Two New Practical Tests for Durability of Asphalt Binders

Haleh Azari, Ph.D.
Alaeddin Mohseni, Ph.D.
Pavement Systems, LLC
For AASHTO COMP Meeting, TS 2b
Aug 7, 2018
Testing Package

Hardware/Software Tool that provides quick and reliable estimates of:

1. Low-Temperature PG and  
2. Fatigue Property of Liquid Binder
iCCL™
incremental Creep for Cracking at Low Temperature
iCCL
Creep Loading on DSR at Low Temperature

- DSR:
  - 8 mm plate, 0.5 mm Gap
- Material:
  - RTFO/PAV
- Loading:
  - Constant Creep for 60 seconds
- Low Temperature:
  - Multi Temperatures or a Fixed Subzero Temperature
- Parameters:
  - Low-Temperature PG
  - Duration: 30 Minutes
  - Correlated to Mixture and Composite Binder
Comparing iCCL to BBR True Grades

True LT PG using BBR and iCCL for 40 Ohio Binders

\[ y = 0.9917x \]
\[ R^2 = 0.9225 \]
Example of iCCL Verification
Low-Temperature PG of Idaho PG 58-28 Binders

![Graph showing iCCL Low Temperature PG for Idaho DOT Binders]
Verification of iCCL using around 500 Binders from 23 Agencies

15 State DOTs: SC, NC, OK, MD, CO, MS, MN, WA, VA, WV, OH, NE, ME, FL, ID

3 Suppliers: Holly Frontier, Ergon, USOil

3 National: AASHTO AMRL, FHWA ALF, MnRoad

2 International: MTO, Swedish Road Authority
iCCL for Original Binder (ongoing)

- Model is being developed to estimate low-Temperature PG from iCCL test of original binder
- So far, 182 binders from 15 state DOTs including 23 binder grades tested
- Model Standard Error of Estimate is 1.0°C
- 98% of LT PG estimates were within 2°C of True PG
- Potential for quick screening
A round robin study was conducted involving four laboratories:

- Anton-Paar Graz, Austria
- Anton-Paar Stuttgart, Germany
- Anton-Paar USA
- Pavement Systems LLC

C.V. of 1.5% was reported
## Comparison of iCCL™ Test with BBR

<table>
<thead>
<tr>
<th>Test Features</th>
<th>BBR</th>
<th>iCCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Prep. and Testing/ Sample</td>
<td>One and half hours</td>
<td>30 minutes</td>
</tr>
<tr>
<td>True Grade</td>
<td>Requires Two Tests</td>
<td>By One Test</td>
</tr>
<tr>
<td>Technician Time/ Sample</td>
<td>One hour</td>
<td>5 minutes</td>
</tr>
<tr>
<td>Test Variability</td>
<td>7%</td>
<td>2%</td>
</tr>
<tr>
<td>Calibration Check</td>
<td>Every Day</td>
<td>Every 3 months</td>
</tr>
<tr>
<td>Use of Hazardous Liquids</td>
<td>Coolant</td>
<td>None</td>
</tr>
<tr>
<td>Testing Original Binder</td>
<td>N/A</td>
<td>Possible</td>
</tr>
<tr>
<td>Air Pressure</td>
<td>Yes</td>
<td>None</td>
</tr>
<tr>
<td>Sample Storage Limit</td>
<td>Two hours</td>
<td>None</td>
</tr>
<tr>
<td>Molding/Demolding</td>
<td>Required</td>
<td>None</td>
</tr>
</tbody>
</table>
UPFiT
Fatigue Test at Intermediate Temperature
Principles of Binder Fatigue Test

1. Fatigue Cracking means:
   • Fatigue due to Repeated Load (Not monotonic load)
   • Test should be carried to fatigue cracking

2. Loading rate should be similar to the field

3. Should include rest period

4. Damage rate should be similar to the field

5. Test should be conducted at Intermediate Temperature which is the material critical fatigue temperature
UPFiT
Repeated Load Test on DSR at Intermediate Temperature

- DSR:
  - RTFO/PAV
  - 8 mm plate, 0.5 mm Gap
- Loading:
  - 0.1 s load / 0.9 s rest
  - 60 cycles/increment
- Temperature Sweep:
  - Start at Midpoint PG,
  - Increase 1°C to reach Failure
- Parameters:
  - Fatigue Index= Permanent Strain rate at failure (m*)
  - Intermediate Temperature= Temperature at failure
- Duration: 30 Minutes
- Correlated to Elastic Recovery
- Determines Level of Modification
- Variability of test (C.V. 6%)
ALF Extracted Binder Fatigue Index (FI)

\[ y = 30.633e^{0.5572x} \]

\[ R^2 = 0.8697 \]
Elastic Recovery vs. Fatigue Index

- Fatigue Index (FI) has the same scale as ER (0 to 100) and has good correlation with ER.
- Figure shows the fit for four sources of data:
  1. Colorado DOT binders (2)
  2. Washington State (4)
  3. AMRL Proficiency Samples (2)
  4. Idaho binders (34)
- ER and FI showed good agreement for PASS/FAIL criteria.
- FI shows level of modification more accurately and precisely than ER.
Sample Preparation and Testing

1. Open the can
2. Measure 31 mg of binder
3. Place it on the plate
4. Click on Start button
5. Get Low-Temp. PG in 30 minutes
6. Get fatigue index (Elastic Recovery) in additional 15 minutes
7. All Calculations are done by the software
Sample Mounting & Cleaning

• All user has to do is to place the sample on the plate
• UPTiM® Software performs the mounting automatically, no manual trimming
• Fast and easy cleaning since sample is small, no solvent is required
Ranking of MnRoad Binders by Fatigue Index

<table>
<thead>
<tr>
<th>Binder</th>
<th>64E-34</th>
<th>58H-34</th>
<th>58H-34 AS</th>
<th>64S-22</th>
<th>52S-34</th>
</tr>
</thead>
<tbody>
<tr>
<td>HT PG</td>
<td>67.7</td>
<td>62.6</td>
<td>63.3</td>
<td>64.6</td>
<td>54.9</td>
</tr>
<tr>
<td>LT PG</td>
<td>-38.5</td>
<td>-37.6</td>
<td>-37.3</td>
<td>-24.7</td>
<td>-38.4</td>
</tr>
<tr>
<td>Fatigue Index</td>
<td>61.3</td>
<td>50.2</td>
<td>49.4</td>
<td>27.8</td>
<td>27.4</td>
</tr>
</tbody>
</table>

UPTiM PG and Fatigue Index for MnDOT Binders
Ranking of Ohio Binders by Fatigue Index (Comparison of PPA and SBS)
Example of Fatigue Index of Unmodified Binders
Idaho PG 58-28
Example of Fatigue Index of Modified Binders

Idaho PG 70-28

High and Low PG and Elastic Recovery for Idaho Binders

<table>
<thead>
<tr>
<th>PG</th>
<th>7-06</th>
<th>7-07</th>
<th>5-48</th>
<th>5-47</th>
<th>7-07</th>
<th>5-44</th>
<th>6-46</th>
<th>6-47</th>
<th>6-44</th>
<th>6-45</th>
<th>5-45</th>
<th>6-47</th>
<th>6-47</th>
<th>6-46</th>
<th>6-38</th>
<th>6-38</th>
<th>7-09</th>
<th>6-38</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>7</td>
<td>5</td>
<td>3</td>
<td>8</td>
<td>7</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>8</td>
<td>3</td>
<td>1</td>
<td>9</td>
<td>6</td>
</tr>
</tbody>
</table>

- **Average of True HT PG - 70-28**: 73 74 73 73 73 73 72 72 73 72 73 72 72 73 72 72 73 73 72 72 72 73
- **Average of True LTPG - 70-28**: -32 -32 -30 -30 -33 -30 -31 -29 -29 -31 -30 -29 -30 -29 -30 -30 -31 -29
- **Average of ER - 70-28**: 89 85 82 82 81 81 81 80 80 60 60 80 79 79 79 78 78 76 74
Summary

- Using iCCL test, low-temperature grade of asphalt binder, identical to BBR, is determined in 30 min from RTFO/PAV with 3 time more precision than BBR.
- iCCL test on original binder could provide a quick estimate of LT PG within 2 °C (same accuracy as BBR).
- iCCL provides the true LT grade by testing one sample.
- UPFiT fatigue test is simple, fast, and reliable alternative to Elastic Recovery.
- iCCL and UPFiT tests have been verified by testing hundreds of asphalt binders from 23 different agencies.
Continued Verification

- Pavement Systems LLC will continue verification of iCCL and UPFiT tests
- An oz. of your PAV and original binders will help in the verification
- Please let us know if you can send us materials
U.S. Round Robin of iCCL Test

• Limited number of iCCL package (MCR 72 and software) will be available for short term loans late Fall through Winter
• Please let us know if you are interested to participate in the round robin and try iCCL to test your binders
• iCCL availability date for purchase: February 2019
Questions?

Contact:
Dr. Haleh Azari, President
Pavement Systems LLC
6105 Maiden lane
Bethesda, MD 20817
(202) 286-0148
azari@pavesys.net

www.pavesys.net