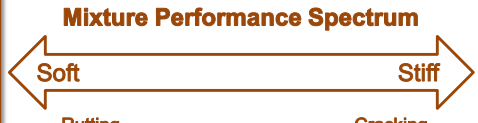
The I-FIT Method Workshop

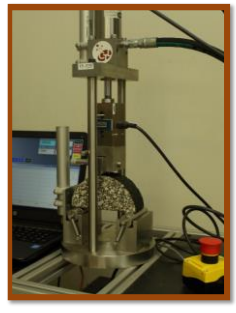
Chicago Testing Laboratory, Inc.

Ahmad El Khatib

Illinois Bituminous Conference
December 12th, 2016

The I-FIT Method





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Workshop Objectives

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

Standard Method of Test for

Determining the Fracture Potential of Asphalt Mixtures Using Semicircular Bend Geometry (SCB) at Intermediate Temperature

AASHTO Designation: TP 124-16[1]
Release: Group 3 (August 2016)

AASHTO

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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 ($area_{lig}$)**
  - 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.

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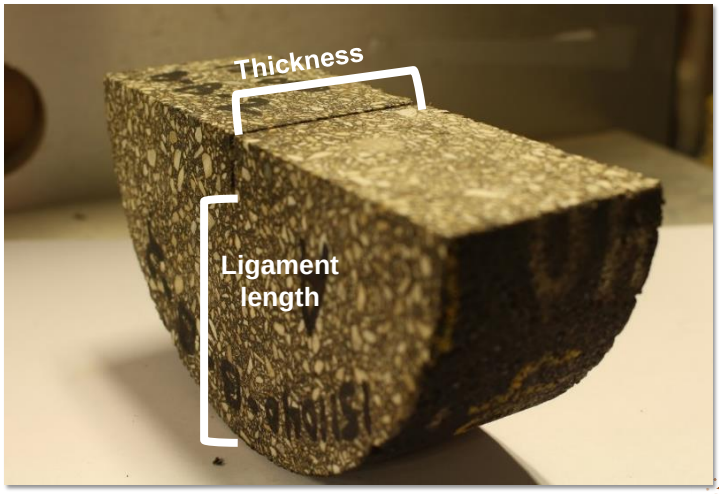
Dimensions



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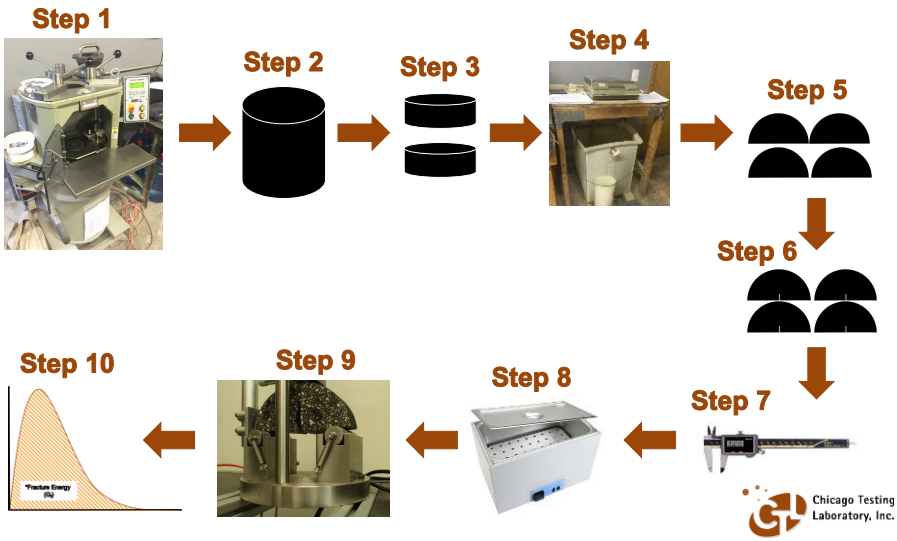
SCB Testing



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Equipment

Loading Device – Testing Fixture – Data Acquisition

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Loading Device

- **Servo-hydraulic or screw-driven**
  - **Minimum resolution of 5 N**

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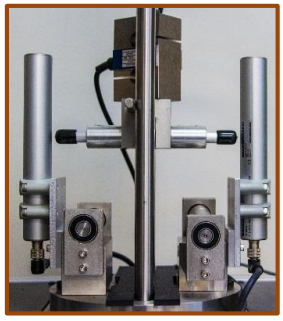
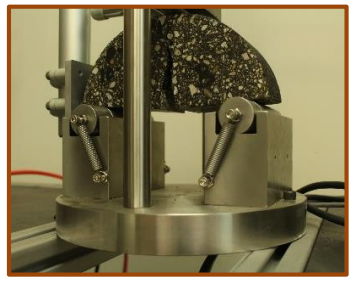
Testing Fixture

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



Method A



Method B

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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

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Compaction

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Sampling

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

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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

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Fabrication

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Fabrication

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

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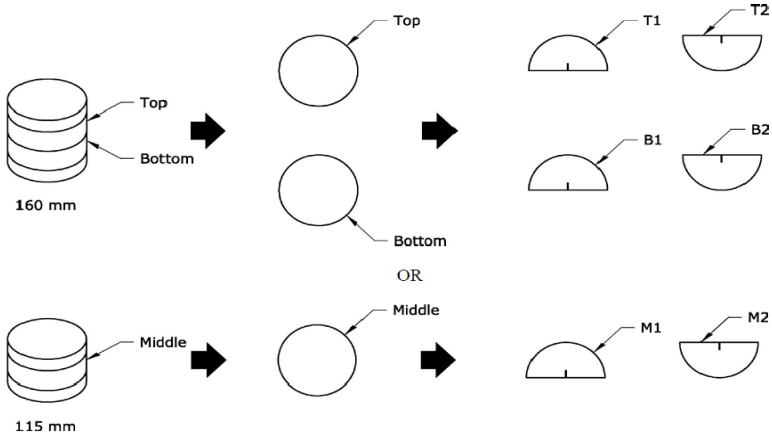
Fabrication



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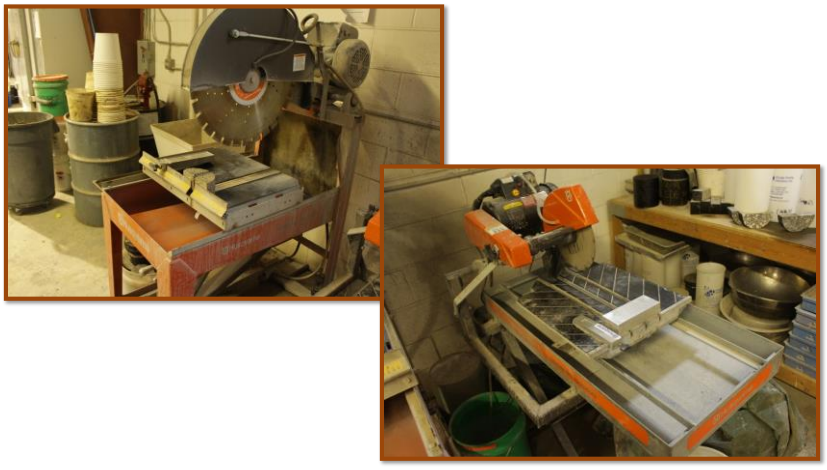
Fabrication Equipment



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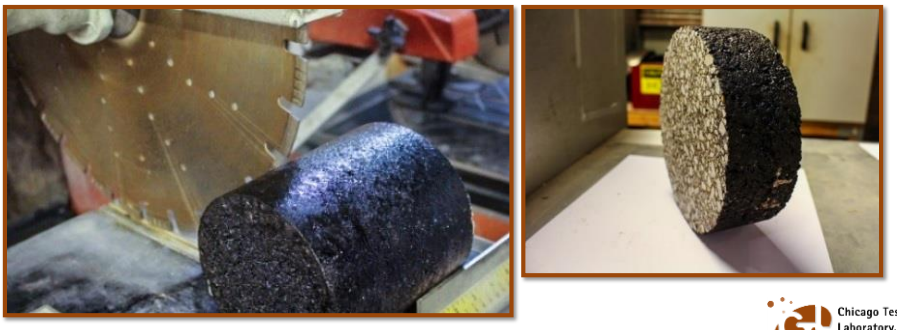
Slicing

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



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Air Void Verification

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

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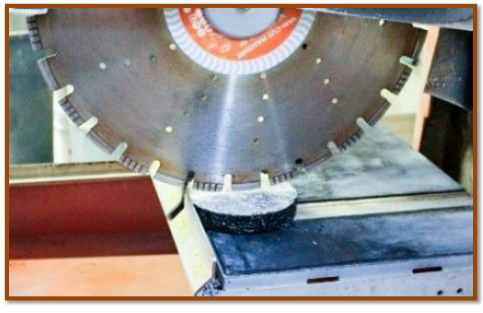
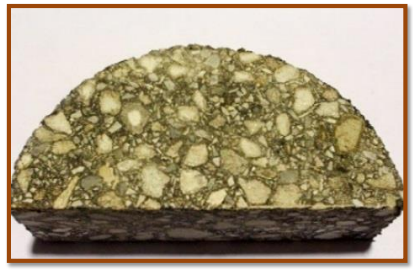
Halving

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





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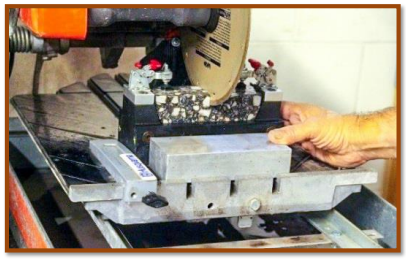
Notching

- Notches are to be 15 ± 1 mm in length and 1.5 mm ± .1 mm in width
- Use of jig is recommended to ensure proper notch



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Dimensioning

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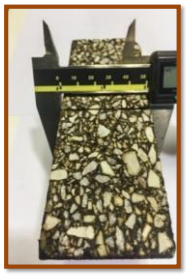
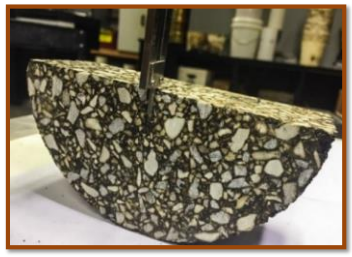
Dimensioning

- 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





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Conditioning

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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 ℃

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Testing

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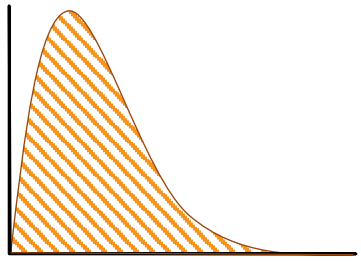
Test Procedure

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



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Data Analysis

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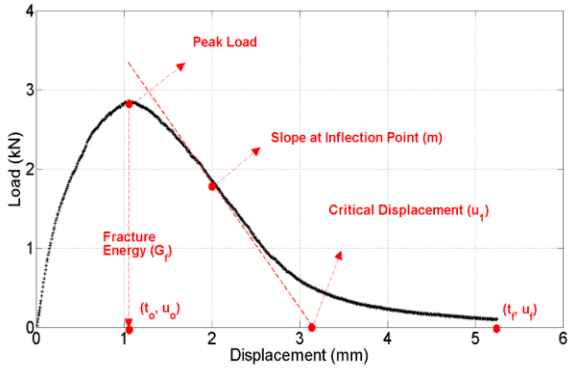
Data Analysis

- Four specimens tested, three selected



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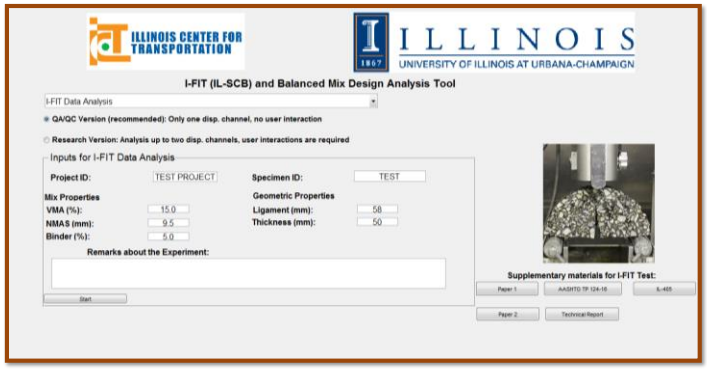
Data Analysis

- 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***



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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:

Point #	Time	Load	Displacement 1	Displacement 2
Data point 1	Data point 1	Data point 1	Data point 1	Data point 1
Data point 2	Data point 2	Data point 2	Data point 2	Data point 2
Data point 3	Data point 3	Data point 3	Data point 3	Data point 3
……..	……..	……..	……..	……..
……..	……..	……..	……..	……..
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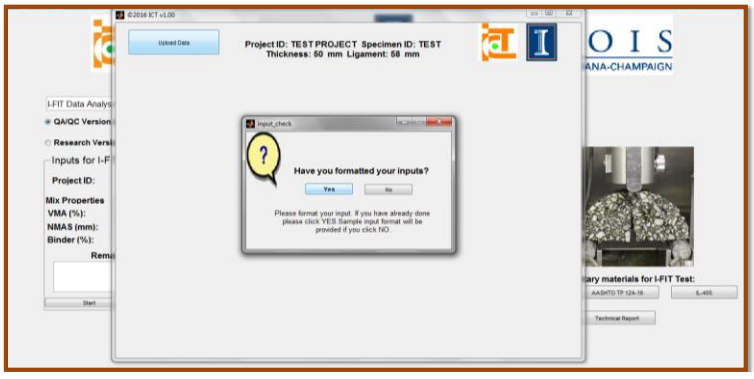

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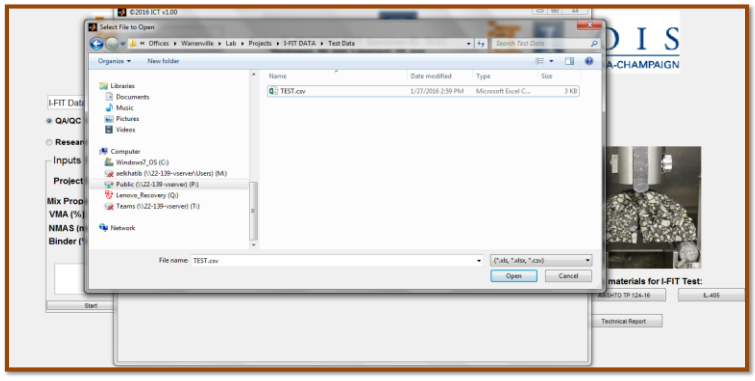
Data Analysis

- Select the desired data file for analysis



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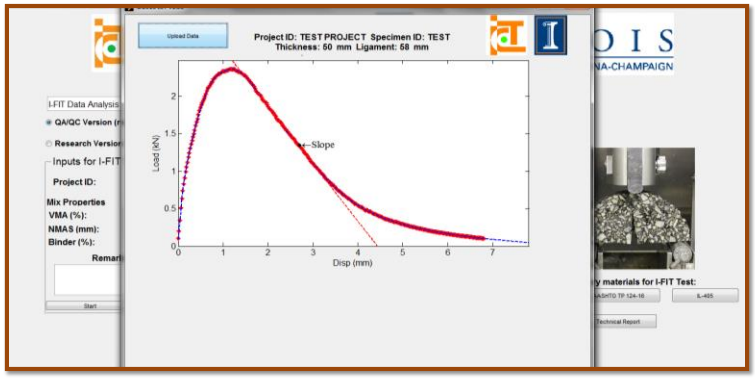
Data Analysis

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



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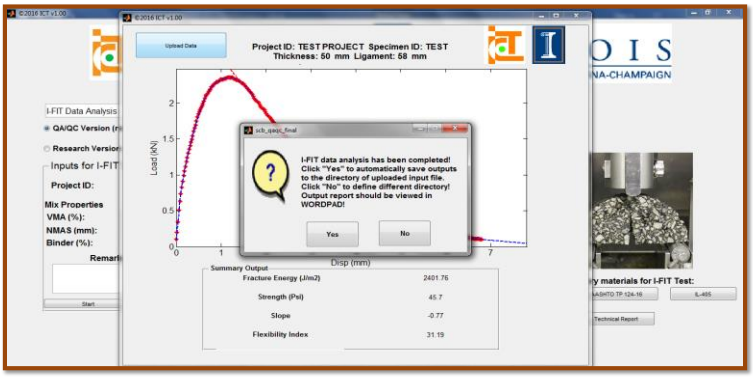
Data Analysis

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



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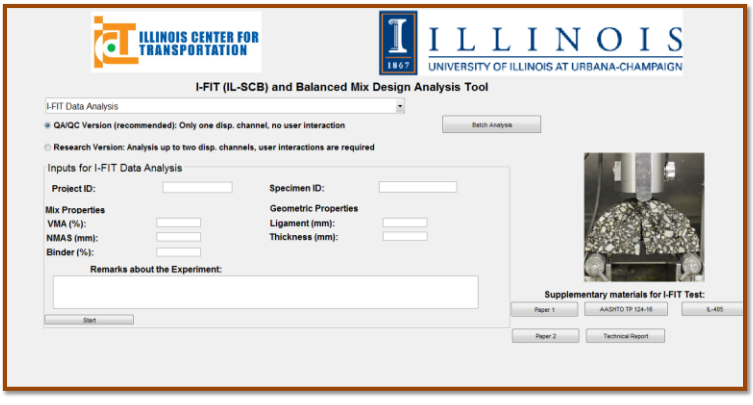
Data Analysis: Batch Analysis

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



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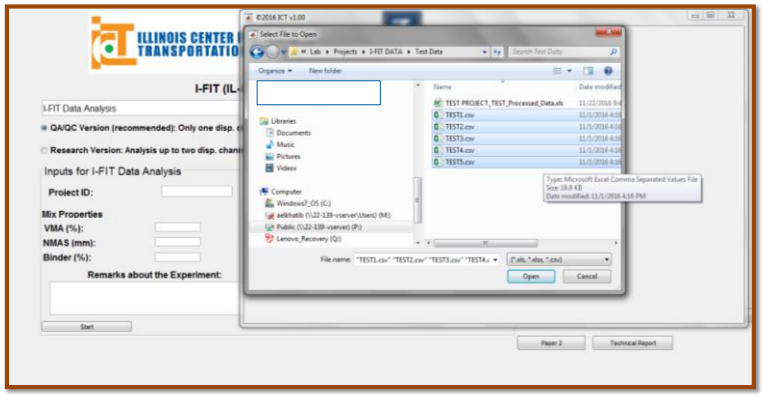
Data Analysis: Batch Analysis

- Select all files to be analyzed



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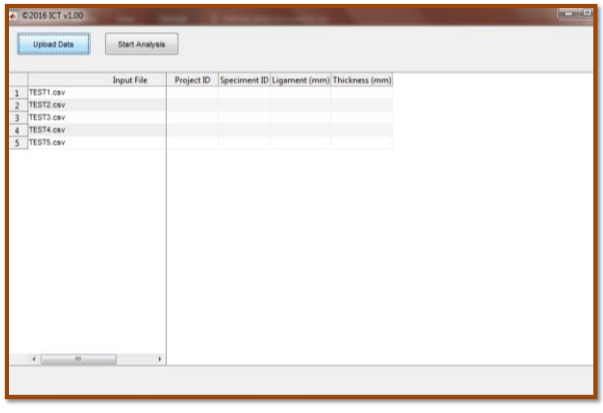
Data Analysis: Batch Analysis

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



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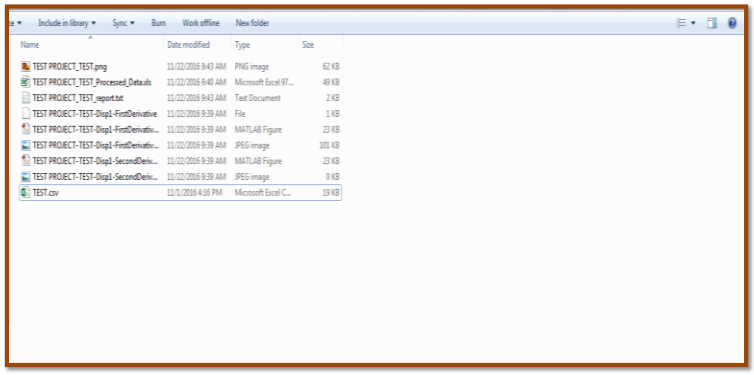
Data Analysis

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



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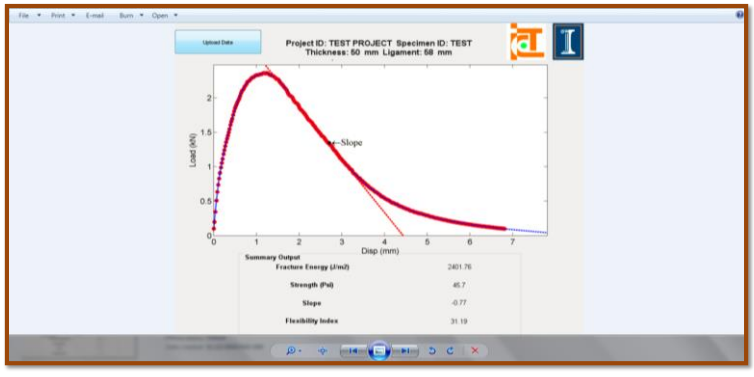
.png

- Screen capture of load-displacement curve and calculated parameters
  - Fracture Energy
  - Strength
  - Slope
  - Flexibility Index



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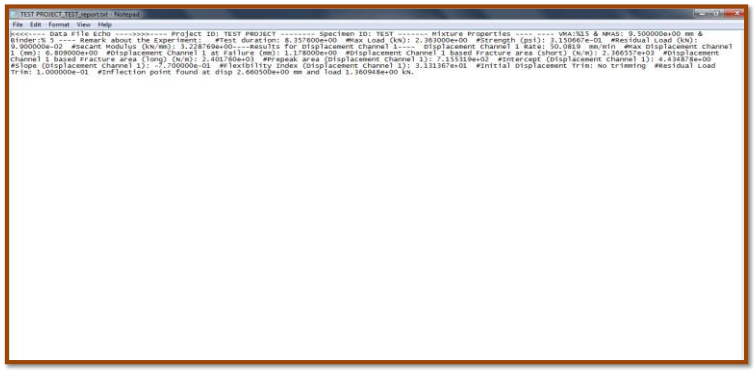
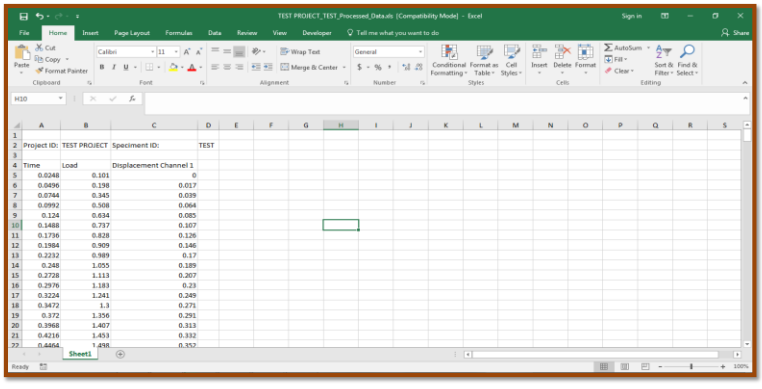
.txt

- Log of test, detailing things such as volumetric properties and remarks regarding the experiment



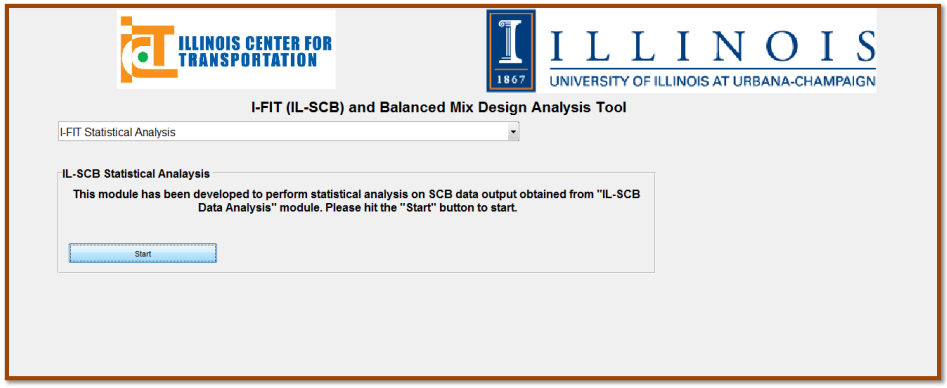
.xls

- A modified data file displaying Project ID and Specimen ID



Statistical Analysis

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



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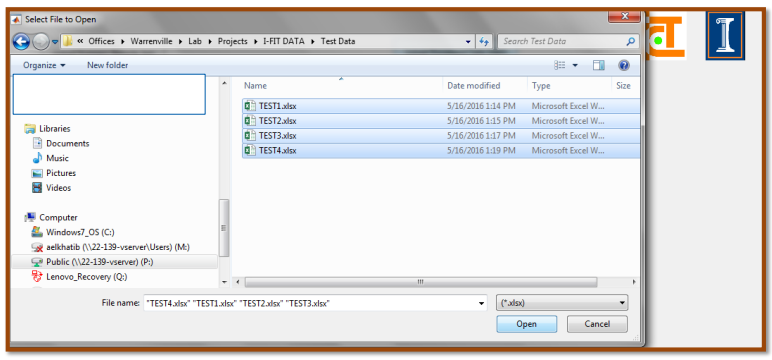
Statistical Analysis

- Select all .xls files to be plotted



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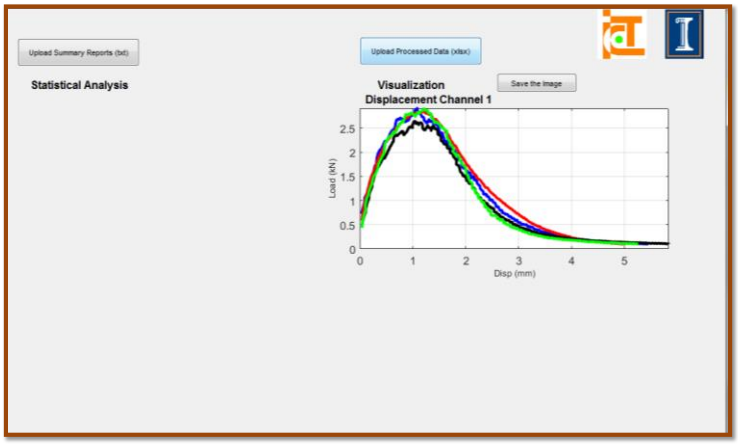
Statistical Analysis

- **Save multi-specimen plot screen capture**



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Results

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Fracture Energy

- Calculated using the expression:

$$G_f = \frac{W_f}{Area_{jig}}$$

where:

- G_f = fracture energy (Joules/m^2)
- W_f = work of fracture (Joules)
- $Area_{jig}$ = ligament area (r-a)*t, (mm^2)
- r = specimen radius (mm)
- a = notch length (mm)
- t = specimen thickness (mm)

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Flexibility Index

- Calculated as follows:

$$FI = \frac{G_f}{|m|} * A$$

where:

- Gf = fracture energy (Joules/m^2)
- A = conversion and scaling factor, equal to 0.01
- m = post-peak slope (kN/mm)

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Reporting

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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/m^2
  - Flexibility index to the nearest 0.1

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Sample Report Template

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30 W. 114 Butterfield Road, Warrenville, IL 60555
I-FIT (Illinois-Flexibility Index Test)
Illinois Test Procedure 405
Method B

Mix Info	Project Name:			Date Tested:			
	Material Code/Mix Type:			CTL Job Number:			
	Mix Producer/Location:						
	Sampled/Tested By:						
		1609031.1-T-1		160903-1-T-2		1609031.1-B-1	1609031.1-B-2
Volumetrics	Gyrations						
	Thickness (mm)						
	Ligament (mm)						
	Notch Length (mm)						
	Air voids (%)						
Testing Summary	Rate (mm/min)						
	Test Duration (sec)						
	Max Load (Psi)						
	Slope						
	Gf (J/m2)						
	Flexibility Index						
	STATISTICAL RESULTS:	Avg. FI	#DIV/0!	Avg. FE	#DIV/0!	Avg. Slope #DIV/0!	Avg. Peak Load #DIV/0!
		Std. Dev. FI	#DIV/0!	Std. Dev. FE	#DIV/0!	Std. Dev. Slope #DIV/0!	Std. Peak Load #DIV/0!
		COV FI	#DIV/0!	COV FE	#DIV/0!	COV Slope #DIV/0!	COV Peak Load #DIV/0!

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