Laboratory Performance Asphalt Mixtures Containing High RAP Content with Crumb Rubber Additives

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Sustainable Materials for Pavement Infrastructure: Use of Waste Tires in Asphalt Mixtures

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My Story

- Background
- Objectives
- Scope
- Methodology
- Discussion of Results
- Conclusions

Sustainability -- Definition

- Meeting the needs of the present without compromising the future
  - 1987 United Nation conference
  - World Commission on Environment and Development (WCED)
- “Do onto future generations as you would have them do onto you"
  - Golden Rule
- "Sustainable means using methods, systems and materials that won't deplete resources or harm natural cycles"
  - Rosenbaum, 1993

Sustainable Development

- Economical Sustainability
  - Balanced cost-revenue relationship
    - LCA
    - Managing Resources
- Environmental
  - Friendly to the ecosystems
  - Minimum harm to the surroundings
  - Recycling
    - minimize the use of natural resources
  - Renewable sources of energy
    - reduce energy consumption,
    - reduce greenhouse gas emissions
- Materials Performance
  - Better or similar performance
  - Meet people’s needs
  - ensure a high level of user comfort
- Three aspects must be considered altogether

Sustainability Materials/Technology

- **Recycled Materials**
  - **Waste Tires**

Background

- LDOTD asphalt cement specification requires
  - elastomeric type of polymer modifier
    - Styrene Butadiene Styrene (SBS)
  - enhanced performance
    - rutting and fatigue cracking
- Shortage in SBS
  - 2008
  - reported by several polymer suppliers
- Potential to utilize crumb rubber from *waste tires*
  - absorption properties
    - carry engineered additives
  - Improve performance
    - revitalize aged binders
      - fatigue cracking

Background

- Most State Specification
  - Limit the % of RAP allowed in flexible pavement layers
    - HMA mixture
  - asphalt binders ***hardened and oxidized***
  - causing premature cracking in pavements
- What is the solution to Increase Use of RAP?
  - soften the asphalt cement binder of RAP materials
    - engineered additives
  - crumb rubber from waste tires in ***dry process***
    - Carrying agent of engineered additives
  - will enable the use of higher % RAP

Background

- Method of sustainability in the asphalt industry
  - Use of recycled materials
  - Direct impact on cost and the environment
  - GREEN & LEED
    - Leadership in Energy and Environmental Design
- NCHRP 10-91 [RFP]
  - Guidebook for Selecting and Implementing Sustainable Highway Construction Practices
  - … identify effective sustainability practices that can be implemented during the construction of highway projects…"

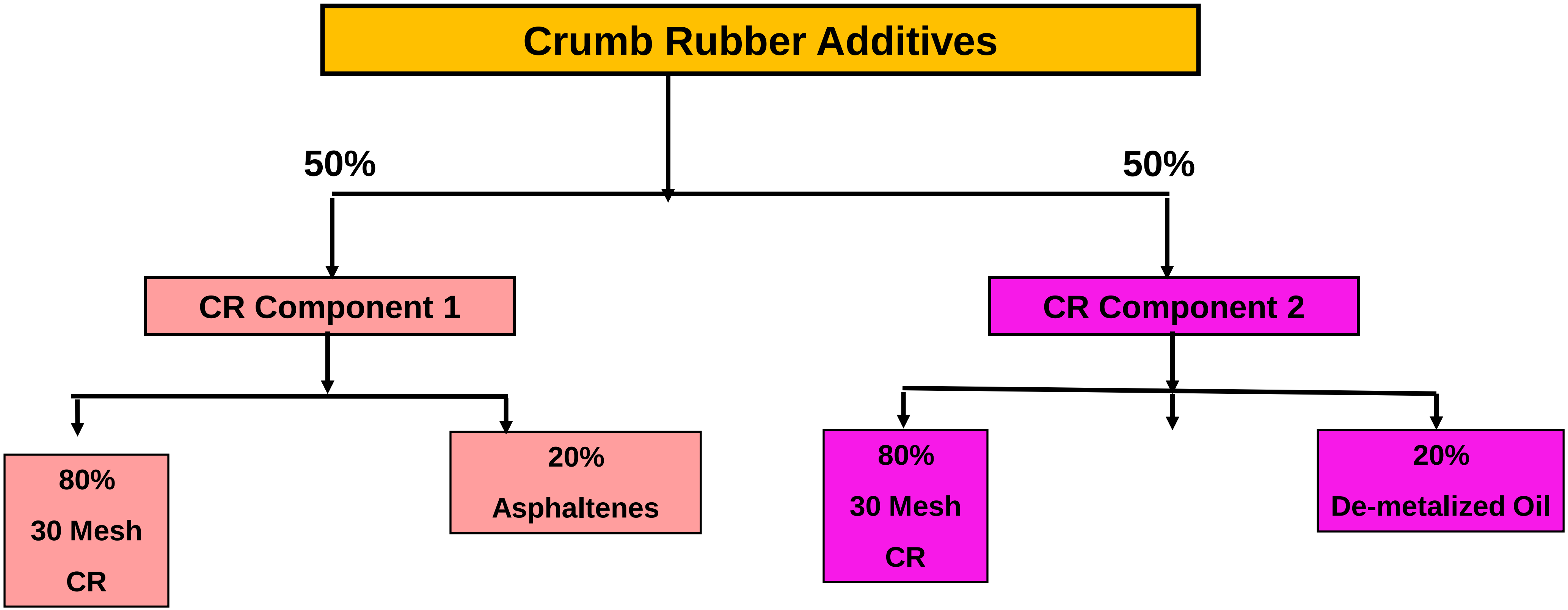
Objectives

- Fundamentally characterize the laboratory performance
  - Conventional HMA mixtures
  - Mixtures containing high RAP content and waste tire crumb rubber/engineered additives
    - Dry process

Scope

- **Four 19.0 mm Level 2 HMA mixtures**
  - **Siliceous limestone aggregates**
    - **commonly used in Louisiana**
  - **Mixture 1: Conventional one, 76CO**
    - **No RAP**
    - **Binder: PG 76-22M**
    - **control mixture**
  - **Mixture 2: 76CRM**
    - **No RAP**
    - **Binder: PG 64-22 + 30 mesh CR & engineered additives: *wet blend***
      - **PG 76-22M**
  - **Mixture 3: 76RAP15**
    - **15% RAP**
    - **Binder: PG 76-22M**
  - **Mixture 4: 64RAP40**
    - **40% RAP**
    - **Binder: PG 64-22**
      - **30 mesh CR & engineered additives: *dry blend***

Crumb Rubber/Engineered Additives (Dry Process)



CR Supplied by: Mr. John Osborn of Elastomeric Concentrates, LLC

Asphalt Mixture Preparation

Superheated Agg/RAP

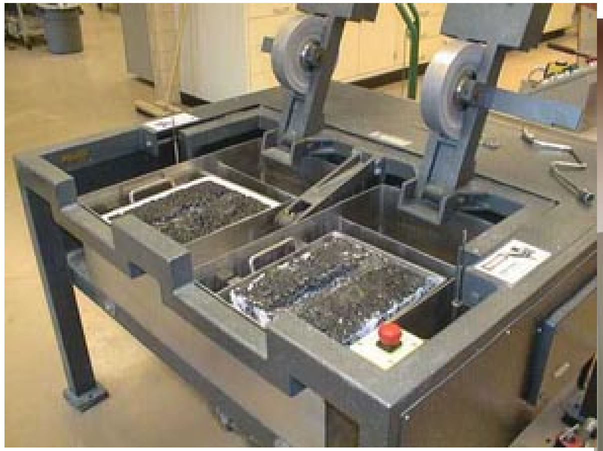
Laboratory Materials Characterization

<u>Binder</u>

- PG grading

<u>Mixture</u>

- Permanent Deformation
  - Loaded Wheel Test
  - Dynamic Modulus Test
- Fracture/Durability
  - Semi Circular Bend Test
  - Moisture Susceptibility
    - Lottman Test
- Triplicate
- $V_A = 7.0\% \pm 0.5$



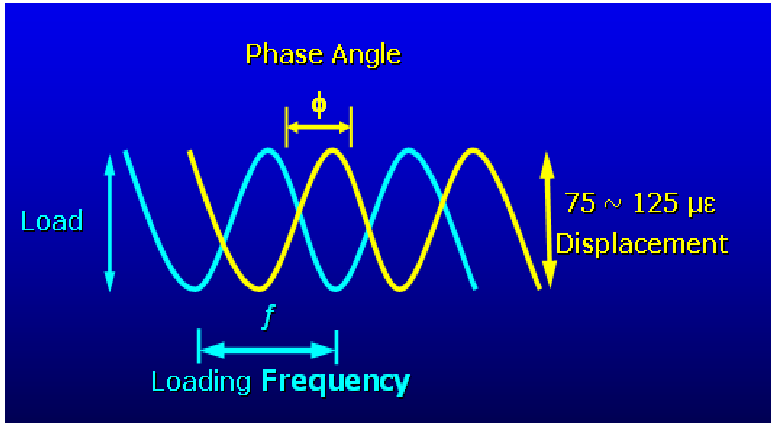
Dynamic Modulus |E*| Test

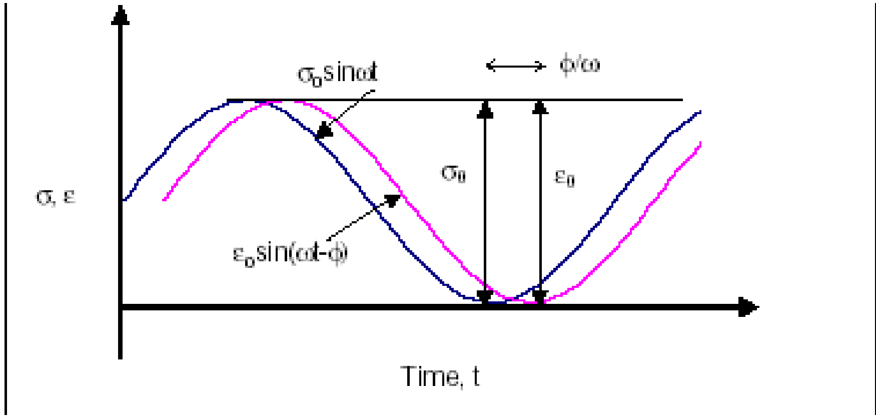
- IPC SPT (AMPT)
- AASHTO TP-62
- Sinusoidal axial compressive stress is applied to a specimen
  - temperature and frequency

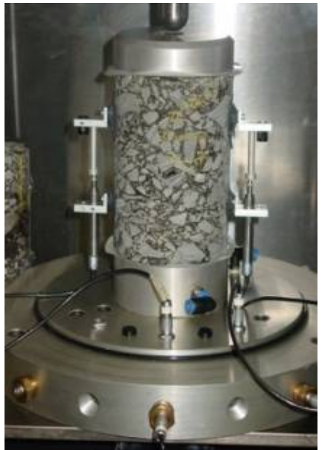
- Dynamic modulus $|E^*| = \dfrac{\sigma_0}{\varepsilon_0}$

- Phase Angle $\phi = \dfrac{T_i}{T_p} \times 360°$

Frequency (HZ)	25, 10, 5, 1, 0.5, 0.1
Temp. (°C)	-10, 4.4, 25, 38, 54.4







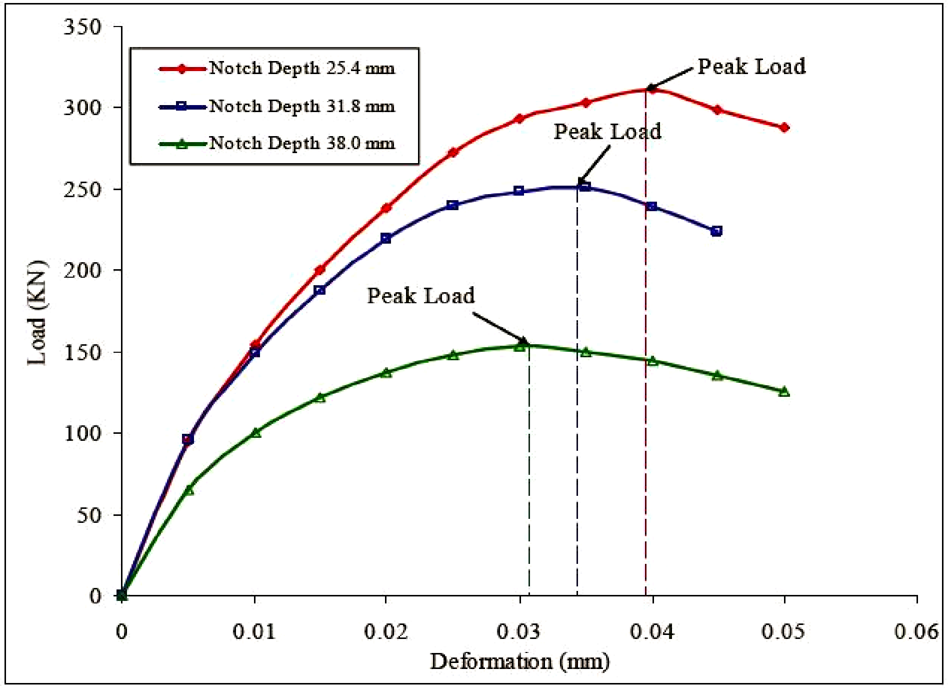
Fracture Property – 25C
Semi-Circular Bend (SCB) Test

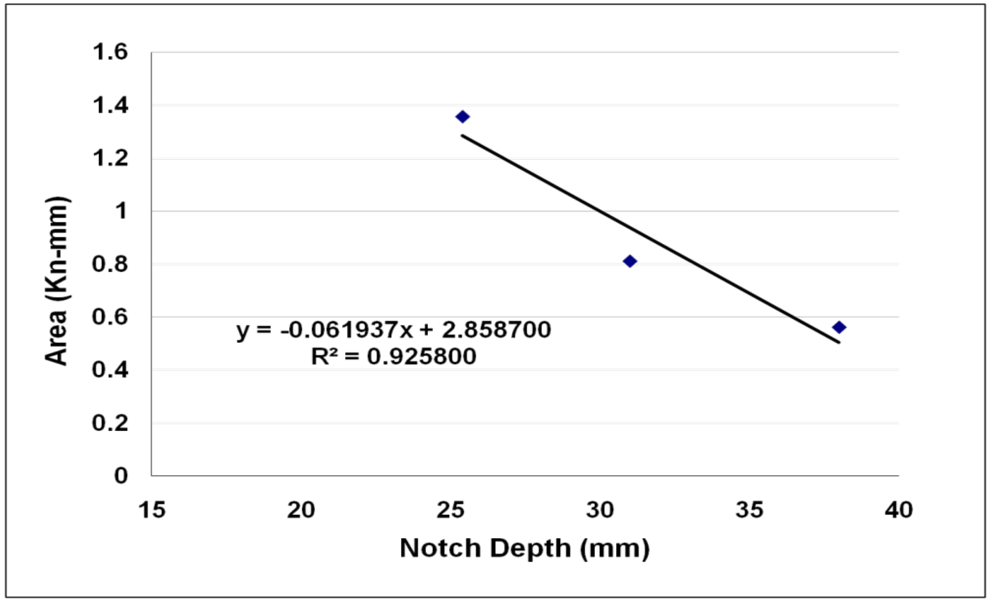
- **The critical value of fracture resistance**

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

Loading rate: 0.5 mm/min
Notch Depth (mm): 25.4, 31.8, 38.0
Test temperature: 25 ºC
Dimension: 150mm dia by 57mm wide

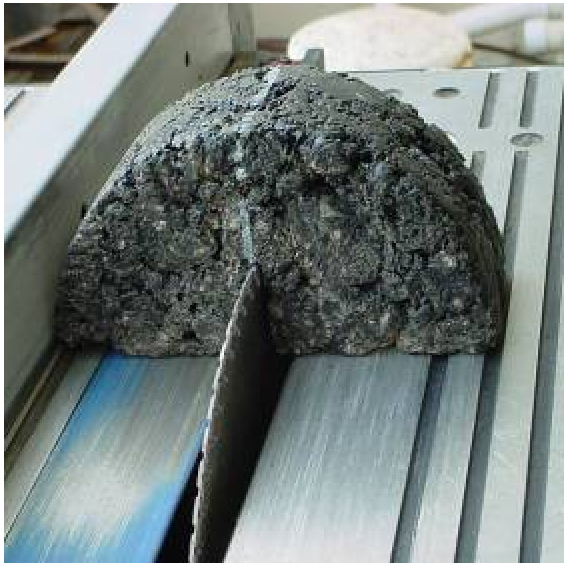
b = Sample Thickness,
a = notch depth,
U = strain energy to failure

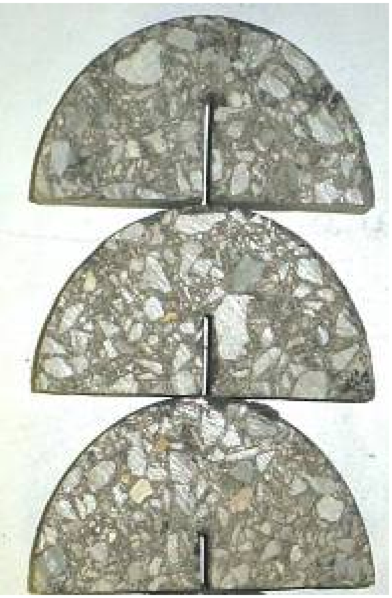




Fracture Property – 25C
Semi-Circular Bend (SCB) Test

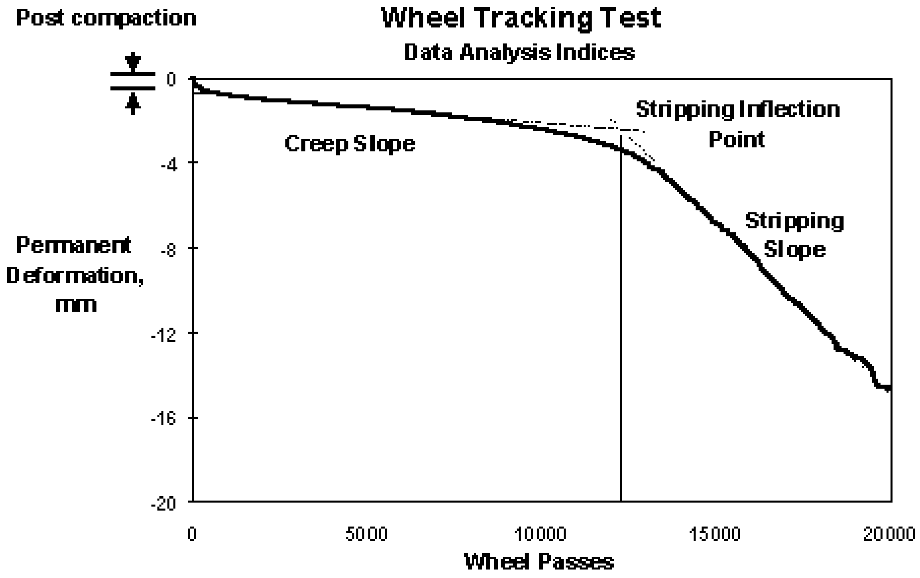
150mm x 57mm

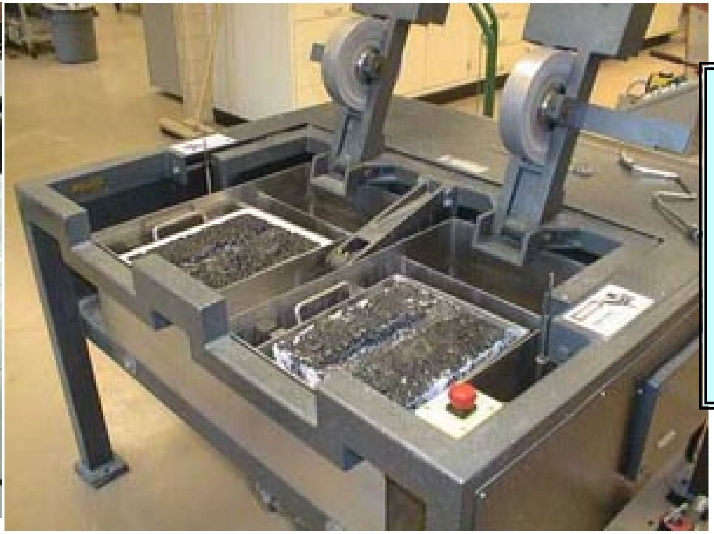




High Temperature Property – 50C Loaded Wheel Tracking Test

- AASHTO T 324
- Damage by rolling a steel wheel across the surface of a sample
  - Cylindrical, Slab
- 50 ^{o}C, Wet or dry
- Deformation at 20,000 passes is recorded





Wheel Diameter: 203.5 mm (8 inch)

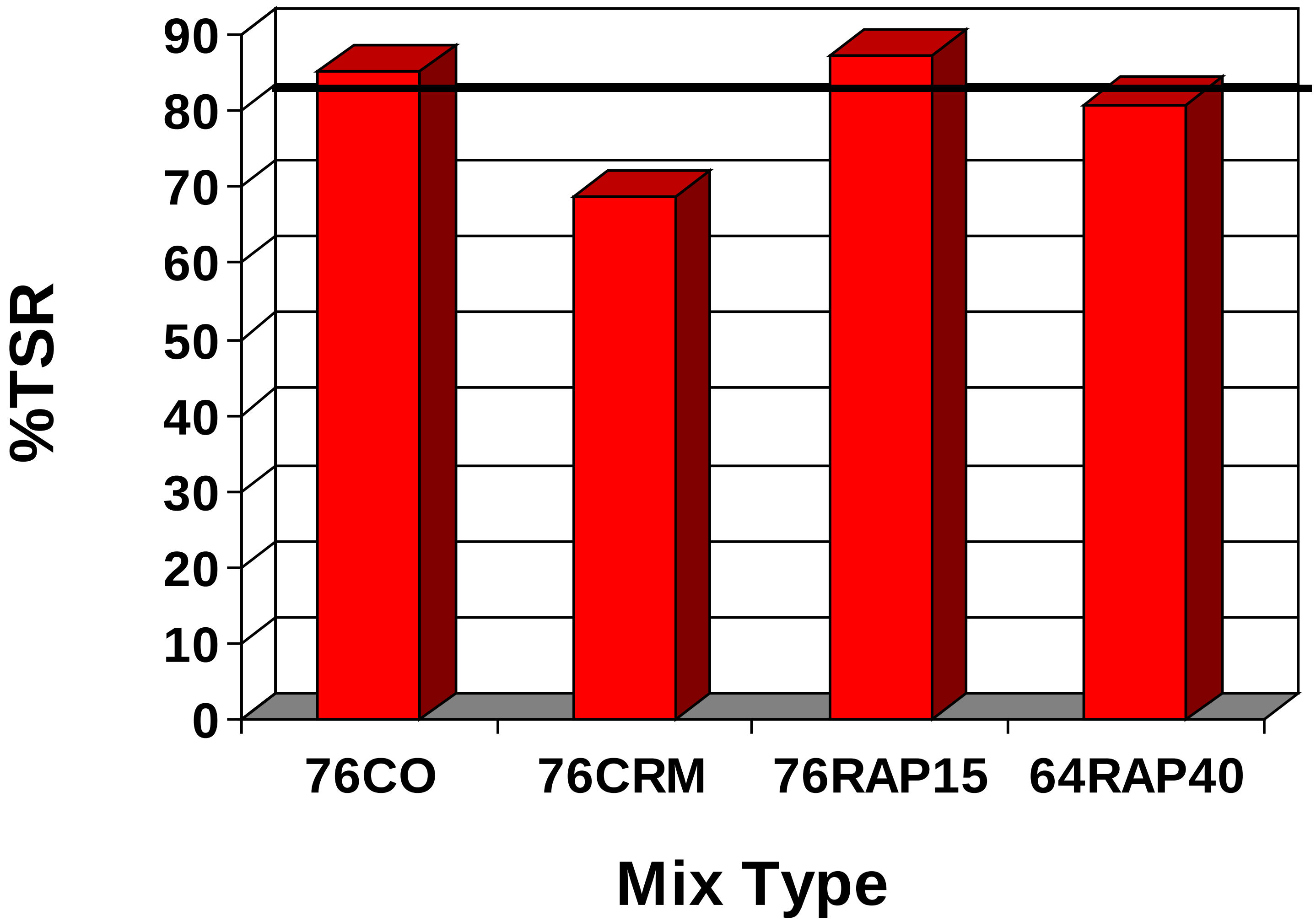
Wheel Width: 47mm (1.85 inch)

Fixed Load: 703 N (158 lbs)

Rolling Speed: 1.1 km/hr

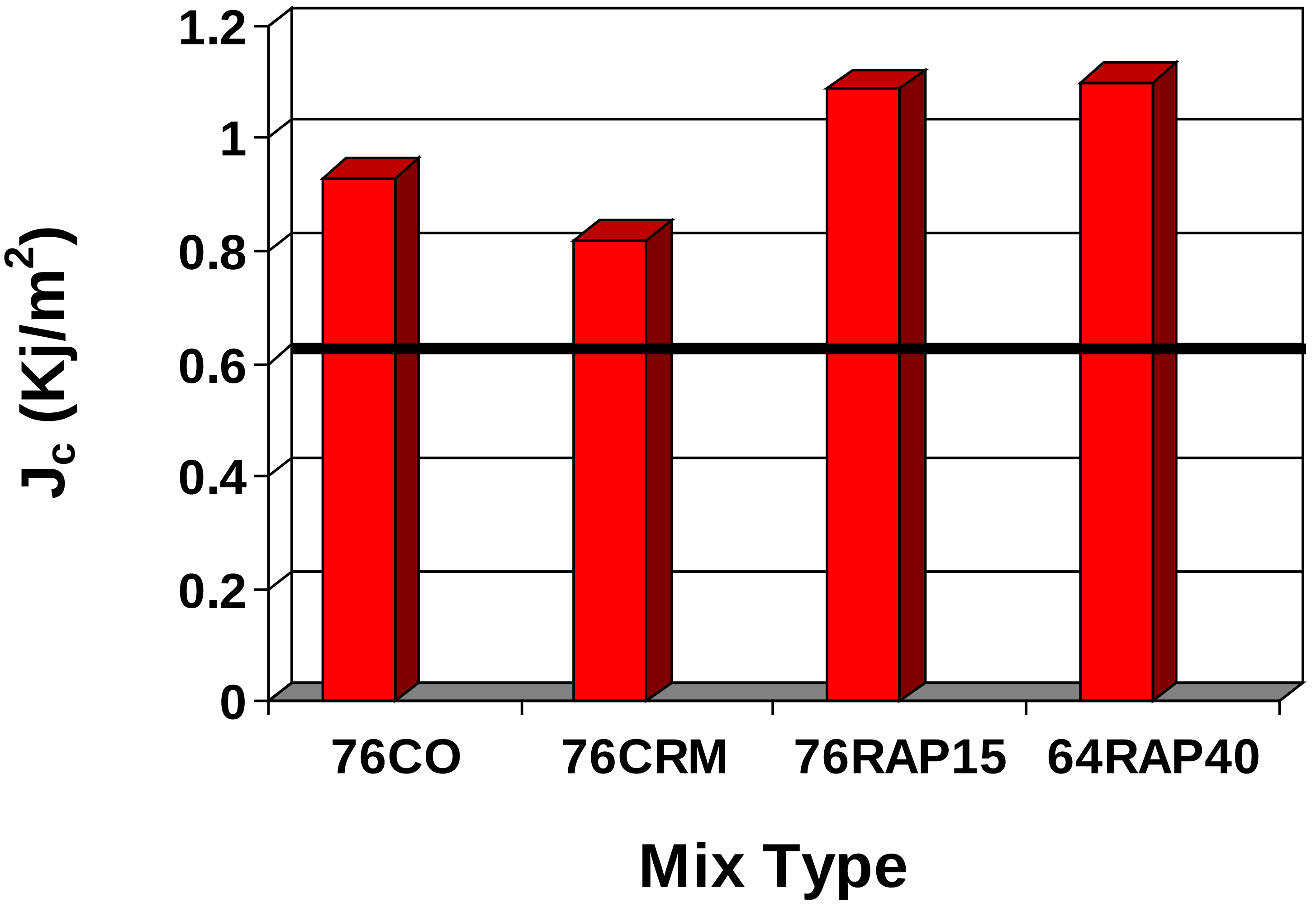
Passing Rate: 56 passes/min

Moisture Susceptibility Test Results -- %TSR
No Antistrip Additives

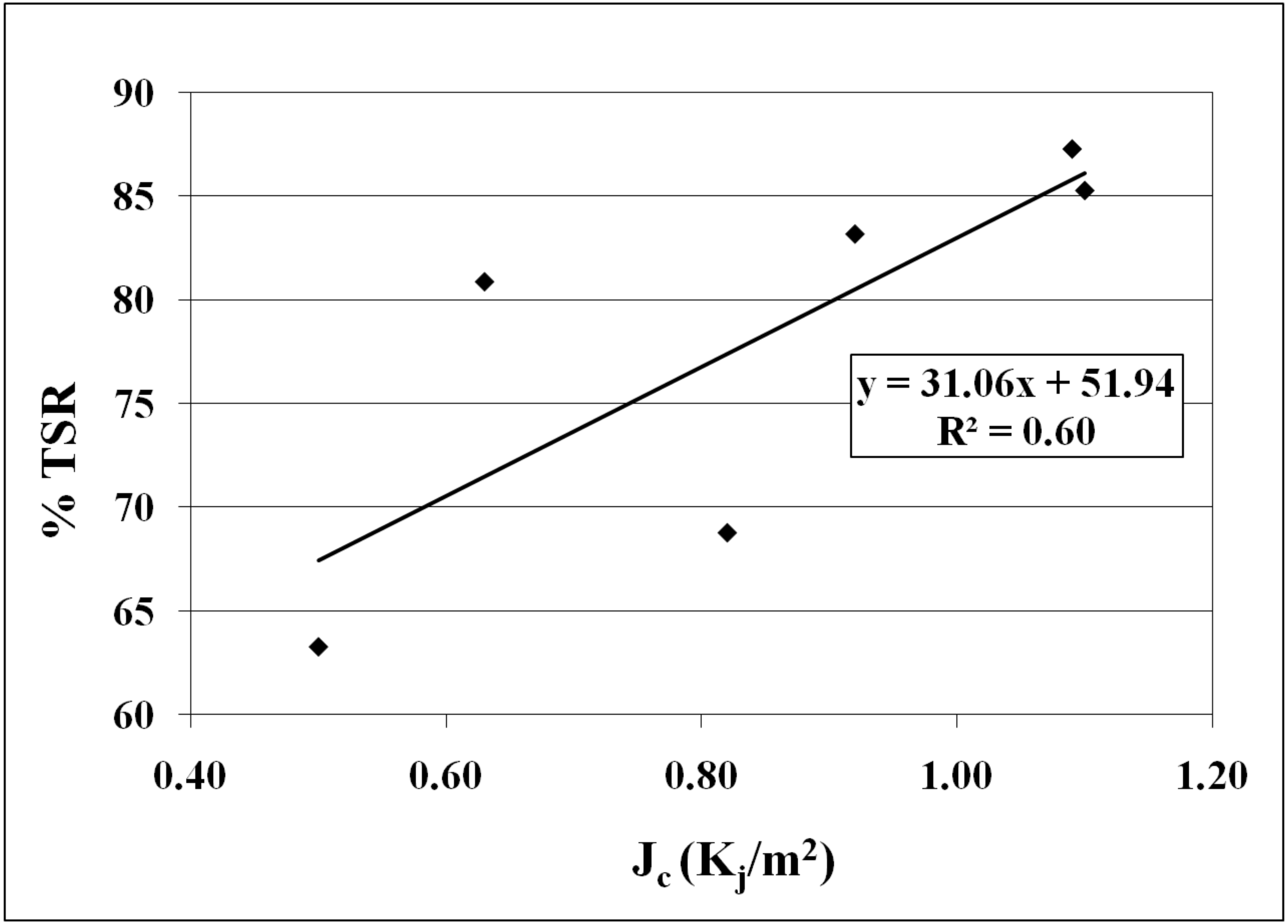


Dry ITS: 140Psi-150Psi

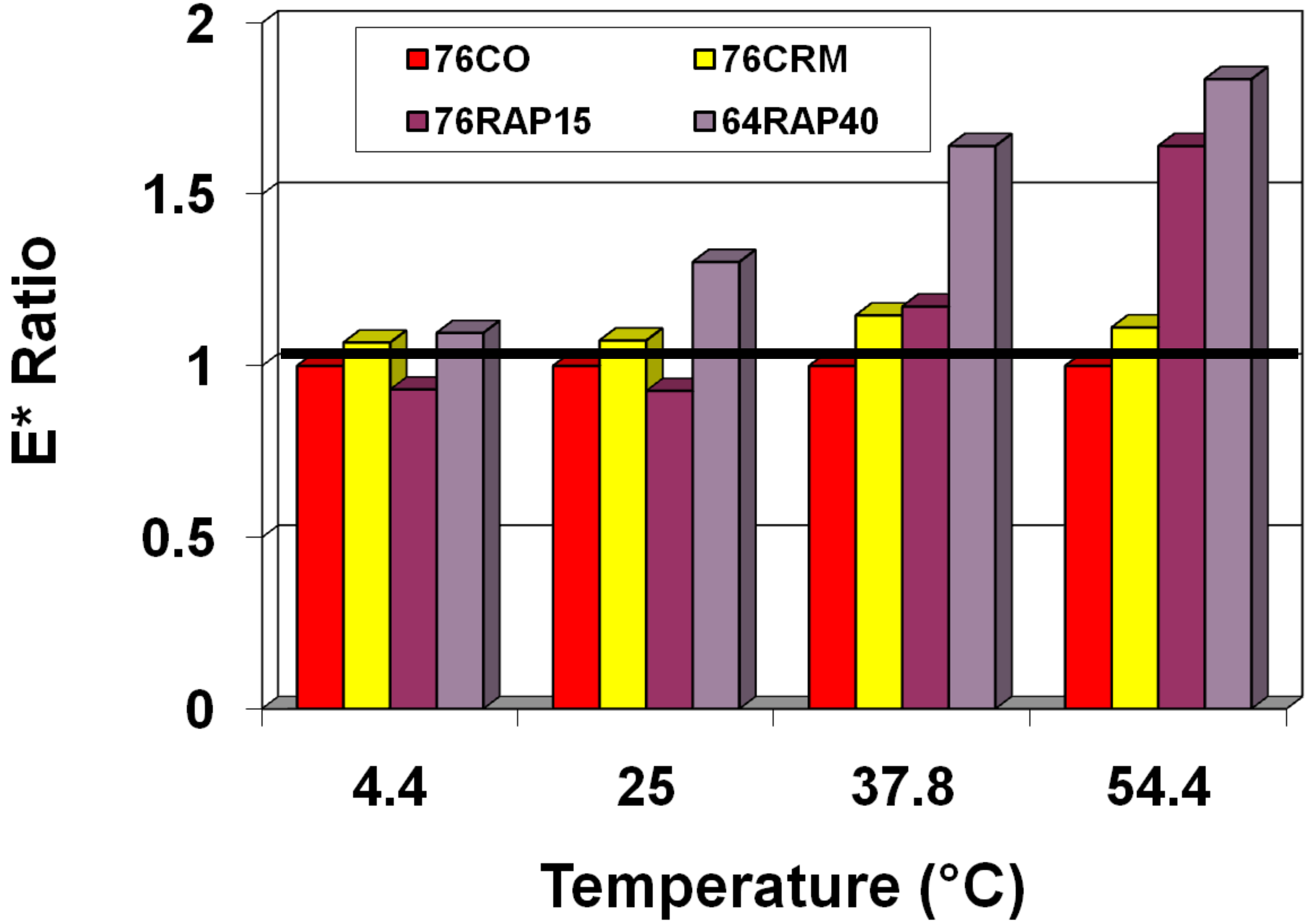
Fracture Property – 25C
Semi-Circular Bend (SCB) Test



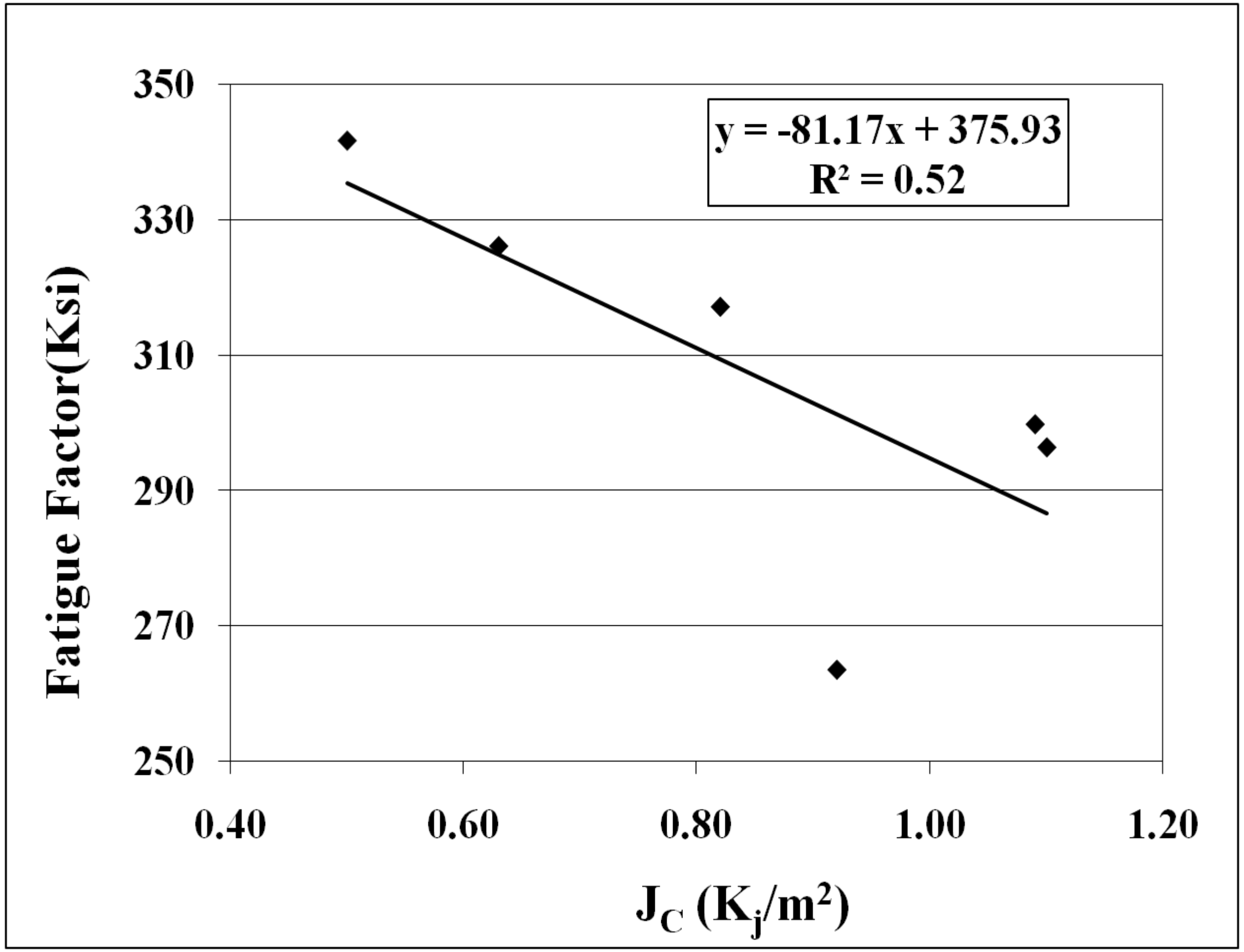
Correlation – TSR vs Jc



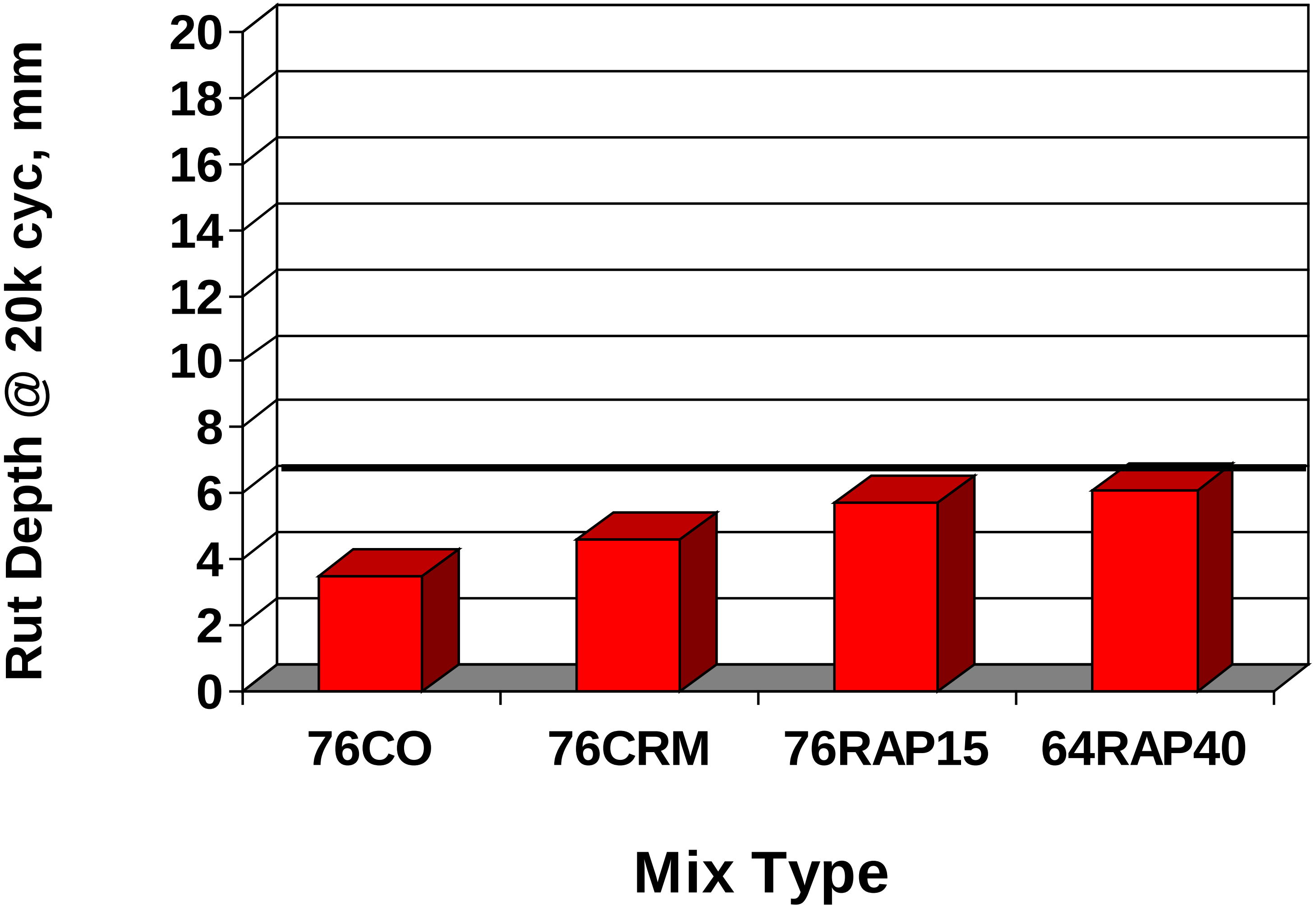
Complex Modulus Test Results – E* Ratio to PG 76-22M



Correlation -- Fatigue Factor vs J_c



High Temperature Property – 50C, Wet Loaded Wheel Tracking Test Results



Summary

- **Addition of CR additives had a positive influence on the asphalt cement binder and provide**
- ***Moisture Susceptibility***
  - **Mixtures 76CO, 76RAP15, 64RAP40**
  - **Passed with %TSR**
- **Intermediate Temperature**
  - **Critical Strain Energy, Jc from SCB test**
  - **Met the minimum value of 0.6 for fracture resistant mixtures**
- **High Temperature**
  - **Mixture performed well, < 6mm**
- **Fair Correlations**
  - **%TSR vs. Jc**
  - **E* fatigue factor vs. Jc**

Future Research

- Innovations that will maximize the use of CRM asphalt mixtures in flexible pavements.
  - Dry process feed systems;
  - Engineered asphalt-rubber system processed from waste tires that can be used in dry process for several applications such as:
    - Warm mix asphalt mixture;
      - Environmental and economical benefits
    - Allowing the use of higher percentages of RAP; and
    - Modifications of binder properties to improve the mixture resistance to moisture damage.
- Pavement thickness equivalency
    - between conventional mixes and CRM asphalt mixes
    - ensure cost competiveness of these mixes.


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Photo: Jim Zietz, Office of Public Affairs

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