LABORATORY PERFORMANCE OF ASPHALT MIXTURES CONTAINING RE-REFINED ENGINE OIL BOTTOMS (REOB) MODIFIED ASPHALT BINDERS

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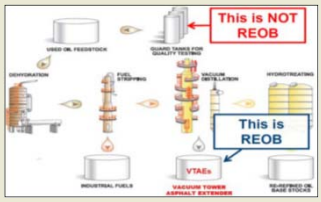
Outline

- Background
- Objective
- Scope
- Experimental Design
- Results
- Conclusions

Background

What is REOB?

- Re-refined Engine Oil Bottoms
- Or Vacuum Tower Asphalt Extender (VTAE)
- Non-distillable residuum from a vacuum tower
- Used as a softening agent with the increasing use of RAP/RAS



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Background

The effect of REOB ?

- Rutting susceptibility
- Moisture damage
- Fatigue performance
- Low-temperature (Thermal) cracking

Rutting

Fatigue Cracking

Stripping

Thermal Cracking

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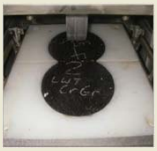
Objective

Evaluate the laboratory performance of asphalt mixtures containing REOB modified binders at low , intermediate, and high temperatures.

TSRST

SCB



LWT

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Scope:

- 12.5 mm NMAS Superpave Mixture
- Binders:
  - PG 70-22 M binder modified with 0%, 5%, 10%,15% REOB

Mixture Name	Percentage of REOB
0% REOB	0
5%REOB	5
10%REOB	10
15%REOB	15

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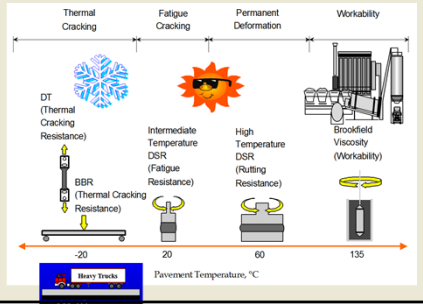
Experimental Design:

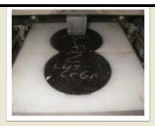
Binder Experiment

- **Performance Grading and ΔT_c**
  - 0%, 5%, 10% 15% REOB modified binders



Experimental Design:

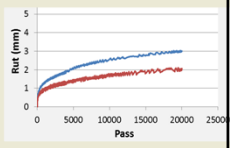
Mixture Experiment

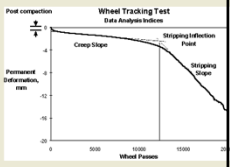


- **High temperature performance**
  - Hamburg Loaded Wheel Tracking (LWT)
  - AASHTO T 324
  - Rutting and moisture susceptibility
- **Intermediate temperature performance**
  - Semi-Circular Bend(SCB)
  - ASTM D 8044
  - Intermediate temperature Cracking
- **Low temperature performance**
  - Low temperature creaking
  - AASHTO TP 10
  - Thermal Stress Restrained Specimen Test (TSRST)

Hamburg Loaded Wheel Tracking Test – 50°C

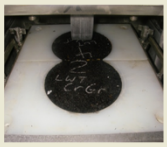
- AASHTO T 324
- Rolling steel wheel across the surface of a sample
- Specimen Geometry
  - Cylindrical: SGC ($\emptyset\ 150 \times 60\ mm$) or Core
  - Slab: 320- L, 260- W, and 80-mm thick
- Wet or dry
- Analysis
  - Deformation at 20,000 passes is recorded
  - Indices :
    - Rut Depth
    - Stripping Inflection Point (SIP)





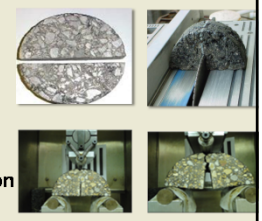
Specification of LWT Test:

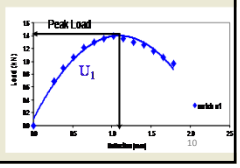
- Wheel Diameter: 203.5 mm (8 inch)
- Wheel Width: 47mm (1.85 inch)
- Fixed Load: 703 N (158 lbs)
- Rolling Speed: 1.1 km/hr
- Passing Rate: 56 passes/min



Semi Circular Bend (SCB) Test, 25C

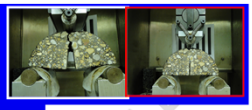
- ASTM 8044 / LADOTD TR 330
- Temperature: 25°C
- Half-circular Specimen
  - Laboratory prepared
  - Field core
  - 150mm diameter X 57mm thickness
  - simply-supported and loaded at mid-point
- Notch controls path of crack propagation
  - 25.4-, 31.8-, and 38.0-mm
- Aging: 5 days, 85°C
- Loading type
  - Monotonic
  - 0.5 mm/min
  - To failure
- Record Load and Vertical Deformation
- Compute Critical Strain Energy: J_c

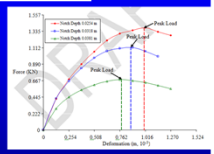


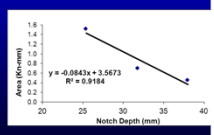


SCB Test – Analysis

- Apply load to specimen in displacement control
  - 0.5 mm/min (slow rate);
- Collect force and displacement
  - sampling rate of 10 Hz;
- Plot force versus displacement
- Compute U: area under the curve up to peak load
  - For each notch depth
- Plot notch depth versus the corresponding U
- Determine slope of the line (notch depth vs U graph)
- Compute Jc: slope of line ÷ sample thickness







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

Jc= critical strain energy release rate (kJ/m²);
b = sample thickness (m);
a = notch depth (m);
U = strain energy to failure (kilo-Joule, kJ); and
dU/da = change of strain energy with notch depth, KJ/m .

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 simple
- Testing time is around 10 minutes per specimen
- Ease of sample preparation
- Stress field resembles pure tensile conditions

Thermal Stress Restrained Specimen Test

- AASHTO TP 10
- Determine cracking susceptibility
  - low temperature
- Specimen Geometry :
  - Beam specimens
    - 250 × 50 × 50 mm
  - Circular specimen
    - Ø 50 × 250 mm
- LTA
  - AASHTO R 30
  - 5 days, 85°C

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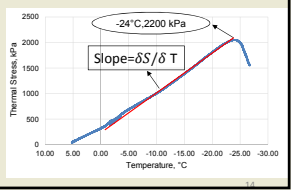
Thermal Stress Restrained Specimen Test

- Test
  - Condition specimen 5°C for 6 hours
  - Apply initial tensile load
  - Apply thermal loading 10 ± 1 °C/ hour
  - Continuously record
    - Load, displacement, temperature
- Output
  - Fracture temperature
  - Fracture strength

where:

$$\sigma_{ult} = \frac{P_{ult}}{A}$$

P_{ult} = ultimate tensile load at fracture
A = average cross-sectional area of specimen
- Slope of thermal stress curve
- Slope=$\delta Stress/\delta$ Temperature



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Test Results

LWT

SCB

TSRST

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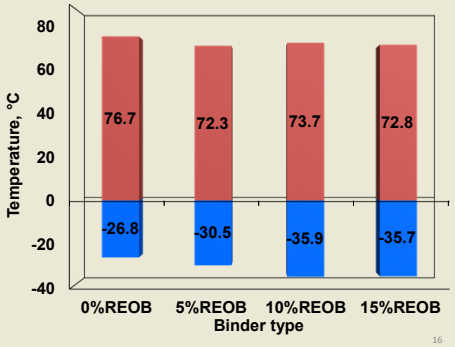
Performance Grade of Asphalt Binders



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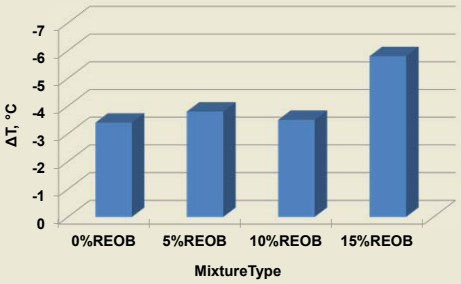
Performance Grade of Asphalt Binders



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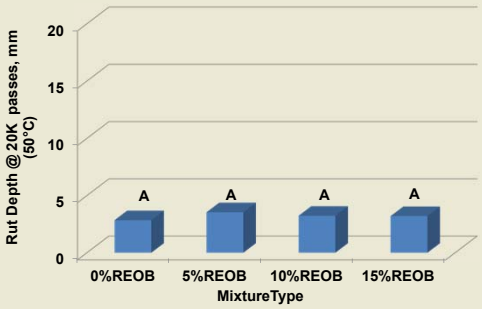
Hamburg Loaded-wheel Tracking Test Results



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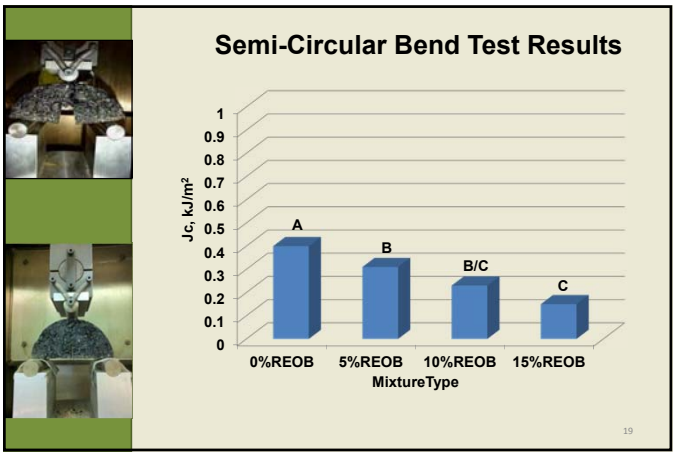

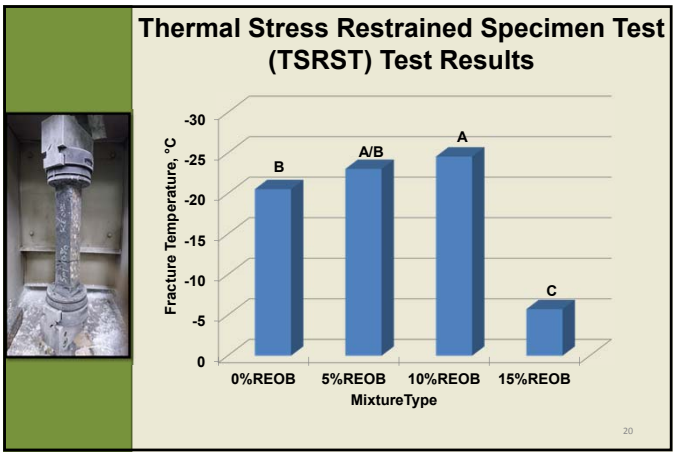

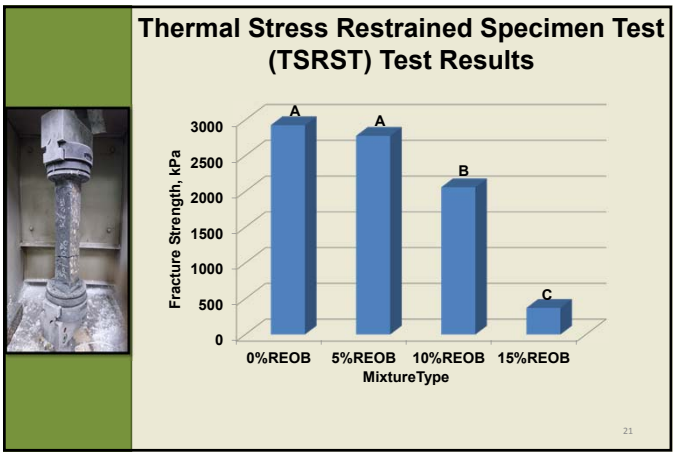

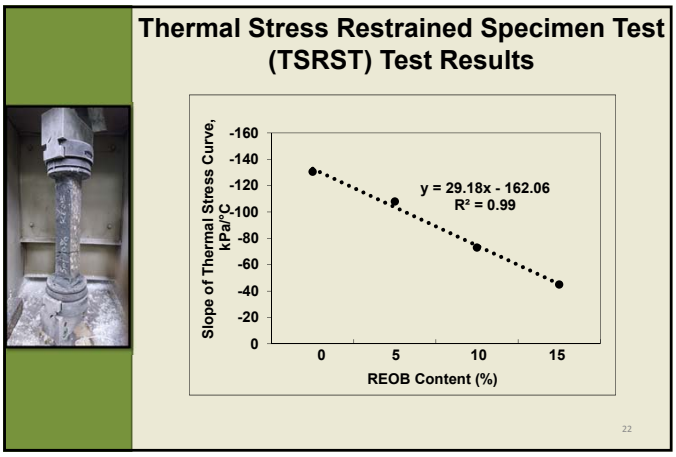

Laboratory Performance Test Results of

Mixtures containing various percentages of REOB

Mixture Type	High Temp (LWT)	Intermediate Temp (SCB)	Low Temp (TSRST)
0% REOB	A	A	B
5%REOB	A	B	A/B
10%REOB	A	B/C	A
15%REOB	A	C	C

Note: The letter A was assigned to the best performer followed by the other letters in appropriate order.

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Conclusion:

Laboratory performance of mixture containing REOB

- **High Temperature**
  - LWT rut depth
  - Rutting resistance:
    - Mixtures containing REOB = control mixture
    - Use of REOB did not adversely affect moisture susceptibility
- **Intermediate Temperature**
  - SCB J_c
  - J_c decreased with an increasing of REOB content
  - REOB negatively affected intermediate-temperature cracking resistance
- **Low Temperature**
  - TSRST fracture temperature
  - Similar low-temperature thermal cracking resistance exhibited with an increase of REOB content up to 10%
    - 15% REOB showed a reduction of low-temperature creaking resistance

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THANK YOU