The I-FIT Method Workshop

Illinois Bituminous Conference
December 12th, 2016

The I-FIT Method

Mixture Performance Spectrum

Soft  Rutting Resistance  Cracking Resistance  Stiff
Workshop Objectives

- Attendees shall be able to:
  - Process material
  - Prepare test specimens
  - Operate major testing equipment
  - Analyze and report test data

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Definitions

- **Flexibility Index (FI)**
  - Quantification of an asphalt mixture’s damage resistance and cracking potential. A higher flexibility index results in more resistance to damage. The flexibility index is calculated using the fracture energy, the post-peak slope, and the ligament area.

- **Fracture Energy (FE)**
  - $G_f$ is the energy required to develop a unit surface area of cracking.

- **Post-Peak Slope (m)**
  - The tangential slope at the first inflection point past the peak load in the load-displacement curve.

- **Ligament area ($a_{lig}$)**
  - The cross-sectional area of the specimen which the crack propagates through, calculated using the ligament length and the specimen thickness.

- **Ligament Length**
  - The length between the tip of the specimen notch and the top-most point of the specimen.
Dimensions

SCB Testing

Step 1 → Step 2 → Step 3 → Step 4 → Step 5

Step 6 → Step 7 → Step 8 → Step 9 → Step 10
Equipment

Loading Device – Testing Fixture – Data Acquisition

Loading Device

- Servo-hydraulic or screw-driven
  - Minimum resolution of 5 N
Testing Fixture

- Method A or Method B
  - 25 mm diameter steel rollers
- 120 mm apart

Data Acquisition

- Minimum of 20 Hz
- Internal or external displacement measurement
  - At least 0.01 mm precision
- Must allow feedback to control displacement rate at 50 mm/min
Compaction

Sampling

- Important for ensuring proper representation of test results
- Segregation should be avoided
- Re-blend and split material into approximately 6800g for each compaction
Compaction

- Cylinders compacted per Illinois Modified AASHTO T312
  - Material transfer into mold
- 160 mm ± 1 mm high
  - 115 mm if 160 mm too high
  - ± 8 for field cores
- 150 mm ± 1 mm diameter
- 7.0 ± 1.0% air void target on slice using AASHTO 269
  - Densification

Fabrication
Fabrication

- Diamond-impregnated blades
- Wet saws
- Saw speed
- Three primary cuts:
  - Slicing
  - Halving
  - Notching
Fabrication Equipment

Slicing

- Two 50 mm ± 1 mm slices from center of each 160 mm high cylinder
  - For field cores, 25 to 50 mm slices
Air Void Verification

- After slicing, specimens to be dried
  - Air dry or core dry
- Verify air voids are $7.0 \pm 1.0\%$ on slice per Illinois Modified AASHTO T269 and T166
- If air voids insufficient, recompact

Halving

- Halve each slice to create semi-circles
- Avoid placing notch in stone > 9.5 mm on both sides
Notching

- Notches are to be $15 \pm 1$ mm in length and $1.5 \pm 0.1$ mm in width
- Use of jig is recommended to ensure proper notch

Dimensioning
Dimensioning

Three dimensions of interest:
- Notch depth — 3 measurements to the nearest 0.1 mm
- Ligament length — 2 measurements to the nearest 0.5 mm
- Thickness — 2 measurements to the nearest 0.5 mm

Conditioning
Conditioning

- Approved methods:
  - Water bath
  - Oven
  - Temperature chamber

- Stagger specimens

- Specimens must be conditioned prior to testing
  - 2 hours ± .5 hours conditioning
  - 25 ± 0.5 °C

Testing
Test Procedure

- Initial contact load of 0.1 kN
- Ramping of loading at 50 mm/min
- Unloading until 0.1 kN
- Ensure symmetrical loading of specimen

Data Analysis
Data Analysis

- Four specimens tested, three selected

![Graph showing load vs. displacement with various points labeled: Peak Load, Fracture Energy, Slope at Inflection Point, Critical Displacement, and Wj.]

Data Analysis

- Select *I-FIT Data Analysis* from the drop-down menu at the top
- Select *QA/QC Version (recommended)* option
- Input the *Project ID* and the *Specimen ID* into the appropriate text boxes
- Mix Information is input into the *Mix* section and *Geometric Information*
- Click *Start*
Data Analysis

- Click **Upload Data** to display pop up window
- Verify Project ID, Specimen ID, Dimensions

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Data Analysis

- Verify that data input file meets requirements of software for processing:

<table>
<thead>
<tr>
<th>Point #</th>
<th>Time</th>
<th>Load</th>
<th>Displacement 1</th>
<th>Displacement 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data point 1</td>
<td>Data point 1</td>
<td>Data point 1</td>
<td>Data point 1</td>
<td>Data point 1</td>
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<tr>
<td>Data point 2</td>
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<td>Data point 3</td>
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</tr>
</tbody>
</table>

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Data Analysis

- Select the desired data file for analysis

Data Analysis

- Load vs. displacement curve is plotted
- Post-peak slope is selected
- Smooth curve desired
Data Analysis

- Output files automatically saved after user clicks Yes
- Saved to same file location as input file

Data Analysis: Batch Analysis

- Multiple files can be analyzed at once for efficiency
- Click the Batch Analysis button
Data Analysis: Batch Analysis

- Select all files to be analyzed

Data Analysis: Batch Analysis

- Input Project ID, Specimen ID’s, Ligament Length, and Thickness for each specimen
- Click *Start Analysis*
Data Analysis

- Various files saved automatically in selected location
  - .png
  - .txt
  - .xls
  - .fig

.png

- Screen capture of load-displacement curve and calculated parameters
  - Fracture Energy
  - Strength
  - Slope
  - Flexibility Index
.txt
- Log of test, detailing things such as volumetric properties and remarks regarding the experiment

.x1s
- A modified data file displaying Project ID and Specimen ID
Statistical Analysis

- All load-displacement curves can be plotted together using this feature

Statistical Analysis

- Select all .xls files to be plotted
Statistical Analysis

- Save multi-specimen plot screen capture

Results
Fracture Energy

- Calculated using the expression:

\[ G_f = \frac{W_f}{Area_{jig}} \]

where:
- \( G_f \) = fracture energy (Joules/m²)
- \( W_f \) = work of fracture (Joules)
- \( Area_{jig} \) = ligament area (r-a)*t, (mm²)
- \( r \) = specimen radius (mm)
- \( a \) = notch length (mm)
- \( t \) = specimen thickness (mm)

Flexibility Index

- Calculated as follows:

\[ FI = \frac{G_f}{|m|} * A \]

where:
- \( G_f \) = fracture energy (Joules/m²)
- \( A \) = conversion and scaling factor, equal to 0.01
- \( m \) = post-peak slope (kN/mm)
Reporting

Reporting Requirements

- ITP 405 requires the following to be reported:
  - Bulk specific gravity to the nearest 0.001
  - Average air void content to the nearest 0.1%
  - Thickness and ligament length to the nearest 0.1 mm
  - Peak load to the nearest 0.1 kN
  - Post-peak slope to the nearest 0.1 kN/mm
  - Fracture energy to the nearest 1 J/m²
  - Flexibility index to the nearest 0.1
## Sample Report Template

Chicago Testing Laboratory, Inc.

### Project Name: 

<table>
<thead>
<tr>
<th>Date Tested:</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Mix Produced/Location:</td>
<td></td>
</tr>
<tr>
<td>Sampled/Tested By:</td>
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</table>

<table>
<thead>
<tr>
<th>Gyration</th>
<th>1G09031-1.1-3</th>
<th>1G09031-1.1-4</th>
<th>1G09031-1.1-5</th>
<th>1G09031-1.1-6</th>
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<tbody>
<tr>
<td>Thickness (mm)</td>
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<tr>
<td>Alignment (mm)</td>
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<tr>
<td>Notch Length (mm)</td>
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<tr>
<td>Air voids (%)</td>
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<tr>
<td>Rate (mm/min)</td>
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<tr>
<td>Test Duration (sec)</td>
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<tr>
<td>Max Load (Ps)</td>
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<tr>
<td>Slope</td>
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<tr>
<td>BFU/m2</td>
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<tr>
<td>Resilibility Index</td>
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### Statistical Results:

<table>
<thead>
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</tbody>
</table>

Thank You