VTRC Virginia Transportation Research Council

SEAUPG Southeastern Asphalt User Producer Group — We Bring Innovation to Transportation

Sustainable Asphalt Mixtures Incorporating Recycled Plastic Waste: *Virginia's Efforts*

Southeastern Asphalt User / Producer Group (SEAUPG)

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Virginia's Network

- Third largest public roadway network in US
- Maintain all state roadway systems: interstate, primary, secondary, and frontage
- 98% of hard-surfaced roadways have asphalt surfaces

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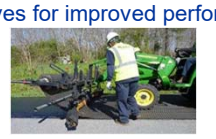
Research and Innovation

Materials


- ❑ Use of high performing mixes
  - ➢ Highly modified polymer mixes
  - ➢ Stone Matrix Asphalt (SMA)
- ❑ 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**



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From the Literature…

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….to VDOT's Vision

Prospective Benefits & Implementation

- ❑ Assess the feasibility of using RPM mixtures
  - ➢ Improve pavement performance as a ***sustainable*** solution
  - ➢ Help divert plastic waste from being placed in a landfill
  - ➢ Utilize plastic waste as commodity replacement for other raw materials
- ❑ Develop material property database for RPM mixtures
  - ➢ Gain gradual knowledge with regards to the types of plastic that may be compatible with locally available raw materials
  - ➢ Provide VDOT with additional alternatives to modify binders and mixtures
- ❑ Provide an better understanding of the potential environmental impacts

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Sustainable RPM Mixtures
Overarching Objectives

- Document, Assess, and ***Benchmark*** RPM asphalt field trials alongside VDOT controls (**D** and **E** mixes)
  - ***Design Stage***: Selection of appropriate types and contents
  - ***Paving Operations:*** Production and constructability
  - ***Laboratory Performance:*** Short- and long-term properties
  - ***Field Performance:*** Non-destructive testing & distress survey

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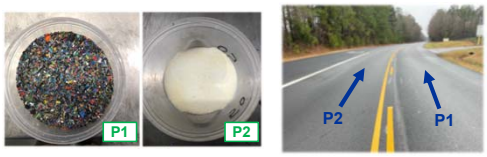
Sustainable RPM Mixtures
RPM Trials – Summer 2021

Year	Contractor	Mixture Type / Description	Locations
2021	Colony Construction	**SM12.5-D1**: 30% RAP + PG64**S**-22	--
		SM12.5-E1: 15% RAP + PG64**E**-22 (~3.5% SBS, wet)	Old Stage Road, Chester
		SM12.5-P1: 15% RAP + PG64**S**-22 + **P1** (5%, dry)	
		SM12.5-P2: 15% RAP + PG64**S**-22 + **P2** (3%, dry)	



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Sustainable RPM Mixtures
Experimental Program

- Laboratory Evaluation
  - Non-reheated / reheated specimens (BMD testing)
  - Three levels of testing complexity
  - 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)

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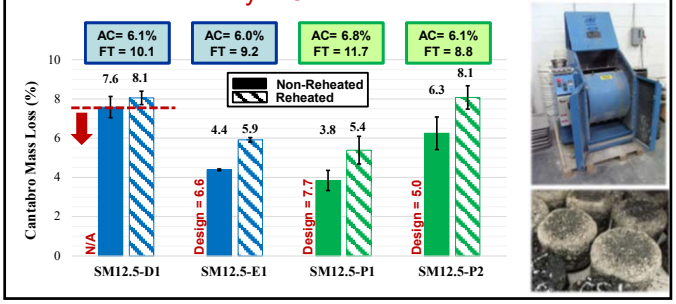
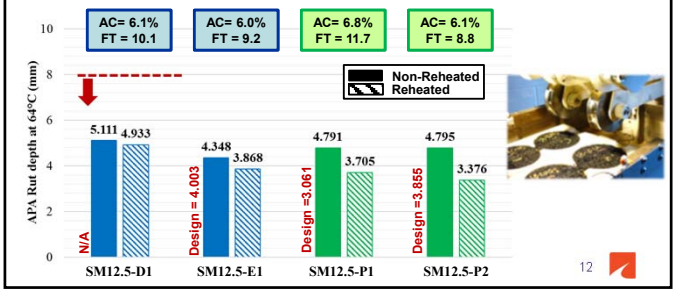
Sustainable RPM Mixtures
Durability – Cantabro Mass Loss



Sustainable RPM Mixtures
Rutting – APA Test (64ºC, 8000 cycles)



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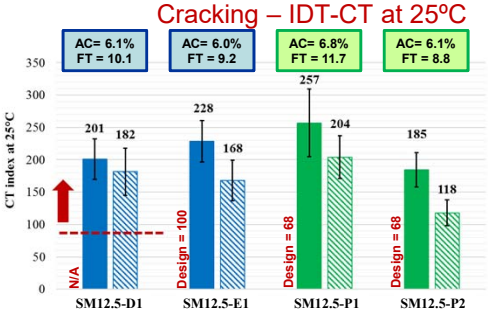
Sustainable RPM Mixtures

Cracking – IDT-CT at 25ºC



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Sustainable RPM Mixtures

Experimental Program

Sustainable RPM Mixtures

Initial Long-Term Oven Aging Protocol

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

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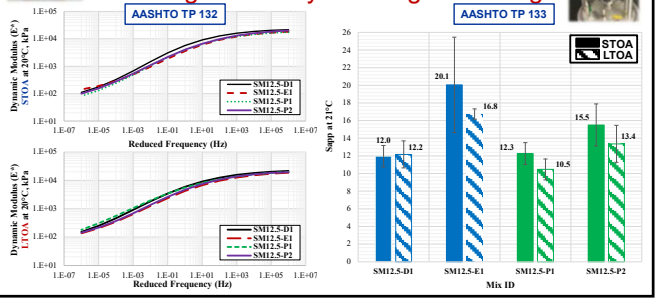
Sustainable RPM Mixtures

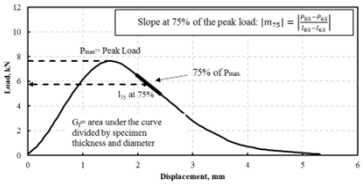
Cracking – E* & Cyclic Fatigue Testing



Sustainable RPM Mixes

Cracking Performance Data

$$CT\ index = \frac{t}{62} * \frac{1}{D} * G_f * \frac{l_{75}}{|m_{75}|}$$



To increase CT index

- Increase G_f → increase toughness
- Increase $\frac{l_{75}}{|m_{75}|}$ → reduce brittleness

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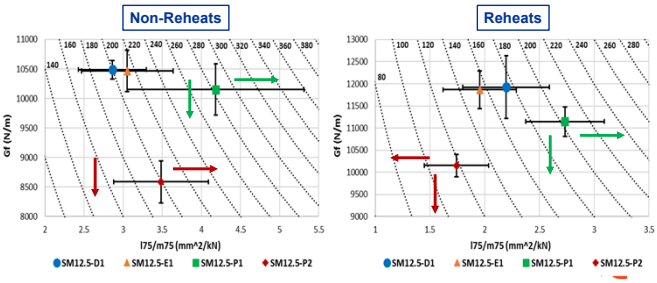
Sustainable RPM Mixes

Cracking Performance Data



Sustainable RPM Mixtures

Comprehensive Binder Testing

Loose Mixtures

Extraction

Recovery

Recovered Binder

- → Testing on as recovered binder residue: simulate short-term aging, *RTFO*
- → Testing on PAV 20 hrs aged binder residues: simulate mid-term aging, *PAV20hrs*
- → Testing on PAV 40 hrs aged binder residues: simulate long-term aging, *PAV40hrs*

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Sustainable RPM Mixtures

Asphalt Binders – Performance Grade

Mix / Binder ID	PGH	MSCR @ 64°C		after 20 hrs PAV			after 40 hrs PAV		
		Jnr@3.2 Max 0.5	%R@3.2	PGI	PGL	ΔTc Min -5	PGI	PGL	ΔTc Min -5
SM12.5-D1	65.7	0.56	9.8	27.0	-20.8	-2.7	--	-18.0	-4.1
SM12.5-E1	81.2	0.22	48.3	24.4	-23.4	-2.5	--	-19.1	-5.4
SM12.5-P1	74.1	1.02	5.5	23.9	-24.4	-1.7	--	-16.6	-7.8
SM12.5-P2	75.0	0.87	5.3	25.5	-22.3	-1.9	--	-18.3	-4.7

→ *Question: Were we able to extract ALL plastic particles with the binder?*

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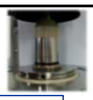
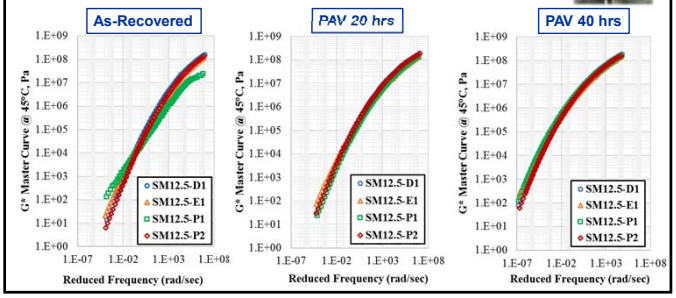
Sustainable RPM Mixtures

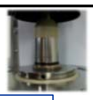
Asphalt Binder – |G*| Master Curves

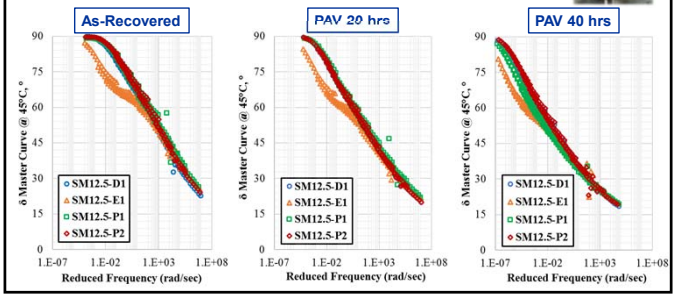




Sustainable RPM Mixtures

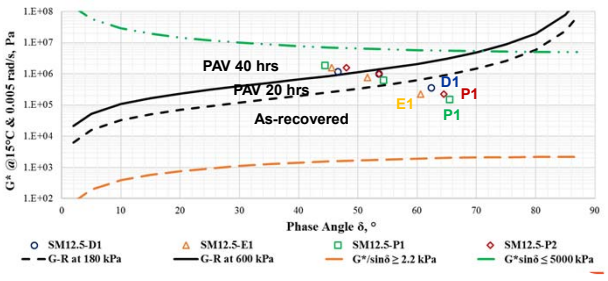
Asphalt Binder – δ Master Curves





Sustainable RPM Mixtures

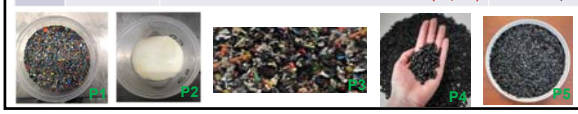
Asphalt Binder Aging Susceptibility



Sustainable RPM Mixes

RPM Trials – Summer 2022

Year	Contractor	Mix Type / Description	Location
2022	Colony Construction	**SM9.5-D2:** 30% RAP + PG64S-22	--
		SM9.5-P1: 15% RAP + PG64S-22 + **P1** (5%, dry)	SR 645, Prince George
		SM9.5-P3: **40% RAP** + PG64S-22 + **P3** (8%, dry)	SR 630, Prince George
	Allan Myers	**SM9.5-D3:** 30% RAP + PG64S-22	--
		SM9.5-P4: 15% RAP + PG64S-22 + **P4** (2%, dry)	SR 622, Dorset Rd
		SM9.5-P5: 15% RAP + PG64S-22 + **P5** (3%, wet)	SR 622, Dorset Rd



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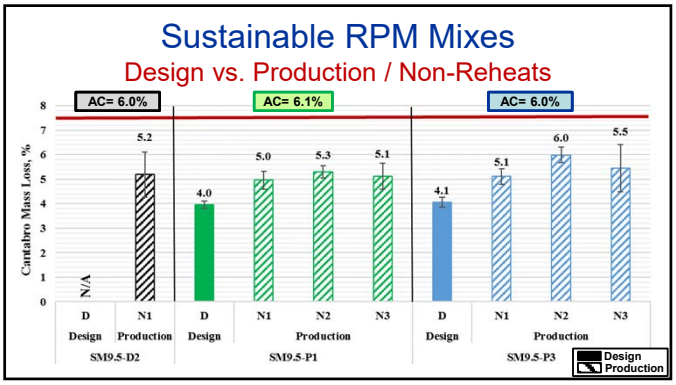
Sustainable RPM Mixes

Design vs. Production / Non-Reheats



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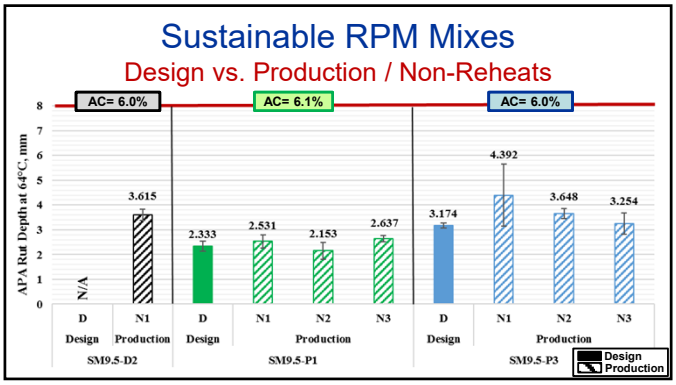

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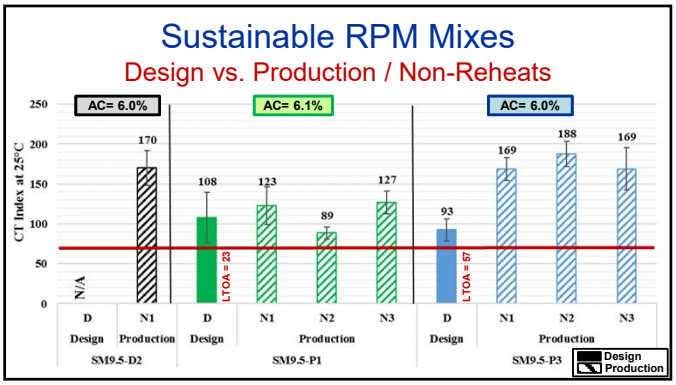

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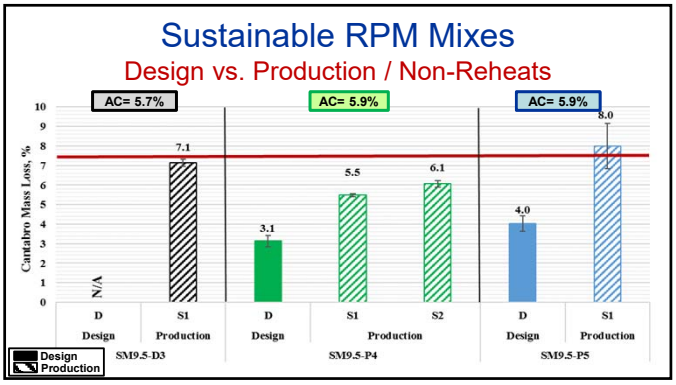
Sustainable RPM Mixes

Design vs. Production / Non-Reheats



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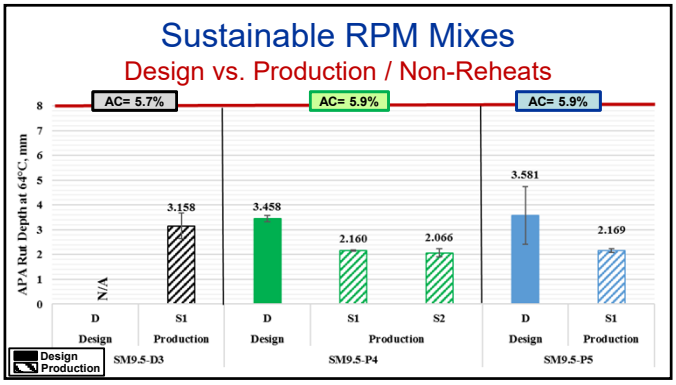

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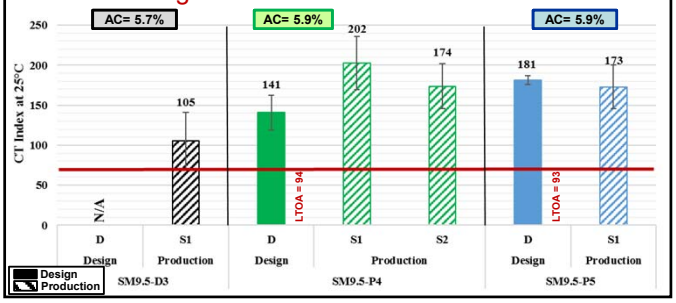

Sustainable RPM Mixtures

Lessons Learned – Final Thoughts *(1)*

- Mix Design - Should we …
  - Account for the plastics content in terms of binder contribution?
  - Select the plastics content based on binder and/or mixture performance testing?
- 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

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Sustainable RPM Mixtures

Lessons Learned – Final Thoughts *(2)*

- Dry Process
  - Preferred by contractors – more flexibility and less encountered issues?
  - Full blending? Some plastic left out un-melted or semi-melted?
- Wet Process
  - Full blending? Some plastic left un-melted or semi-melted?
  - Handling at the plant? Need for much higher temperatures?
- General
  - Consistency in performance of RPM mixes? Guaranteed?
  - What is suitable for dry process? What is suitable for wet process?

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Sustainable RPM Mixtures

Ongoing Efforts

- Develop analysis methods to determine if microplastics are present in wear related particles.
- Additional evaluation of mid- and long-term aged RPM mixes
- Recycling process of RPM mixes
  - Impact on material design and performance properties
  - Evaluation of fumes and emissions generated from RPM mixes
- Recycled plastic waste (types, source, processing) in VA
- Potential development of a Roadmap / Implementation plan
- Environmental impacts NOT quantified yet → LCA case studies as part of the FHWA Climate Challenge Project for VA

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Acknowledgments

- VTRC Leadership Team, Staff, and Technicians
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  - Associated Asphalt Partners, LLC
- Plastic-Based Additive Suppliers
  - MacRebur Ltd
  - KAO Chemicals
  - Advanced Materials Group
  - GreenMantra Technologies
- Machines Supplier: Hi-Tech Asphalt Solutions, Inc.

Thank You!

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