Towards Sustainable Paving – Virginia's Efforts on Binder Modification using Hybrid Rubber and Recycled Plastic Waste

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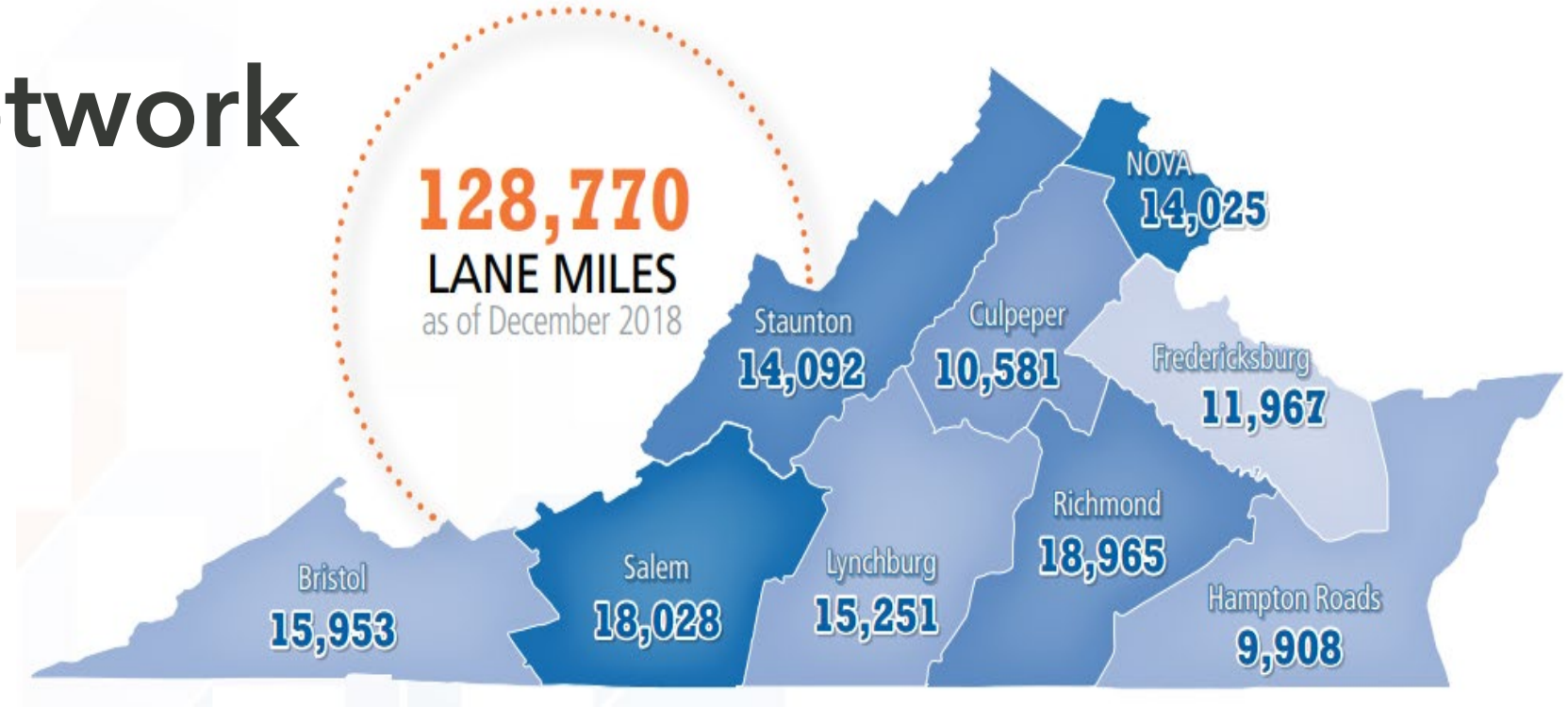
Background

VDOT's Network, Mission, and Research

Virginia's Network

VDOT
Virginia Department of Transportation

3rd largest US public roadway network



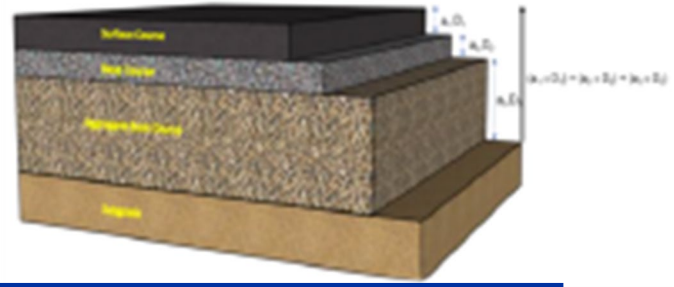
- Maintain all state roadway systems: interstate, primary, secondary, and frontage
- 98% of hard-surfaced roadways have asphalt surface
  - **Interstate:** > 1,000 of 5,000 lane-miles of asphalt over JCP
  - **Primary Network:** > 1,100 of 22,000 lane-miles of asphalt over JCP

Mission and Primary Goal

- In-Pursuit of ***"Durability"*** from Multiple Perspectives

Materials

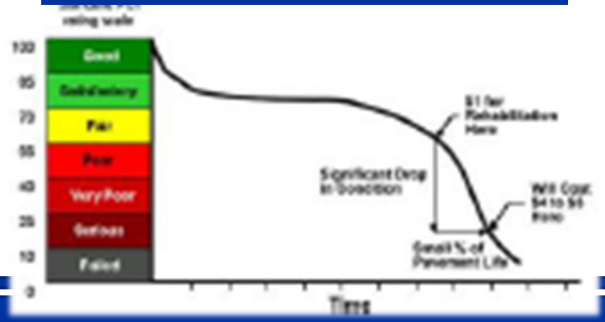
Pavement Structural Design



Construction

Preservation, Maintenance, & Repair

Management



Research Support - Materials

- Use of high performing mixes
  - Highly modified polymer (HP) mixes
  - Stone Matrix Asphalt
- Adoption of Balanced Mix Design
  - Performance drives design, not only volumetrics
- Evaluating additives / alternatives for improved performance
  - Recycling agents
  - Paving fabric interlayers
  - ***Rubber / Hybrid Rubber***
  - ***Recycled Plastic Waste***

HRMA Binders and Mixtures

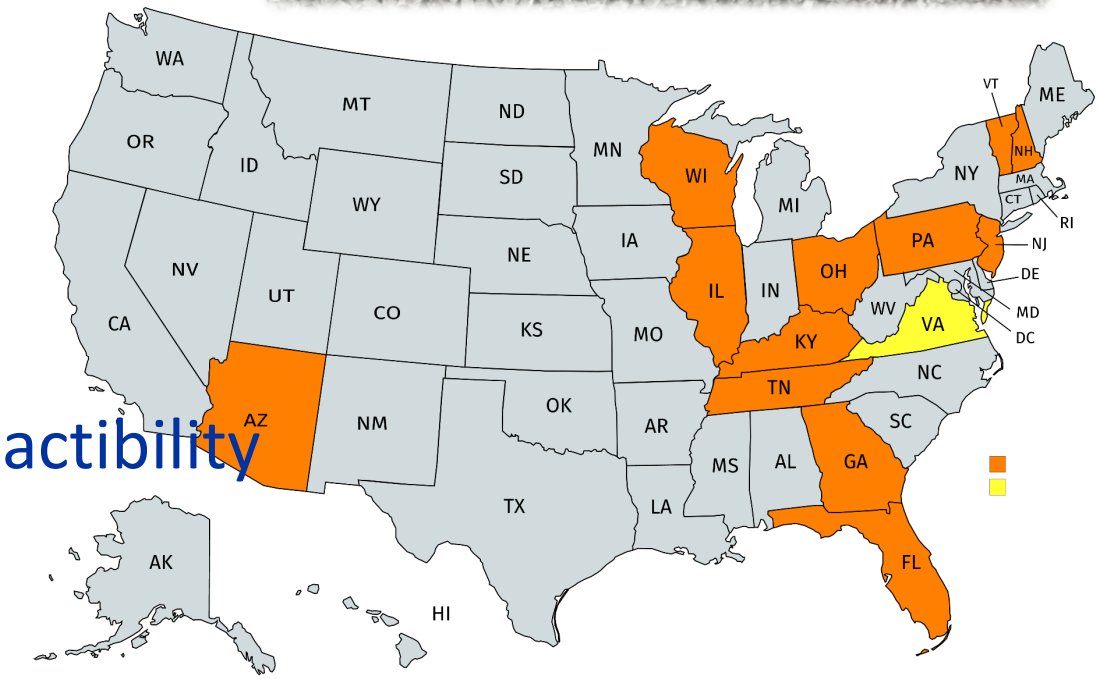
Background, Trials, Experimental Program, Results, and Future Efforts

Introduction

- Currently, VDOT primarily relies on SBS modified asphalt binders
- Recently, GTR modified binders were used in two field projects in Richmond District – GTR blending in the plant ***(wet process)*** or through a feeding machine for ***dry process***
- ***Hybrid Rubber Modified Asphalt (HRMA)*** is an additional option / alternative for asphalt binder modification.

Background

- HRMA
  - 75% GTR + 20% SBS + 5% Chemistry
- Modification
  - Terminal or Plant
  - Very high solubility
  - Very high elastic recovery (~85%)
  - High workability and effective compactibility



HRMA Trials – Summer 2021

Producer	Location	Mix Type (~700 tons per mix per night [1 night])
Virginia Paving	Rte 120 / Glebe Rd	**SM-9.5 E:** 15% RAP + PG64E-22
		SM-9.5 HRMA: 15% RAP + HRMA binder
Superior Paving	Rte 625 / Waxpool	**SM-12.5 E:** 15% RAP + PG64E-22
		SM-12.5 HRMA: 15% RAP + HRMA binder

Experimental Program

- Laboratory Evaluation
  - Non-Reheated Specimens (Volumetrics & BMD Testing)
  - Reheated Specimens (Three [3] Levels of Testing)
  - Field Cores (thickness, density, permeability, & cracking testing)
  - Evaluation of Virgin and Extracted & Recovered Binders
- Structural assessment via NDT
  - Run FWD, GPR, and Profilometer (IRI)
- Surface Condition Survey
  - Initial, 12-month, and 24-month (+ periodical visits)

Experimental Program

Plant Produced Laboratory Compacted Mixtures

Testing Complexity

- **Basic**
- **Intermediate**
- **Advanced**

Resistance to Cracking

- IDT-CT
- Texas Overlay & I-FIT
- Cyclic Fatigue Test

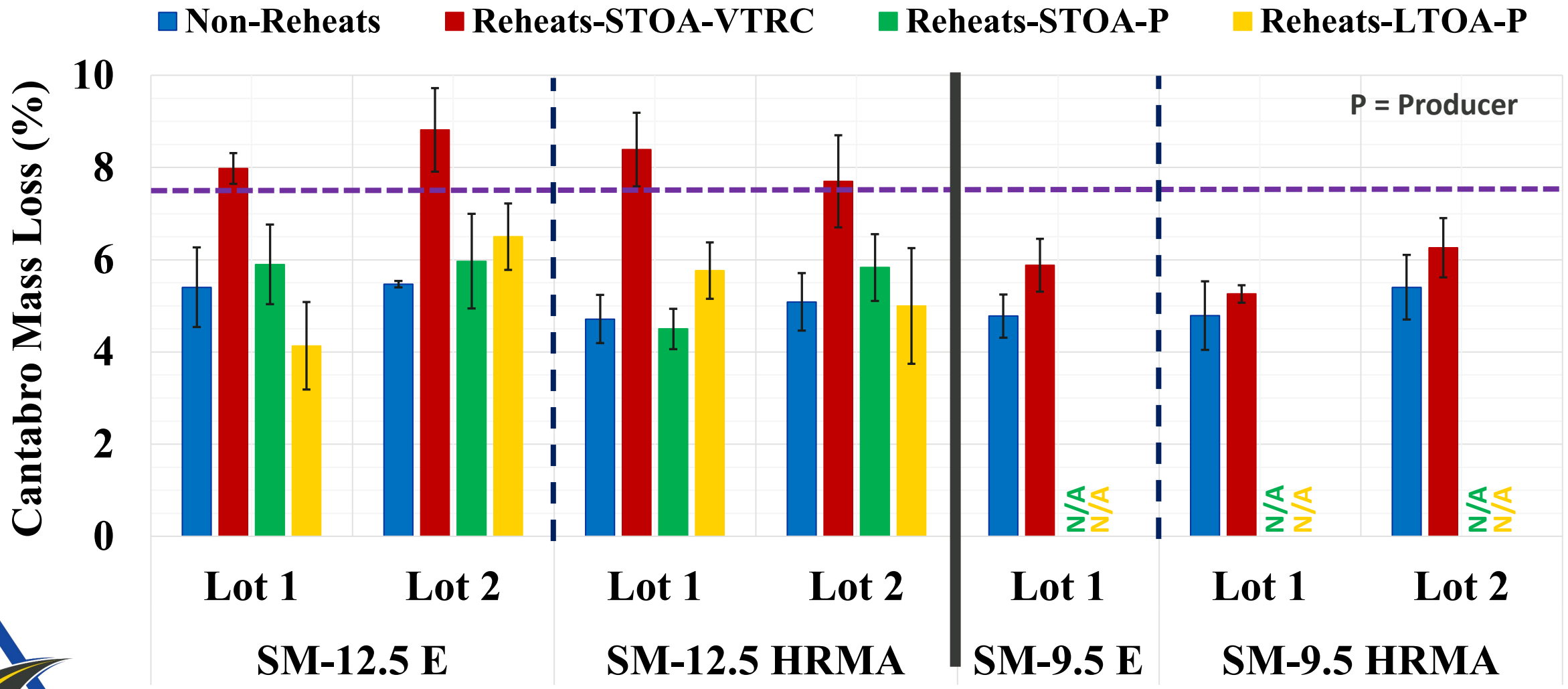
Resistance to Rutting

- IDT High Temp & IDEAL-RT
- APA Test
- Stress Sweep Rutting & Repeated Load Triaxial Tests

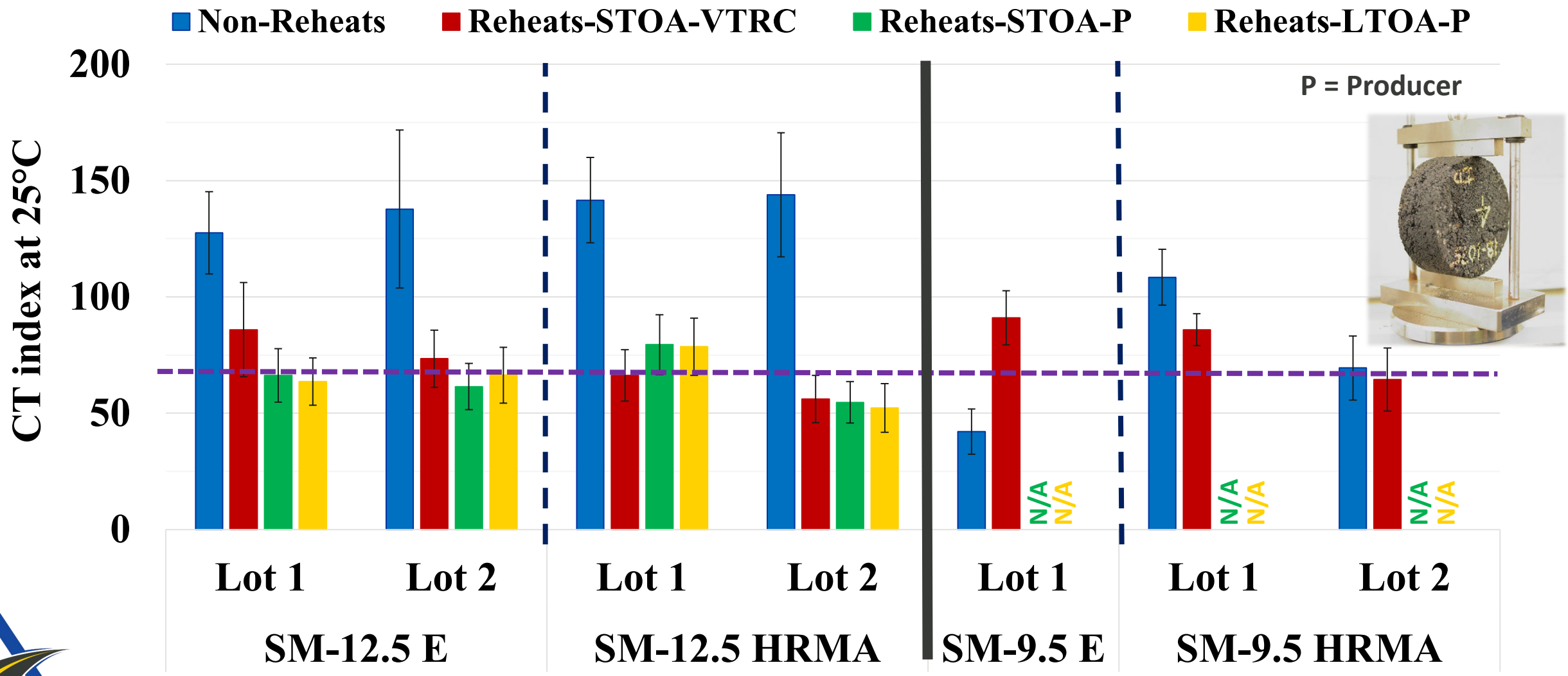
Initial Long-Term Oven Aging Protocol

- Assuming mixes in Virginia experience overall cracking after 8 years of field aging:
  - **Loose mixture aging at 135°C**
    - ➢STOA at 135°C for **4 hrs** followed by LTOA for **~8 hrs** at 135°C
  - **Loose mixture aging at 95°C**
    - ➢STOA at 135°C for **4 hrs** followed by LTOA for **3 days** at 95°C
  - **Compacted mixture aging at 85°C**
    - ➢STOA at 135°C for **4 hrs** followed by compaction then LTOA for **4 days** of compacted specimens at 85°C

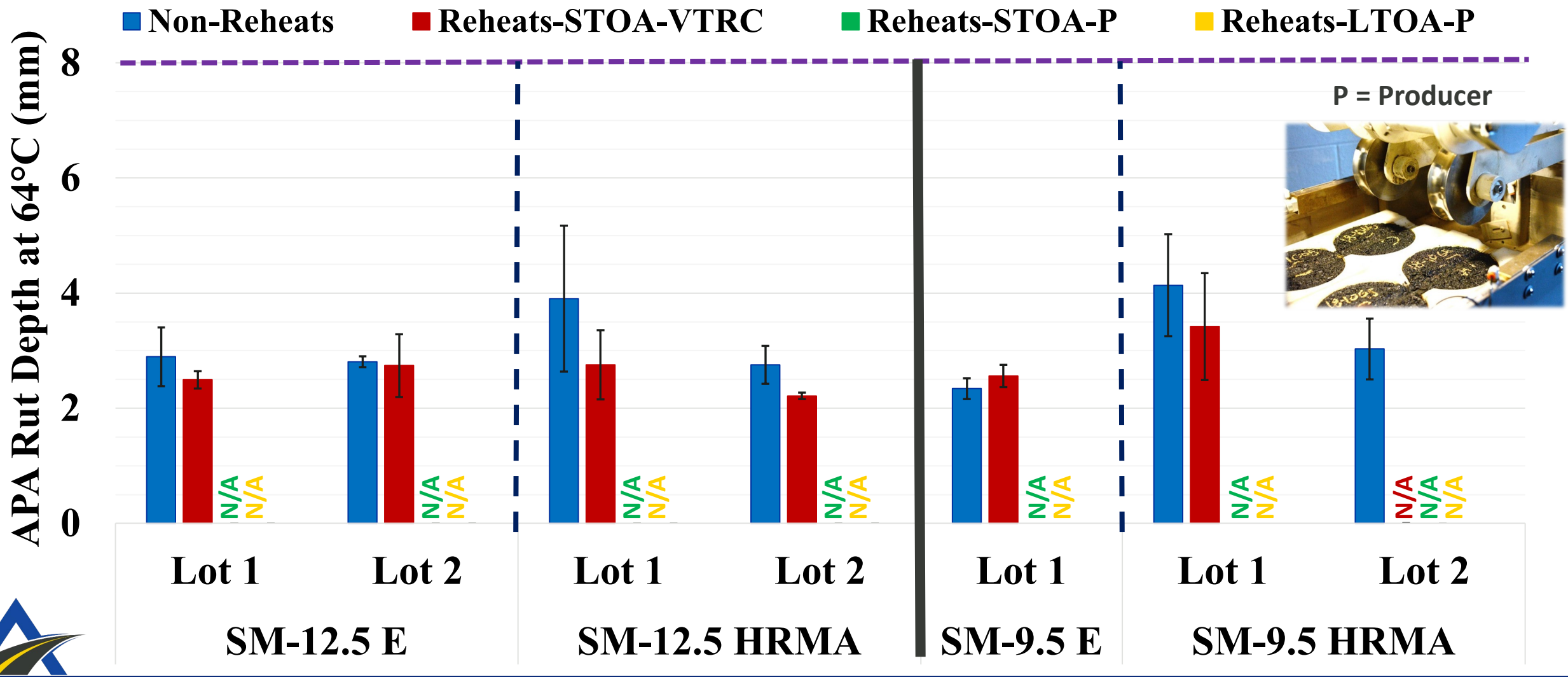
Durability – Cantabro Mass Loss



Cracking - IDT-CT at 25°C



Rutting - APA Test (64°C, 8000 cycles)

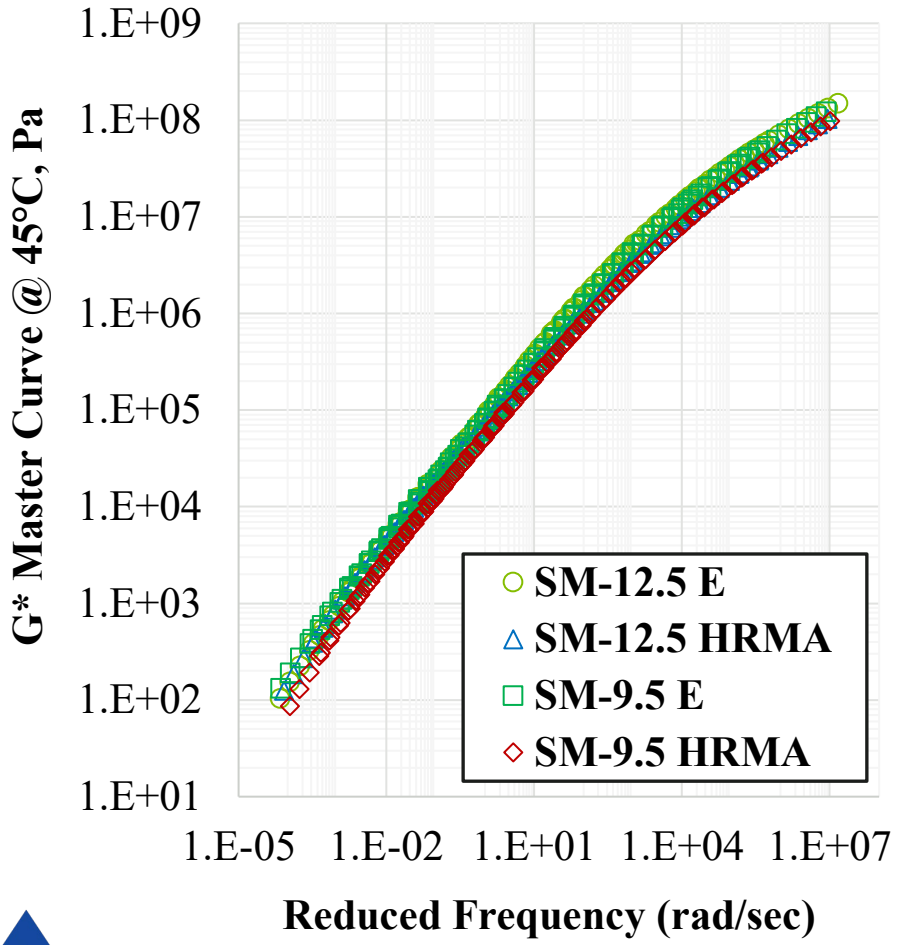


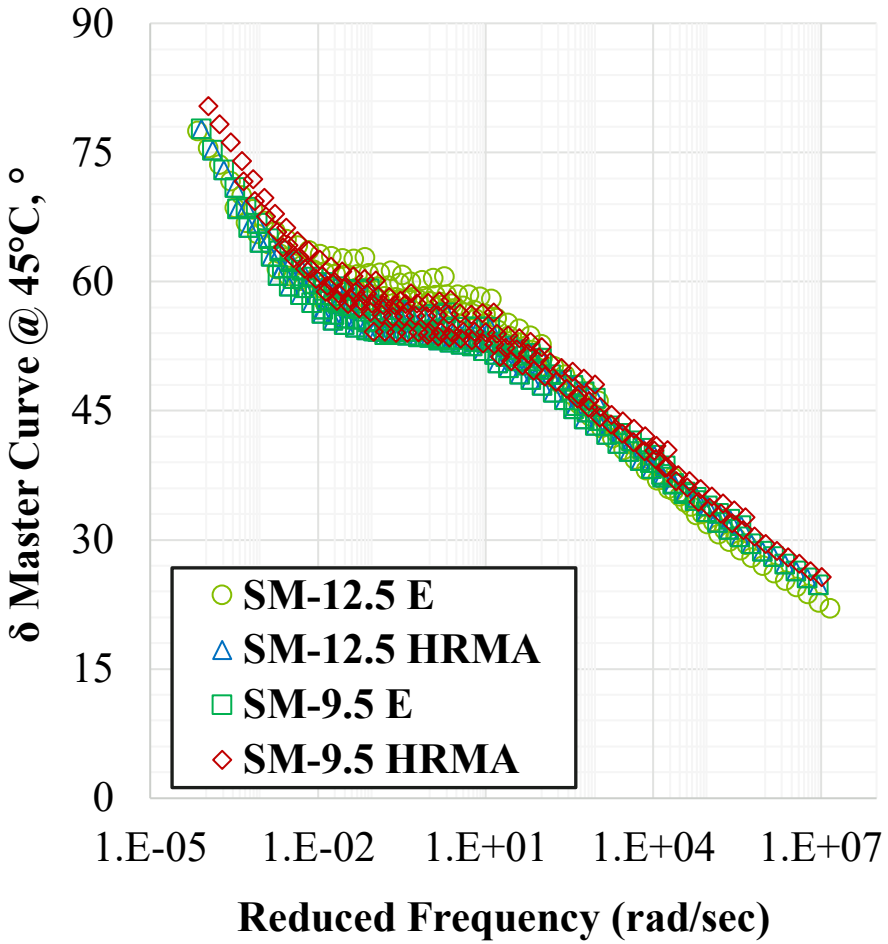
Asphalt Binders - PG

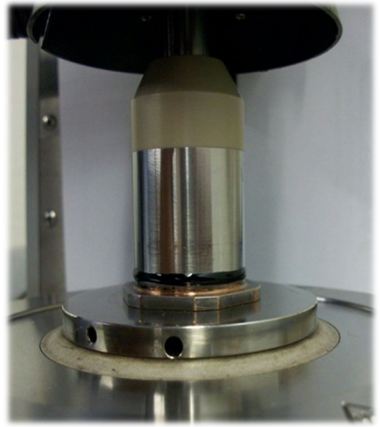
Mix / Binder ID	PGH	MSCR @ 64°C		after 20 hrs PAV			after 40 hrs PAV		
		Jnr@3.2	%R@3.2	PGI	PGL	ΔTc	PGI	PGL	ΔTc
SM-12.5 E	79.1	0.19	67.6	23.8	-24.1	-1.9	25.9	-20.1	-4.7
SM-12.5 HRMA	79.6	0.19	62.8	19.5	-27.7	-1.8	22.0	-25.0	-3.2
SM-9.5 E	80.8	0.13	75.1	20.9	-25.9	-1.3	24.7	-22.3	-3.8
SM-9.5 E (E&R)	76.3	0.36	57.2	20.1	-26.6	-2.3	xx	xx	xx
SM-9.5 HRMA	79.3	0.27	56.3	18.4	-28.3	-1.7	20.6	-25.7	-3.2
SM-9.5 HRMA (E&R)	73.7	0.81	31.5	17.9	-27.8	-3.4	xx	xx	xx

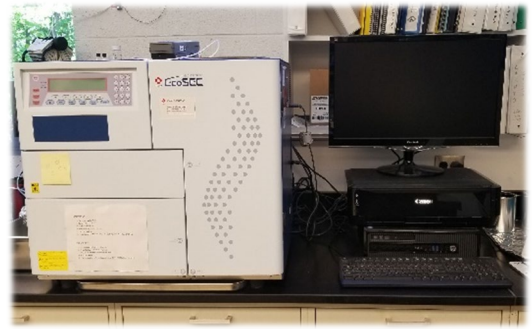
→ ***Was able to design a binder with a performance equal or better to the conventional E binder !!***

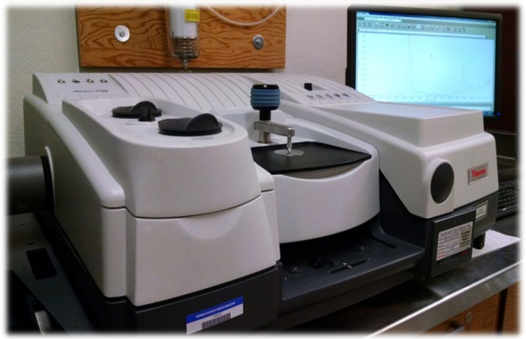
Asphalt Binders – Master Curves



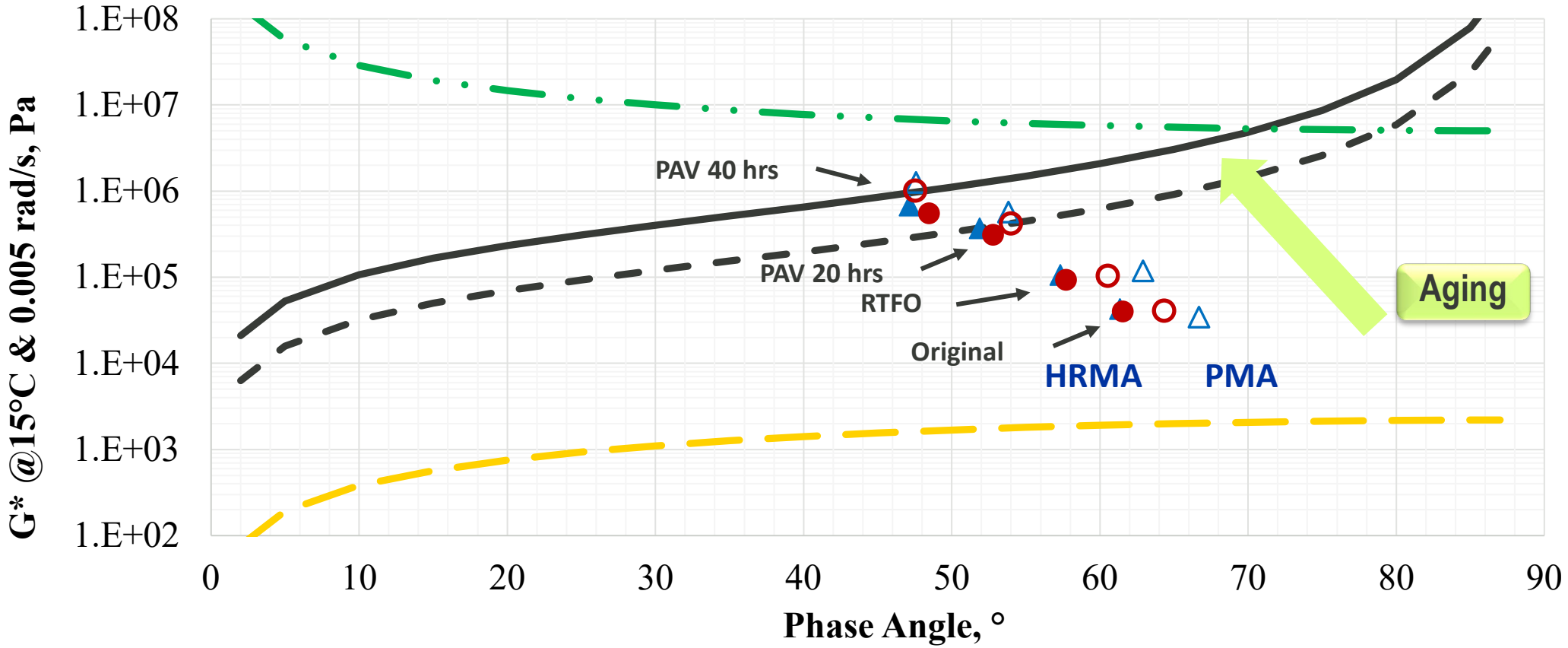








Asphalt Binders – Aging Susceptibility



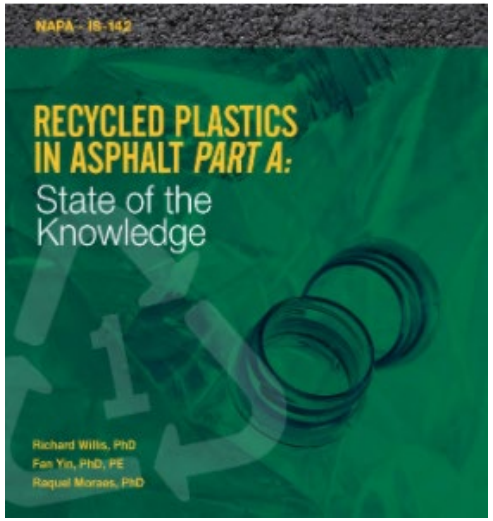
Upcoming Efforts – SMA-HRMA

- Construct and Assess SMA-HRMA Field Trials
  - The compatibility of the expansion effect of HRMA binders and the differences in volumetric properties and aggregate gradation characteristics of SMA mixtures are expected to result in a premium performance of the SMA-HRMA resultant mixture

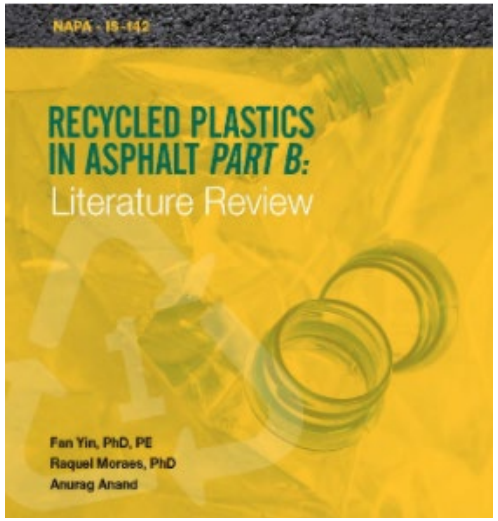
→ Provide VDOT with additional alternatives to modify asphalt binders and mixtures (SM-PMA & SMA-PMA vs. SM-HP & SMA-HP vs. ***SM-HRMA & SMA-HRMA***)

RPM Binders & Mixtures

Motivations, Vision, Field Trials, Results, and Lessons Learned



From the Literature …



Methods of Incorporating Recycled Plastics

Sourcing & Types of Recycled Plastics

Plant Operations

RPM Asphalt Mixtures

Laboratory Characterization of Binders and Mixtures

Construction

Health & safety

High-Priority Knowledge Gaps & Questions

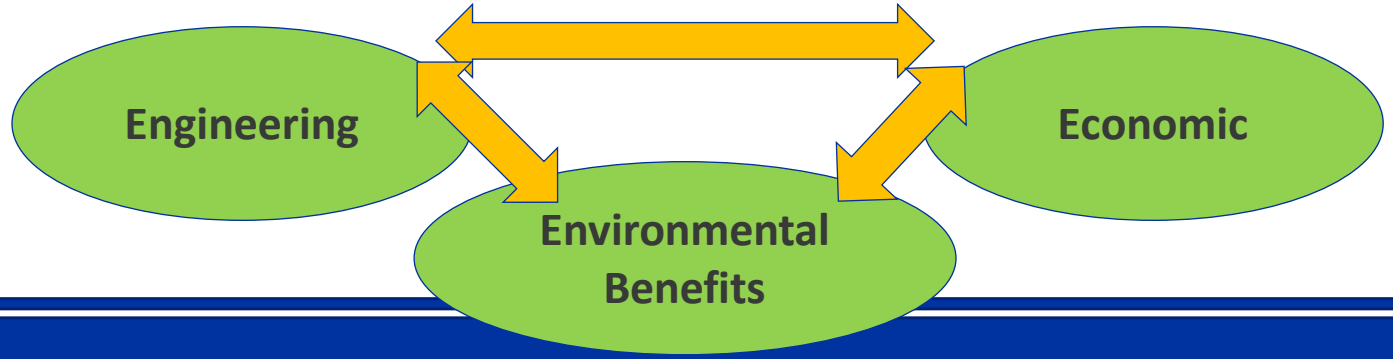
… to the Commonwealth of Virginia

- Literature related to Virginia
  - Maupin in 1991 & 1994: Novophalt, 5% of Polyethylene
  - S. Diefenderfer & McGhee in 2015: SBS-PE from Honeywell

- Literature on the use of recycled plastic waste in asphalt
  - Lacks clear experimental plans
  - Suffers from the use of dated test methods

Objectives

- Document, Assess, and ***Benchmark*** RPM asphalt field trials alongside VDOT controls (D and E mixes)
  - Constructability and lab & initial field performance
- Attempt to detect and quantify the presence of microplastics in material generated from pavement wear that could be mobilized via storm water runoff



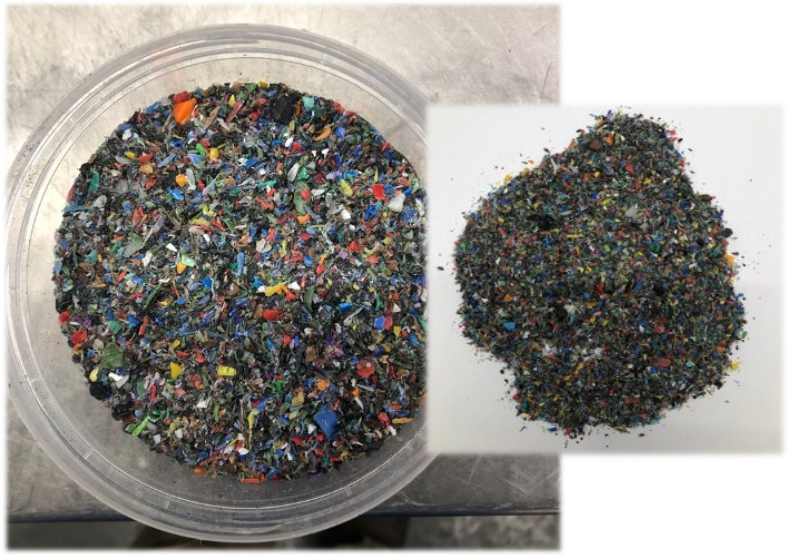
RPM Trials – Summer 2021

Producer	Location	Mix Type (600-700 tons per mix per night [1 night])
Colony Paving	Old Stage Road, Chester, VA (No mill, 1.5 inch on top of existing pavements)	**SM-12.5 E:** 15% RAP + PG64E-22
		SM-12.5 (RPM) Mix 1: 15% RAP + PG64S-22 + Plastics 1
		SM-12.5 (RPM) Mix 2: 15% RAP + PG64S-22 + Plastics 2
		SM-12.5 D: 30% RAP + PG64S-22

MACREBUR
The Plastic Road Company

"MACREBUR"

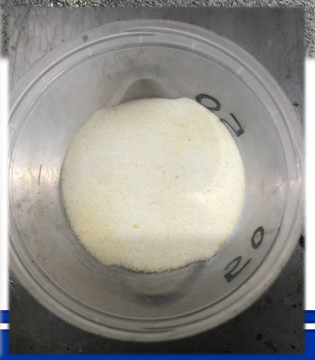
MR-6



kao

"NEWTLAC 5500


NTC5500
MR-6



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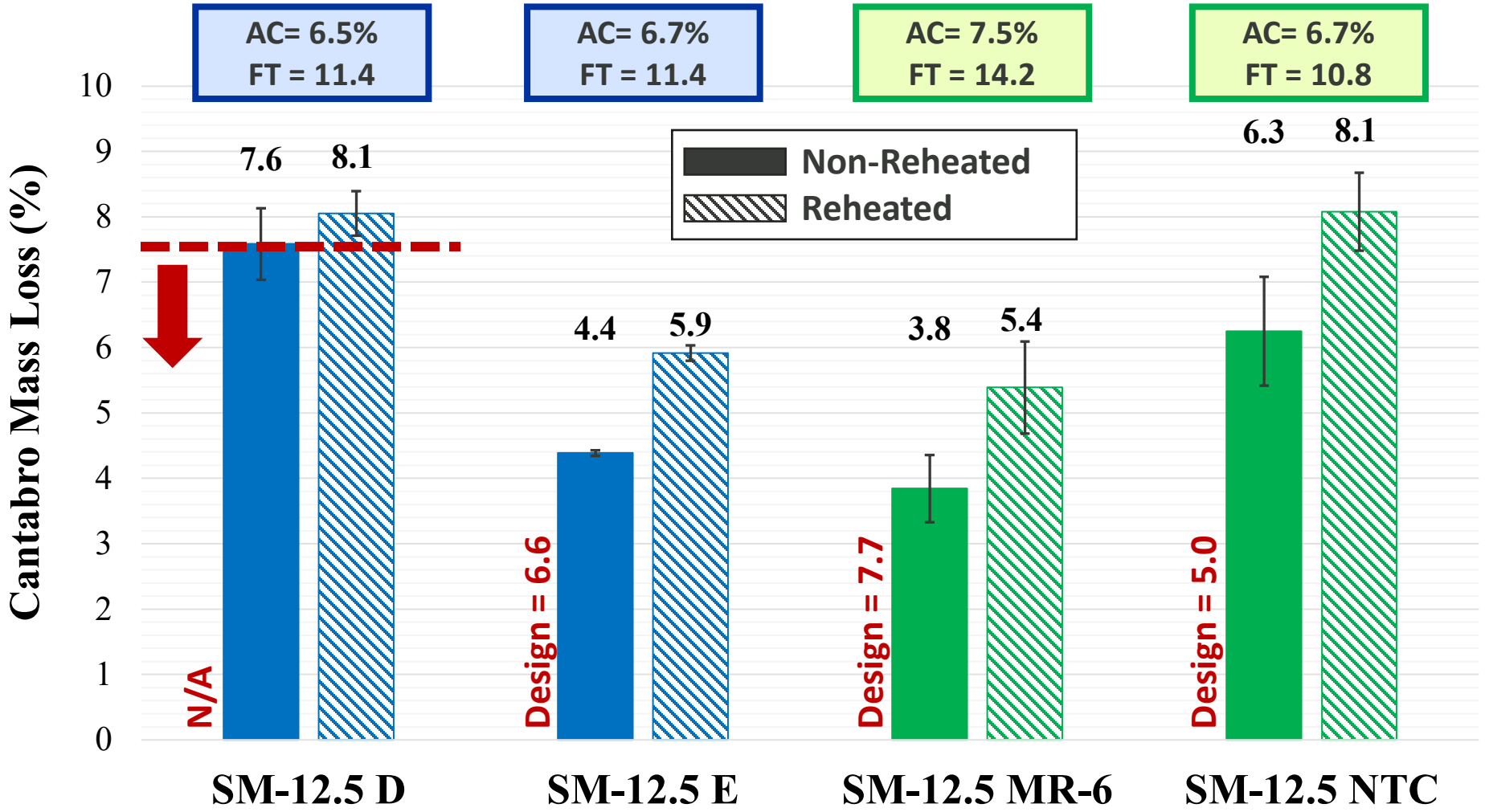

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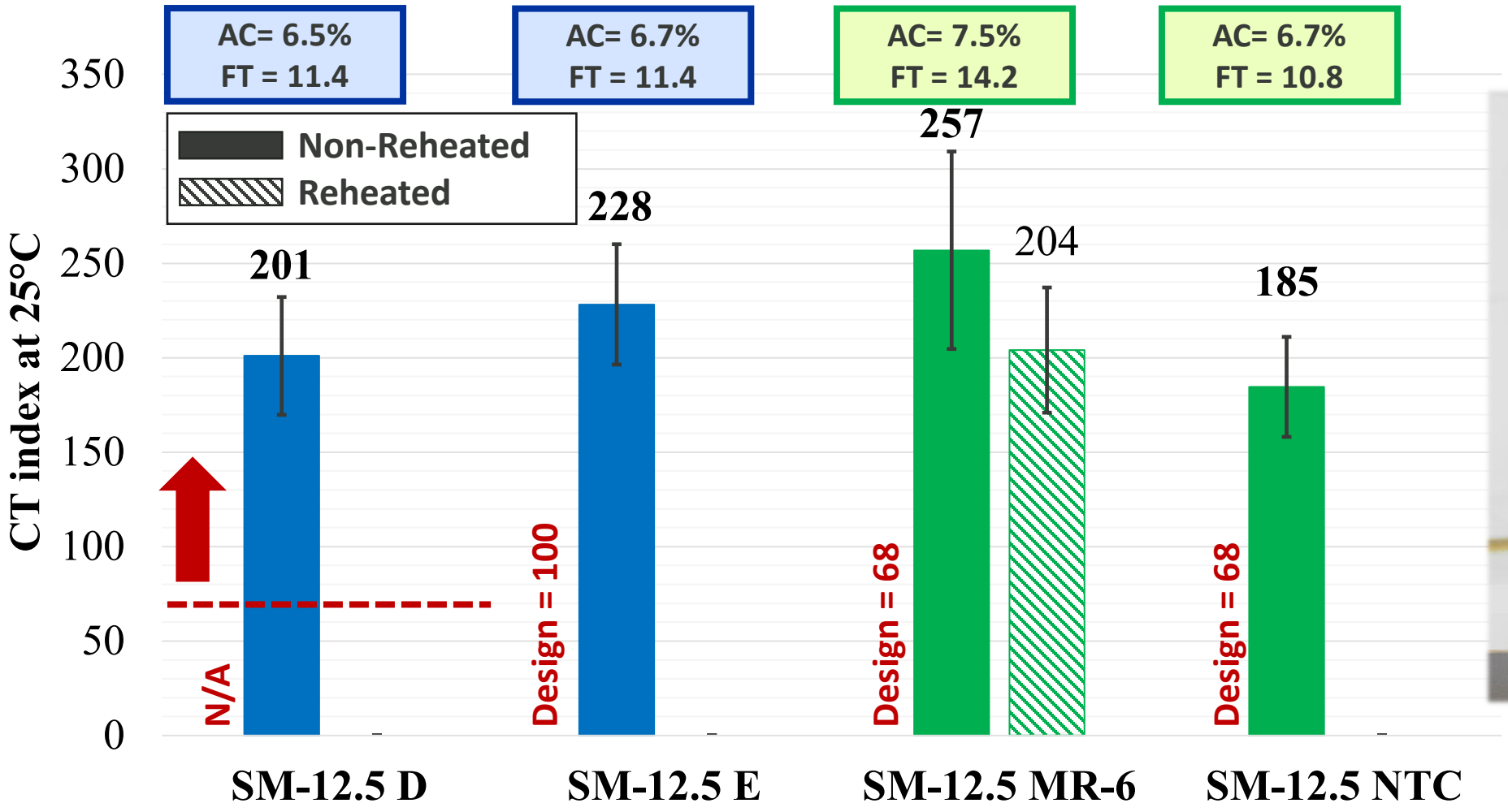

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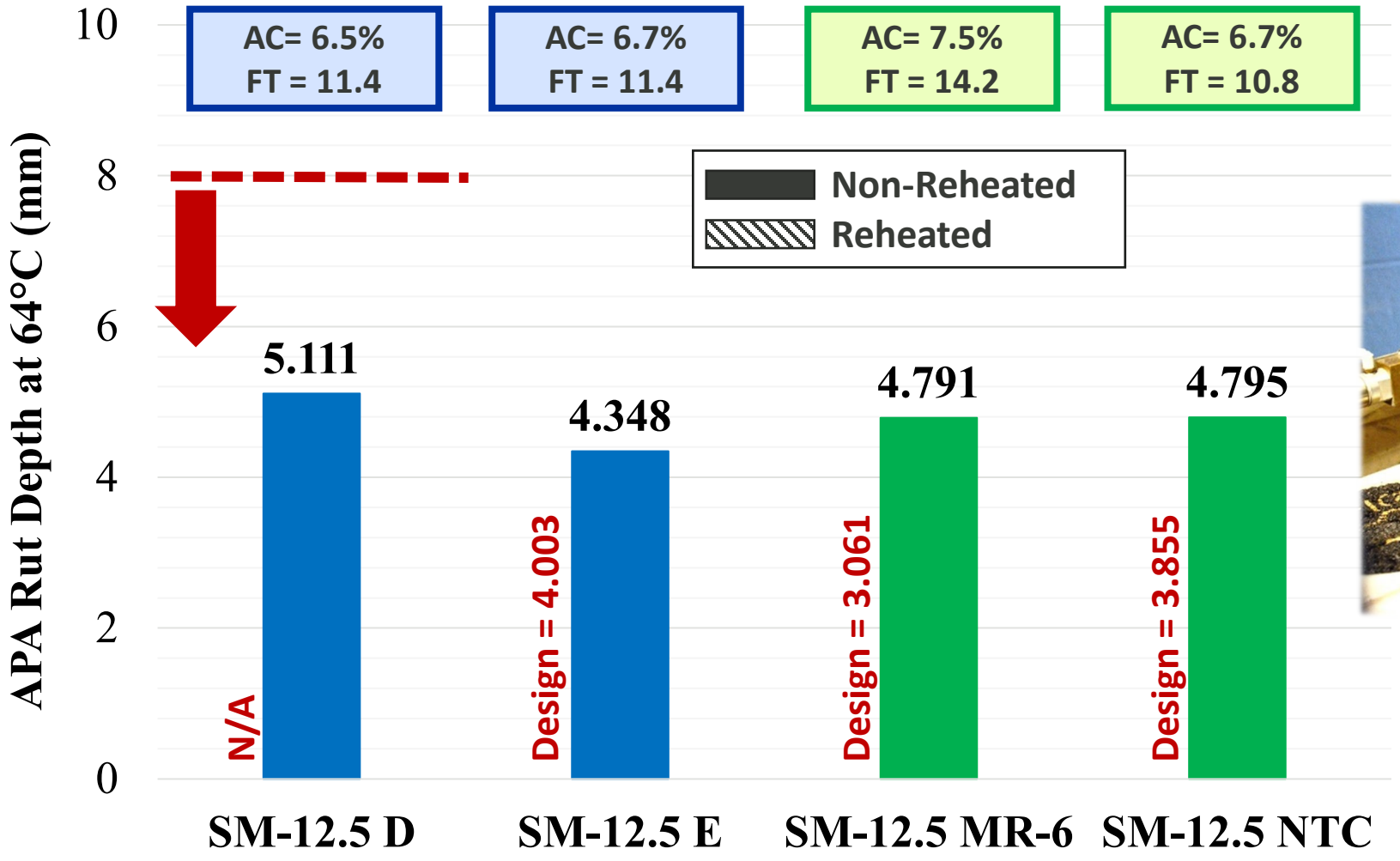


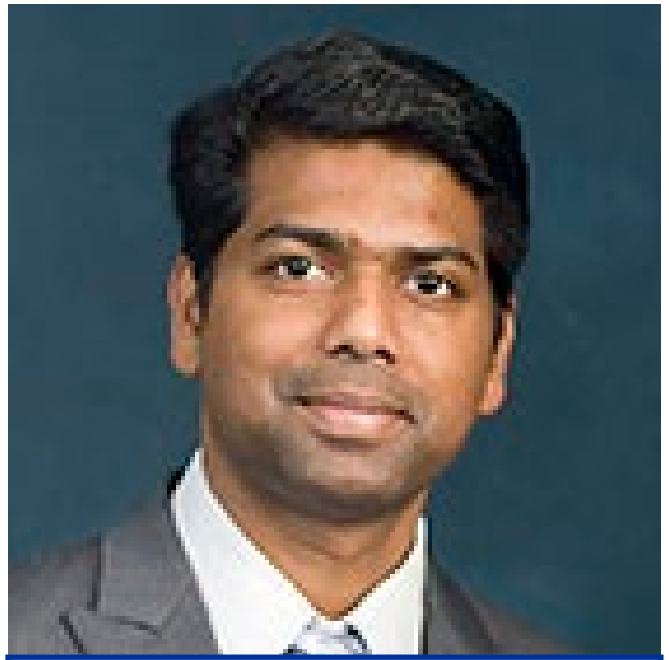
Lessons Learned – Design to Production

- Mix Design: Volumetrics & Performance
  - Account for the % of plastics to be added in terms of binder contribution
  - Plastics in production do not behave like a typical or HP SBS polymer (when it comes to volumetrics)
  - Select your % of plastics based on binder testing and/or performance of mixtures at various plastic contents
- Production: Plant to the Field
  - Mix should be produced very hot (regardless of using WMA)
  - Feeding machines should be calibrated and verified prior to the work
  - Do not pave during relatively cold nights + extensive planning
  - No need to purchase new equipment / no changes in compaction efforts and paving practices

Planning – Upcoming Efforts

- Place and evaluate a minimum of ***four (4)*** additional field trials featuring similar and new types of plastic waste
- Additional evaluation of aged asphalt binders and mixtures containing recycled plastic waste
- Recycling process of asphalt mixtures already containing recycled plastics
  - Impact on material properties, production at the plant, and environment
- Recycled plastic waste (types, source, processing) available in Virginia and the surrounding area

Acknowledgments



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- VTRC Leadership Team, Staff, and Technicians
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- Asphalt Binder Suppliers: Associated Asphalt Partners, LLC
- Additives Suppliers
  - Hybrid Rubber (RMA) by Ingevity
  - MR-6 by MacRebur Ltd
  - NEWTLAC 5500 by KAO Chemicals
- Machines Supplier: Hi-Tech Asphalt Solutions, Inc.

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Thank You!

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