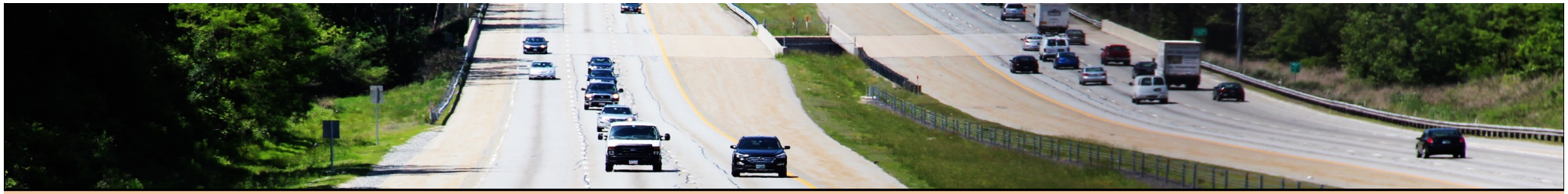

Case Study of High RAP Content Surface Mixtures Placed on High-Volume Roads

NEAUPG

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Commonwealth Professor Walaa S. Mogawer, P.E., F.ASCE

University of Massachusetts Dartmouth

Acknowledgment

Name	Affiliation
Dr. Ibrahim A. Abdalfattah	UMass Dartmouth Highway Sustainability Research Center (HSRC) Senior Research Engineer
Alexander Austerman, P.E.	UMass Dartmouth Highway Sustainability Research Center (HSRC) Senior Research Engineer
Kevin Stuart	Consultant
Ed Naras	MassDOT Pavement Management Engineer
Mark Brum, P.E.	FHWA RI Division Construction Engineer (Formerly MassDOT)

Presentation Outline

- ❑ Problem Statement
- ❑ Objectives
- ❑ Methodology
- ❑ Results
- ❑ Conclusions

Problem Statement

- MassDOT specifications allow up to 15% Reclaimed Asphalt Pavement (RAP) in surface course mixtures.

- Based on a UMass/MassDOT 2020 study entitled *"Influence of Reclaimed Asphalt Pavement (RAP) Source and Virgin Binder Source on RAP Specifications and Balanced Mix Design"* the following was concluded:

  - The RAP content could be increased over the 15% maximum based on the properties of the RAP, which is source dependent.

  - The RAP source has a significant effect on the cracking resistance of the asphalt mixture.

Problem Statement

MassDOT approved demonstration projects beginning in 2021 for high RAP surface mixtures with RAP contents between 25% and 30%.

These mixtures were placed on high-volume interstate projects to evaluate the RAP content specification limit and to document/evaluate their production, placement, and variability.

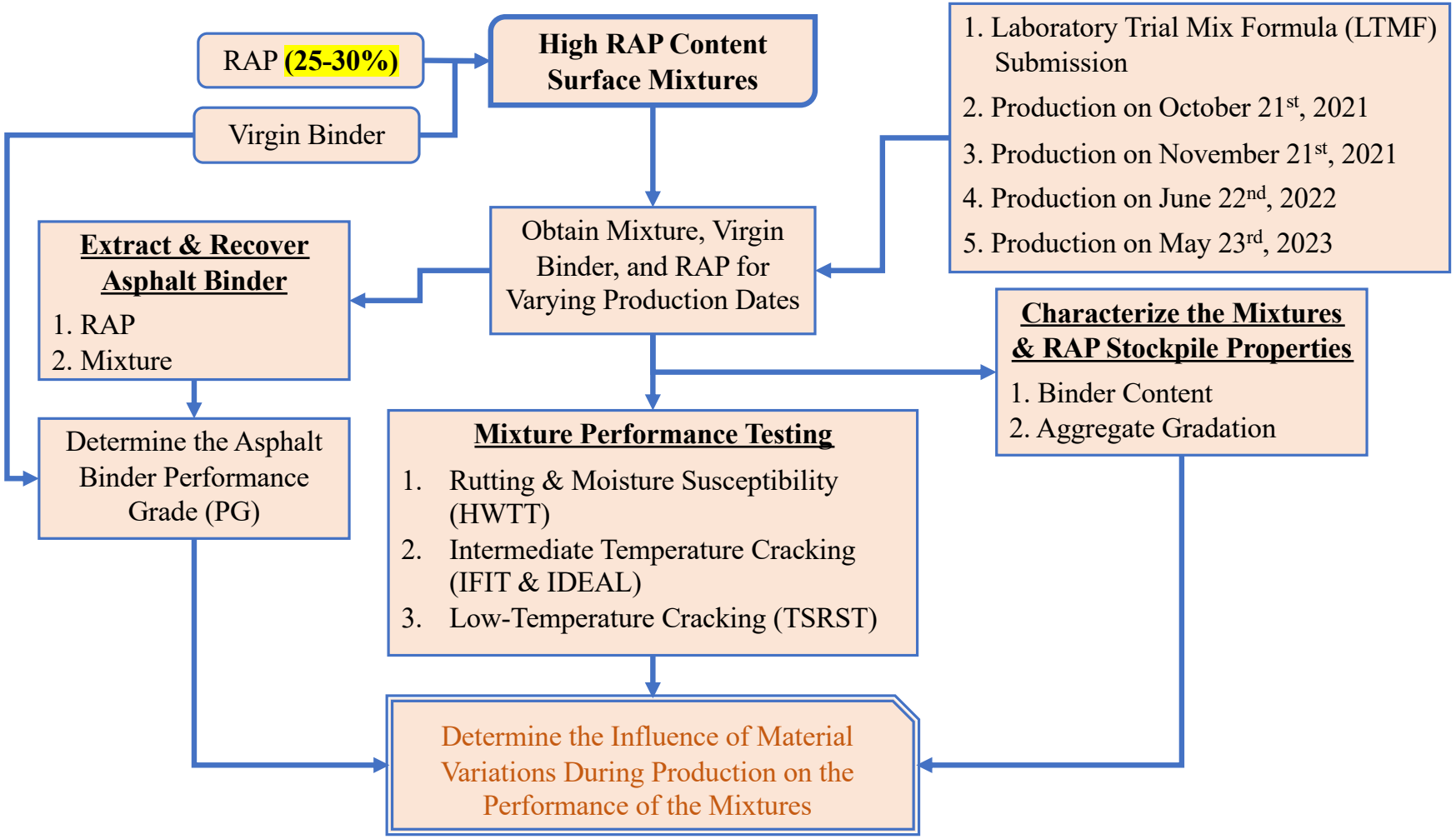
Objectives

1. Evaluate the variability of each high RAP content surface mixture, obtained on different production days, with respect to the properties of the virgin binder and RAP, and laboratory mixture performance (cracking and rutting).

2. Determine the effect of virgin binder and RAP properties on the laboratory performance of the mixtures.

3. Determine the influence of material variations during production on the performance of the mixtures.

Methodology - Experimental Plan



Results – Virgin Asphalt Binders

Virgin Asphalt Binders:

Asphalt Binder	Average Continuous Grade (°C)			Average MSCR Test Results at 64 °C		PG*	Average ΔT_C
	High	Intermediate	Low	$J_{nr\ 3.2}$, kPa^{-1}	$J_{nr\ diff}$, %		
VB for LTMF (Control)	71.8	10.2	-37.1	0.09	85.1	70-34 PG64E-34	+0.8
VB for 10/21	74.8	13.6	-33.3	0.12	68.6	70-28 PG64E-28	-0.3
VB for 11/21	69.9	9.0	-36.8	0.10	75.2	64-34 PG64E-34	+0.7
VB for 6/22	72.5	8.7	-37.0	0.08	88.6	70-34 PG64E-34	+0.3
VB for 5/23	68.4	9.1	-37.1	0.13	68.7	64-34 PG64E-34	+0.5

** MassDOT specification requires the final blended binder grade (RAP and virgin) after extraction and recovery to be a PG64E-28.*

Results – Extracted & Recovered RAP Binders

Extracted & Recovered RAP Binders:

Asphalt Binder	Average Continuous Grade (°C)			PG	Average ΔT_C
	High	Intermediate	Low		
LTMF RAP Binder (Control)	89.5	25.2	-21.4	PG88-16	-2.9
RAP for 10/21 Production	88.5	26.6	-20.3	PG88-16	-2.8
RAP for 11/21 Production	84.0	23.0	-23.4	PG82-22	-2.3
RAP for 6/22 Production	84.1	21.7	-25.5	PG82-22	-1.1
RAP for 5/23 Production	89.3	26.3	-20.2	PG88-16	-3.4

- The maximum difference among the continuous high-, intermediate-, and low-temperature grades during the production was 5.3°C, 5.0°C, 5.3°C, respectively.
- This highlights that properties of the RAP stockpile used in producing high RAP content mixtures should be verified during production to ensure that the approved mix design will be maintained.

Results – Extracted & Recovered Mixture Binders

Extracted & Recovered Mixture Asphalt Binders:

Asphalt Binder	Average Continuous PG Grade (°C)			Average MSCR Test Results at 64 °C		PG	Average ΔT_C
	High	Intermediate	Low	$J_{nr\ 3.2}$, kPa^{-1}	$J_{nr\ diff}$, %		
LTMF Mixture Binder (Control)	79.2	16.8	-30.0	0.2	33.7	76-28 PG64E-28	-1.1
Produced on 10/21	72.6	18.6	-28.2	0.9	44.0	70-28 PG64V-28	-1.0
Produced on 11/21	73.4	14.6	-30.6	0.5	47.4	70-28 PG64E-28	-2.2
Produced on 6/22	74.8	19.7	-25.5	0.8	17.6	70-22 PG64V-22	-2.4
Produced on 5/23	71.0	14	-32.9	0.8	58.8	70-28 PG64V-28	1.2

- Three of four production mixture binders did not meet the MassDOT specification criteria of a PG64E-28.
- The results showed a higher variability among the continuous intermediate- and low-temperature grades with a maximum difference of 5.8ºC and 7.4ºC, respectively.
- Most binders met the MassDOT low-temperature PG grade criterion (i.e., -28).

Results – RAP Binder Content & Aggregate Gradation

Mix ID	LTMF RAP (Control)	RAP for 10/21	RAP for 11/21	RAP for 6/22	RAP for 5/23	Standard Deviation	Suggested NCHRP 752 Standard Deviation Limits
Sieve Size	Percent Passing by Weight						
19 mm (3/4")	100	100	100	100	100	0	< 5.0
12.5 mm (3/4")	98.1	97.3	98.5	97.6	98.8	0.63	< 5.0
9.5 mm (3/4")	92.4	90.6	90.8	88.2	93.4	1.97	< 5.0
4.75 mm (No. 4)	69.7	71.9	63.5	61.2	73.7	**5.4 F**	< 5.0
2.36 mm (No. 8)	51.9	57.0	46.1	44.2	57.4	**6.05 F**	< 5.0
1.18 mm (No. 16)	39.0	44.0	33.8	32.7	44.1	**5.41 F**	< 5.0
0.6 mm (No. 30)	28.4	32.1	24.5	24.1	32.4	3.99	< 5.0
0.3 mm (No. 50)	18.8	21.7	16.7	17.1	21.8	2.46	< 5.0
0.15 mm (No. 100)	11.7	13.5	10.3	11.0	13.5	1.44	< 5.0
0.075 mm (No. 200)	7.5	8.7	6.5	7.1	8.5	0.93	< 1.5
Asphalt Content, %	4.88	5.37	5.15	5.00	5.46	0.24	< 0.5

Note: F= Standard deviation of measurements outside suggested NCHRP 752 limits

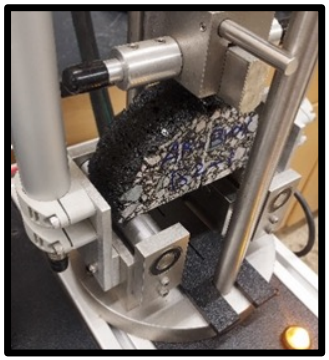
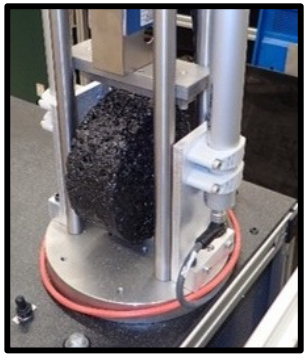
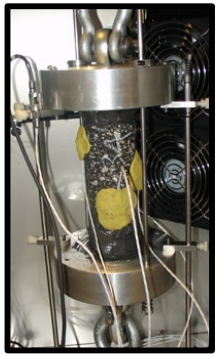
Results – Mixture Binder Content and Aggregate Gradation

Mix ID	LTMF Mixture	10/21 Mixture	11/21 Mixture	6/22 Mixture	5/23 Mixture	9.5 mm Superpave Specification	LL**	UL***
Sieve Size	Percent Passing by Weight							
19 mm (3/4")	100	100	100	100	100	100	100	100
12.5 mm (3/4")	100	**98.2 F**	**98.9 F**	**99.5 F**	**99.9 F**	100 min	100	100
9.5 mm (3/4")	94.0	92.6	93.3	95.2	96.4	90-100	90	100
4.75 mm (No. 4)	62.0	59.8	59.1	**68.2 F**	66	90 max	56	68
2.36 mm (No. 8)	40.0	39.7	39.1	**47.3 F**	43.1	32-67	35	45
1.18 mm (No. 16)	29.0	27.1	26.8	31.6	29	-	26	32
0.6 mm (No. 30)	20.0	18.4	18.5	21.2	19.5	-	17	23
0.3 mm (No. 50)	13.0	12.2	12.6	12.8	12.6	-	10	16
0.15 mm (No. 100)	8.0	7.6	8	7.6	7.4	-	6	10
0.075 mm (No. 200)	4.0	4.6	5.3	4.3	4.6	2-10	2.5	5.5
Asphalt Content, %	5.60	5.74	5.91	**6.1 F**	5.83	-	5.2	6.0

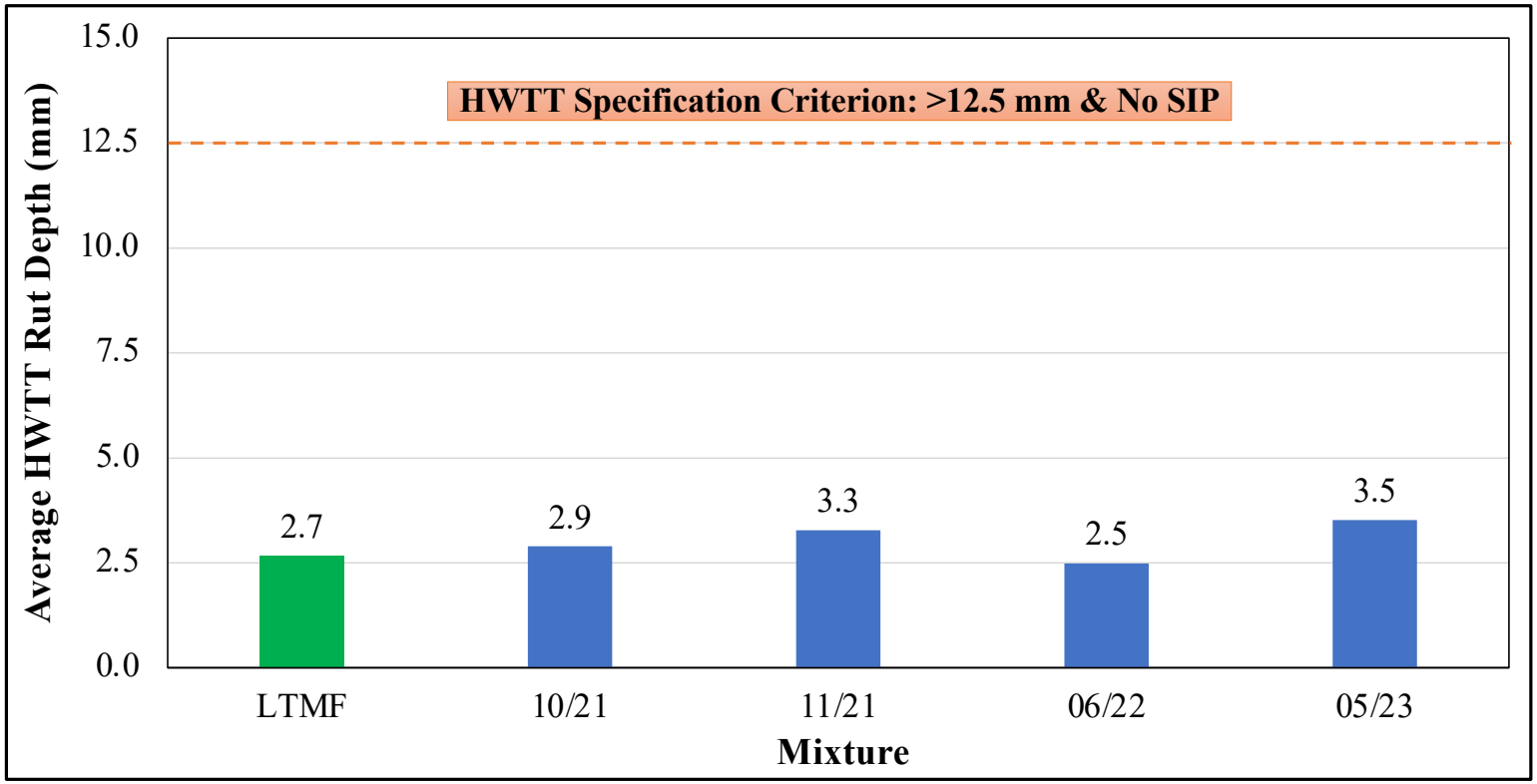
Note: F= Outside MassDOT acceptance limit

*** Lower limit*
**** Higher limits*

Mixture Performance Evaluation

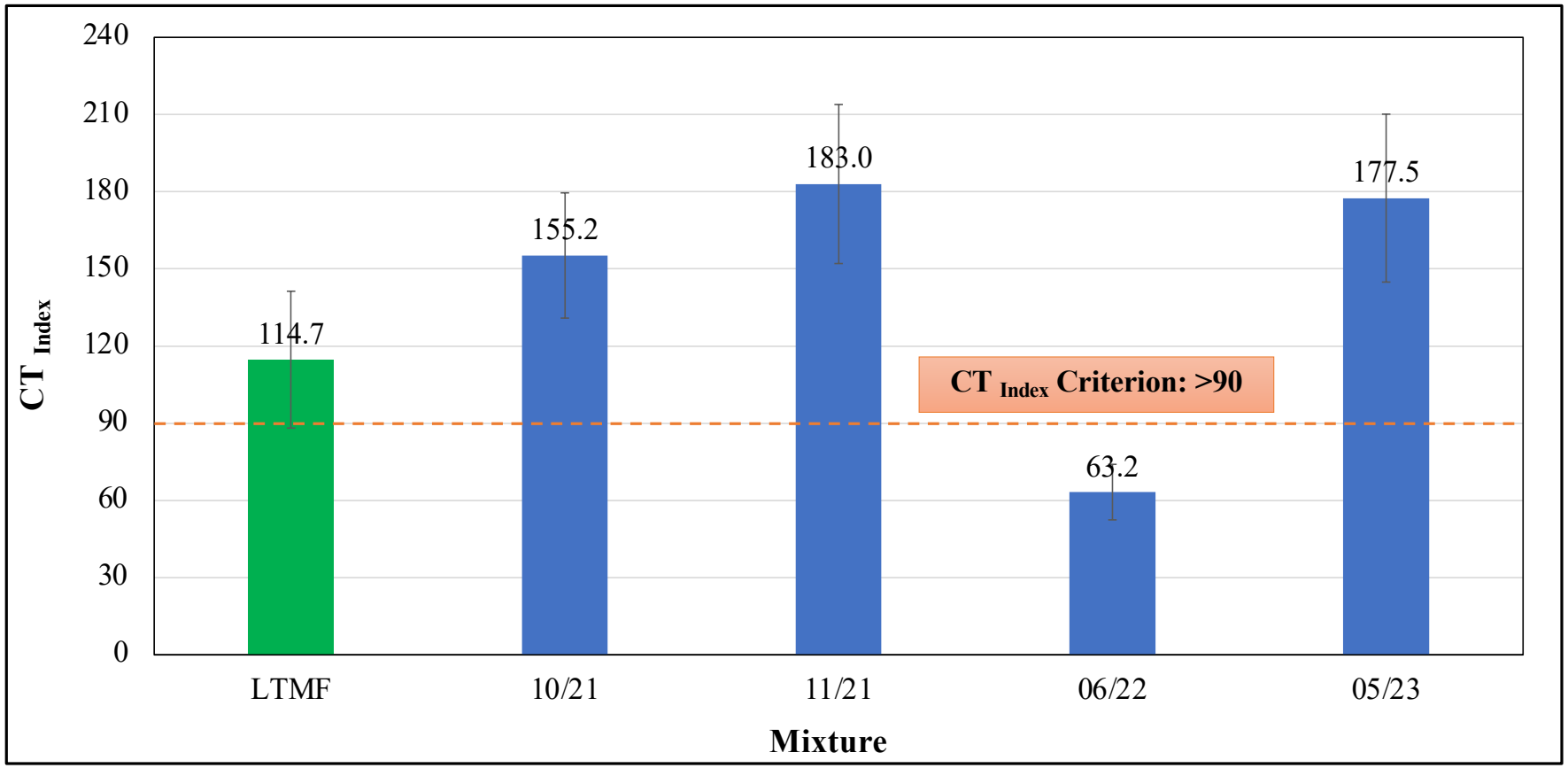
	Rutting & Moisture Susceptibility	Intermediate Temperature Cracking Tests		Low Temperature Cracking
Test	HWTT 	I-FIT 	IDEAL-CT 	TSRST 
Specification	AASHTO T 324	AASHTO T 393	ASTM D 8225	AASHTO TP 10-93
Test Temperature	45°C	25°C	25°C	n/a

Results – HWTT Rutting and Moisture Susceptibility

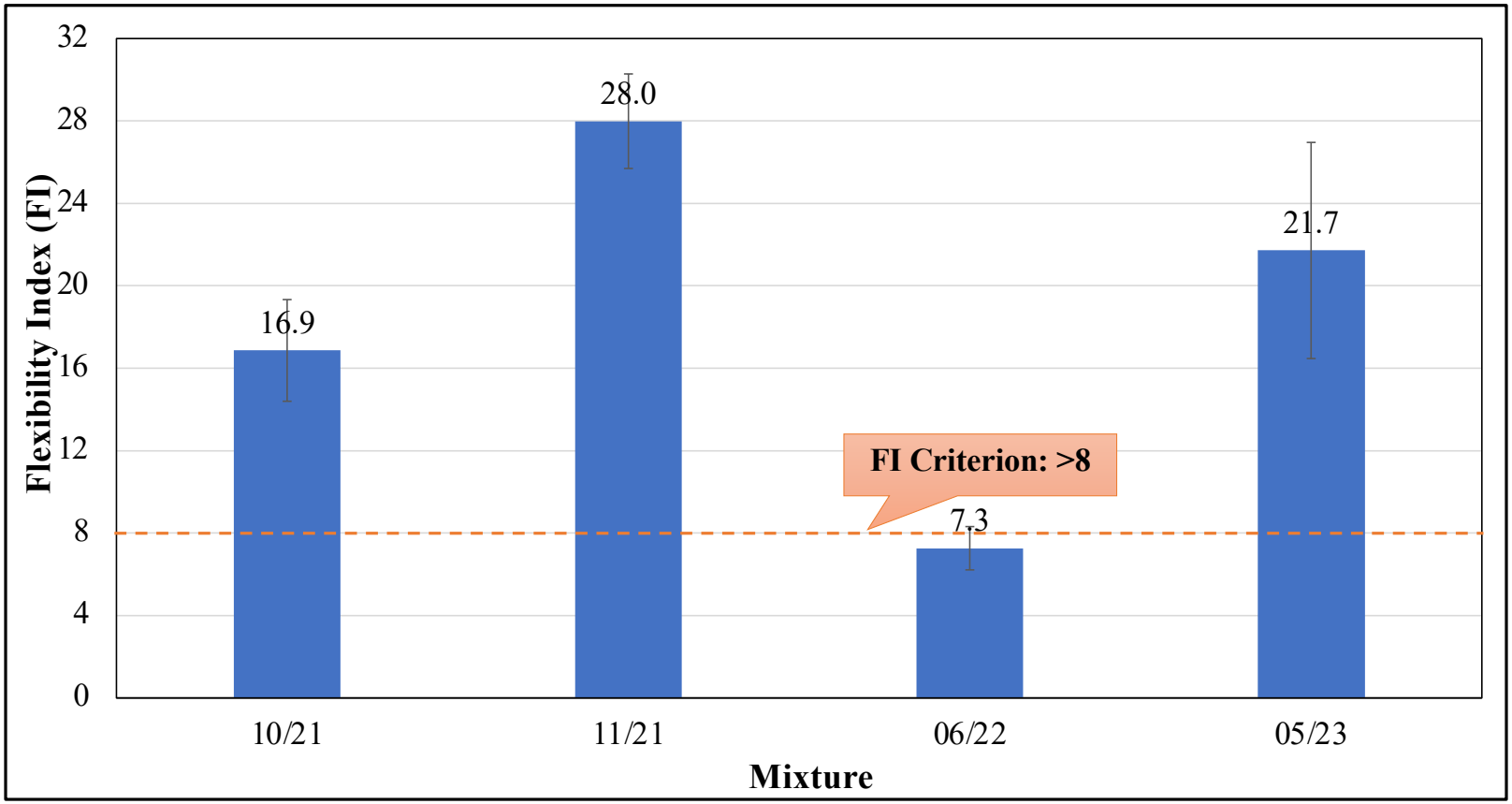


- All mixtures met the MassDOT specification criteria with all mixtures exhibiting very low rut depths and no stripping inflection point, which implies that rutting and moisture damage were not issues for these mixtures.

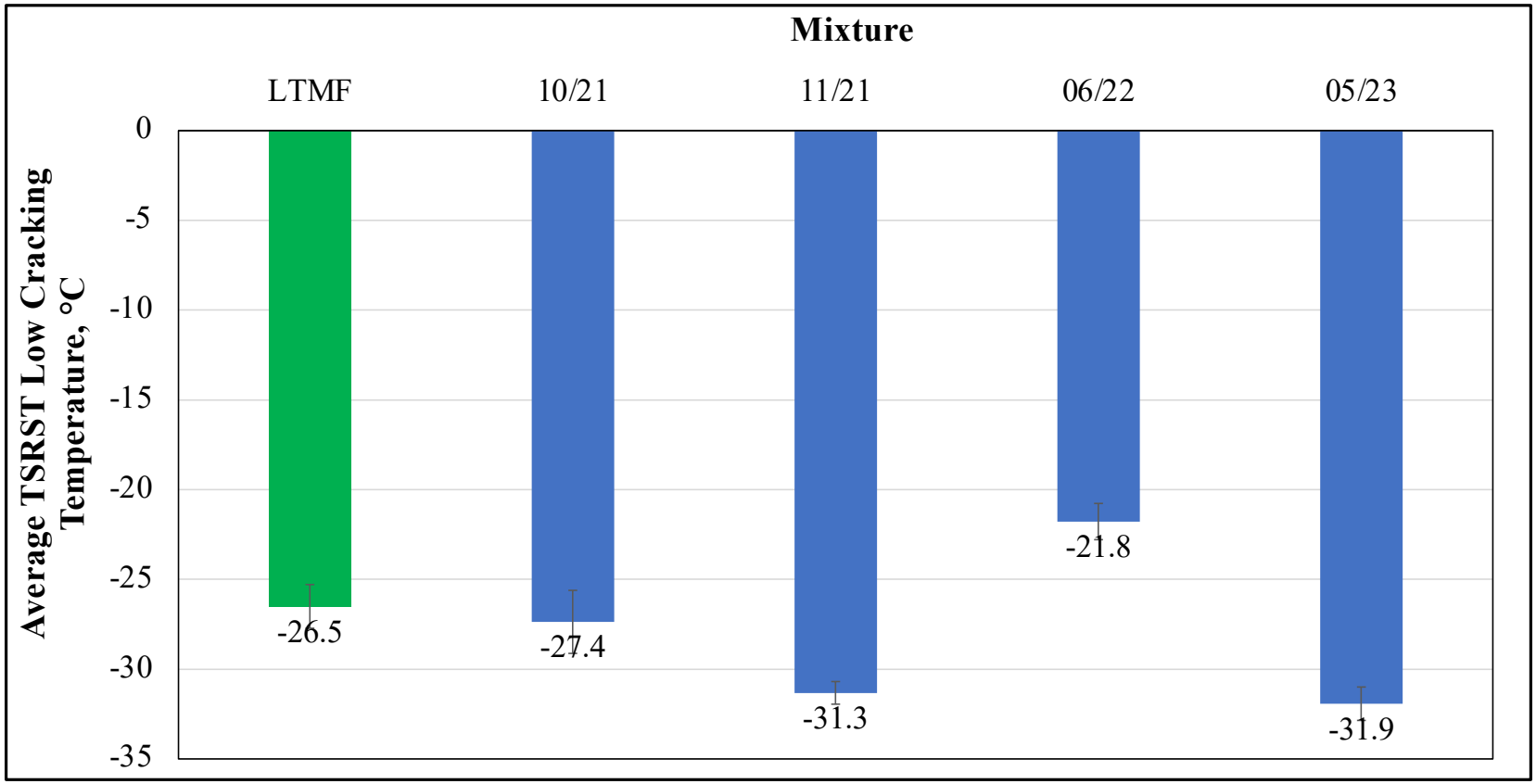
Results – IDEAL-CT Intermediate Temperature Cracking



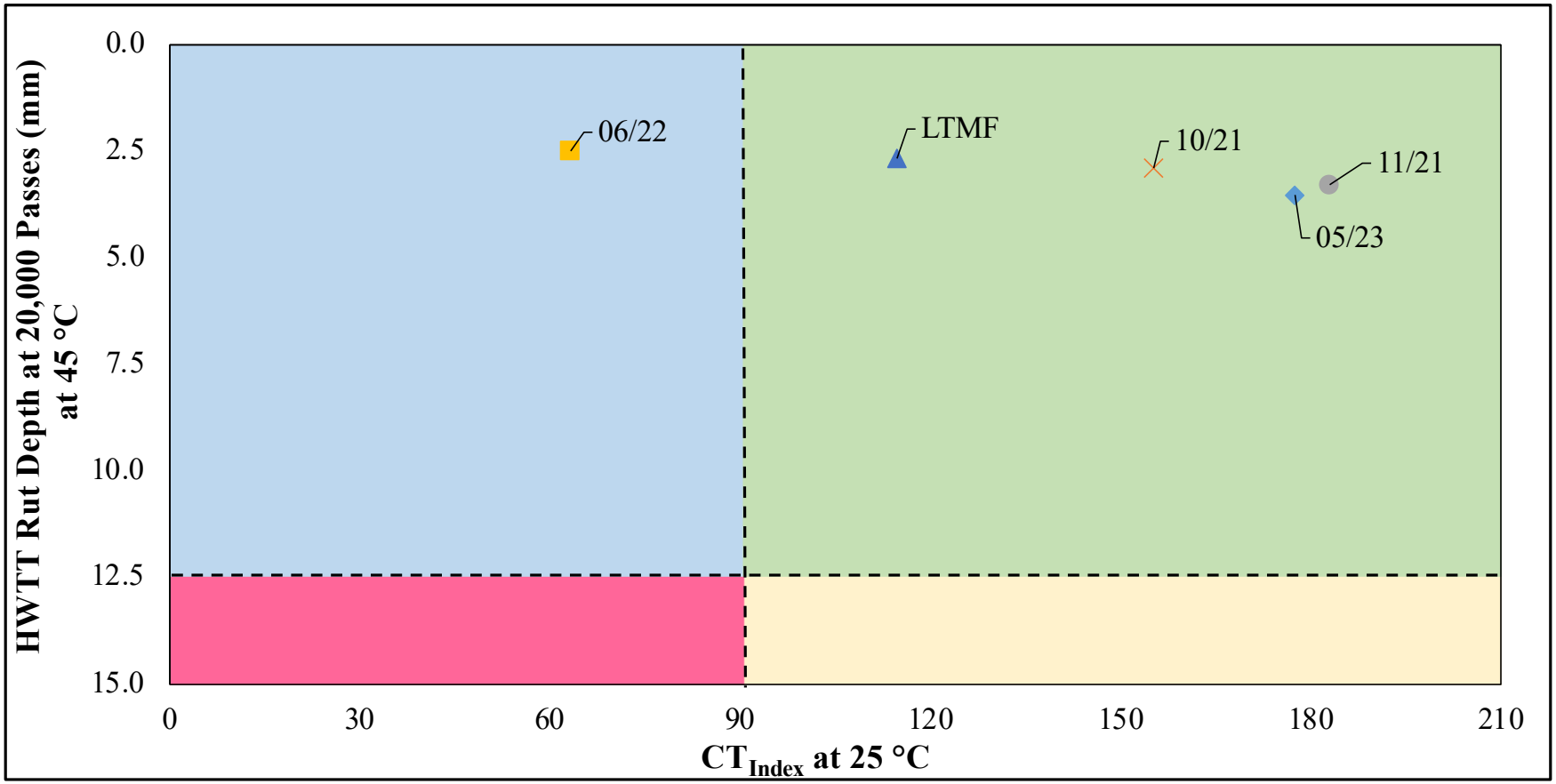
Results – IFIT Mixture Performance Evaluation



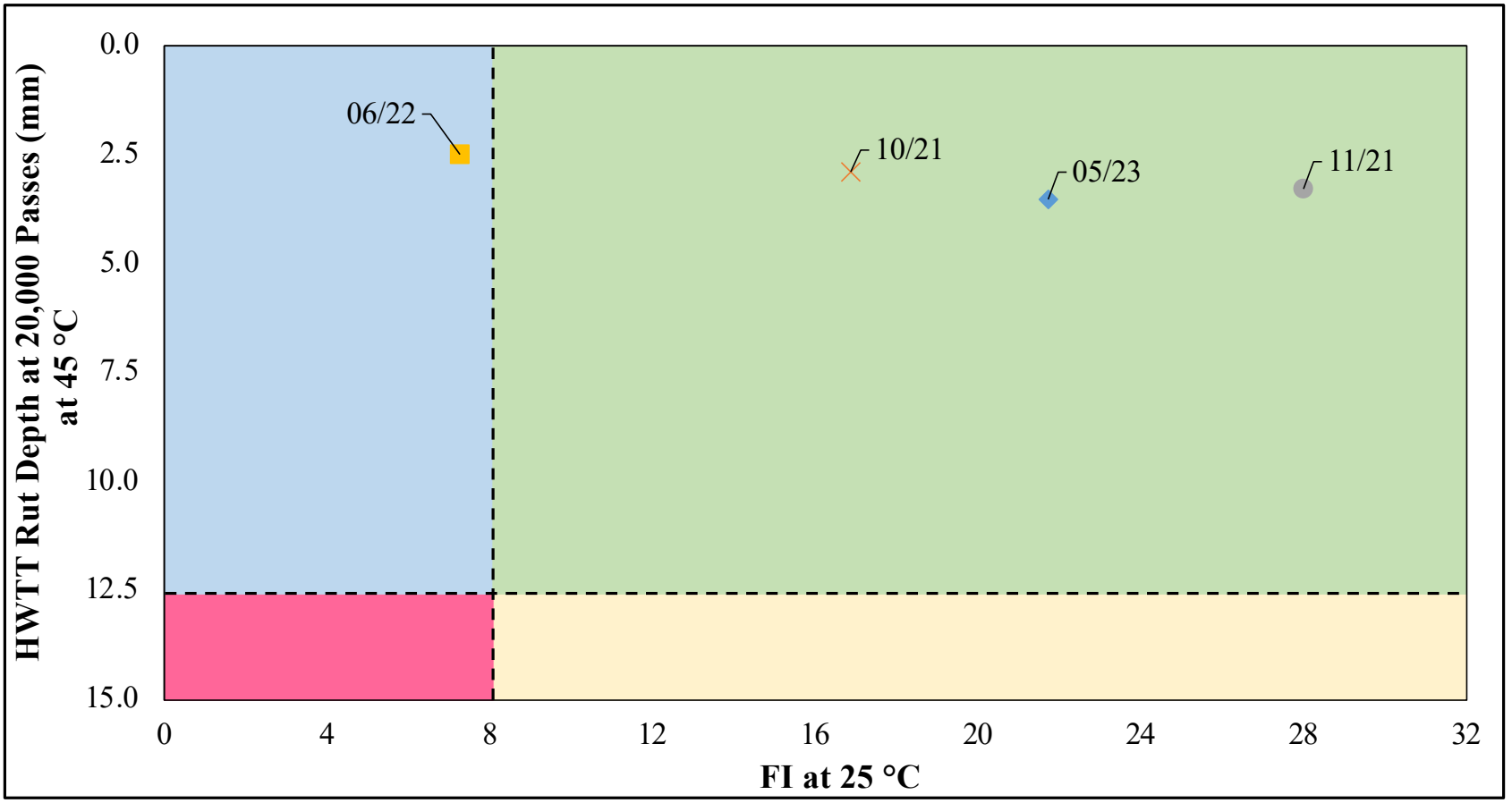
Results – TSRST Low Temperature Cracking



HWTT & CT_{Index} Mixture Performance Space Diagram



HWTT & FI Mixture Performance Space Diagram



Conclusions

- Three of four production mixture binders (extracted & and recovered from the mixture) did not meet the MassDOT specification criteria of a PG64E-28.

- Results indicated that RAP stockpile properties (binder grade) should be verified during production to ensure that the approved mix design will be maintained.

- Results indicated that rutting and moisture damage were not issues for these mixtures.

- Cracking performance test results showed the influence of material variations on performance with respect to when the mixture was produced. The material properties changed over time. This indicates the need for more comprehensive QC/QA testing for these mixtures to ensure that the approved mix design is maintained.

- Surface course mixtures with high RAP content (25-30%) can be produced and provide acceptable balanced performance in terms of rutting and cracking (intermediate and low temperature).


Thank You!