Efforts in Evaluating Recycled Plastic Modified Asphalt
- Laboratory and Field Projects -

Presented By:

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RUTGERS
Center for Advanced Infrastructure and Transportation

Acknowledgements

- Rutgers Asphalt Pavement Laboratory
  - Staff: Chris Ericson, Jake Tulanowski, Ed Wass Jr, Ed Haas, Drew Tulanowski, Shelby Maigis
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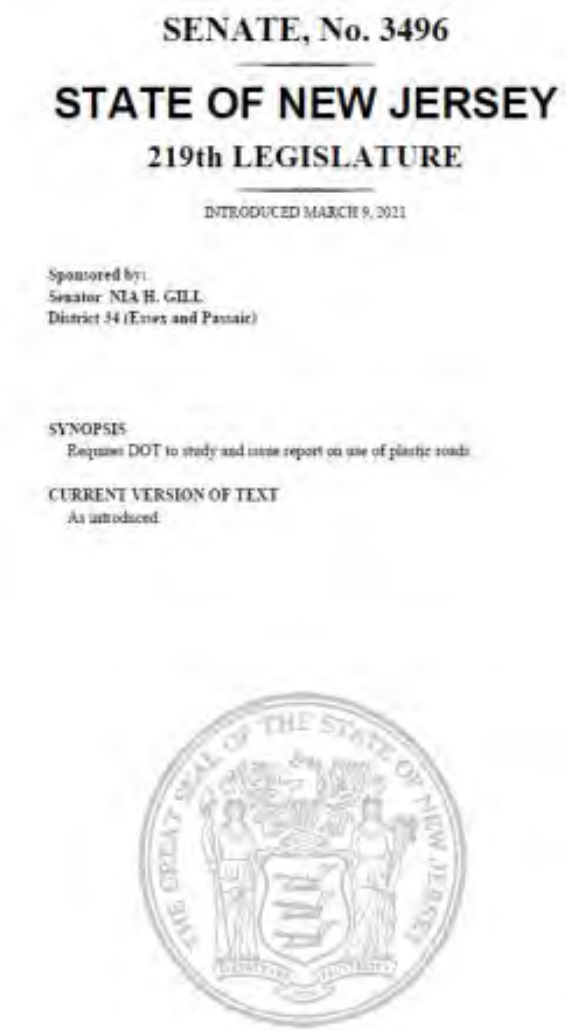
- NYCDOT
- City Asphalt, Staten Island, NY
- Associated Asphalt (Mike Worden, Dave Powers)
- Recycled Plastic Suppliers
  - Green Mantra, KAO, MacRebur, NVI

Motivation and Workplan

- As some may be aware, concept of incorporating recycled plastic in HMA has come up in the media
  - NJ legislature mandated NJDOT to begin evaluating potential incorporation in asphalt pavements
- To help address NJ legislature's request, Rutgers developed lab and field studies to evaluate recycled plastic in HMA



SENATE, No. 3496

STATE OF NEW JERSEY

219th LEGISLATURE

INTRODUCED MARCH 9, 2021

Sponsored by:
Senator NIA H. GILL
District 34 (Essex and Passaic)

SYNOPSIS
Requires DOT to study and issue report on use of plastic roads

CURRENT VERSION OF TEXT
As introduced.

Incorporating Recycled Plastic in HMA

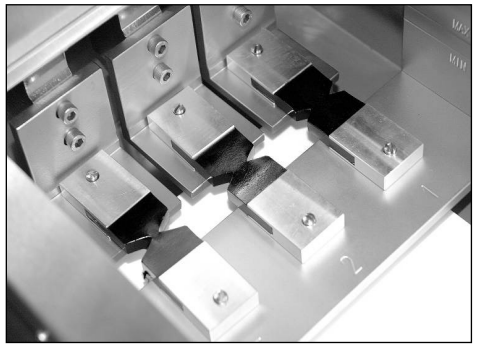
- Evaluating two different processes to use recycled plastic in HMA (similar to recycled crumb rubber)
  - Dry process
    - Adding recycled plastic at the plant during the mixing process
  - Wet process
    - Milling recycled plastic into the asphalt binder in similar manner to current polymer modifiers at refinery

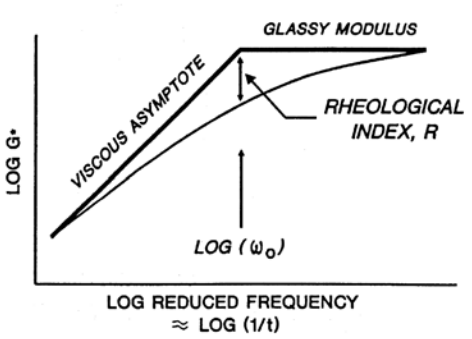
Research Project Overviews

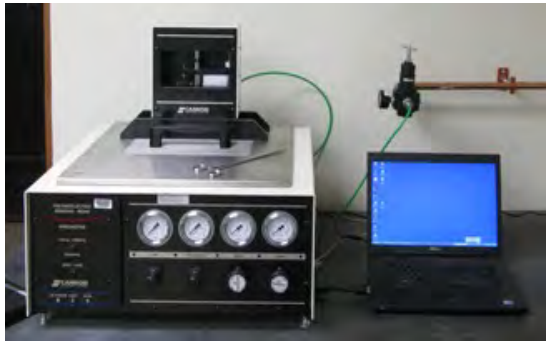
- Dry Process
  - Field Study - NYCDOT
    - Four different dosage rates based on percent of virgin binder in a 40% RAP mix
  - Lab Study - Multiple recycled plastic suppliers at same dosage rate
    - Looked at mixture and recovered binder performance to compare different materials
- Wet Process
  - Lab Study - MacRebur laboratory study
    - 3, 6, 9% based on total weight of neat asphalt binder
  - Field Study - New Jersey Turnpike Authority field study *(testing on-going)*
    - 2% by weight of PG64E-22 from Associated Asphalt terminal
  - PennDOT field study *(just started)*
    - 2% by weight of PG64S-22 from Associated Asphalt terminal
  - *NJDOT field study slated for Spring 2023*

Recycled Plastic in HMA

- Research workplan
  - Asphalt binder testing
    - Separation testing
    - Solubility
    - High temperature
      - MSCR, PG grading
    - Intermediate temperature
      - DENT, Glover-Rowe, Loss Tangent
    - Low temperature
      - PG grading, ΔTc, ABCD
    - Original, RTFO, 20 Hr PAV, 40 Hr PAV

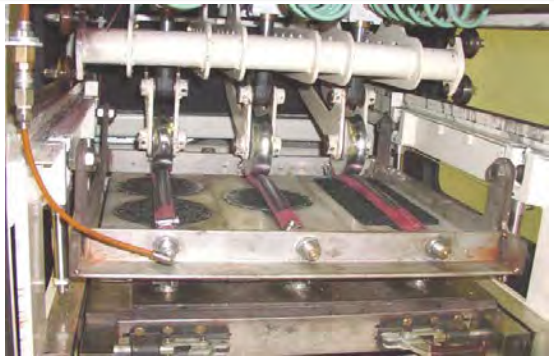


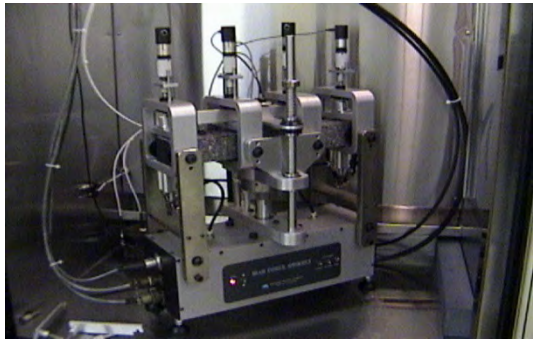




Recycled Plastic in HMA

- Research workplan
  - Asphalt mixture testing
    - Stiffness
      - E*
    - Rutting
      - APA, Hamburg, Flow Number, HT-IDT
    - Cracking
      - Overlay Tester, IDEAL-CT, SCB FI, Flexural Beam, DC(T)
    - Moisture Damage
      - TSR and Hamburg
    - Short-term and Extended conditioning

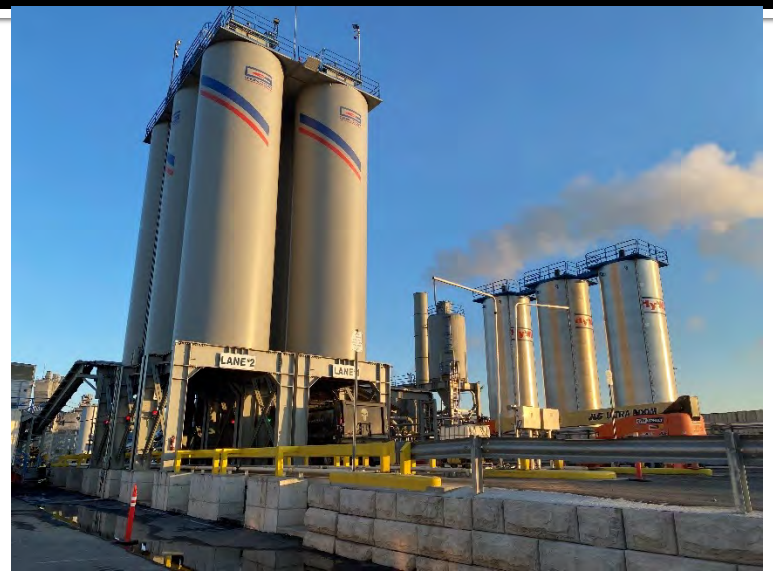




Dry Process Evaluation

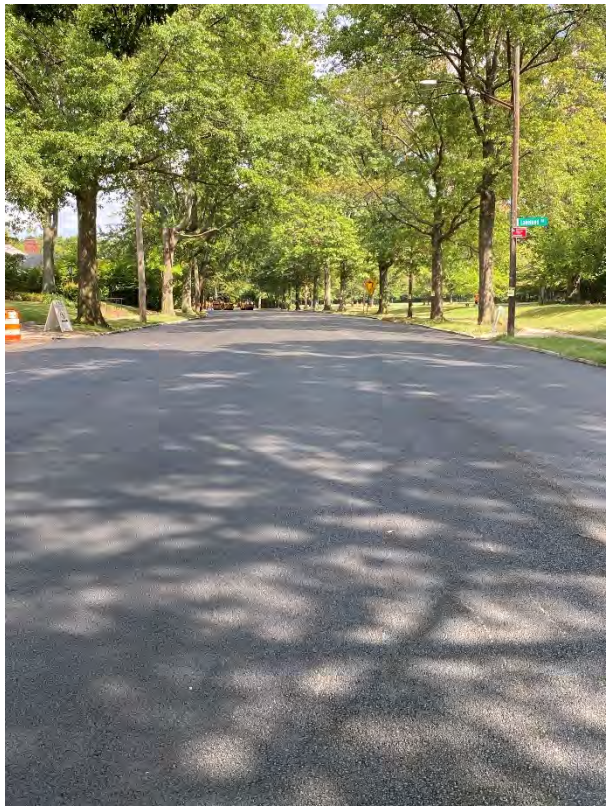
Dry Process – Field Evaluation - NYCDOT

- Project by NYCDOT
- Looked at 4 dosage rates into a 40% RAP mix with 12.5mm NMAS with PG64S-22
  - 0, 6, 10, 12% by wt of virgin binder
  - 0, 3.8, 5.5, 6.5% by wt of total binder
- MacRebur MR8 product added via fiber feeder into RAP collar
- City Asphalt producer
  - Gencor drum plant
  - Fractionated RAP stockpiles



Dry Process – Field Evaluation

- Plant production
  - Approximately 250 tons/hr
    - ≈600 tons total per
  - Production temperatures
    - ≈ 315F for Control
    - ≈ 320 to 330F for recycled plastic
  - ≈ 2 hour silo storage
  - ≈ 8 mile haul (40 to 60 minutes)



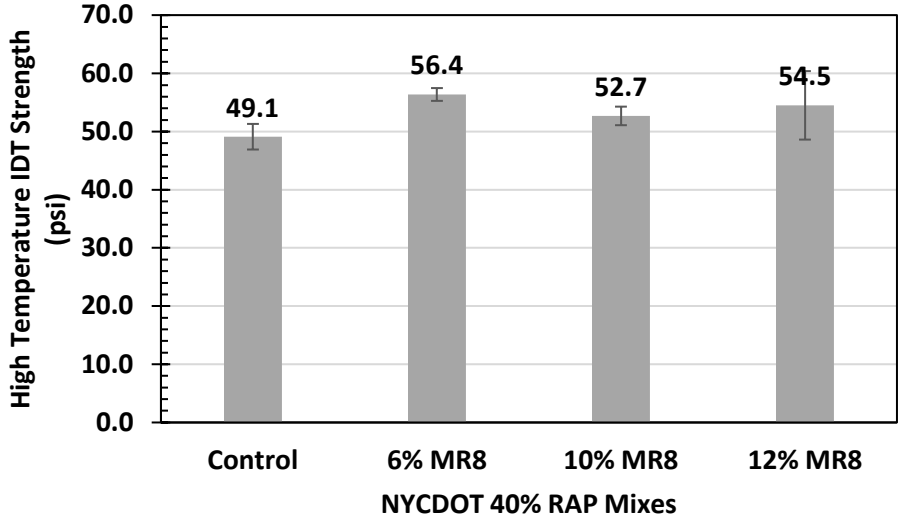
Dry Process – Field – Lab Results

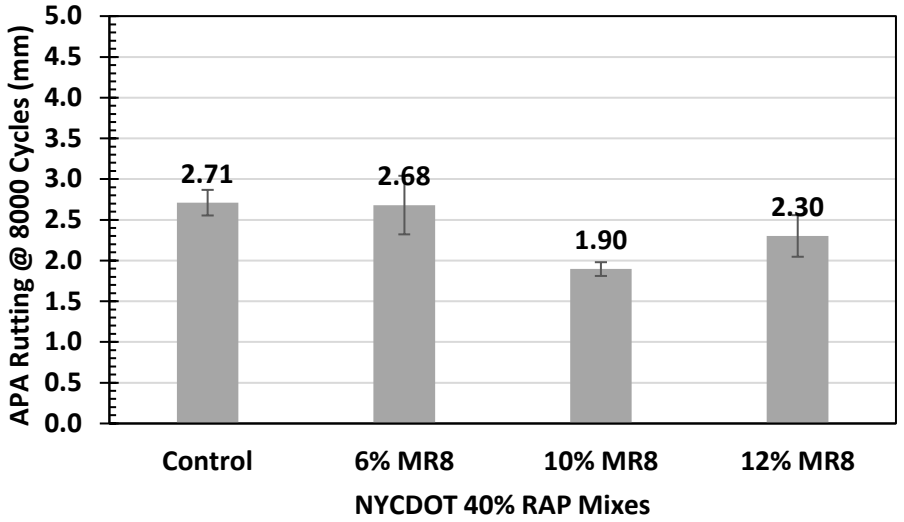
- Goal of NYCDOT was that the addition of recycled plastic would not worsen existing performance
  - High RAP mandate
  - Pavement life function of frequency and severity of utility cuts

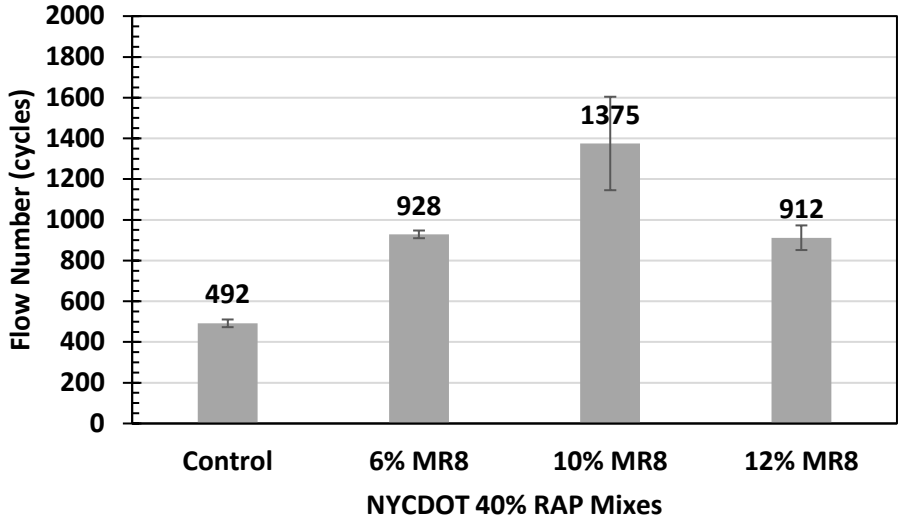
% Plastic	0	6%	10%	12%				
Date:	8/29	8/30	8/31	9/1	JMF			
Time:	10:20 AM	8:00 AM	8:00 AM	7:55 AM	Targets	JMF Limits	General Limits	Tolerance (+/-)
	% Passing							
1"	100.0	100.0	100.0	100.0	**100.0**	100.0	100	
3/4"	100.0	100.0	100.0	100.0	**100.0**	100.0	100	
1/2"	99.1	98.2	97.4	98.1	**100.0**	95 - 100	95-100	
1/4"	71.0	73.8	67.9	70.8	**69.0**	64 - 74	57-75	5
1/8"	38.2	40.5	36.6	39.0	**39.0**	35 - 43	32-52	4
#20	19.8	20.5	18.9	20.5	**21.0**	17 - 25	15-32	4
#40	14.4	15.2	14.0	15.2	**15.0**	11 - 19	8-25	4
#80	8.3	9.3	8.4	9.1	**9.0**	6 - 12	5-17	3
#200	4.9	5.6	5.0	5.5	**5.0**	3 - 7	2-8	2
AC%	5.45	5.53	5.35	5.38	5.3	5.0 - 5.7	5.0-6.2	.4
Gmm	2.611	2.599	2.598	2.604	N/A	N/A	N/A	N/A
Air Voids	4.5	5.3	4.9	5.0	4.0	3.0 - 5.0	3.0 - 5.0	

Dry Process – Field – Lab Results

- Rutting Evaluation
  - AASHTO T340 - APA @ 64C
  - AASHTO T378 – FN @ 54C
  - NCHRP 9-33 – HT-IDT @ 44C

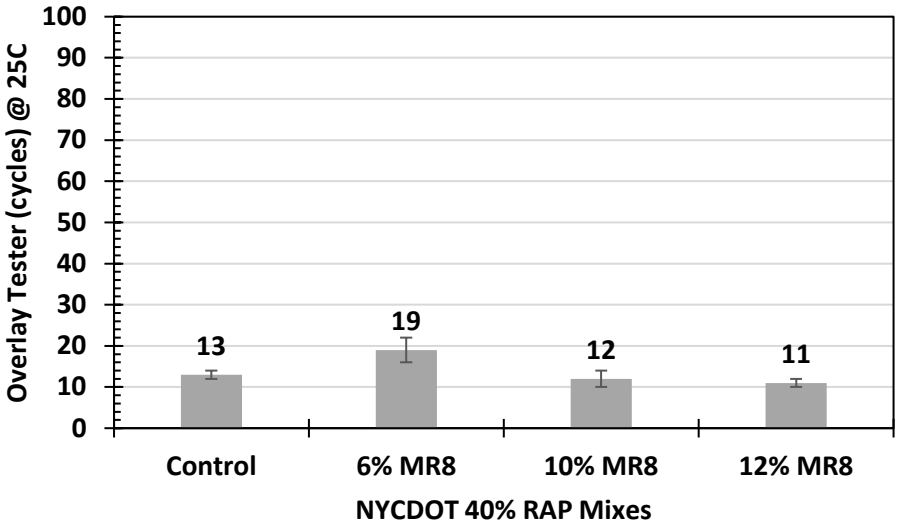


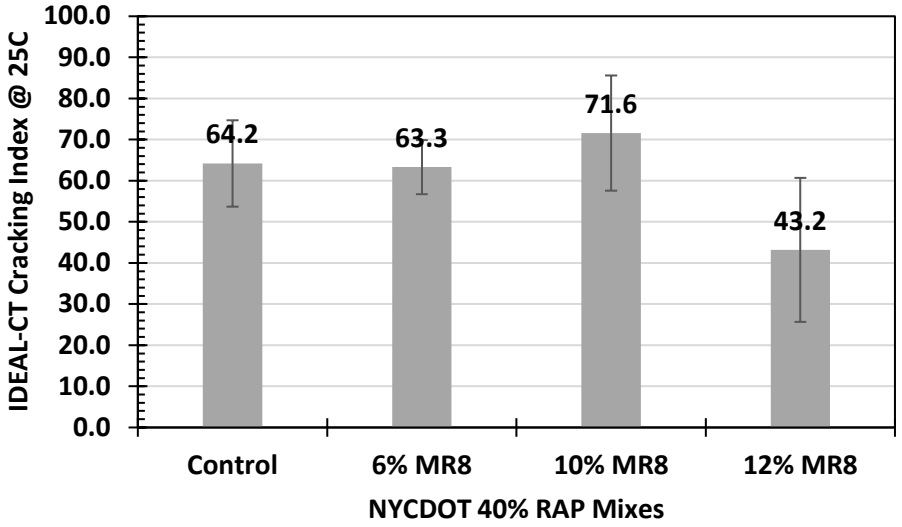


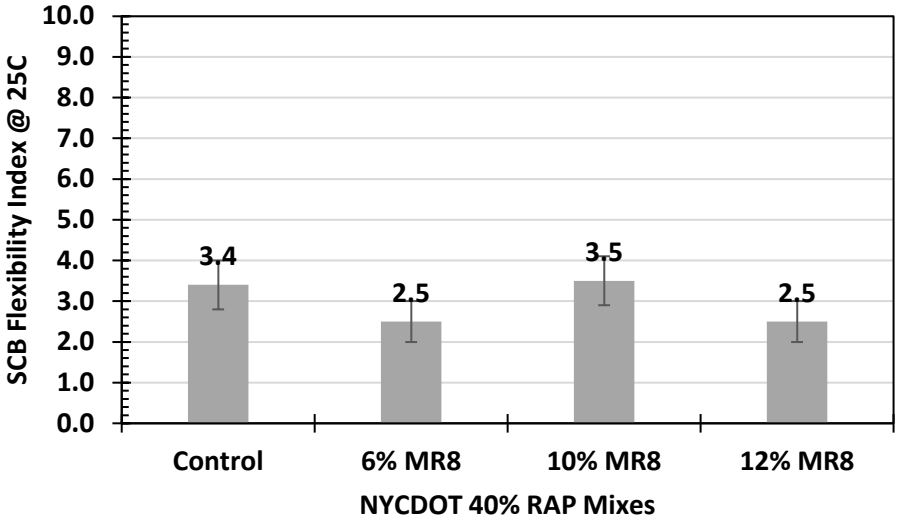


Dry Process – Field – Lab Results

- Fatigue Cracking Evaluation
  - ASTM D8225 - IDEAL-CT @ 25C
  - AASHTO T393 – SCB FI @ 25C
  - NJDOT B-10 – OT @ 25C
  - UNH – G-Rmix @ 20C, 5 Hz







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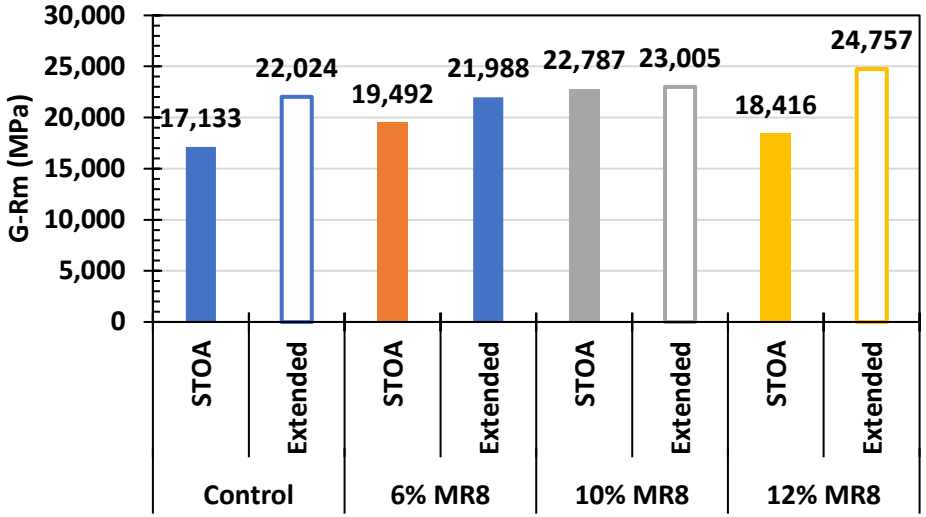
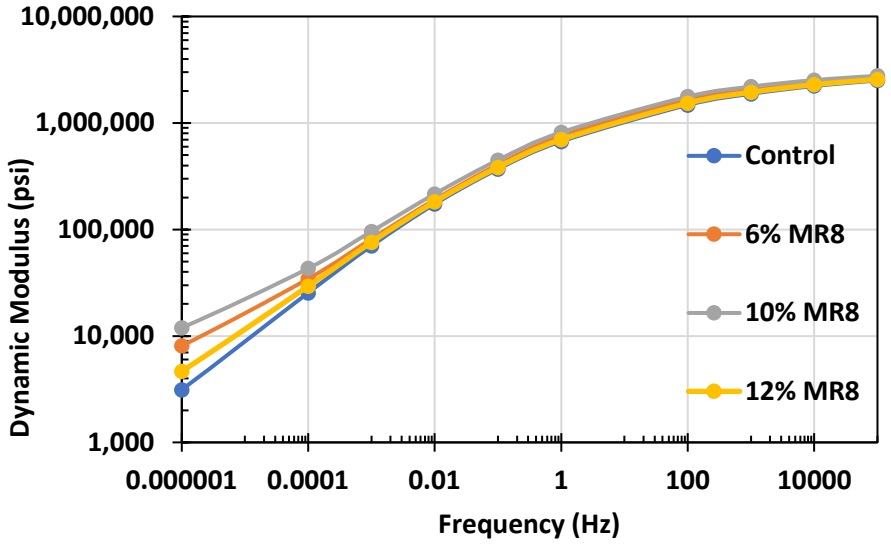
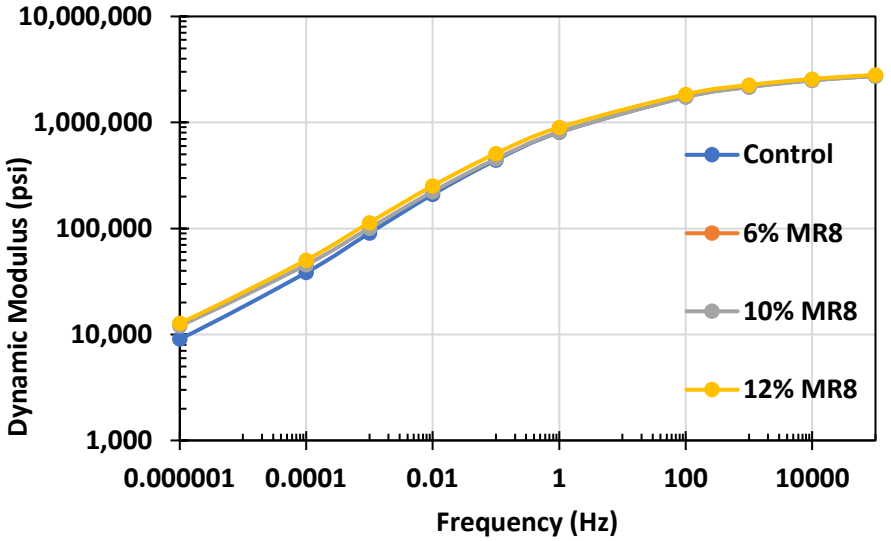


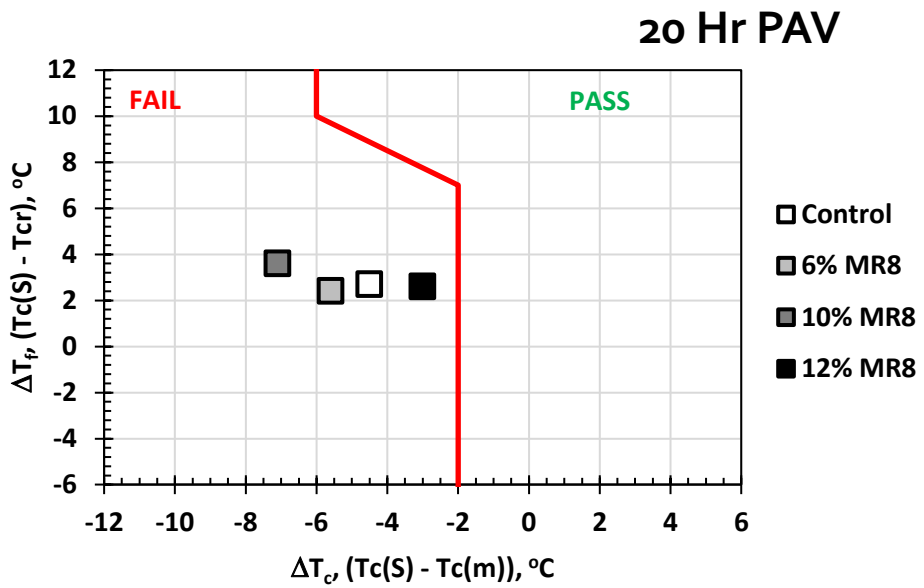




Dry Process – Field – Lab Results

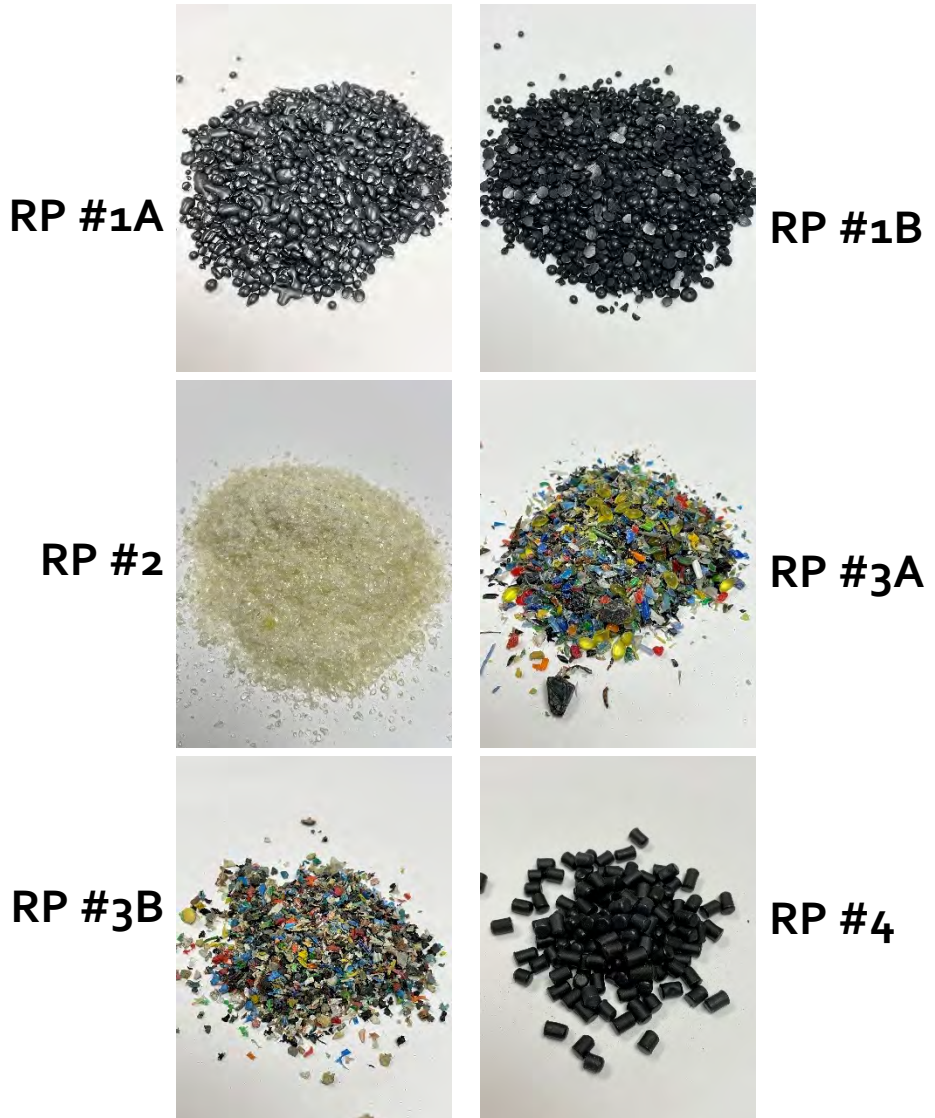
- Recovered Binder Properties

Extracted Binder Sample	High Temperature Grading					Intermediate Temperature		Low Temperature PG Grading		
	PG Grading	MSCR @ 64C								
		Jnr (kPa)	% Rec	Elastomer Line	Z-Factor	PG Grade	GRP @ 25C	BBR (Stiffness)	BBR (m-value)	ΔTc
Virgin	79.2	0.384	17.4	**FAIL**	-20.4	26.2	8077	-25.8	-21.3	-4.5
6% MR8	79.8	0.350	18.6	**FAIL**	-20.1	26	7708	-26.6	-21.0	-5.6
10% MR8	81.5	0.293	24.4	**FAIL**	-16.2	26.5	9446	-26.5	-19.4	-7.1
12% MR8	80.8	0.290	22.1	**FAIL**	-18.6	25.9	7415	-26.1	-23.1	-3



Dry Process – Laboratory Evaluation

- Comparing the asphalt mixture and binder properties using 6 different recycled plastic materials
  - Mixed in lab using NJDOT approved 12.5M64 asphalt mixture
    - 0% RAP; PG64S-22 asphalt binder
    - Aggregates heated to 350F overnight
    - Mixed in heated mixing bucket for 15 secs
    - Added recycled plastic and allow to mix for another 30 secs
    - Add asphalt binder (heated to mixing temp) and mix for another 45
      - Approximately 10 to 15 seconds beyond fully coated



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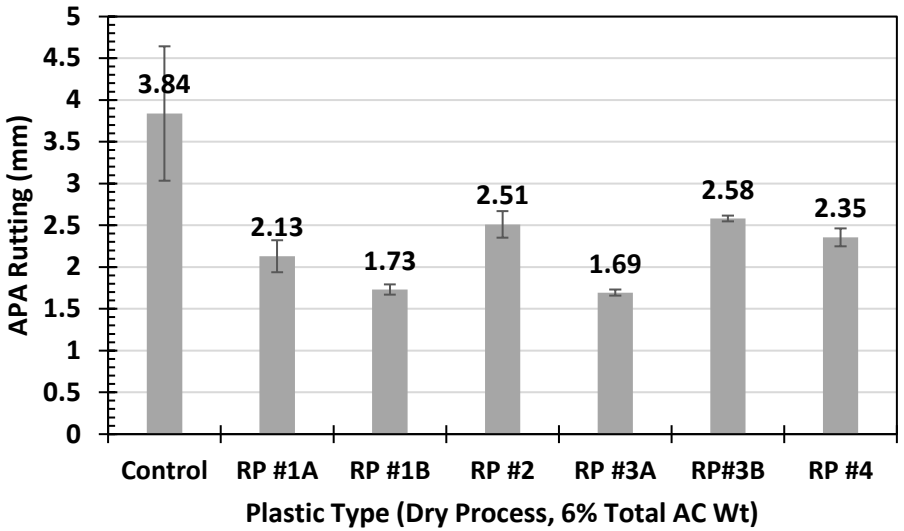

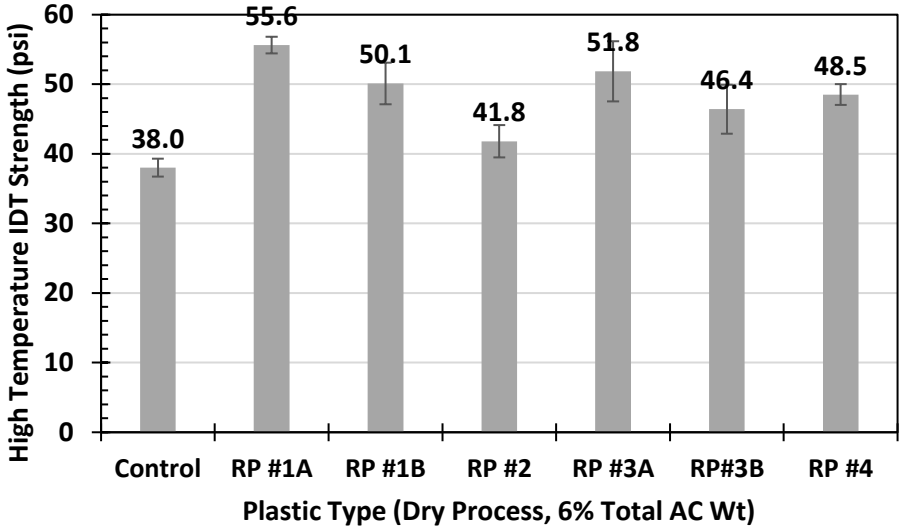

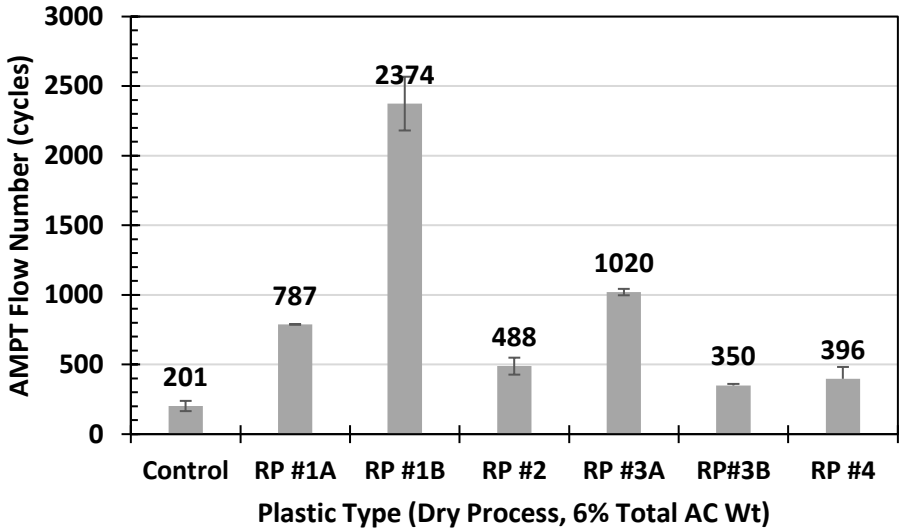

Dry Process – Lab – Lab Results

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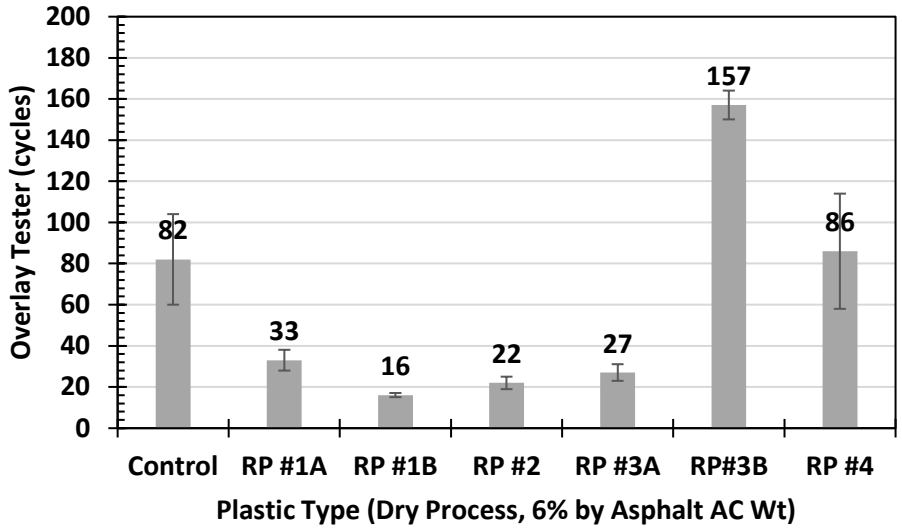
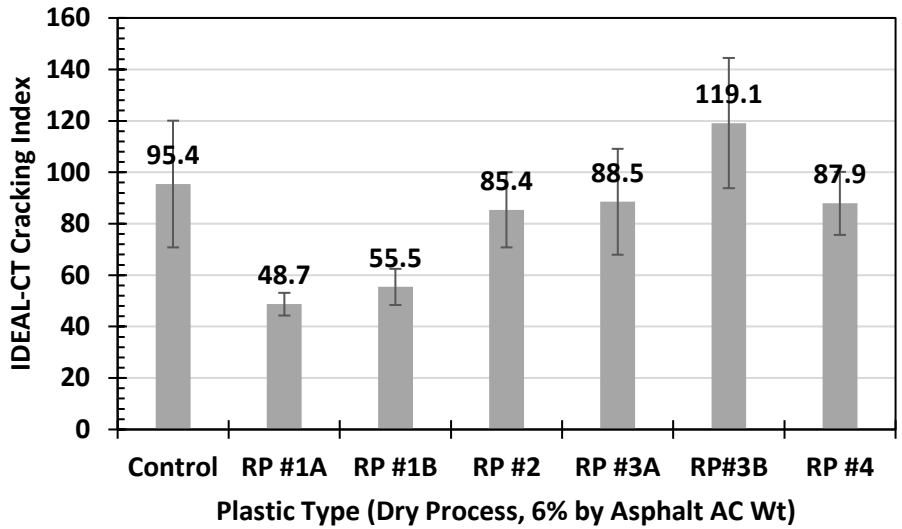
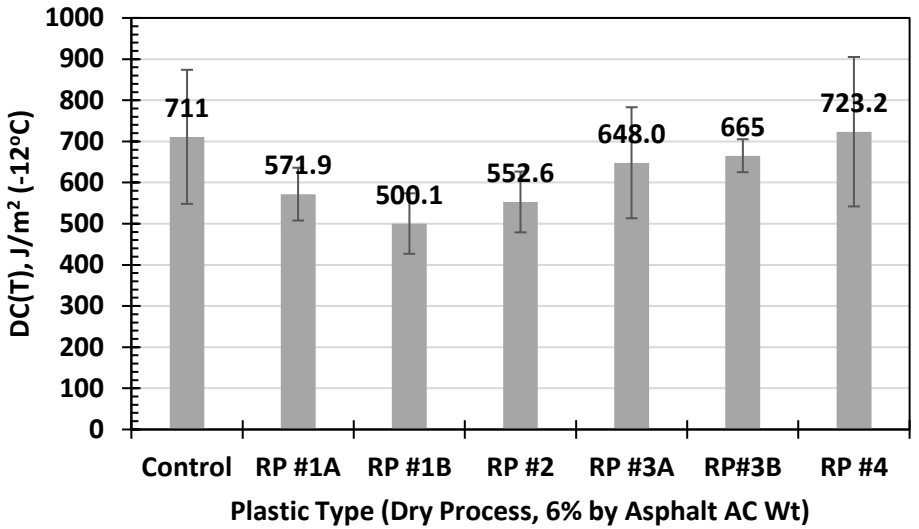
  - ASTM D8225 - IDEAL-CT @ 25C
  - ASTM D7313 – DC(T) @ -12C
  - NJDOT B-10 – OT @ 25C
  - UNH – G-Rmix @ 20C, 5 Hz







Dry Process – Lab – Lab Results

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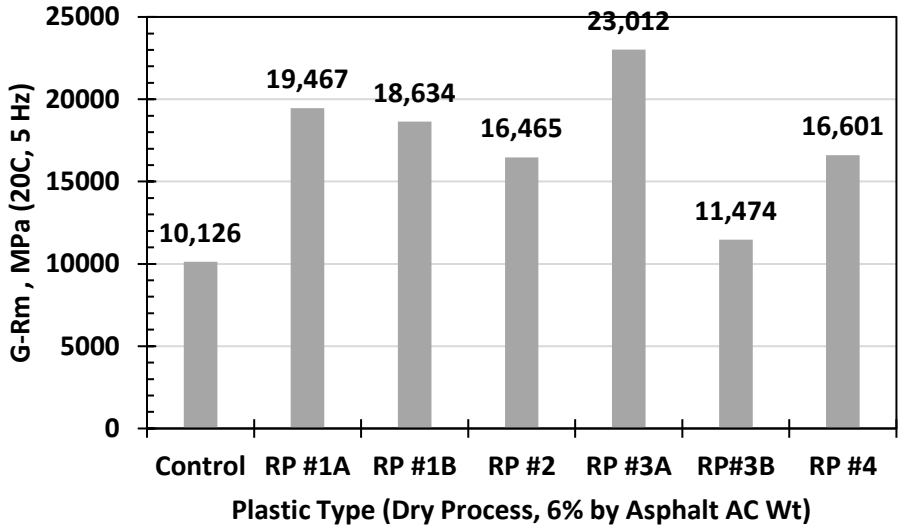
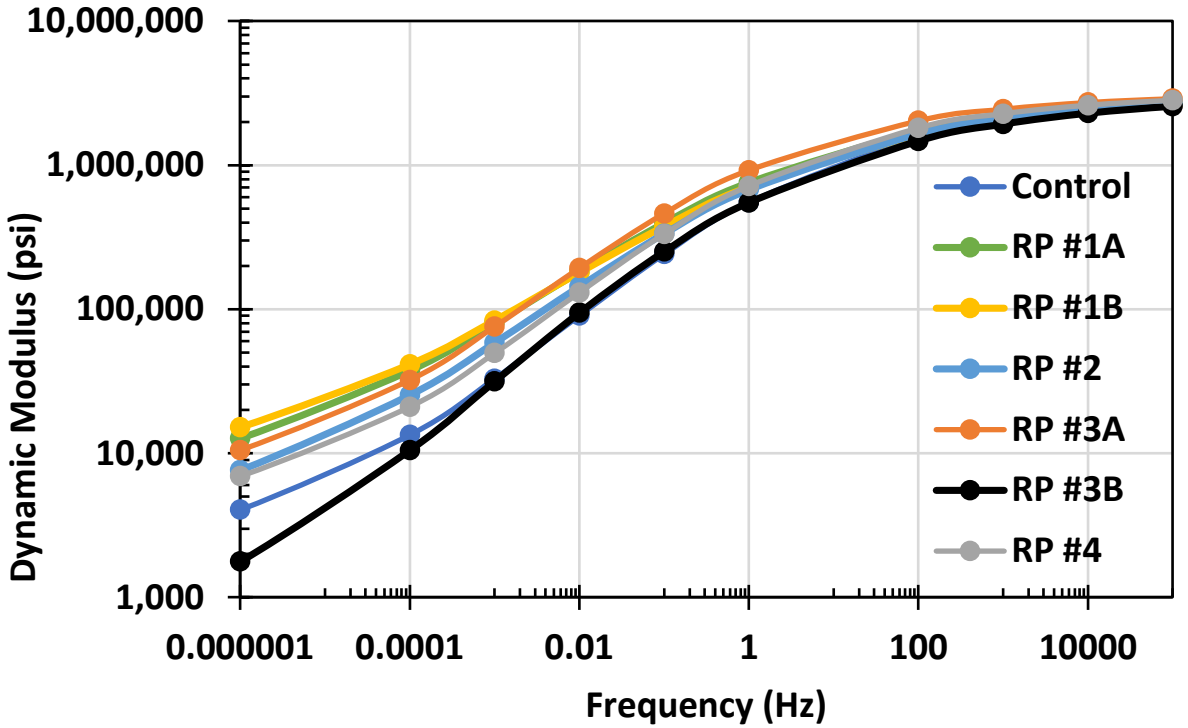
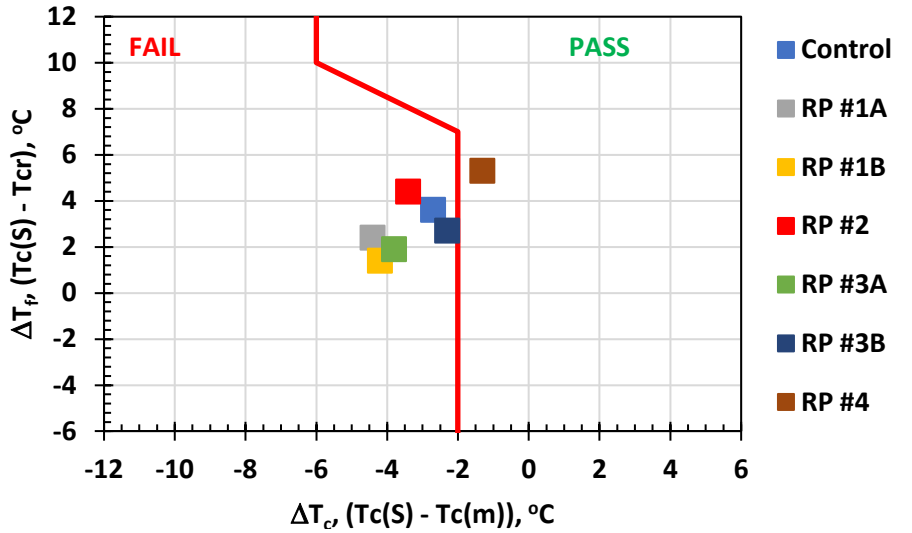


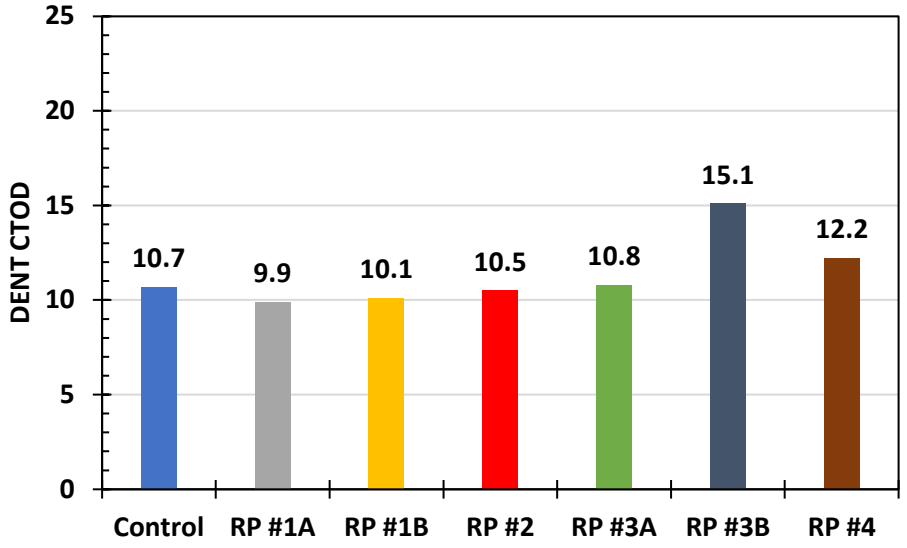


Dry Process – Lab – Lab Results

- Recovered Binder Properties

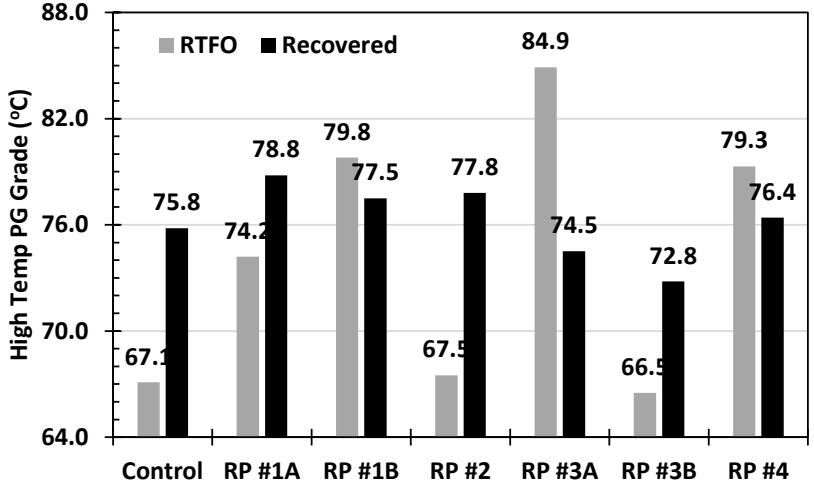
Extracted Sample	High Temperature Grading					Intermediate Temperature		Low Temperature PG Grading		
	PG Grading	MSCR @ 64C								
		Jnr (kPa)	% Rec	Elastomer Line	Z-Factor	PG Grade	GRP @ 25C	BBR (Stiffness)	BBR (m-value)	ΔTc
Control	75.8	0.775	6.5	**FAIL**	-24.9	25.4	6447	-24.5	-21.8	-2.7
RP #1A	78.8	0.478	14.9	**FAIL**	-20.8	25.1	6281	-24.1	-19.7	-4.4
RP #1B	77.5	0.651	9.7	**FAIL**	-23.2	25.1	5139	-25.1	-20.9	-4.2
RP #2	77.8	0.551	8.5	**FAIL**	-25.9	27.6	8311	-23.6	-20.2	-3.4
RP #3A	74.5	0.958	4.9	**FAIL**	-24.8	22.5	6556	-25.7	-21.9	-3.8
RP #3B	72.8	1.934	2.19	**FAIL**	-22.5	23.6	3813	-26.3	-24.0	-2.3
RP #4	76.4	0.758	6.7	**FAIL**	-24.9	26.4	4558	-23.9	-22.6	-1.3

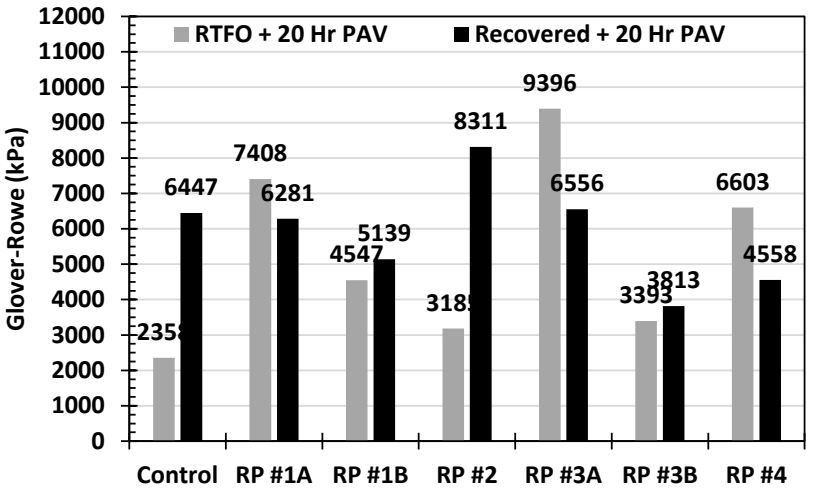


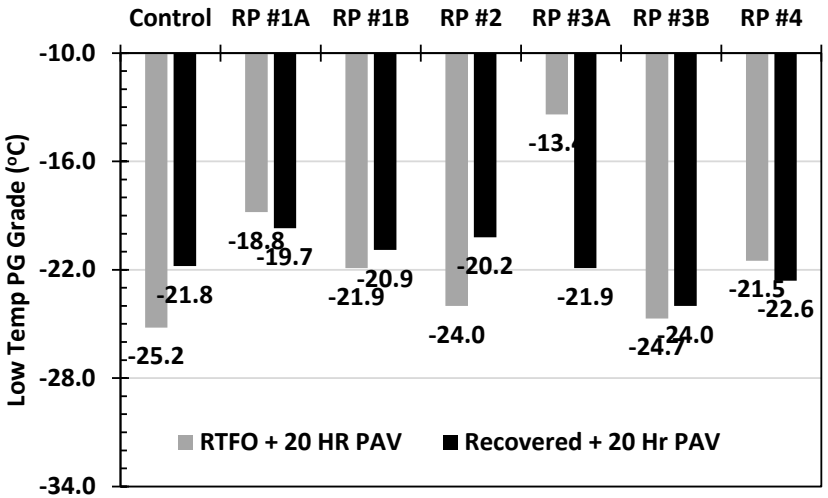


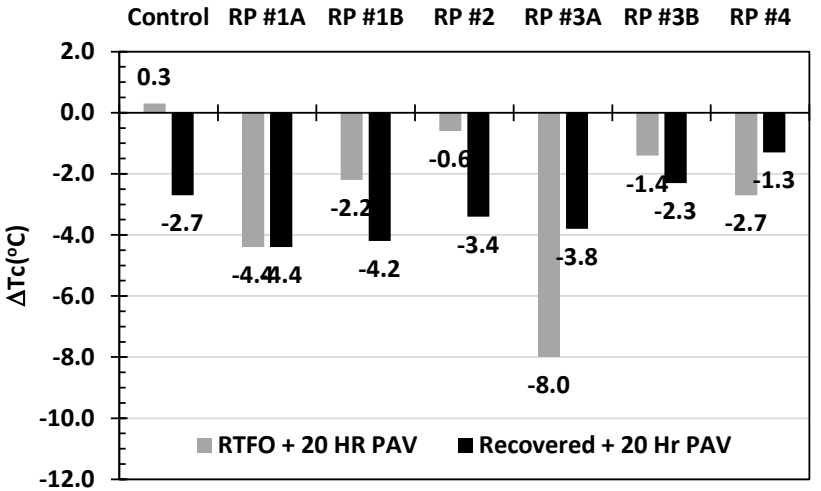
Dry Process – Lab – Lab Results

- Recovered vs Blended Binder Properties







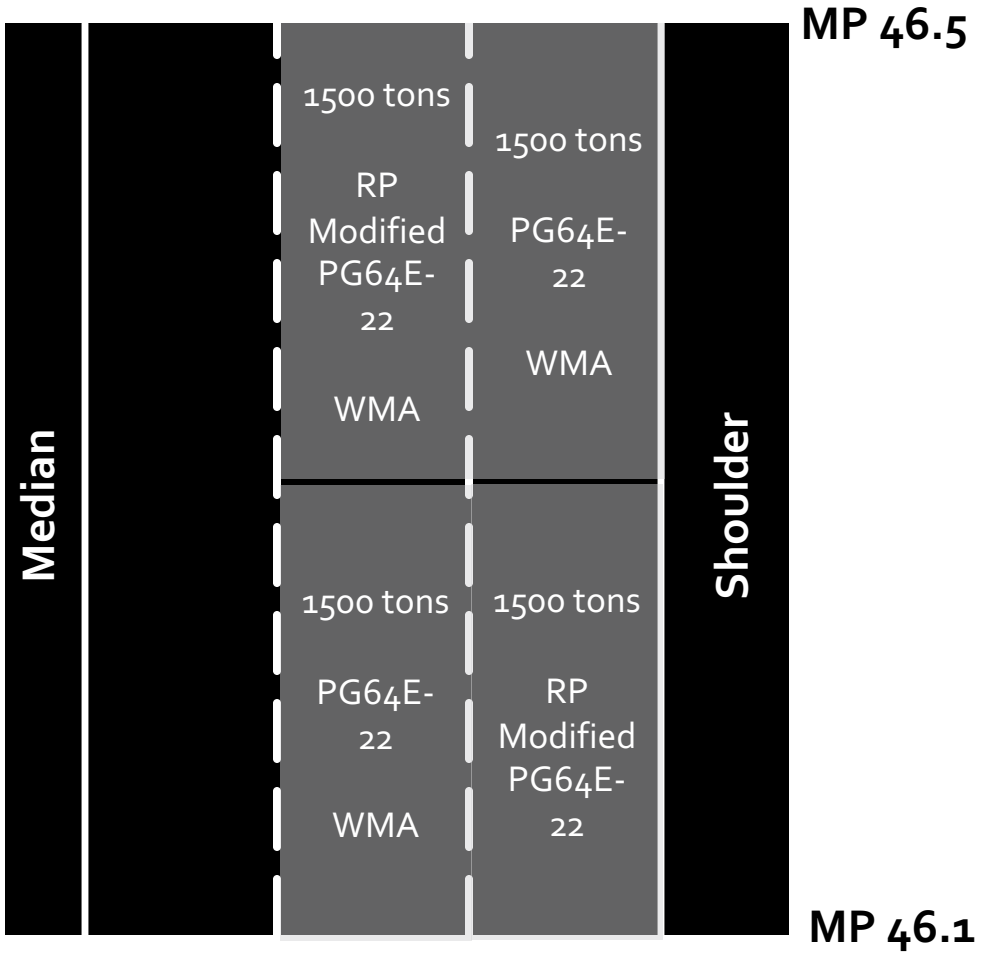


Dry Process – Does it all break down?

Wet Process Evaluation

Wet Process – Field Evaluation

- New Jersey Turnpike
  - NB Lanes, MP 46.1 to 46.5
    - Alternate paved sections to see impact of traffic
  - Mill 2.5”/Pave 2.5” 12.5 NMAS PG64E-22
    - 5.2% AC with 10% RAP
    - WMA required for all NJTA mixes, but was not included in first recycled plastic (RP) section
- All asphalt binder produced at Associated Asphalt (Gloucester City terminal)



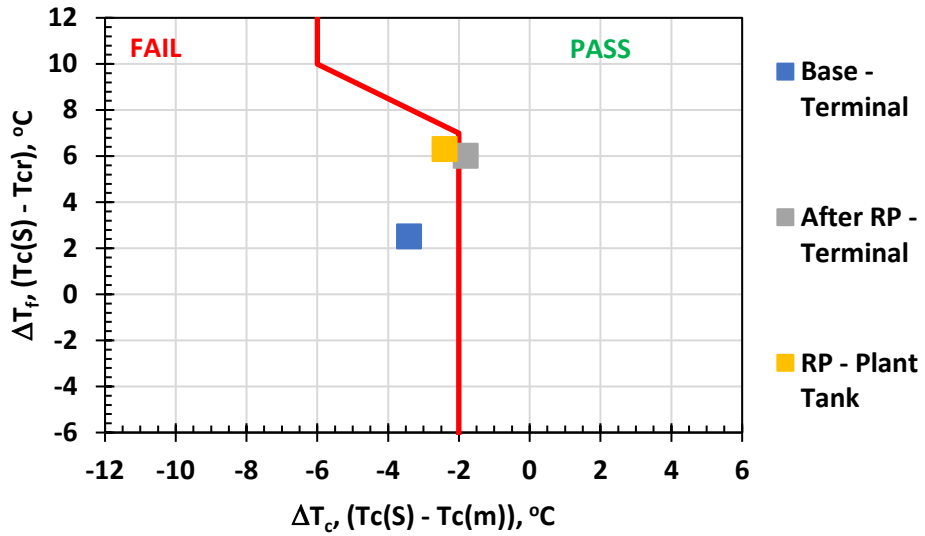
Wet Process – Field Evaluation

- New Jersey Turnpike
  - Production rate of 275 tons/hr
  - Discharge temperature 305F to 315F
  - Temperature behind paver 285 to 295F
    - MTV used for all lanes

Wet Process – Field – Lab Results

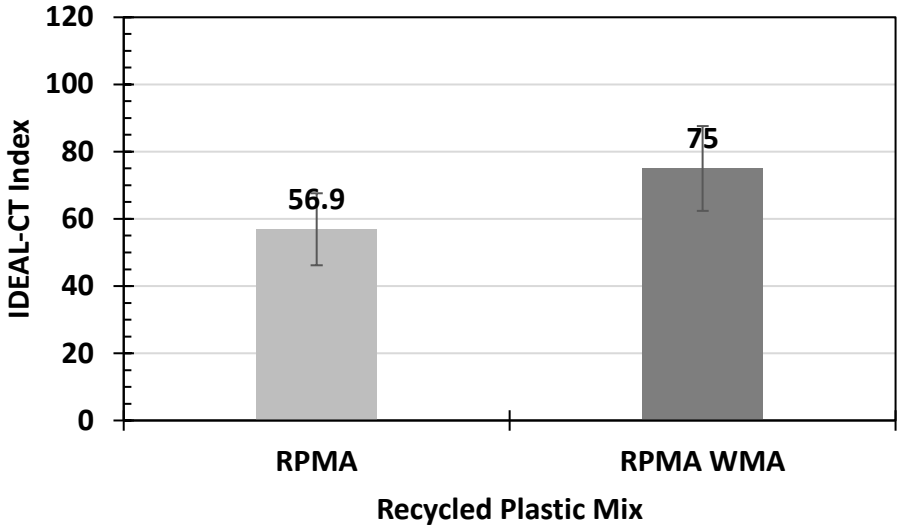
- Asphalt Binder Testing

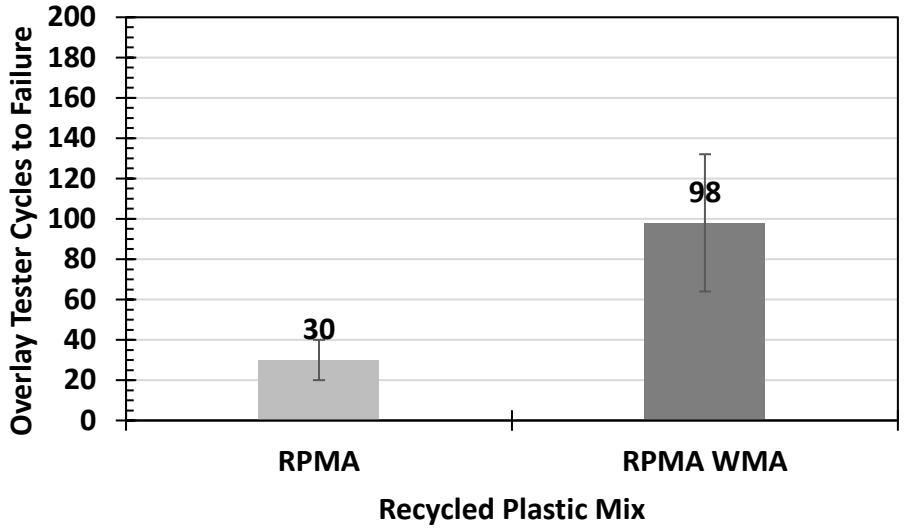
Sample	Solubility (ASTM D2042)	High Temperature Grading							Intermediate Temperature		Low Temperature PG Grading		
		Original		RTFO HT	MSCR @ 64C								
		HT	Phase Angle		Jnr (kPa)	% Rec	Elastomer Line	Z-Factor	PG Grade	GRP @ 25C	BBR (Stiffness)	BBR (m-value)	ΔTc
Base	99.9%	81.1	69.5	80.0	0.153	73.3	**PASS**	25.2	21.4	3138	-31.6	-28.2	-3.4
After MR8 Blended	99.9%	86.9	65.3	85.3	0.056	84	**PASS**	21.3	20.6	3472	-29.4	-27.6	-1.8
Stavola Tank 9-29-22	99.8%	82.1	69.8	82.7	0.111	75.9	**PASS**	23.5	20.4	2520	-29.0	-26.6	-2.4

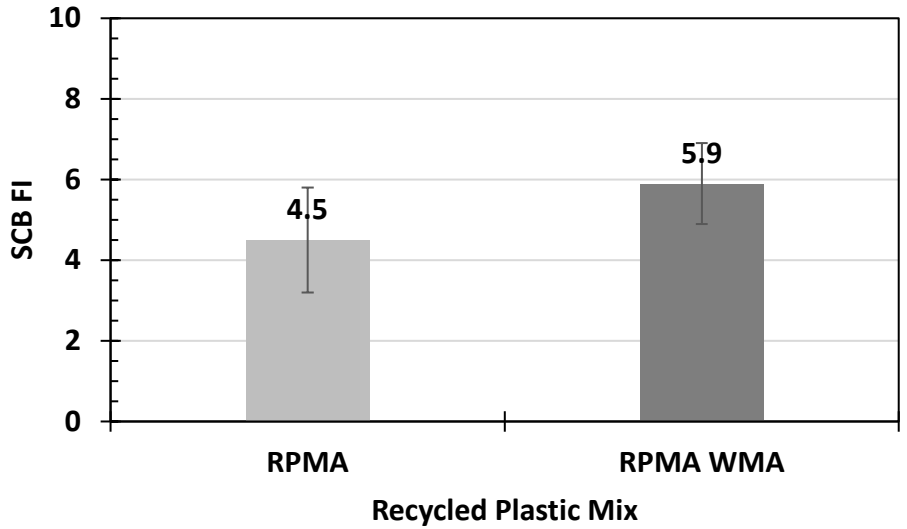


Wet Process – Field – Lab Results

- Asphalt Mixture Testing







Wet Process – Laboratory Study

- 1st Study – MacRebur Materials
  - Binders prepared using high shear mixer
  - 165C for 4 hours (as per manufacturer rec.)
    - Slotted disintegrating head on Silverson mixer
  - No crosslinker or compatibilizer used
  - Dosage rates of 3, 6, 9% by total weight of asphalt binder
  - PG58-28 & PG64-22



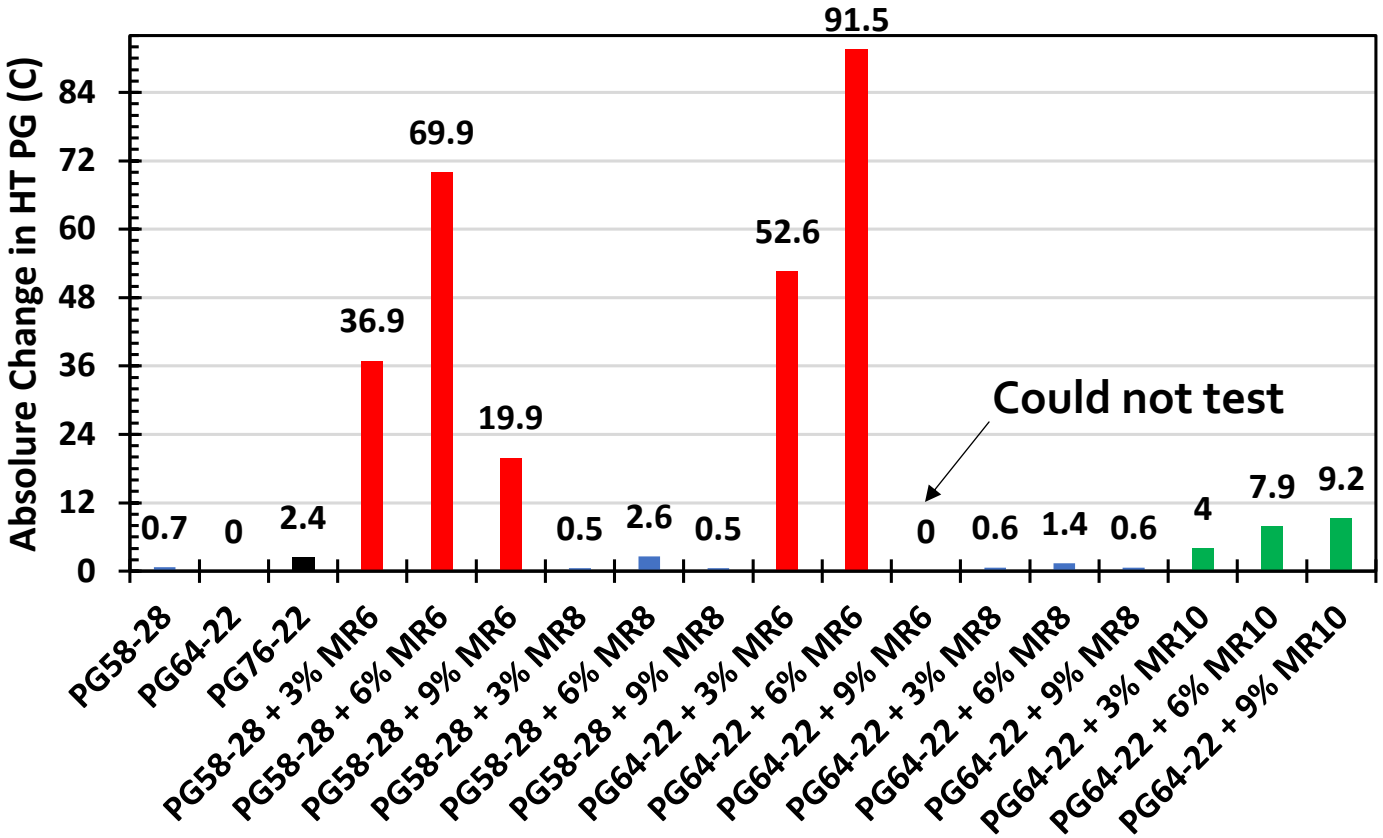


Wet Process – Lab – Lab Results

- Separation (ASTM D7173)
  - Will the modifier separate from the asphalt binder
    - Pour 50 grams of blended binder in "cigar tube" and seal
    - Maintain vertical in oven for 48 hours @ 163C
    - Remove from oven & place vertically in freezer (0 to -20C) for greater than 4 hrs
  - Remove and cut into 1/3 – place upper and lower 1/3 in container, heat and pour out contents
  - Traditionally used with softening point
    - High temperature DSR

Wet Process – Lab – Lab Results

- Separation
  - MR6 showed greatest potential for separation
  - MR8 showed lowest potential (comparable to base binders)



Wet Process – Lab – Lab Results

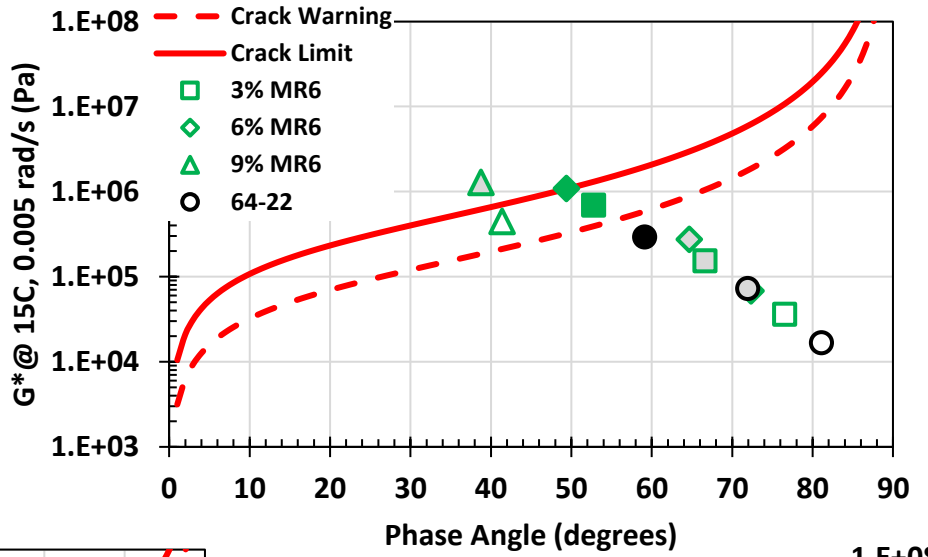
- MR8 (thermoplastic)
  - No change in high temp
  - Slight improvement in Int. & low temp
  - No significant change in viscosity

Base Binder	Additive	Dosage Rate	Rotational Viscosity (Pa s)		High Temperature PG Grade				Intermediate Temp PG Grade	Low Temperature PG Grade		
					Original	RTFO	MSCR @ 64C			Stiffness (S)	m-Value	ΔTc
			135C	165C			Jnr (1/kPa)	% Rec				
58-28	N.A.	0%	0.21	0.065	55.7	55.8	12.09	0.0	10.8	-33.1	-36.8	3.7
64-22	N.A.	0%	0.4275	0.117	66.6	67.1	3.28	0.0	21.7	-25.5	-24.8	-0.7
64-22	MR6	3%	0.812	0.282	73.7	74.7	1.1	3.2	26.1	-24	-21.1	-2.9
		6%	1.612	0.519	78.1	85.6	0.286	25	27.3	-23.4	-16.7	-6.7
		9%										
64-22	MR8	3%	0.463	0.127	67.2	67.1	3.04	0.8	22.7	-26.2	-23.9	-2.3
		6%	0.469	0.129	66.4	67.1	3.1	1	22.2	-26.8	-26.3	-0.5
		9%	0.5232	0.142	67.1	66.3	3.01	0.2	19.3	-27.7	-26.9	-0.8
64-22	MR10	3%	0.65	0.175	71.1	71.4	1.66	4	24.1	-24.7	-21.5	-3.2
		6%	0.884	0.243	74	74.2	1.15	9.1	24.7	-25	-20.2	-4.8
		9%	6.75	0.47	79.5	78.9	0.65	16.6	23.9	-24.3	-16.5	-7.8
76-22	N.A.	0%	1.538	0.385	78.1	78.1	0.232	68.3	22.3	-27	-26.1	-0.9

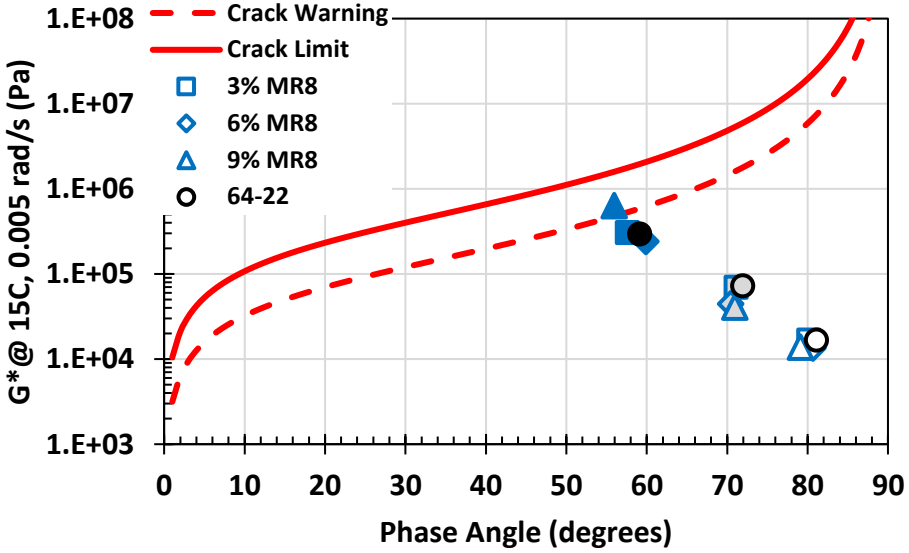
Wet Process – Lab – Lab Results

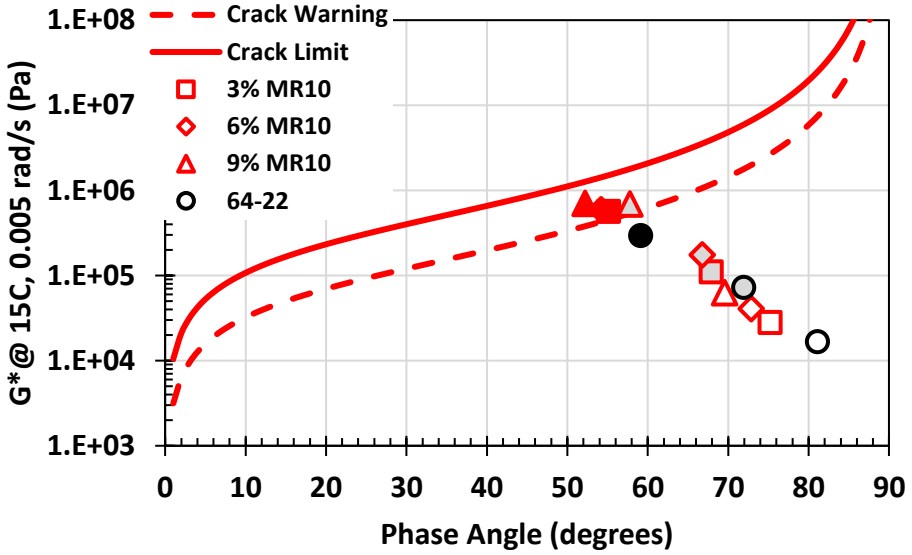
- Glover-Rowe Parameter

$$\frac{G'}{\eta'/G'} = \frac{|G^*| \cdot (\cos\delta)^2}{\sin\delta} \cdot \omega$$



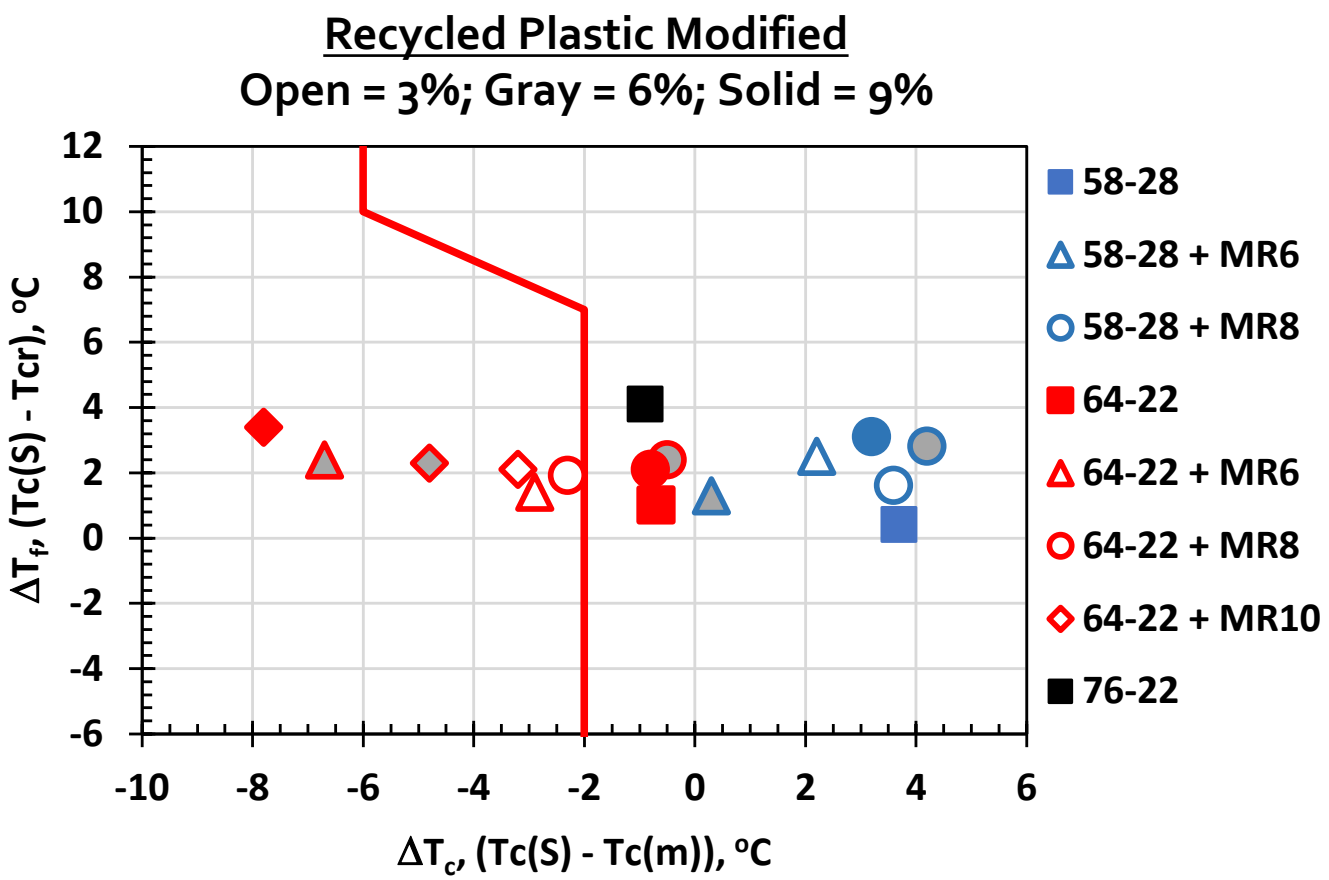
Open symbols = Original
Gray filled = RTFO
Filled = 20 hr PAV

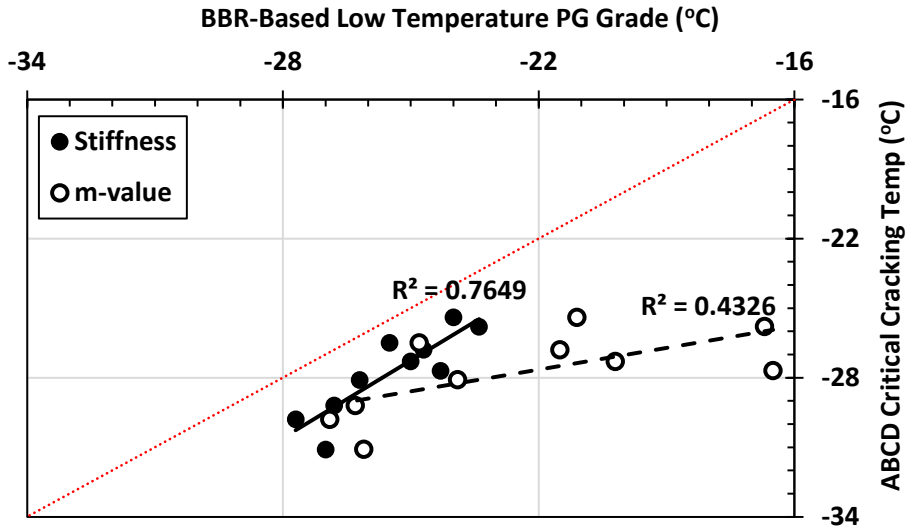


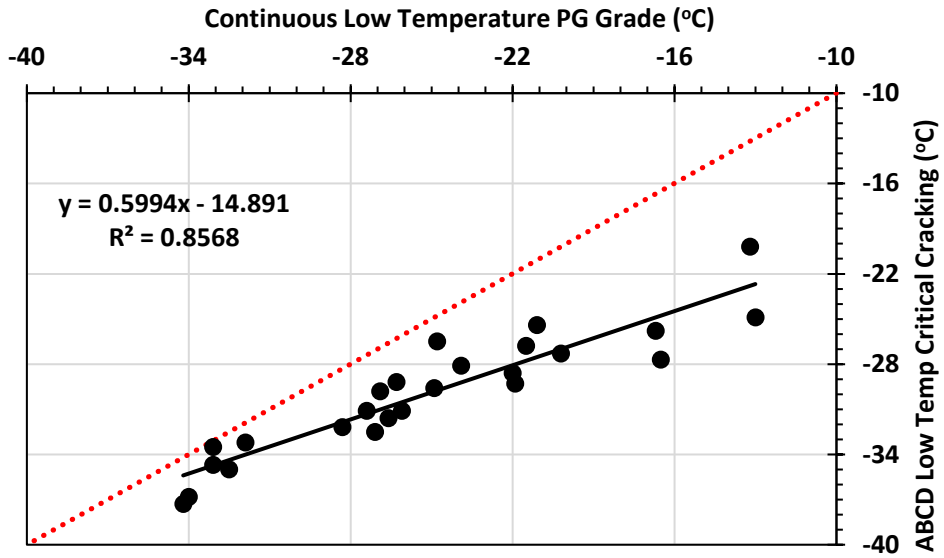


Wet Process – Lab – Lab Results

- ABCD Testing Results

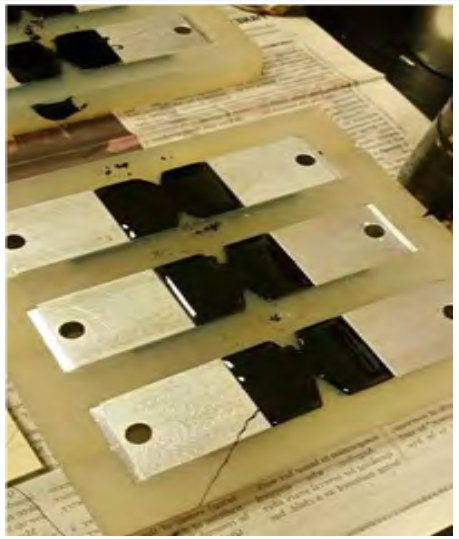


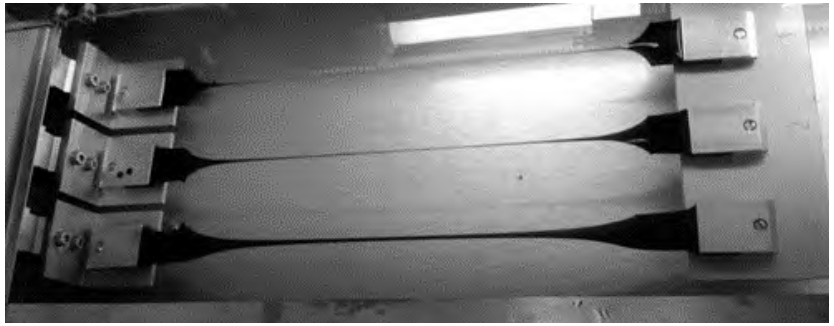


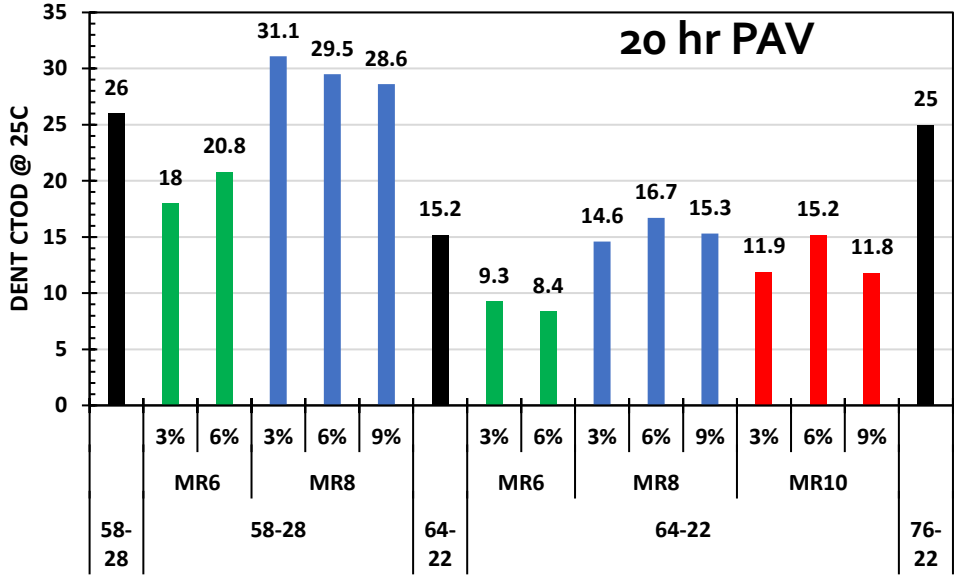


Wet Process – Lab – Lab Results

- Double Edge Notched Tension (DENT)
  - Measure of asphalt binder's ductility
  - Conducted at 25C
  - Compared crack tip opening displacement (CTOD)

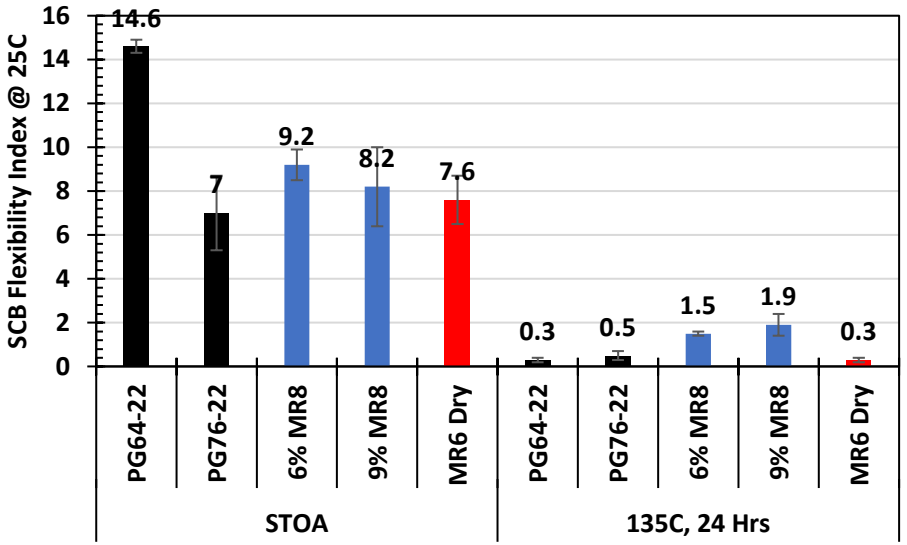




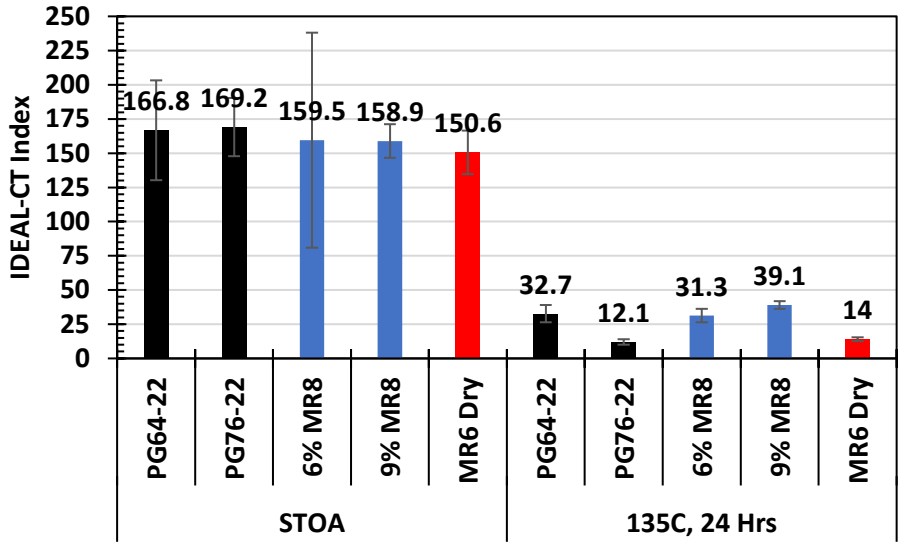


Wet Process – Lab – Lab Results

SCB FI



IDEAL-CT



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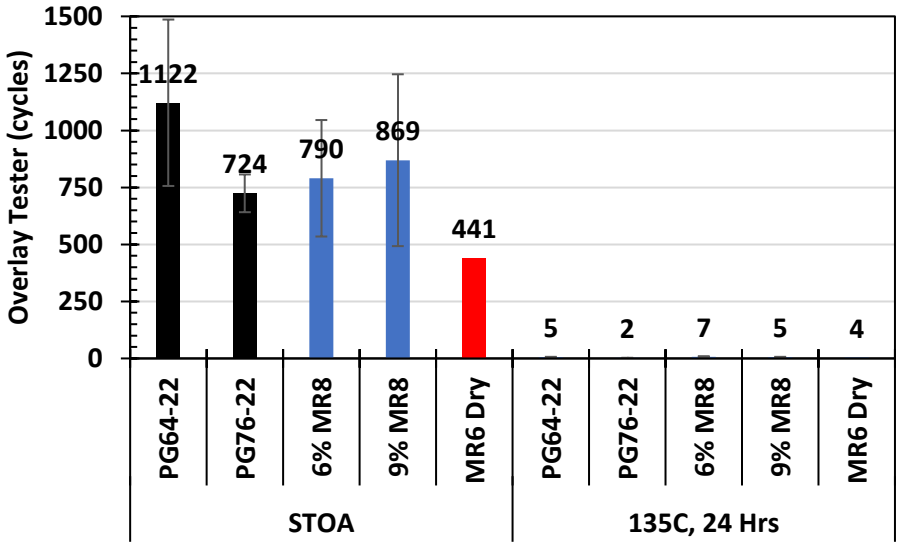
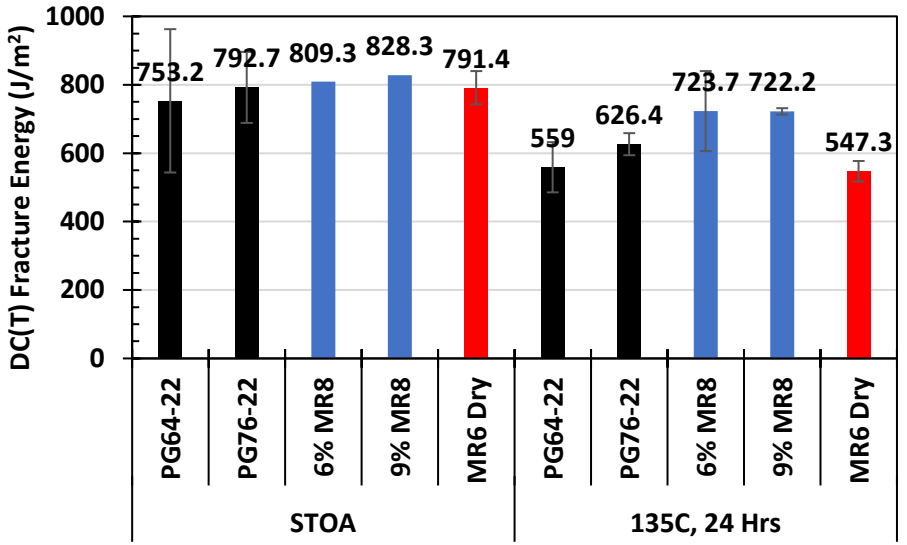


DC(T)



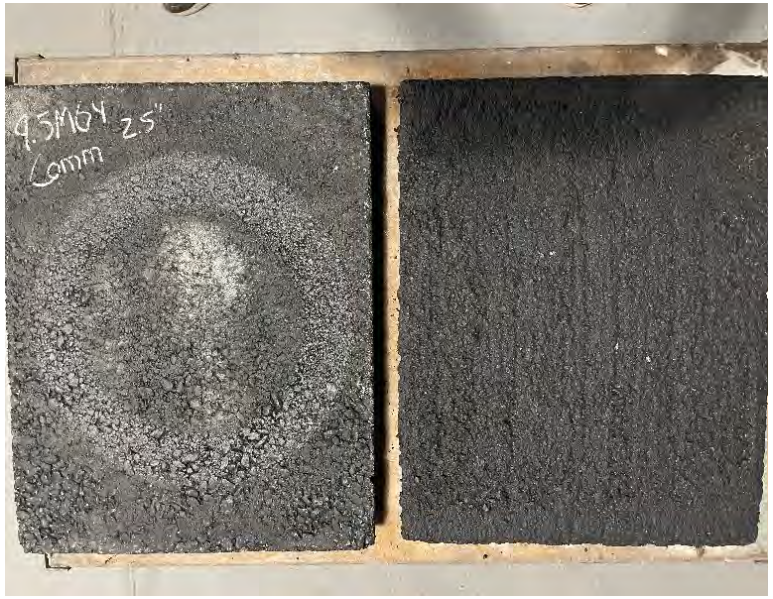
Final Thoughts and Conclusions

Final Thoughts and Conclusions

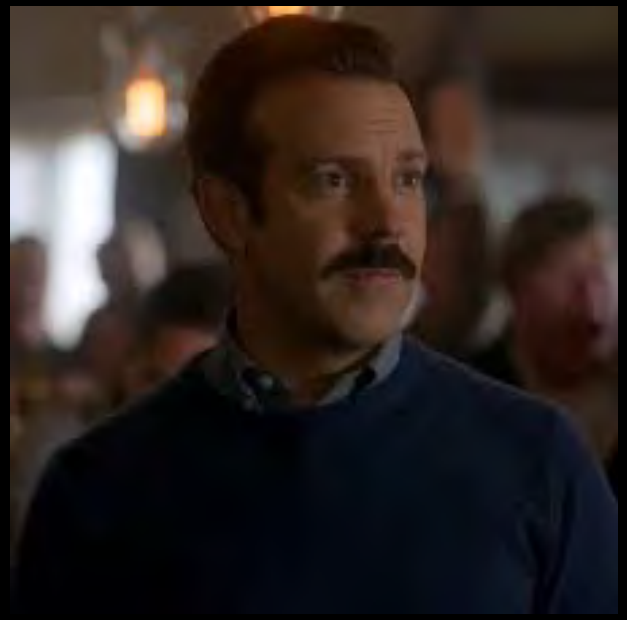
- Dry process
  - Can allow for greater dosage rates & flexibility for asphalt mix suppliers
  - Impact on blending efficiency – visual plastic in cases
- Wet process
  - Promotes high blending and maximizes modification
  - May be restricted by increase in viscosity, reduction in solubility & refinery capabilities
- Overall
  - Different recycled plastic products resulted in varying performance depending on manufacturer
  - Some more suitable for dry process while others may benefit from wet process

Final Thoughts and Conclusions

- Moving forward…
  - Continue with pilot studies to assess structural performance
  - Initiating evaluating environmental (microplastics)
    - 3 Wheel Abrasion with water
    - Wet Hamburg
    - Collaborating with VTRC & Rutgers Environmental faculty



As Ted Lasso reminded us..
"Be curious, not judgmental…"



Thank you for your time!

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