TRBAM-21-00780: Use of Blended Binder Tests to Estimate Performance of Mixtures with High RAP/RAS Content

Yuan Zhang • Daniel Swiertz • Hussain U. Bahia

MARC MODIFIED ASPHALT RESEARCH CENTER

THE UNIVERSITY of WISCONSIN MADISON

Study Objectives

- Help to close knowledge gaps relating to:
  - Selection and usage guidelines for recycling agents used in higher RAP/RAS mixtures following a "Balanced Mixture Design" framework;
  - Defining blended binder properties correlating to mixture performance;
  - Understanding the potential shortcomings of linear blending charts for higher RAP/RAS;
  - Understanding long term aging effects of recycling agents on mixture performance.

Methods & Materials

Design of Experiment

Factor	Description			
Mixture type	Virgin Mix	30% JMF RAP Mix	50% JMF RAP Mix	30% RAP+5% RAS JMF Mix
Base binder used	PG 58-28S			
Recycling agent type	NA	REOB; Bio-Oil#1; Bio-Oil#2		
Recycling agent dose	NA	REOB - 5.0%; Bio-Oils - 3.0%	REOB - 10.0%; Bio-Oils - 5.0% (As percentage of total binder blend)	
Aging condition	Short-Term Oven Aging (4 h at 135 ºC); Loose Mixture = "STOA" Long-Term Oven Aging (8 h at 135 ºC); Loose Mixture = "LTOA"			

Binder Blends* used for Mixture Production

Binder Sample		High Temp. Cont. Grade (ºC)	Low Temp. Cont. Grade (ºC)	ΔTc
Virgin Binder (PG 58-28)		59.7	-30.6	0.56
RAP Binder		84.8	-14.1	-8.3
RAS Binder		136.3***	17.6***	-42.5***
Blend for 30% RAP	No additive	67.9	***-27.9***	***-8.3***
	+5%REOB	64.4	-31.1	-0.44
	+3%Bio-Oil#1	62.3	-32.8	-2.81
	+3%Bio-Oil#2	62.2	-32.9	-0.07
Blend for 50% RAP	No additive	72.6	***-24.8***	0.99
	+10%REOB**	66.9	***-27.0***	-1.73
	+5%Bio-Oil#1	63.3	-34.6	***-9.16***
	+5%Bio-Oil#2	62.2	-33.9	-0.31
Blend for 30%RAP +5%RAS	No additive	81.0	***-22.7***	-0.16
	+10%REOB**	78.8	***-16.4***	***-5.01***
	+5%Bio-Oil#1	73.6	-30.0	***-18.86***
	+5%Bio-Oil#2	73.7	-29.7	-3.64

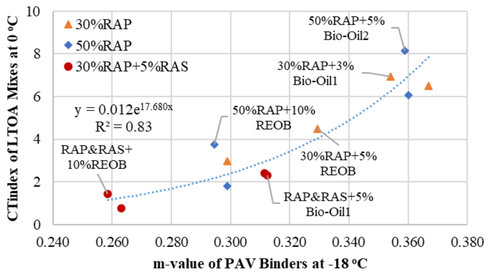
***Recycling agent dose selected to target the equivalent low temperature Continuous Grade of the virgin binder;*

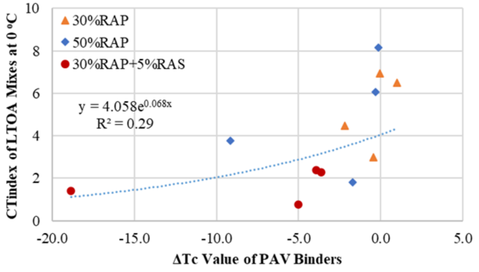
****Practical & cost limitations limited REOB to 10% of the binder blend*

*****PG continuous grade of RAS binder predicted using the blending charts from measured results of a 1:1 mix of RAS binder and virgin binder PG 58-28.*

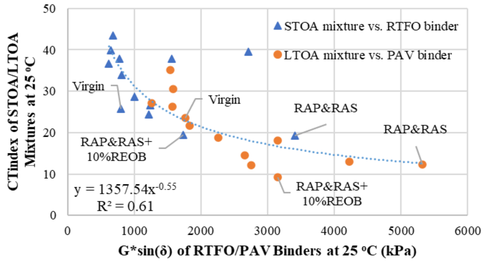
Correlations between Blended Binders and Mixtures

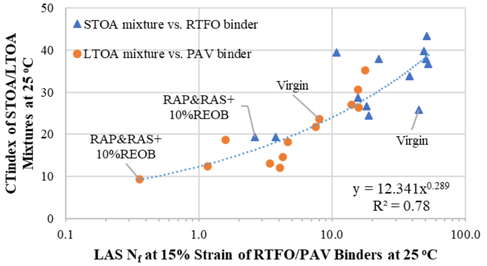
Low Temp. Cracking: CTindex at 0 °C vs. AC Properties at BBR Grade Temp.



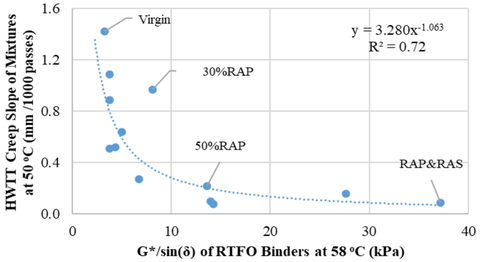


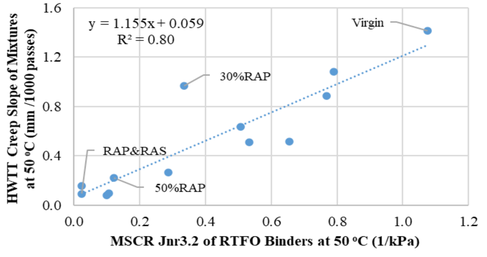
Intermediate Temp. Cracking: CTindex at 25 °C vs. AC Properties at 25 °C





Rutting Resistance: Hamburg Wheel Tracking at 50 °C vs. AC Properties at 50 °C





Main Findings

- The $m_{(60)}$ values are highly corelated with high RAP/RAS mixtures' cracking resistance; and the cracking resistance is "m-controlled";
- LAS Nf at 15% strain and intermediate grade temp. is an effective binder parameter to predict mixture CTindex;
- Blended Jnr3.2 is highly correlated with HWTT rutting performance measured; and Jnr3.2 is a better predictor than G*/sin(δ);
- Linear blending charts may produce significant errors with increasing binder replacement levels;
- Use of 5% RAS in conjunction with RAP should be avoided as recycling agents could not ensure good performance.

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