TRBAM-21-00301: The Role of Binders in Mixture Cracking Resistance Measured by IDEAL-CT Test

Hui Chen● Yuan Zhang● Hussain U. Bahia

MARC MODIFIED ASPHALT RESEARCH CENTER

THE UNIVERSITY of WISCONSIN MADISON

Objective

- Define the role of binders in the cracking resistance of asphalt mixtures at intermediate temperature (25 ºC) by correlating the binder's fatigue response measured by the Linear Amplitude Sweep (LAS, AASHTO TP101-14) and Binder Yield Energy Test (BYET, AASHTO TP123) with mixture's cracking resistance measured by the Indirect Tensile Asphalt Cracking Test (IDEAL-CT, ASTM D8225).

Materials

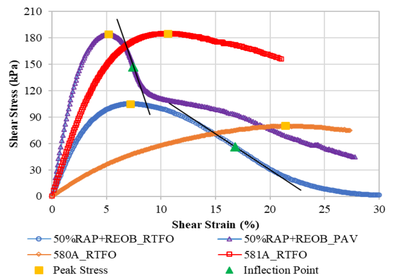
Mix Type	Lab-produced Mixtures (10)				Plant-produced Mixtures (5)				
	Virgin Mix	30% RAP	50% RAP	30%RAP+5%RAS	580A	581A	582A	585A	17-06
Mix Source	WI				CA	TX	WI	IA	WI
AC%	5.5				4.5	5.1	5.6	--	5.7
Virgin binder	PG 58S-28				PG 64V-28	PG 76E-22	PG 58H-34	PG 52H-34	PG 58S-28
RAP/RAS content, %	NA	30%JMF RAP	50%JMF RAP	30%JMF RAP+5%JMFRAS	15%JMF RAP	NA	12%JMF RAP	NA	15%JMF RAP+2%JMF RAS
Percent Replaced Binder	NA	27.00%	45.00%	47.50%	15.30%	NA	11.30%	NA	21.20%
Recycling agent dose	NA	5%REOB; 3%Bio-oils	10%REOB; 5%Bio-oils	10%REOB; 5%Bio-oils	NA	NA	NA	NA	NA

Methods

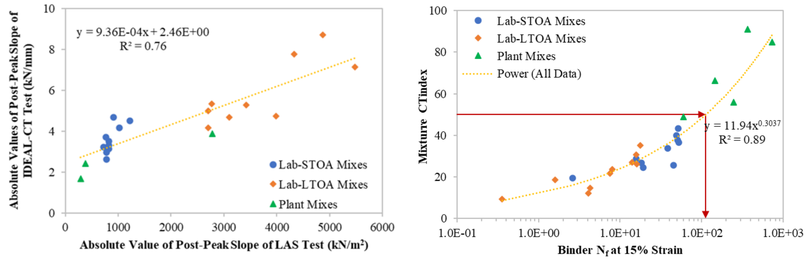
- ***LAS Testing and Data Analysis***
  - The test is to apply a frequency sweep following by a series of oscillatory load cycles at linearly increasing amplitudes (from 0.1% to 30%) at a constant frequency (10 Hz) to cause accelerated fatigue damage.
  - The damage at failure is defined as the damage accumulation that corresponds to a 35% reduction in undamaged value of $|G^*|\cdot\sin\delta$ from the 0.1% strain interval.
  - A three-degree polynomial function is employed to fit the LAS stress-strain curve in the post-peak stage for determining the inflection point and calculating the post-peak slope at that point.
- ***BYET Testing and Data Analysis***
  - The test is to apply constant strain rates of 2.315%/s or 11.575%/s to the DSR sample until the material achieves a strain of 4167% (30 minutes).
  - The slope at the inflection point in post-peak stage and failure energy up to the strain level of 2600% are calculated from the BYET stress-strain curve. A binder CTindex^b is obtained from the BYET tests.

Correlations between Blended Binder and Mixture Properties

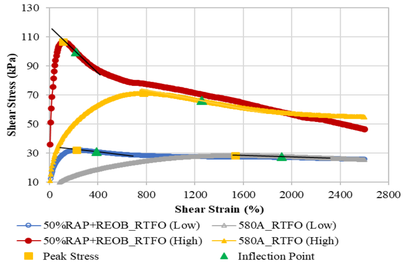
LAS Stress-Strain Curves



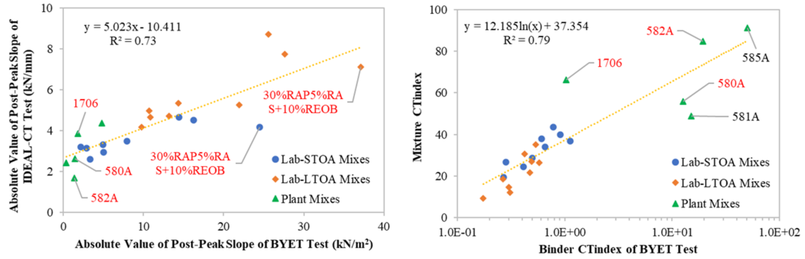
Binder LAS Results VS. Mixture IDEAL-CT Results



BYET Stress-Strain Curves



Binder BYET Results VS. Mixture IDEAL-CT Results



Main Findings

- Evaluating the post peak response of binders measured by the LAS and BYET tests is critical for understanding the role of binders in mixture cracking resistance response measured by the IDEAL-CT test.
- At the strain level of 15%, the LAS fatigue life (Nf @15%) of tested binders can be used to estimate the mixture CTindex with a strong coefficient of determination (R^2=0.89).
- The binder post-peak slope from LAS tests shows good correlation with the mixture post-peak slope measured by the IDEAL-CT tests. This correlation confirms the crack propagation mechanism as the cause of post-peak slope.
- The BYET offers a more direct and simpler method to estimate the mixture CTindex. A logarithmic model is provided for predicting the mixture CTindex from the binder CTindex^b measured by the BYET.