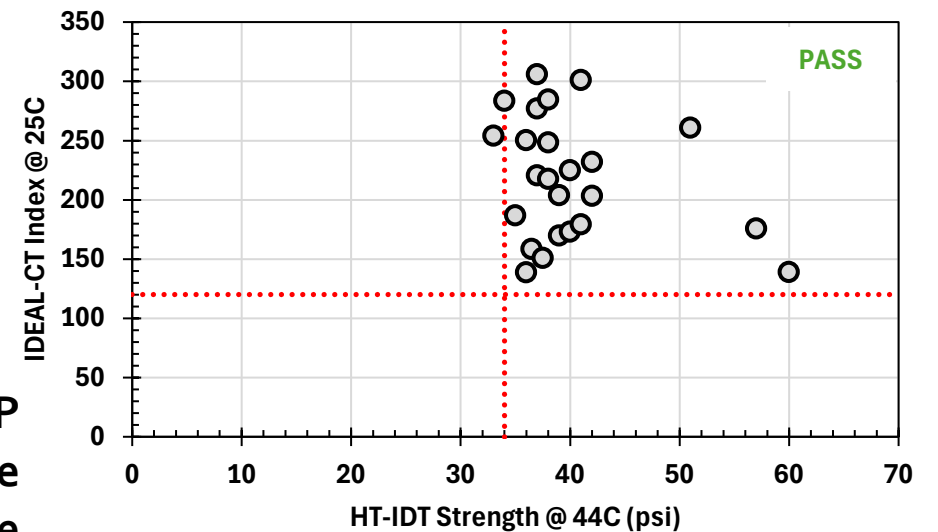


NJDOT HRAP Specification

- Performance-based approach using criteria established for 0% RAP mixes
 - Overlay Tester for cracking
 - APA for rutting
 - IDT testing in 2024 projects
 - Improved volumetrics to ensure enough effective binder
 - Can use softer binder, recycling agents, etc – just as long the final mixture performance meets requirements

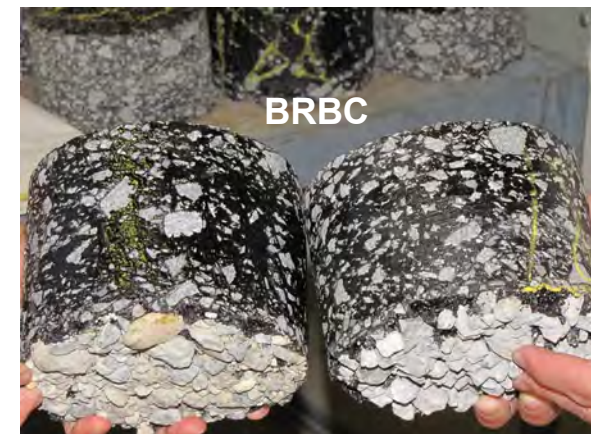
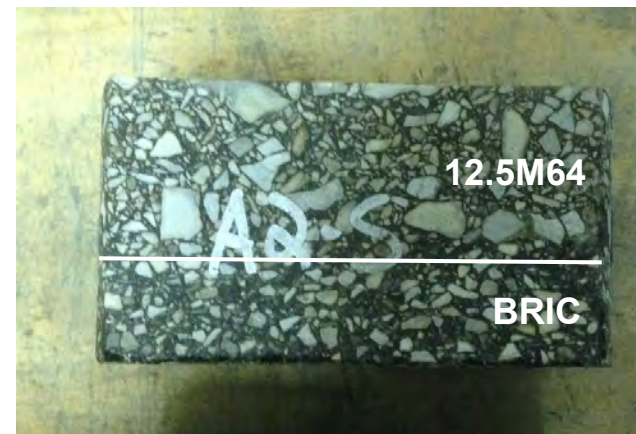
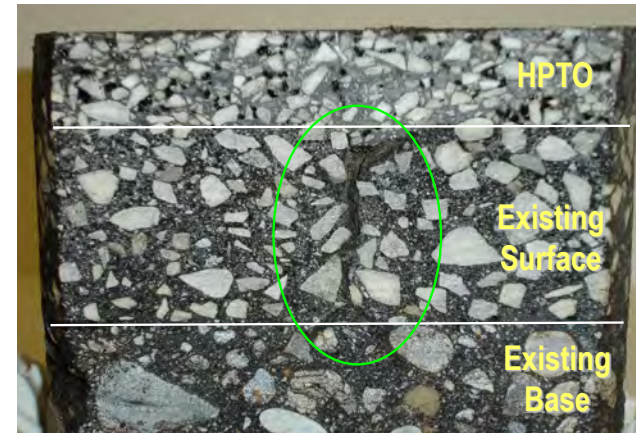


40% RAP
Intermediate
Course

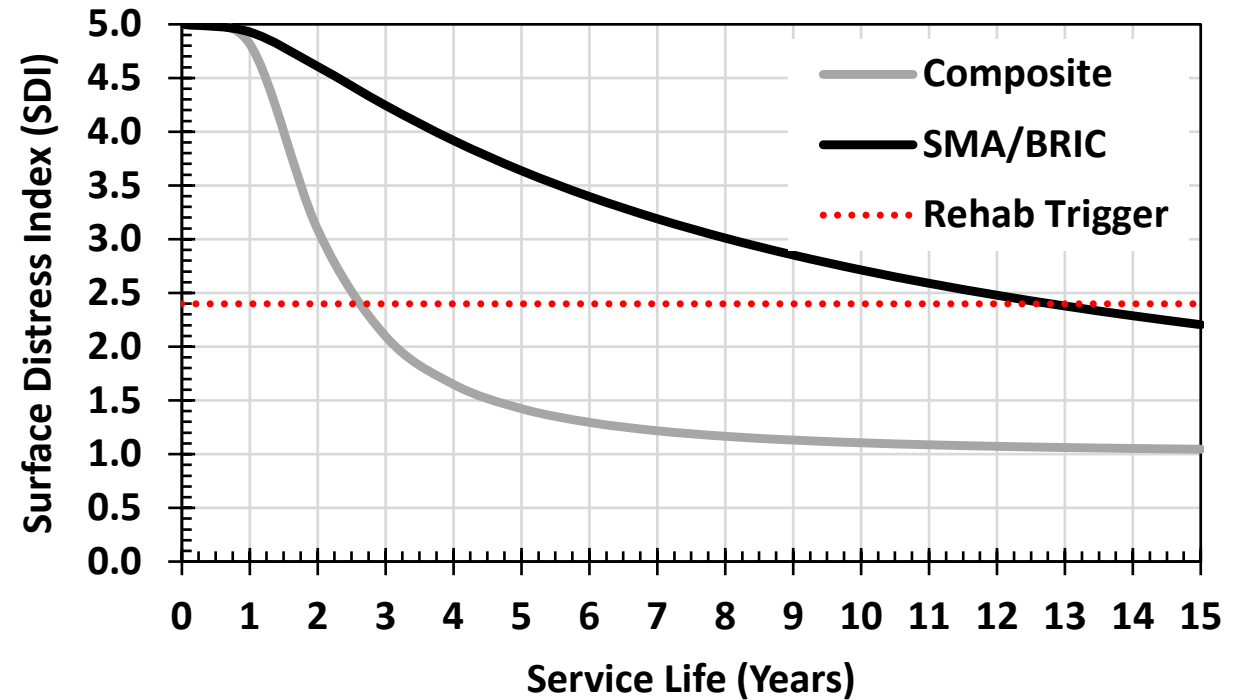
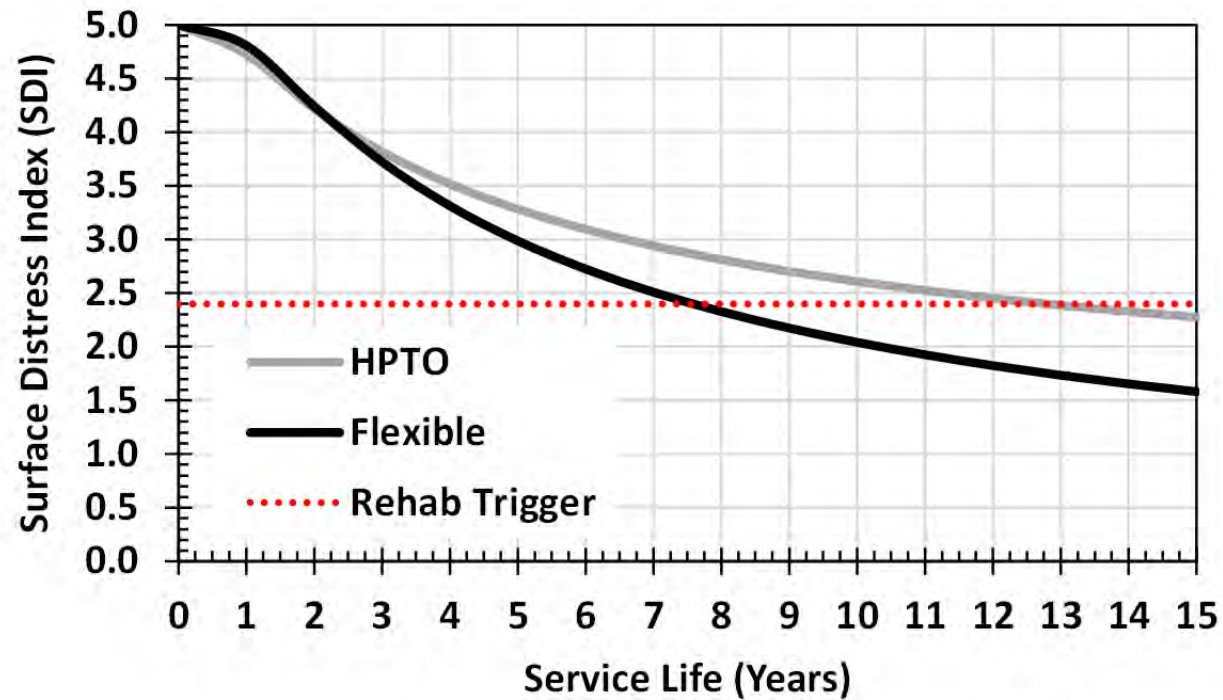


NJDOT Performance-Based Mixes (BMD)

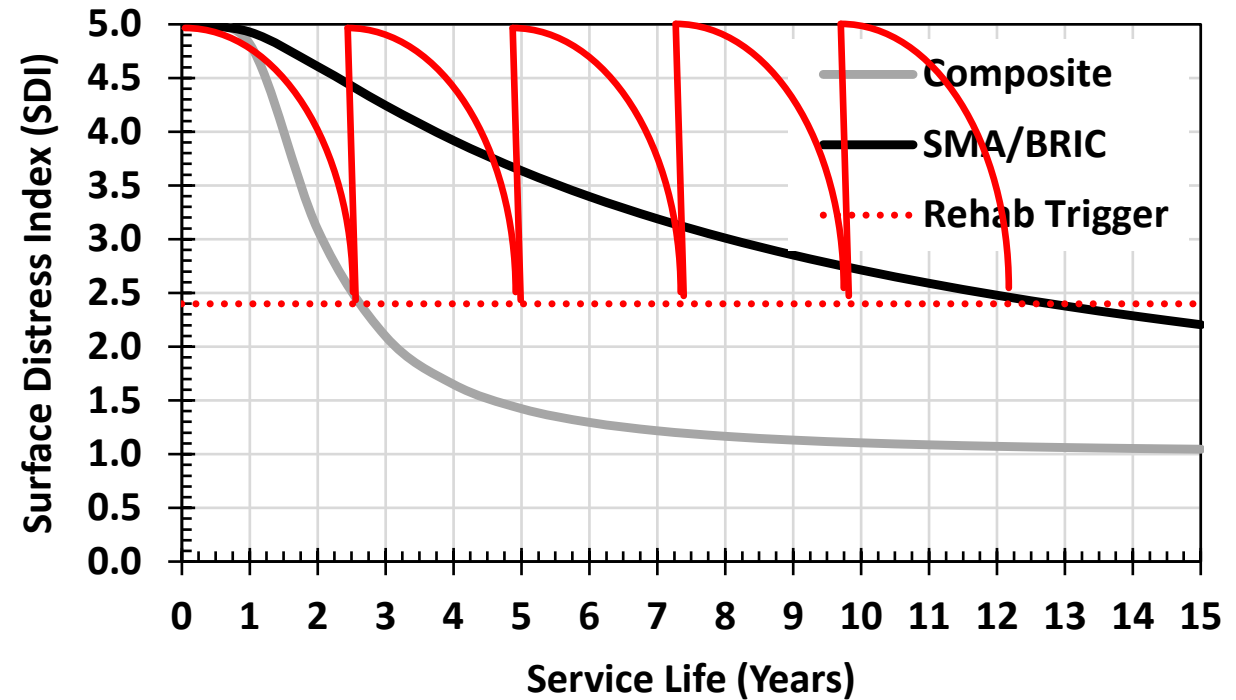
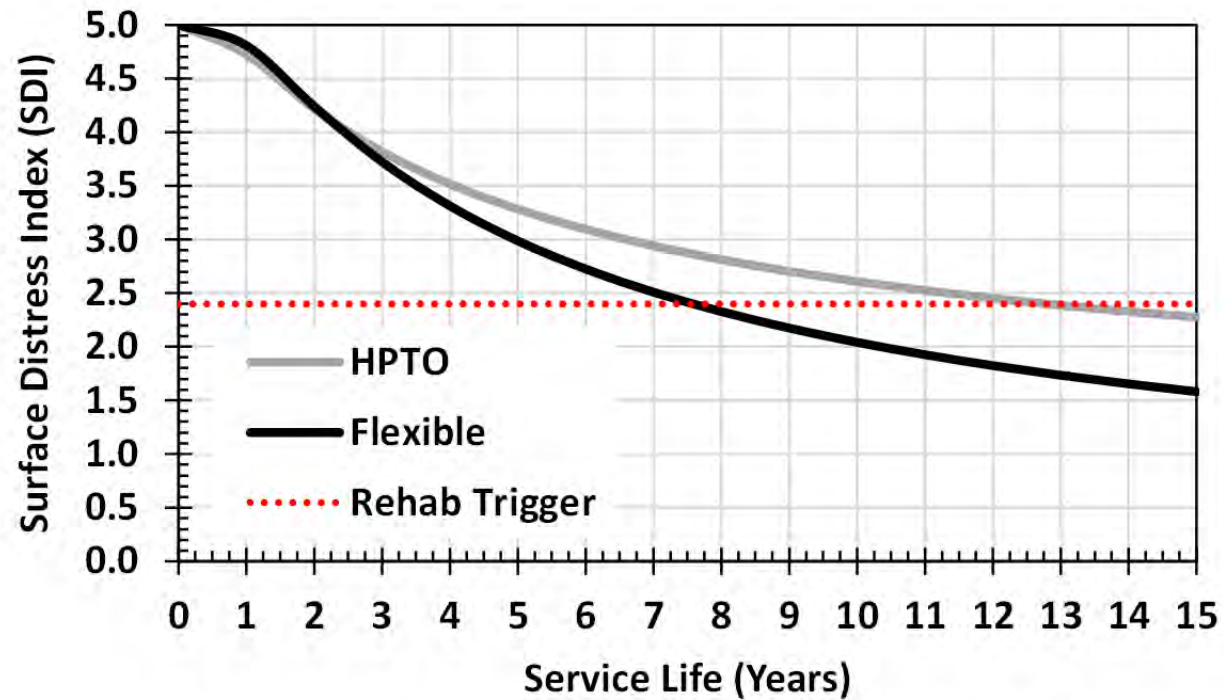
- From 2005 to 2010, developed asphalt mixtures for targeted pavements/conditions
 - Thin-lift applications
 - Bridge deck resurfacing/preservation
 - Composite pavements
 - Perpetual pavements
- Selecting the right mix for the right location at the right time!
 - Different test modes and criteria



NJDOT Performance-Based Mixes (BMD)

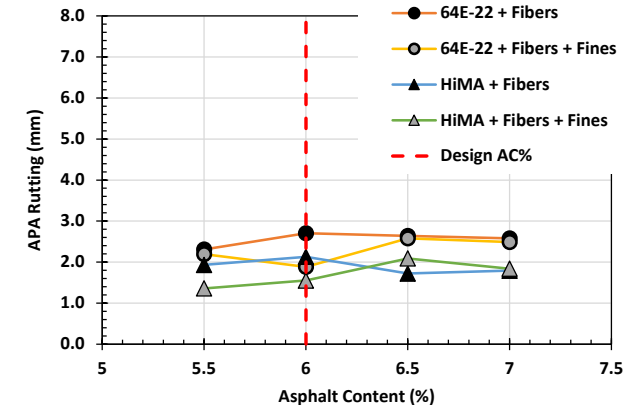
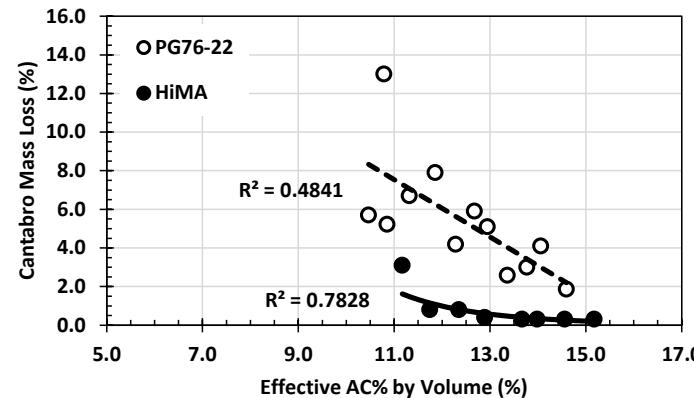
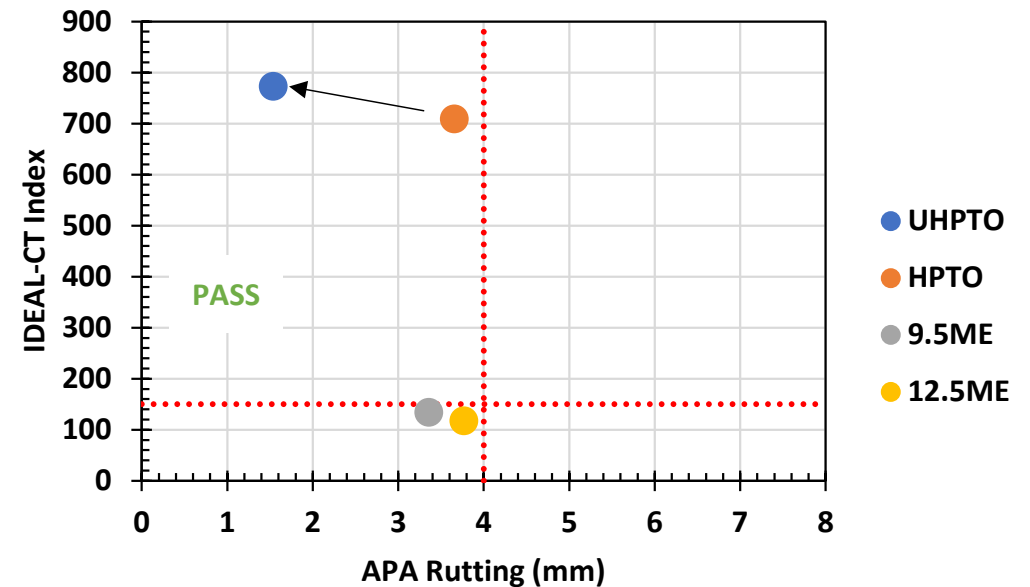


NJDOT Performance-Based Mixes (BMD)



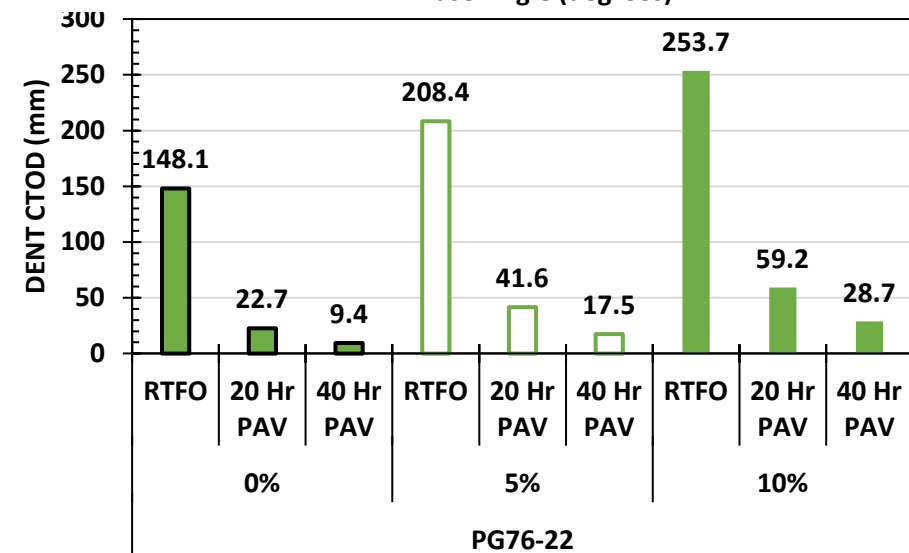
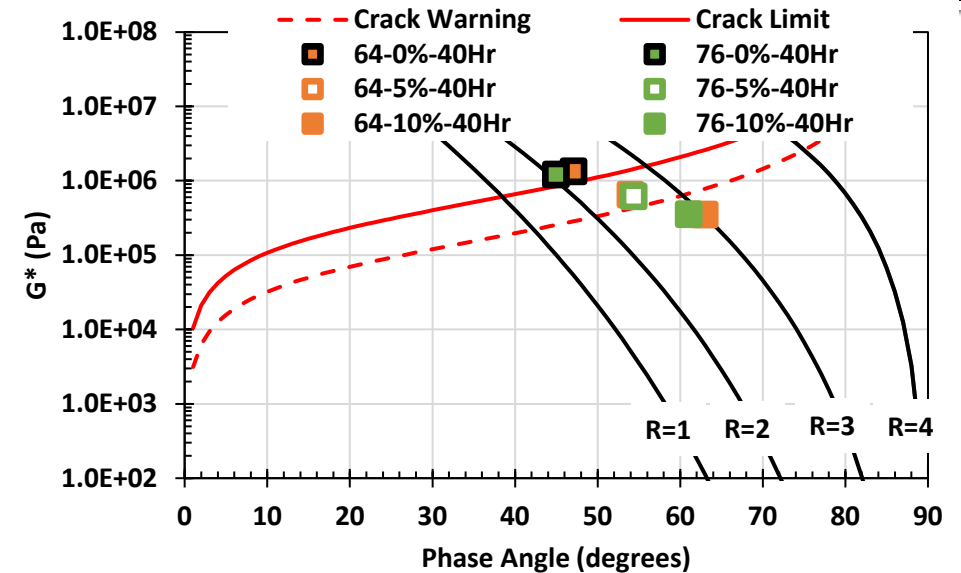
NJDOT's HiMA Efforts

- Understanding potential for better performance, NJDOT looking at HiMA in thin lifts (HPTO)
- On-going research into use in OGFC materials
 - Noise-reducing; reduce splash & spray; evidence filters runoff
 - Stopped use due to winter maintenance and durability issues



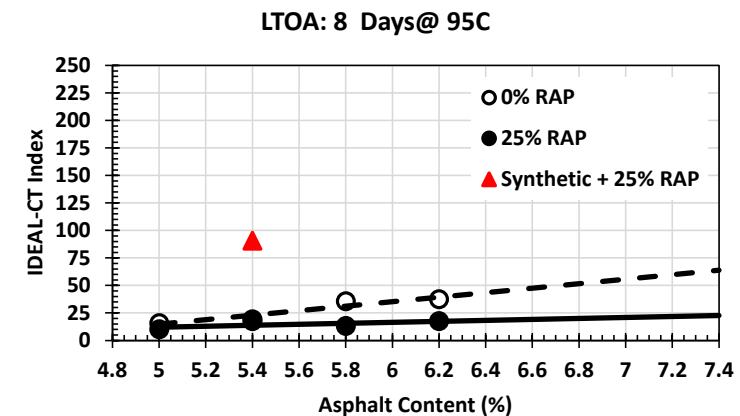
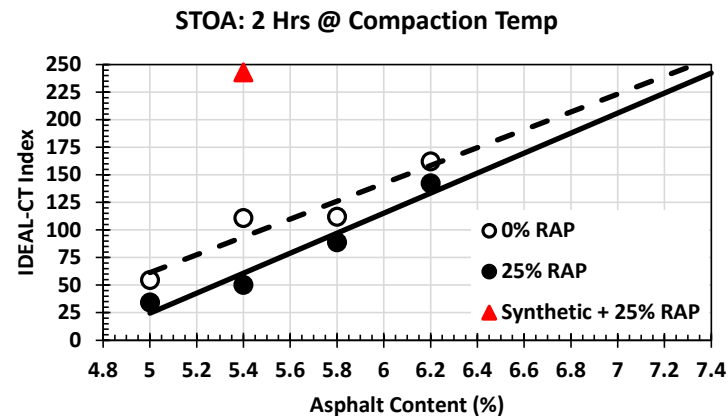
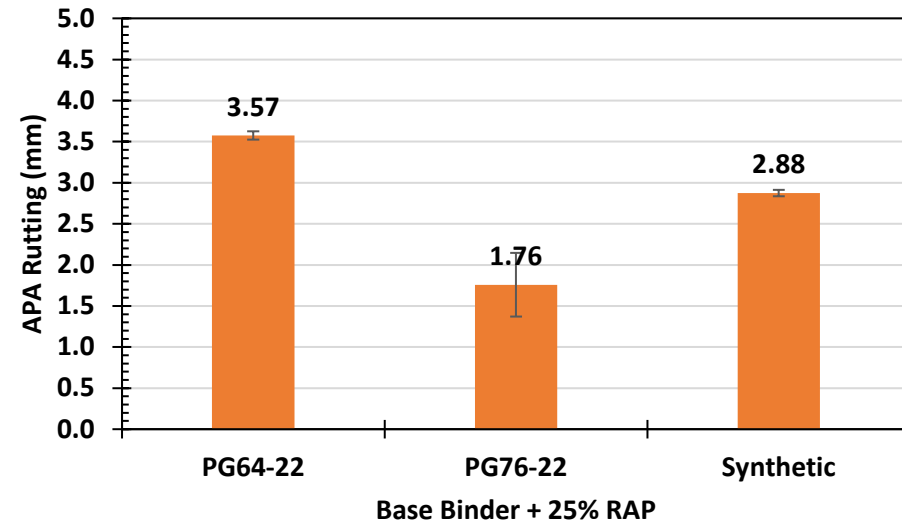
Anti-oxidants for Asphalt?

- Can the aging of asphalt materials be lessened?
 - Additives developed to reduce the impact of oxidative aging on asphalt
 - Increase fatigue life and improved durability
 - Donate or accept free radicals
 - Decompose hydroxides to stable sulfides



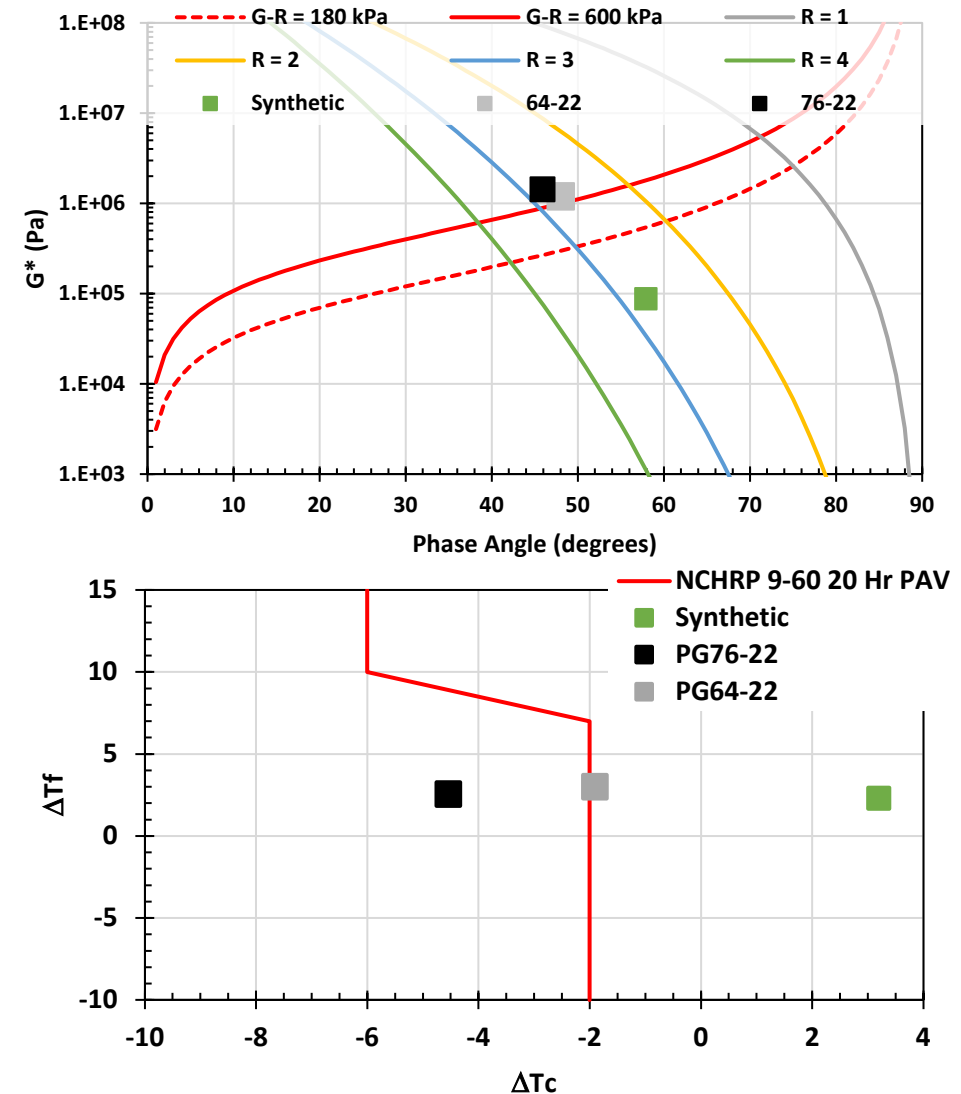
Synthetic Binders (Non-petroleum Based Binders)

- Can we reduce the amount of petroleum-based binders for a renewable resource?
 - Synthetic binder evaluated sequesters atmospheric carbon
 - Actually classified as a negative carbon footprint
 - Improved asphalt mixture and recovered binder performance of 25% RAP mix



Synthetic Binders (Non-petroleum Based Binders)

- Can we reduce the amount of petroleum-based binders for a renewable resource?
 - Synthetic binder evaluated sequesters atmospheric carbon
 - Actually classified as a negative carbon footprint
 - Improved asphalt mixture and recovered binder performance of 25% RAP mix

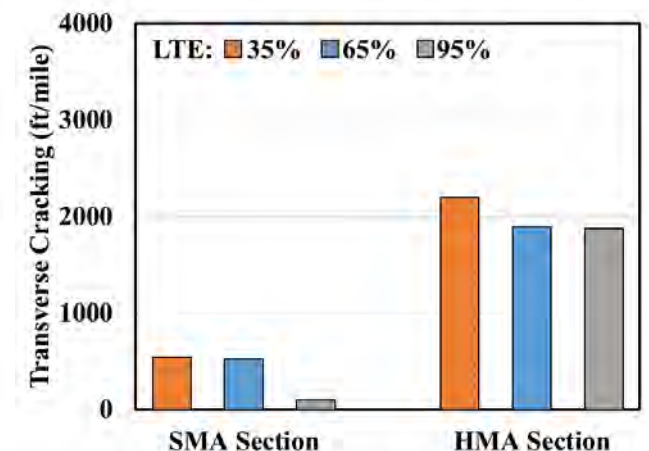
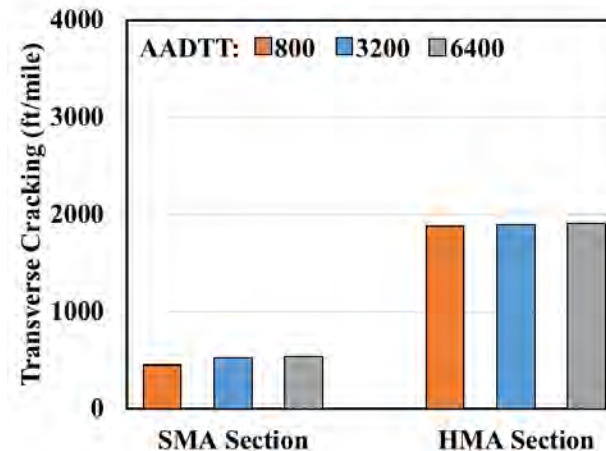
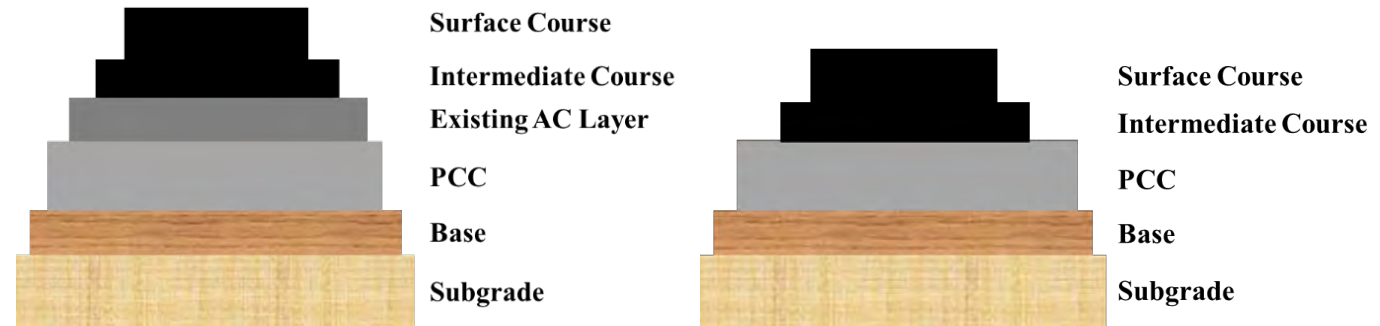


Environmentally Friendly Pavements

Pavement Design and Preservation

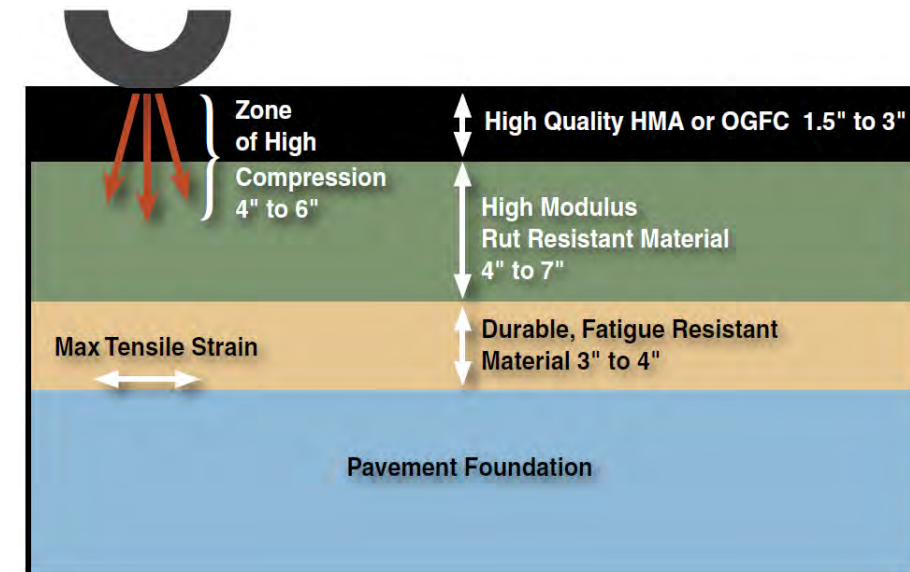
PAVEMENT-ME Research

- PAVEMENT-ME is just not a pavement design method, but a pavement performance prediction
 - Can be used as lifecycle assessment (if calibrated properly)
- Significant efforts in calibrating and implementing system
 - Traffic families
 - Materials catalog
 - Flexible and composite pavement calibration
 - HMA and SMA



Perpetual Pavement Design

- Aging concrete pavements, when applicable, rubblized
- Utilized as base aggregate course for perpetual pavement design
 - Option #1
 - Design and construct the pavement to achieve a high stiffness, resulting in a pavement structure with minimal deflections/strains
 - Traditionally done with excessive thickness and cement treated base/subbase and subgrades
 - Option #2
 - Design/construct the asphalt materials, especially the base course, to be strain tolerant (i.e. – design the asphalt material to bend without cracking under resultant tensile strains)



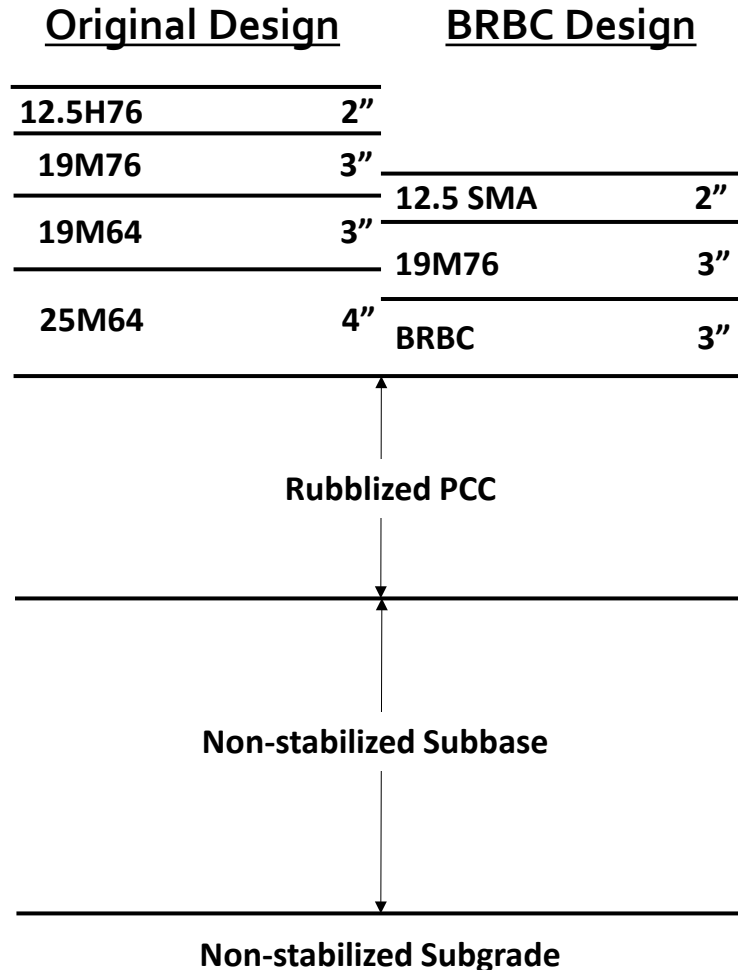
Perpetual Pavement Design – NJDOT's "Design Role Reversal"

- Evaluated maximum tensile strain with selected HMA thickness over rubblized PCC
 - Used JULEA software – same in MEPDG
- Used methodology in NCHRP Report 646
- Conduct flexural beam fatigue at 400 and 800ms
 - 3 samples each
- Use 95% confidence interval with a selected # of repetitions
 - Designing HMA to meet pavement performance needs – "Role Reversal"



Perpetual Pavement Design – NJDOT's Bituminous Rich Base Course (BRBC)

- Volumetric
 - Design AV = 4%
 - $N_{des} = 75$
 - VMA $\geq 13\%$
 - VFA 65 – 78%
 - RAP $\leq 25\%$
 - No performance test requirements



- BRBC
 - Design AV = 3.5%
 - $N_{des} = 50$
 - VMA $\geq 13.5\%$
 - No RAP
 - PG76-28
 - APA Rutting $\leq 5.0\text{mm}$
 - Flexural Beam Fatigue (Based on project needs)

Example: NJ I295, MP45 to 57.3; 23 Overpass Structures Requiring Undercutting

Bituminous Rich Base Course (BRBC)

- Volumetric
 - Design AV = 4%
 - $N_{des} = 75$
 - VMA $\geq 13\%$
 - VFA 65 – 78%
 - RAP $\leq 25\%$
 - No performance test requirements



- BRBC
 - Design AV = 3.5%
 - $N_{des} = 50$
 - VMA $\geq 13.5\%$
 - No RAP
 - PG76-28
 - APA Rutting $\leq 5.0\text{mm}$
 - Flexural Beam Fatigue (Based on project needs)

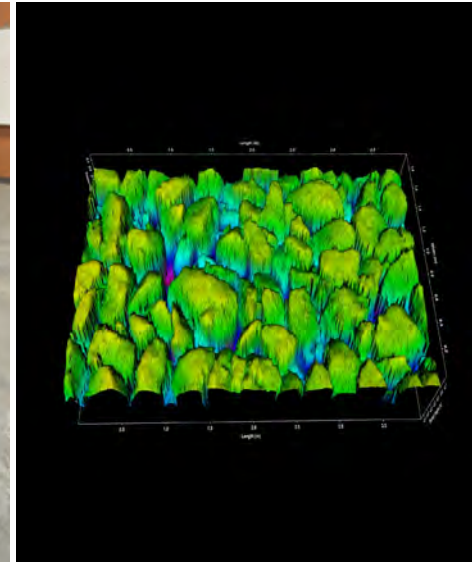


Project Saved:

- Over 170,000 tons HMA
- Over 2700 round trips of delivery trucks
- Approximately \$7 million

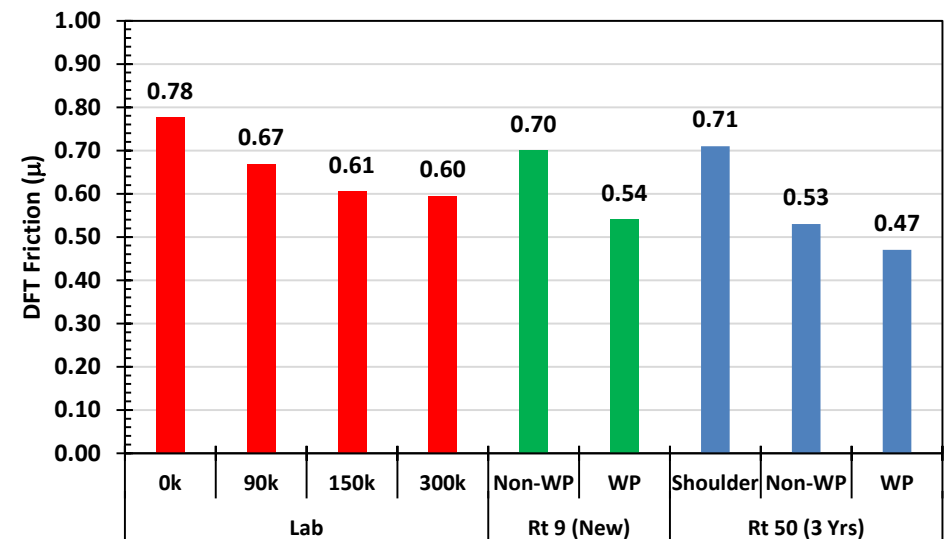
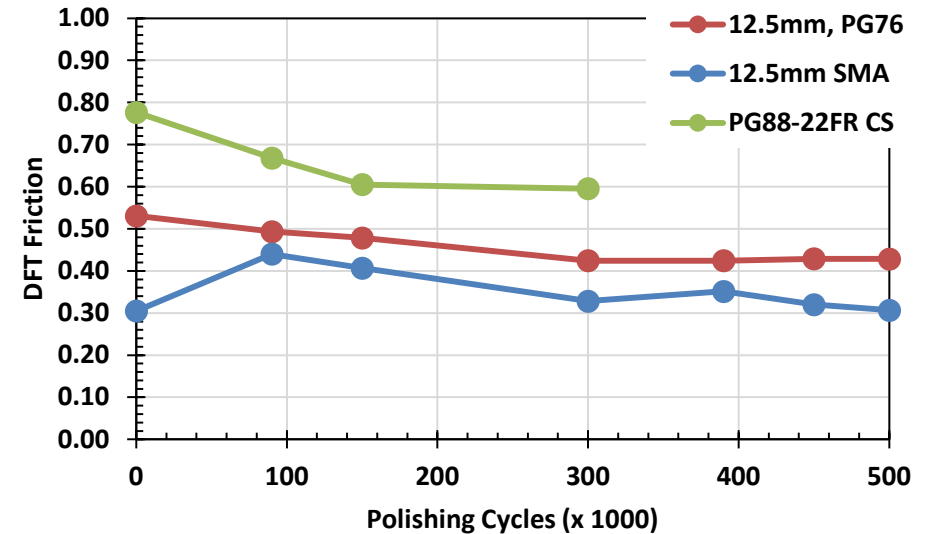
Pavement Preservation

- NJDOT has a robust pavement preservation program
 - Micro-surface, chip seals, slurry seals, HPTO
 - Maintaining “good” pavements in “good” condition
- Developing a chip seal for greater durability under heavier traffic conditions
 - PG88-22FR chip seal



Pavement Preservation

- NJDOT has a robust pavement preservation program
 - Micro-surface, chip seals, slurry seals, HPTO
 - Maintaining “good” pavements in “good” condition
- Developing a chip seal for greater durability under heavier traffic conditions
 - PG88-22FR chip seal

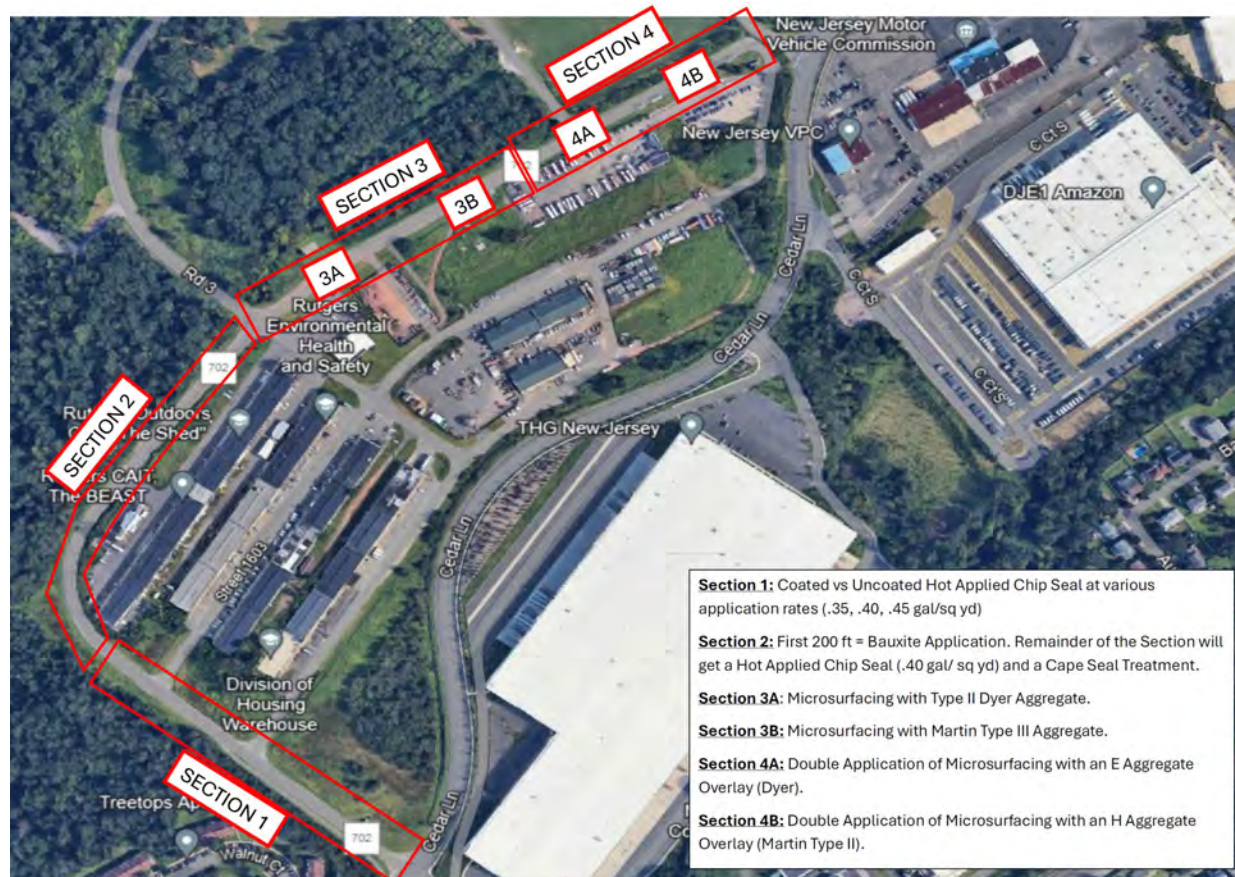


Pavement Preservation – Rutgers Test Sections



(Asphalt Paving Systems, APS)

Pavement Preservation – Rutgers Test Sections

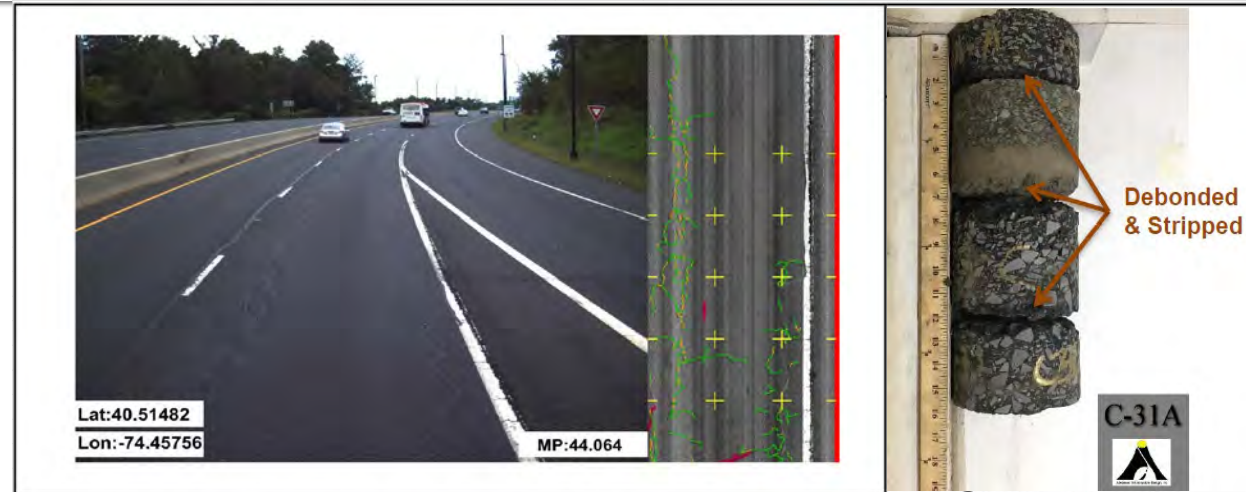


Environmentally Friendly Pavements

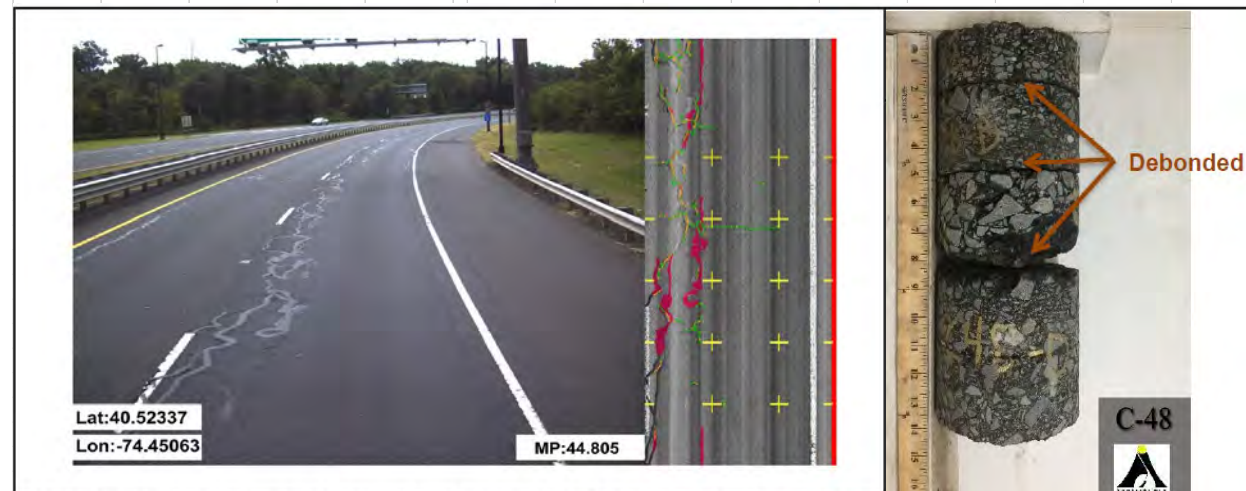
Construction Practices

Bonding of Pavement Layers

- Literature indicates that even a 10% reduction in interlayer bond strength can reduce pavement life by 50%
- NJDOT concerned with bonding on milled surfaces
 - Research study from 2021 to 2022 showed bond shear strength of milled surfaces approximately $\frac{1}{2}$ of paved surfaces
 - Majority of recovered cores from distressed areas show debonding and on-set of stripping



Description: L-Longitudinal Cracking between lanes; L-Transverse Cracking; M-Fatigue Cracking in Lane 2



Description: L-Longitudinal Cracking between lanes; M-Fatigue Cracking in Lane 2; L-Transverse Cracking; L-Block Cracking

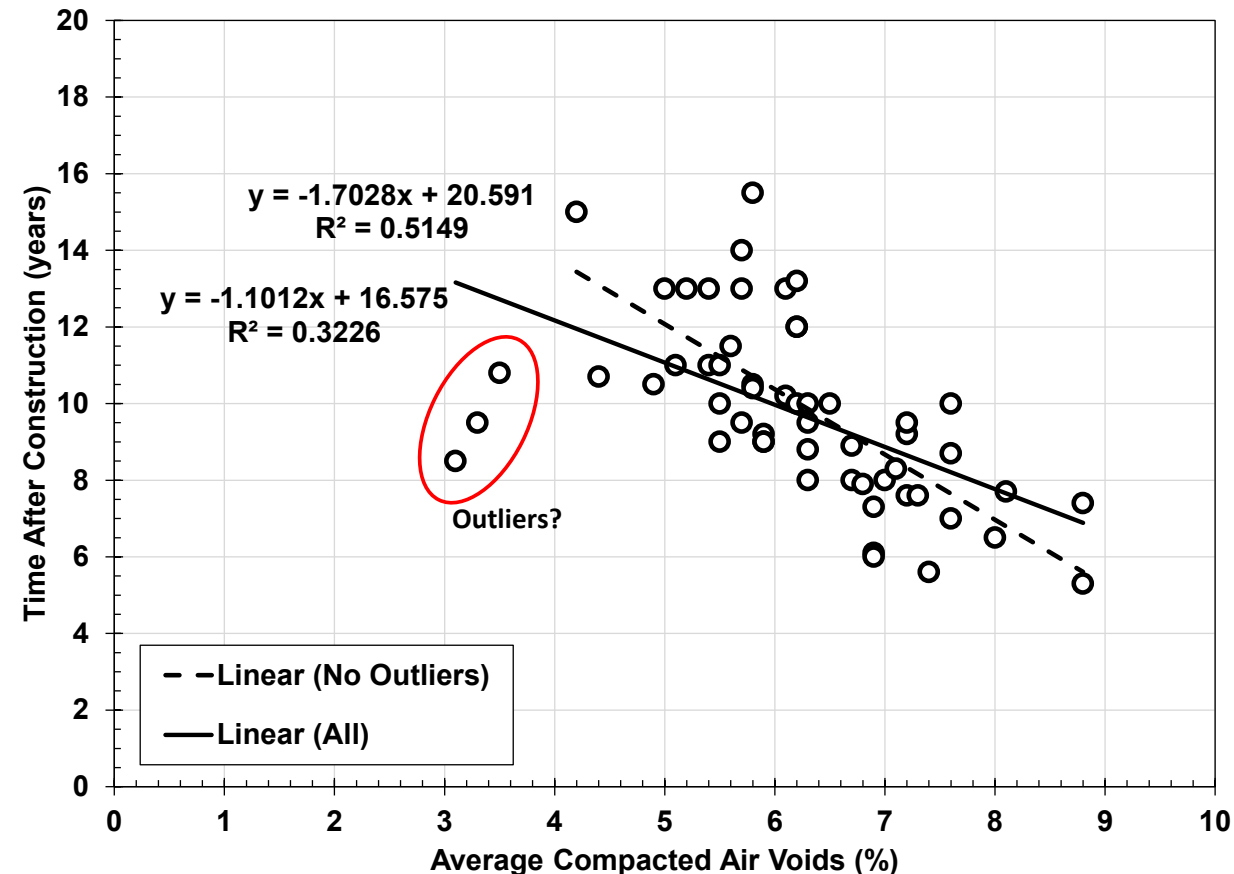
Bonding of Pavement Layers

- NJDOT developed bond strength procedure, criteria and pay adjustment (2025)
 - Average of 5 random cores per Lot
 - Recovered unbonded = 0.0 psi
- Investigating surface prep practices, as well as alternate tack coat materials and field monitoring practices
 - Pavement surface drier, fine/micro milling drums to provide smoother texture

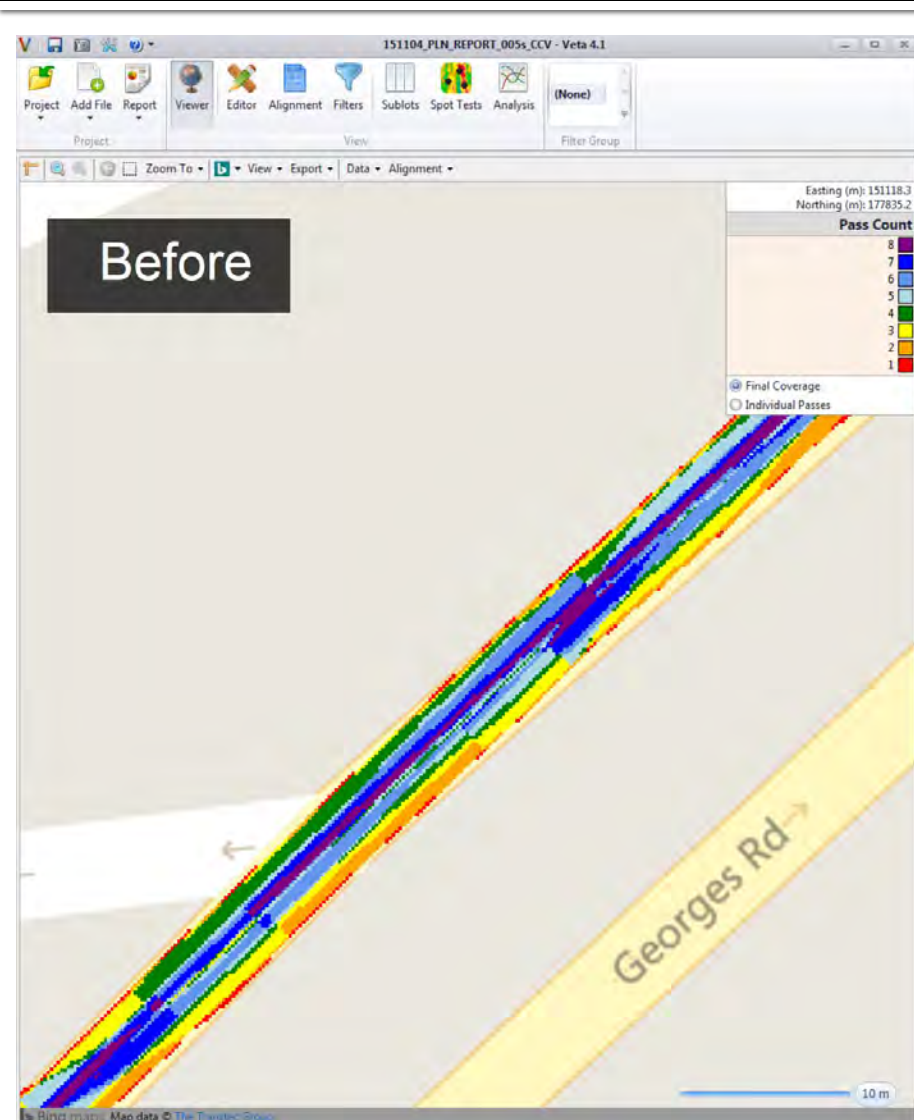


Improved Density for Improved Pavement Life

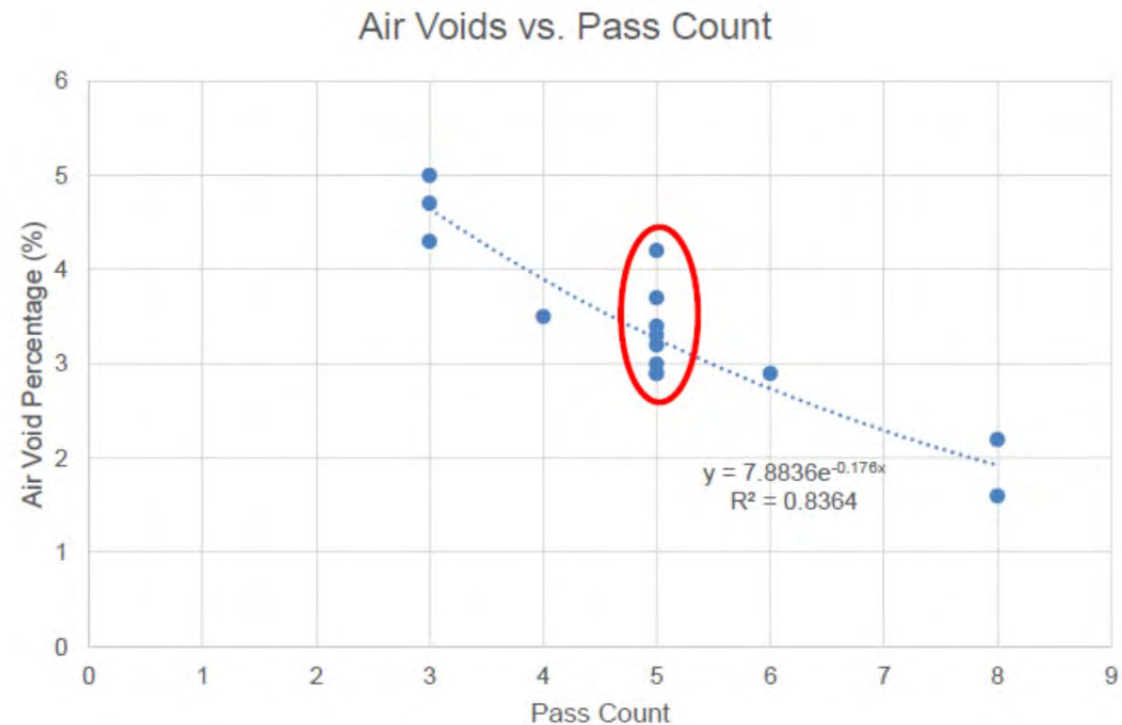
- In-place air voids has direct impact on pavement life
 - NJDOT study showed over 1 year of service life change per 1% air void level!
 - 2020 NJDOT study on field cores
 - 9.5 mm NMAAS
 - Ave = 6.3% (Std Dev = 2.08%)
 - 18.7% of cores with air voids > 8%
 - 12.5 mm NMAAS
 - Ave = 5.3% (Std Dev = 1.81%)
 - 6.6% of cores with air voids > 8%



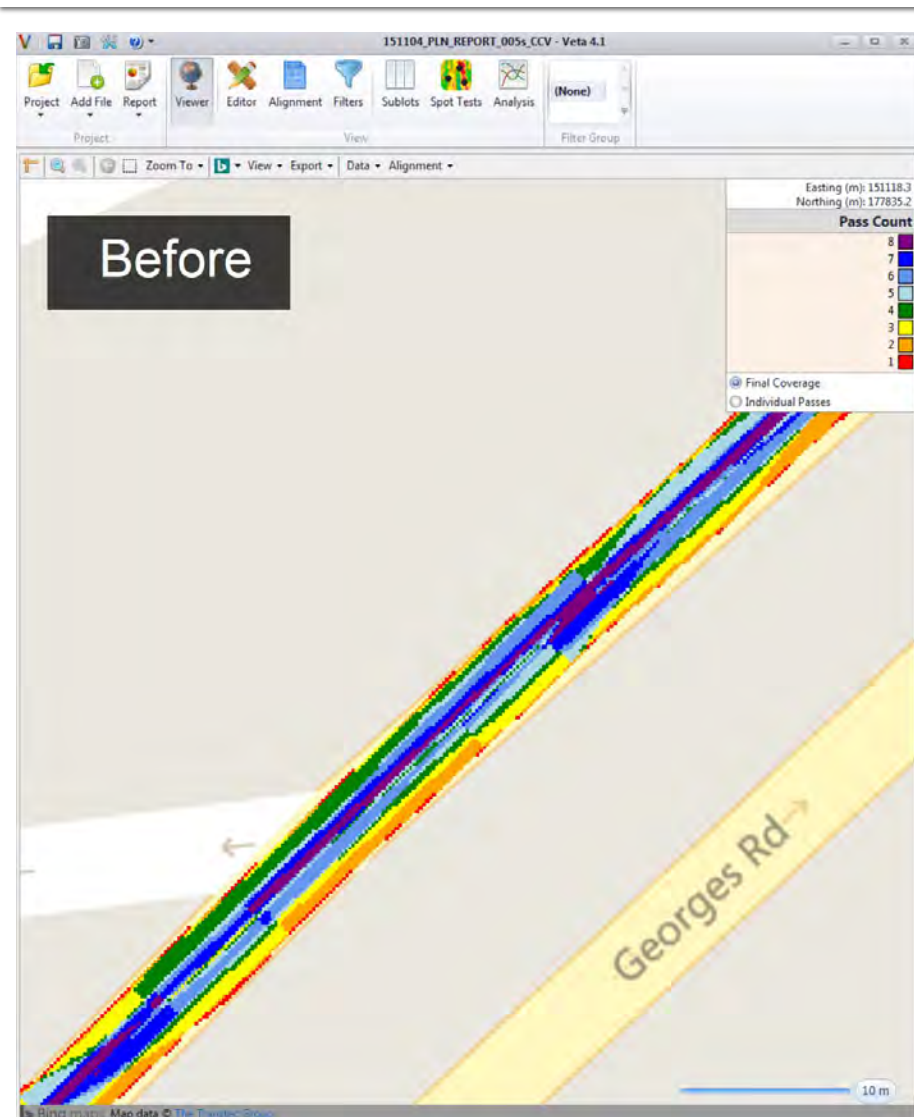
Improved Density for Improved Pavement Life



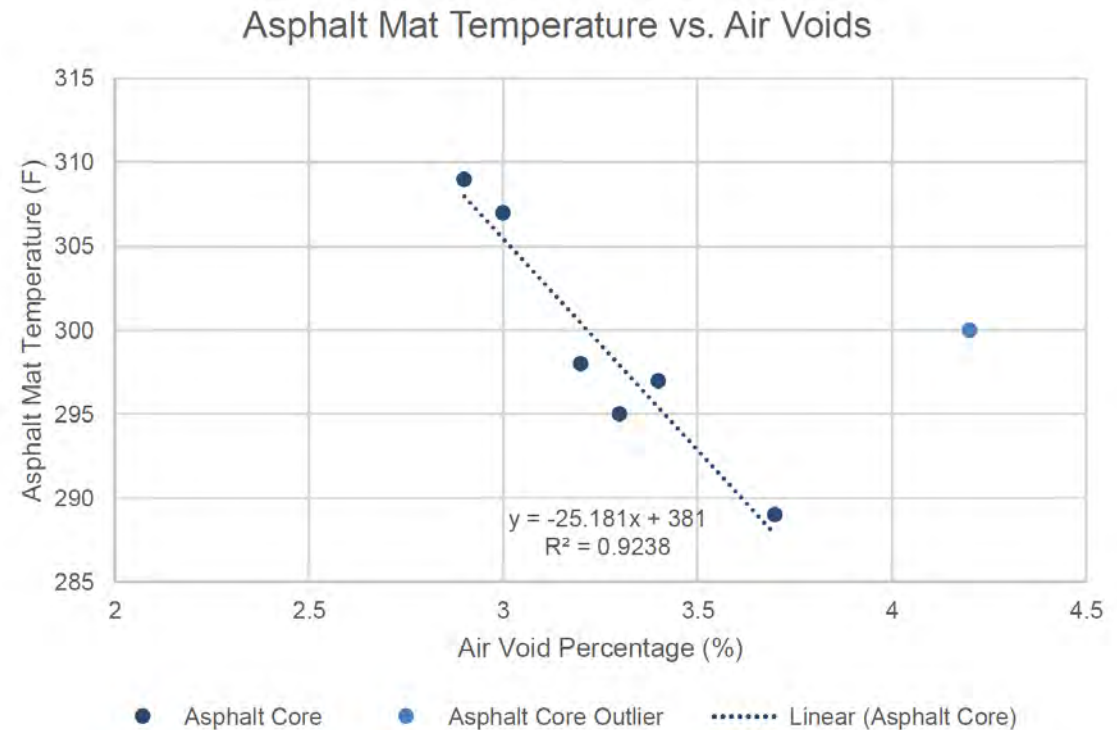
- Encouraged industry to embrace benefits of intelligent compaction



Improved Density for Improved Pavement Life



- Encouraged industry to embrace benefits of intelligent compaction



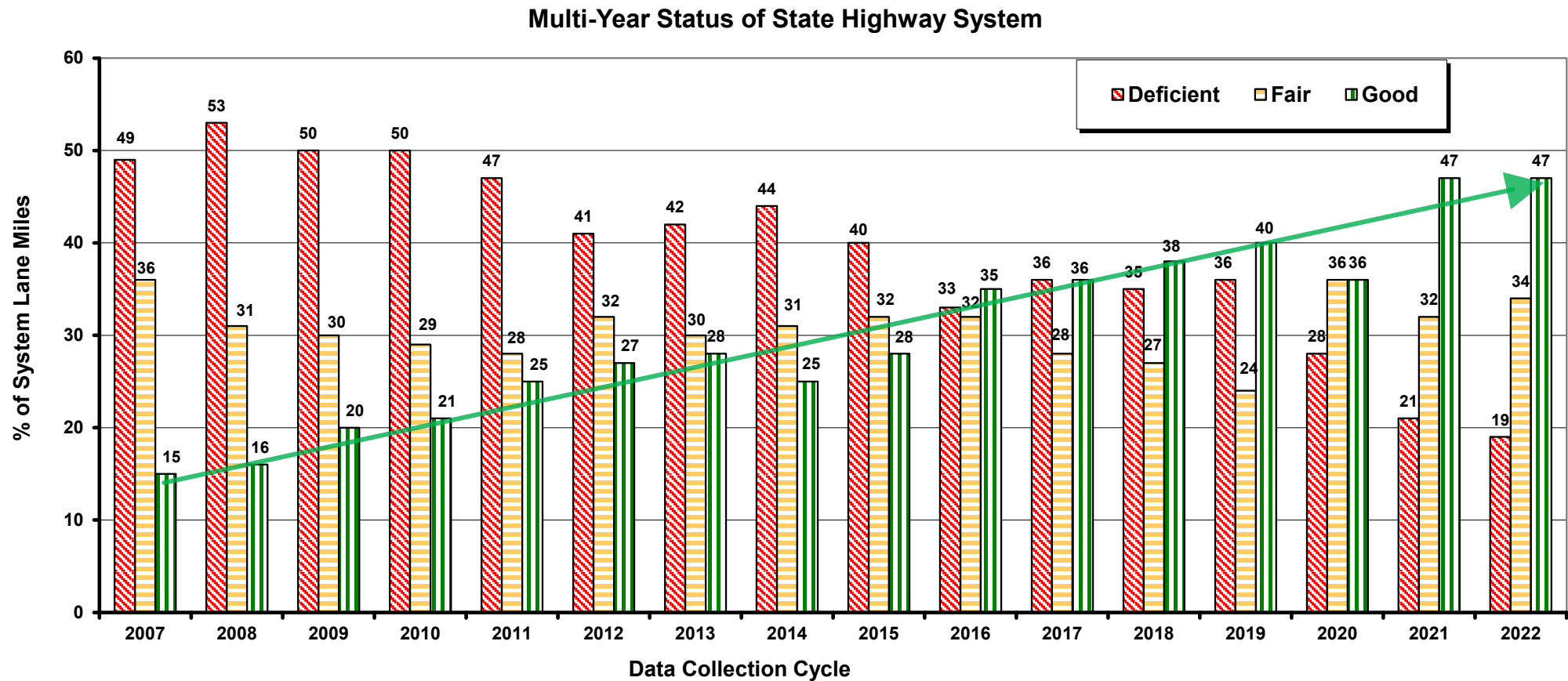
Environmentally Friendly Pavements

Final Thoughts

Final Thoughts

- Being “environmentally friendly” is not simply recycling or recycling more
 - Just using higher RAP contents because there is a surplus of RAP is like a doctor prescribing medicine to treat the symptom but never addressing the root cause
 - The underlying issue is the pavements are not lasting long enough!
- Applying research, lab and field, has shown successful for the NJDOT (i.e. – BMD, pavement preservation, etc.) while evaluating new concepts results in a robust pavement program & system

Final Thoughts



Source: NJDOT Pavement Management System

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