Performance Testing: A Path to Implementation
Why do we need 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 and Design-Build projects
Why do we need performance Tests

- 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 Aging?

Changes in asphalt properties with time
Proof’s in the Pudding
NCAT TEST TRACK
Performance Correlations

Flow Number vs Rutting Rate

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

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

<table>
<thead>
<tr>
<th>Test Result</th>
<th>Field Performance</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pass</td>
<td>Good</td>
<td>Correct</td>
</tr>
<tr>
<td>Fail</td>
<td>Good</td>
<td>Type I Error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Contractor Suffers</td>
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<tr>
<td></td>
<td>Bad</td>
<td>Correct</td>
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<tr>
<td></td>
<td></td>
<td>Type II Error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Agency Suffers</td>
</tr>
</tbody>
</table>
Using Mix Properties in Performance Models

Calibration of TX-ME Fatigue Model Using the NCAT Test Track
Performance Tests
Rut Resistance
Flow Number ($F_N$) Test

- Air voids (7%)
- Deviator stress (70 – 100 psi)
- Confining pressure (0 - 10 psi)
Performance Testing of HMA

Flow Number Test (cont.)

- Primary: strain rate decreases with loading time
- Secondary: strain rate is constant with loading time
- Tertiary: strain rate increases with loading time
- Lower flow number should correspond to greater rutting
Asphalt Pavement Analyzer
Bending Beam Fatigue Test

Deflection is measured at the center of the beam.

Beam will fatigue here.

Clamp

Clamp

Clamp

119 mm  119 mm  119 mm

380 mm
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.
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
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

AASHTO T 283, TENSILE STRENGTH RATIO

- Procedure is well established for mix design approval and verification of plant mix
- 1 week to complete the test
- Precision statistics unknown, suspected to be poor
- Pass/Fail criteria on TSR
- Some states also have minimum conditioned tensile strength

AASHTO T 324, HAMBURG WHEEL TRACKING TEST

- Specified by a few states and used by numerous researchers
- 1 to 2 days to complete test
- $60,000 equipment cost
- Precision statistics unknown, suspected to be poor
- Pass/Fail criteria on SIP
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.
TTI Method

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

\[ R^2 = 0.9919 \]
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)

TSRST test system

Specimen with strain extnsometers

Specimen with acoustic emission sensors

amec
M-E Pavement Design

Climate → Materials → Structure

Traffic

Response

Damage Accumulation

Damage

Time

Distress
Dynamic Modulus ($|E^*|$)

Performance Testing of HMA
Specimen for E* Test

150 mm by 100 mm, cored from SGC specimen
Numerous “performance tests” are available for each type of asphalt pavement distress
More research is needed to validate tests and establish their repeatability
Implementation of performance tests will require substantial investments in equipment and training
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.