Performance Testing of Asphalt Mixtures
Outline

• A few thoughts on developing performance tests
  – Yes we need ‘em.
  – Who’s on first?
  – Its like an onion.
  – A snapshot in time.
  – Proof’s in the pudding.

• Moisture Damage Susceptibility
• Thermal Cracking
• Top-Down Cracking
YES, WE NEED ‘EM
Uses of Performance Tests

- For Research Purposes
  - To evaluate new materials or design strategies
- As Part of Mix Design Process
  - To identify mixtures prone to performance problems
  - To gain confidence on Warranty projects
- For Quality Assurance Purposes
  - To assess how plant mix could impact performance and use in pay adjustment factors
WHO’S ON FIRST?
WHAT ARE THE MOST CRITICAL NEEDS?
What Are the Primary Modes of Distress?

Fictitious Example Data

Percent of Lane Miles Deficient for Each Mode of Distress
IT’S LIKE AN ONION
Stress Distributions in a Pavement

Each Layer in an Asphalt Pavement has Different Critical Stresses
IT’S A SNAPSHOT IN TIME
How to Deal with Healing?

Changes in asphalt properties with time
PROOF’S IN THE PUDDING
Performance Correlations

\[ y = 22817x^{-1.674} \]

\[ R^2 = 0.6742 \]
Relationship to Performance

<table>
<thead>
<tr>
<th>Test Result</th>
<th>Field Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fail</td>
<td>Type I Error</td>
</tr>
<tr>
<td></td>
<td>Contractor Suffers</td>
</tr>
<tr>
<td>Pass</td>
<td>Correct</td>
</tr>
</tbody>
</table>

Typologies:
- **Type I Error**: Contractor suffers while the true performance is good.
- **Type II Error**: Agency suffers while the true performance is good.
- **Correct**: True performance matches the test result.

Using Mix Properties in Performance Models

Calibration of TX-ME Fatigue Model Using the NCAT Test Track
OTHER PERFORMANCE TESTS
Moisture Damage Susceptibility

Small pothole with flushed binder on the surface – a sign of moisture damage.

A 1.5” overlay less than one year old that was placed on a layer that was weakened by moisture damage.
Moisture Damage Susceptibility

Cores showing moisture damage (stripping) in an underlying layer

Severe stripping – the asphalt binder is gone
Moisture Damage Susceptibility Tests

AASHTO T 283, Tensile Strength Ratio

AASHTO T 324, Hamburg Wheel Tracker
Hamburg Wheel Tracking Test

- Test combines rutting assessment with moisture susceptibility
- Load = 685 N (154 lb)
- Full test is 20,000 passes
- Temperature: 50 or 60 C
- Air Voids: 6 + 0.5%
- Tested under water

- ~ 2 days to complete

Hamburg Wheel Tracker capable of running two sets of specimens simultaneously

**Rut Depth vs. Number of Wheel Passes**

- **Consolidation**
  Even after compaction, the sample continues to consolidate for the first few wheel passes. \( \Delta V > 0 \)

- **Stripping Point**
  The sample begins stripping, which contributes to an increasing rate of rutting.

- Inverse stripping slope
- Slope is the inverse of creep.
Moisture Damage Susceptibility Testing

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Tensile Strength Ratio</th>
<th>Hamburg Wheel Tracking Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure is well established for mix design approval and verification of plant mix</td>
<td>1 week to complete the test</td>
<td>Specified by a few states and used by numerous researchers</td>
</tr>
<tr>
<td>Precision statistics unknown, suspected to be poor</td>
<td>Pass/Fail criteria on TSR</td>
<td>1 to 2 days to complete test</td>
</tr>
<tr>
<td>Pass/Fail criteria on TSR</td>
<td>Some states also have minimum conditioned tensile strength</td>
<td>$60,000 equipment cost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Precision statistics unknown, suspected to be poor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pass/Fail criteria on SIP</td>
</tr>
</tbody>
</table>
Top-Down Cracking

Wheelpath cracking – but the cracks do not go all the way through the pavement.

Core showing that the crack is limited to the top layer or two.
Three IDT tests are performed on each specimen:
1. Creep compliance
2. Resilient modulus
3. Tensile strength

Results of those three tests are used to calculate the Dissipated Creep Strain Energy (DCSE)
Energy Ratio Validation in Florida

DCSE_{HMA}<0.75

DCSE_{HMA}>2.5
Many cracks that are evident on the surface are caused by cracks or joints in the underlying pavement.
The Texas Overlay Tester is a self contained device

Specimens prepared for testing
Texas Overlay Tester

TTI Method

\[ y = -23.223 \ln(x) + 83.765 \]

\[ R^2 = 0.9919 \]
Thermal Cracking

- The most prevalent form of distress in cold weather climates
- Caused by contraction during temperature drops
- Cracking begins at the surface

Thermal cracks typically go across the pavement
Indirect Tensile Creep Compliance and Strength Test (AASHTO T 322)

- Specimens cut from SGC cylinders
- 0°, -10°, -20° C
- Creep test: apply constant load for 1000 sec., measure strain
- Compliance is the inverse of stiffness
- Strength Test: vertical displacement

Setting up a specimen for the IDT Creep Compliance Test
Semi-Circular Bend (SCB) Test

- Recommended by Univ. of Minnesota in TPF-5(080) & TPF-5(132) Pooled Fund Studies
- Two parameters are generated: fracture toughness and fracture energy
Thermal Stress Restrained Specimen Test (TSRST)

Specimen with acoustic emission sensors

TSRST test system

Specimen with strain extensometers
Summary

• Numerous “performance tests” are available for each type of asphalt pavement distress
• More research is needed to validate tests and establish their repeatabilities
• Implementation of performance tests will require substantial investments in equipment and training
Performance testing is the art of molding materials we do not wholly understand... into shapes we cannot precisely analyze, so as to withstand forces we cannot assess, in such a way that the community at large has no reason to suspect our ignorance.

Source unknown