Implementation of Semi-Circular Bending Test

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Southeastern Asphalt User Producer Group
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Acknowledgements

- LTRC Asphalt Research Group
  - Jeremy Icenogle, Patrick Frazier, Willie Gueho, Md. Kabir, Bill King
- DOTD Materials Lab
- Participating Contractors

Introduction

- LADOTD's current QA/QC practice relies upon:
  - Gradation
  - AC Content
  - VFA, VMA, % Air Voids
  - Moisture Susceptibility Test (Modified Lottman), and
  - Roadway Parameters: Density, Smoothness
- But these volumetric properties alone are not adequate to reflect the pavement performance in the field.
- Must develop methods to evaluate pavement performance indicators

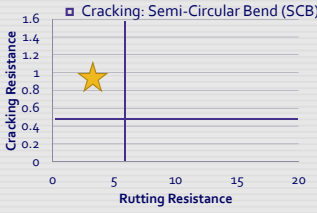
Introduction

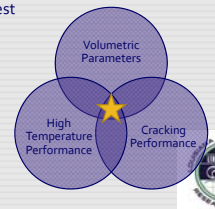
- **In addition** to current volumetric criteria
- Laboratory testing is required to evaluate the as-built pavement qualities.
- These tests will screen materials prone to rutting, cracking and alternative moisture damage indicators.

- Create a **Balanced Mixture Design**

Introduction

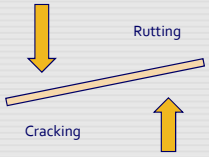
- What is a balanced mixture design?
  - Process to ensure adequate resistance to rutting and cracking distress
- Two laboratory tests are proposed:
  - Rutting: Loaded Wheel Tracking (LWT) Test
  - Cracking: Semi-Circular Bend (SCB) Test





Introduction

- Loaded Wheel Tracking (LWT) test as a measure of mixture rutting resistance.
- Semi-Circular Bend (SCB) tests for intermediate temperature cracking resistance.



LWT Specification

Nominal Max., Size Agg.	0.5 inch (12.5 mm)			0.75 inch (19 mm)			1.0 inch (25 mm)					1.5 inch (37.5 mm)	SMA
Type of Mix	Incidental Paving[3]	Wearing Course		Wearing Course	Binder Course		Binder Course		Base Course	ATB[3]		Base Course	Wearing
Level[3]	A	1	2	2	1	2	1	2	1	1		1	2
Asphalt Binder	Table 502-2, (3% minimum for Asphalt Treated base (ATB), 6% min for SMA)												
Friction Rating[3]	Table 502-3												
RAP, Max. % of Mix[4]	20	15	15	15	20	20	20	20	30	30		30	0
	Compacted Mix Volumetrics [4]												
VMA, Min. %[5]	13.0	13.0	13.0	12.0	12.0	12.0	11.0	11.0	11.0	n/a		10.5	16.0
Air Voids, %[4]	(2.5-4.5);; (no limit for ATB)												
VFA, %[4]	(69-80); no limit for ATB												
$N_{initial}$ 90% max.[7] (Gyrations)	7	7	7	7	7	7	7	7	7	n/a		7	7
N_{design} 96.5±1 % (Gyrations)	65	65	75	75	65	75	65	75	65	30		65	65
N_{max} 98 % max. (Gyrations)	100	100	115	115	100	115	100	115	100	n/a		100	100
LWT, max. rut-design, mm @ # passes, @ 50°C	10 @ 10,000	10 @ 20,000	6 @ 20,000	6 @ 20,000	10 @ 20,000	6 @ 20,000	10 @ 20,000	6 @ 20,000	12 @ 20,000	10 @10,000		12 @ 20,000	6 @ 20,000
Dust/Effective Asphalt Ratio, %	0.6 – 1.6												
Lift Thickness, inch (mm)	2.0- (50-)	1.5–2.0 (38-50)		1.5–2.0 (38-50)	2.0–3.0 (50-75)		2.5–4.0 (65-100)		2.5+ (65+)	3.0+ (75+)	4.0+ (100+)		1.5-2.0 (38-50)

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LWT, max. rut-design, mm @ # passes, @ 50°C	10 @ 10,000	10 @ 20,000	6 @ 20,000	6 @ 20,000	10 @ 20,000	6 @ 20,000	10 @ 20,000	6 @ 20,000	12 @ 20,000	10 @10,000		12 @ 20,000	6 @ 20,000
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Lift Thickness, inch (mm)	2.0- (50-)	1.5–2.0 (38-50)		1.5–2.0 (38-50)	2.0–3.0 (50-75)		2.5–4.0 (65-100)		2.5+ (65+)	3.0+ (75+)	4.0+ (100+)		1.5-2.0 (38-50)

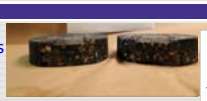
Laboratory Experiment: LWT Test

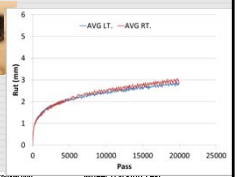
- Performance Indicator
  Resistance to Rutting and Moisture Sensitivity
- Test Protocol
  AASHTO T324
- Temperature
  50°C
- Loading

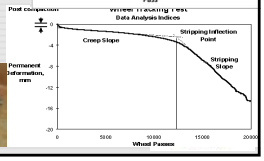
Wheel Diameter: 203.5 mm (8 inch)
Wheel Width: 47mm (1.85 inch)
Fixed Load: 703 N (158 lbs)
Rolling Speed: 1.1 km/hr
Passing Rate: 52 passes/min

Laboratory Experiment: LWT Test

- Performance Indicators
  Resistance to Rutting and Moisture Sensitivity
- Rutting Indicator:
  - Plot Rut Depth vs Number of Passes
  - Report Rut Depth at
    - 1000, 5000, 7500, 10000, 15000, and 20000 Passes
- Moisture Sensitivity Indicator
  - Determine Stripping Inflection Point
    - The point where slope of the line begins to steepen

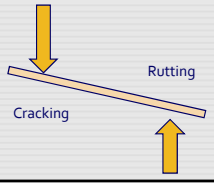






Balanced Specifications?

- Loaded Wheel Tracking (LWT) test as a measure of mixture rutting resistance.
- Semi-Circular Bend (SCB) tests for intermediate temperature cracking resistance.



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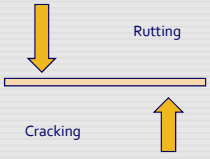
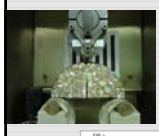
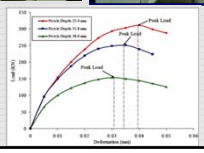


Semi Circular Bend Test

- Developed
- Circulated





Standard Method of Test for

Evaluation of Hot-Mix Asphalt (HMA) Crack Propagation using the Semi-Circular Bend Test (SCB)

AASHTO Designation X XXX-XX

LSU

1. SCOPE

1.1. This test method covers procedures for the preparation, testing, and measurement of fracture failure of semi-circular HMA mixture specimens loaded monotonically.

1.2. This standard may involve hazardous material, operations, and equipment. This standard does not purport to address all safety problems associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

2. REFERENCED DOCUMENTS

2.1. AASHTO STANDARDS

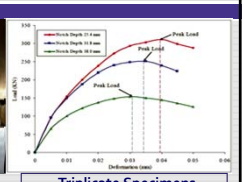
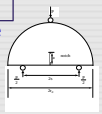
- PP 2, Practice for Mixture conditioning of Hot Mix Asphalt (HMA)
- TP 4, Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the SHRP Gyratory Compactor
- T 67, Standard Practices for Load Verification of Testing Machines
- T 166, Bulk Specific Gravity of Compacted Hot Mix Asphalt Using Saturated Surface-Dry Specimens
- T 168, Sampling Bituminous Paving Mixtures
- T 209, Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt (HMA)
- T 269, Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
- T 312, Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor

SCB Test

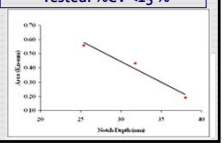
- Performance Indicator
  Resistance to Crack Propagation
- Test Protocol
  Mohammad et al. [2004]
- Temperature
  25°C
- Loading
  0.5 mm/min vertical deformation
- The Critical Value of Fracture Resistance,

$$J_c = -\left(\frac{1}{b}\right)\frac{dU}{da}$$

b = sample thickness,
a = notch depth,
U = strain energy to failure

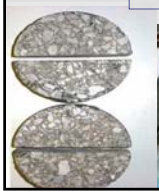
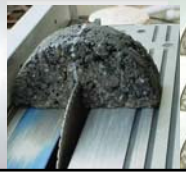

Triplicate Specimens
Tested: %CV <15 %



SCB Sample Preparation

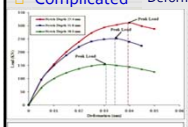
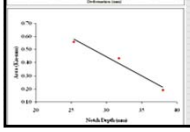
150mm x 57mm



Conventional SCB Test

- Servo Hydraulic Test System
- Environmental Chamber
- Expensive
- Complicated

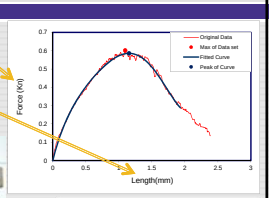
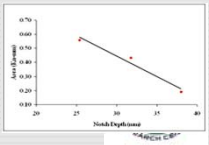



Deformation

Load

Modified SCB Test



Load

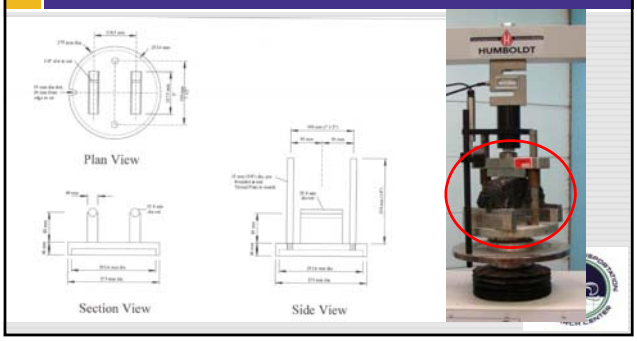
Deformation

Force (Kn)

Length(mm)

$$J_c = -\left(\frac{1}{b}\right)\frac{dU}{da}$$

Modified SCB Test

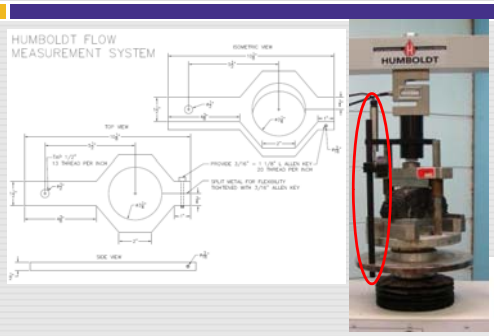


Plan View

Section View

Side View

Modified SCB Test



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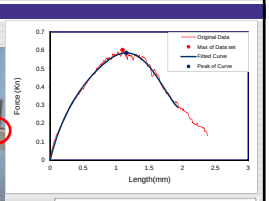
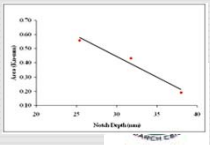


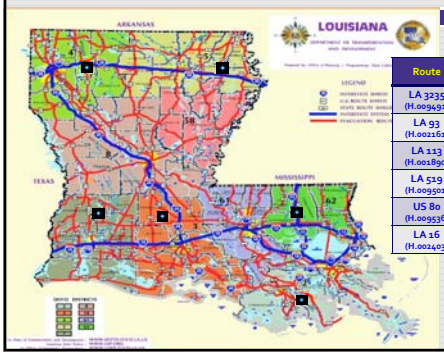
$$J_c = -\left(\frac{1}{b}\right)\frac{dU}{da}$$

*Temperature is controlled using an external environmental chamber



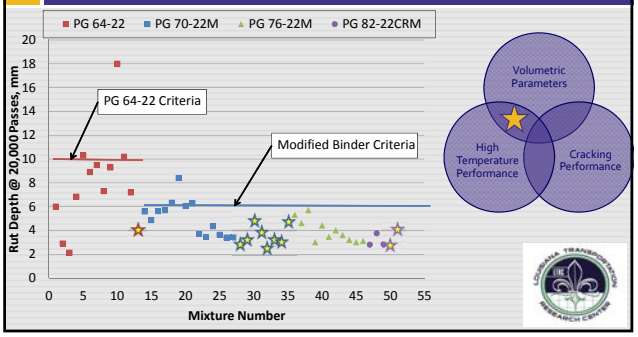
Test Equipment

2013 Pilot Project Descriptions

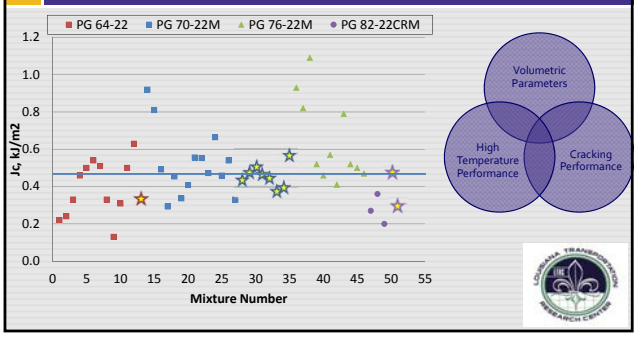


Route	DOTD Dist.	Description
LA 3235 (H.009492)	02	2" Lvl 1 BC 1.5" Lvl 1F WC
LA 93 (H.002161)	03	3" Lvl 1 BC 2" Lvl 1 WC
LA 123 (H.001890)	07	2" Lvl 1 BC 2" Lvl 1 WC
LA 519 (H.009501)	04	2" Lvl 1 WC
US 80 (H.009536)	05	2.5" Lvl 1 BC 2" Lvl 1 WC
LA 16 (H.002403)	62	2" Lvl 2 BC 1.5" Lvl 2 FWC

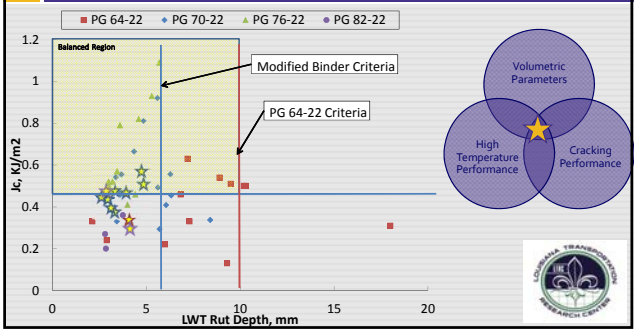
Analysis: Loaded Wheel Tester



Analysis: Semi-Circular Bend

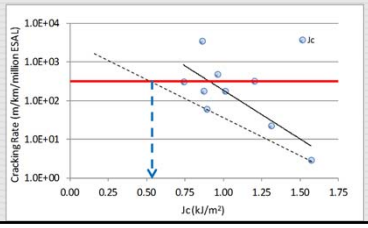


Analysis: Balanced Design



What's Next?

- Completion of Pilot Project Evaluation – Evaluation of Field Cores
- Continued evaluation of the SCB test
- Validate Jc criteria for mixture design
  - Communicate with other on-going research projects: 10-4B



What's Next?

Tests for Fatigue Cracking

Test	Std. Method	Field Verified	Eqmt. Cost	Time to Result	Best Buy
BBF	●	○	◒	●	
SVECD	○	●	◒	◒	
Overlay Tester	○	○	◒	●	
SCB	◒	●	◒	●	
Energy Ratio	◒	◒	●	◒	
Fracture Energy	◒	◒	◒	◒	

What's Next?

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Thank You!