

A stylized illustration of a two-lane asphalt road curving through a landscape. The road has white dashed lane markings and a solid white edge line. On the left side of the road, there is a grassy shoulder and a small blue signpost. On the right side, there is a dense line of green trees and a larger blue signpost. The background is a solid light blue sky.

Construction and Performance Impacts of Asphalt Mix Additives

2021 (Eighth)
Research Cycle

NCAT Pavement Test Track

NCAT Pavement Test Track



Appreciation

- Public and private funding partners
- Astec/Roadtec
- Wirtgen/Hamm
- Vulcan Materials (base, mixes), many others!
- Hi-Tech Asphalt Solutions
- Valero Asphalt
- Ingevity (pump and additives)
- Ergon Asphalt and Emulsions
- Lee County Engineer (subgrade)
- East Alabama Paving
- Chris Clark Grading and Paving
- NCAT Team and Auburn University

Experiment Design for 2021 (#8)

		C	C	C	C	M	M	A	M	A	S	C	A	A	
		GA	GA	AL	AL	OK	OK	FH	TX	TX	VA	CG	MS	AL	
		N13	N12	N11	N10	N9	N8	N7	N6	N5	N4	N3	N2	N1	
		250	250	250	250	500	500	750	500	750	300	250	750	750	
		0												0	
	W1														E10
		0												500	M
	W2														AL
		0												0	E9
	W3														E8
	M													0	
	NC	500													E7
	W4													250	C
	W5														FL
		0												250	E6
	W6														C
		0												250	FL
	W7														E5
		0												0	E4
	W8														
		0												0	E3
	W9														
		0												0	E2
	C														C
	SB	250												250	AT
	W10	250	300	250	500	750	750	500	750	300	250	250	750	0	E1
		C	S	C	M	A	A	M	A	S	C	C	A		
		OK	MS	MS	TN	TN	FL	KY	B2	SC	TX	TX	VA		
		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	

- Structural sections only in tangents
- Location must meet research needs
- Plan around traffic continuations
- States often prefer not to relocate
- Some sections may need rebuilding.

2021 NCAT Pavement Test Track

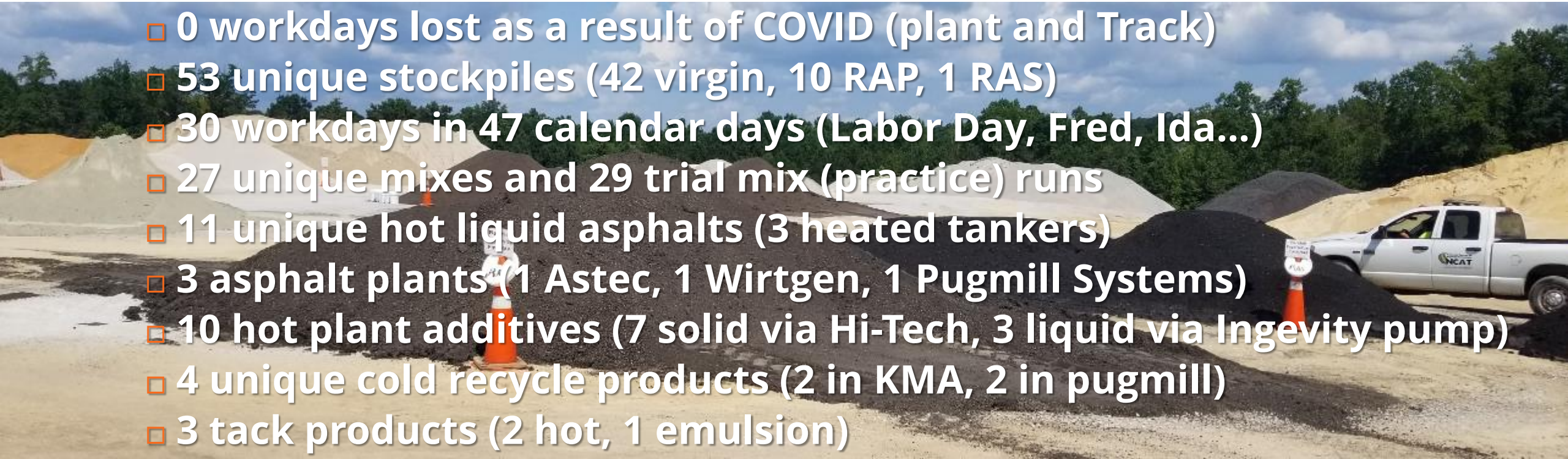
- 32 sponsored sections
 - ▣ 16 traffic continuations
 - ▣ 7 mill/inlay sections
 - ▣ 9 structural sections
- 16 repaved/rebuilt sections
 - ▣ ~1/3 of the Track (typical).

Traffic Continuations₁₆

- Higher RAP with recycling agents – CA_{N3}
- Foamed cold central plant recycle (CCPR) base – VA_{N4}
- High performance thinlays (DGA, SMA) – $AL_{N10,N11}$
- Crack prevention interlayer strategies – $GA_{N12,N13}$
- Soybean based polymer modified asphalt – SB_{W10}
- BMD via recycling agents, gradation change, etc. – $OK_{S1}, TX_{S10,S11}$
- Impact of base stabilization, subgrade modification – MS_{S2}
- Long term benefit of surface rejuvenators – MS_{S3}
- Full depth rapid rebuilds (grinding vs thinlays, HiMA) – SC_{S9}
- Open graded friction surface rejuvenation – SR_{E1}
- Impact of density on performance – $FL_{E5,E6}$



2021 Track Build by the Numbers

- 
- ❑ 0 workdays lost as a result of COVID (plant and Track)
 - ❑ 53 unique stockpiles (42 virgin, 10 RAP, 1 RAS)
 - ❑ 30 workdays in 47 calendar days (Labor Day, Fred, Ida...)
 - ❑ 27 unique mixes and 29 trial mix (practice) runs
 - ❑ 11 unique hot liquid asphalts (3 heated tankers)
 - ❑ 3 asphalt plants (1 Astec, 1 Wirtgen, 1 Pugmill Systems)
 - ❑ 10 hot plant additives (7 solid via Hi-Tech, 3 liquid via Ingevity pump)
 - ❑ 4 unique cold recycle products (2 in KMA, 2 in pugmill)
 - ❑ 3 tack products (2 hot, 1 emulsion)

New Mill/Inlay Sections₇

- BMD via recycling agents, gradation, etc. – $OK_{N8,N9}$, TX_{N6}
- BMD with SGC for design and Marshall for QC – TN_{S4}
- Bond strength with different tack products and/or rates – NC_{W4}
- Friction performance mix optimization – KY_{S7}
- High performance open graded friction course surface – AL_{E9}

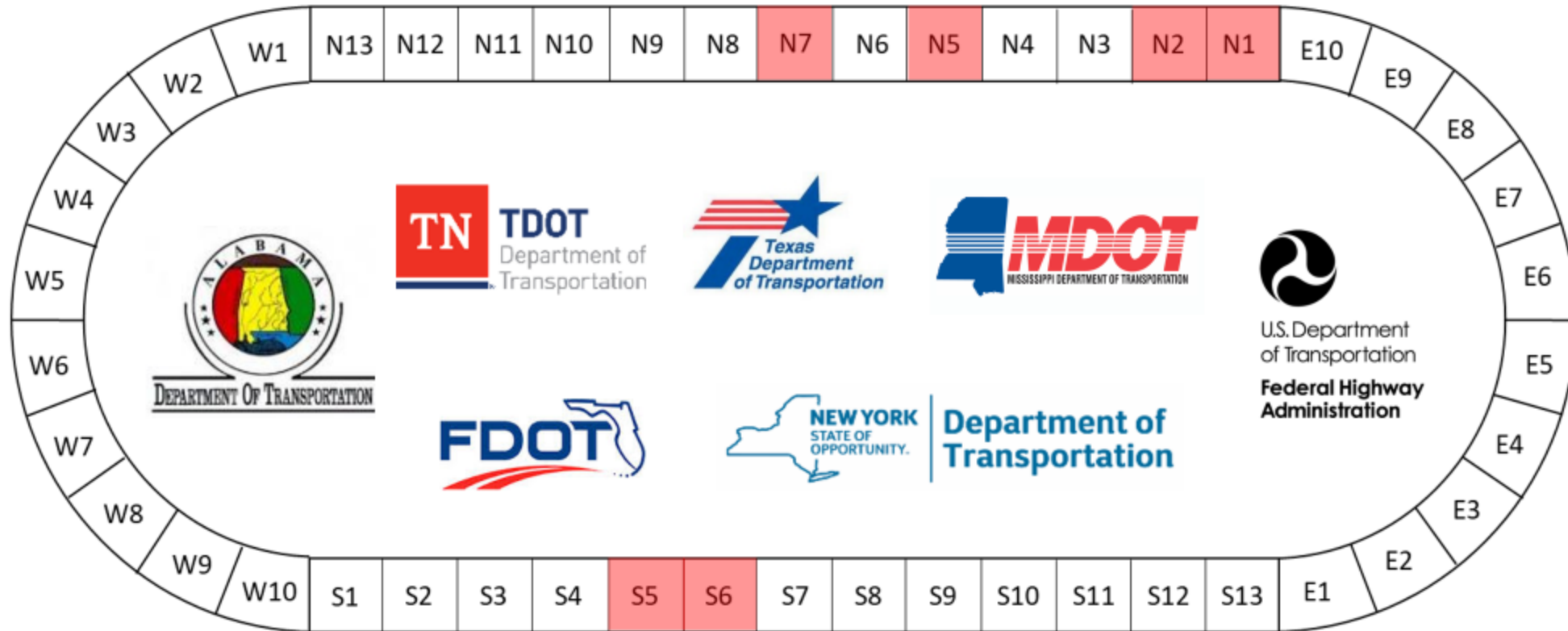


New Structural Sections₉

- Minimum HMA thickness over cold (re)recycling – VA_{S12}
- Additive Group (AG) study for additive impact on pavement life
- “AG+” New polymer from old recycled tire rubber – Sigmabond HP_{S8}
- “AG+” High polymer performance with reduced viscosity – BASF_{S13}



2021 Additive Group (AG) Study

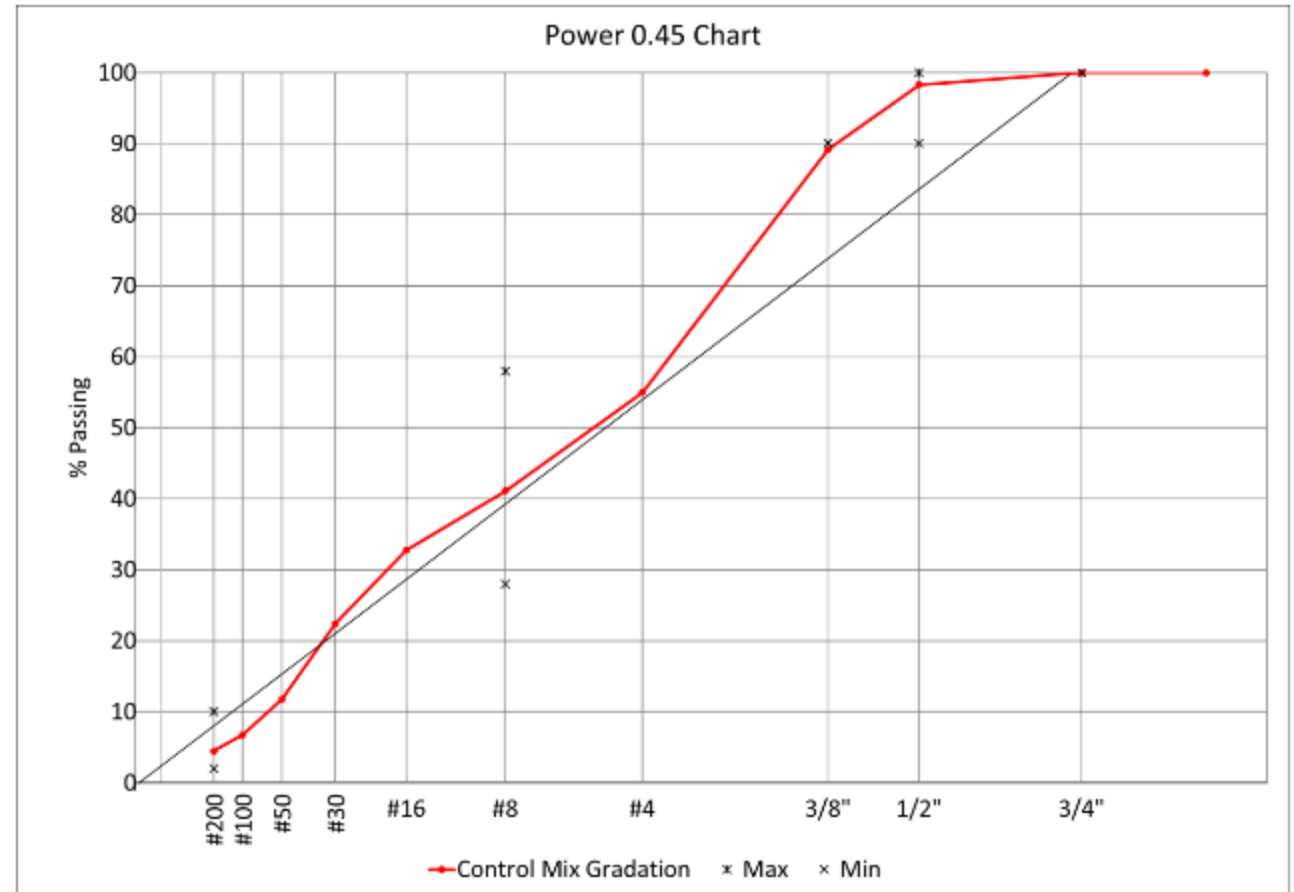


Phase 1 Studies (BMD+Fatigue)

Category	Mix ID	Company
Control	PG 76-22	
	PG 67-22 (reference only)	
Recycled Rubber	Rheopave™	Lehigh
	SmartMIX™	Liberty
	TB Rubber Binder	Entech
	TOR Coated Rubber	Evonik-Entech
Recycled Plastics	CERANOVUS® A115	GreenMantra
	LLDPE+ELVALOY™ RET	Dow
	NecoPlastic	NecoTech
	NecoFibers	NecoTech
Aramid Fibers	Ctrl for FORTA FI®	
	FORTA FI®	FORTA
	Ctrl for ACE XP®	
	ACE XP®	SurfaceTech
Reactive Polymer	B2Last®	BASF

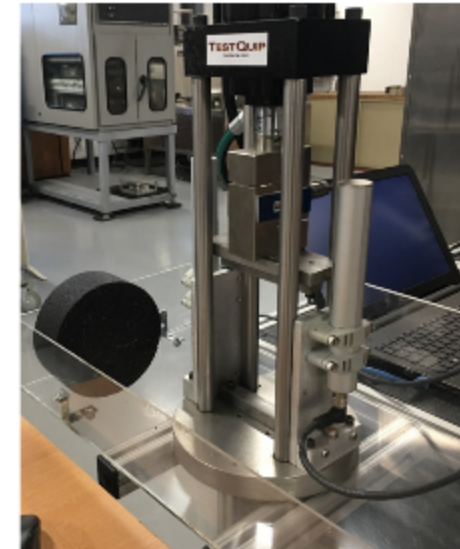
AG+ Control Mix (Lab and Track)

- 12.5 mm NMAS
- 20% RAP
- $N_{des} = 60$ gyrations
- 76-22 Binder
- Aggregates:
 - Granite 78 – 26%
 - Granite 89 – 25%
 - Sand – 28%
 - BHF – 1%
 - RAP – 20%



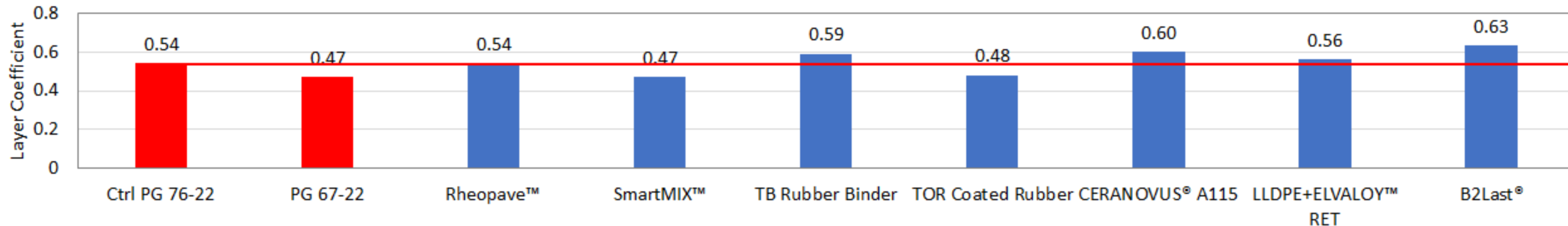
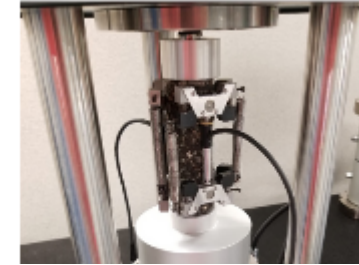
Balanced Mix Design for AG+ Study

- IDEAL-CT (CT_{Index})
 - LMLC-STOA at 4hrs & 135°C
 - At 25°C
 - Control mix criterion:
 - Min. $CT_{Index} = 50$
- HWTT
 - LMLC-STOA at 4hrs & 135°C
 - At 50°C
 - Control mix criterion:
 - Max. rut = 12.5 mm at 20,000 passes

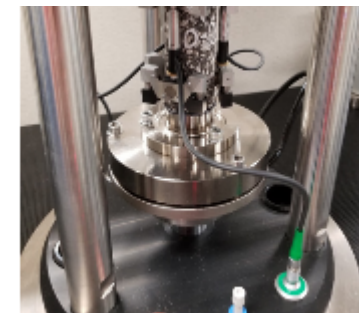


Fatigue Testing and Modeling

- Dynamic Modulus (E^*)
 - Small Specimen – AASHTO TP 132-19
 - Generate E^* master curves



- Small Specimen – AASHTO TP 133-19
- 21°C and 10 Hz
- Generate S_{app} and FlexPAVE Inputs



Agency Selected AG Treatments

- Recycled tire rubber
 - ▣ “Wet” Entech PG76-22_{N2}
 - ▣ “Dry” Smart Mix in PG67-22_{N1}
- Recycled low density plastic
 - ▣ “Wet” Dow with Elvaloy PG76-22_{S6}
 - ▣ “Dry” pellets with PG76-22_{S5}
- High strength aramid fibers
 - ▣ Surface Tech ACE XP with PG76-22_{N5}
- Control with PG76-22_{N7}

2021 Construction Schedule

Date	Sublot	Spons	Mix Description	PI(s)	Gage	Binder	Special	Hi-Tech	Blend	Tack
8/13	W4-1	NC	40% RBR w/ RAP+RAS (Tack)	Moraes		58-28			Evotherm P25	67-22 vs CRS-1H
8/16	S4-1	TN	Gyratory BMD with Marshall QC	Bowers/Timm		70-22			Evotherm P25	67-22
8/19	S7A-1	KY	BMD+3WP+DFT (0.35)	Gu/Nathan		76-22			Evotherm P25	67-22
8/19	S7B-1	KY	BMD+3WP+DFT (0.45)	Gu/Nathan		76-22			Evotherm P25	67-22
8/24	R5-2	RG	AG Control	Bowers		67-22			Evotherm P25	NA
8/24	R6-2	RG	Foamed CR	Bowers		67-22	KMA Foam			NA
8/25	R7-2	RG	Emulsion CR	Bowers		Ergon CSS-1H	KMA Ingevity			NA
8/25	R8-2	RG	Rej. CR using BioMAG	Bowers		BioMAG Only	Pugmill BioMAG			NA
8/25	R9-2	RG	Rej. CR using ReCharge	Bowers		ReCharge Only	Pugmill ReCharge			NA
8/26	R10-2	RG	Rej. CR using Emulsion + Delta S	Bowers		SS-1H+Delta S	Pugmill Delta S			NA
8/27	R5...10-1	RG	1 inch Preservation Thinlay	Bowers		67-22			Evotherm P25	67-22
9/2	E9-1	AL	High Performance OGFC	Musselman		76-22		Cellulose	Evotherm P25	eTac HD
9/3	N7-1	AG-TX	AG Control	West/Timm	H	76-22			Evotherm P25	NA
9/7	N8-2	OK	S1-2 from 2018	Fabricio/Adam	H	64-28			EvoFlex CA-4	67-22
9/8	S12-2	VA	Foam Re-Recycled Wirtgen Mix	Bowers/Timm	H	67-22	Cement			NA
9/9	N8-1	OK	S1-1 from 2018 but 30% RAP	Fabricio/Adam		70-28			EcoBlend+P25	67-22
9/9	S12-1	VA	SMA Surface	Bowers/Timm		76-22		Cellulose	Evotherm P25	67-22
9/10	N9-1	OK	N9-1 from 2018 but with RTR	Carolina/Adam		58-28		AsphaltPlus	Evotherm P25	67-22
9/13	N6-1	TX	BMD	West/Nathan		Valero 70-22	Heated Tanker		Evotherm P25	67-22
9/14	N2-1	AG-MS	AG Entech Wet Rubber	Carolina/Timm	H	Entech	Heated Tanker		Evotherm P25	NA
9/14	N1-1	AG-AL	AG SmartMix Dry Rubber	Carolina/Timm	H	67-22		SmartMix	Evotherm P25	NA
9/17	S13-1	B2	AG+ B2Last HiMod	Tran/Timm	H	BASF HP			Evotherm P25	NA
9/21	S5-1	AG-FH	AG Dry Plastic	Yin/Timm	H	76-22		Dry Plastic	Evotherm P25	NA
9/22	S6-1	AG-TN	AG Dow Wet Plastic	Yin/Timm	H	Dow			Evotherm P25	NA
9/23	T1-1	FF	AG Forta	Tran		76-22	Forta Fibers		Evotherm P25	NA
9/23	N5-1	AG-FL	AG ACE Fibers	Tran/Timm	H	76-22	ACE Fiber		Evotherm P25	NA
9/24	S8-1	USP	AG US Polyco	Carolina/Timm	H	Sigmabond HP	Heated Tanker		Evotherm P25	NA

Hi-Tech Asphalt Solutions Feed System



Astec Double Barrel Green Plant



Plant Extras



Hi-Tech Asphalt Solutions Feed System



← Smart Mix₁₂



← Asphalt Plus₁₂

Dry Plastic_{8½} →



Thick Lift Paving



Bulk Research Sampling



Preliminary AG+ Track Performance

- 138k ESALs
- No cracking
- No rutting
- No roughness
- Spring 2022...



2021 Track Build Takeaways

- ❑ Designs can take time/effort with BMD and friction requirement
- ❑ Additive utilization is nothing to fear by industry/agencies
- ❑ BMD compliance is “easier” than volumetrics
- ❑ Meaningful quality indicators for agencies
- ❑ Practical production targets for contractors
- ❑ Higher cracking indicator from production
- ❑ No difficulty in meeting density requirement
- ❑ More bins in design are needed with “challenging” stockpiles
- ❑ Unique bin calibrations are essential with short/limited production runs
- ❑ Ability to waste dust is helpful when volumetrics are required.

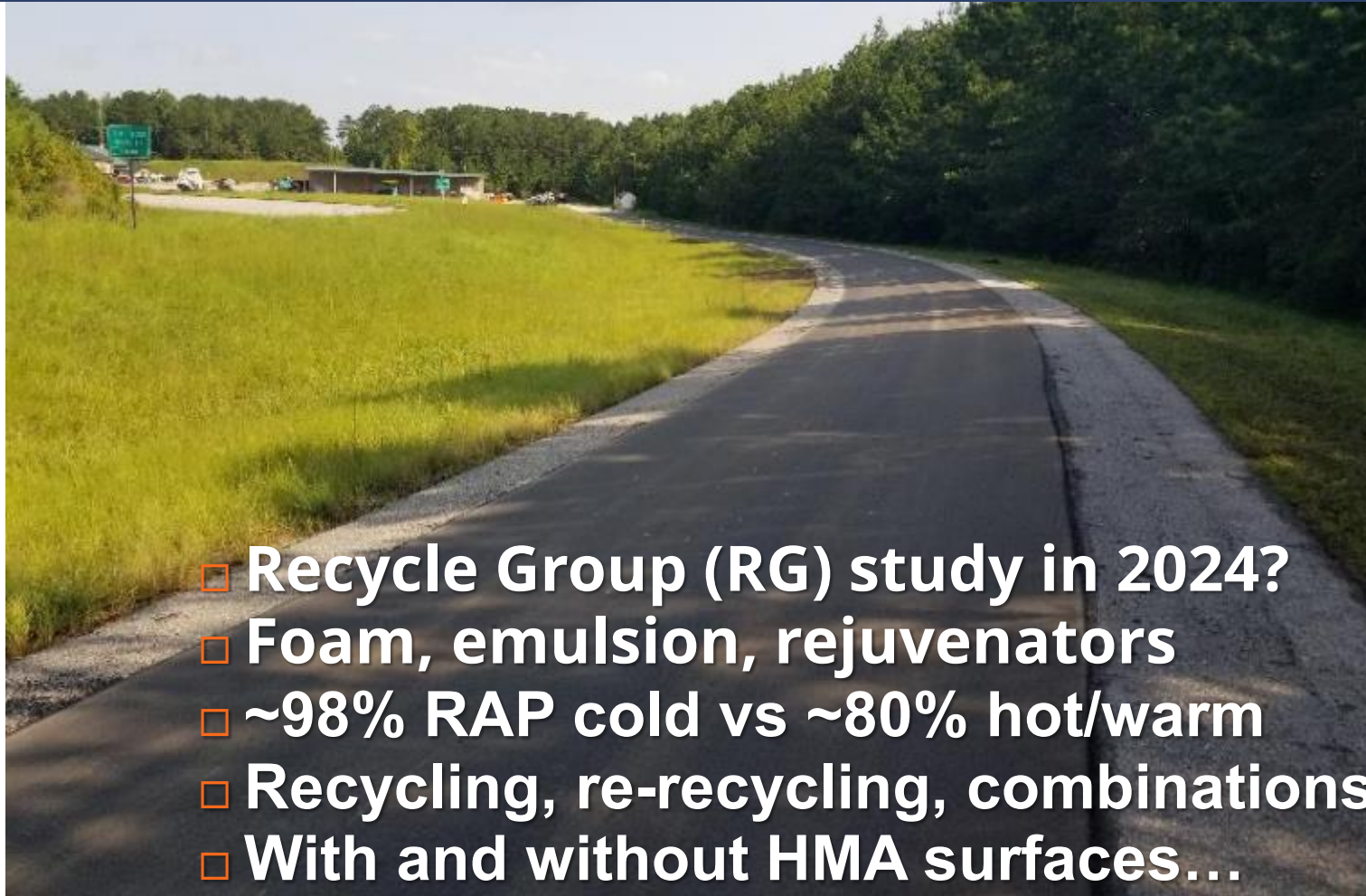


Cold Recycle Ramp Sections

- 6" dense crushed limestone base on compacted Track subgrade
- 4" cold recycle mill/inlays using processed RAP from AG study
- R5_{HMA} control then R6_F, R7_E, in KMA & R8_{BM}, R9_{RC}, R10_{E+DS} in Pugmill
- 1" preservation thinlay surface on the Track since 2003.

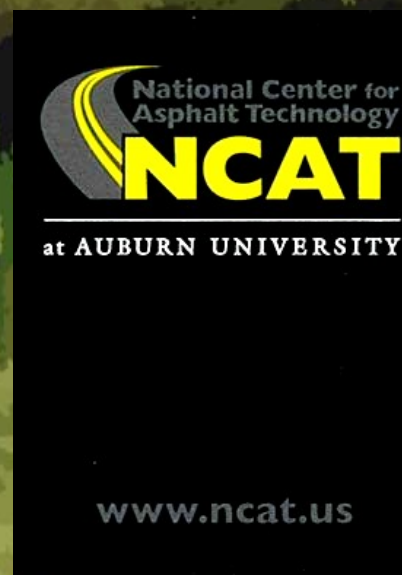


Cold Recycle Ramp Sections



- ❑ Recycle Group (RG) study in 2024?
- ❑ Foam, emulsion, rejuvenators
- ❑ ~98% RAP cold vs ~80% hot/warm
- ❑ Recycling, re-recycling, combinations
- ❑ With and without HMA surfaces...

Questions and Answers



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