LADOTD Balanced Mixture Design

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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
- EMCRF
  - Dr. Louay Mohammad , Dr. Minkyum Kim

Introduction

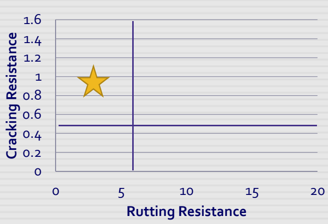
- LADOTD's conventional design practice:
  - Gradation
  - AC Content
  - VFA, VMA, % Air Voids
  - Moisture Susceptibility Test (Modified Lottman), and
  - Roadway Parameters: Density, Smoothness
- Increases in recycled material content
- Methods to evaluate mixture performance indicators
  - Determine Asphalt Quality vs Quantity

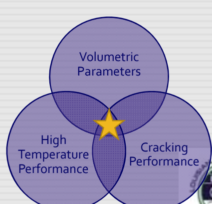
How?

- New laboratory tests to evaluate the as-built pavement qualities.
- The test will screen materials prone to rutting, cracking and alternative moisture damage indicators.
  - Create a **Balanced Mixture Design**

How?

- What is a balanced mixture design?
  - Process to ensure adequate resistance to both rutting and cracking distresses
- Laboratory testing:
  - Rutting and Cracking





How?

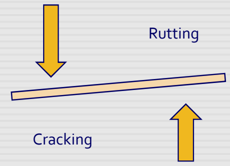
- Mechanistic Tests
  - Pavement Performance
- Intermediate Temperature
  - Fatigue endurance
- High Temperature
  - Permanent deformation
- Features
  - Fundamental
  - Easy to Use
  - Reliable
  - Cost

Major Issue

- Current LADOTD volumetric specifications created stiff mixtures very strong vs rutting failure.
- Concerns that the mixtures are too dry and too stiff.
  - Early cracking and durability
- Two research projects to create new specification parameters
  - LTRC Project 11-3b
  - LTRC Project 10-4b

LTRC Research Project 11-3b

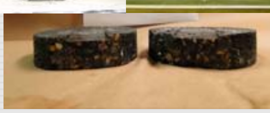
- To implement the Loaded Wheel Tracking (LWT) test as a measure of mixture rutting resistance.
- To evaluate Semi-Circular Bend (SCB) test for intermediate temperature cracking resistance.



Rutting Resistance: LWT Test

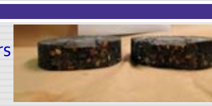
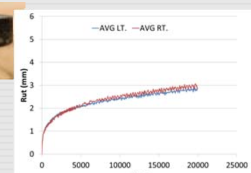
- Performance Indicator
  Resistance to Rutting and Moisture Sensitivity
- Test Protocol
  AASHTO T324
- Temperature
  50°C
- Loading

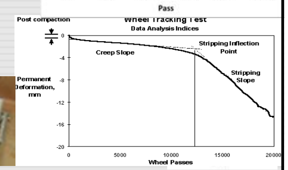

Wheel Diameter: 203.5 mm (8 inch)
Wheel Width: 47mm (1.85 inch)
Fixed Load: 703 N (158 lbs)
Rolling Speed: 1.1 km/hr
Passing Rate: 52 passes/min



Rutting Resistance: 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



Cracking Test?

- Several options available!
  - Bending Beam Fatigue, SVECD, Overlay Tester, Intermediate Temperature SCB, Energy Ratio, Fracture Energy (ITS)
- Which one is best?
  - Each has advantages and disadvantages
- LADOTD selected Intermediate Temperature SCB
  - LADOTD TR 330

Why SCB?

- Gyratory and field core
- Simplicity of testing equipment
  - can be adapted to plant lab
- History of forensic success and field correlation
- Fundamental fracture mechanics principles
- Test procedure
- Repeatable
  - Reporting COV of fracture energy less than 15%

Intermediate Temperature Cracking: SCB Test

- Performance Indicator
  Resistance to Crack Propagation
- Test Protocol
  TR 330
- 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

Standard Method of Test for

Evaluation of Asphalt Mixture Crack Propagation using the Semi-Circular Bend Test (SCB)

AASHTO Designation X XXX-XX

1. SCOPE

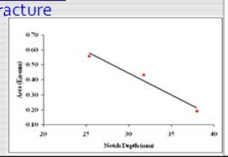
1.1. This test method covers procedures for the preparation, testing, and measurement of fracture failure of semi-circular asphalt mixtures of specimens loaded monotonically.

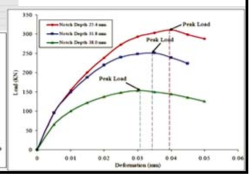
1.2. This standard may involve hazardous material, operations, and equipment. This standard does not purport to address all safety problems associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and to determine the applicability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

2. REFERENCED DOCUMENTS

2.1. AASHTO STANDARDS

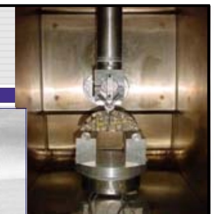
- PP 2, Practice for Mixture conditioning of Hot Mix Asphalt (HMA)
- T 67, Standard Practices for Load Verification of Testing Machines
- T 166, Bulk Specific Gravity of Compacted Hot Mix Asphalt Using Saturated Surface-Dry Specimens
- T 168, Sampling Bituminous Paving Mixtures
- T 209, Theoretical Maximum 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





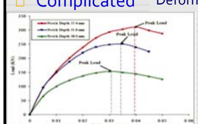
SCB Sample Preparation

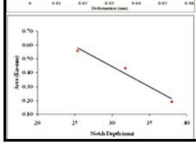
150mm x 57mm



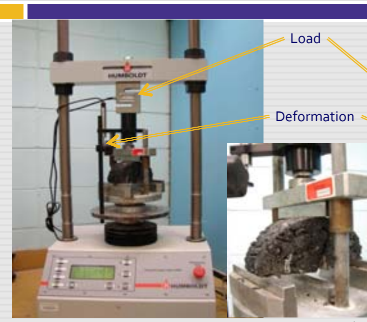
Conventional SCB Test

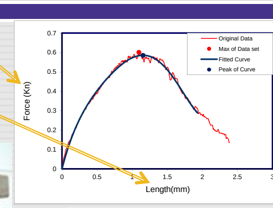
- Servo Hydraulic Test System
- Environmental Chamber
- Expensive
- Complicated

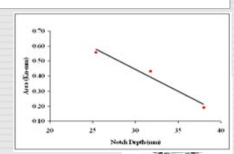




Modified SCB Test

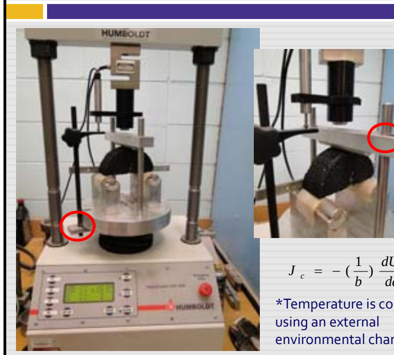


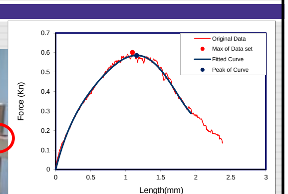




$$J_c = -\left(\frac{1}{b}\right)\frac{dU}{da}$$

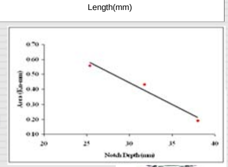
Modified SCB Test





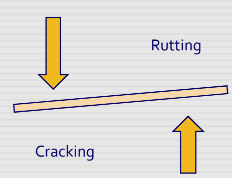
$$J_c = -\left(\frac{1}{b}\right)\frac{dU}{da}$$

*Temperature is controlled using an external environmental chamber

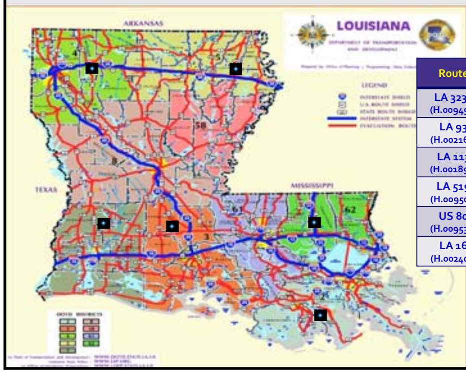


LADOTD Specification Changes

- Lowered Gyrations (Level 1 and Level 2)
  - L1: 65 Gyrations N_d
  - L2: 75 Gyrations N_d
- VTM Remains
  - 3.5%
- Raised design VFA
  - 72%
- Raised VMA
  - 0.5% Increase for each NMAS

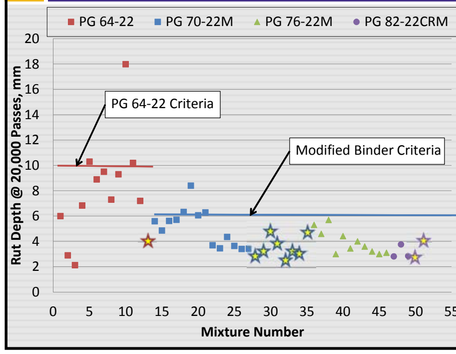


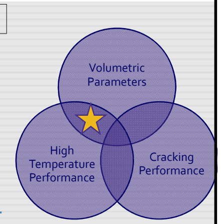
2013 Pilot Project Descriptions



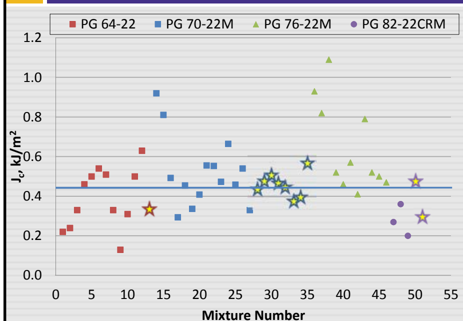
Route	DOTD Dist.	Description
LA 3235 (H.009491)	02	2" Lvl 1 BC 1.5" Lvl 1F WC
LA 93 (H.002161)	03	3" Lvl 1 BC 2" Lvl 1 WC
LA 113 (H.001890)	07	2" Lvl 1 BC 2" Lvl 1 WC
LA 519 (H.009501)	04	2" Lvl 1 WC
US 80 (H.009536)	05	2.5" Lvl 1 BC 2" Lvl 1 WC
LA 16 (H.002403)	62	2" Lvl 2 BC 1.5" Lvl 2 FWC

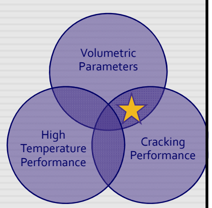
Analysis: Loaded Wheel Tester



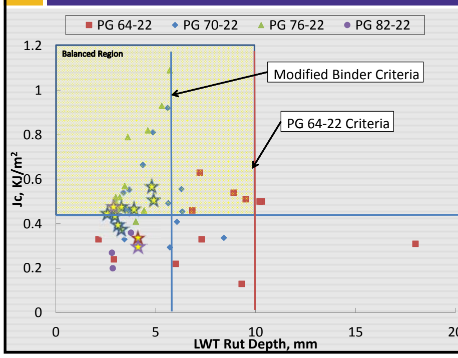


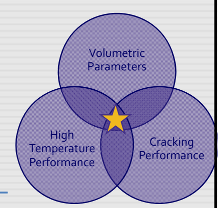
Analysis: Semi-Circular Bend





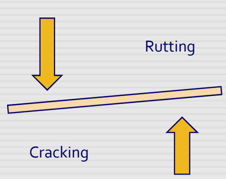
Analysis: Balanced Design





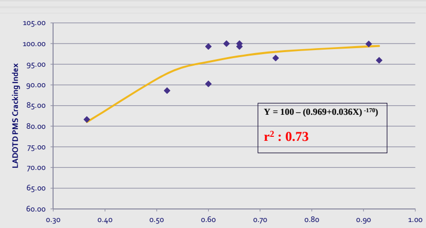
LTRC Research Project 10-4b

- Development of performance-based specification criteria.

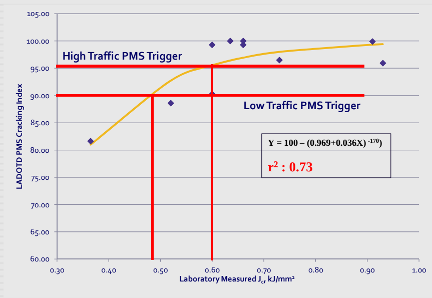


Field Validation: LTRC Project 10-4B

- Laboratory and Field evaluation of 10 projects
  - Projects in service for 3 – 10 years.
  - Does SCB parameter translate to field performance?



Field Validation: LTRC Project 10-4B



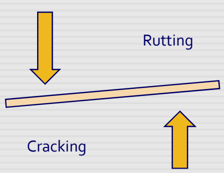
Field Validation: LTRC Project 10-4B


Table 502-7
Asphalt Concrete General Criteria

LWT, Rut Depth, 50°C, Wet	Level 1 : 10mm @ 20,000 passes maximum, Level 2 : 6mm @ 20,000 passes maximum.
SCB, min, J_c, kJ/m^2 @ 25^0 C, Aged	Level 1 : Jc = 0.5 minimum , Level 2 : Jc = 0.6 minimum.

LADOTD Specification Changes

- LWT required for all mixtures
  - L1: 10mm @20K passes (maximum)
  - L2: 6mm @ 20K passes (maximum)
- SCB required for all mixtures
  - L1: PG 70-22m, 0.5 kJ/m² (minimum)
  - L2: PG 76-22m, 0.6 kJ/m² (minimum)
- Allow for 5% increase in RAP if "fractionated" -split on the 1". (still must meet LWT and SCB for design)



LADOTD Experience

- Developed a system to conduct mechanical property test to determine the anticipated performance of asphalt mixtures
  - LWT and SCB were the most feasible for implementation by state and contractor.
- Incorporate tests into state specification compliance evaluation.
- Develop a plant lab SCB test protocal.
  - Utilize Marshall Load Frames.
- Contractors in the state have adopted the methodology and are currently evaluating mixtures with success.
  - Reporting low variability of fracture energy
    - <15%
  - Specimen fabrication is a complication
  - Long Term aging protocol – 5 day @ 85°C is a concern.

What's Next?

- New round of pilot project to further evaluate plant produced mixture and field cores
- Continue collecting a database of mixture LWT and J_c results and compare to field performance.

Thank You!