Balanced Asphalt Mixture Design: Louisiana's Approach

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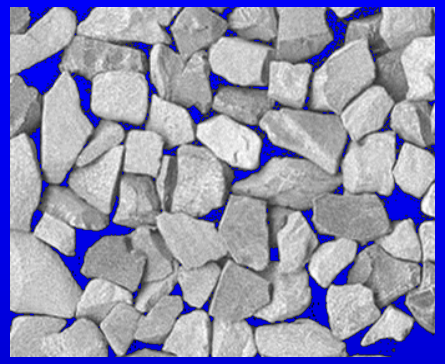
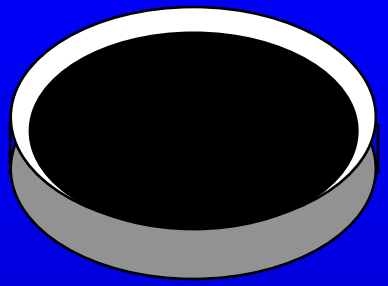
My Story

- Asphalt Mixture Design
- Review performance Tests
  - High Temperature
  - Intermediate Temperature
- Mixture Design
  - Volumetric
  - Mechanistic
- Summary
- Recommendation

Materials Used In Asphalt Mixture

- Asphalt cement
- Aggregate
  - Coarse
  - Fine
- Increased use of Reclaimed Materials
  - RAP
  - CRM
  - Industrial waste

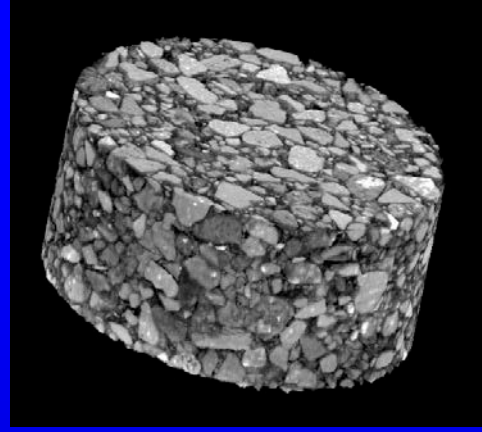




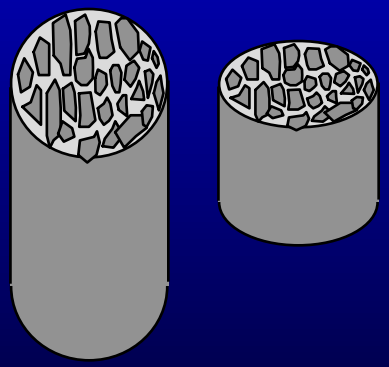
Objectives of Mixture Design

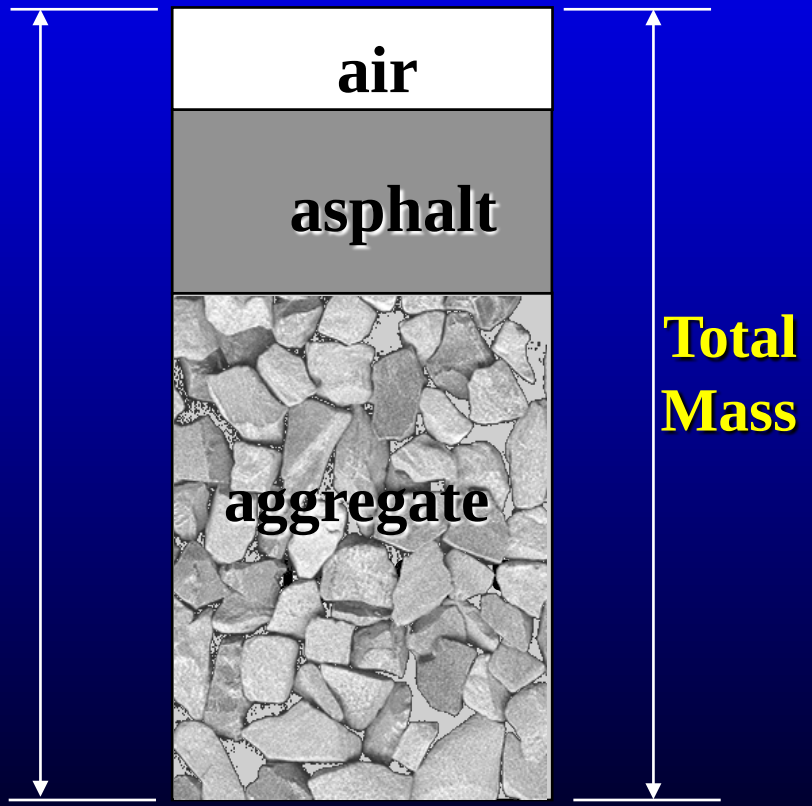
- **Perform**
  - permanent deformation
  - fatigue cracking – repeated load
  - low temperature cracking
  - moisture induced damage
- **Safety**
  - Resist skid
- **Constructable**
  - Workability

What Are the Criteria -- Superpave?



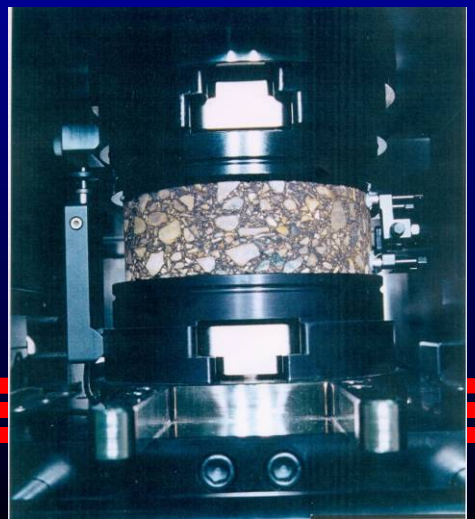
- **Volumetrics**
  - Voids in the Total Mix, VTM
  - Voids in the Mineral Aggregate, VMA
  - Voids Filled with Asphalt, VFA
- **Densification**
  - Stages during lab compaction process



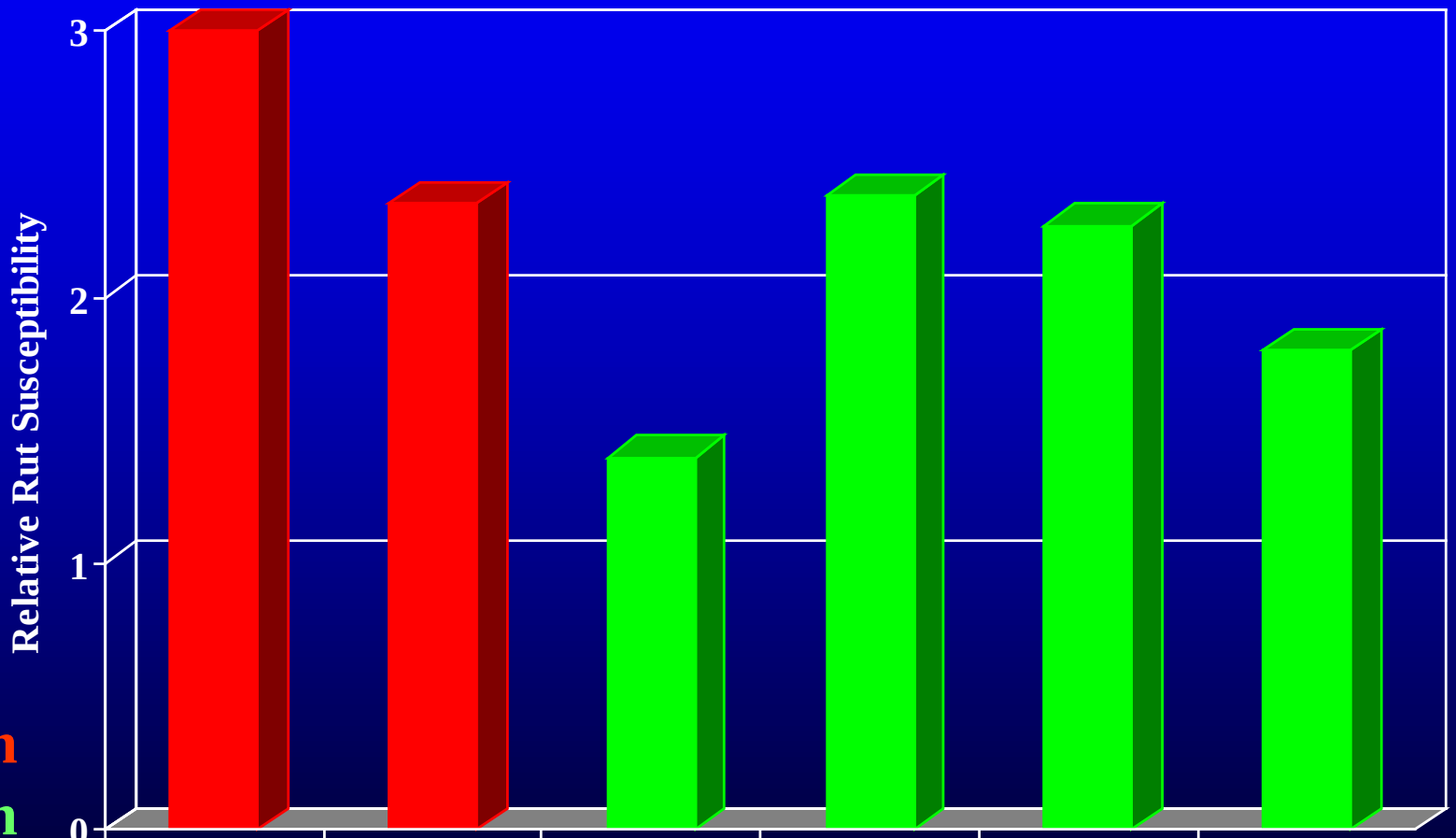


Background

- **Superpave volumetric mix design**
  - Ensure satisfactory performance: did use strict requirement
    - material specifications
    - volumetric mix criteria.
  - **No mechanical “proof” test**
    - Marshall mix design
- **Mechanical tests**
  - mix verification for intermediate and high volume traffic
    - advanced materials characterizations tests :
    - Superpave Shear Tester
  - Not widely used



Overall Relative Rut Susceptibility Ranking Level I



Fair

Good

Excellent

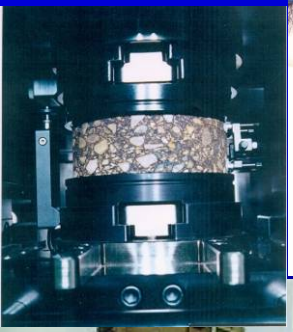
25 mm

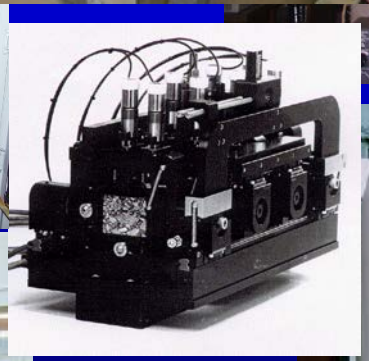
19 mm

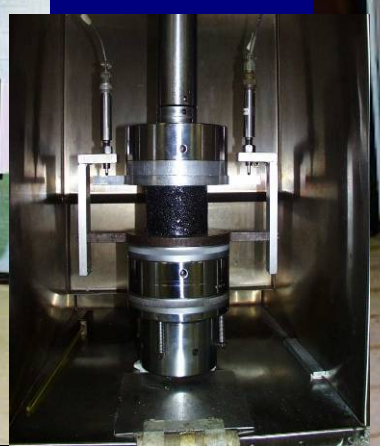
The Search: *Performance Mixture Testing*

- Increase Use of Reclaimed materials
- Mechanistic Tests
  - Pavement Performance
- **Intermediate Temperature**
  - **Fracture/Fatigue**
- High Temperature
  - Permanent deformation
- Features
  - Based on measuring fundamental properties
  - Repeatability
  - Simple, repeatable, easily-calibrated,
  - quick, not requiring highly-trained personnel,
  - Can utilize low-cost equipment.
  - Sensitive to subtle changes in mixture properties

Laboratory Performance







Laboratory Performance Tests

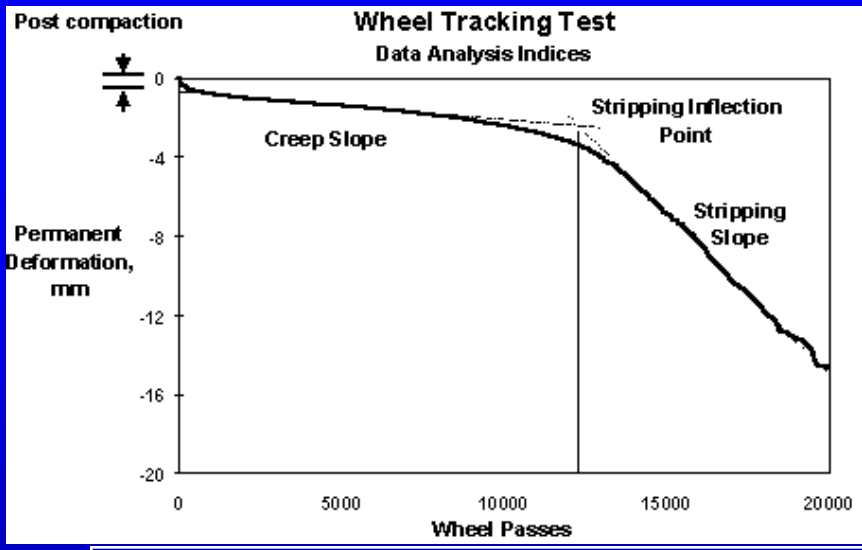
Mixture

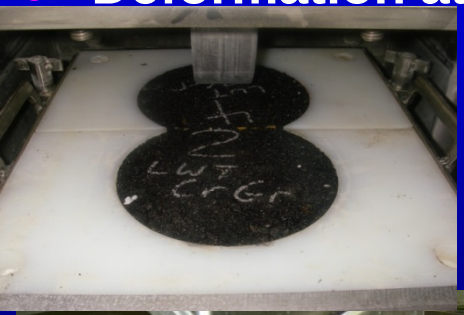
- Rutting Performance of Mixtures
  - Loaded Wheel Tracking Test
  - Flow Number

- Fatigue Performance
  - Semi Circular Bend Test

Loaded Wheel Tracking Test

- AASHTO T 324
- Damage by rolling a steel wheel across the surface of a sample
- Cylindrical: Core or SGC
- Slab: 320- L, 260- W, and 80-mm thick
- 50 °C, Wet or dry
- Deformation at 20,000 passes is





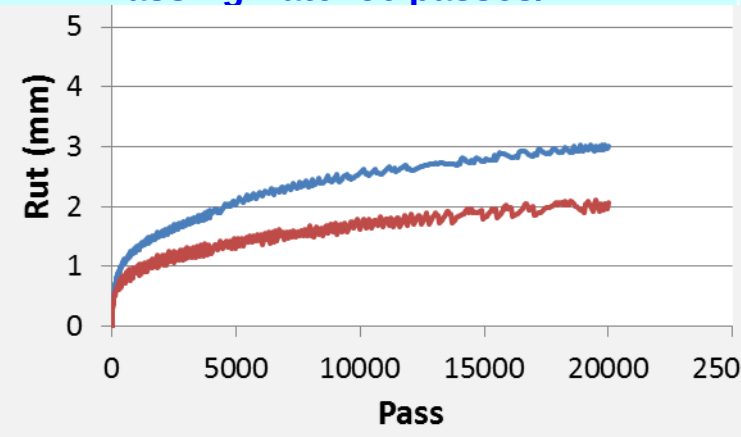
Wheel Diameter: 203.5 mm (8 inch)

Wheel Width: 47mm (1.85 inch)

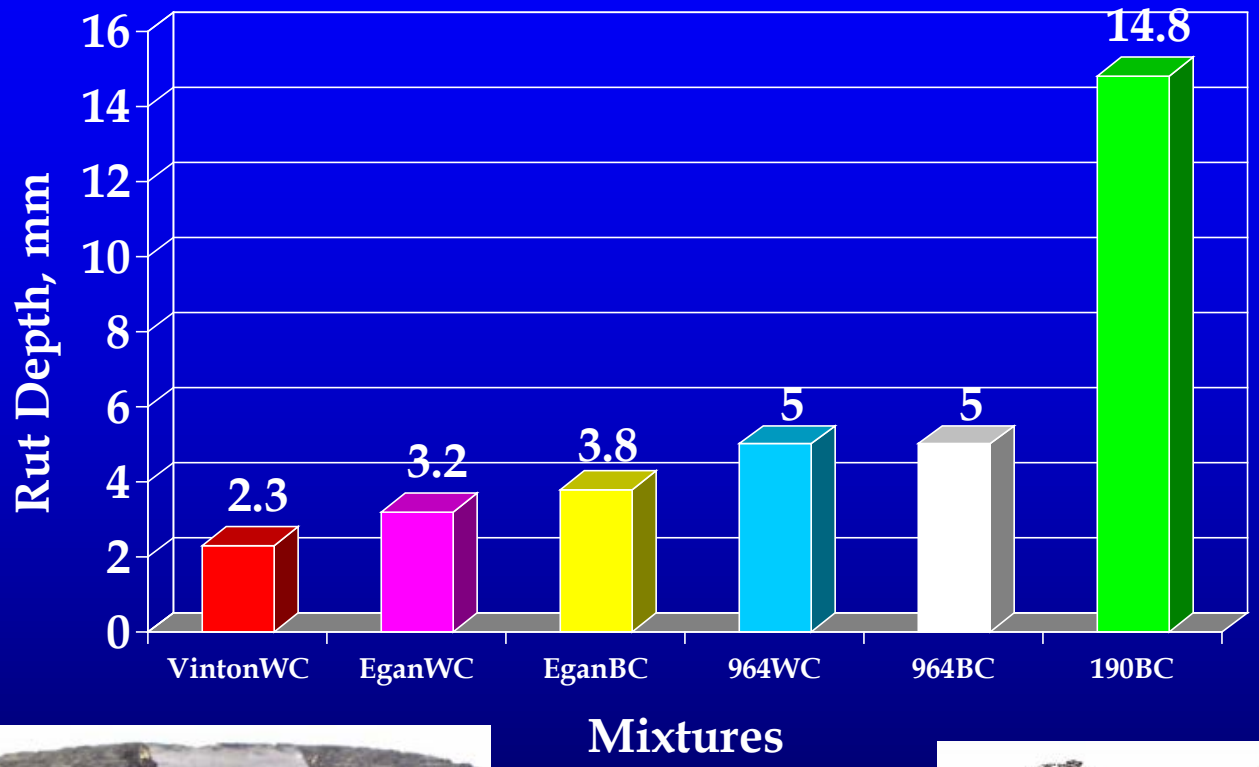
Fixed Load: 703 N (158 lbs)

Rolling Speed: 1.1 km/hr

Passing Rate: 56 passes/min

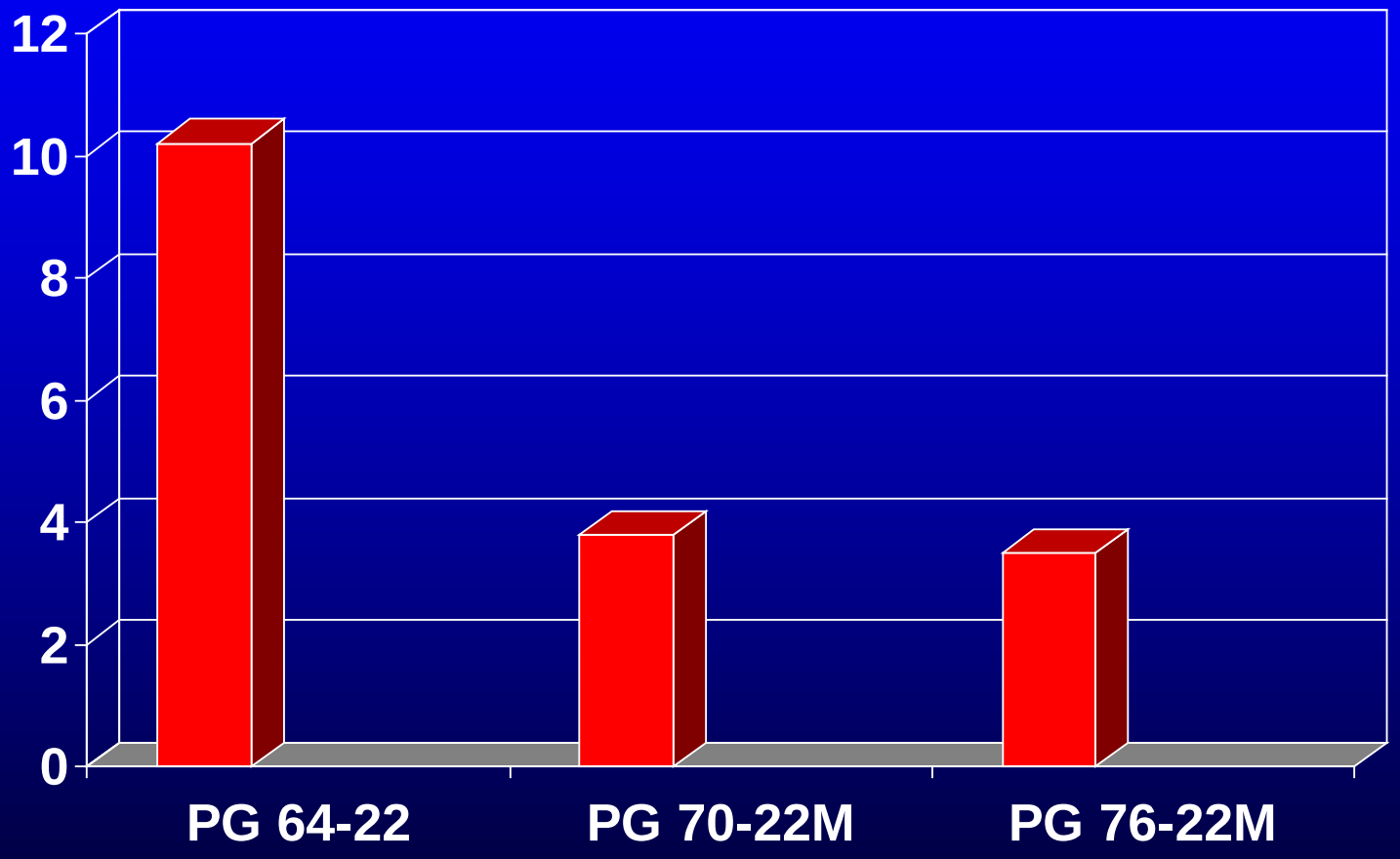


LWT Test Results – 50C, Wet

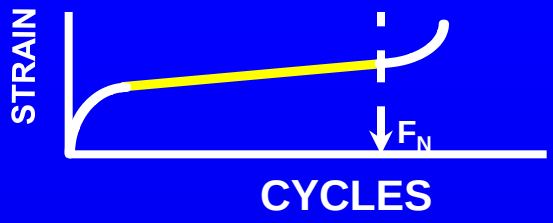


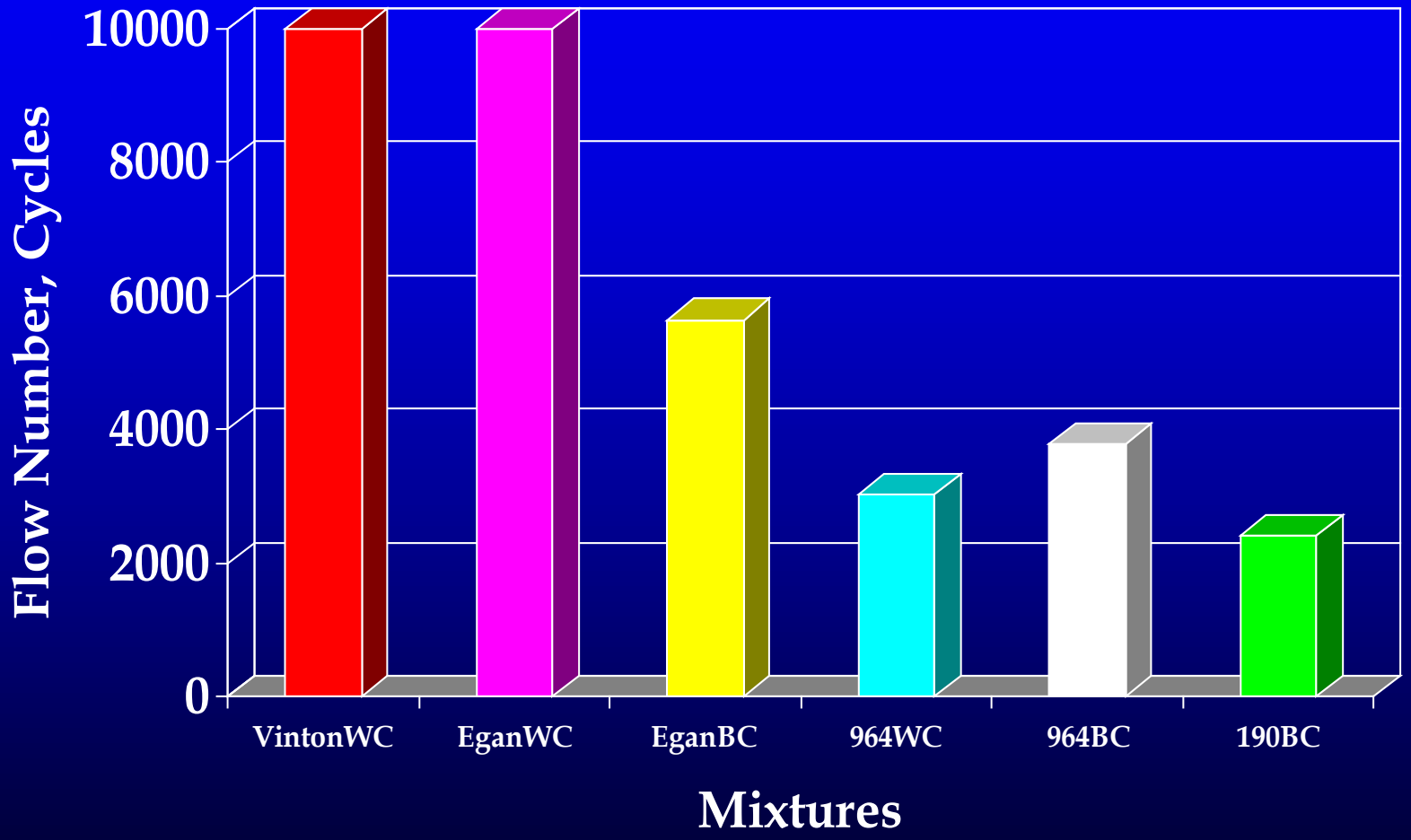
- I-10 Vinton
  - SMA
  - 12.5 mm WC (Vinton WC)
- I-10 Egan
  - Superpave
  - 12.5 mm WC (Egan WC)
  - 25.0 mm BC (Egan BC)
- US 190 Port Allen
  - Superpave
  - 25.0 mm BC (190BC)
- LA 964
  - Marshall
  - 19.0 mm WC (964WC)
  - 25.0 mm BC (964BC)

LWT Test Results – 50C, Wet



Repeated Load Permanent Deformation Test -- F_N





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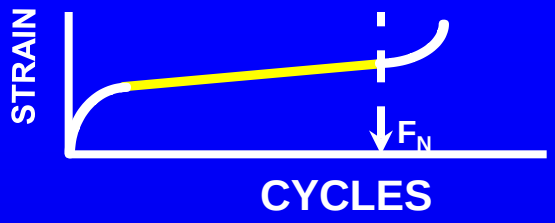
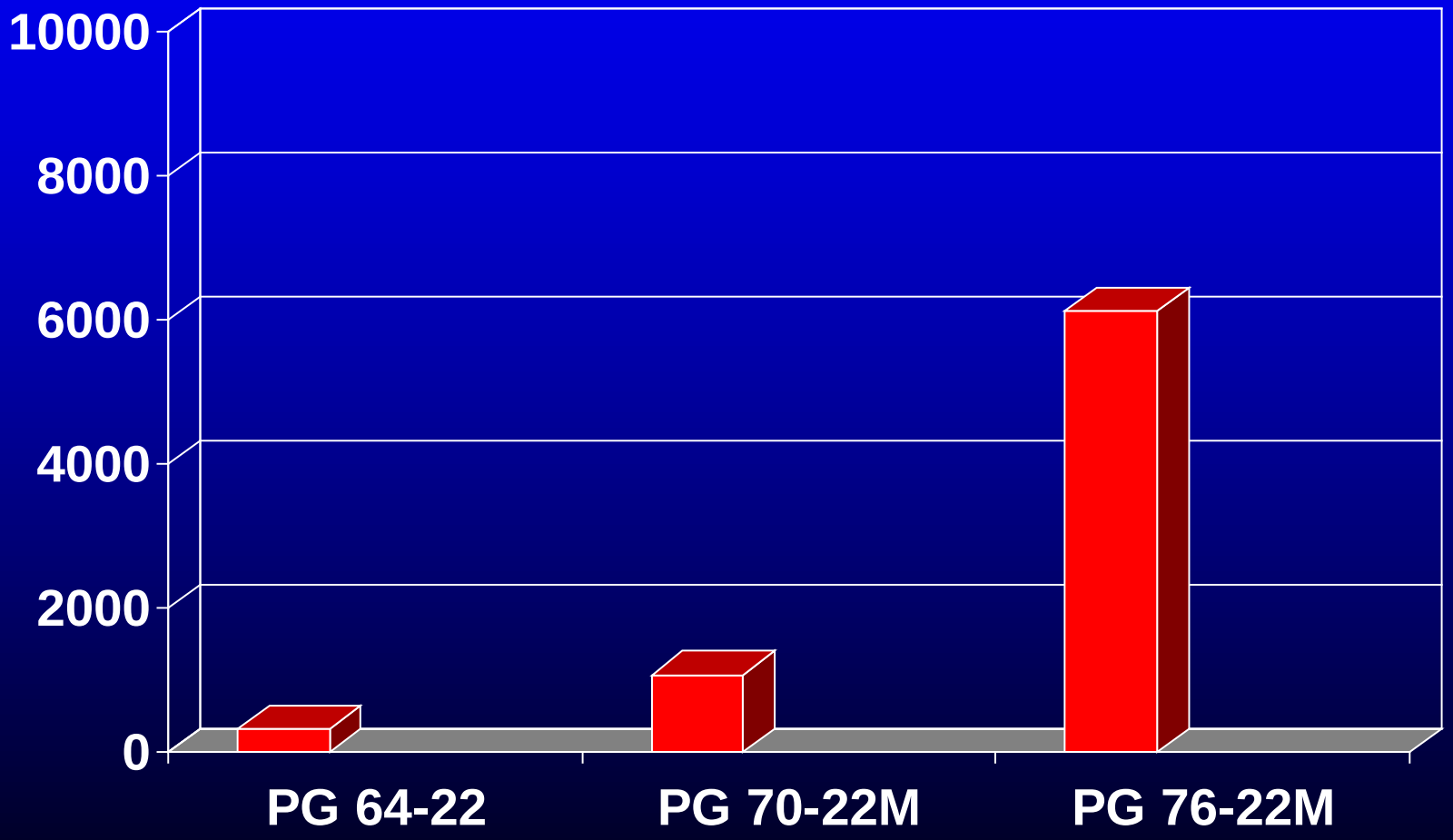
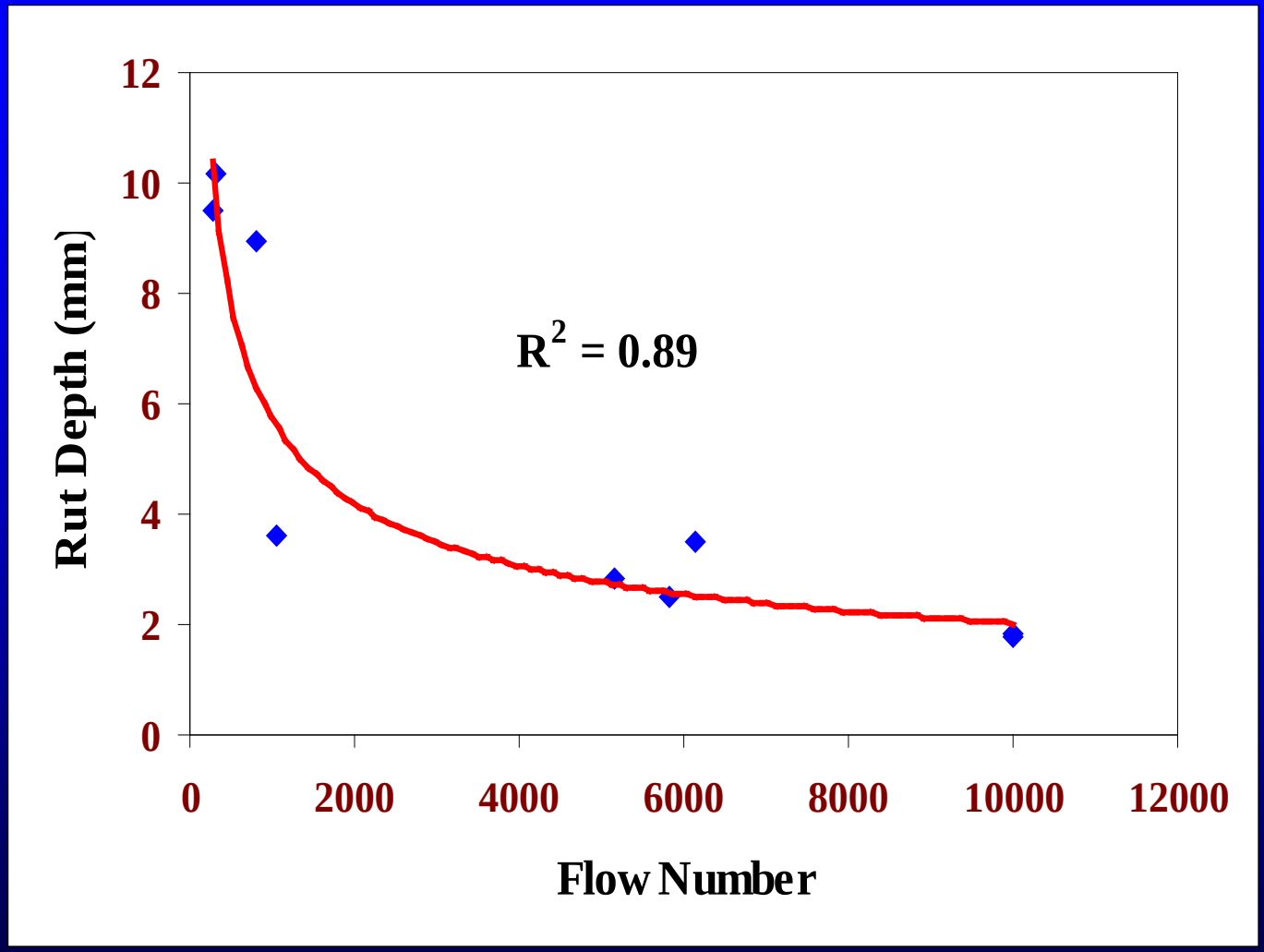




Relationship B/W LWT Rut Depth & F_N



Permanent Deformation

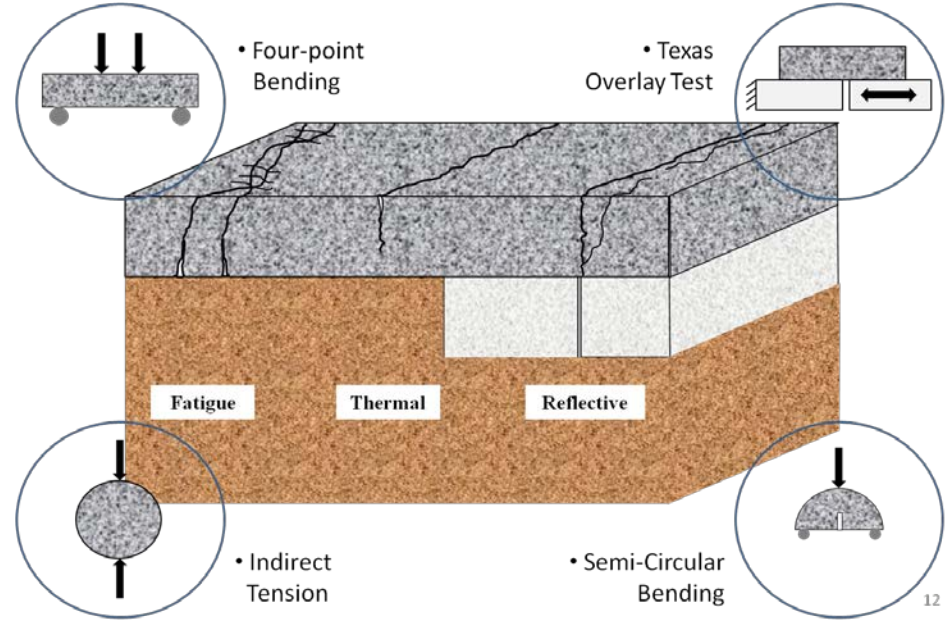
- Good correlation B/W LWT & FN
- Recommend LWT
  - LWT max. design rut, mm @ 50^0 C

Table 502-7
Asphalt Concrete General Criteria

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[8]
Type of Mix	Incidental Paving[1]	Wearing Course		Wearing Course	Binder Course		Binder Course		Base Course	ATB[7]	Base Course	Wearing
Level[2]	A	1	2	2	1	2	1	2	1	1	1	
LWT max. design rut, mm @ 50^0 C	10 @ 10,000 passes	10 @ 20,000 passes	6 @ 20,000 passes	6 @ 20,000 passes	10 @ 20,000 passes	6 @ 20,000 passes	10 @ 20,000 passes	6 @ 20,000 passes	12 @ 20,000 passes	10 @10,000 passes	12 @ 20,000 passes	6 @ 20,000 passes

Laboratory Test Methods to Characterize Fatigue/Fracture Resistance

- **Four-Point Bending Fatigue Test**
- ***A*sphalt *M*ixture *P*erformance *T*est**
- ***D*isk-shaped *C*ompact tension *T*est**
- **Texas Overlay Tester**
- ***D*issipated *C*reep *S*train *E*nergy *T*est**
- ***I*ndirect *T*ensile *S*trength Test**
- **Simplified Viscoelastic Continuum Damage**
  - **Pull-Push Test**
- **IDT Fracture Energy**
- **Semi-circular bending (SCB) test**



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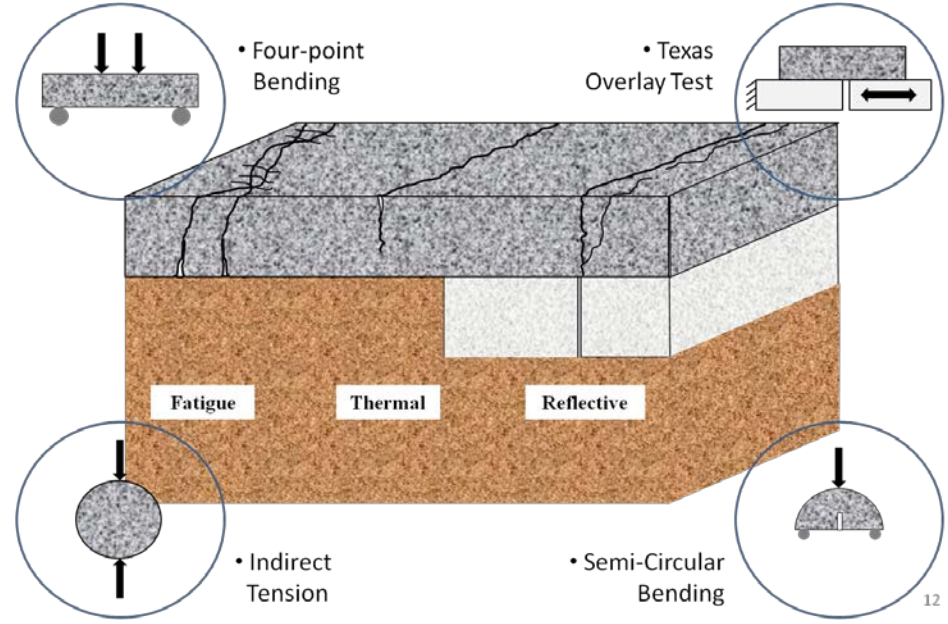
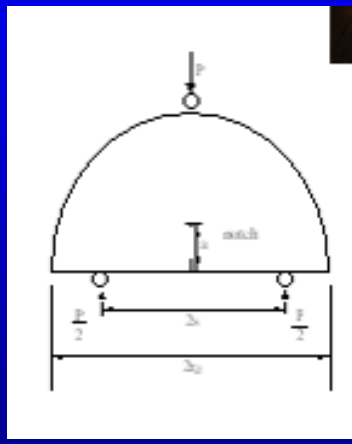
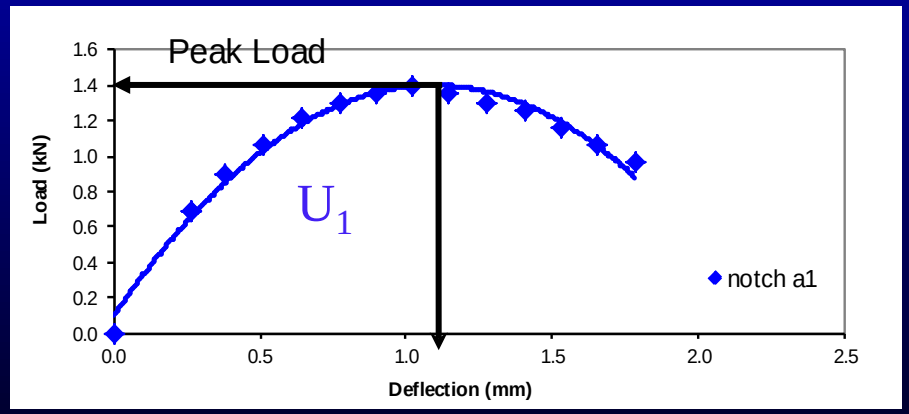
- Indirect tensile strength (IDT) test
- Simplified Viscoelastic Continuum Damage
  - Pull-Push Test
- IDT Fracture Energy
- **Semi-circular bending (SCB) test**



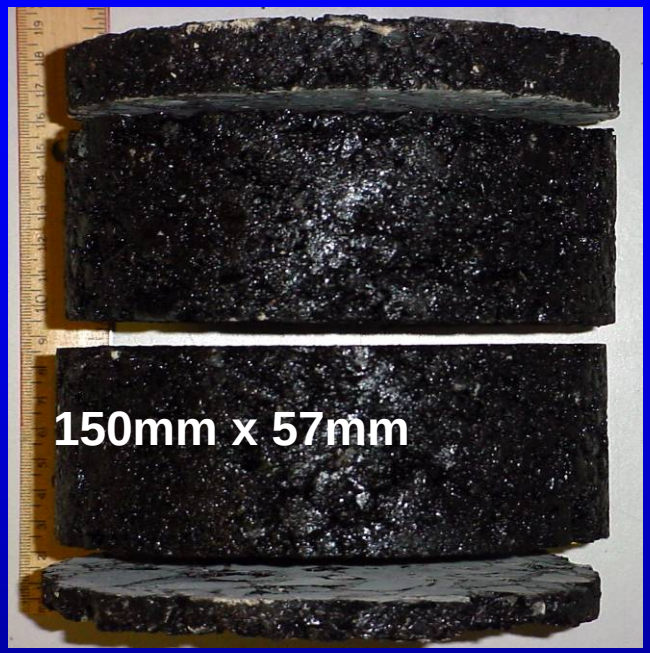
Semi Circular Bend (SCB) Test

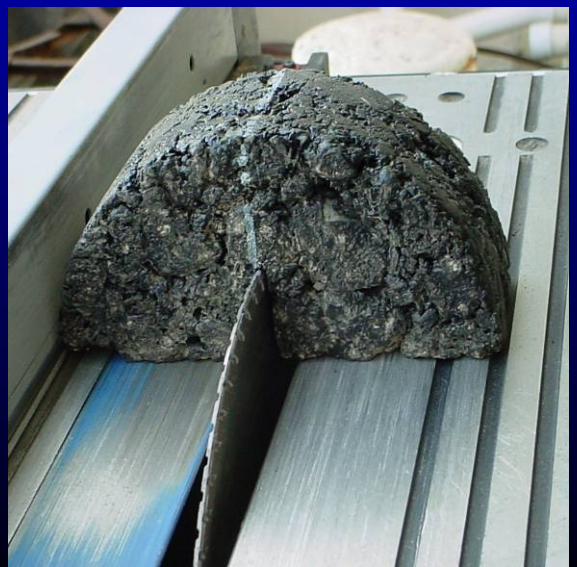
- Fracture mechanics
  - used for evaluating fracture resistance in rock mechanics
- Temperature: 25°C
- Half-circular Specimen
  - Laboratory prepared
  - Field core
  - 150mm diameter X 57mm thickness
  - simply-supported and loaded at mid-point
- Notch controls path of crack propagation
  - 25.4 -, 31.8-, and 38.0-mm
- Loading type
  - Monotonic
  - 0.5 mm/min
  - To failure
- Record Load and Vertical Deformation
- Compute Critical Stain Energy: Jc

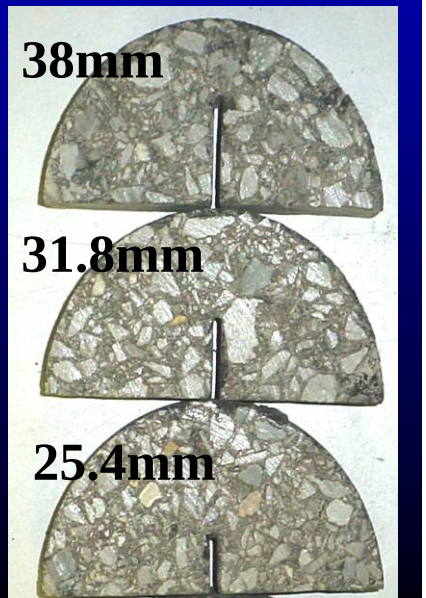




SCB Test - Sample Preparation





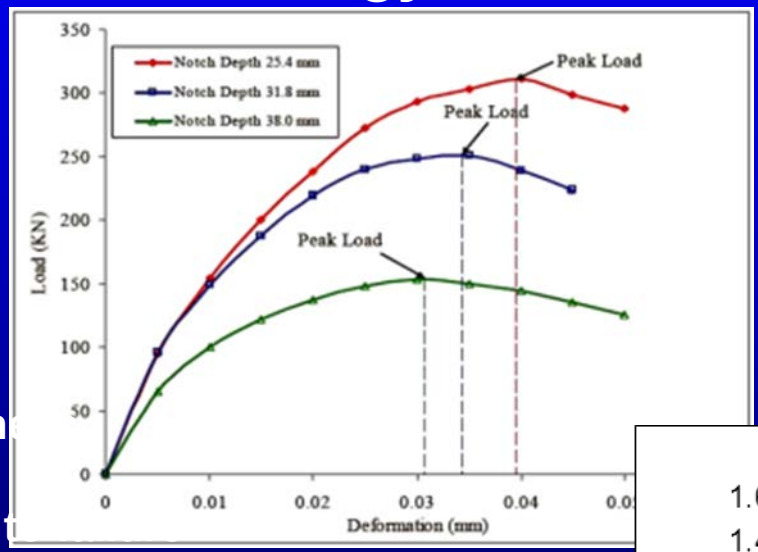


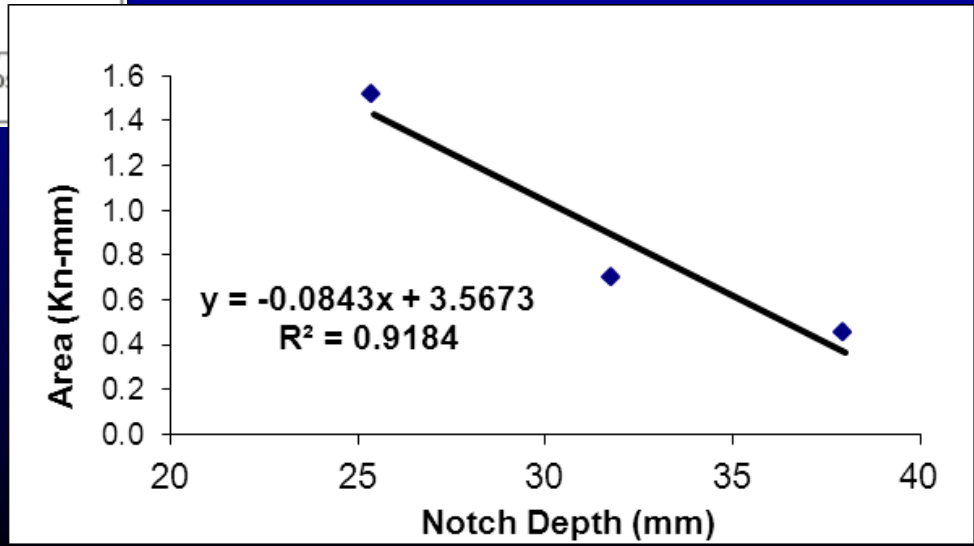
SCB Test – Analysis

- Calculate Energy at failure (U) for each notch depth
- Plot U vs. a and determine slope (dU/da)
- Compute Critical Stain Energy
  - Jc

$$J = -\frac{1}{B}\left(\frac{\partial U}{\partial a}\right)$$

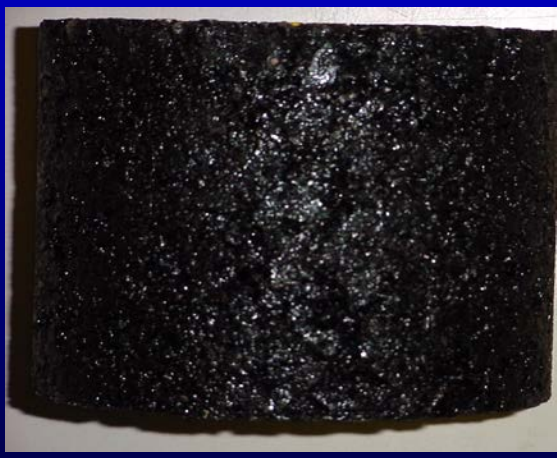
B = sample thickn
a = notch depth
U = strain energy





Advantages of SCB Test

- Utilize *laboratory* SGC specimens or *field* cores
- multiple specimens can be obtained from one core
  - reducing the error caused by heterogeneities among samples
- Test setup is very simple
- Testing time is around 10 minutes per specimen
  - Ease of sample preparation
- Stress field resembles pure tensile conditions



Draft Standard Test Method

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

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

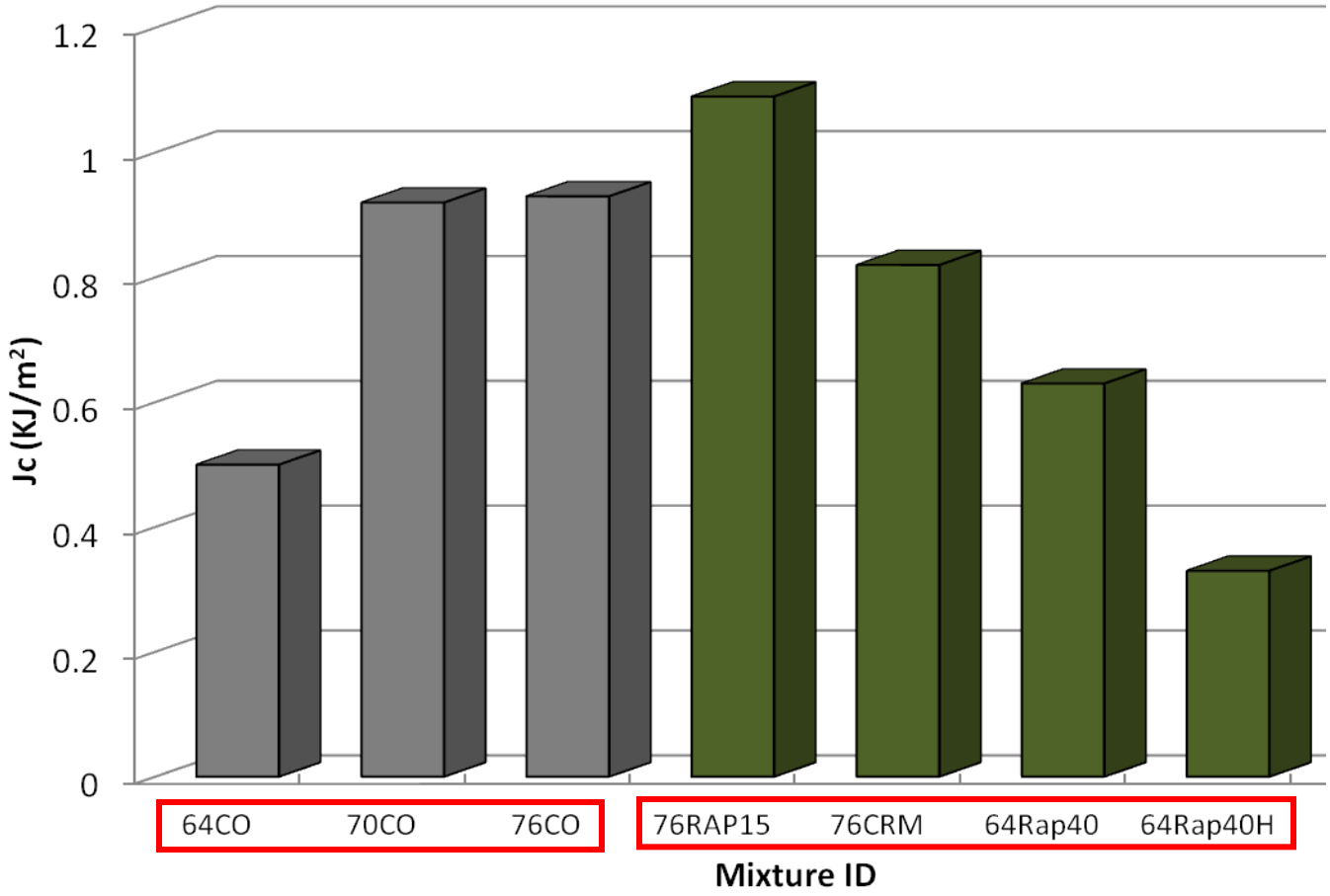
- PP 2, Practice for Mixture conditioning of Hot Mix Asphalt (HMA)
- TP 4, Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the SHRP Gyratory Compactor
- T 67, Standard Practices for Load Verification of Testing Machines
- T 166, Bulk Specific Gravity of Compacted 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

Equipment


HUMBOLDT
F1
F2
F3
F4
SET UP
UP
STOP
SPEED
DOWN
Emergency Stop
MasterLoader HM-3000
HUMBOLDT


SPT

SCB Test Results – 25C



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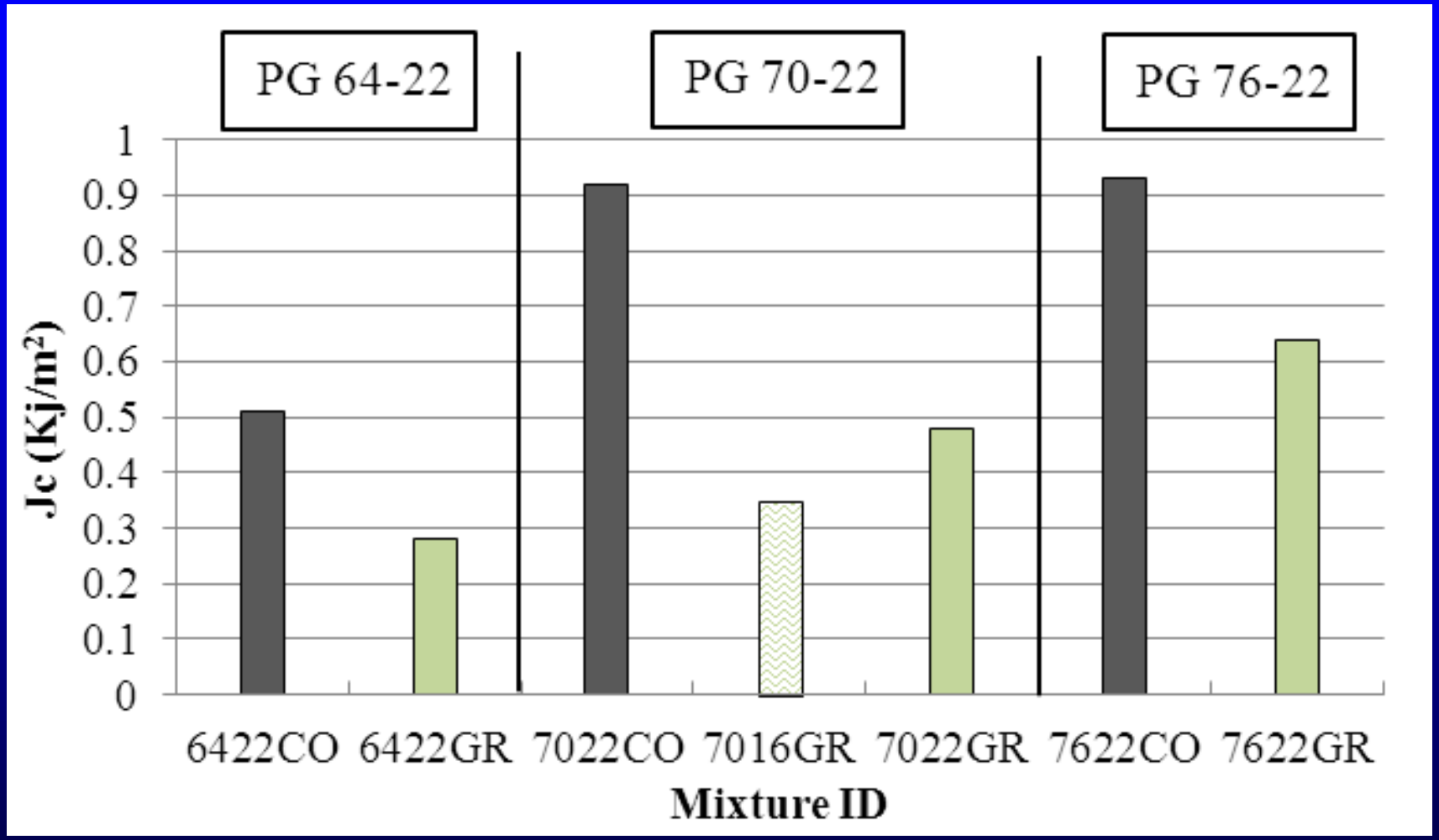

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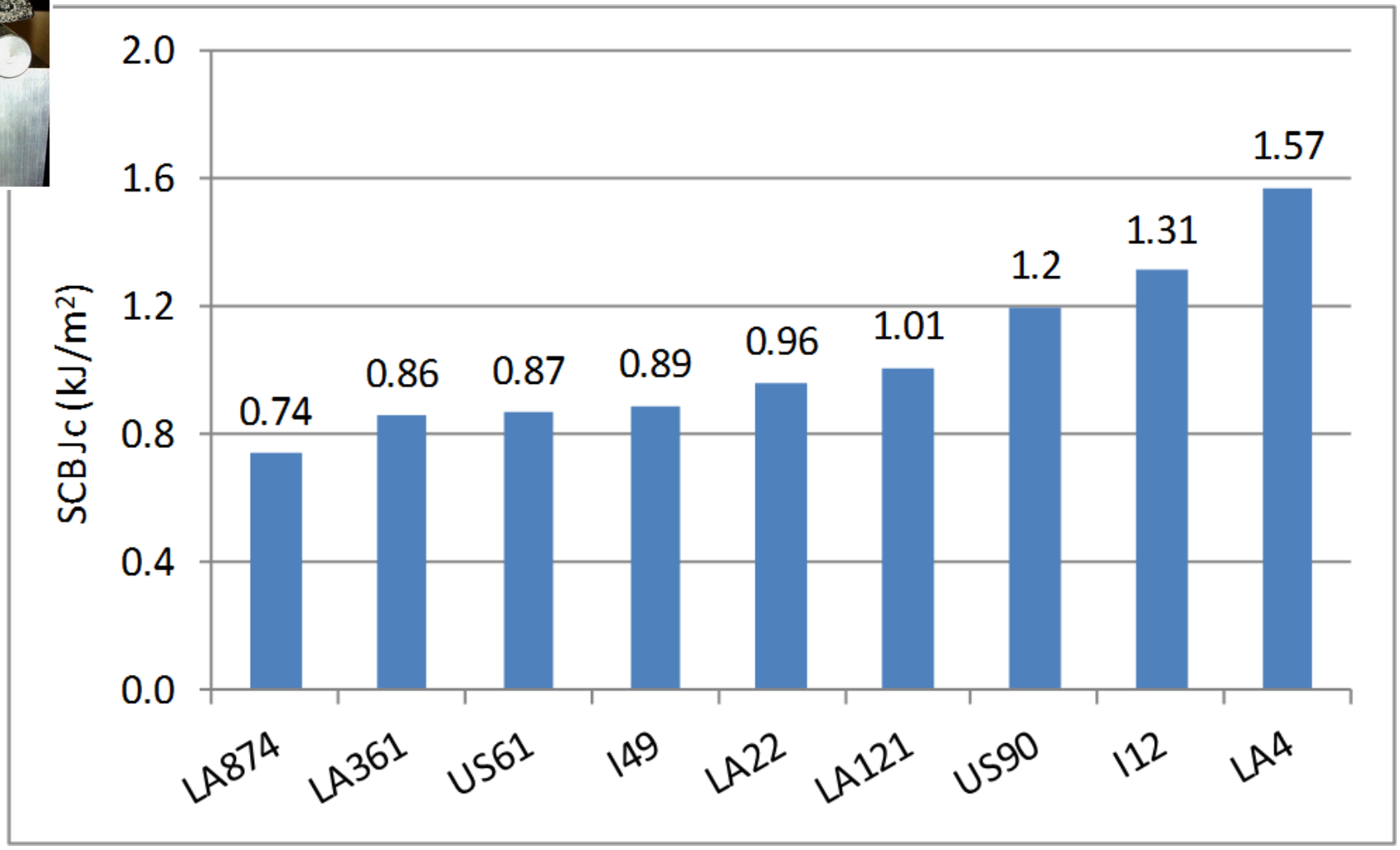
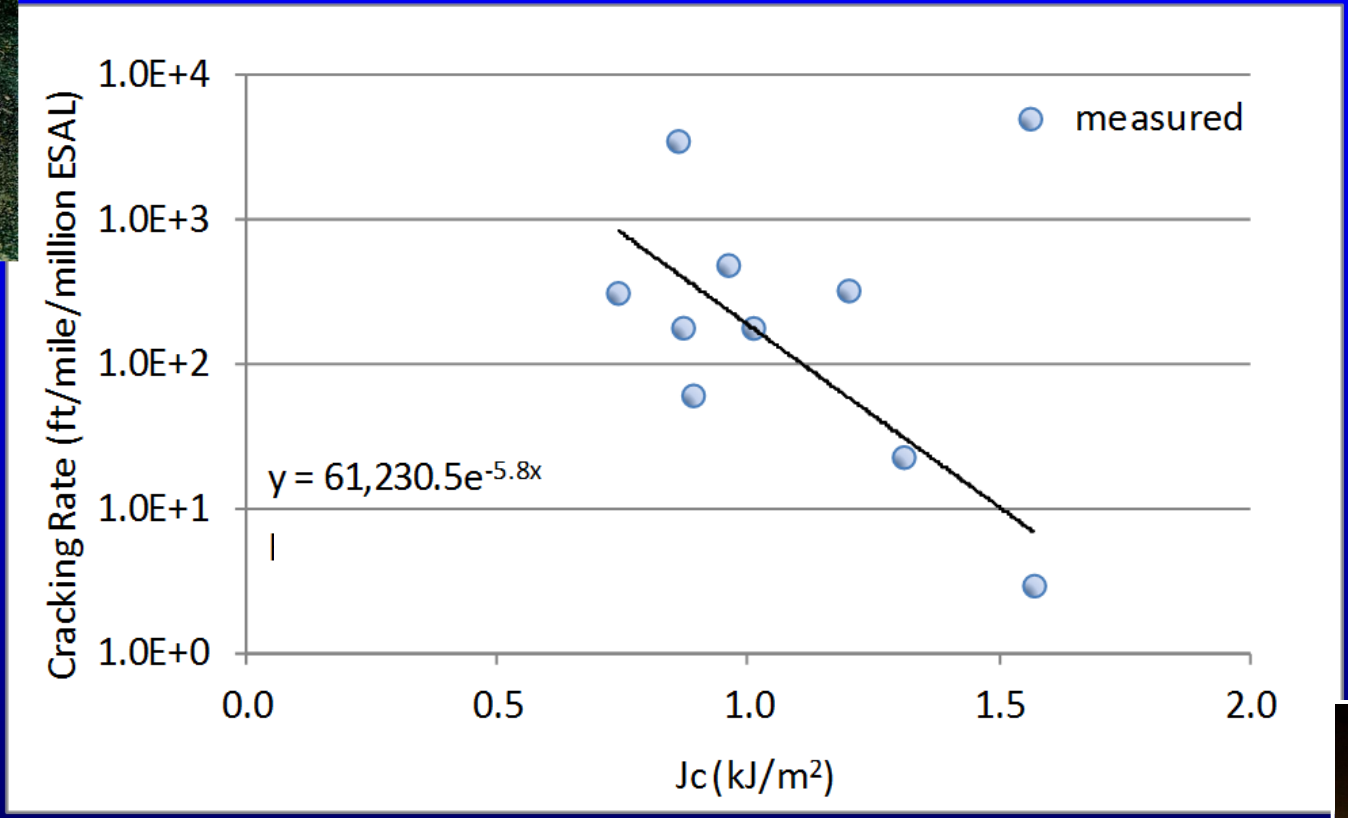
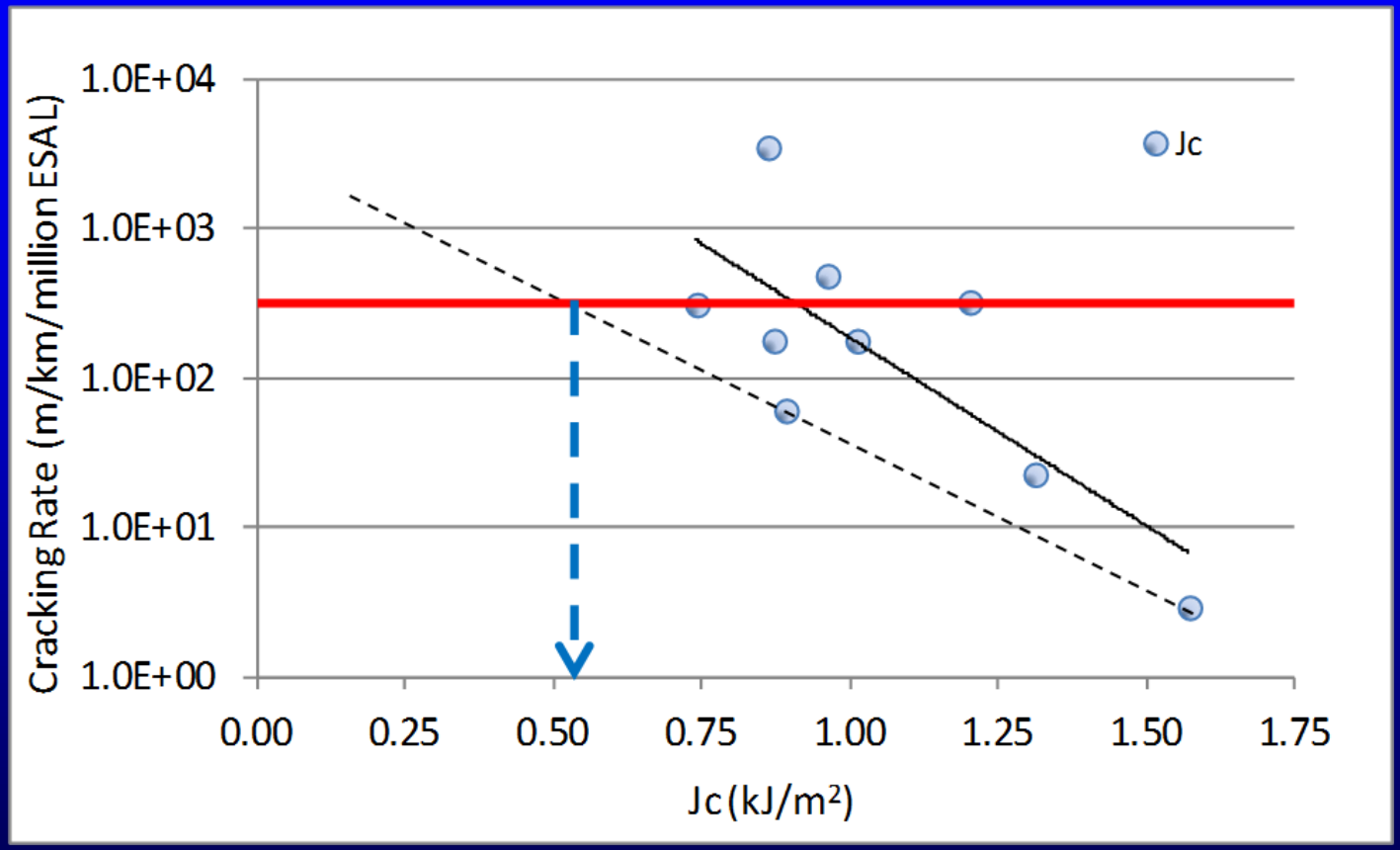


Laboratory Results vs. Field Performance

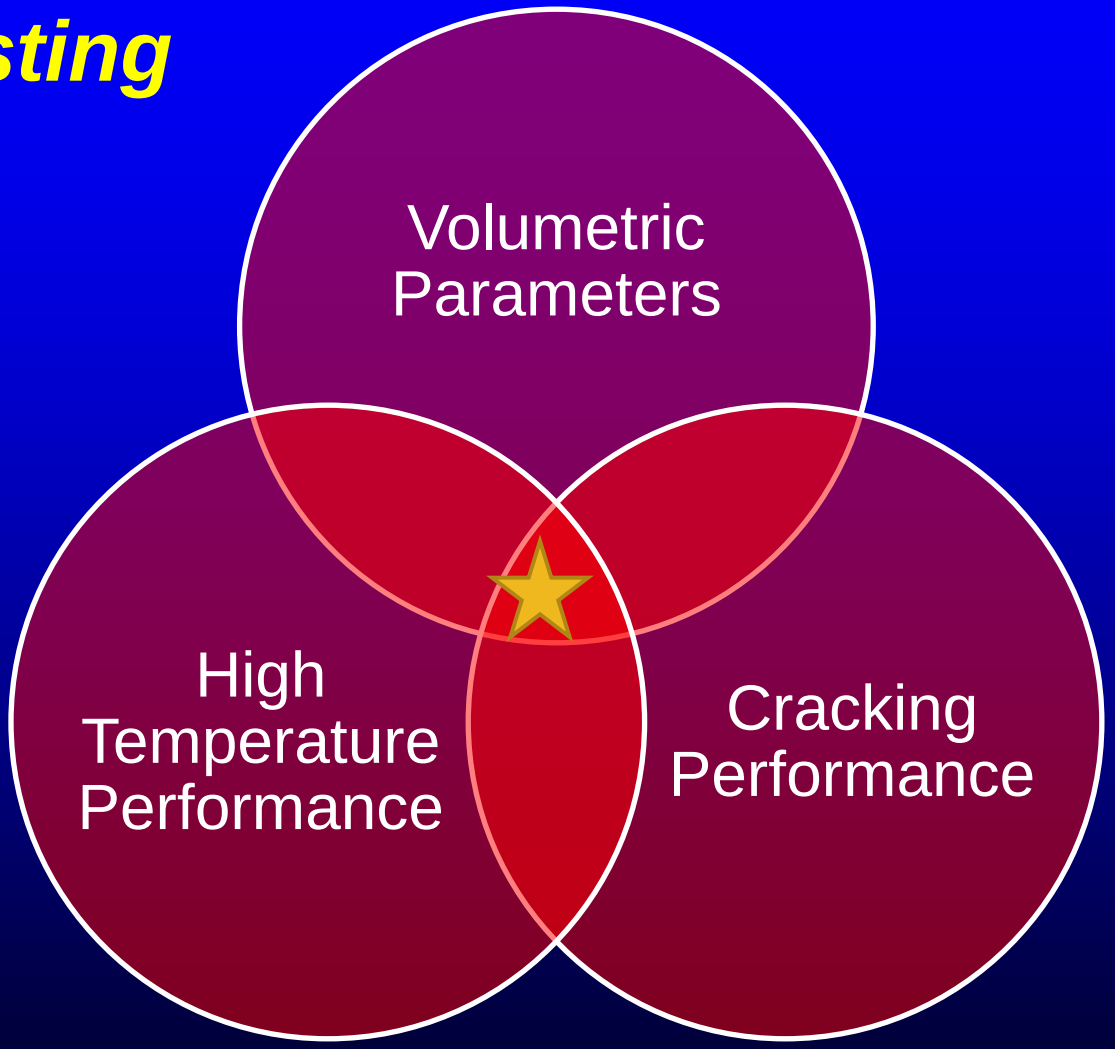


TRB 2012: Characterization of Fracture Properties of Asphalt Mixtures As Measured by Semi-Circular Bending Test and Indirect Tension Test

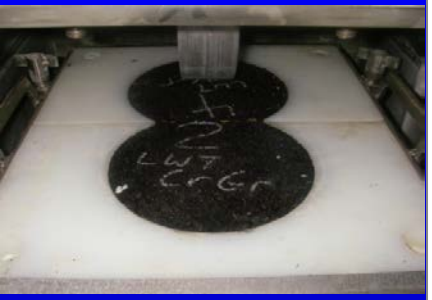
Development of a Laboratory Criteria

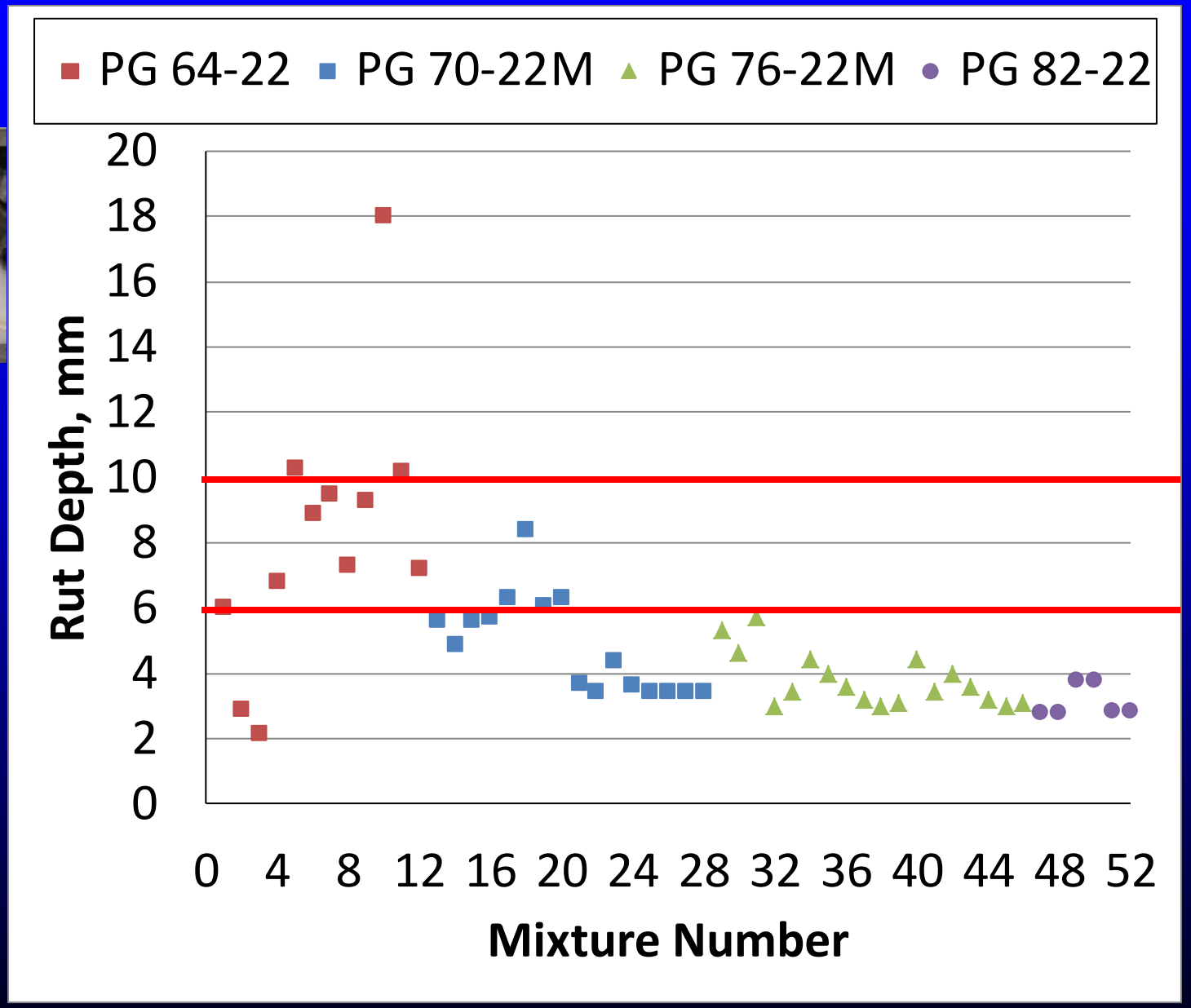


Mixture Design Volumetric and Performance Mixture Testing

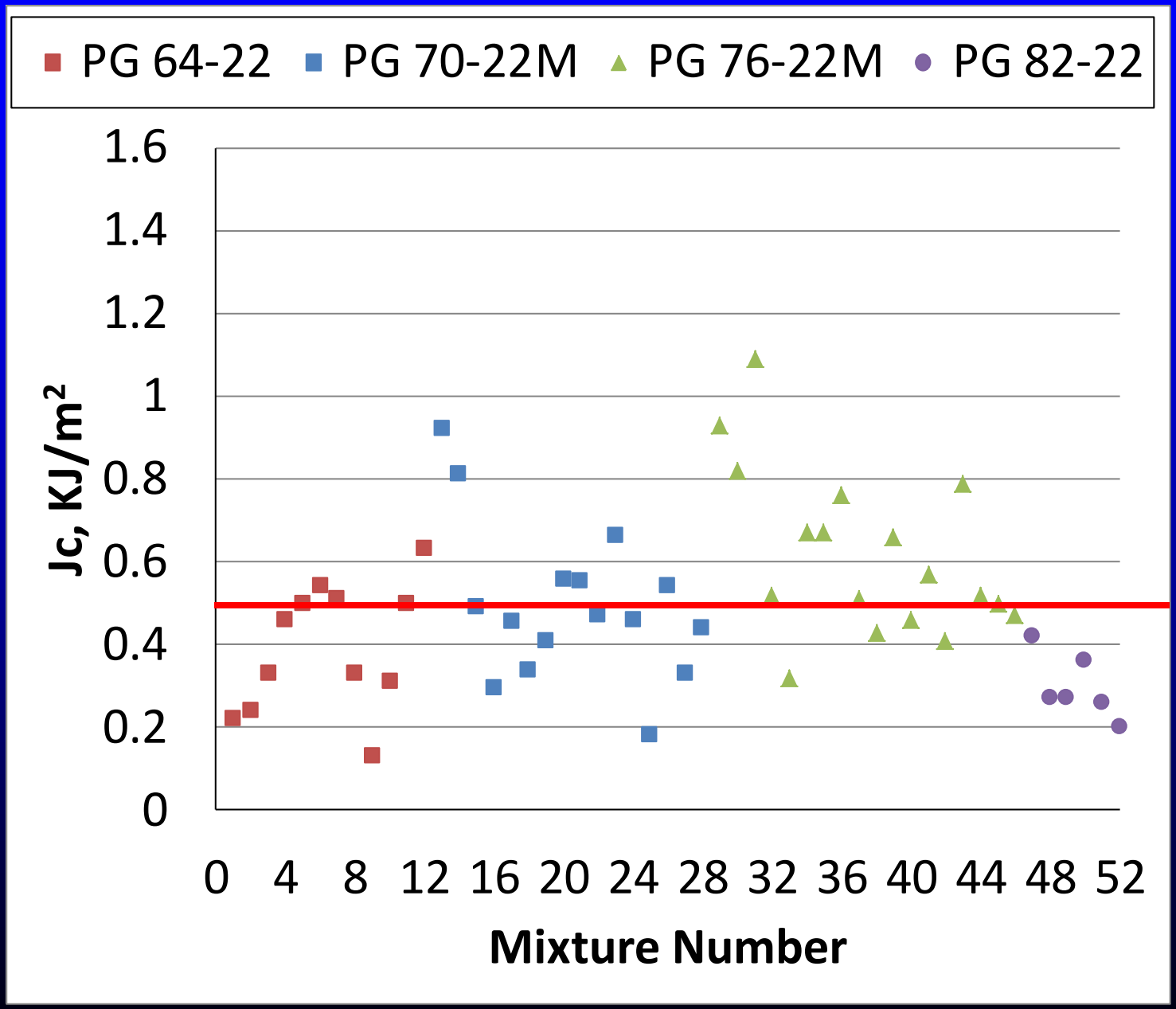


LWT Test Results





SCB Test Results



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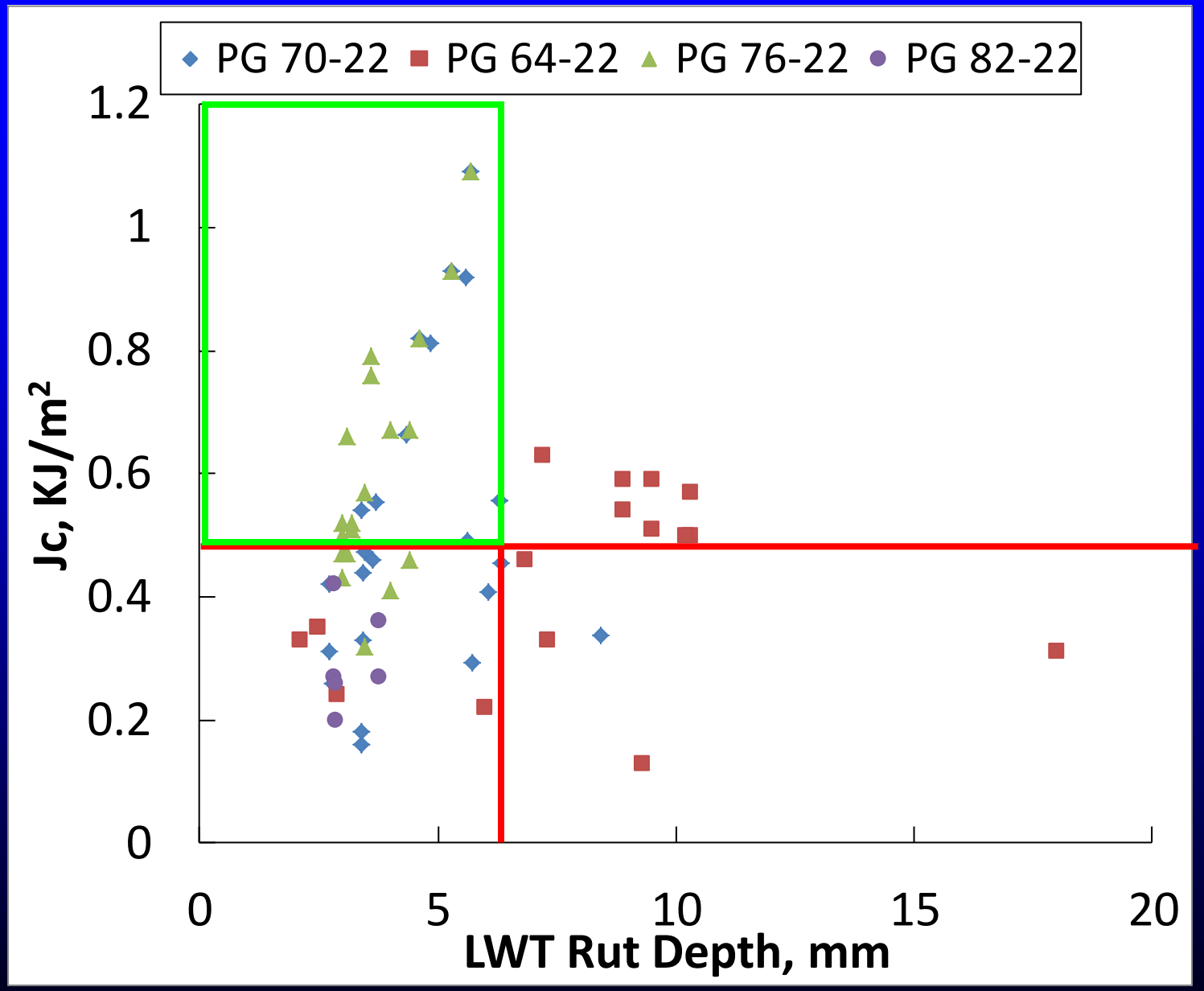

Summary

- LWT and SCB tests have been selected
  - Performance tests
  - High temperature and Intermediate temperature cracking performance
- Good correlation B/W LWT and Fn test results
- Semi-Circular Bending (SCB) test
  - Draft standard test method
  - Specimen: laboratory, field
  - Equipment: adopted to low-cost equipment, AMPT
  - Analysis
  - Lab vs. field performance
- Jc was sensitive to mixture parameters considered
- reasonably effective laboratory tool for evaluating fracture resistance
- Good correlation b/w SCB test results and field cracking rate
- Further validation with more field and laboratory data is underway

Thank you