Rutting and Fatigue Performance Tests

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Advanced Asphalt Technologies, LLC
Outline

• What is a Performance Test
• Rutting and Fatigue Tests
  – Equipment
  – Time and Complexity
  – Standardization
  – Example Uses
• Needed Work
• Summary
What is a Performance Test?

• Test that indicates how a mix will resist a particular form of distress
  – Rutting
  – Cracking
    • Bottom-Up Fatigue
    • Top-Down
    • Reflective
    • Thermal Cracking
  – Moisture Damage
• Some are pass/fail, some are used in models
Rutting Performance Tests
Strength & Repeated Load

Wheel Tracking
- Hamburg
- Asphalt Pavement Analyzer

Flow Number
Flow Time
Repeated Shear
Constant Height
High Temperature
Indirect Tensile
Wheel Tracking Tests

Hamburg

Asphalt Pavement Analyzer
Wheel Tracking Test Standardization

- Hamburg
  - AASHTO T324, *Hamburg Wheel-Track Testing of Compacted Hot Mix Asphalt (HMA)*

- Asphalt Pavement Analyzer
  - AASHTO TP63 *Determining the Rutting Susceptibility of Hot Mix Asphalt Using the Asphalt Pavement Analyzer (APA)*
Strength and Repeated Load Tests

Flow Number
Flow Time

High Temperature
Indirect Tensile

Repeated Shear at Constant Height
Strength & Repeated Load Standardization

• Repeated Shear
  – AASHTO T320, *Determining the Permanent Shear strain and Stiffness of Asphalt Mixtures Using the Superpave Shear Tester (SST)*

• Flow Number
  – AASHTO TP79, *Determining the Dynamic Modulus and Flow Number for Hot Mix Asphalt (HMA) Using the Asphalt Mixture Performance Tester (AMPT)*

• Flow Time
  – Draft, but no AASHTO or ASTM

• High Temperature IDT
  – Draft, but no AASHTO or ASTM
Beyond Research

- Wheel track testing is part of mix design process in several states

- Leaders
  - APA in Georgia
  - Hamburg in Texas
IDT in Acceptance

- Port Facility Upgrade
  - 200,000 tons of HMA
  - Client extremely concerned about rutting
  - High temperature IDT used in acceptance
IDT Control Chart

Lot Value  Mean  2 Sigma  3 Sigma  Minimum

Tensile Strength, psi

Lot

NAPA 56th Annual Meeting
2/7/2011
Fatigue Performance Tests

Repeated Load
- Flexural Beam
- Continuum Damage
- Texas Overlay

Fracture Energy
- Indirect Tensile
- Disk-Shaped Compact Tension
- Semi-Circular Bend
- Fenix
Repeated Load Tests

Flexural Fatigue
Continuum Damage
Repeated Load Tests 2

Texas Overlay
Repeated Load Fatigue Standardization

- **Flexural**
  - AASHTO T321, *Determining the Fatigue Life of Compacted Hot Mix Asphalt (HMA) Subjected to Repeated Flexural Bending*

- **Continuum Damage**
  - Draft, but no AASHTO or ASTM

- **Texas Overlay**
  - TXDOT, but no AASHTO or ASTM
Fracture Energy Tests

Disk-Shaped Compact Tension Test

Indirect Tension Test
Fracture Tests Continued

Fénix Test

Semi-Circular Bend Test
Fracture Energy Standardization

• Disk-Shaped Compact Tension

• Indirect Tension
  – Draft, but no AASHTO or ASTM

• Semi-Circular Bend
  – Draft, but no AASHTO or ASTM

• Fénix
  – Spanish, but no AASHTO or ASTM
Beyond Research

• Flexural Fatigue was specified by CalTrans on I-710 project
  – Mix design

• Overlay Test was specified by NJDOT on a couple of projects
  – Mix design and acceptance
  – Tests conducted at Rutgers University

• Continuum Damage
  – Higher RAP Content mixtures
MSHA Field Project

- SMA With 10% RAP
- I-270 Near Washington Beltway
- RAP and Virgin Mixtures
- Evaluations
  - Modulus
  - Permanent Deformation
  - Continuum Damage Fatigue
Plant Aged Dynamic Modulus

E* (ksi)

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<th>Reduced Frequency, Hz</th>
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<td>1.E-04</td>
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<tr>
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Log Shift Factor

Temperature, C

-3  -2  -1  0  1

Without RAP

With RAP

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Test Development

Need
- Research
  - Draft Test Method
  - Prototype Equipment
  - Validated Criteria
- Commercial Equipment
  - Specification
  - First Article Equipment

Ruggedness
- Critical Aspects
- Improve
  - Test Method Equipment
- Round Robin Testing
  - Precision and Bias
- Engineering Practice
## Rutting Tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Validated Criteria or Model</th>
<th>AASHTO or ASTM Standard</th>
<th>Commercial Equipment</th>
<th>Precision Statement</th>
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<td>APA</td>
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<td>Flow Number</td>
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<td>Y</td>
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<td>Flow Time</td>
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<td>Repeated Shear</td>
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<td>Y</td>
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<tr>
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## Fatigue Tests

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<th>Precision Statement</th>
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<td>Flexural</td>
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<td>Continuum Damage</td>
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<td>IDT FE</td>
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<td>?</td>
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<td>Fénix</td>
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<td>N</td>
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Importance of Fabrication
NCHRP 9-29 ILS

Cores Fabricated in a Single Lab

8 Labs

9.5 mm Dense
12.5mm SMA
25 mm Dense

Loose Mix

Dynamic Modulus
Confined Flow
Unconfined Flow

Dynamic Modulus
Confined Flow
Unconfined Flow

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|E*| Reproducibility

- 9.5 mm Dense Loose Mix
- 12.5 mm SMA Loose Mix
- 25 mm Dense Loose Mix
- 9.5 mm Dense Cores
- 12.5 mm SMA Cores
- 25 mm Dense Cores

Reproducibility Coefficient of Variation, %

|E*|, MPa

Reproducibility Coefficient of Variation, %

100 1000 10000
Summary

• Several rutting and fatigue performance tests available
  – Mostly used in research and product evaluation
  – Some rutting tests are used in practice
  – Limited use of fatigue tests in practice

• Further development needed
  – Verification
  – Standardization
  – Precision
  – Specimen fabrication
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