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INTERTWINEDNESS

Information Garnered from the Latest NCAT Test Track Cycle

Thomas Harman
Senior Research Engineer

PAPA

Have an Idea, Thought, Comment???

Tom.Harman@Auburn.edu

Image: Ginger Boo

Innovation is Disruptive

Image: https://www.iheart.com/content/2024-12-17-beautiful-pennsylvania-road-crowned-most-scenic-drive-in-the-state/

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The Who –
The Critical Role of Champions

- 80/20 Rule
- 10% more is only 4 hours a week
- Have a Plan
- S.M.A.R.T. Goals
- Use your Resources
- You are not alone

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Challenge

"Whenever enemies have the ability to attack the innovator, they do so with the passion of partisans, while the others defend them sluggishly so that the innovator and their party alike are vulnerable."

-Niccolȯ Machiavelli, The Prince (1513)


NCAT's mission is to provide innovative, relevant, and implementable research, technology development, and education that advances safe, durable, and sustainable asphalt pavements
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About NCAT | Test Track | Pavement Preservation | Education & Training | Our Research

NCAT

- About NCAT
  - Facilities
  - Research Faculty and Engineers
  - Staff
  - Contact Us
  - Applications Steering Committee
  - Board of Directors
  - Jobs
  - Annual Report

NCAT welcomes new inductees to the Wall of Honor

The National Center for Asphalt Technology (NCAT) was established in 1986 as a partnership between Auburn University and the Nat Association (NAPA) Research and Education Foundation to provide practical research and development to meet the needs of maintai infrastructure. NCAT was created to ensure this industry's ability to provide pavements that are durable, sustainable, quiet, safe and e state highway agencies, the Federal Highway Administration and the highway construction industry to develop and evaluate new prod and construction methods that quickly lead to pavement improvements.

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The 3-E's...

Engineering
Economics
Environment

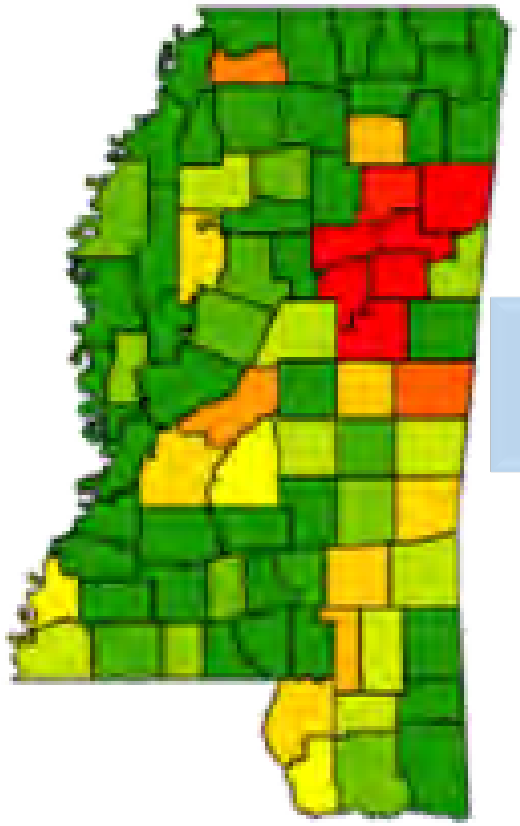
MDOT
MISSISSIPPI DEPARTMENT OF TRANSPORTATION

Volumetric-only mix design is not fully capable of dealing with present-day mixes

ERDC
ENGINEER RESEARCH & DEVELOPMENT CENTER

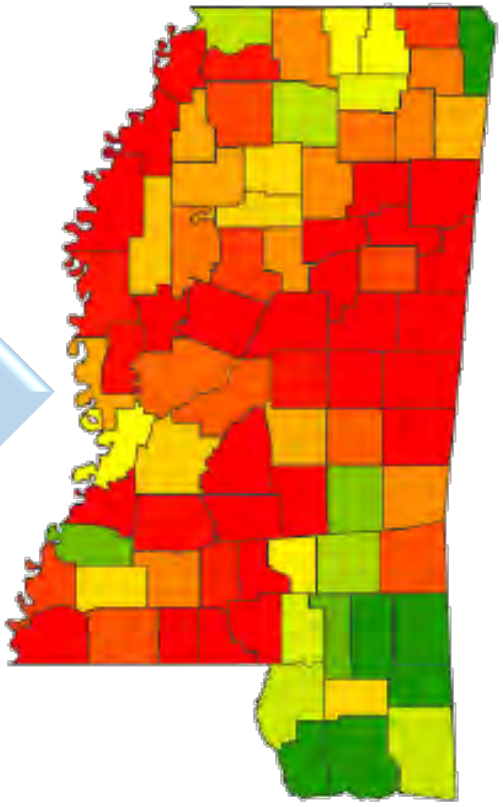
US Army Corps of Engineers

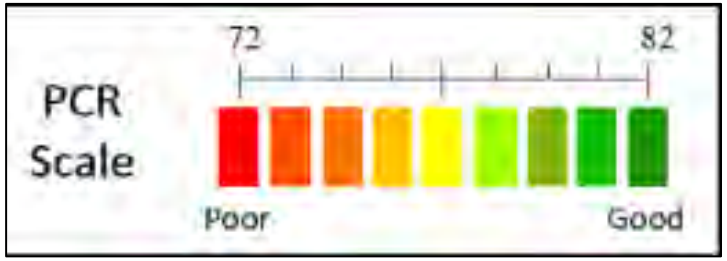
2002



Unintended Consequences

2020





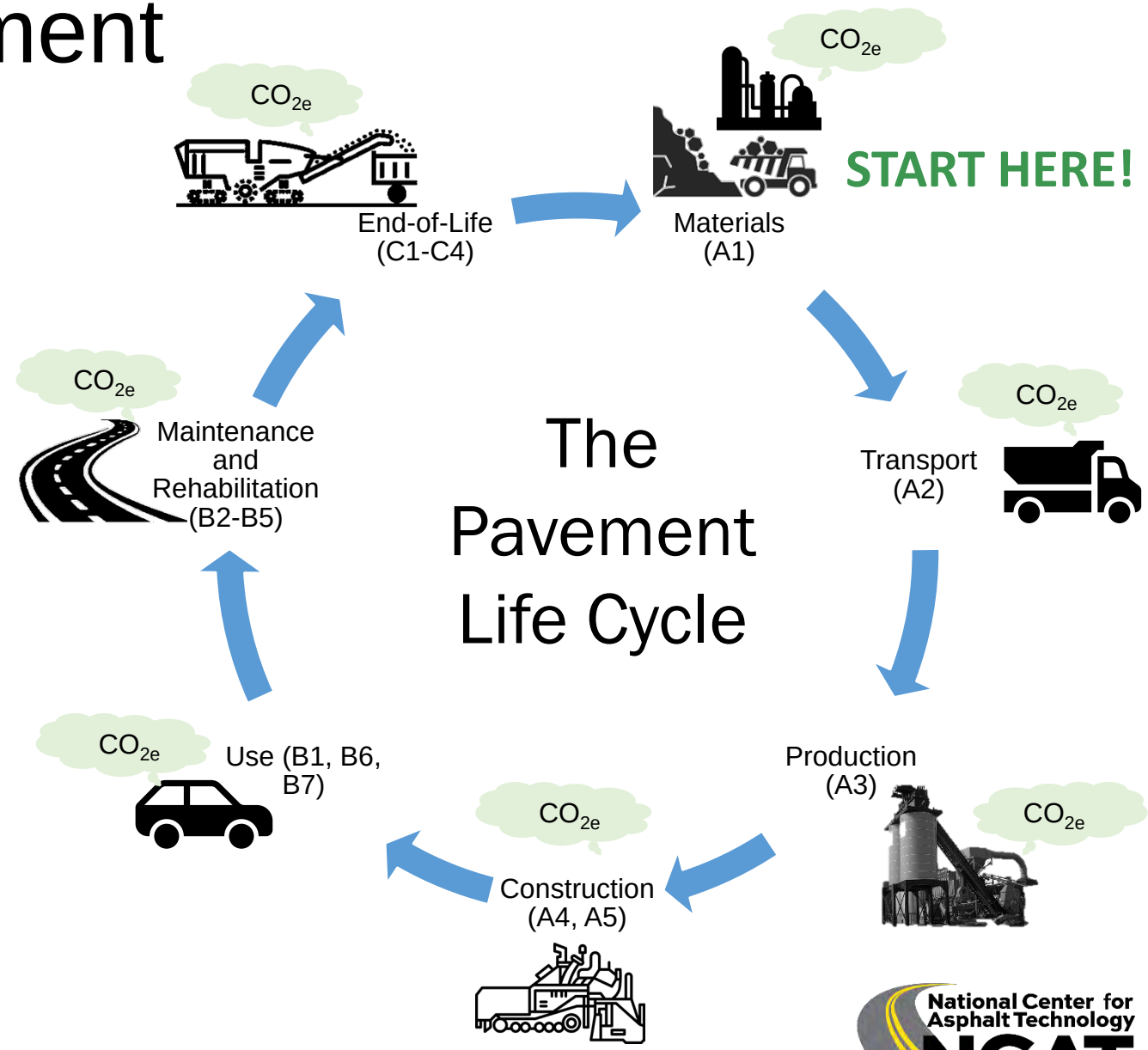
Pavement Condition Rating

Life Cycle Assessment

- A systematic analysis of the potential environmental impacts of products during their entire life cycle

$ LCCA is a financial accounting

LCA is eco-accounting



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What are LCA, EPD, and PCR?

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openLCA

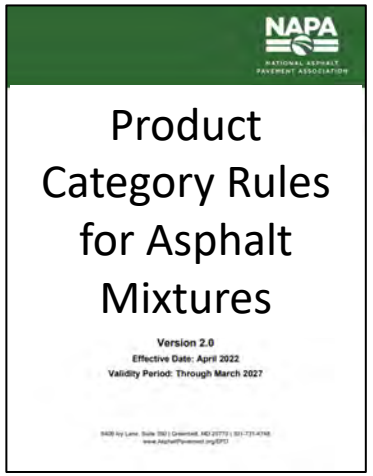
LCA PAVE

The Analysis:
"Evaluates the environmental impacts of a product over its service-life"

TABLE 3. ENVIRONMENTAL IMPACT SUMMARY TABLE

IMPACT CATEGORY	POTENTIAL IMPACT PER METRIC TONNE ASPHALT MIXTURE (PER TON ASPHALT MIXTURE)
Global warming potential (GWP-100)	61.90 (56.16) kg CO2 Equiv.
Ozone depletion potential (ODP)	9.31e-08 (8.44e-08) kg CFC-11 Equiv.
Eutrophication potential (EP)	1.19e-02 (1.08e-02) kg N Equiv.
Acidification potential (AP)	1.92e-01 (1.74e-01) kg SO2 Equiv
Photochemical ozone creation potential (POCP)	4.00 (3.63) kg O3 Equiv.

The Communication:
"Provides environmental information of a product"



The Guidelines:
"Set of specific rules, required for developing EPDs of a product"

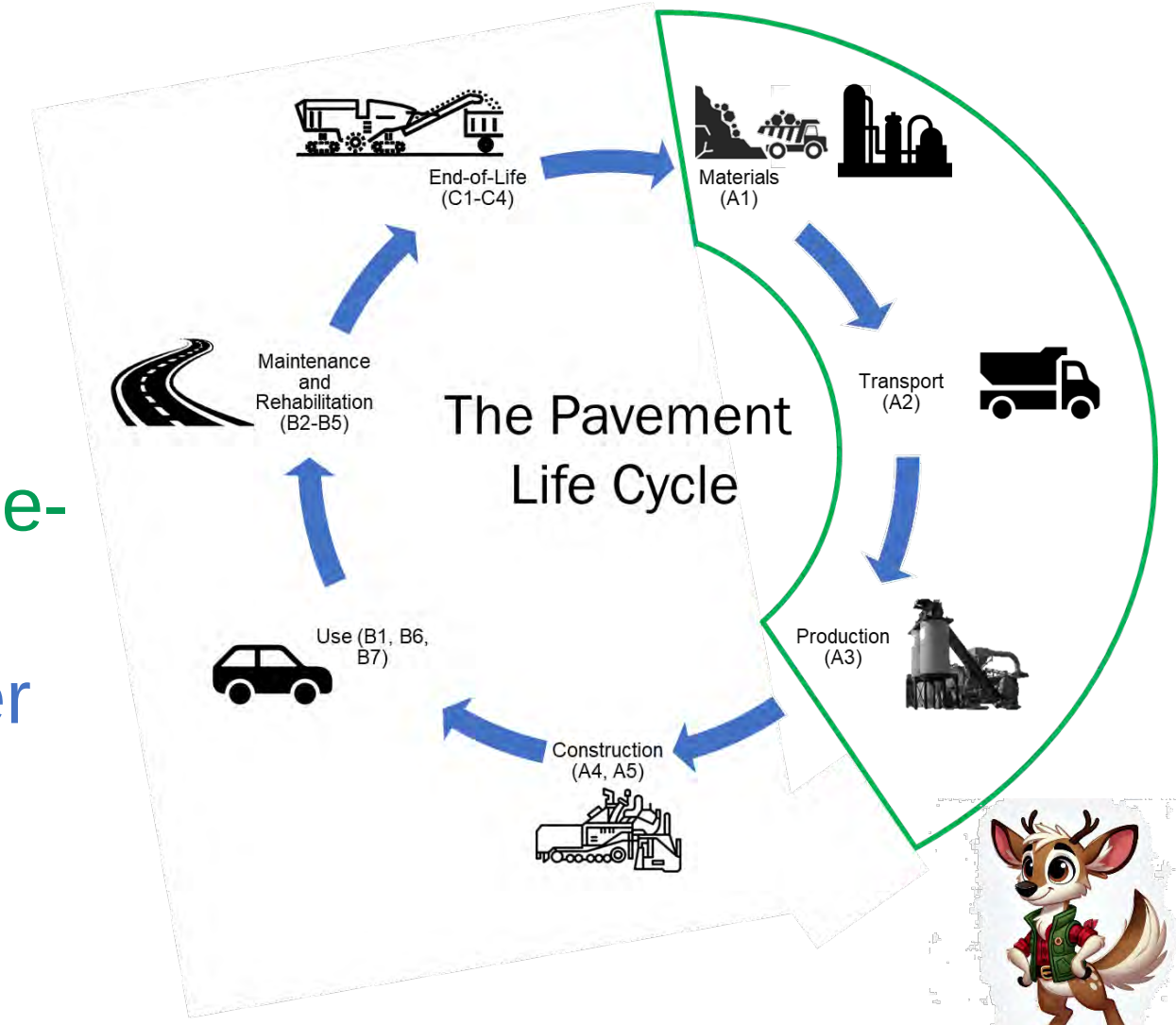
LCA

EPD

PCR

Asphalt Mixture EPD's

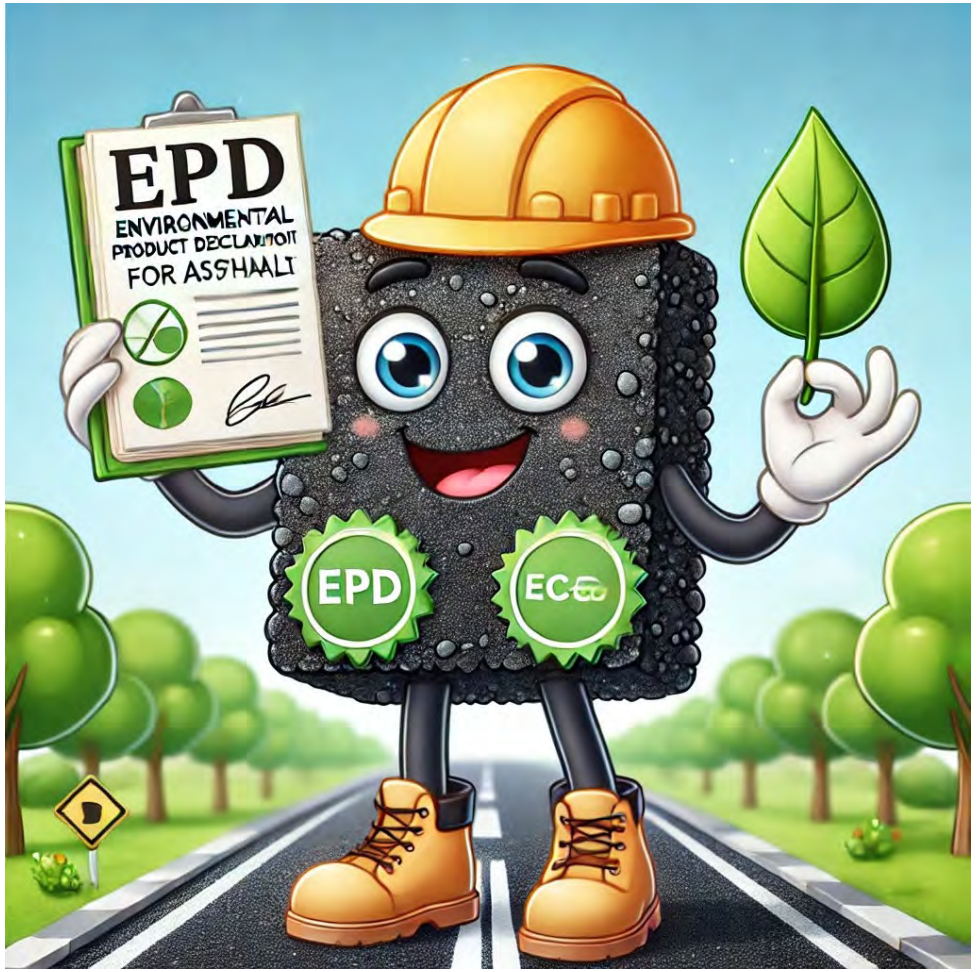
- The current NAPA Eco-Label program covers only the "Cradle-to-Gate" system boundary (EPD)
- Is it fair to compare the environmental impacts of two mixtures just based on "Cradle-to-Gate"?
- How important is it to consider life-extension benefits in LCA consideration?



Pennsylvania

- Currently…
  - 19 Organizations
  - 70 Asphalt Plants
  - 1,456 Individual Mixes

Company	Plant	Mix	Plant Type	Location	EPD
Allan Myers Materials	Coatesville Asphalt Plant	CA-ATPBC202	Stationary	410 Doe Run Road Coatesville, PA	69.393.4270 v2
Allan Myers Materials	Coatesville Asphalt Plant	CA-PERMA3H1	Stationary	410 Doe Run Road Coatesville, PA	69.393.4311 v3
Allan Myers Materials	Coatesville Asphalt Plant	CA-W1912101	Stationary	410 Doe Run Road Coatesville, PA	69.393.1331 v12
Allan Myers Materials	Coatesville Asphalt Plant	CA-W1912102	Stationary	410 Doe Run Road Coatesville, PA	69.393.4200 v4
Allan Myers Materials	Coatesville Asphalt Plant	CA-W1912103	Stationary	410 Doe Run Road Coatesville, PA	69.393.1330 v10
Allan Myers Materials	Coatesville Asphalt Plant	CA-W1912201	Stationary	410 Doe Run Road Coatesville, PA	69.393.1329 v4
Allan Myers Materials	Coatesville Asphalt Plant	CA-W1912202	Stationary	410 Doe Run Road Coatesville, PA	69.393.4207 v3
Allan Myers Materials	Coatesville Asphalt Plant	CA-W1912203	Stationary	410 Doe Run Road Coatesville, PA	69.393.1328 v2
Allan Myers Materials	Coatesville Asphalt Plant	CA-W1972101	Stationary	410 Doe Run Road Coatesville, PA	69.393.1327 v3



https://asphaltepd.org/published/

Random EPD from PA…

Emerald ECO LABEL

An Environmental Product Declaration (EPD) for Asphalt Mixtures

Company Information

Product Description

This EPD reports the potential environmental impacts and additional environmental information for an asphalt mixture, which falls under the United Nations Standard Products and Services Code 30111509. Asphalt mixtures are typically incorporated as part of the structure of a roadway, parking lot, driveway, airfield, bike lane, pedestrian path, railroad track bed, or recreational surface.

Mix Name: CA-ATPBC202

Specification Entity: PennDot

Specification: ATPB

Gradation Type: permeable

Mix Design Method: superpave

Nominal Maximum Aggregate Size: 37.5 mm

Performance Grade of Asphalt Binder: PG 64-22

Customer [Project/Contract] Number: Not Reported

This mix producer categorizes this product as a Warm Mix Asphalt (WMA) asphalt mixture produced using chemical additive. This asphalt mixture was produced within a temperature range of 138 to 160°C (280.0 to 320.0°F) f. Energy and environmental impacts are based on a plant's average performance over a 12-month period and are not adjusted for mix-specific production temperatures.

This declaration is an EPD in accordance with ISO 14025:2006[1] and ISO 21930:2017[2]. The PCR is *Product Category Rules for Asphalt Mixtures*[3,4]. This EPD transparently describes the potential environmental impacts associated with the identified life cycle stages of the described product.

Declaration Number: 69.393.4270 v2 **Software Version:** 2.3.0

Date of Issue: Nov. 18, 2024 **Period of Validity:** March 31, 2027

This EPD is valid for asphalt mixtures produced at the location indicated on this page. Data used to inform this EPD reflect plant operations from a 12-month period beginning on Jan. 1, 2022.

This EPD can be found at https://asphaltepd.org/epd/d/rQUyBL/

LCA performed by: Ben Ciavola, PhD

EPD Units: ##.## kg CO_2e / ton of mix


Emerald ECO LABEL

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Performance Grade of Asphalt Binder: PG 64-22

Customer: [Project/Contract] Number: Not Reported

This mix producer categorizes this product as a Warm Mix Asphalt (WMA) asphalt mixture produced using chemical additive. This asphalt mixture was produced within a temperature range of 130 to 160°C (260.0 to 320.0°F) E Energy and environmental impacts are based on a plant's average performance over a 12-month period and are not adjusted for mix-specific production temperatures.

This declaration is an EPD in accordance with ISO 14025:2006[1] and ISO 21930:2017[2]. The PCR is Product Category Rules for Asphalt Mixtures[3]. This EPD transparently describes the potential environmental impacts associated with the identified life cycle stages of the described product.

Declaration Number: EB-355 4270 v2 Software Version: 2.3.0

Date of Issue: Nov. 19, 2024 Period of Validity: March 31, 2027

This EPD is valid for asphalt mixtures produced at the location indicated on this page. Data used to inform this EPD reflect plant operations from a 12-month period beginning on Jan. 1, 2022.

This EPD can be found at https://asphaltepd.org/epd/d/iQUyRi/

LCA performed by: Ben Clavola, PhD

A1 - MATERIALS 15.03

A2 - TRANSPORT 3.45

A3 - PRODUCTION 22.93

41.41

A Simple Mix from a Typical Plant

Materials (A1)

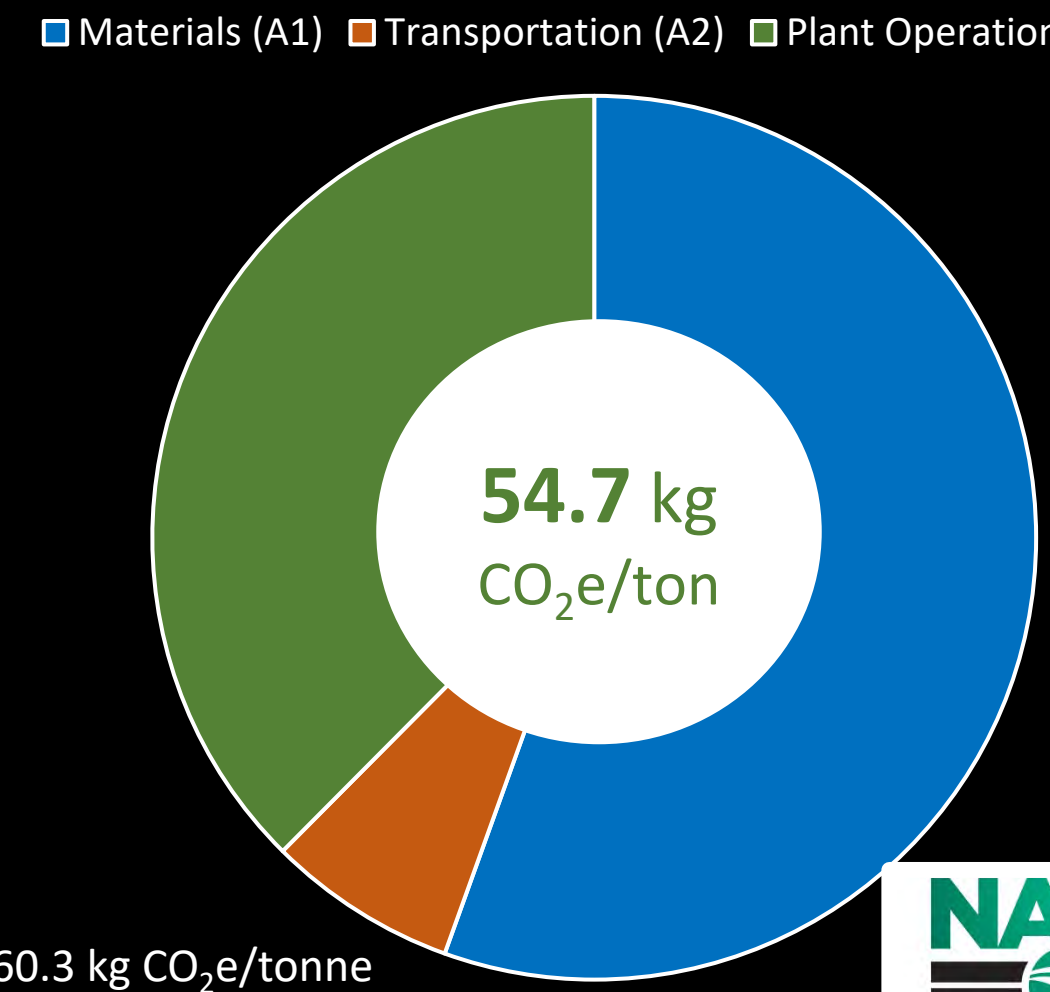
- 95% aggregates
- 5% asphalt binder

Transport (A2)

- 22 miles by truck

Plant Operations (A3)

- Burner fuel – Natural Gas
- 289,000 Btu/ton
- 3.3 kWh/ton – Average grid



60.3 kg CO_2e/tonne

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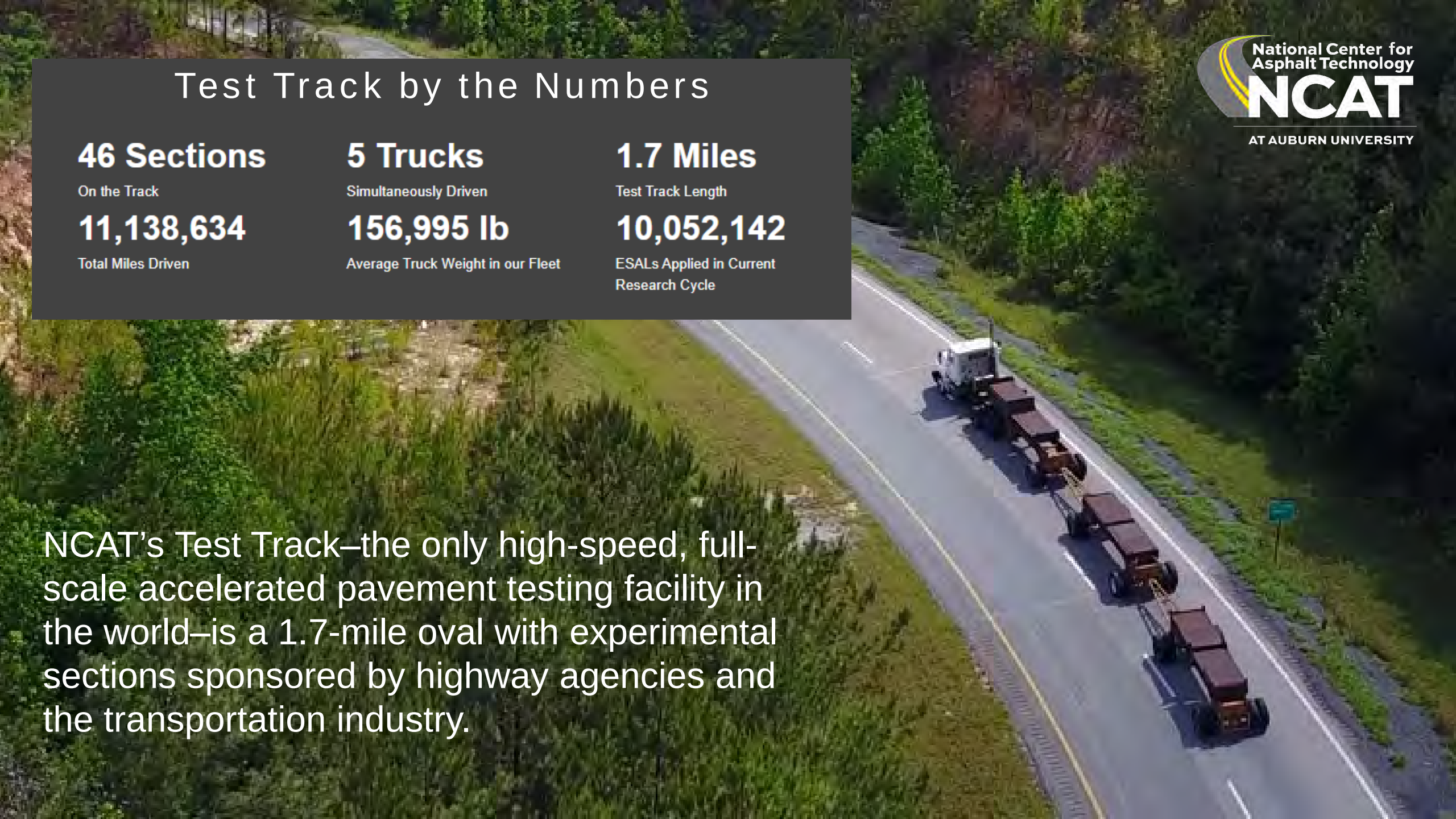
The NCAT Test Track

America's Asphalt Pavement Proving Ground



Test Track by the Numbers

46 Sections
On the Track

5 Trucks
Simultaneously Driven

1.7 Miles
Test Track Length

11,138,634
Total Miles Driven

156,995 lb
Average Truck Weight in our Fleet

10,052,142
ESALs Applied in Current Research Cycle

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NCAT's Test Track–the only high-speed, full-scale accelerated pavement testing facility in the world–is a 1.7-mile oval with experimental sections sponsored by highway agencies and the transportation industry.

NCAT Test Track

1. BALANCED MIX DESIGN
2. AGGREGATE PROPERTIES
3. BINDER CHARACTERISTICS
4. STRUCTURAL PAVEMENT DESIGN
5. TIRE-PAVEMENT INTERACTION
6. ADDITIONAL GOODIES

Our 8th Research Cycle Sponsors!

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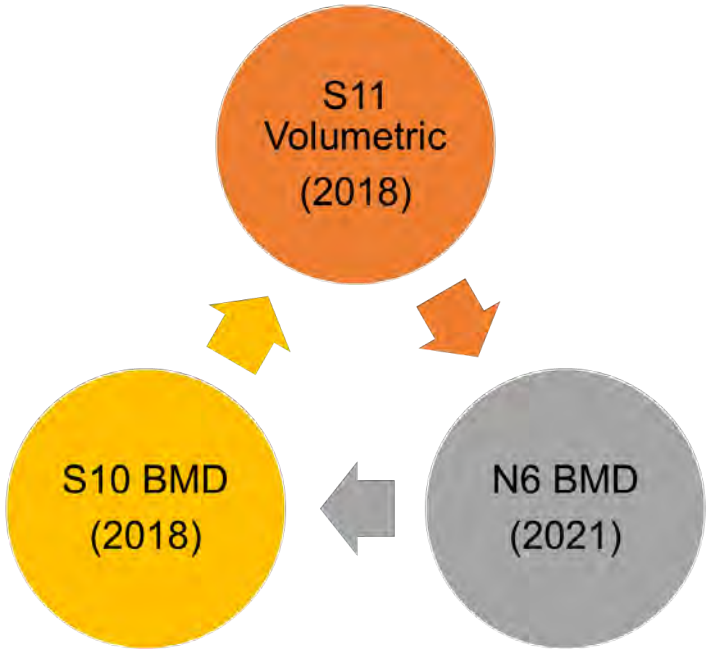
BMD and Sustainbility

BMD Experiment

- Field performance comparison of asphalt mixes designed with Volumetric vs. BMD approaches
  - 2.5-inch mill-and-inlay
  - Underlying pavement 15-20% lane area cracking



Mixture Designs

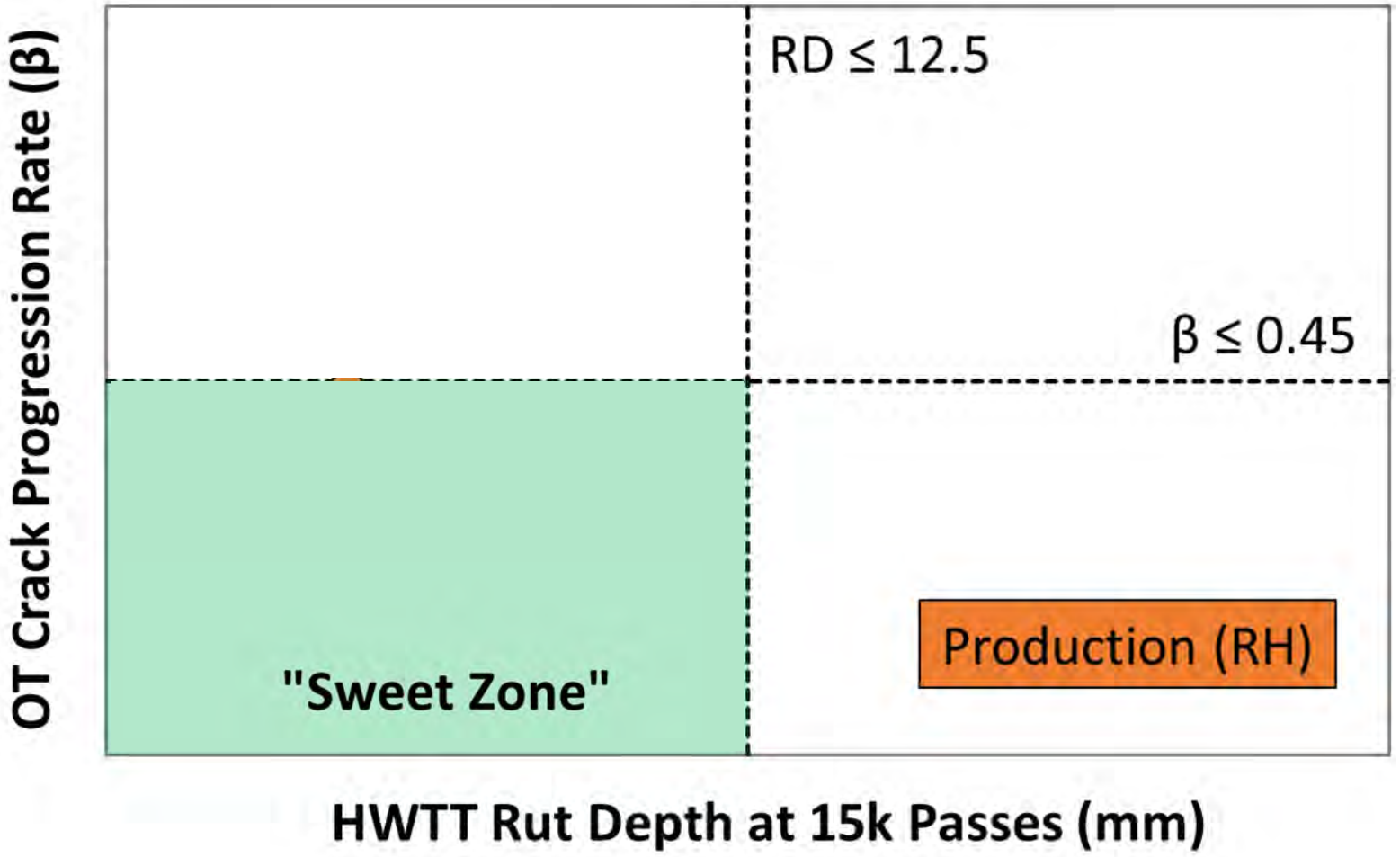
- TxDOT 12.5mm Superpave-C surface mix – “Volumetric”
- PG 70-22 SBS binder in all three test sections
- BMD approach A: Volumetric Design with Performance Verification

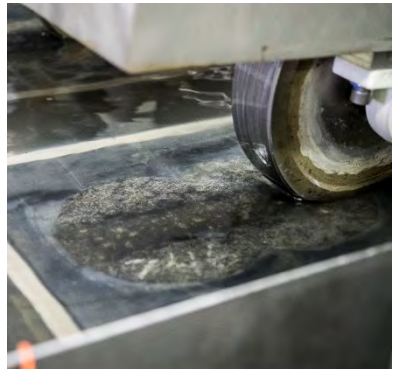
Mix Design	S11 Volumetric (2018)	S10 BMD (2018)	N6 BMD (2021)
Total Binder Content	**4.7**	**5.5**	**5.3**
RAP Binder Replacement	20	20	19
Air Voids (50 Gyrations)	4.0	4.0	4.0
VMA*	15.0	16.6	16.4
V_{be}*	11.0	12.6	12.4
VFA*	73	76	76

* based on G_{se}

BMD Performance Diagram

Overlay Test

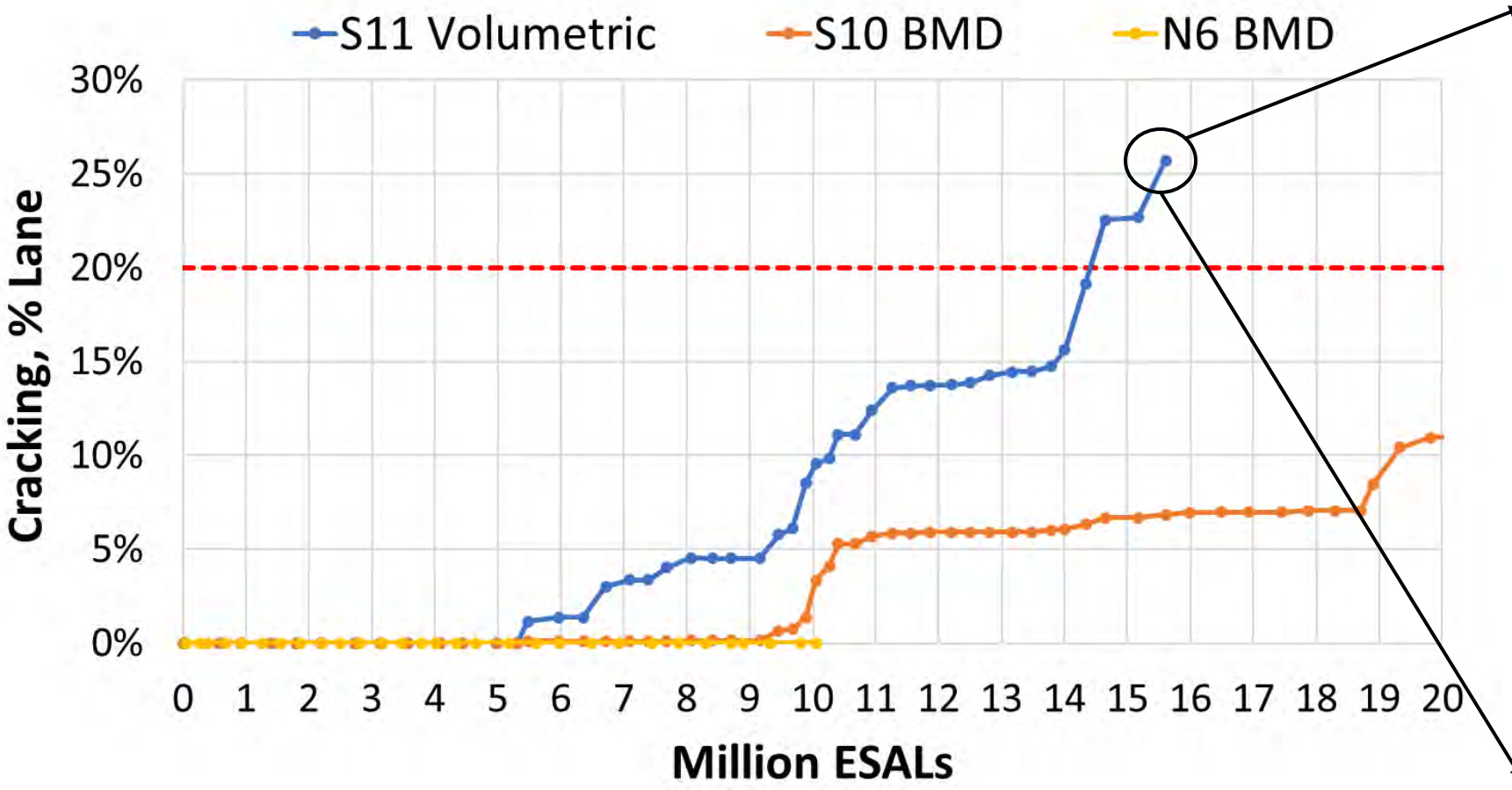




Hamburg WTT

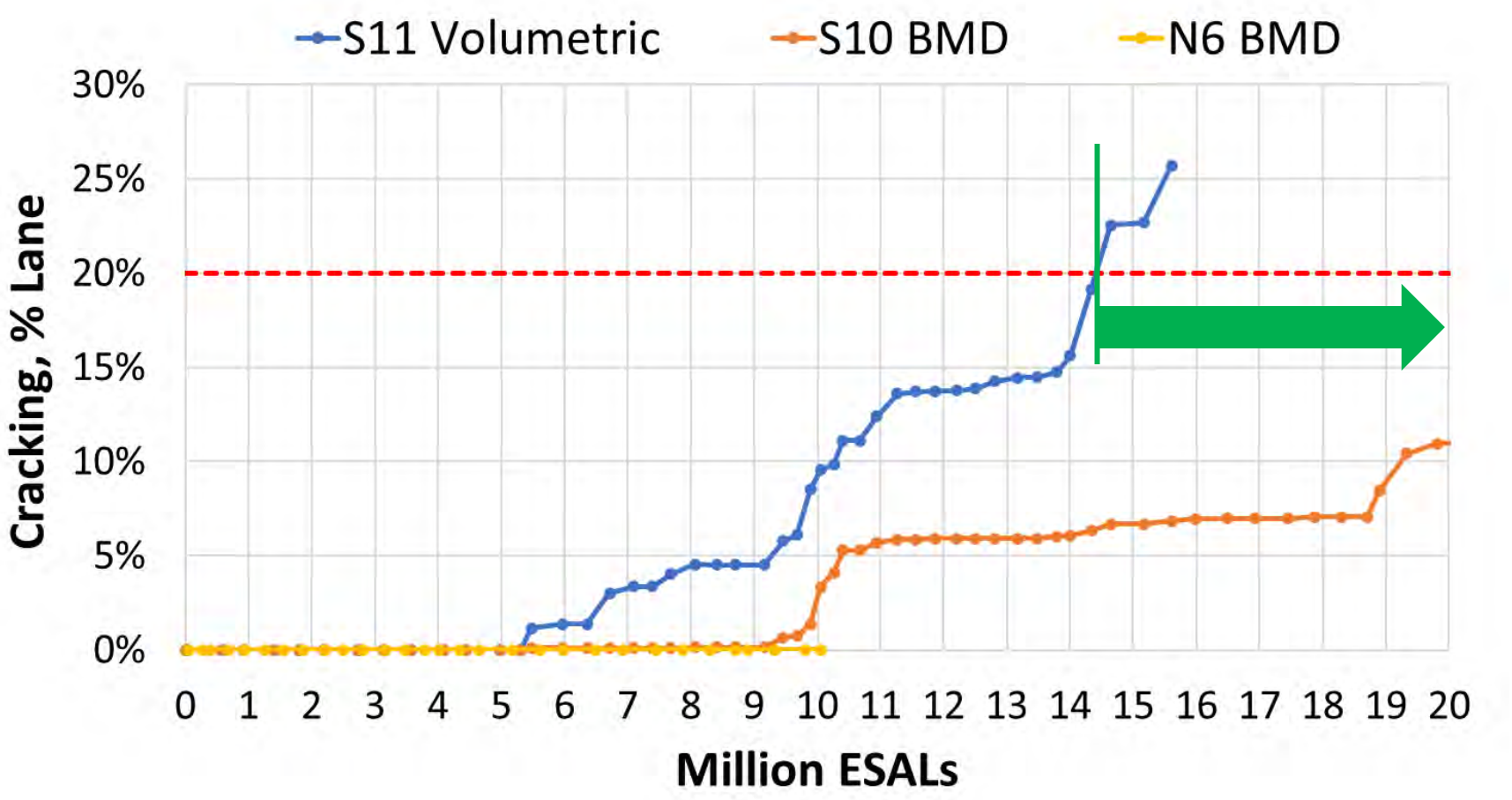
Testing of reheated (RH) production samples.

TxDOT BMD Field Cracking Results



Cracking performance: S10 BMD > S11 Volumetric

TxDOT BMD Field Cracking Results



BMD overlay life extension
> 5.5 MESALs
(>1.3 times longer)

LCCA for Texas Mix Comparison

- TxDOT Life Cycle Cost Analysis Policy
  - 40-year Analysis Period
  - Discount rate: 3.72%
  - 12-year performance period for volumetric mix
  - Volumetric mix: **$80.0/ton** per TxDOT bid price database
  - BMD mix: **$84.8/ton**
    - $80/ton + 0.64% more virgin PG 70-22 binder × $750/ton

Texas Department of Transportation™

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M&R Schedule for LCCA and LCA

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Year	Volumetric Mix (14.4 MESAL Life)	BMD Mix (20 MESAL Life)	BMD Mix (30 MESAL Life)
0	Initial construction	Initial construction	Initial construction
12.0	2.5” mill & fill		
16.6		2.5” mill & fill	
24.0	2.5” mill & fill		
25.0			2.5” mill & fill
33.2		2.5” mill & fill	
36.0	2.5” mill & fill		
40.0	End of analysis period	End of analysis period	End of analysis period
Remaining Life (yrs.)	8.0	9.8	10.0

Life Cycle Cost Analysis Results

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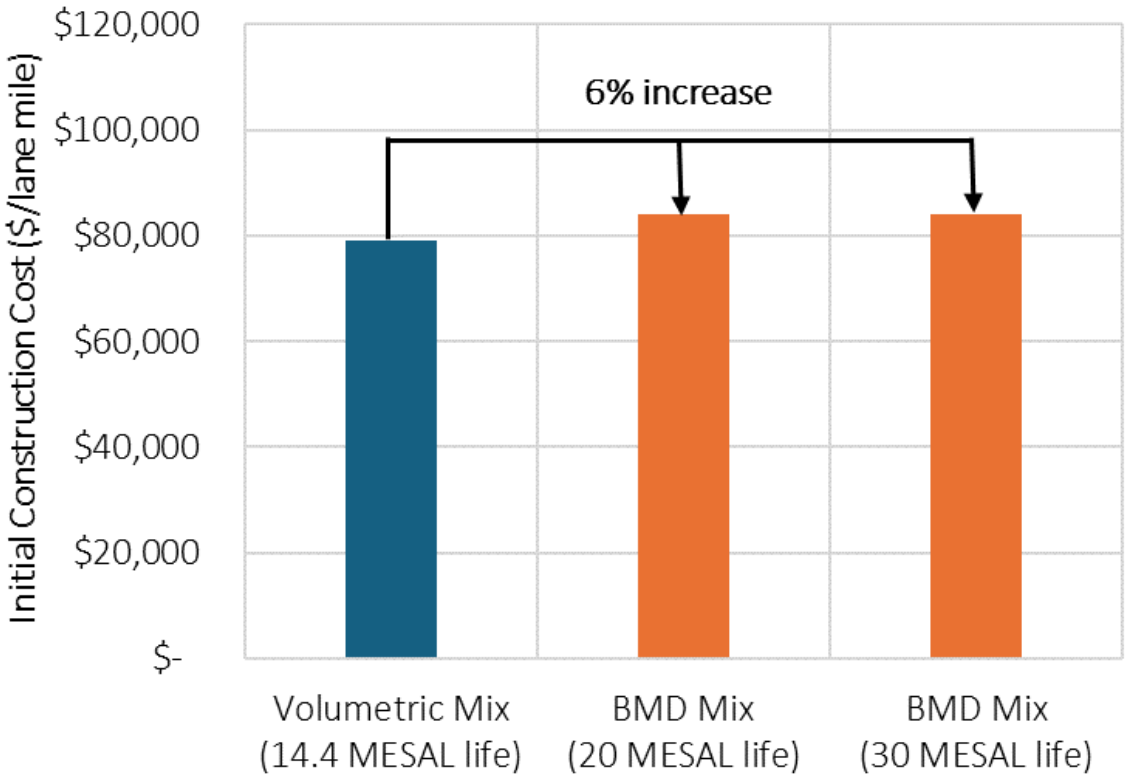
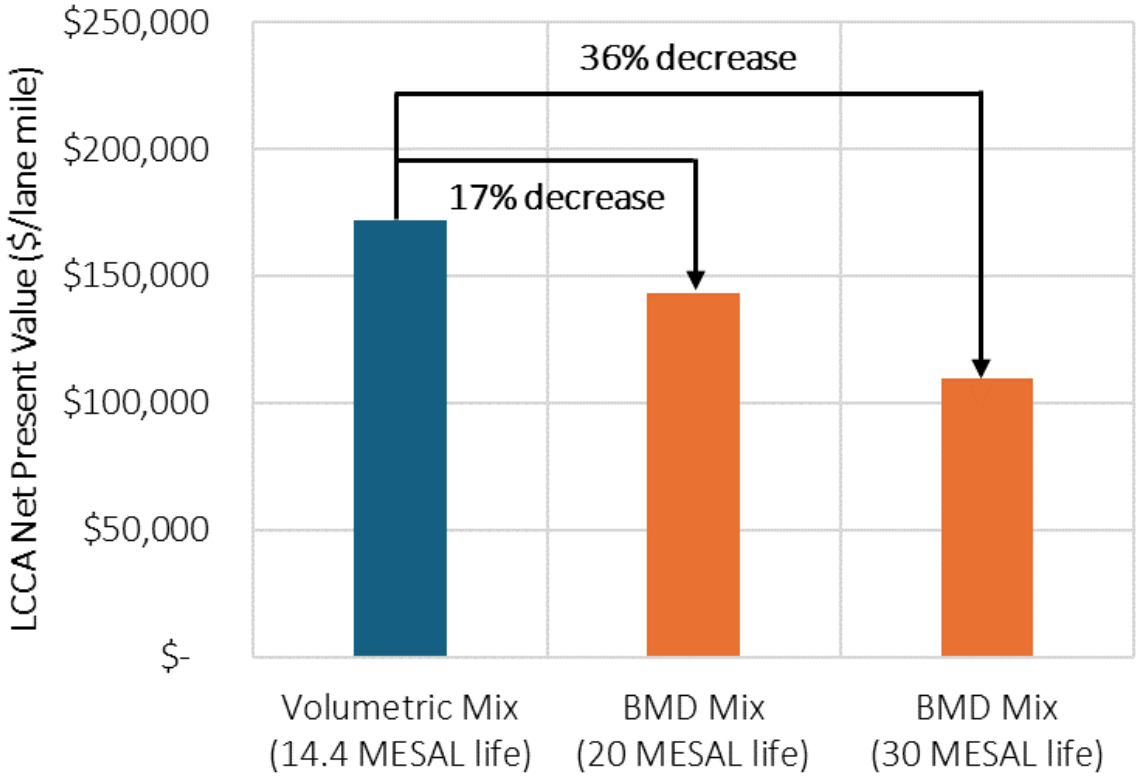
Initial Construction Cost Comparison



LCCA Net Present Value Comparison



Functional Unit – One Lane mile

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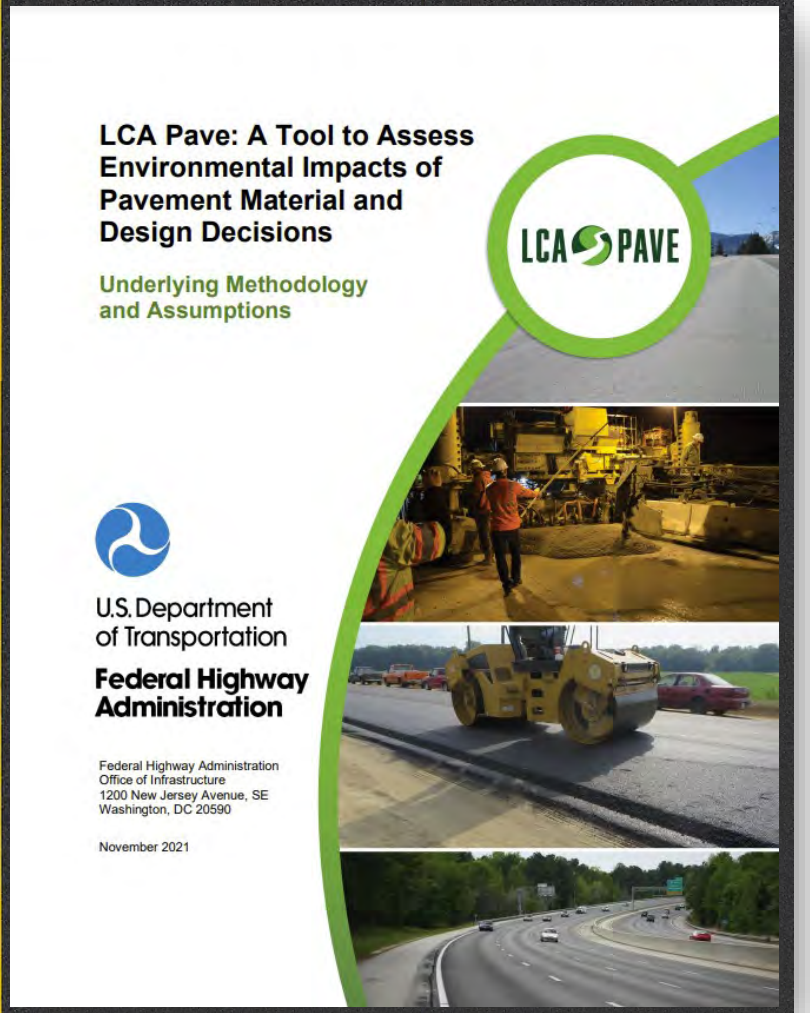
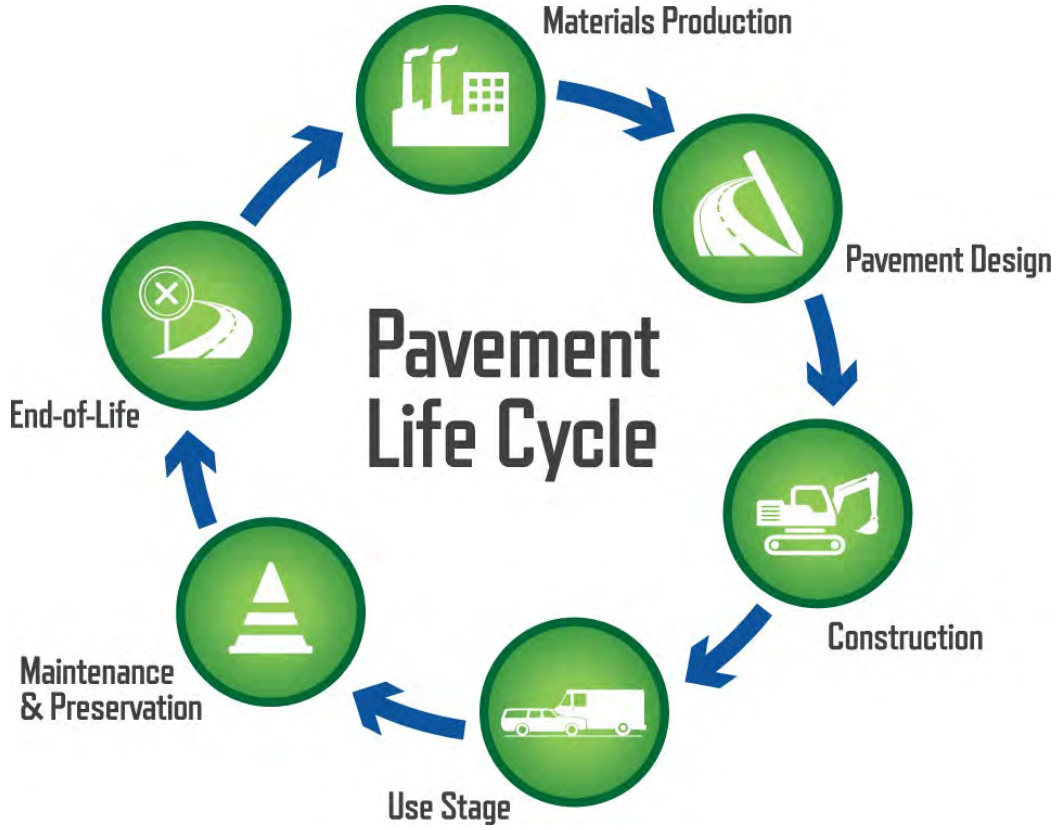


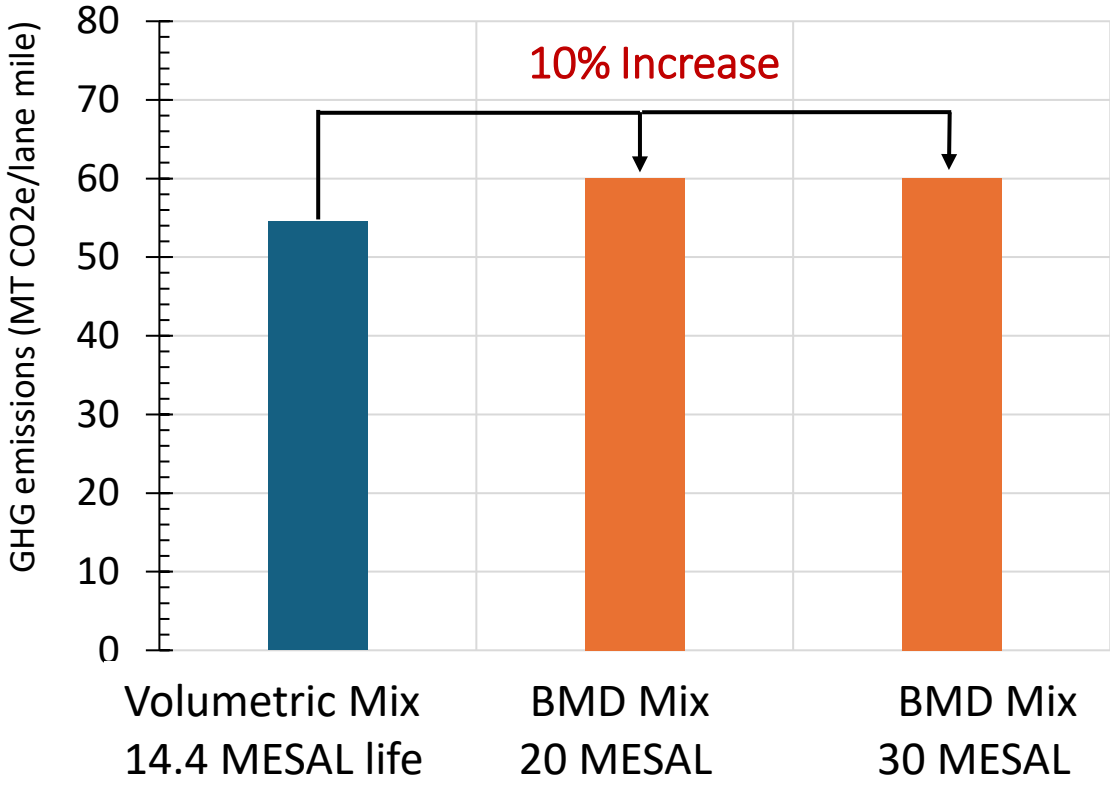
Life Cycle Assessment

- Same Analysis Period and Performance Periods as LCCA
  - Use Stage is not included
  - No Third-Party Validation (R&D)

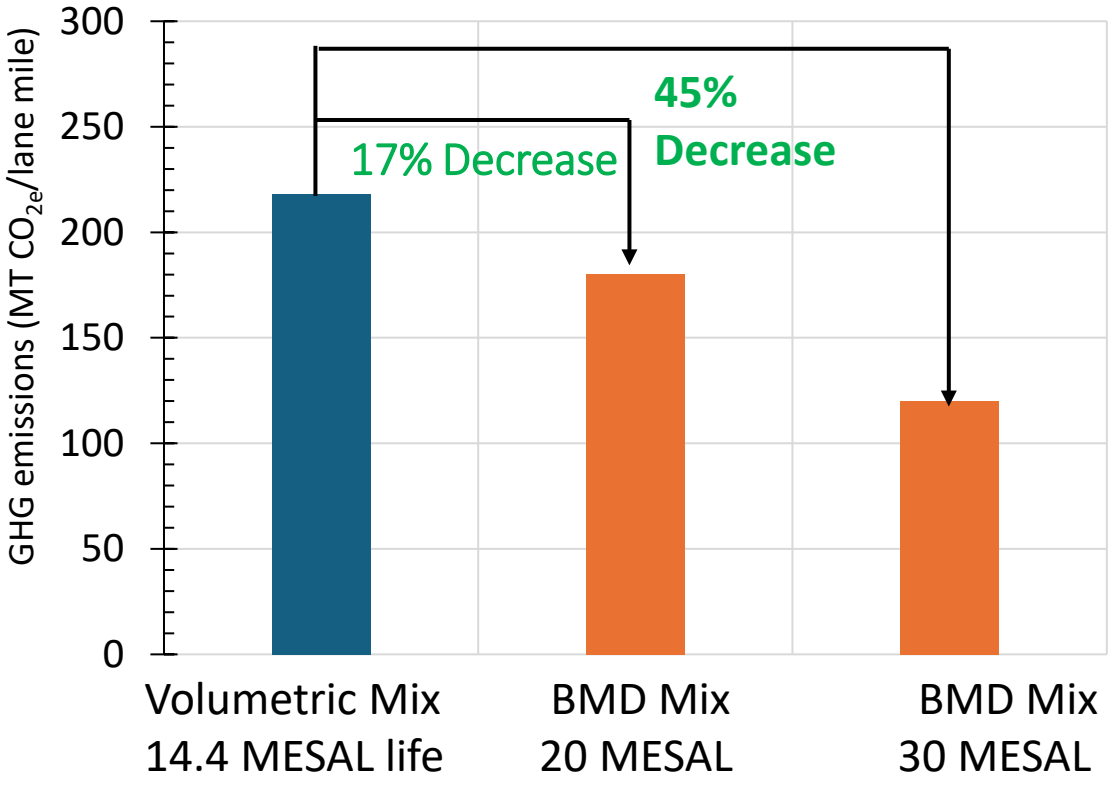


Life Cycle Assessment Results

Initial Construction
(Cradle-to-Constructed)



Full Life Cycle
(Cradle-to-Grave)



Functional Unit – One Lane mile

MT = Metric ton

Life Cycle Integration

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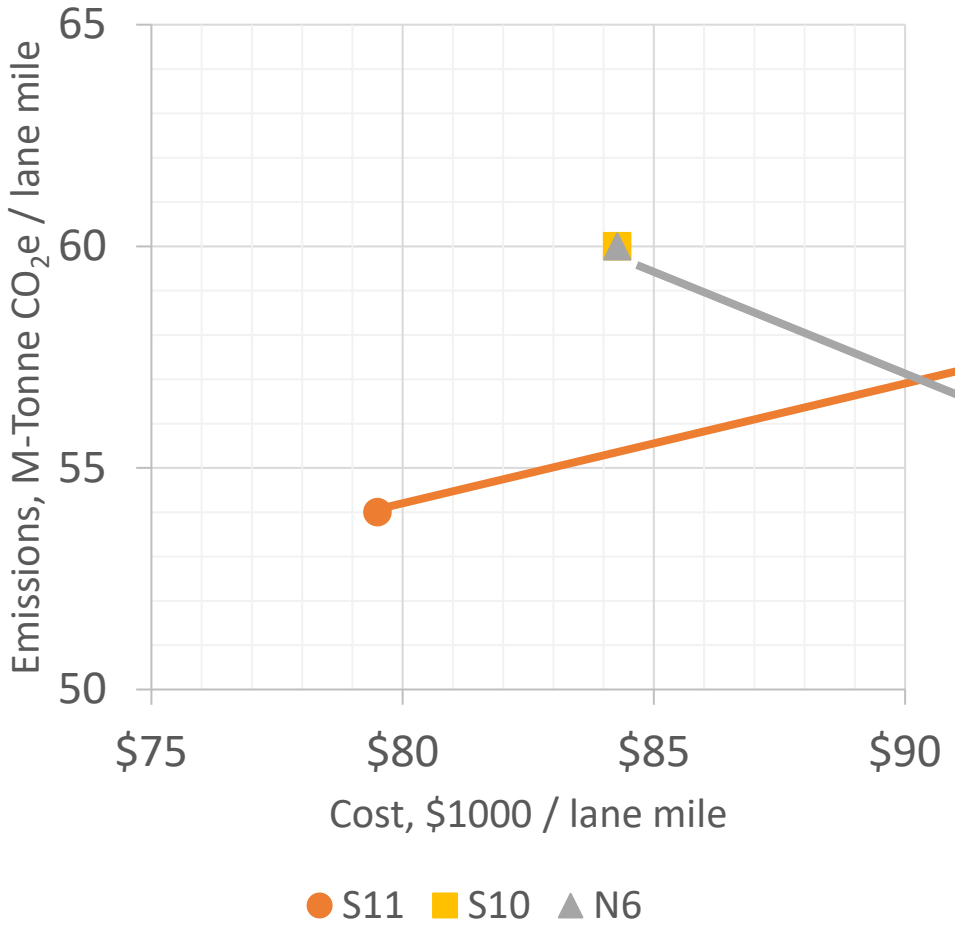
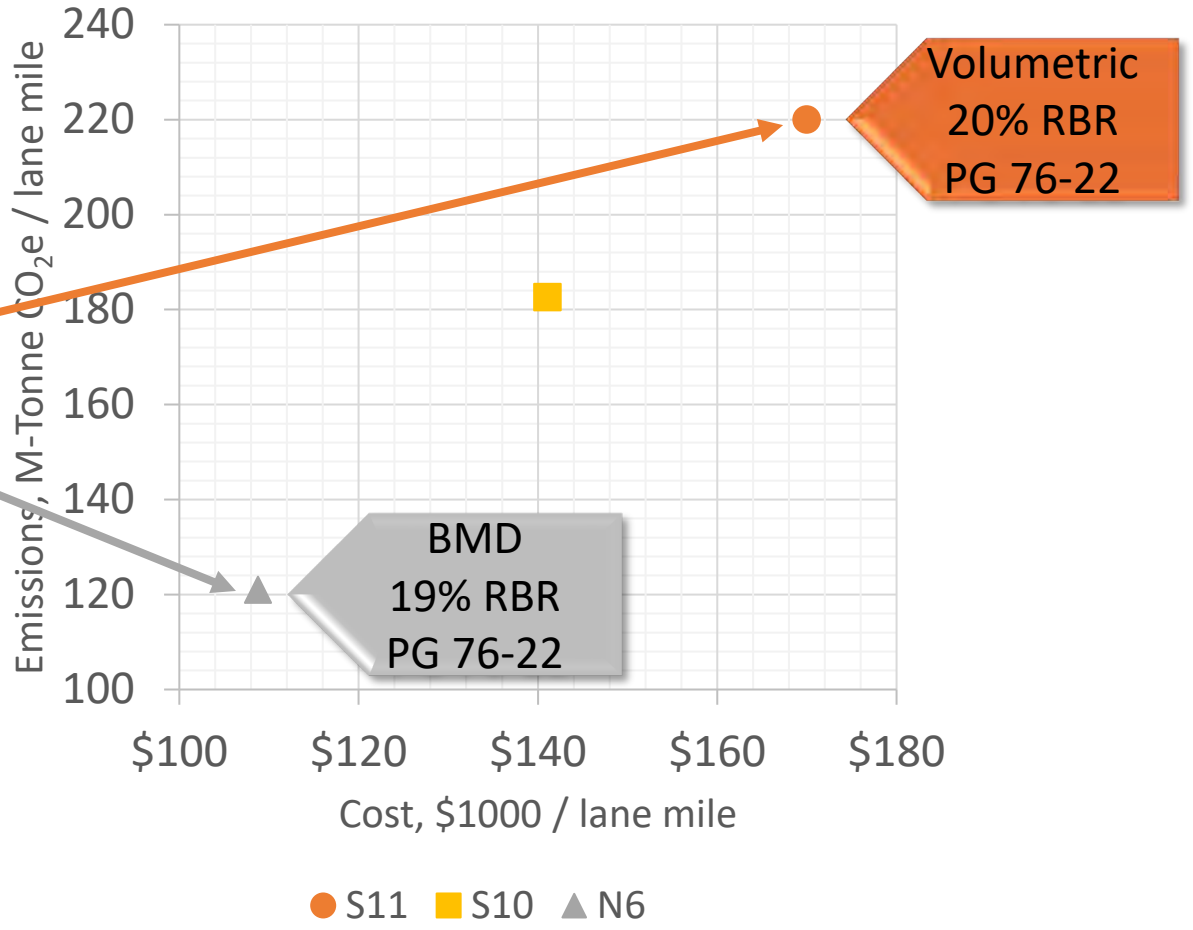
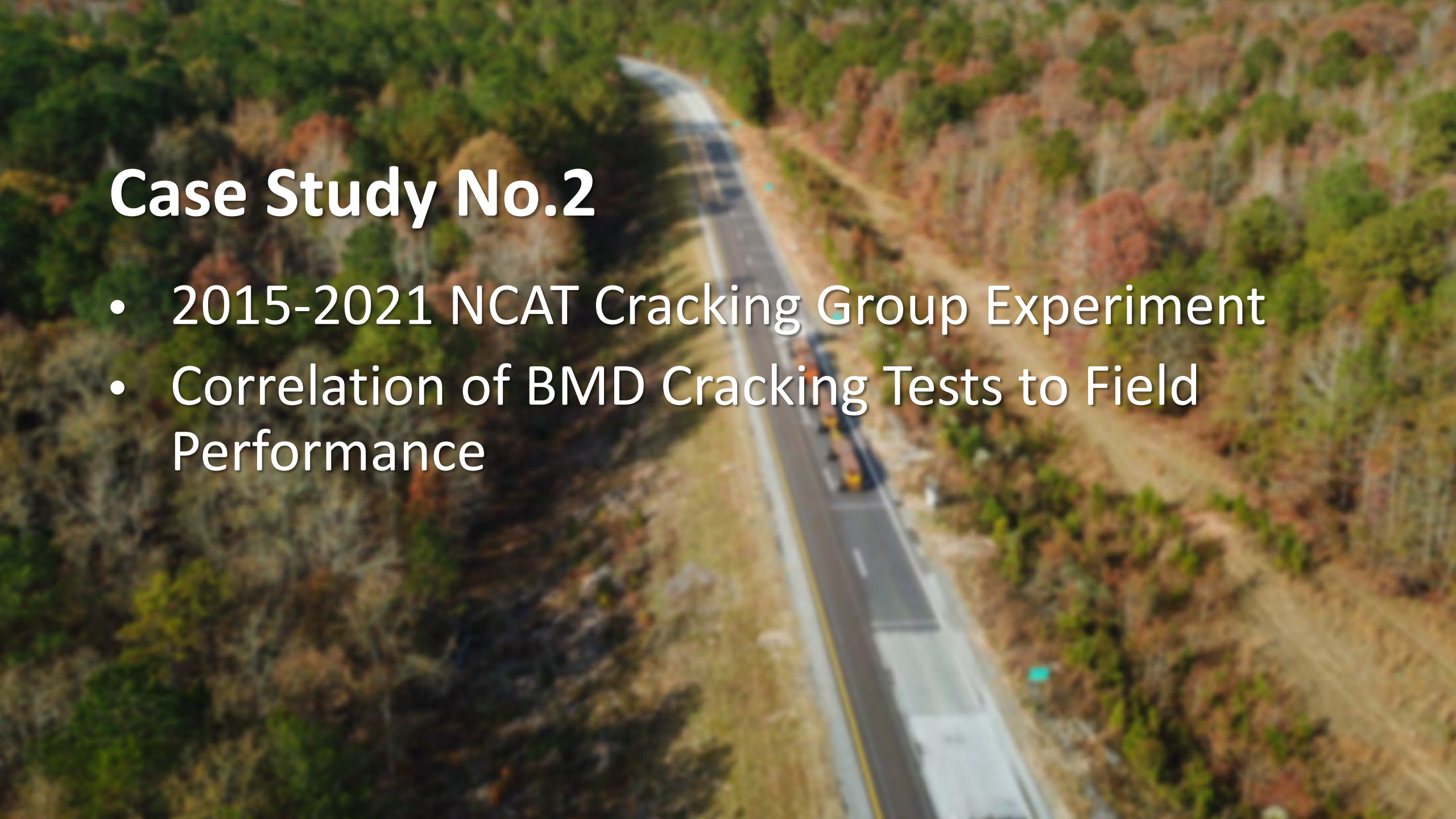
Initial Construction
(Cradle-to-Constructed)



Full Life Cycle
(Cradle-to-Grave)

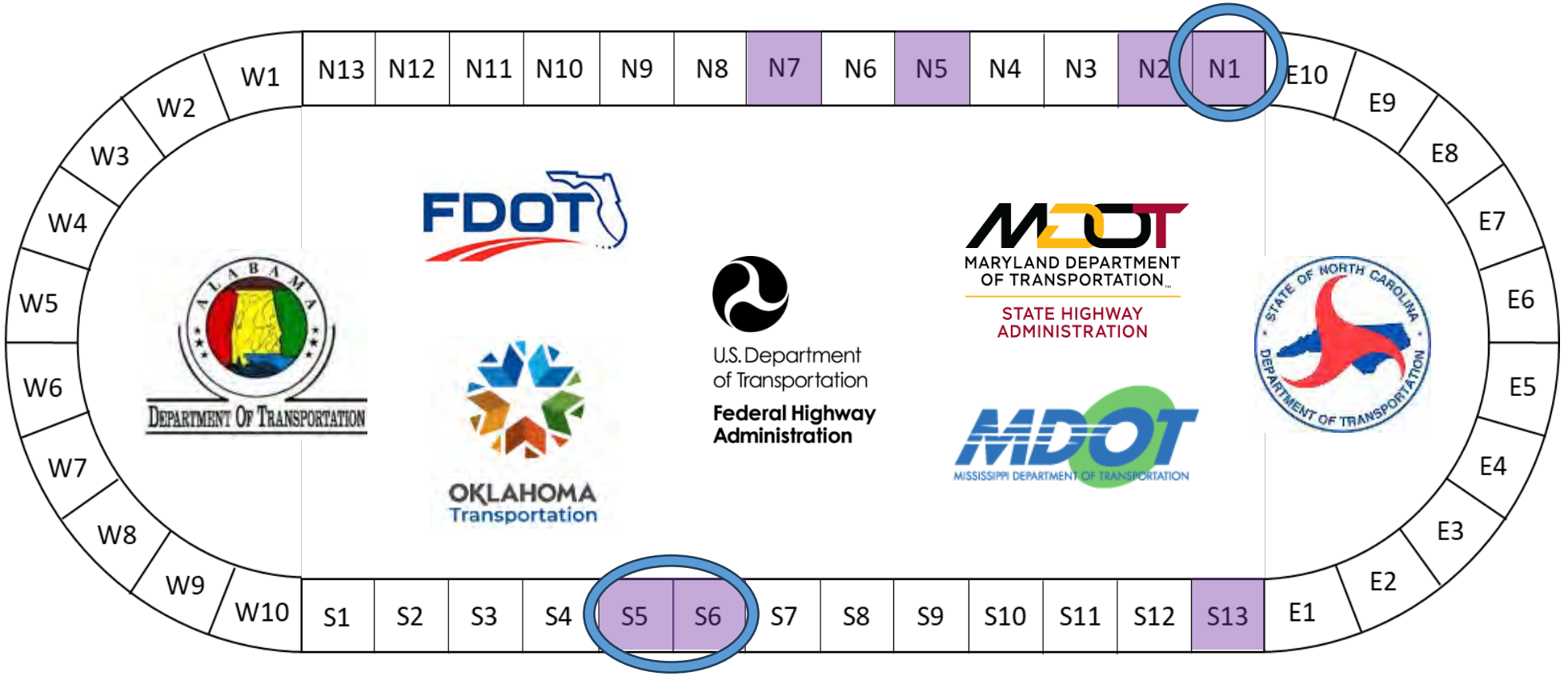




Case Study No.2

- 2015-2021 NCAT Cracking Group Experiment
- Correlation of BMD Cracking Tests to Field Performance

2015-2021 Cracking Group Experiment



BMD and Sustainbility

NCAT Cracking Group Experiment – QC Results

Section	Description	NMAS	Eff. Binder Content (%)	Air Voids (%)	VMA (%)	As-Const. Density (%G_{mm})	Recovered Binder Cont. Grade
N1	20% RAP, PG 64-22 *(Control)*	9.5 mm	4.7	3.8	14.7	93.6	88.6 -16.6
S5	35% RAP, PG 64-28	9.5 mm	5.1	3.2	15.1	92.2	82.8 -23.0
S6	Control w HiMA	9.5 mm	5.0	3.1	14.7	91.8	101.4 -21.5

Cracking Group
Test Section Layer Thicknesses

Surface (Experimental) Layer	**1.5”**
HiMA mix Intermediate Layer	2.25”
HiMA mix Base Layer	2.25”
Granular base	6”
Stiff track subgrade	infinite

6”

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Cracking Group Experiment: BMD Cracking Test Results & Field Performance

Section	Description	Critically Aged Test Results					% Lane Area Cracking
		CT_{index}	Flexibility Index	OT-β	**NCAT-OT β**	S_{app}	Feb. 2021 20 MESALs
N1	20% RAP PG 64-22 (Control)	8.8	0.6	2.08	**0.50**	18.6	44.5
S5	35% RAP PG 64-28	16.3	1.8	1.54	**0.33**	45.3	1.1
S6	Control w HiMA	18.7	3.8	1.07	**0.27**	48.0	0.9

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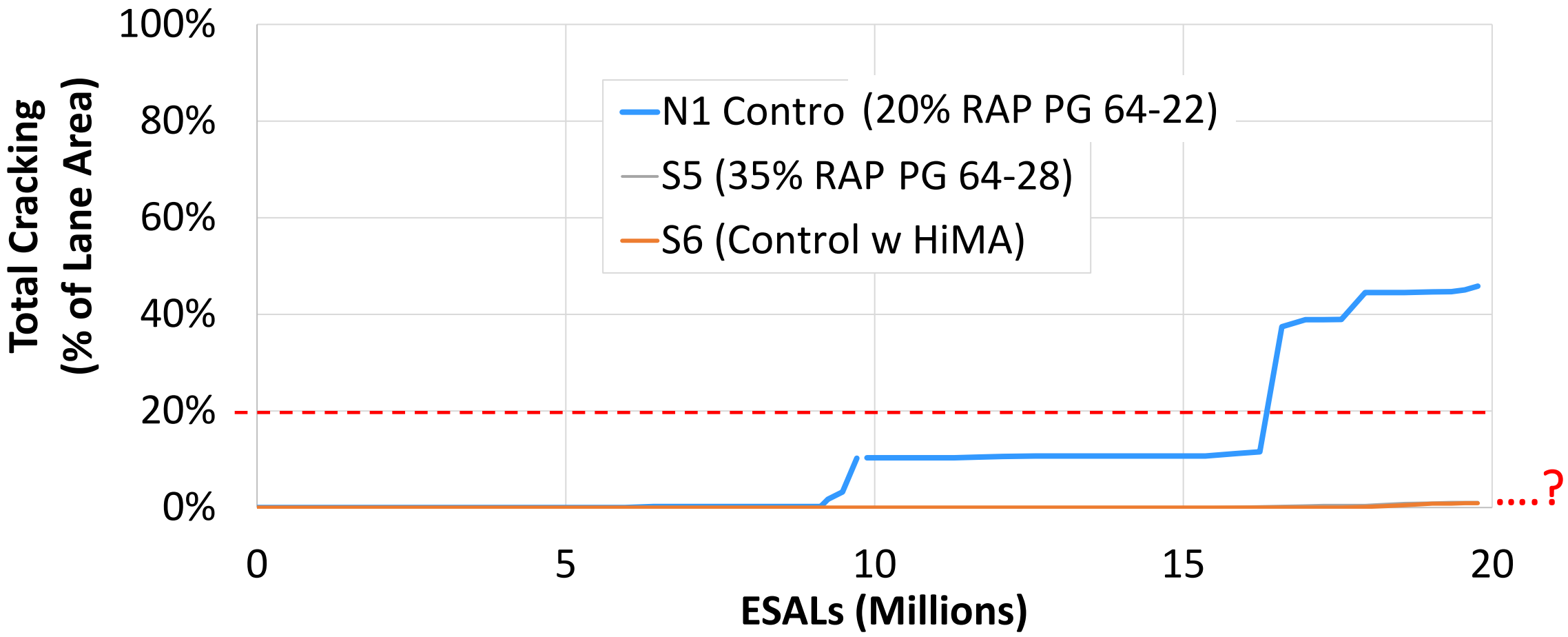
Cracking Group Field Performance



LCCA for Cracking Group

- NCAT LCCA recommendations for ALDOT Alabama Department of Transportation
  - 40-year Analysis Period
  - Discount rate: 4.0%
  - Performance Periods
    - Control mix: 1 yr. on TT = 3.5 yrs on I-85 = 11.4 years
    - 35% RAP mix = ratio of NCAT-OT β = 1.51 = 17.2 years
    - HiMA mix = ratio of NCAT-OT β = 1.85 = 21.1 years
  - Mix Costs
    - Volumetric mix: **$70/ton** per ALDOT bid price database
    - 35% RAP mix: **$70/ton** (PMA binder & RAP savings wash)
    - HiMA mix: **$100/ton** (estimate)

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Life Cycle Cost Analysis Results

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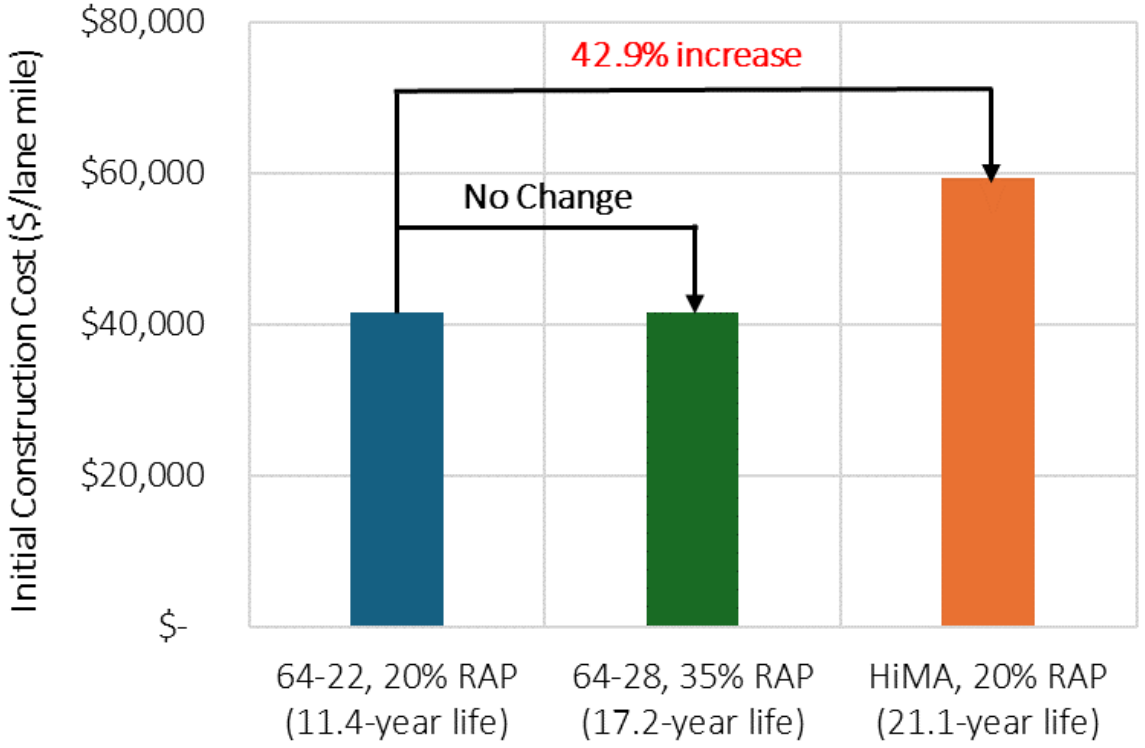
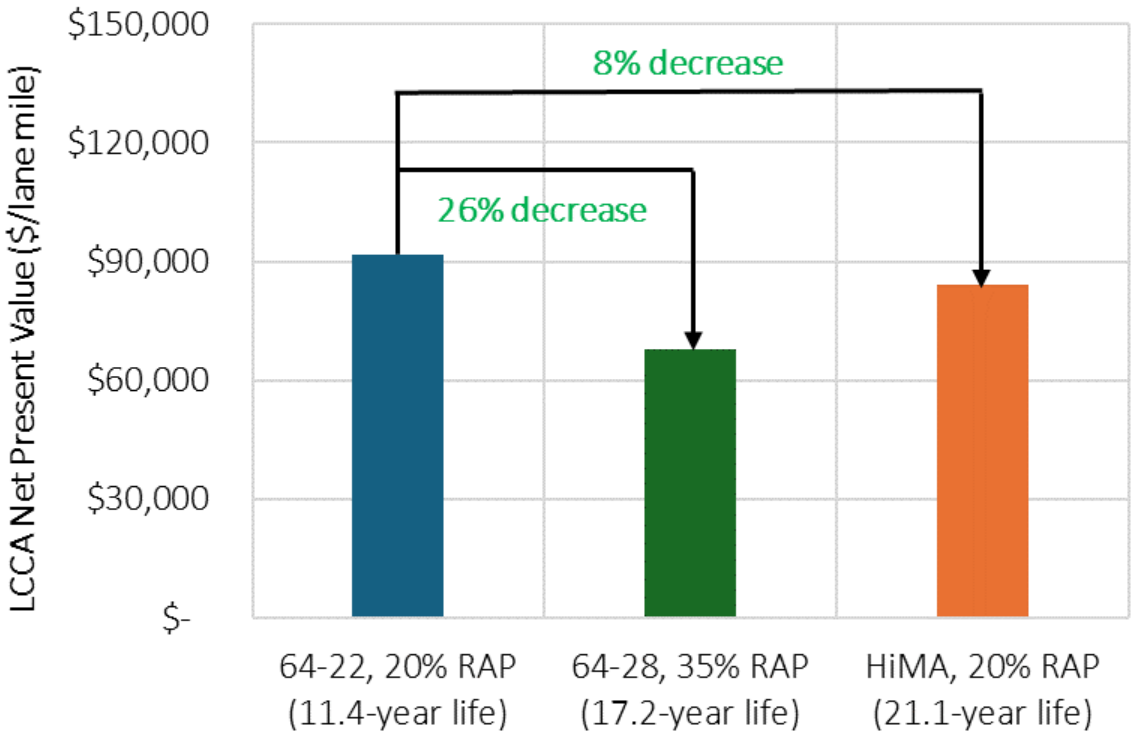
Initial Construction Cost Comparison



LCCA Net Present Value Comparison



Functional Unit – One Lane mile

Life Cycle Assessment Results

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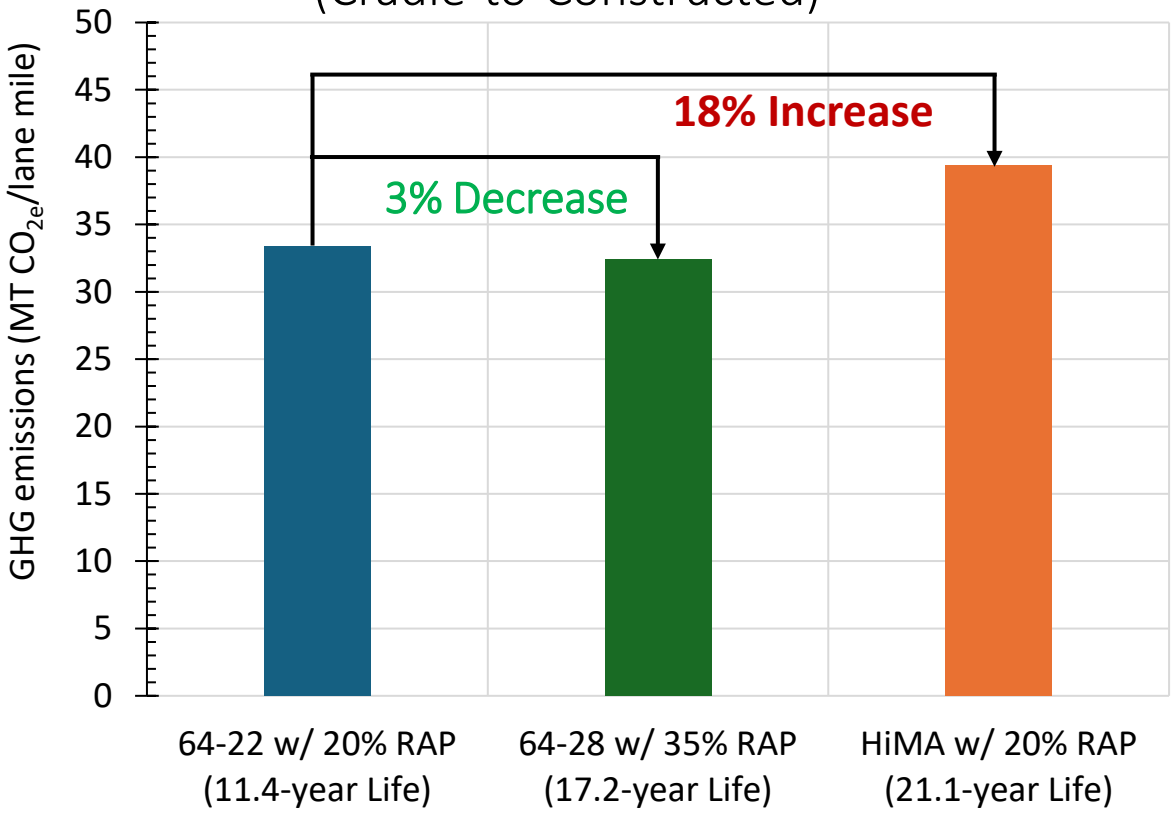
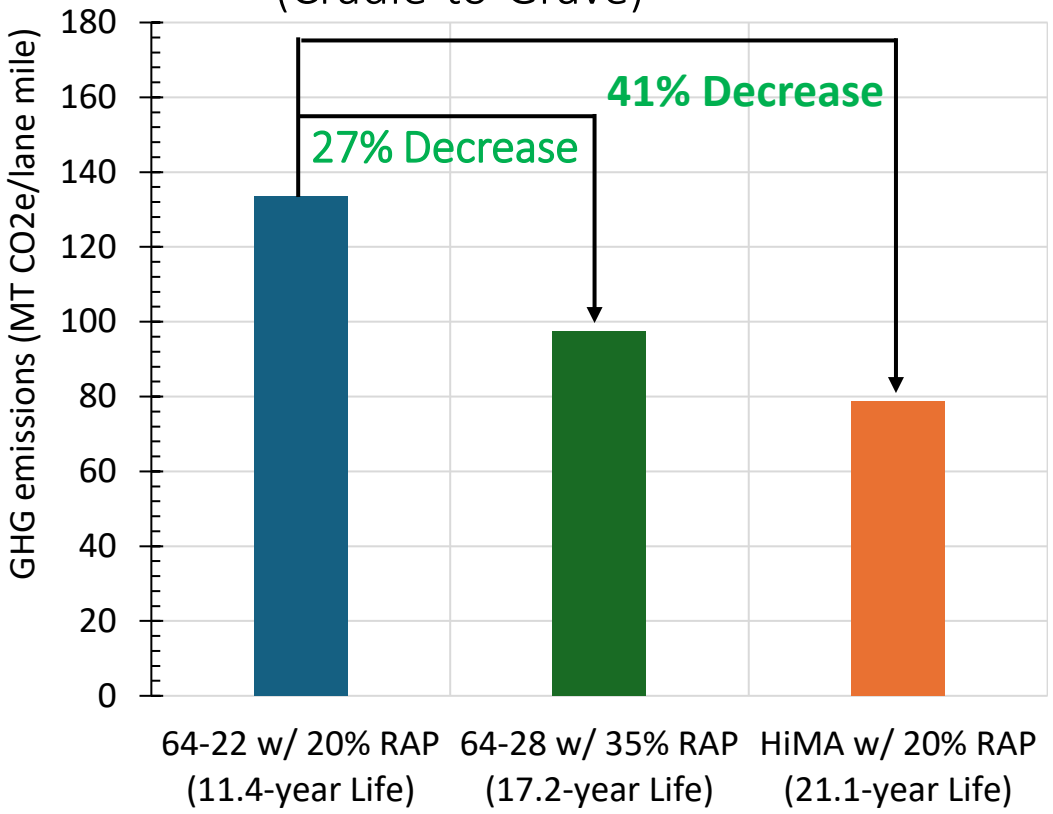
Initial Construction

(Cradle-to-Constructed)



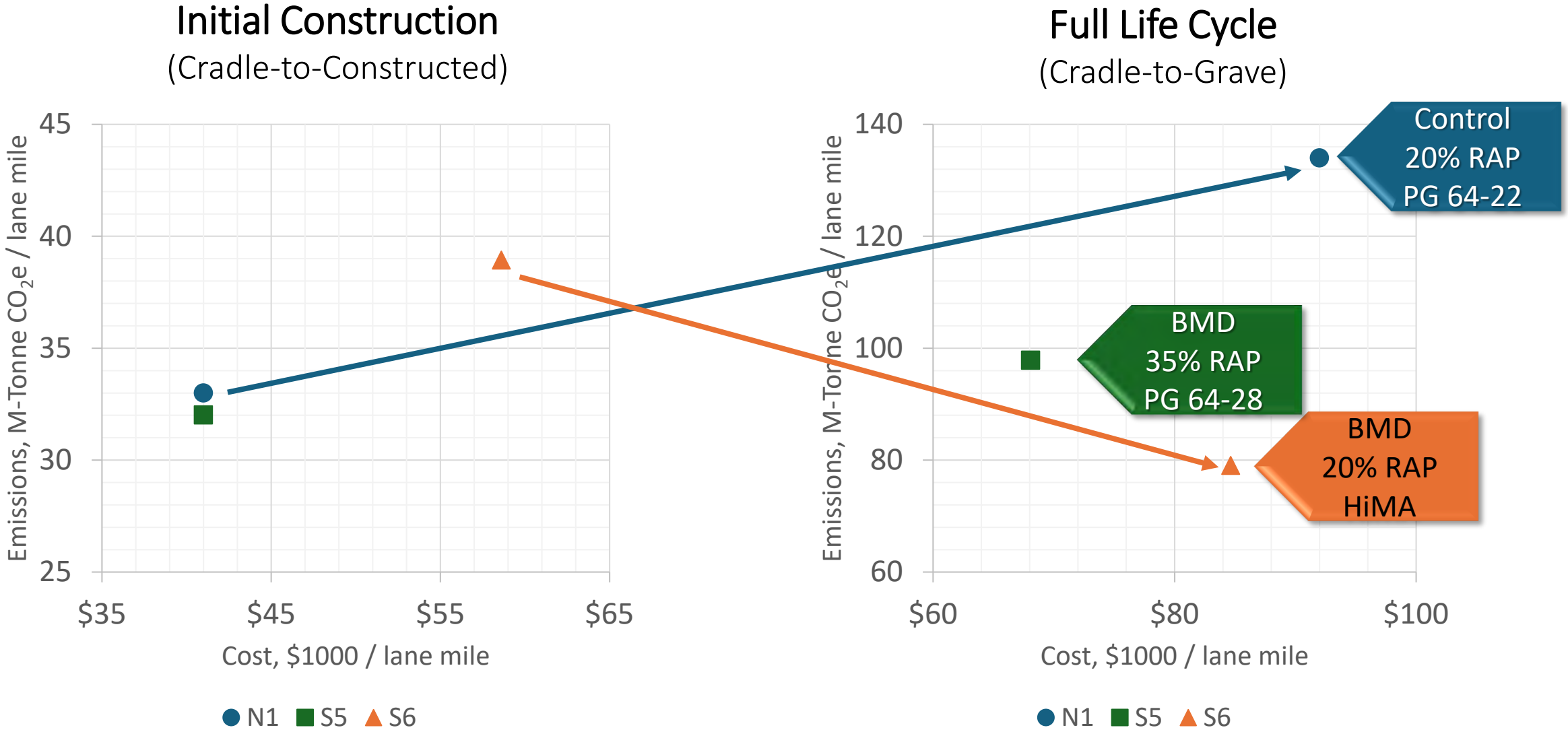
Full Life Cycle

(Cradle-to-Grave)



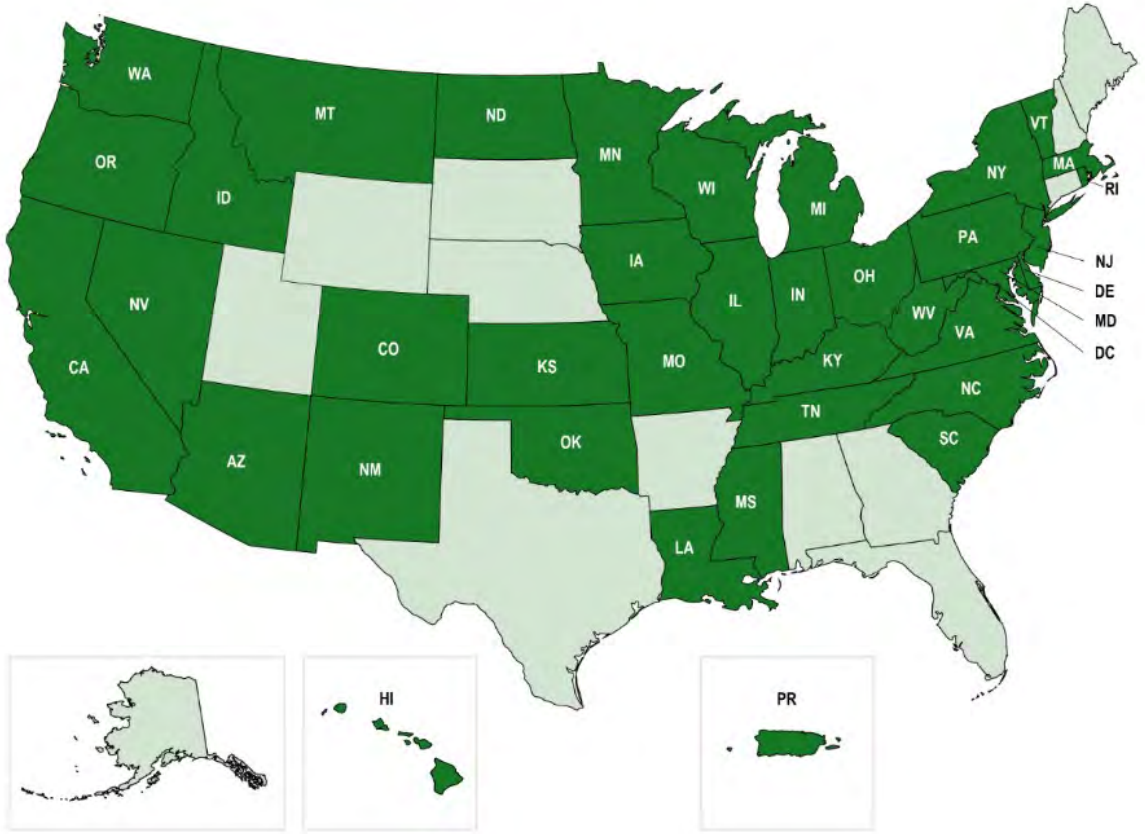
Functional Unit – One Lane mile

Life Cycle Integration



FHWA LCTM Grant Program

- Nov 2024, 37 State DOTs, DC, and Puerto Rico were awarded grants for a total of $1.2 billion dollars.
- The maximum grant per recipient was $32 million dollars.



https://www.fhwa.dot.gov/lowcarbon/

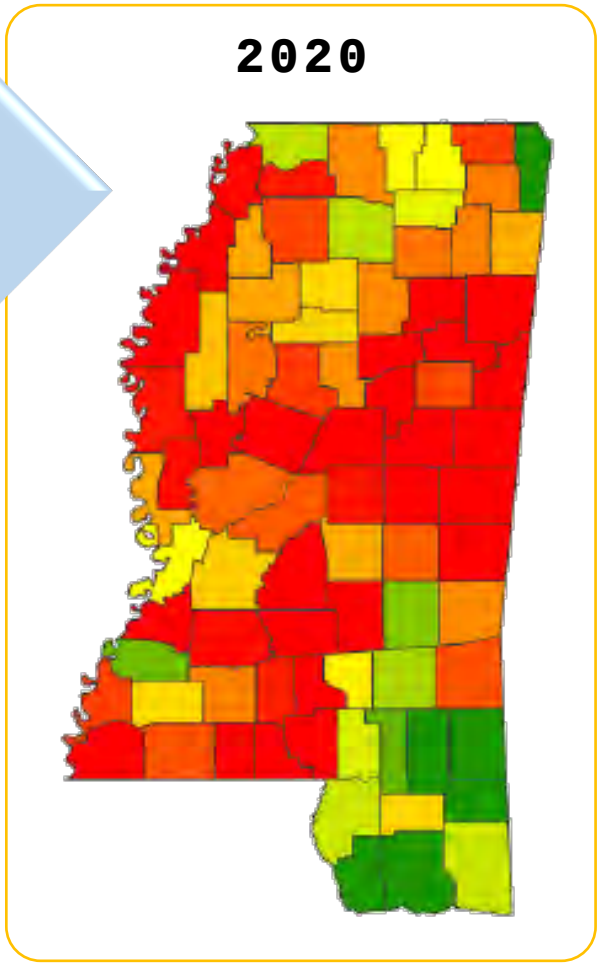
Image: FHWA website.

Why BMD?

- Volumetrics **do not** ensure performance

- What may be the impact of conducing EPD benchmarking on existing materials?

Superpave Consequences



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LCTM Challenge

EPDs do not ensure performance

Traditional Asphalt AQCs
are primarily a measure of quantity NOT quality

BMD needs to be integrated into Mix Design & QA

Consider Leveraging BMD

- PennDOT advancing BMD
  - ✓ HWTT
  - ✓ IDEAL-CT
  - ✓ Delta Tc

Table 1. PennDOT's Preliminary Performance Test Criteria for Mix Design Approval

Traffic Level (Million ESALs)	HWTT			IDEAL-CT	AASHTO R 114, ΔTc*
	Maximum Rut Depth at 20,000 Passes (mm)	Stripping Inflection Point (SIP), Minimum Passes	Minimum Passes at 12.5 mm Rut Depth	Cracking Tolerance Index (CT_{index})	ΔTc
< 3	≤ 15	N/A	N/A	> 70	>-5.0°C
	>15 to ≤ 20	≥ 14,000	10,000		>-5.0°C
3 to <10	≤ 10	N/A	N/A	> 80	>-5.0°C
	>10 to ≤ 15	≥ 14,000	12,000		>-5.0°C
	>15 to ≤ 20	≥ 16,000	14,000		>-5.0°C
≥ 10	≤ 10	N/A	N/A	> 90	>-5.0°C
	>10 to ≤ 12	16,000	15,000		>-5.0°C

* Only applies to JMFs with a total RBR greater than or equal to 0.35

https://www.asphaltpavement.org/uploads/documents/ERT%20Related/BMD_Resource_Guide/PA-SOP_11.2024.pdf

Nuggets

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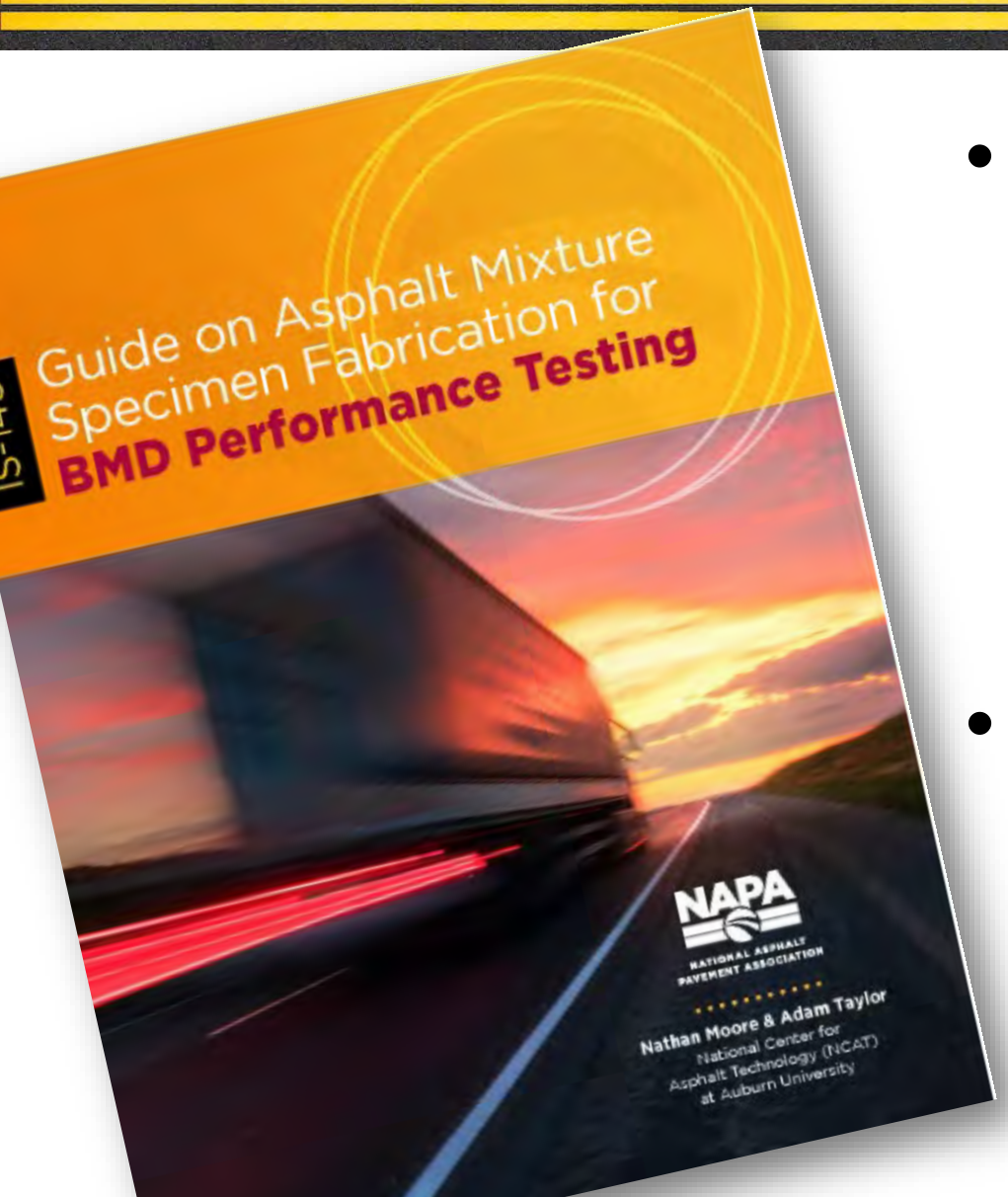
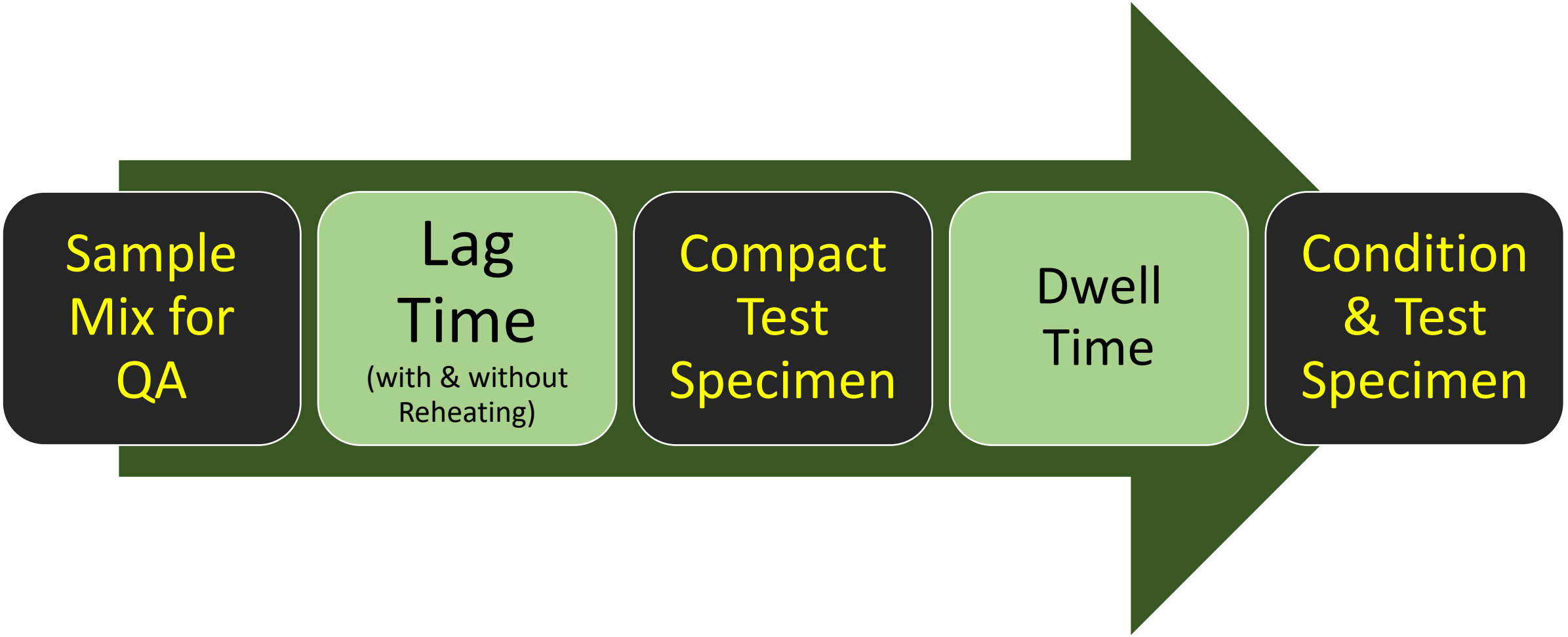
Sample Preparation Guide



- As the asphalt industry moves toward BMD and performance testing it is important to remember that the preparation of the samples being tested can affect the results of the testing.
- The *Guide on Asphalt Mixture Specimen Fabrication for BMD Performance Testing* is helpful in obtaining consistent results

YouTube

The Challenge of Time/Logistics



Online Opportunities

National Center for Asphalt Technology NCAT AT AUBURN UNIVERSITY presents

FROM RESEARCH TO IMPLEMENTATION

WEBINAR SERIES

Topic:

Mix Selection for Layers

January 15, 2024 : 10-11am CT

REGISTER TODAY

Buzz Powell (NCAT) and a guest will discuss ways to use more locally available aggregates and RAP in mixes to better utilize existing resources.

Free to Test Track Sponsors : $25 for Non-Sponsors

Free to DOT staff.

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ASPHALT TRAINING

QUICK VIDEO SESSIONS

YouTube

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CDOT
CPI
CRH
CWM Contracting Co
Department of Transportation – United States of America
Ergon Asphalt & Emulsions, Inc.
Flexible Pavements of Ohio
FDOT
FORTA Asphalt Fiber – Stronger Lasting
GDOT – Georgia Department of Transportation
Department of Transportation – State of Hawaii
The Heritage Group
Idaho Transportation Department
Illinois Asphalt Pavement Association
Indiana Department of Transportation
ingevity
Kentucky Transportation Cabinet
MaineDOT
Mathy Construction Co.
MDOT – Michigan Department of Transportation
Minnesota Department of Transportation
MDOT – Mississippi Department of Transportation
MoDOT
NAPA – National Asphalt Pavement Association
West Contracting
National Center for Asphalt Technology – NCAT – At Auburn University
NSSGA – National Stone, Sand & Gravel Association
Nebraska Department of Transportation
NMDOT
New York State Department of Transportation
North Carolina Department of Transportation
North Dakota – Be Legendary.
Ohio Department of Transportation
Oklahoma Transportation
pennsylvania – Department of Transportation
Puerto Rico Highway and Transportation Authority
Rieth-Riley – 100% Employee Owned
Rogers
SCDOT – South Carolina Department of Transportation
TN TDOT – Department of Transportation
Texas A&M Transportation Institute
Texas Department of Transportation
University of Nevada, Reno
VDOT – Virginia Department of Transportation
Walbec Group
WSDOT
Wisconsin Department of Transportation

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Field Validation

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Guidelines and Recommendations for Field Validation of Test Criteria for Balanced Mixture Design (BMD) Implementation

1 Advantages, Disadvantages, and Limitations of Existing Open-Road Test Sections

2 Types of Distresses Evaluated in Field Sites

3 Range of Mixtures and Materials in the Field Validation Effort

4 Number of Test Sections for a Site

5 Length of Test Sections

6 Roadway Geometrics to Avoid

7 Sampling, Conditioning, and Testing Plan

8 Pavement Performance Monitoring, Traffic, and Climate Data Collection

9 Forensic Investigation

10 Data Analysis and Application of the Results in Specifications

11 Establishing Interim Minimum Criteria

APPENDIX
History of Road Tests

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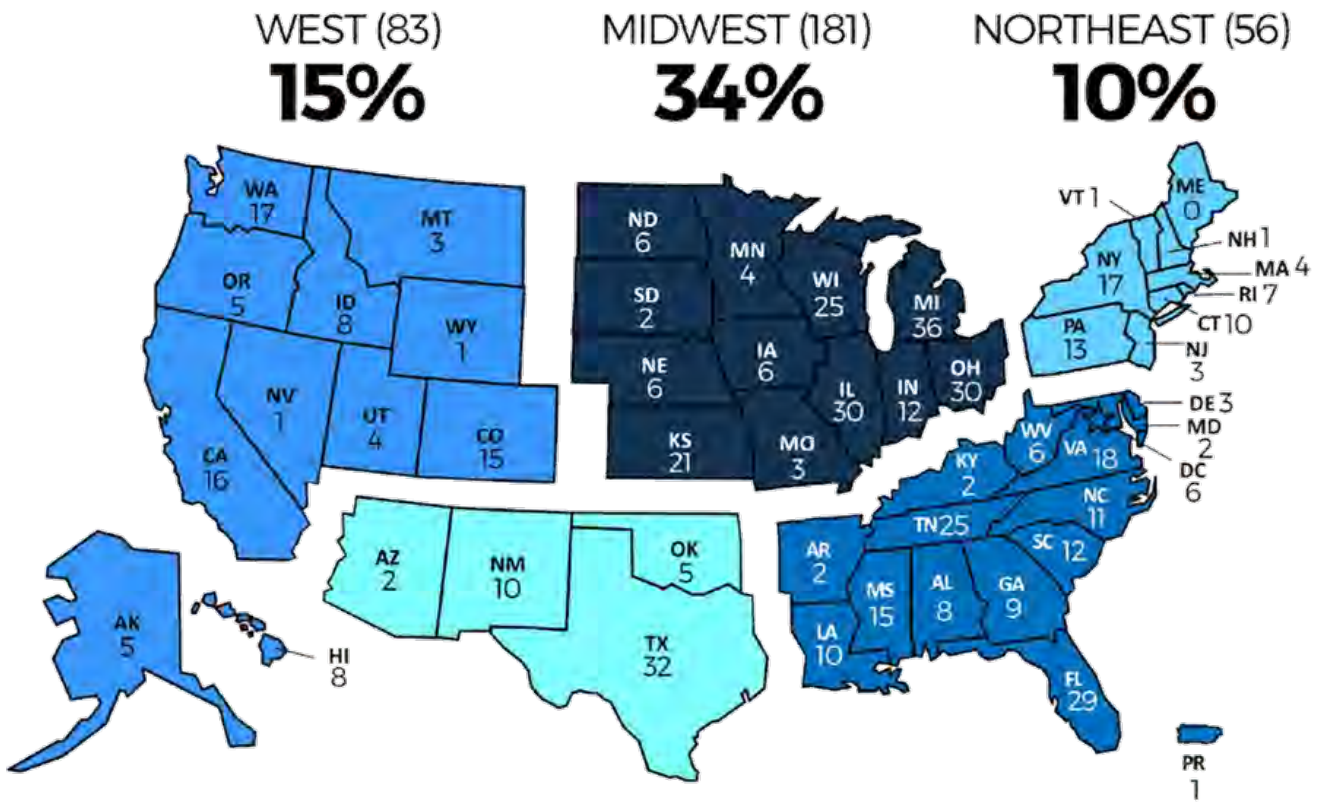
Customized Training

Professor Training Course

This five-day educational program provides college and university civil engineering faculty clear and up-to-date instructional resources to teach the asphalt portion of an undergraduate civil engineering materials course.

542 Professor Training Course Attendees by Region (1988-2018)



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Thank You