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Indirect Tensile Asphalt Cracking Test (IDEAL-CT)

Test Background

- Developed at the Texas Transportation Institute (TTI)
- Developed using a cylinder geometry to characterize asphalt mixture cracking resistance
- ASTM D8225-19
- Video – Test Overview
  - https://www.youtube.com/watch?v=gXvZTE3eBNw

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Specimen Preparation

- Gyratory Samples
  - 150 mm diameter, 62 ± 1 mm tall
  - target ± 0.5 percent air voids (7.0% air voids is common target)
- Field Cores
  - Lift thickness should be greater than 38 mm
  - 150 ± 2 mm diameter
  - If lift thickness > 62 mm, trim the top and bottom surfaces and use the middle 62 mm section
- Replicates
  - **Minimum** of three replicates
  - Recommend 4 to 5

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Test Parameters

- Temperature
  - Intermediate performance grade temperature (PG IT) ± 0.5°C
  - $PG\ IT = \frac{PG\ HT + PG\ LT}{2} + 4$
  - If *PG IT* > 25°C, use 25°C
  - Examples
    - For a project requiring performance grade (climatic temperature) of 64-28, *PG IT* = 22, use 22°C
    - For a project requiring performance grade (climatic temperature) of 70-22, *PG IT* = 28, but use 25°C

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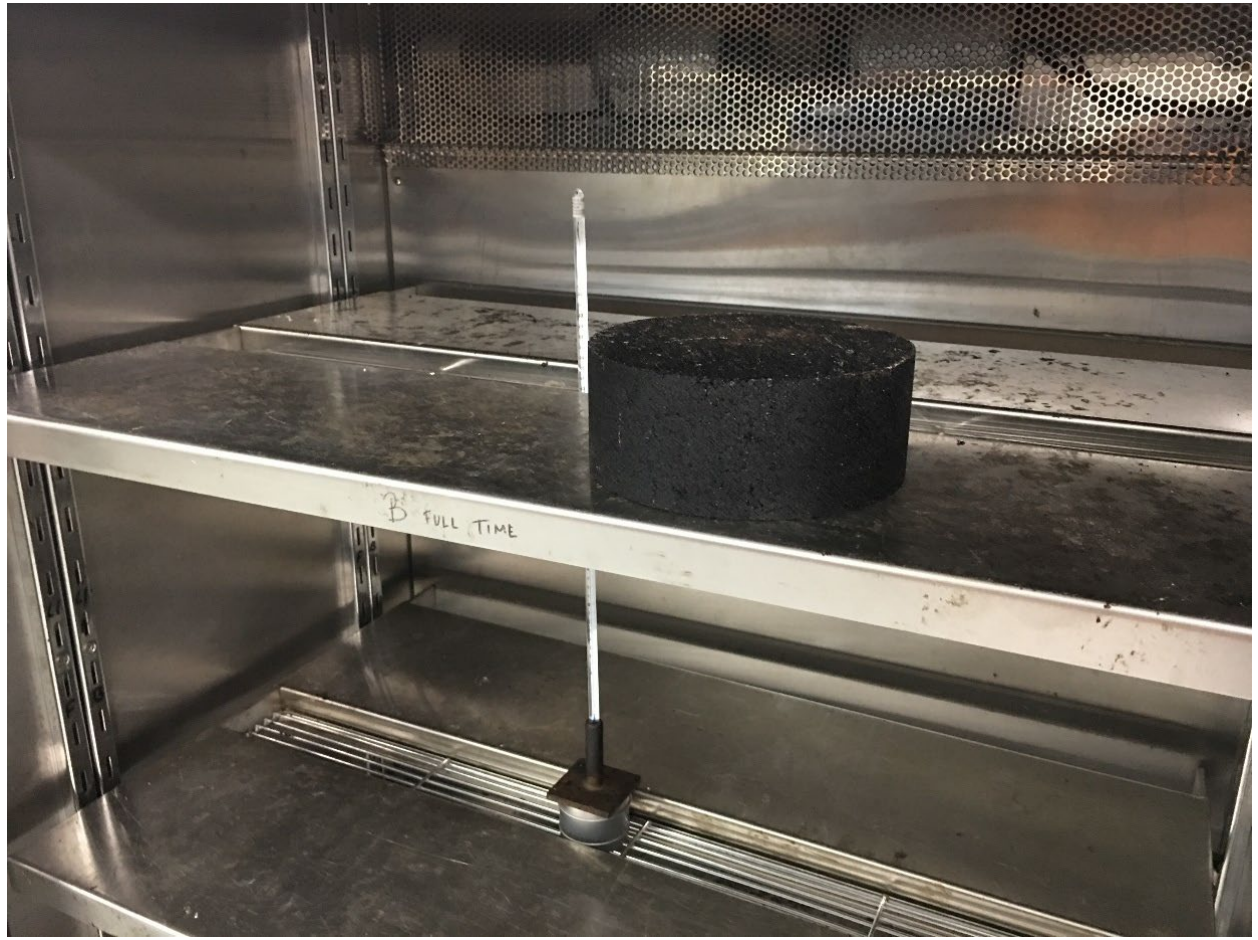
Test Parameters

- Specimen Conditioning
- 2 hours ± 10 minutes in an environmental chamber or 30 minutes in a water bath
- Testing should be completed in 4 minutes or less after removal from conditioning

Conditioning Specimen



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Test Parameters

- Test Setup
  - Specimen centered in the fixture and making uniform contact on the support
- Contact Load
  - 100 ± 10 N in Load Line Displacement (LLD) Control
- Load Rate
  - 50 ± 2.0 mm/min in LLD Control
- Test Duration
  - Typically less than 10 seconds
  - Test stopped when load drops below 100 N

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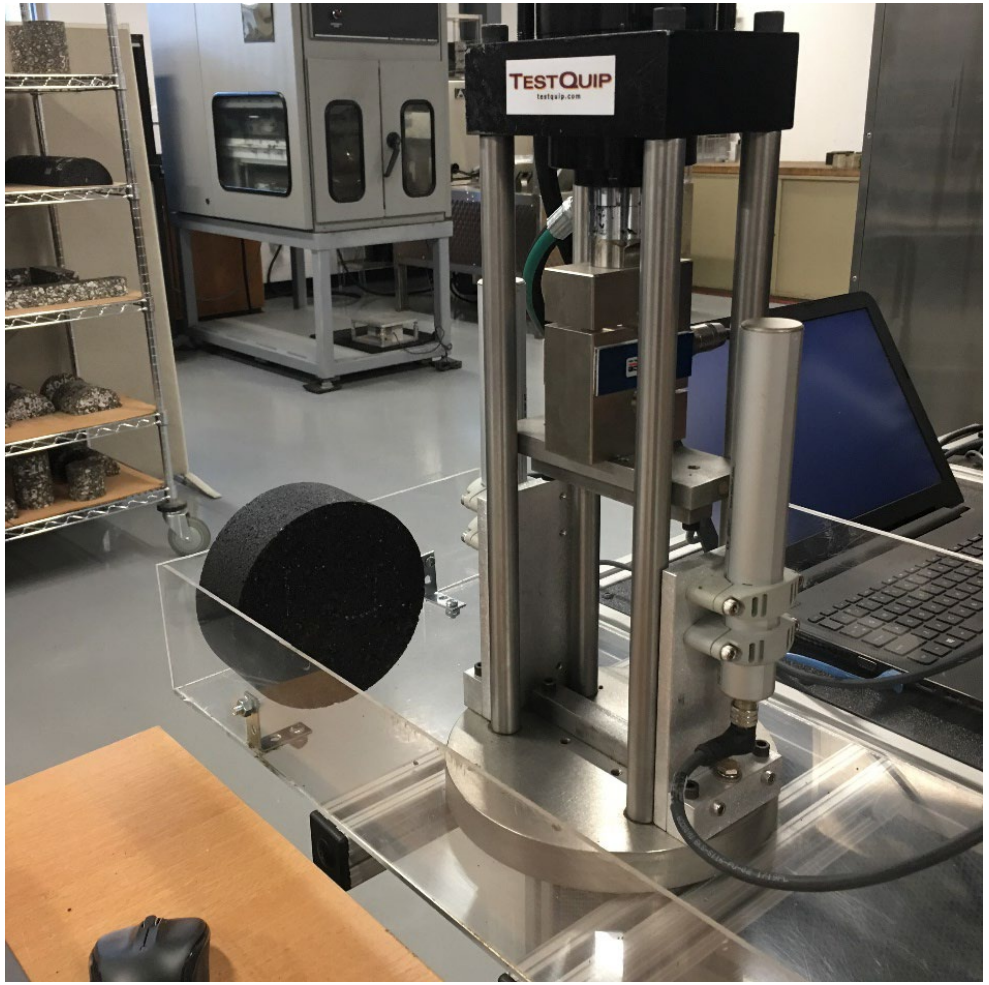
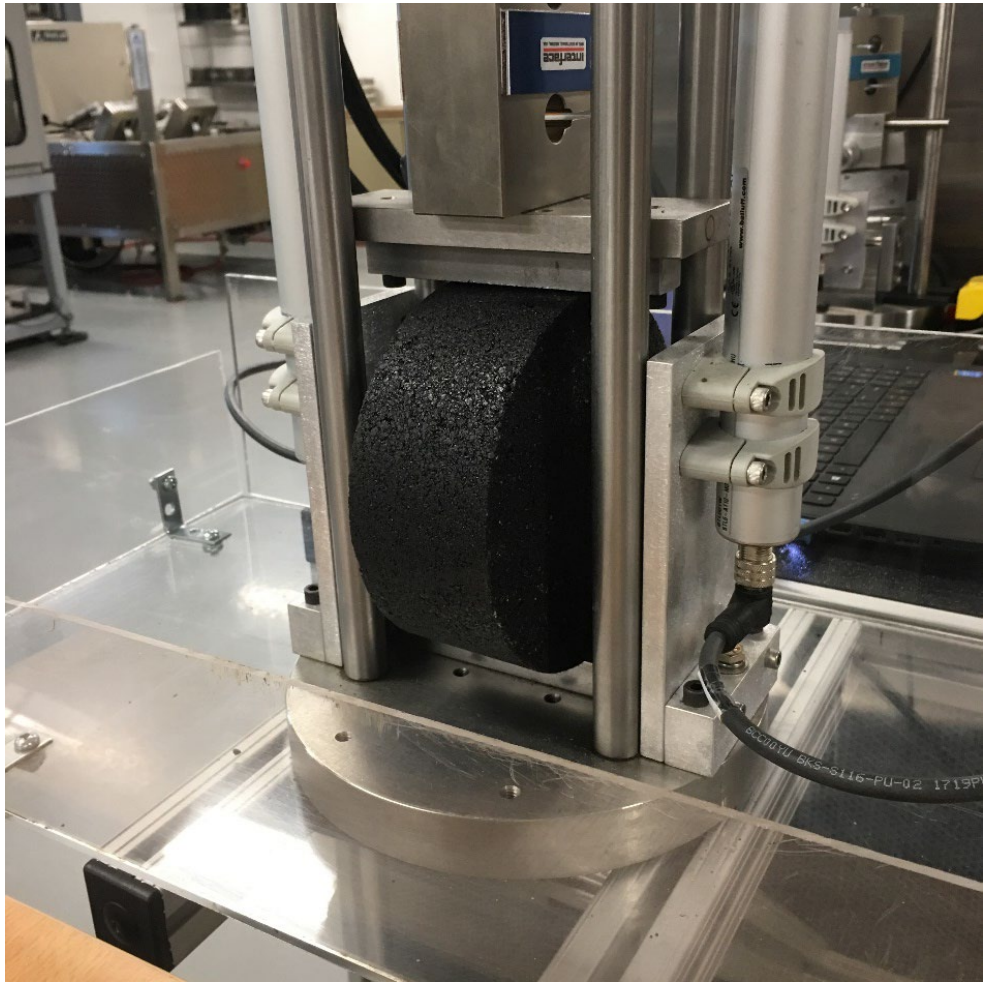
Test Setup





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Test Video

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Specimen after Testing

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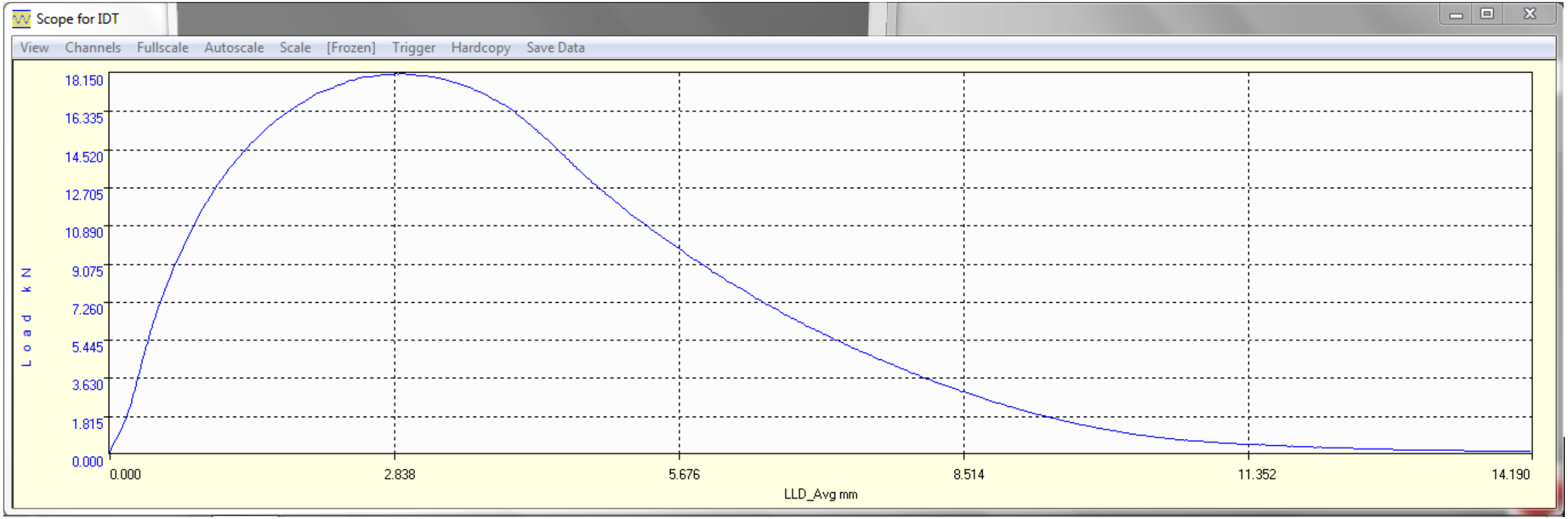
IDEAL-CT Raw Data



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Calculating CT_{Index}

- Work of fracture (W_f)
  - Area under the load-displacement curve
  - Unit: Joules
- Failure energy (G_f)
  - Work of fracture (W_f) divided by the cross-sectional area (product of the diameter and thickness) of the specimen
  - Unit: Joules/m^2
  - $G_f = \frac{W_f}{D \times t} \times 10^6$

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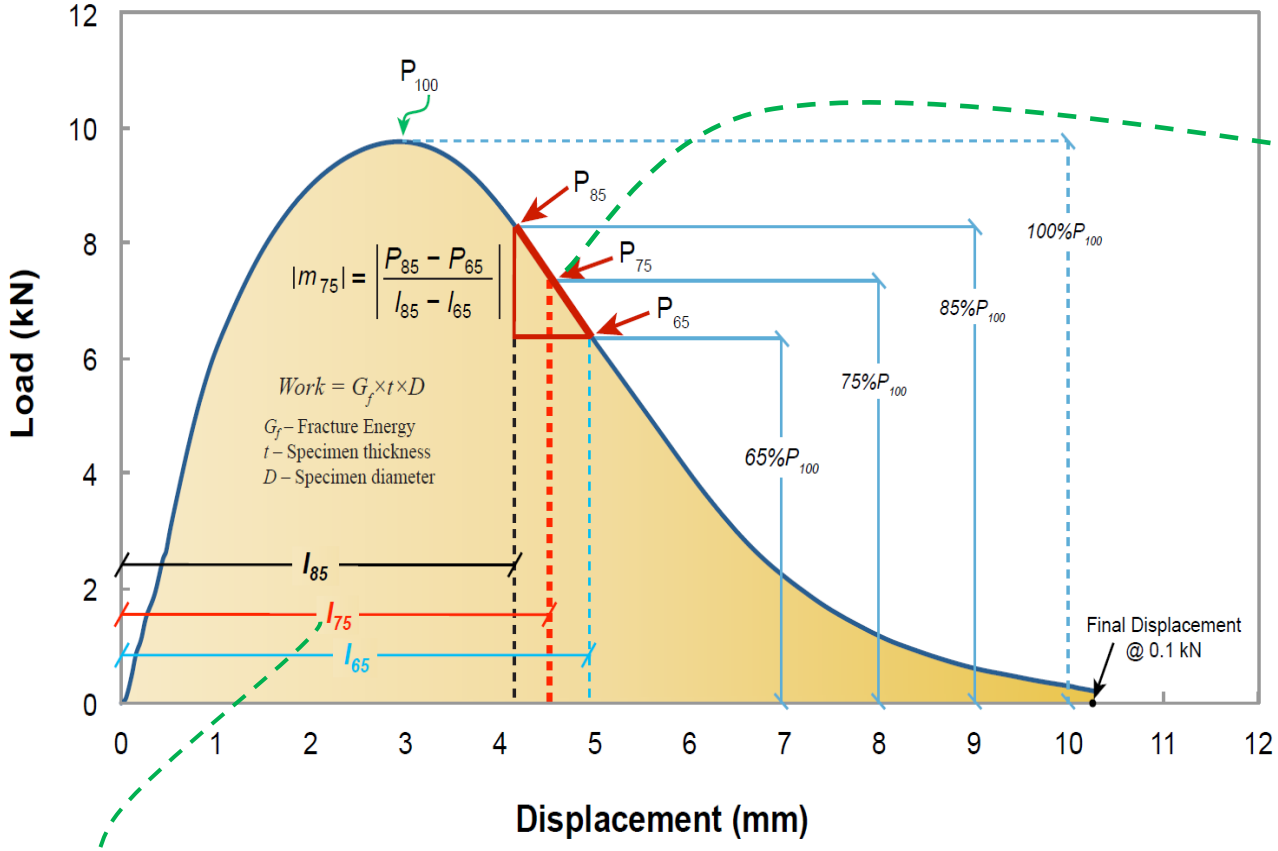
Calculating CT_{Index}



Post-peak slope (m_{75}) - slope of the tangent line at the 75% peak load point after the peak

Deformation tolerance (l_{75}) - displacement at 75% of the peak load after the peak

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Calculating CT_{Index}

- Cracking tolerance index (CT_{Index})
  - Calculated from the parameters obtained using the load-displacement curve
  - $CT_{Index} = \frac{t}{62} \times \frac{G_f}{|m_{75}|} \times \frac{l_{75}}{D} \times 10^6$ (unitless)
  - t: specimen thickness, mm
  - G_f: fracture energy, Joules/m^2
  - $|m_{75}|$: absolute value of post-peak slope m_{75}, N/m
  - l_{75}: displacement at 75% of peak load after the peak, mm
  - D: specimen diameter, mm

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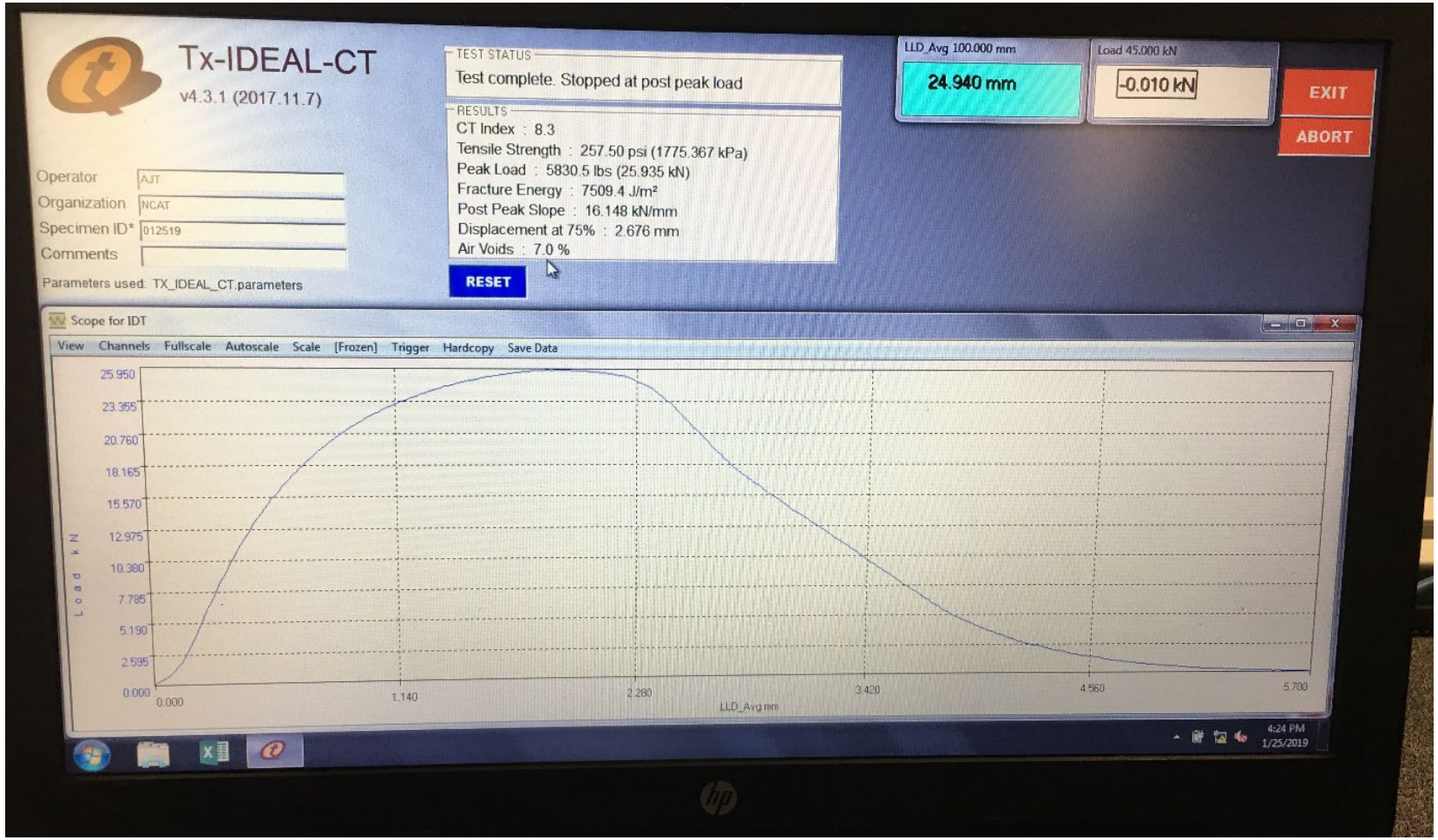
Data Processing Software



(NCAT Excel template available upon request)

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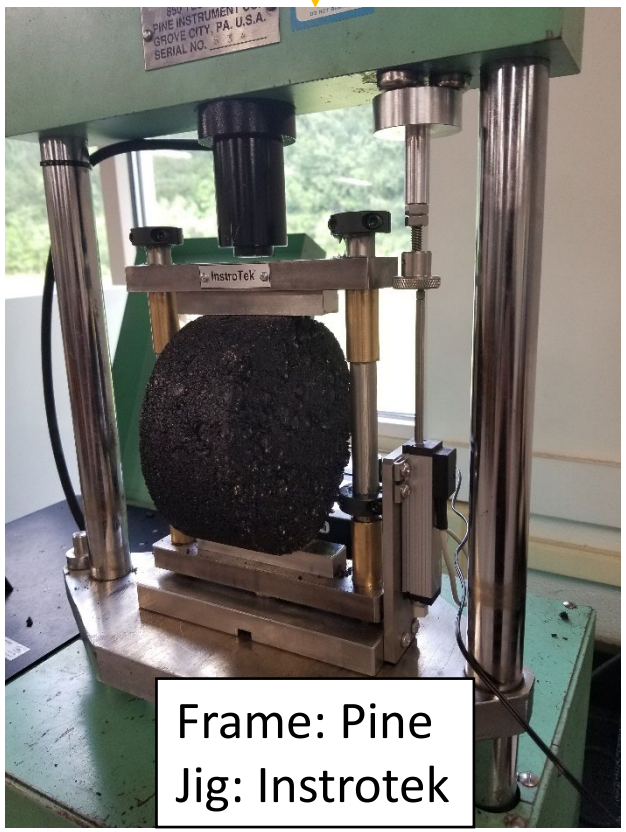
Equipment Examples

Used for IDEAL **Only**

Troxler/TestQuip

Humboldt

Instrotek



Frame: Pine
Jig: Instrotek

Used for IDEAL & I-FIT

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Calibration

- Have a professional service calibrate machine components annually
  1. LVDT
     - Both LLD and Actuator
  2. Load Cell
  3. Loading Rate
     - Verify rate is 50 +/- 2 mm/minute

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Test Variability

- NCAT Experience – CT_{Index} Coefficient of Variation
  - within-lab COV typically about 20%
  - Use ASTM E178 to eliminate outliers

	A	B	C	D	E	F	G	H	I	J	K	L	M
1								ASTM E178 Outlier Evaluation					
2	Replicates	5				Variable	Replicate	Avg	St Dev	t-stat	E 178 crit	Outlier?	
3	Significance	5%				67	1	37.94	18.36	1.583	1.671		
4						22	2	37.94	18.36	-0.895	1.671		
5	Note:					45	3	37.94	18.36	0.368	1.671		
6	* Significance level represents one-sided test					28	4	37.94	18.36	-0.525	1.671		
7	* If outliers can occur on either side of tail,					28	5	37.94	18.36	-0.531	1.671		
8	the true significance level is 2x the input.						6						
9							7						

  - NCAT Round-Robin (15 labs, 1 mix) – NCAT Report 22-01
    - Between-lab COV: 35.3% when each lab fabricated specimens
    - Between-lab COV: 20.2% when one lab fabricated all specimens

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Eliminate Outliers

- Each agency should have a **standardized** practice for how to deal with potential outliers
- ASTM E178 = Standard Practice for Dealing with Outlying Observations
- For each mix, calculate the average and standard deviation of the result
  - i.e. CT_{Index}

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Eliminate Outliers

- Calculate the T_n statistic for the appropriate number of replicates (n)
  - Typically 4 or 5
  - $T_n = \frac{x_n - \bar{x}}{s}$
- T_c for 90% Confidence (Table 1 – ASTM E178-16a)
  - 4 replicates = 1.425
  - 5 replicates = 1.602
- If the absolute value of $T_n > T_c$ then the replicate can be considered an outlier at 90% confidence

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Example of Outlier Analysis

- Average CT_{Index} = 72.6
- Standard Deviation = 10.5
- T_c = 1.671
- Replicate 1: CT_{Index} = 75 – T_n = 0.229
- Replicate 2: CT_{Index} = 81 – T_n = 0.800
- Replicate 3: CT_{Index} = 80 – T_n = 0.705
- Replicate 4: CT_{Index} = 55 – T_n = -1.676 (Outlier)
- Replicate 5: CT_{Index} = 72 – T_n = -0.057

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Example of Outlier Analysis

- Before Outlier Removal
  - Average = 72.6
  - Standard Deviation = 10.5
  - COV (%) = 14.4%
- After Outlier Removal
  - Average = 77.0
  - Standard Deviation = 4.2
  - COV (%) = 5.5%

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Outlier Evaluation

- Technician notes regarding a particular sample may also create outliers
  - Something may have gone wrong during fabrication or testing
- A statistical outlier may not be a practical outlier
  - Always look at the raw data
    - Example: Try 108, 109, 104, 111, 102, 90

Advantages – IDEAL-CT

- Specimen Fabrication is straightforward
  - No sawing required
  - Disclaimer: Straightforward ≠ Impossible to Mess Up
- Relatively low cost performance testing equipment
- Test is quick to perform
- Training is straight-forward
  - Specimen preparation standardization is recommended
  - CT_{Index} is sensitive to sample fabrication (reheating and conditioning procedures)

Limitations

- Effect of density
  - Trend of increased CT_{Index} with higher specimen air voids observed in several studies
  - Agencies should standardize specimen air void content

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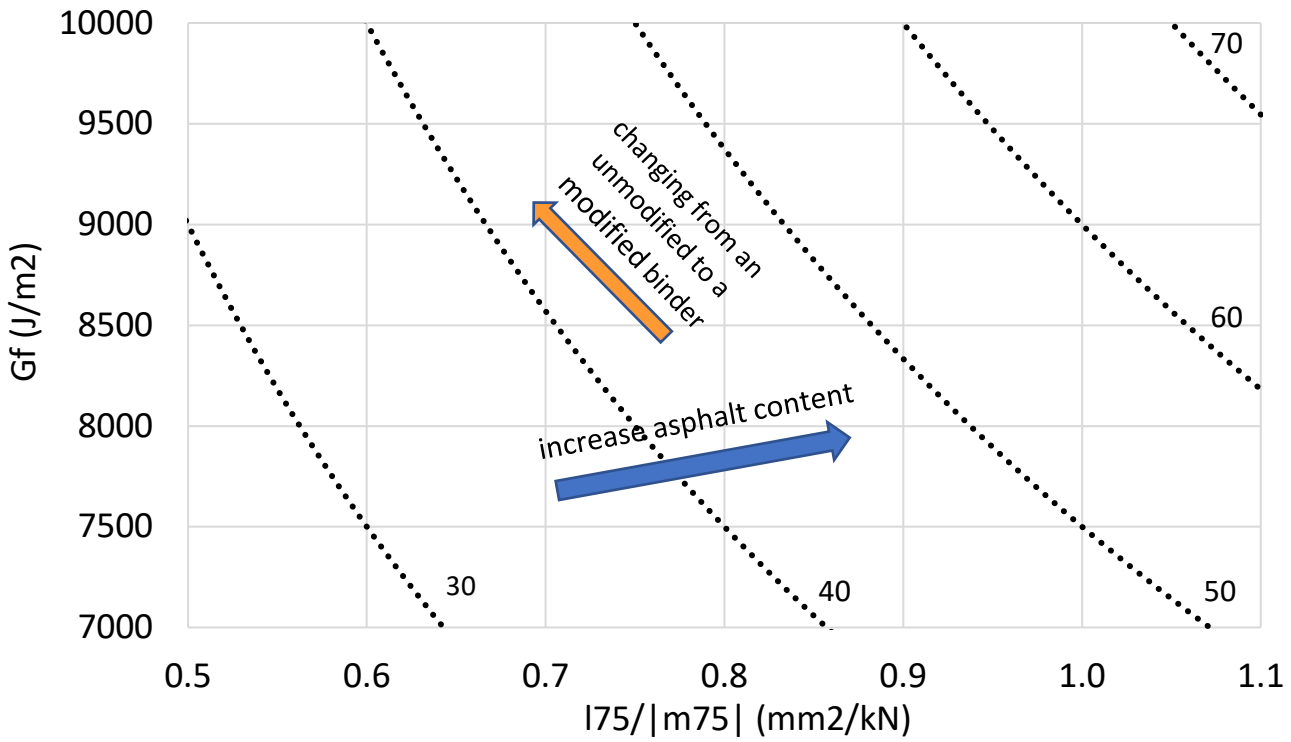
Additional Insights



The CT_{Index} Interaction Diagram may be helpful in understanding the effects of many common mix variables.

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Questions?

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