Tests to Assess the Potential for Moisture Damage in Asphalt Mixtures

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Asphalt Institute Spring 2002 Meeting
Houston, TX
Moisture Damage Tests

- Pre-SHRP
  - Immersion-Compression Test
  - Boil Test
  - Texas Freeze-Thaw Pedestal Test
  - Swell Test (Hveem)
  - Lottman Test
  - Root-Tunnicliff Test
Moisture Damage Tests

Post-SHARP

- Environmental Conditioning System
- Modified Lottman Test
- Root-Tunnicliff Test
- Hamburg Wheel Tracking Test
Modified Lottman Test

- Standard Procedure
  - AASHTO T-283

- Specimen Size
  - 4-inch (100-mm) diameter; 2.5-inch (63-mm) height
  - 6-inch (150-mm) diameter; 3.75-inch (95-mm) height

- Percentage of Air Voids
  - Construction air voids
    - 7.0 ± 1.0%
Modified Lottman Test

- **Aging**
  - **Loose Mix**
    - 16 hours at 60C in forced draft oven
  - **Compacted Specimen**
    - 72-96 hours at ambient temperature (20-25C)
Modified Lottman Test

Specimen Conditioning (Conditioned Subset)

- Partial Vacuum Saturation
  - After compacted specimen aging
  - Initial saturation of 55-80%
Modified Lottman Test

Specimen Conditioning (continued)

- Freeze Cycle
  - 15 hours at -18°C
- Thaw Cycle
  - 24 hours at 60°C
Modified Lottman Test

Specimen Conditioning (All Specimens)
- Temperature Equilibration
  - 2 hours at 25C (water bath)
Modified Lottman Test

Mechanical Test
- Indirect Tensile Strength
  - 50 mm/min. displacement rate
  - Peak Load at Failure
Modified Lottman Test

Test Result

- Tensile Strength Ratio
  - Average Indirect Tensile Strength of Conditioned Specimens ($S_{t,wet}$)
  - Average Indirect Tensile Strength of Conditioned Specimens ($S_{t,dry}$)

$$TSR = \frac{S_{t,wet}}{S_{t,dry}}$$
**Modified Lottman Test**

- **Interpreting the Results**
  - TSR $\geq 0.80$
    - Acceptable resistance to moisture damage
  - Some agencies use TSR $\geq 0.70$ as criterion

- **Mix Adjustments for Poor TSR**
  - Liquid anti-stripping additives
  - Hydrated Lime
  - Change of aggregate/mix design
Root-Tunnicliff Test

- Standard Procedure
  - ASTM D4867

- Specimen Size
  - 4-inch (100-mm) diameter; 2.5-inch (63-mm) height
  - 6-inch (150-mm) diameter; 3.75-inch (95-mm) height

- Percentage of Air Voids
  - Construction air voids
    - 7.0 ± 1.0%
Root-Tunnicliff Test

- **Aging**
  - Loose Mix
    - None required
  - Compacted Specimen
    - None required (cool)

- **Specimen Conditioning (Conditioned Subset)**
  - Partial Vacuum Saturation
    - Initial saturation of 55-80%
Root-Tunnicliff Test

- Specimen Conditioning (continued)
  - Freeze Cycle
    - 15 hours at -18C (OPTIONAL)
  - Thaw Cycle
    - 24 hours at 60C

- Specimen Conditioning (All Specimens)
  - Temperature Equilibration
    - 2 hours at 25C (water bath)
Root-Tunnicliff Test

Mechanical Test

- Indirect Tensile Strength
  - 50 mm/min. displacement rate
  - Peak Load at Failure
Root-Tunnicliff Test

Test Result

- Tensile Strength Ratio
  - Average Indirect Tensile Strength of Conditioned Specimens ($S_{t,\text{wet}}$)
  - Average Indirect Tensile Strength of Conditioned Specimens ($S_{t,\text{dry}}$)

$$\text{TSR} = \frac{S_{t,\text{wet}}}{S_{t,\text{dry}}}$$
Root-Tunnicliff Test

Interpreting the Results
- TSR ≥ 0.80
  - Acceptable resistance to moisture damage
- Some agencies use TSR ≥ 0.70 as criterion

Mix Adjustments for Poor TSR
- Liquid anti-stripping additives
- Hydrated Lime
- Change of aggregate/mix design
Environmental Conditioning System (ECS)

- Standard Procedure
  - SHRP-developed (A-003A)
  - Oregon State University (Terrel et. Al.)

- Specimen Size
  - 4-inch (100-mm) diameter; 4-inch (100-mm) height

- Percentage of Air Voids
  - Construction air voids
Aging

- **Loose Mix**
  - 4 hours at 135C
- **Compacted Specimen**
  - None required (cool)
Specimen Conditioning and Testing

- Initial Resilient Modulus (uniaxial)
- Thawing Cycles (1+)
  - 60C
  - Repeated loading, Mr
- Freeze Cycle
  - Optional
  - Repeated Loading, Mr
Interpreting the Results

- Modulus Ratio
  - Multiple conditioning cycles
  - Accumulation of moisture damage
Loaded Wheel Tests

- **Test Temperature**
  - High Temperatures (40-60°C)
  - Conducted under water

- **Loading**
  - Repeated Wheel Passes
    - Pressurized rubber hose w/ wheel
    - Steel wheel
    - Pneumatic wheel
Asphalt Pavement Analyzer
Hamburg Wheel Tracker
Hamburg Wheel Tracking Test

- Rut Depth
- Load Cycles

- Stripping Slope
- Rutting Slope
- Inflection Point
Other Tests

ECS Conditioning w/ Mechanical Property Test

- ECS Conditioned
- Dry (Unconditioned)
Partial Vacuum Saturation w/ Mechanical Property Tests

Arizona US-93 Moisture Sensitivity

<table>
<thead>
<tr>
<th>Test</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSR Design</td>
<td>75%</td>
</tr>
<tr>
<td>TSR Field</td>
<td>80%</td>
</tr>
<tr>
<td>G*10Hz 20C</td>
<td>85%</td>
</tr>
<tr>
<td>G*10Hz 40C</td>
<td>90%</td>
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</tbody>
</table>

Test Results:
- TSR Design: 75%
- TSR Field: 80%
- G*10Hz 20C: 85%
- G*10Hz 40C: 90%
Thanks !