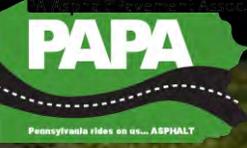




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Variability in Asphalt Concrete Performance Tests Lab/Plant/Field

**Pennsylvania Asphalt Pavement Association
66th Annual Conference**

Mansour Solaimanian

January 21, 2026





OUTLINE



Laboratory Performance Tests



Discussion of Variability

within HWT

within IDEAL-CT

Lab/Plant/Field: HWT

Lab/Plant/Field: IDEAL-CT



Summary & Conclusions



OUTLINE



Laboratory Performance Tests



Discussion of Variability

within HWT

within IDEAL-CT

Lab/Plant/Field: HWT

Lab/Plant/Field: IDEAL-CT



Summary & Conclusions

Tests to Assess Rutting Potential



← **HWT**

SST →



← **APA**

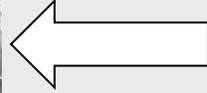
→ **Flow Number**



Tests to Assess Cracking Potential



Tension/Comp.



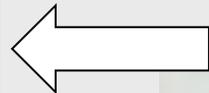
IDEAL-CT



DCT

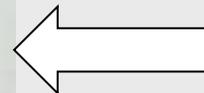


SCB



08.30.2012

TX Overlay



4-Pt. Bending





OUTLINE



Laboratory Performance Tests



Discussion of Variability

within HWT

within IDEAL-CT

Lab/Plant/Field: HWT

Lab/Plant/Field: IDEAL-CT



Summary & Conclusions



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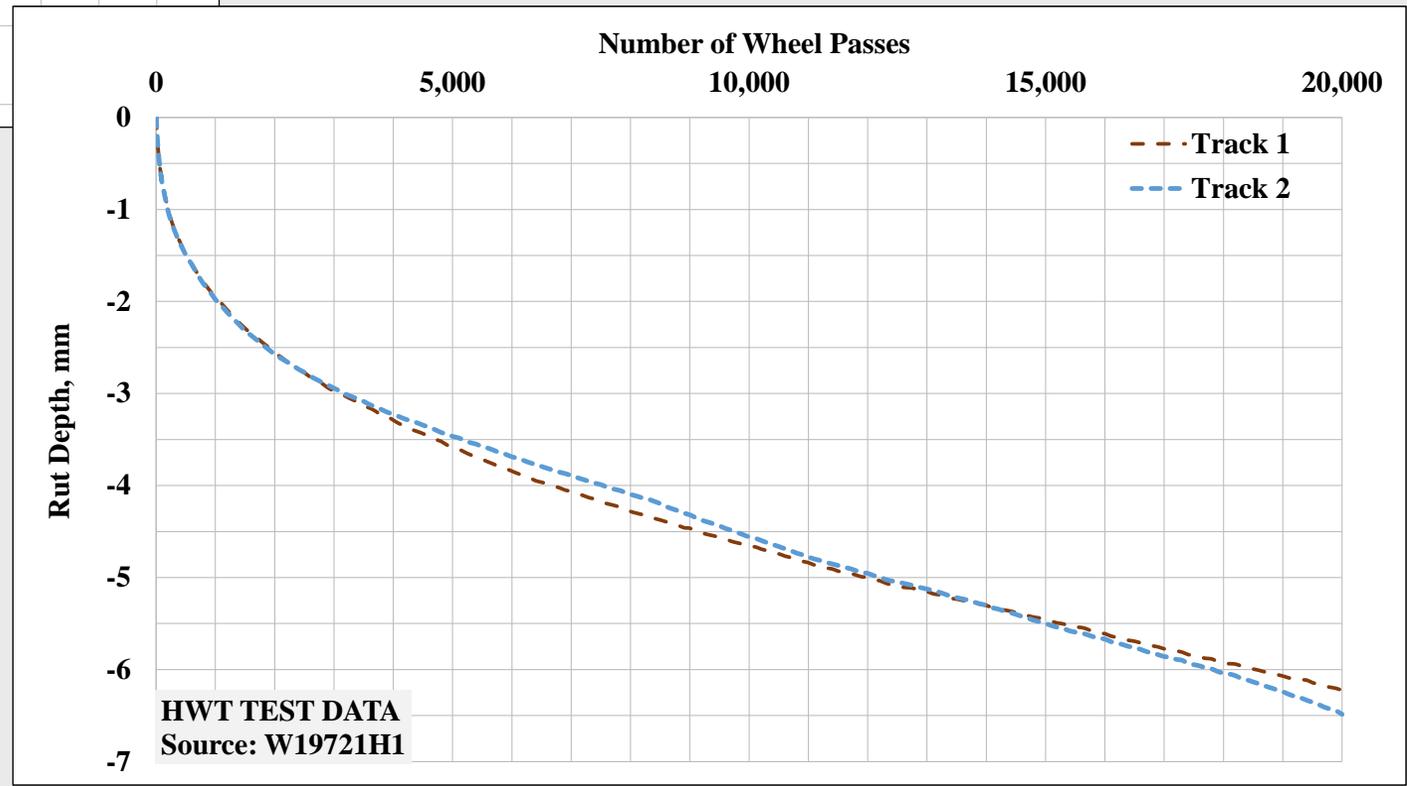
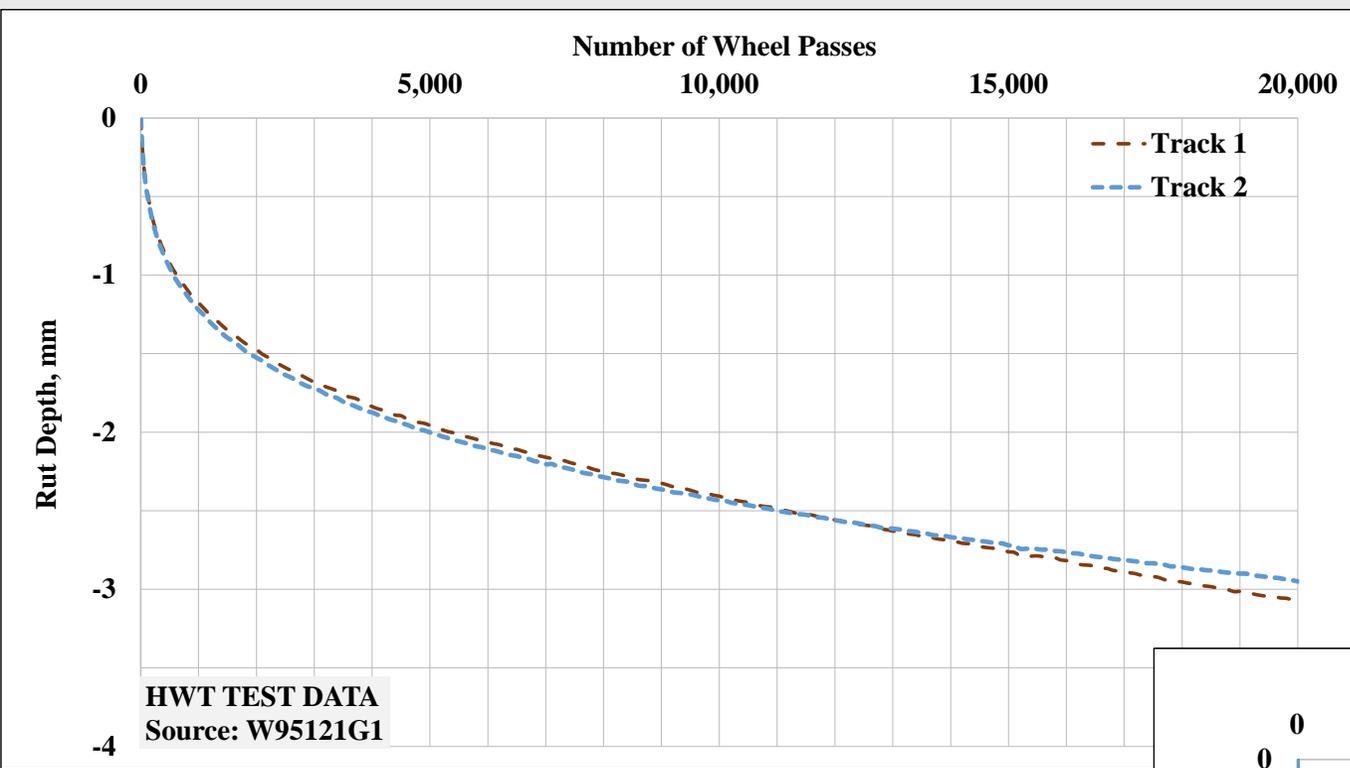
Variability in Wheel Tracking Test Results

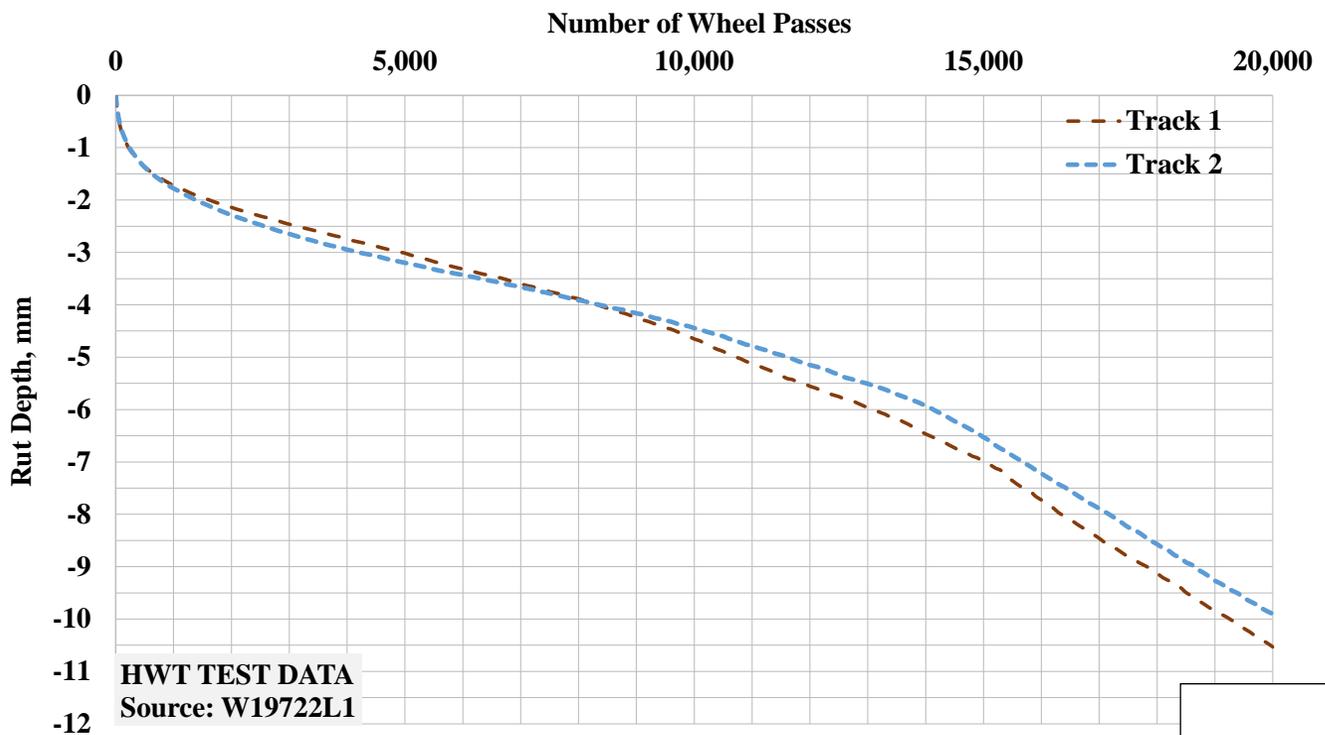
**Latest Test Standard:
AASHTO T 324-23**

**Currently, No
Precision & Bias
Statement**



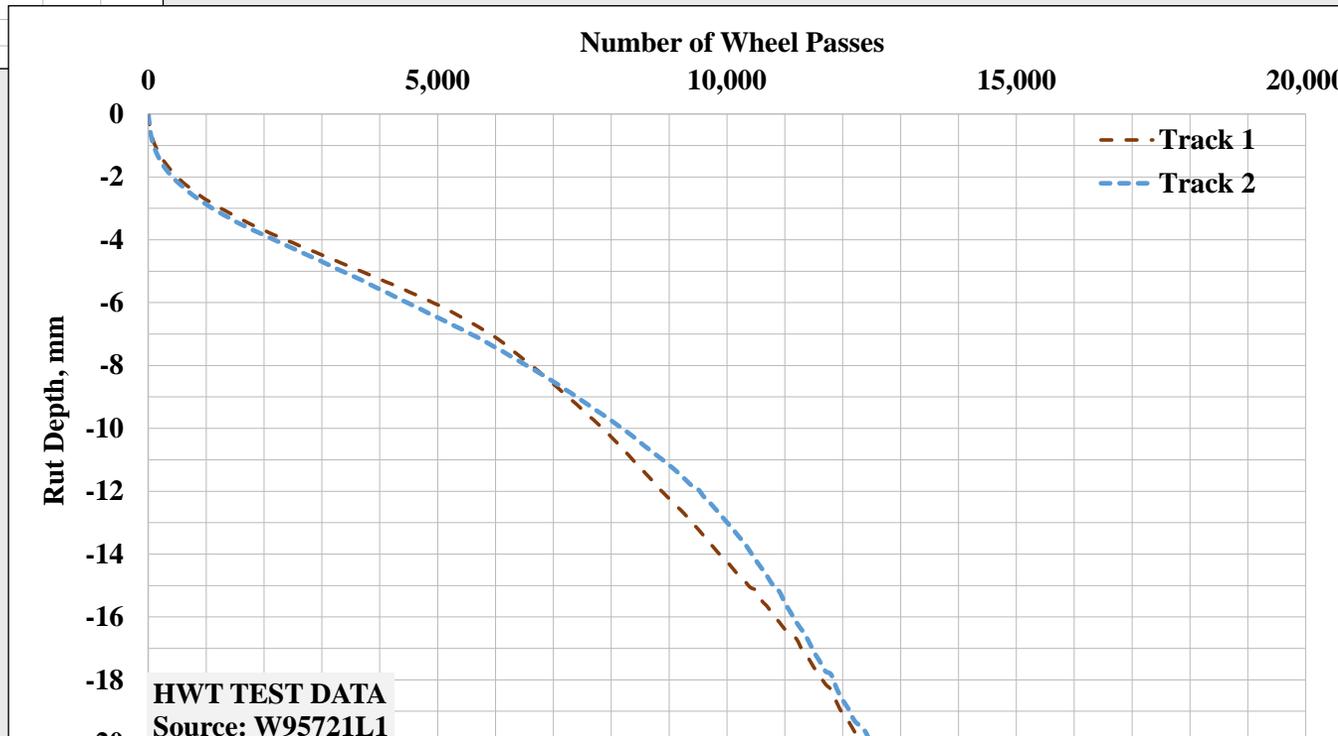
HWT Test: Excellent Mix Performance & Excellent Match between Tracks

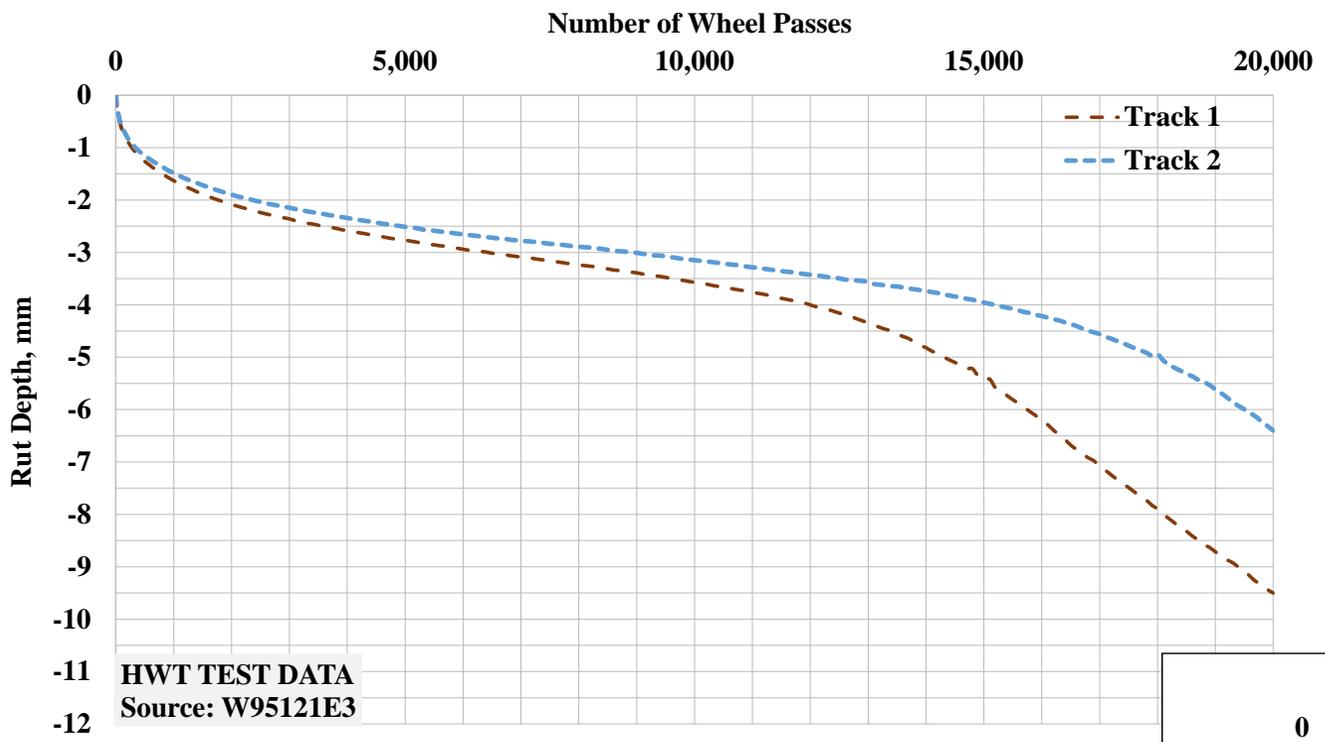




HWT Test:
Good Mix Performance &
Excellent Match between Tracks

HWT Test:
Poor Mix Performance &
Excellent Match between tracks



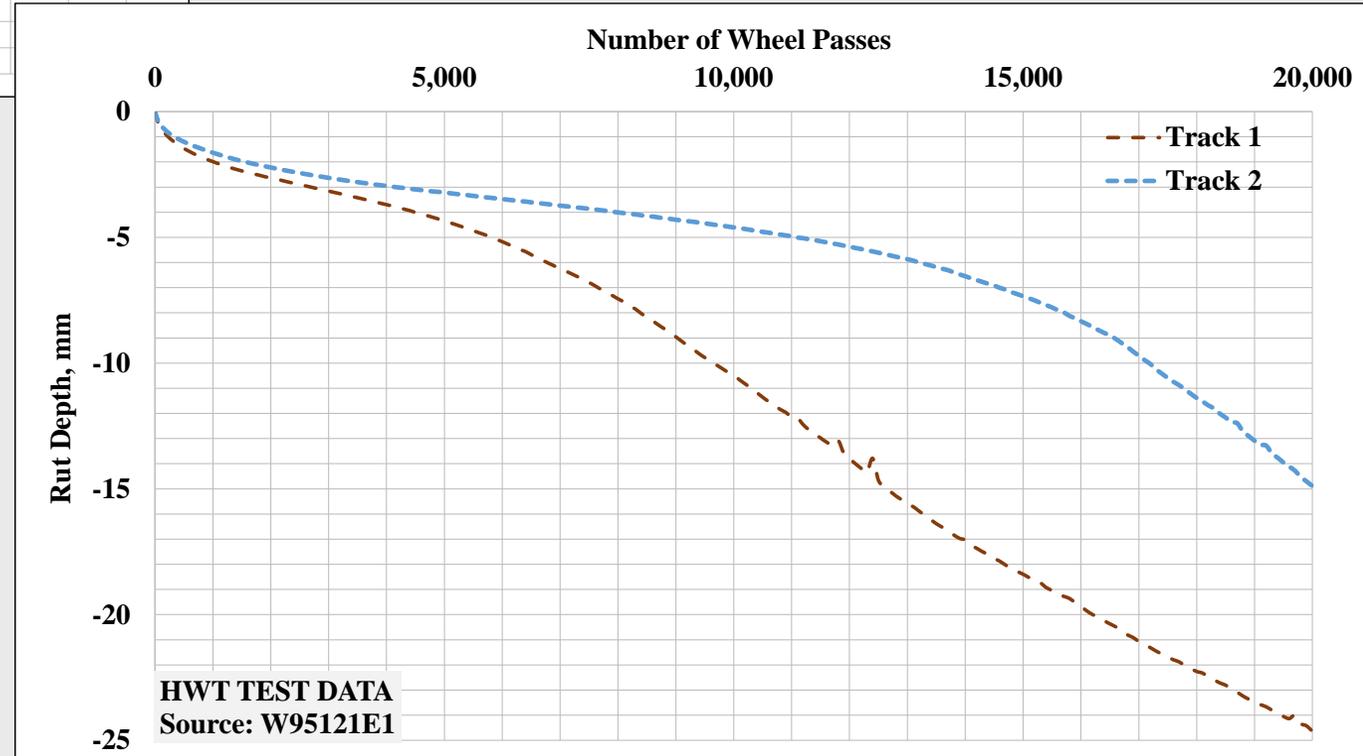


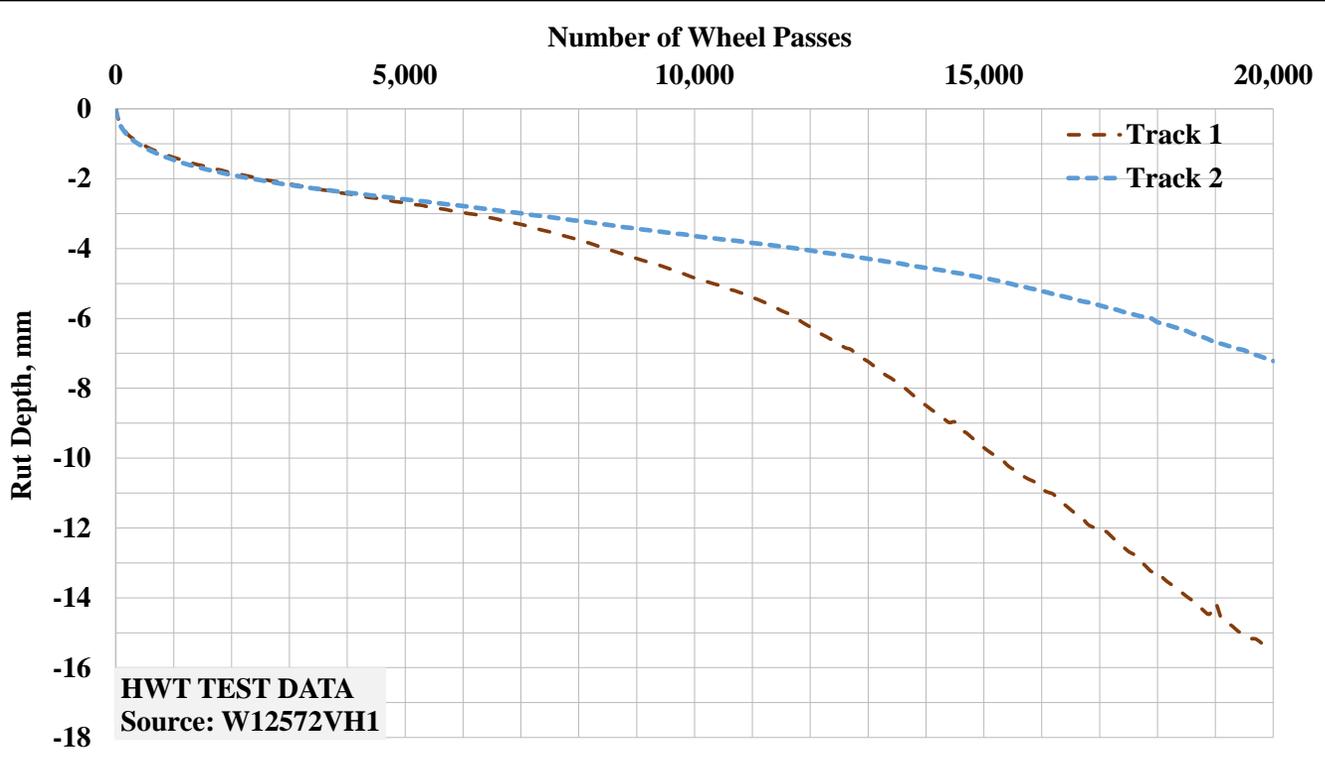
HWT Test: How to Decide if Needed to Repeat the Test?

One option is to use
Normalized (Scaled) Range (NR):

$$NR = \frac{\text{Range}}{\text{Avg. of 2 Tracks}}$$

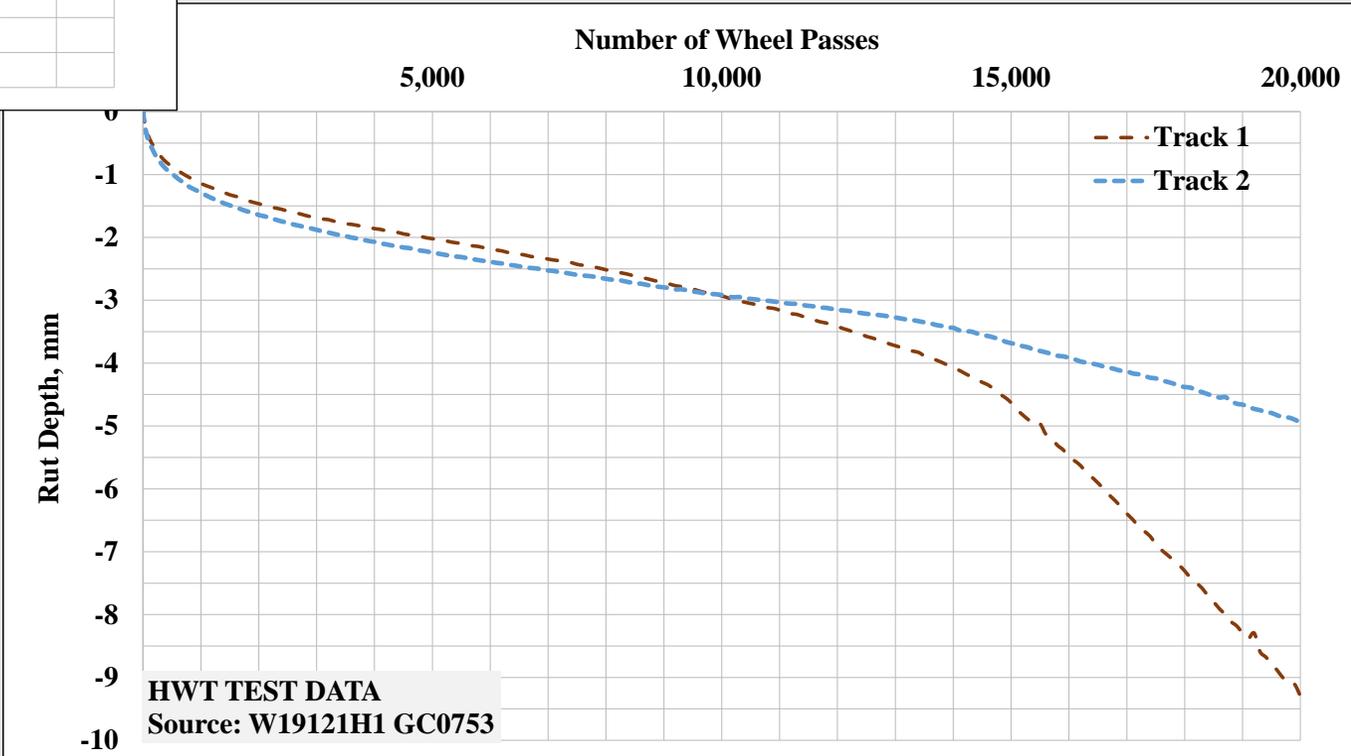
Max. Rut Depth:
 (1) = 6.5 mm & (2) = 9.6 mm
Range = 3.1 mm, Avg.=8.05, NR = 38.5%





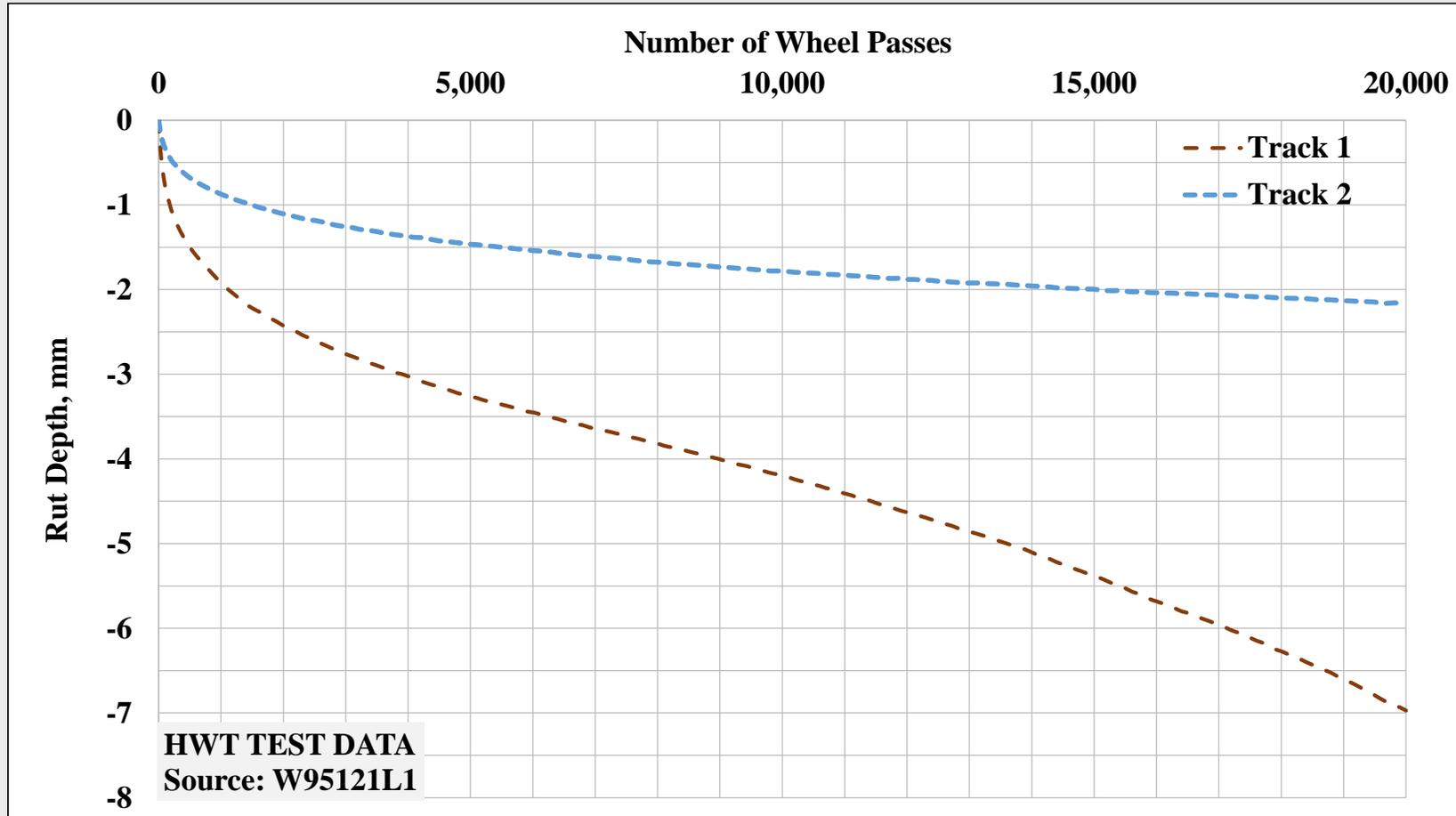
HWT Test:
Significant difference in rut depth and Strip Slope/Creep Slope between the tracks

HWT Test:
Significant difference in rut depth and Strip Slope/Creep Slope between the tracks





HWT Test: Significant difference in rut depth between the tracks



OUTLINE



Laboratory Performance Tests



Discussion of Variability

within HWT

within IDEAL-CT

Lab/Plant/Field: HWT

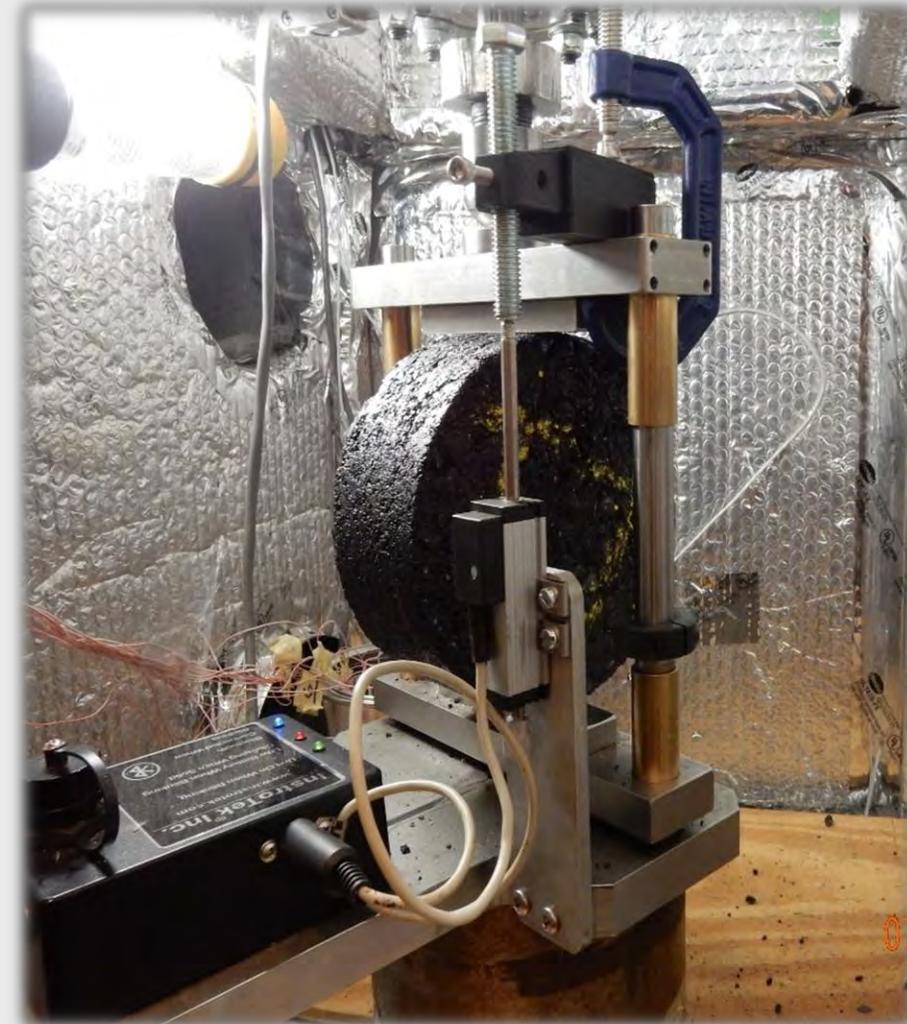
Lab/Plant/Field: IDEAL-CT



Summary & Conclusions

Variability in IDEAL-CT Test Results

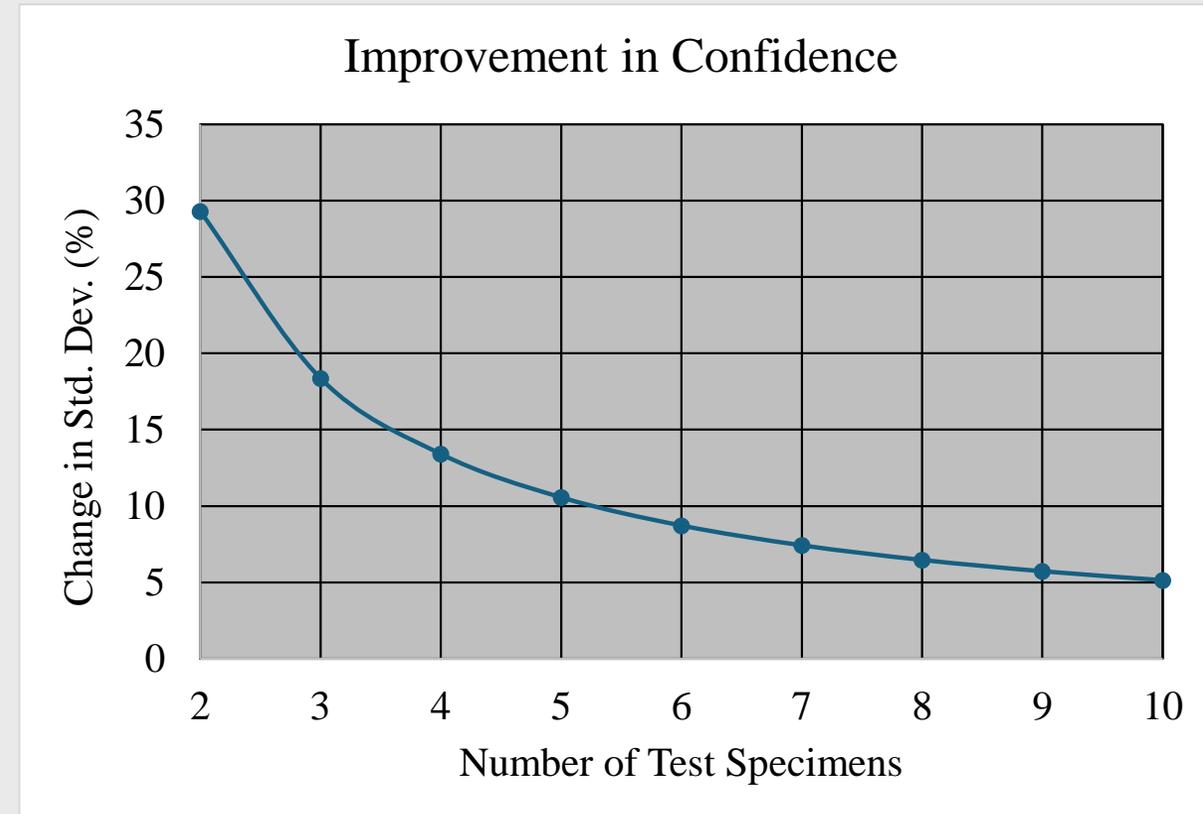
Latest Test Standard: ASTM D8225-19
Preliminary Statistics on the Index:
Within Lab Std. Dev. = 13.5



How Many Specimens to Test in IDEAL-CT?

The Principle of Diminishing Returns:

As the number of samples increases, the additional improvement in test variability decreases.

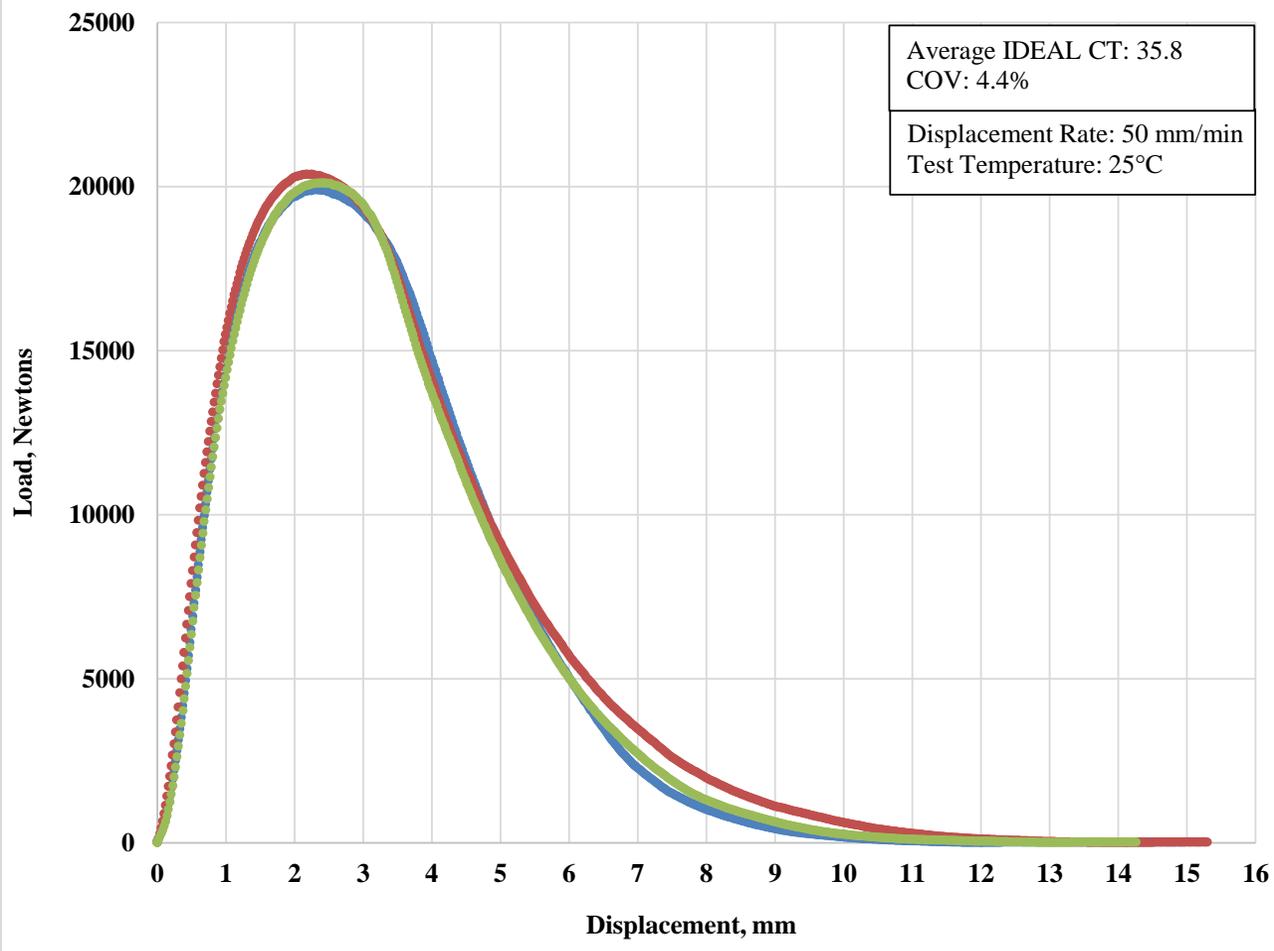




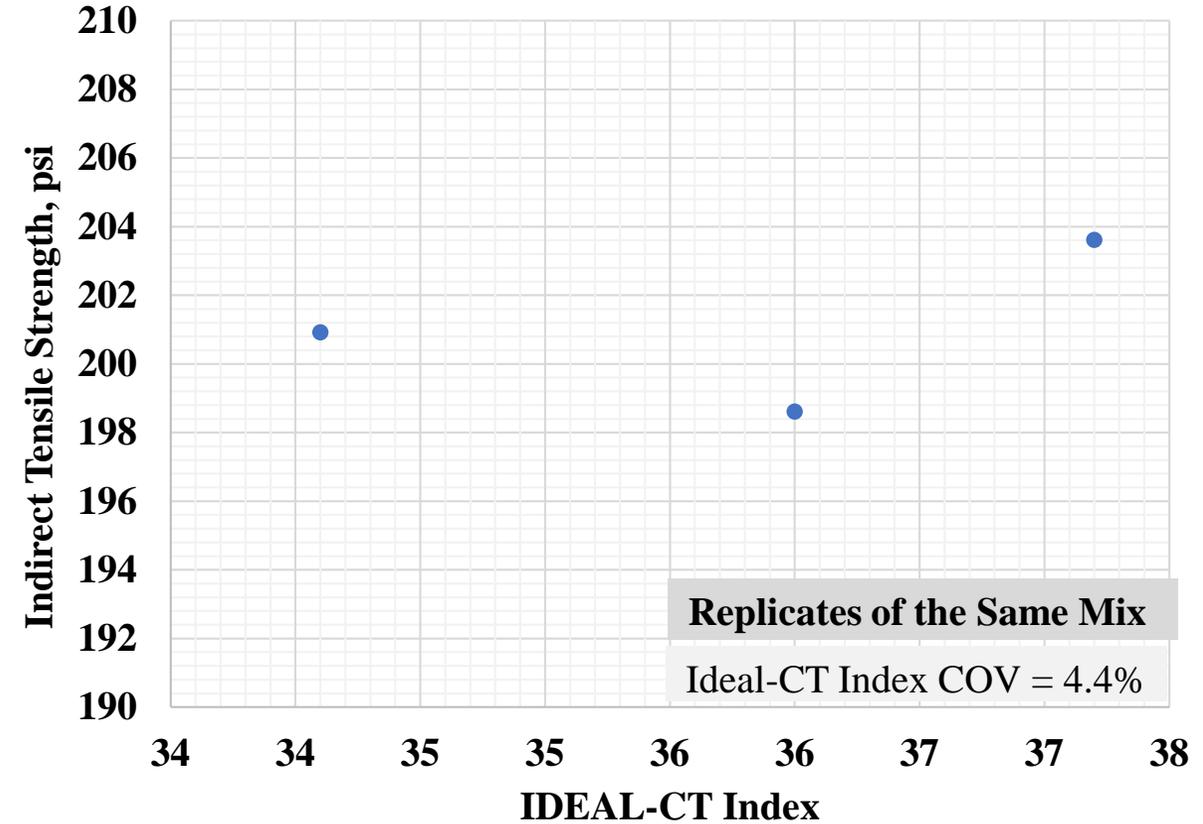
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IDEAL-CT: Data Variability



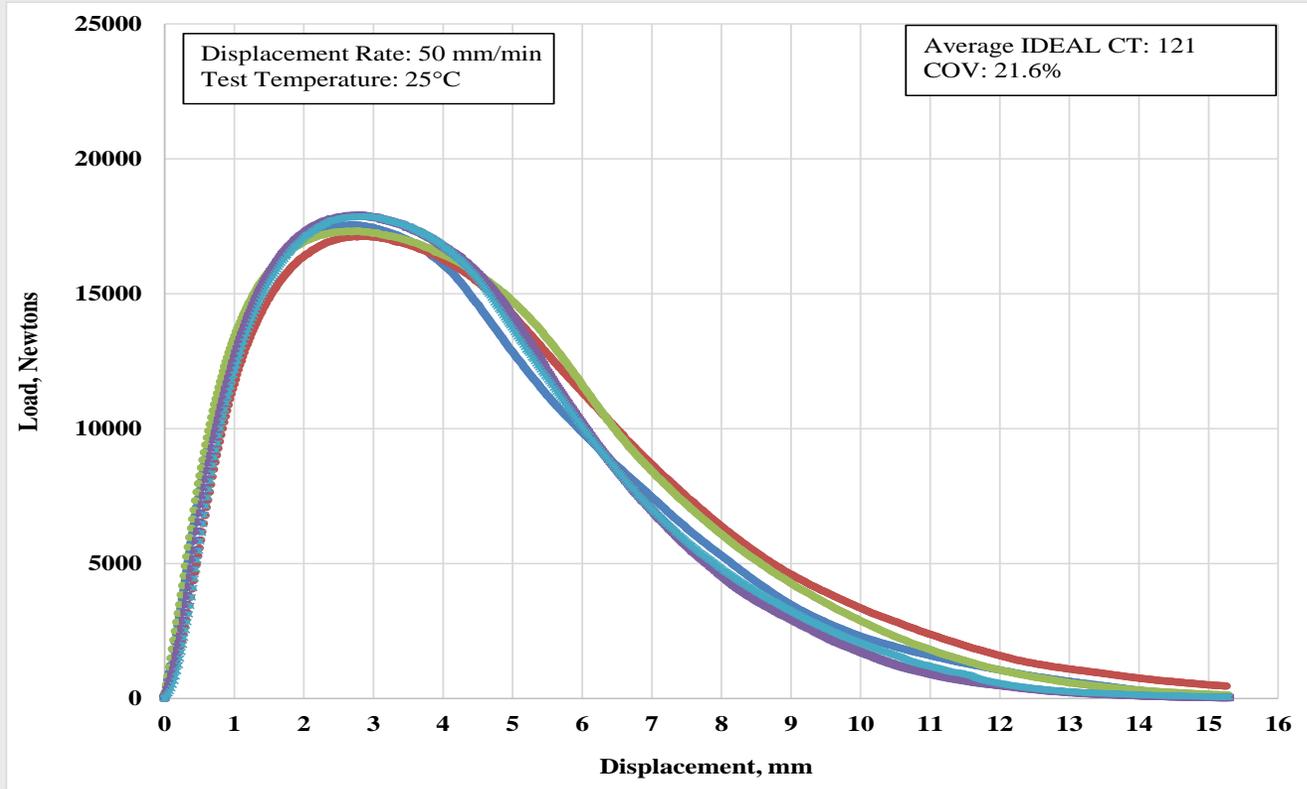
**Extremely well controlled.
Low Variability**



**Mix too brittle,
PG 64-22 and 25% RAP
Long-Term Conditioned**

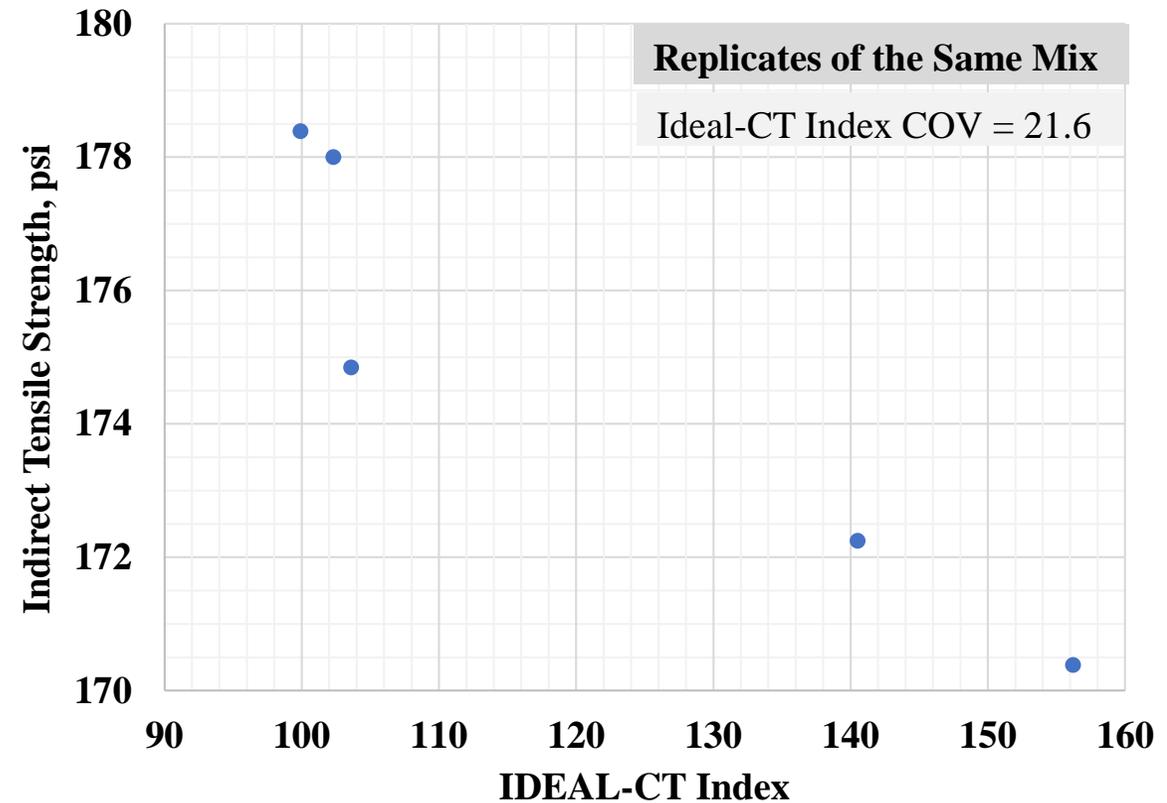


IDEAL-CT: Data Variability

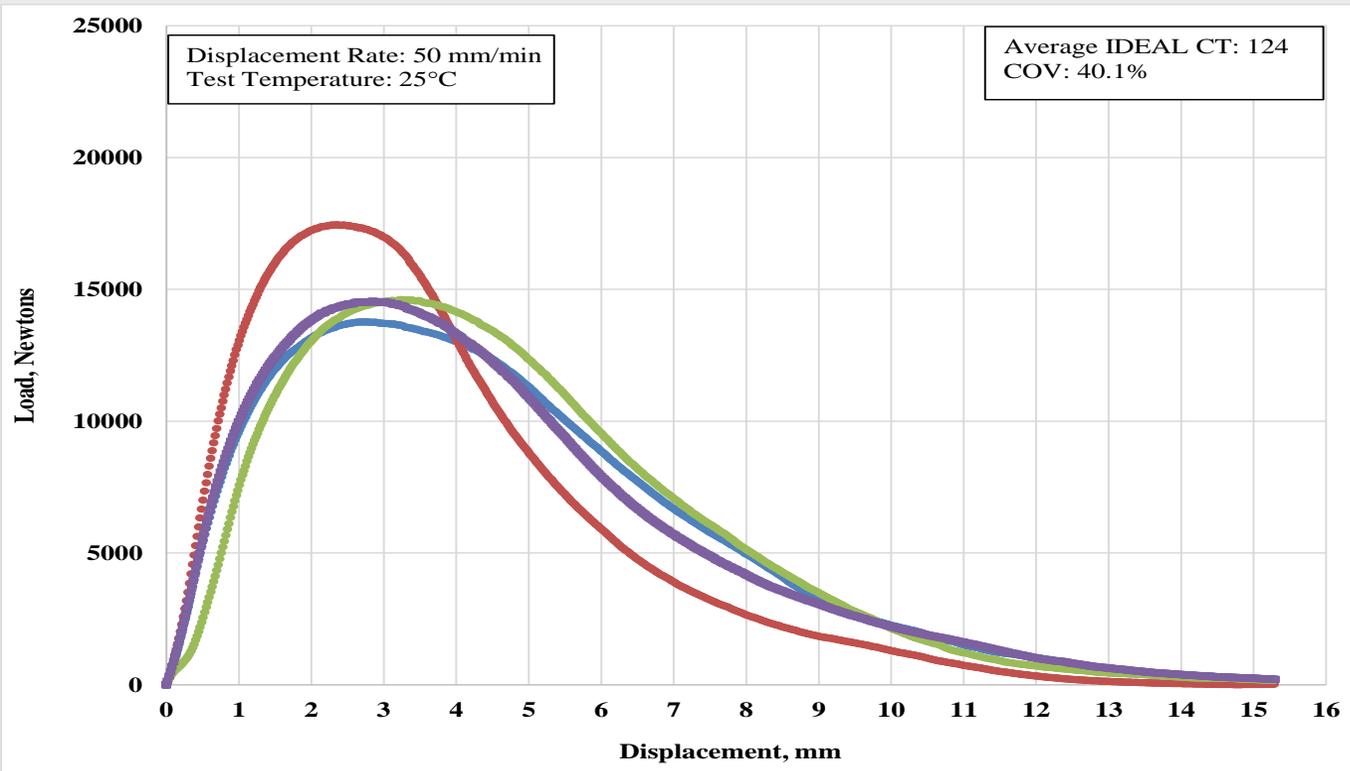


**Well controlled.
Acceptable Variability**

**Mix Acceptable,
PG 64-22 and 0% RAP**

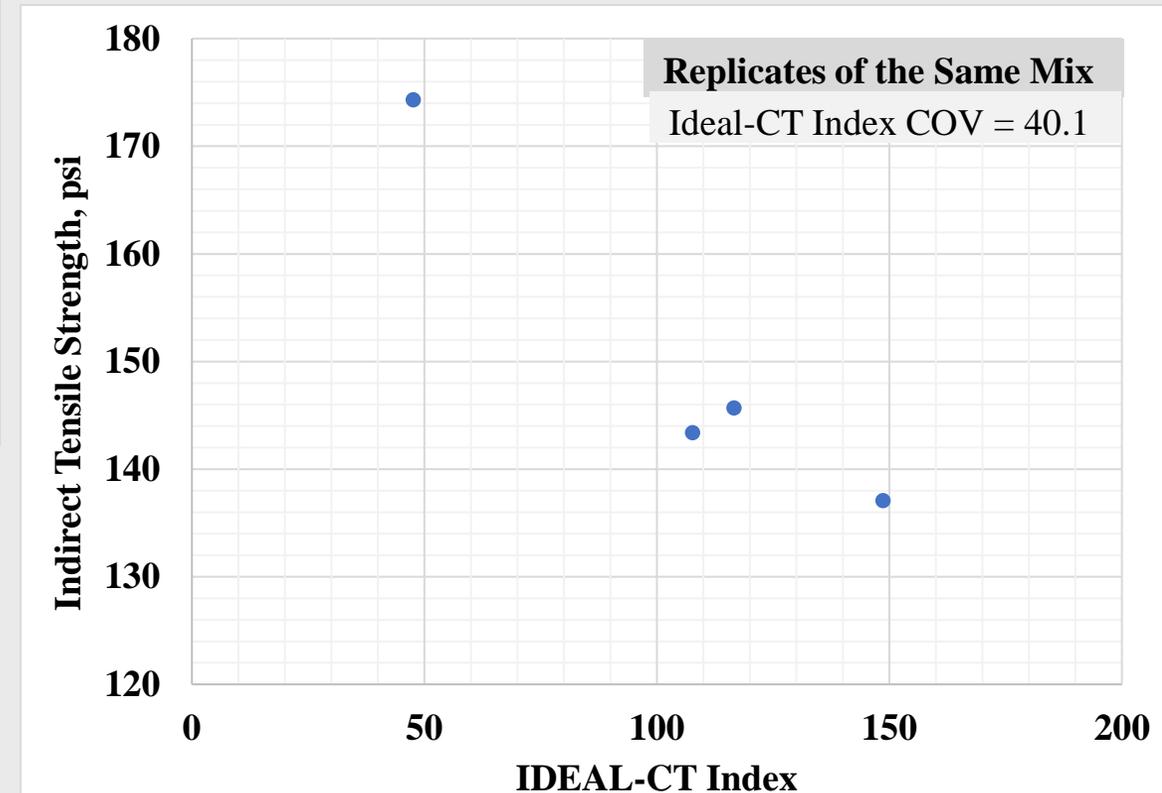


IDEAL-CT: Data Variability



**Outlier? Maybe
High Variability**

**Either remove outlier (through stat. test)
Or repeat testing.**

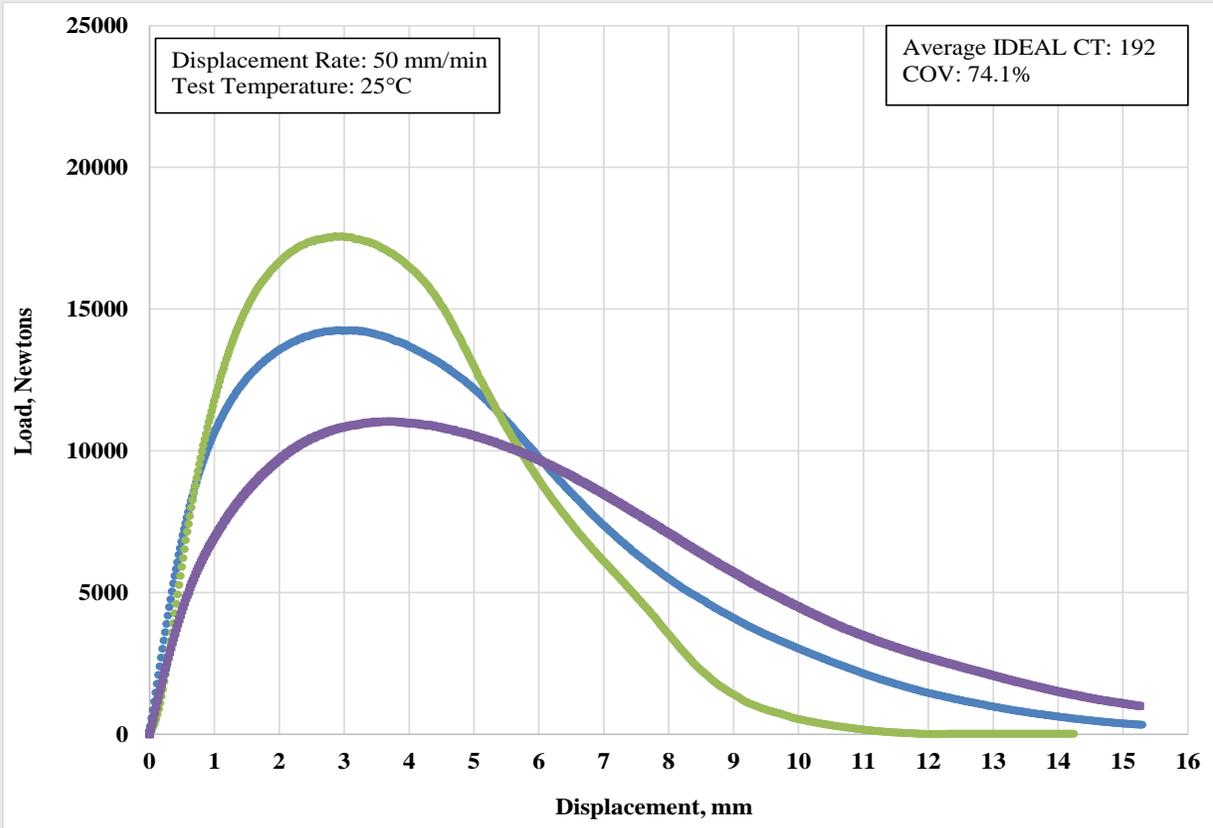




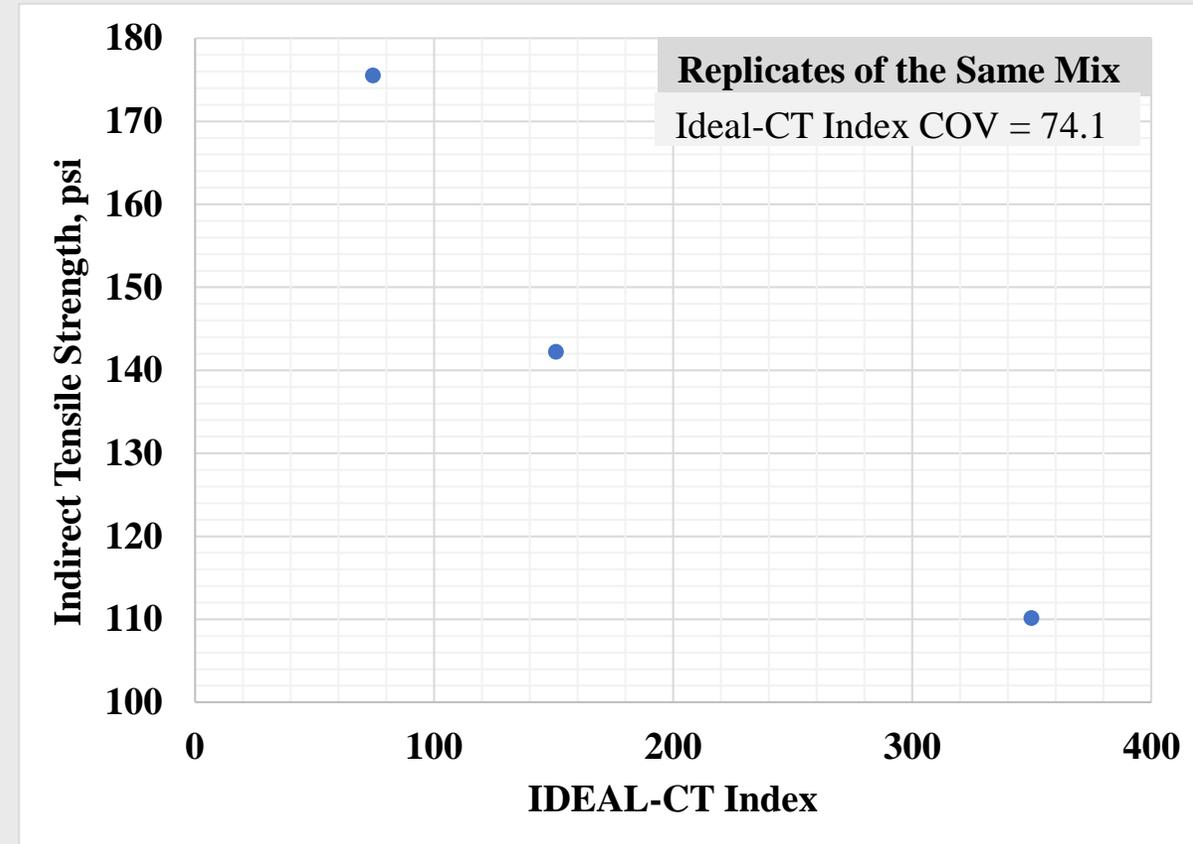
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IDEAL-CT: Data Variability



High Variability.
Not much hope here.
Problem when testing only three.

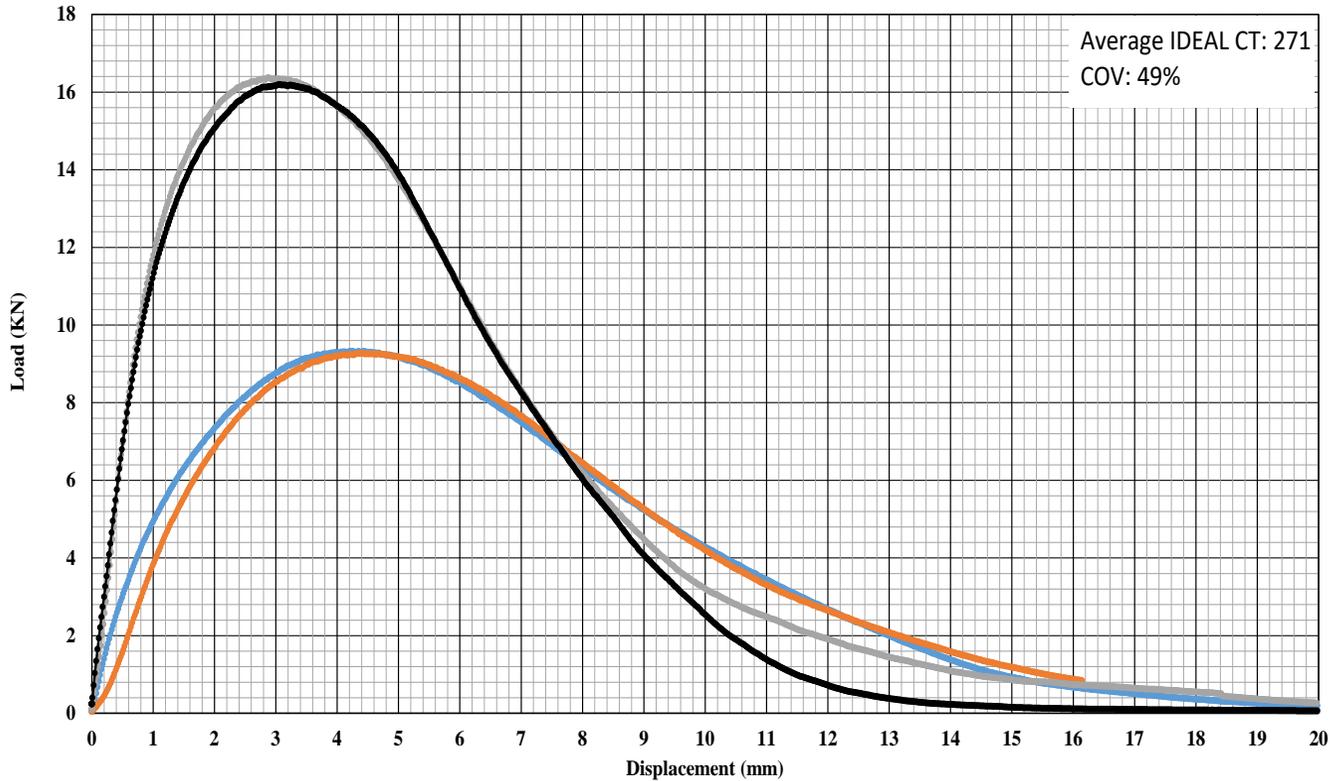


Test four specimens to increase chances of acceptance. Repeat testing



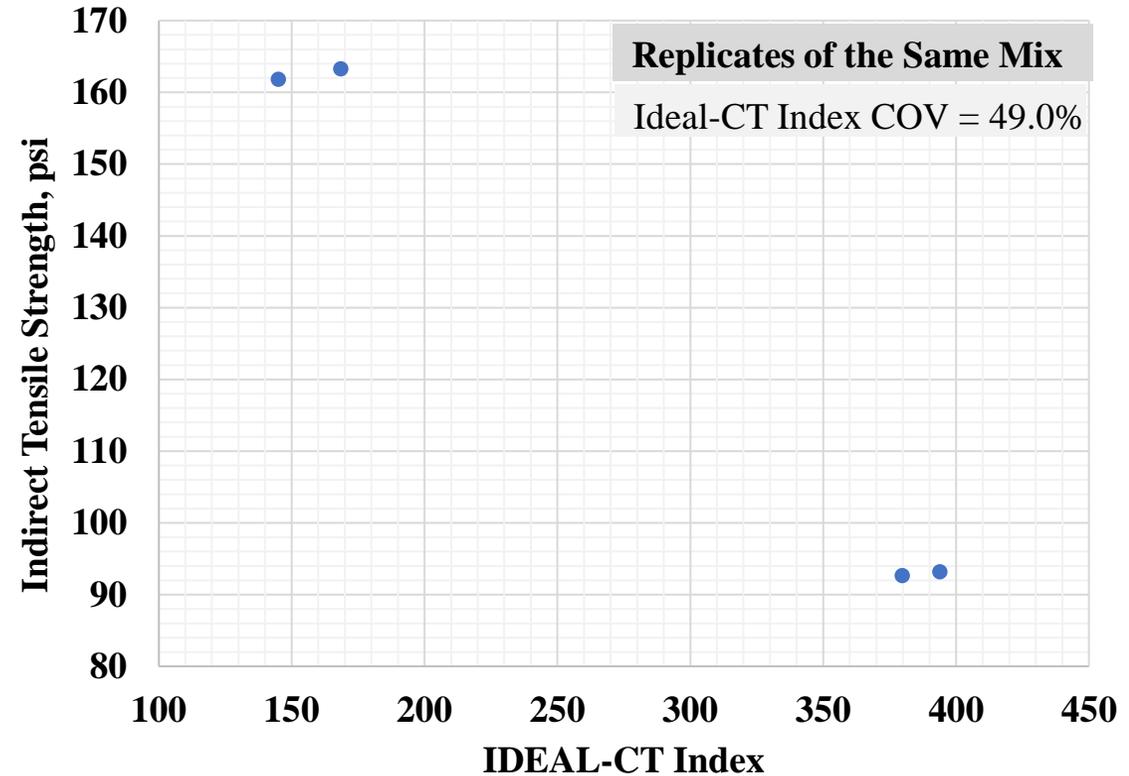
IDEAL-CT: Data Variability

Load vs. Displacement



**High Variability
Even Split.**

**High Flexibility on All Specimens
in spite of high variability**



OUTLINE



Laboratory Performance Tests



Discussion of Variability

within HWT

within IDEAL-CT

Lab/Plant/Field: HWT

Lab/Plant/Field: IDEAL-CT

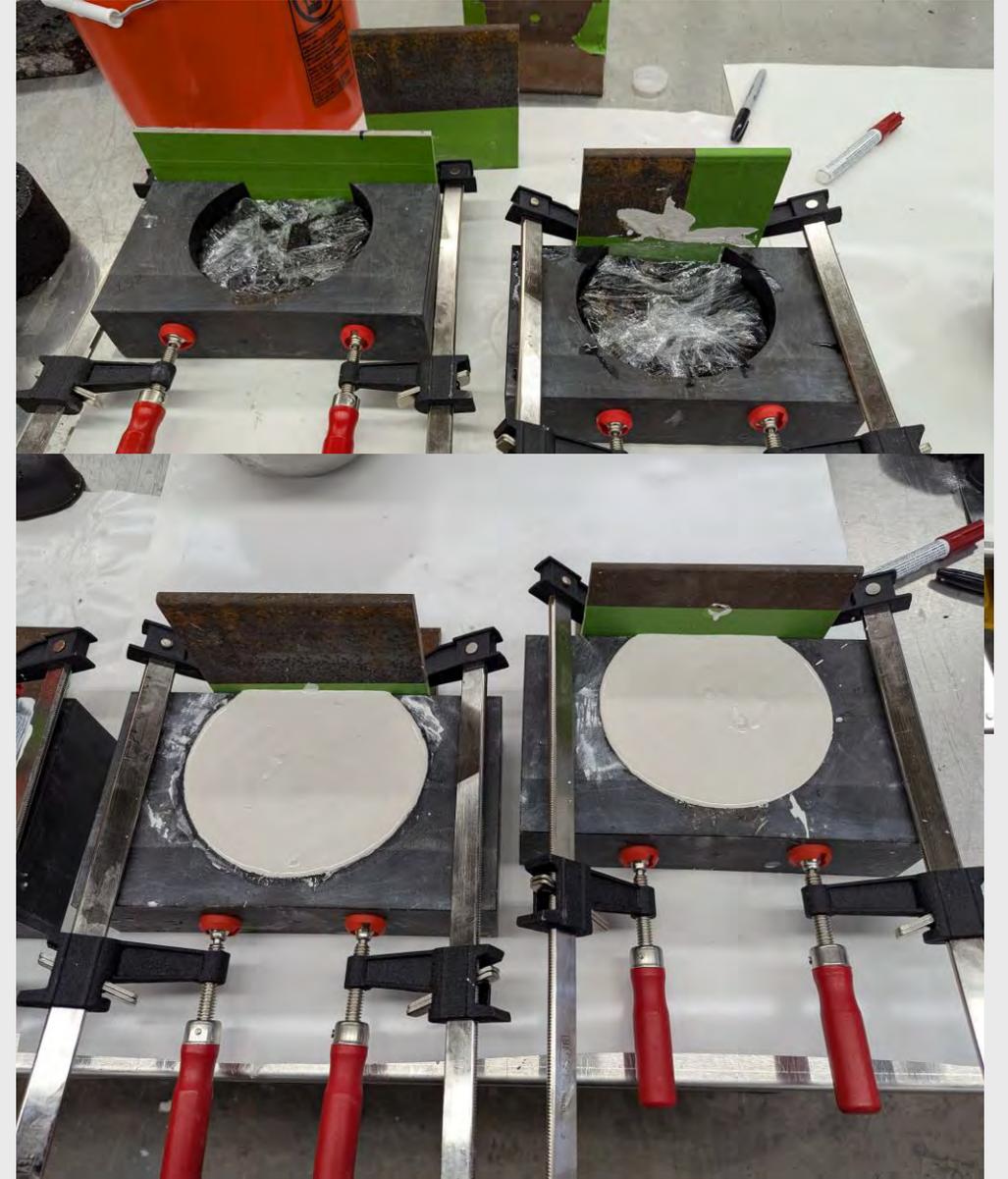


Summary & Conclusions



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Hamburg Wheel Track Test (HWTT)



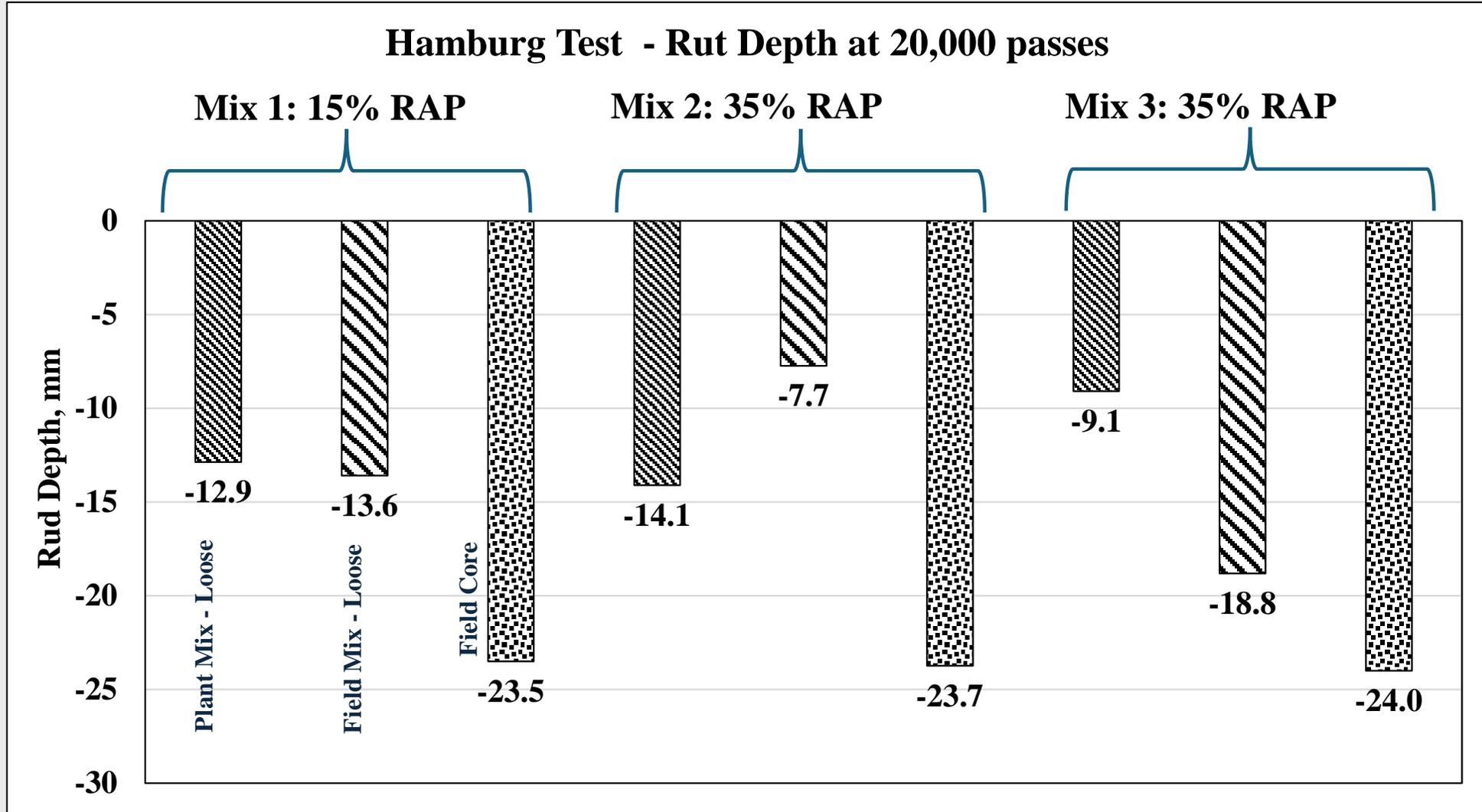
**Do Cores Fit in HWT Molds?
Thickness & Diameter Problem
Need curing compound.**



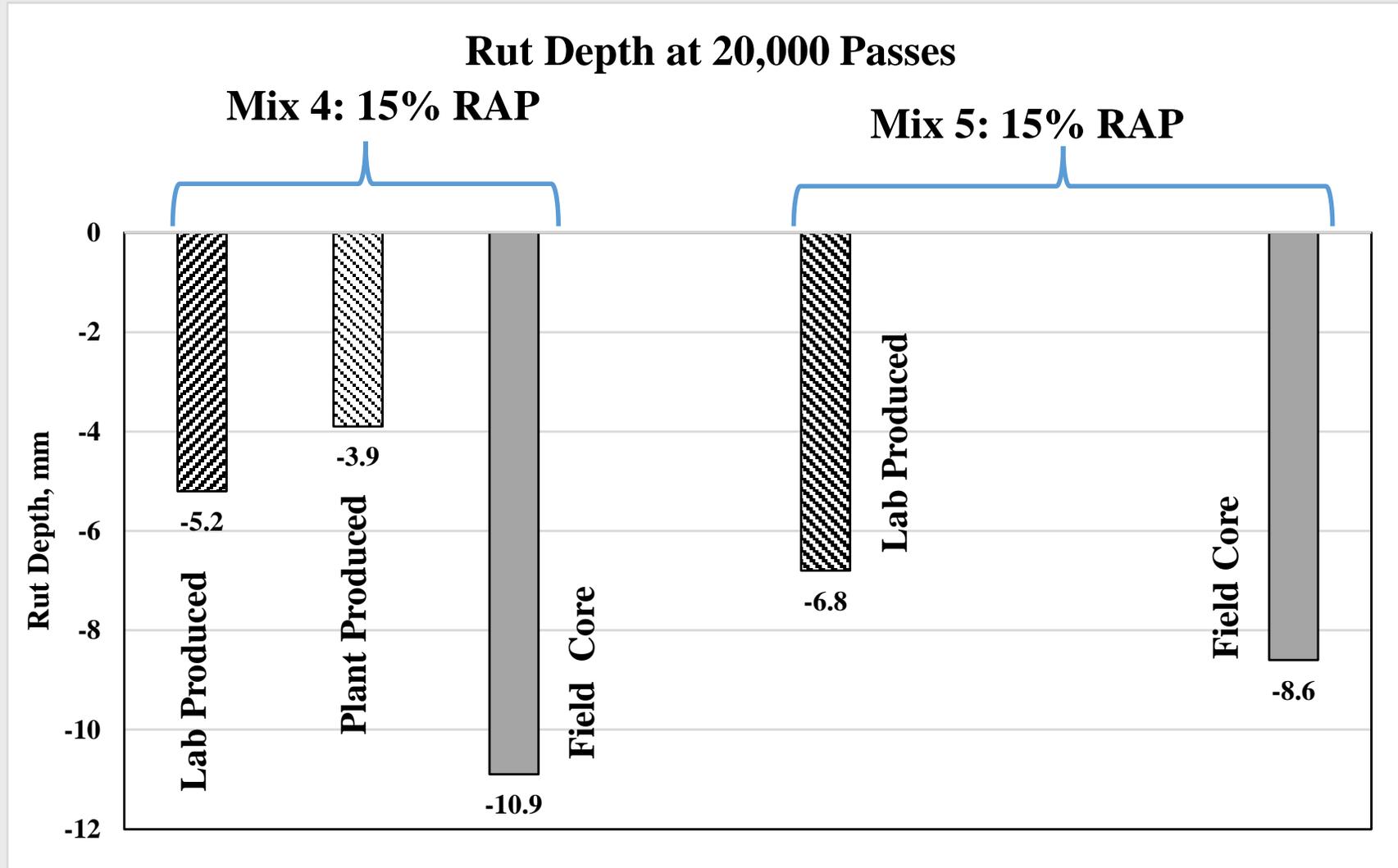
Hamburg Wheel Track Test (HWTT)



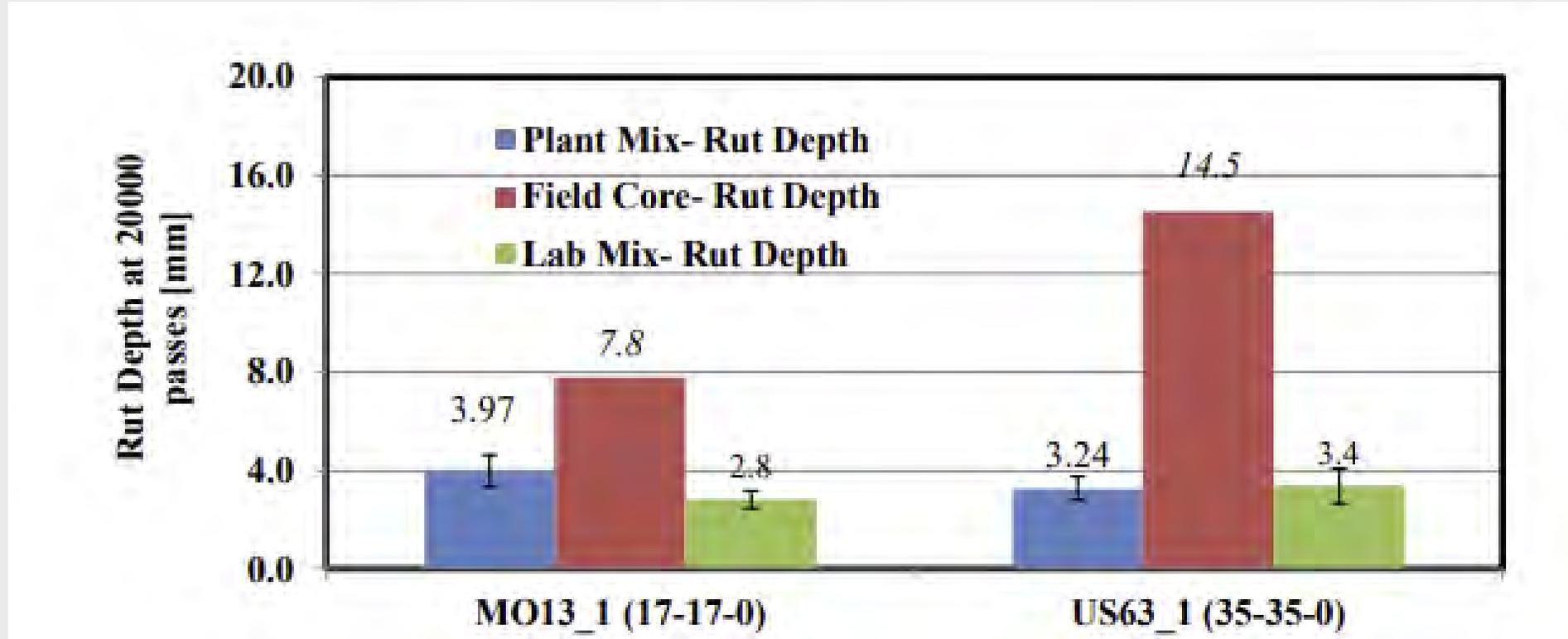
Hamburg Wheel Track Test (HWTT)



Hamburg Wheel Track Test (HWTT)

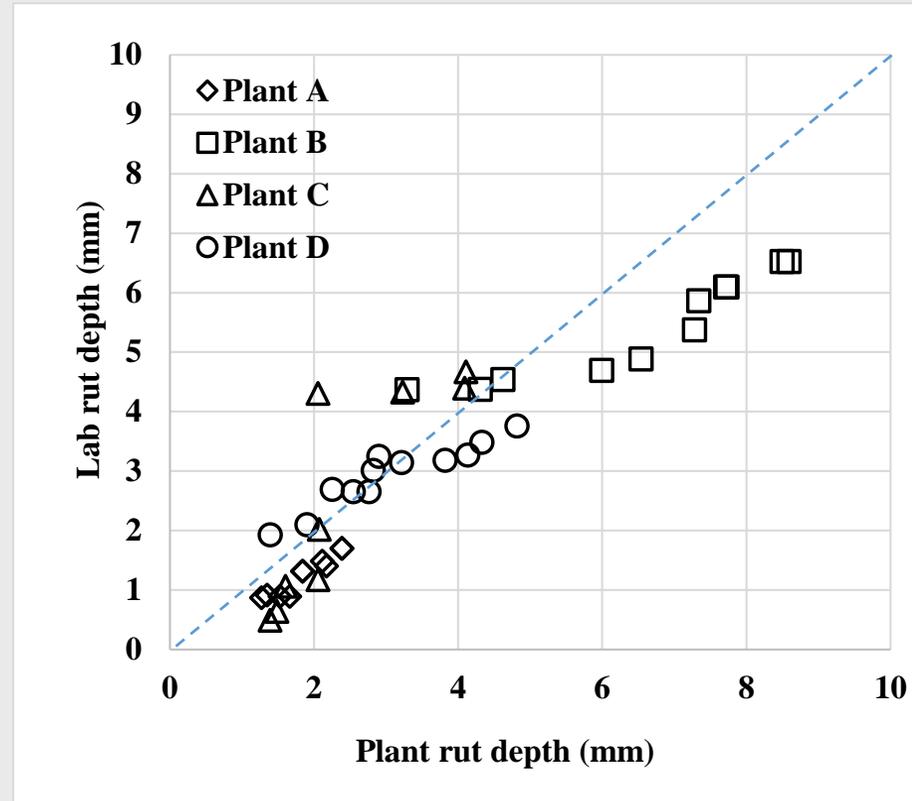


Comparison with Other work



Source: Performance Characteristics of Modern Recycled Asphalt Mixtures in Missouri, Including Ground Tire Rubber, Recycled Roofing Shingles, and Rejuvenators”
Buttlar et al., 2019,

Comparison with Other work



Rut depth comparisons between laboratory and asphalt plant compacted specimens

Source: “Plant and Laboratory Compaction Effects on Performance Properties of Plant-Foamed Asphalt Mixtures Containing RAP.” Journal of Materials in Civil Engineering 27.9 (2015): 04014240.

Feipeng Xiao et al., 2015

OUTLINE



Laboratory Performance Tests



Discussion of Variability

within HWT

within IDEAL-CT

Lab/Plant/Field: HWT

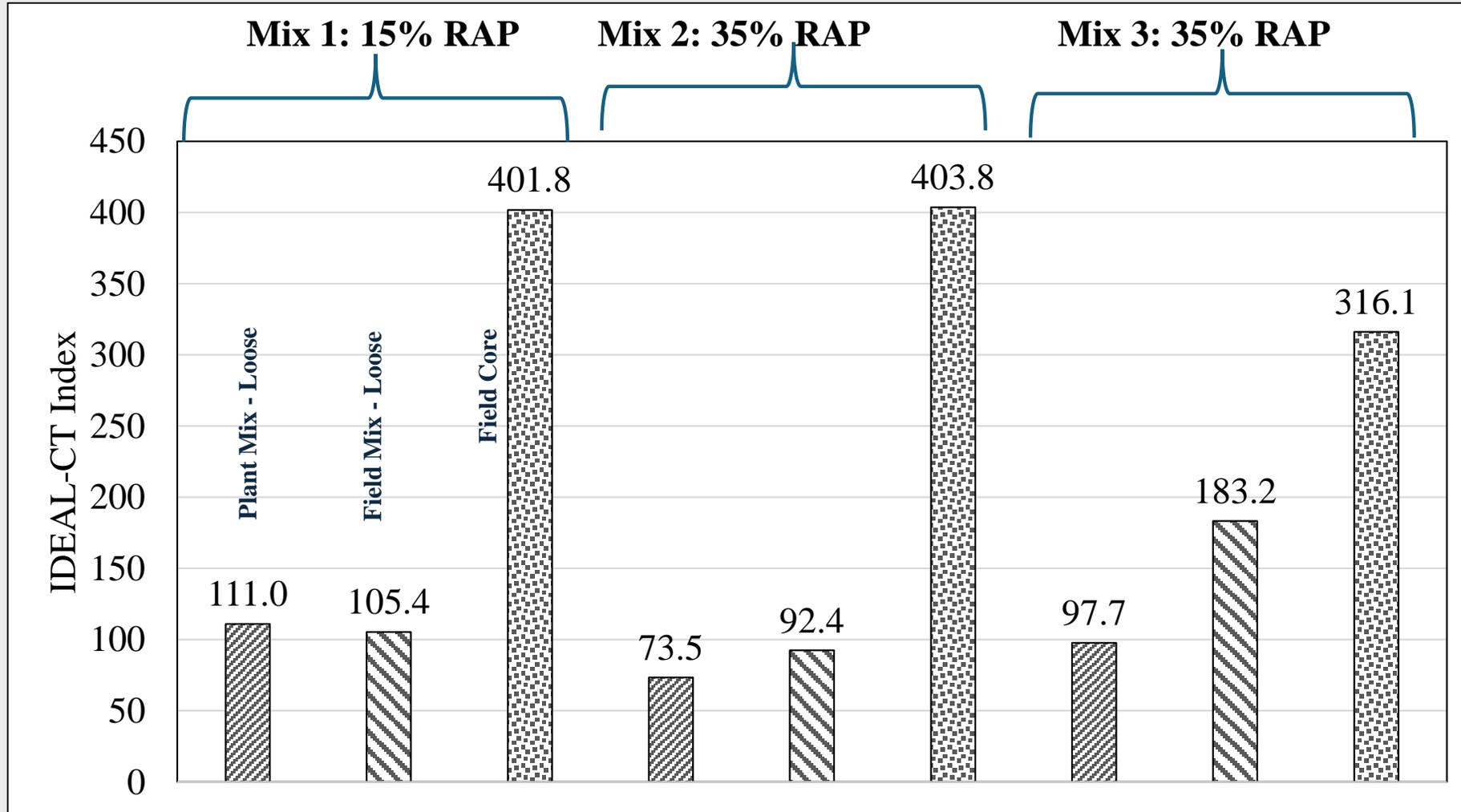
Lab/Plant/Field: IDEAL-CT



Summary & Conclusions

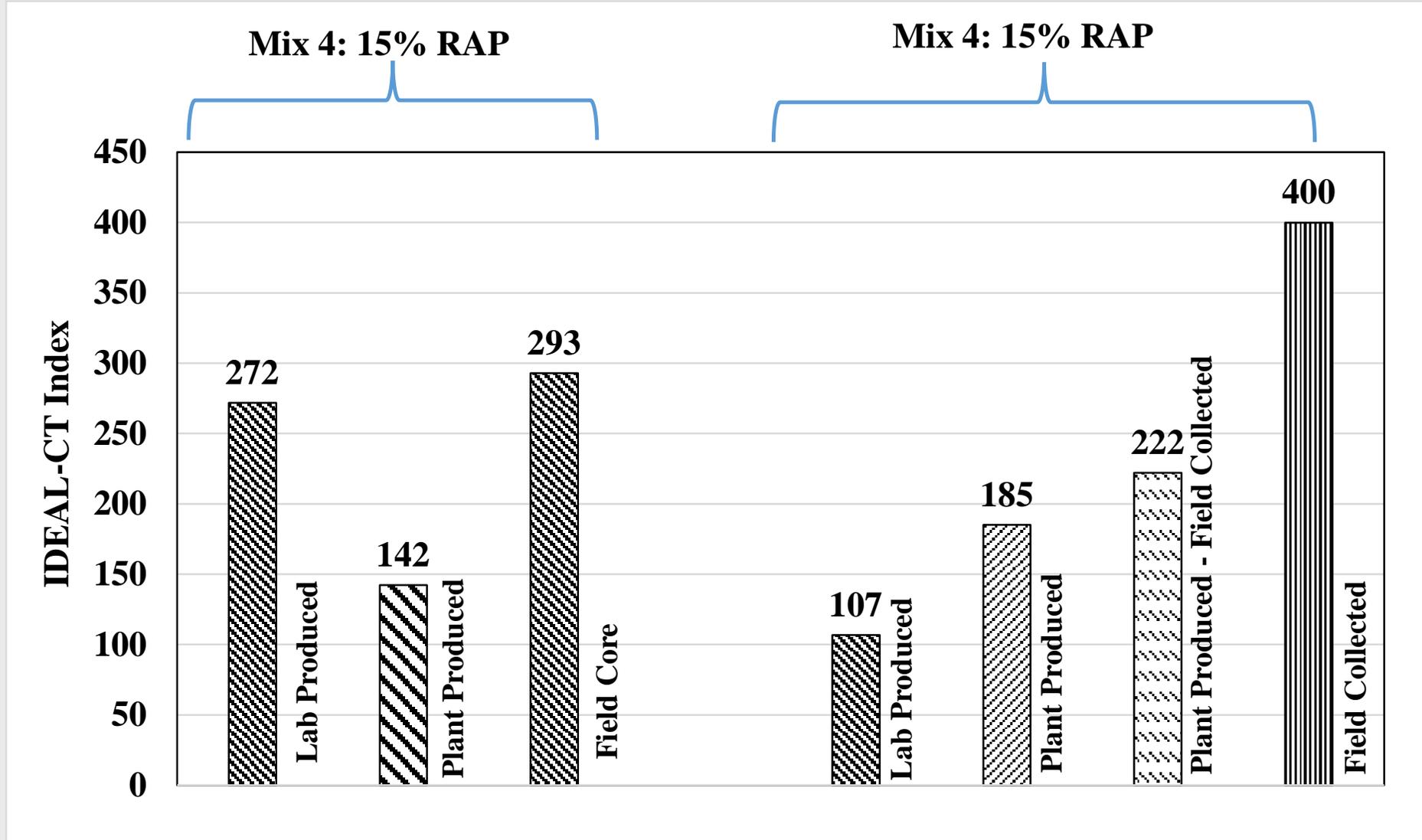


IDEAL-CT: Plant Mix vs Field Cores

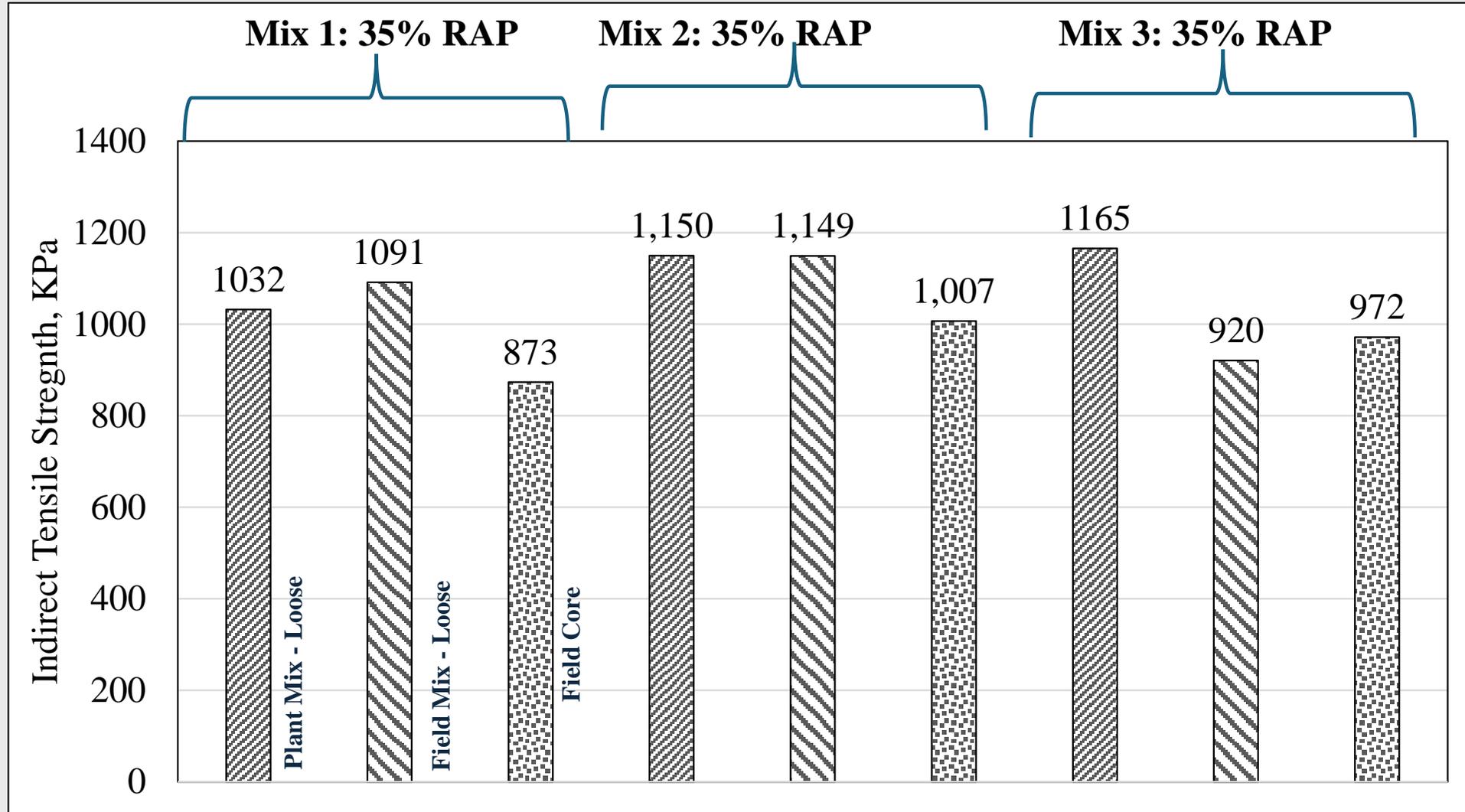




IDEAL-CT: Lab/Plant/Field

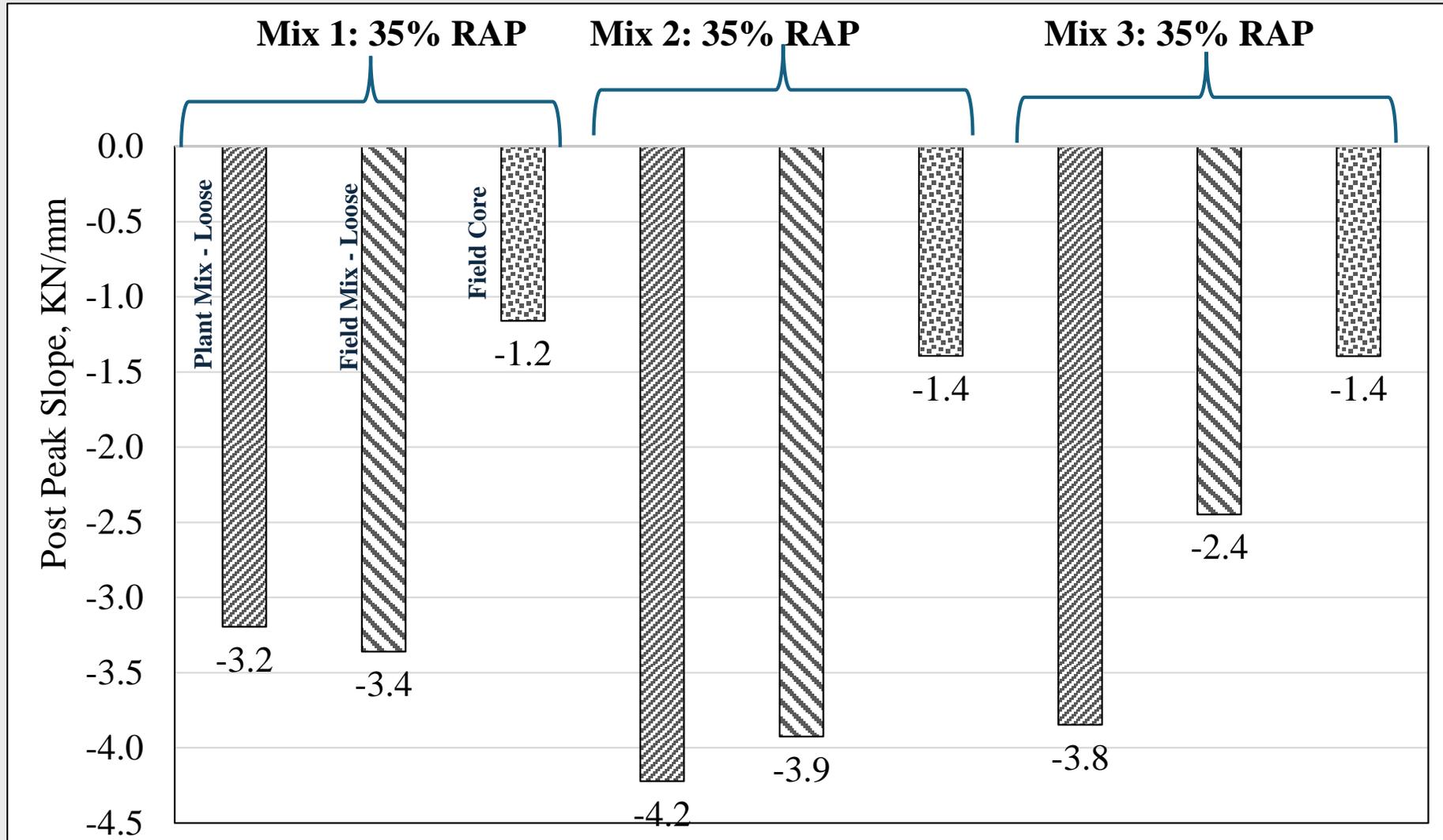


IDEAL-CT: Strength Comparison





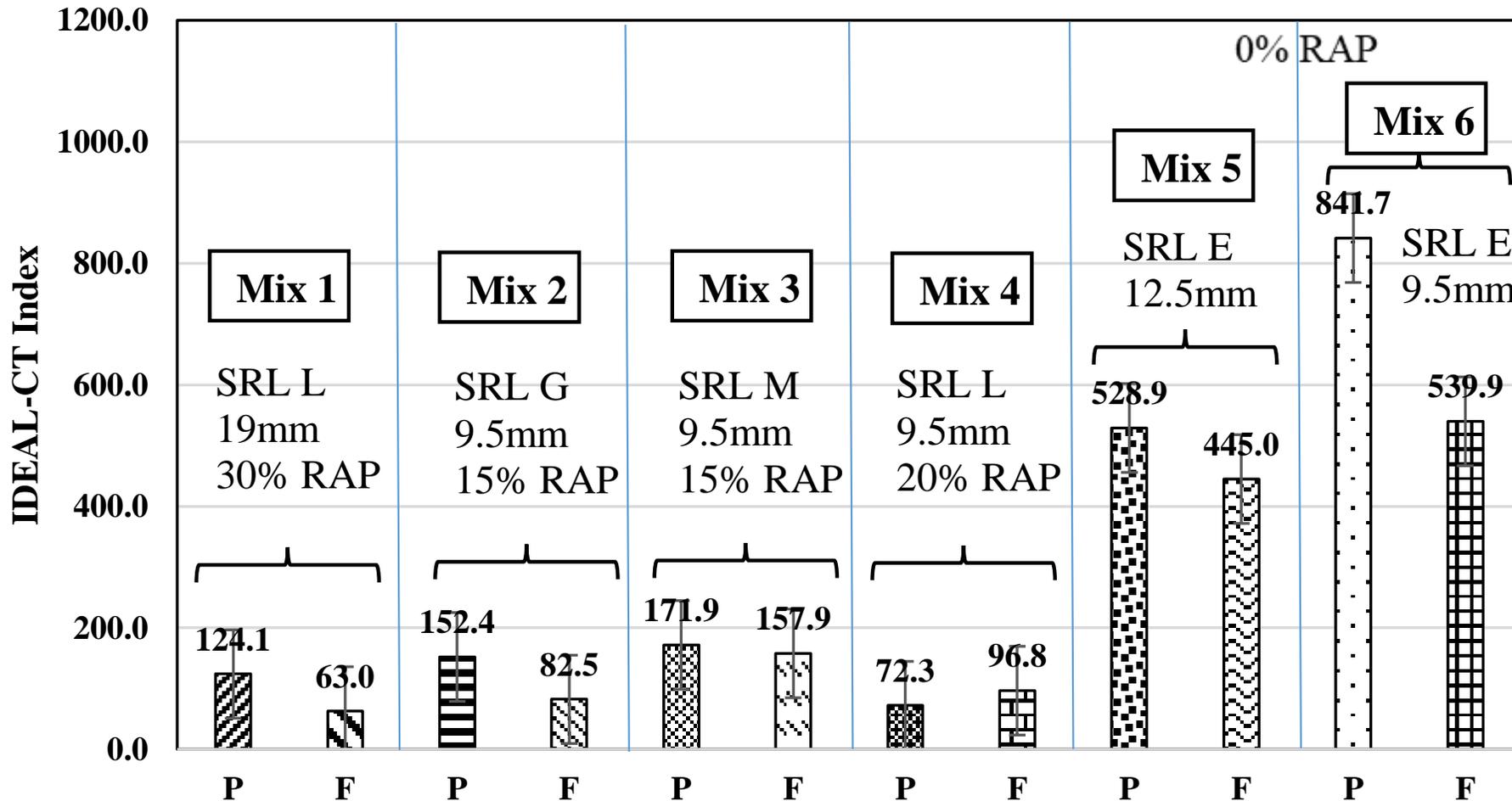
IDEAL-CT: Slope Comparison



IDEAL-CT:

Effect of Sampling Location

IDEAL-CT Index



Collection Points:

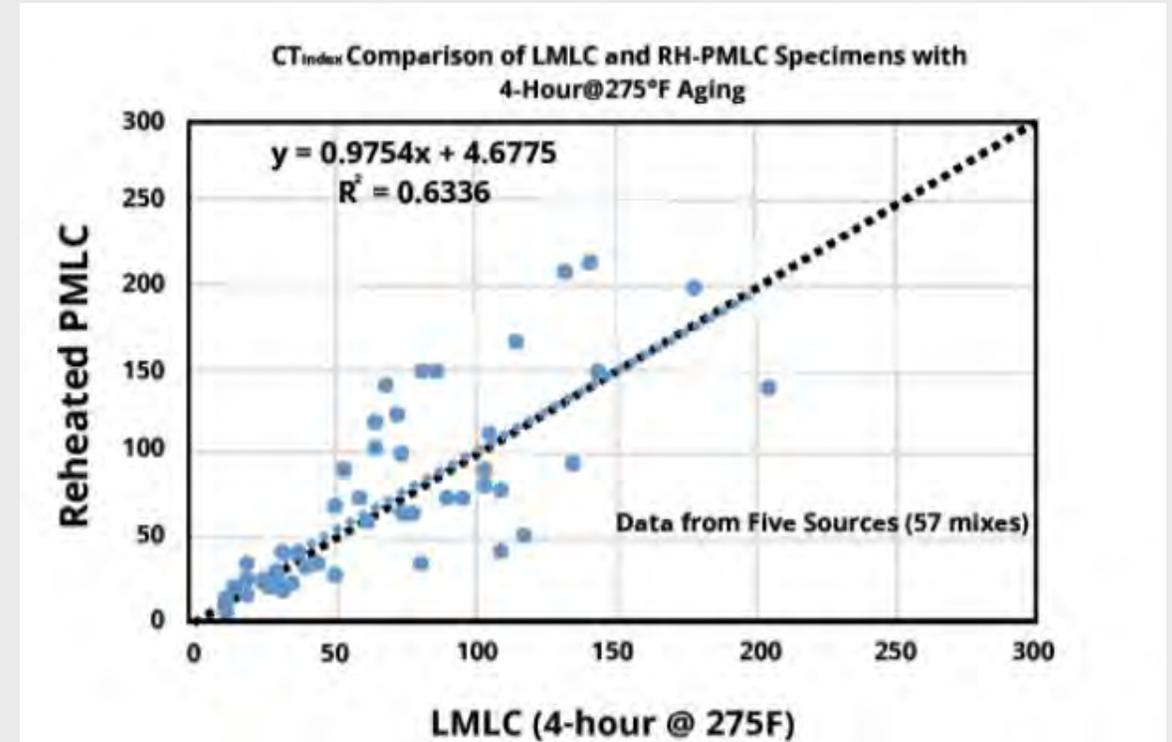
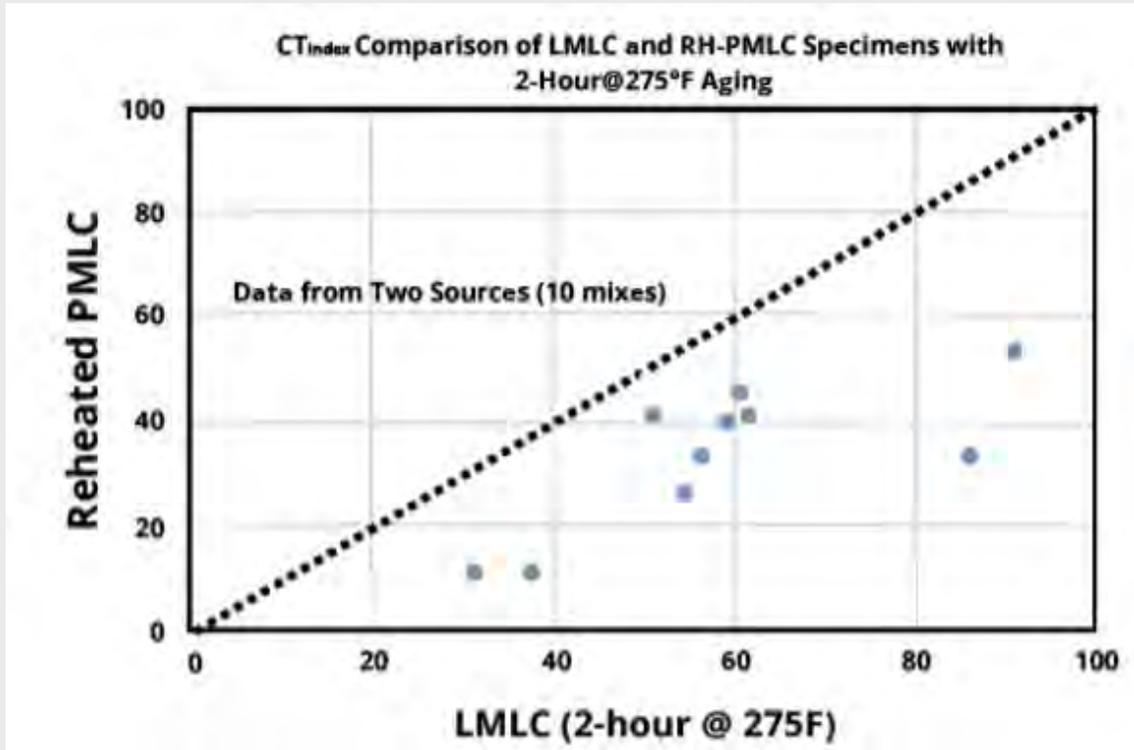
P:
at the plant

F:
behind the paver



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IDEAL-CT: Short-Term Aging Effect



Source: “Differences in Lab vs. Plant Mixtures Using IDEAL-CT.”

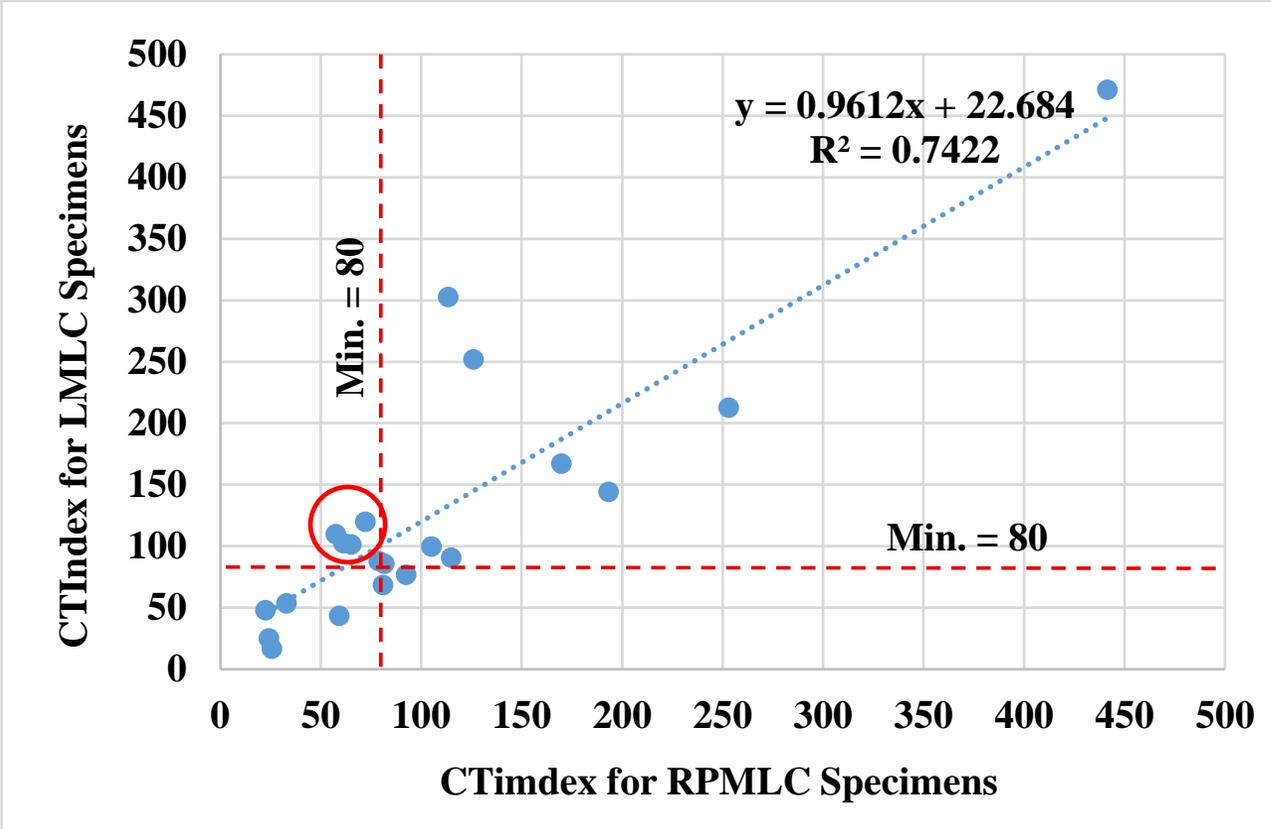
Chen Chen et al., 2025

Website: NCAT Newsroom. Available at:

<https://www.eng.auburn.edu/research/centers/ncat/newsroom/2025-spring/lab-vs-plant-idealct.html>



IDEAL-CT: Lab vs Reheated Mixes



21 Mixtures – Various Plants
2 hours at compaction temperature

|RPMLC - LMLC| <25 for 12 Mixes

|RPMLC - LMLC| >25 & < 50 for 5 Mixes

|RPMLC - LMLC| >50 for 4 Mixes

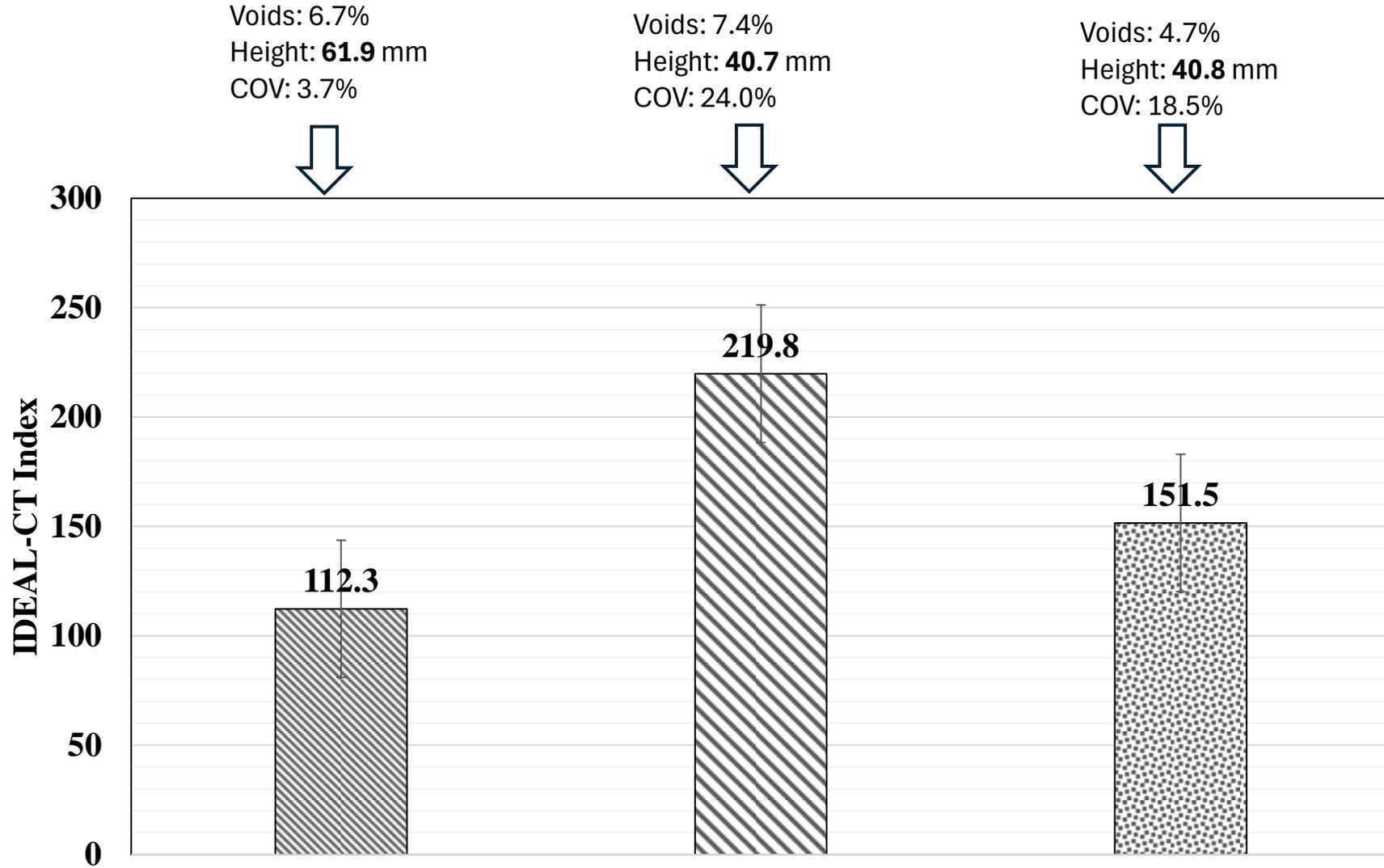
Correlation Between CT_{index} of the RPMLC Specimens and the LMLC specimens

Source: “Performance Evaluation Methods for Balanced Design of Asphalt Mixtures.”
Al-Khayat, Haydar Tahseen Ali., 2023, Doctoral dissertation



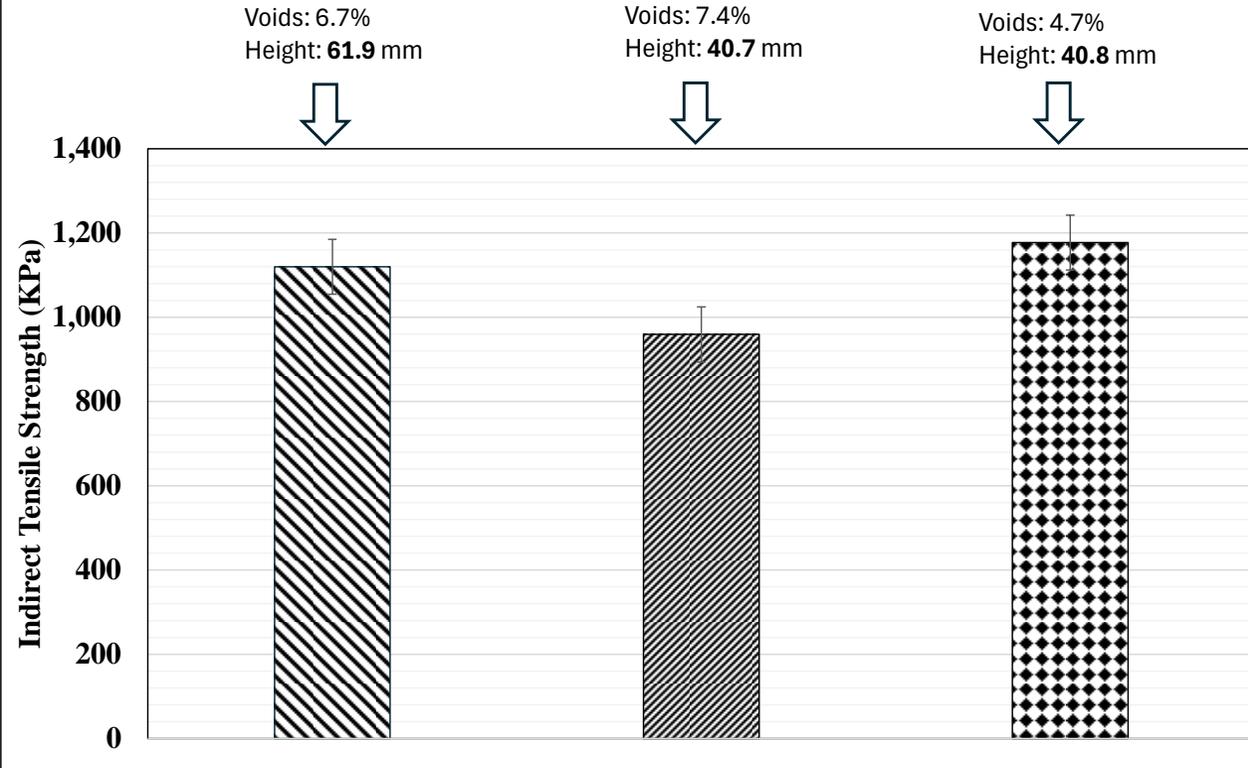
IDEAL-CT: Thickness Effect

Lab Prepared 9.5-mm mix, 35% RAP

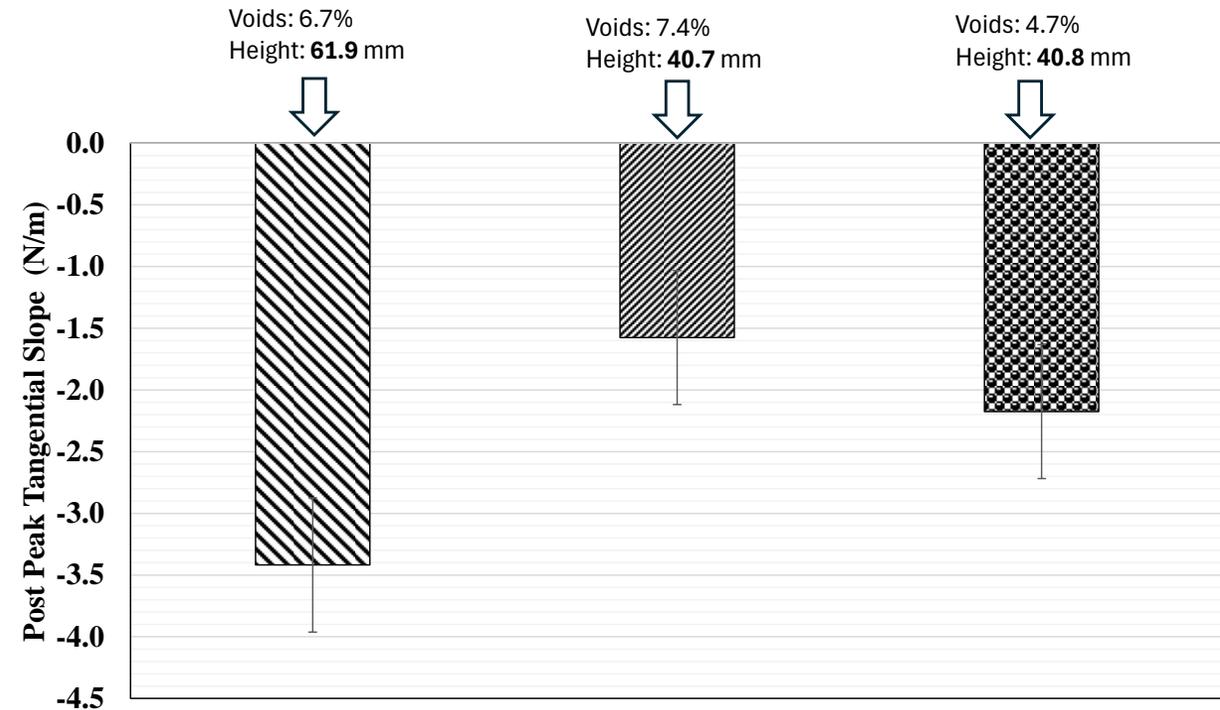


IDEAL-CT: Thickness Effect

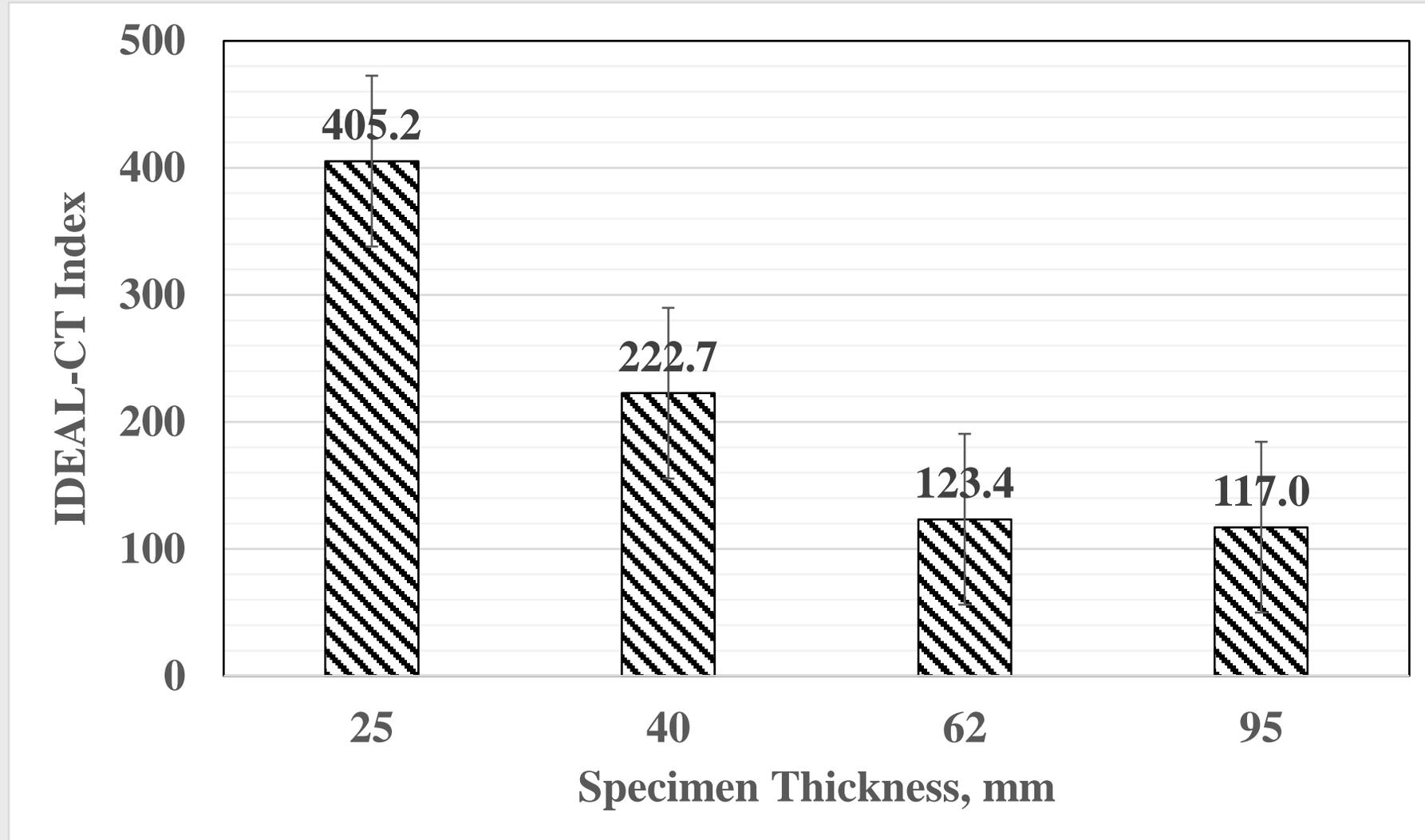
Lab Prepared 9.5-mm mix, 35% RAP



Lab Prepared 9.5-mm mix, 35% RAP



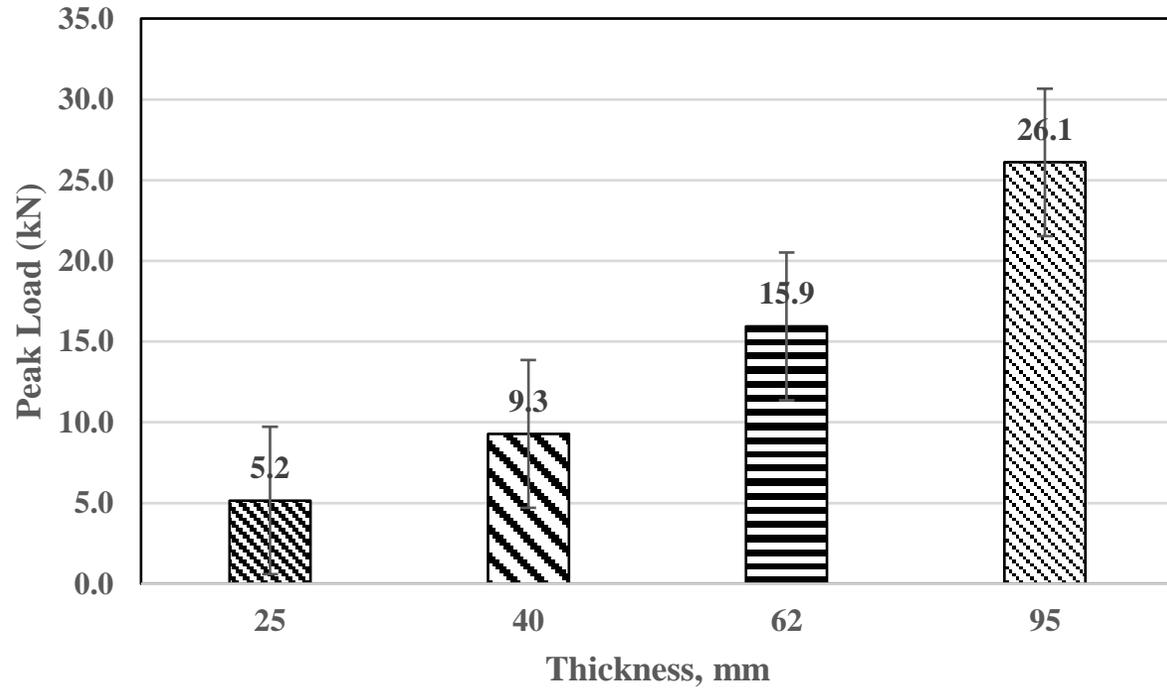
IDEAL-CT: Thickness Effect



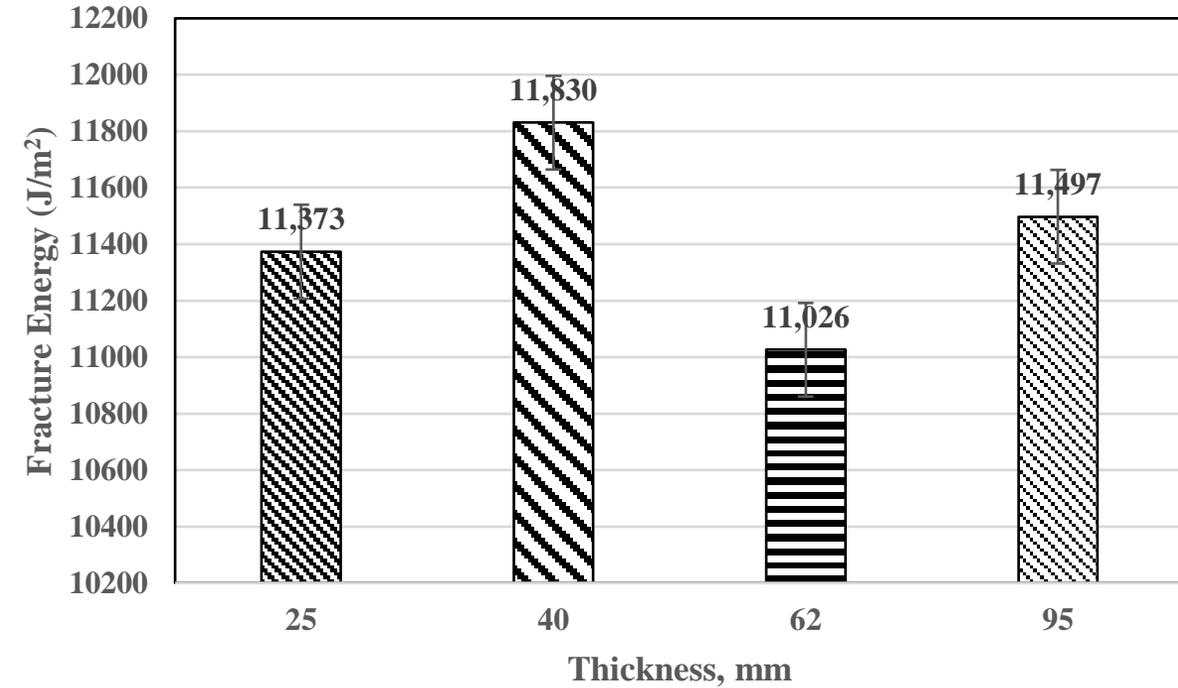
Sandstone Aggregate

IDEAL-CT: Thickness Effect

Peak Load - Mix NB



Fracture Energy - Mix NB



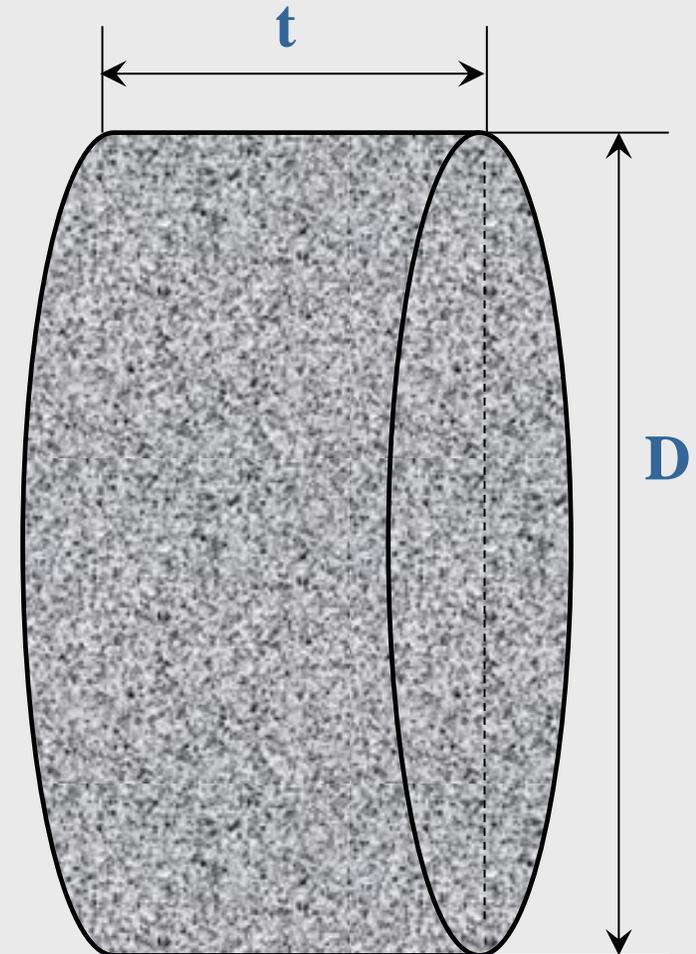
ASTM D6931-17 (Old): Indirect Tensile Strength Test

The Standard Addresses Aspect Ratio (D/T).

ASTM D6931-17 Requirement:

- ❖ For D= 100, min. t = 50 mm (Lab Specimens)
- ❖ For D = 100, min. t = 38 mm (Cores)
- ❖ For D= 150, min. t = 75 mm (Lab Specimens)

$$S_t = \frac{2P}{\pi t D}$$



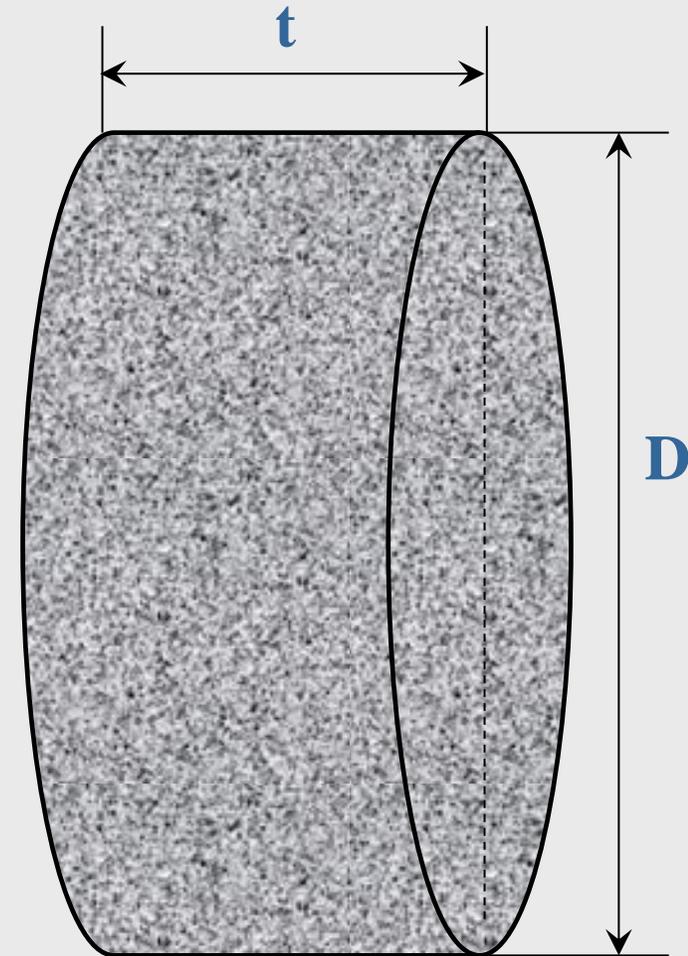
ASTM D6931-24 (New): Indirect Tensile Strength Test

ASTM D6931-24 Requirement:

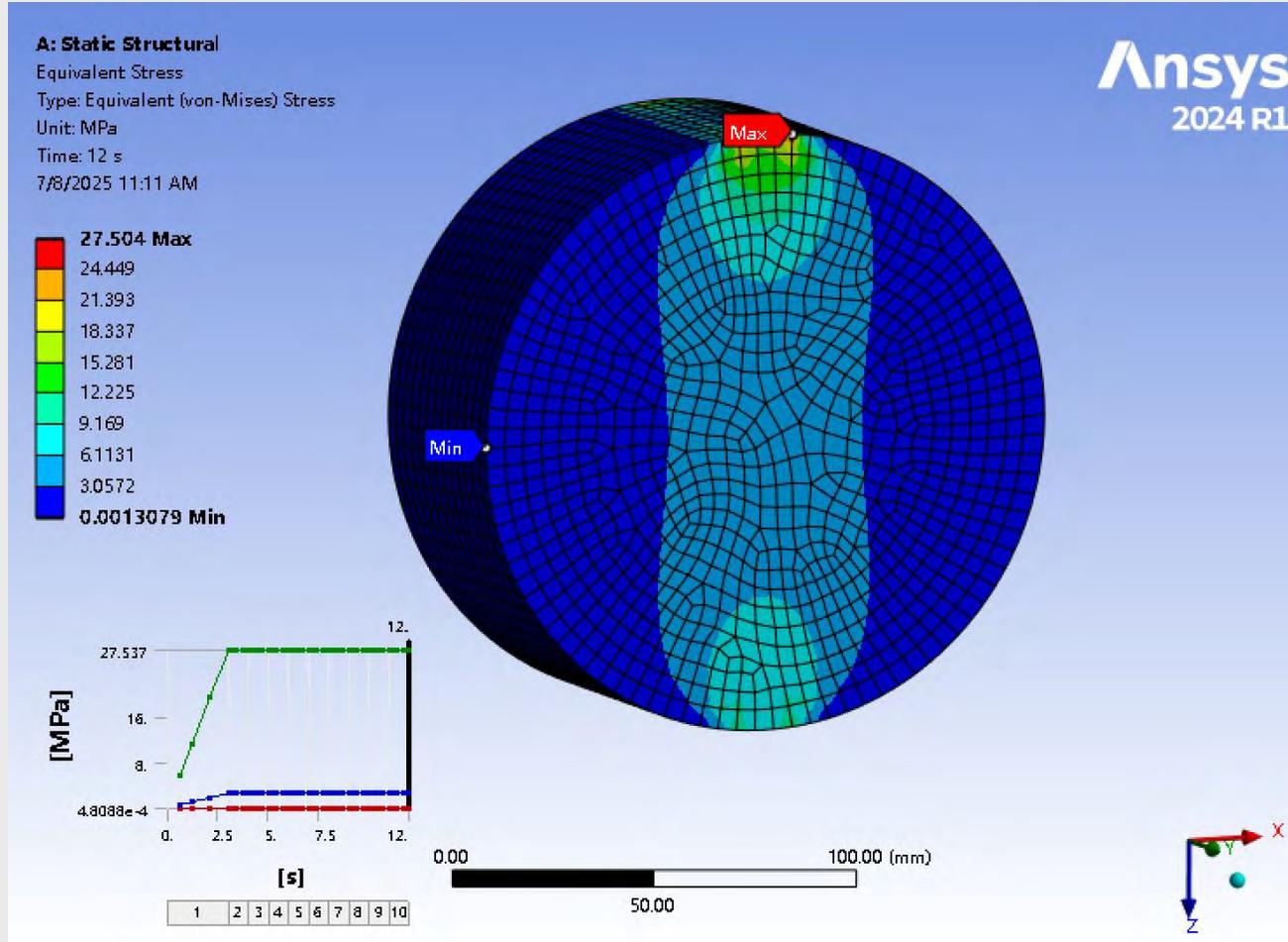
- ❖ **D= 100 or 150 mm**
- ❖ **t = 63 mm (conventional)**

- ❖ **If NMAS \geq 25 mm, D=150 and t = 95 mm**

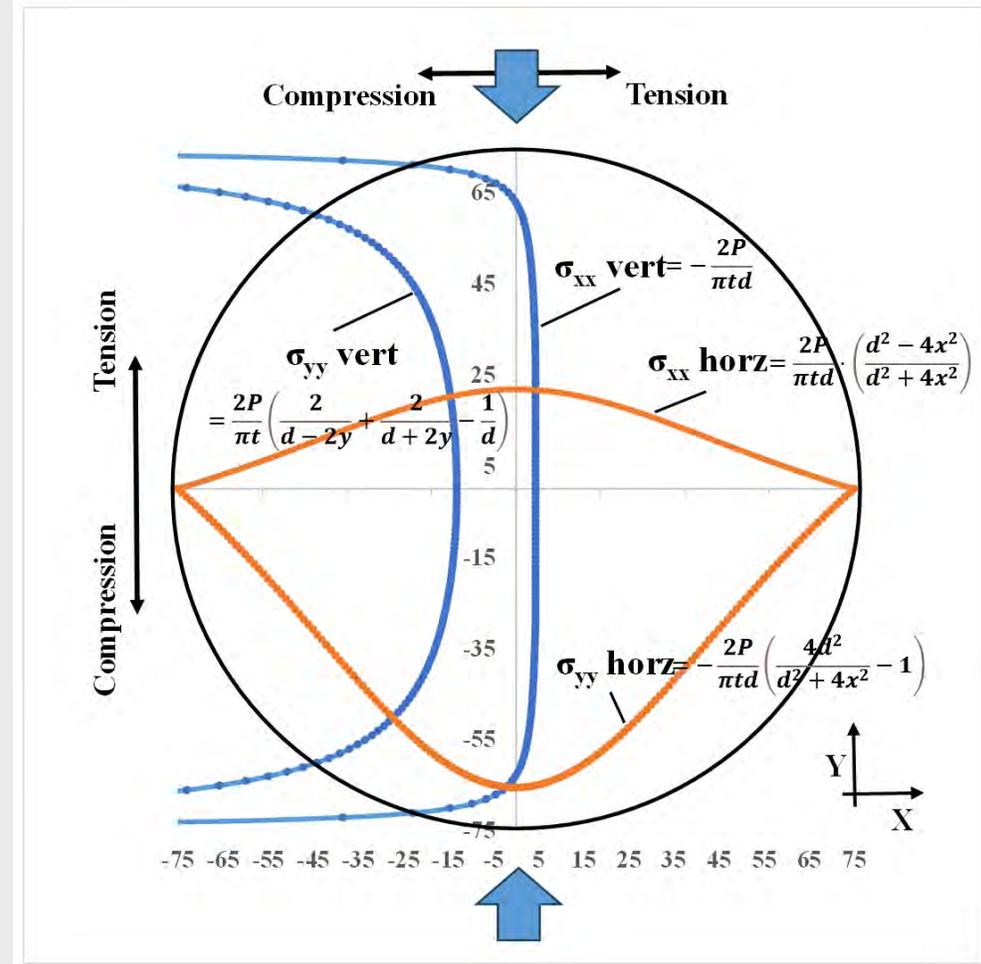
$$S_t = \frac{2P}{\pi t D}$$



FEM vs. Theoretical Calculation

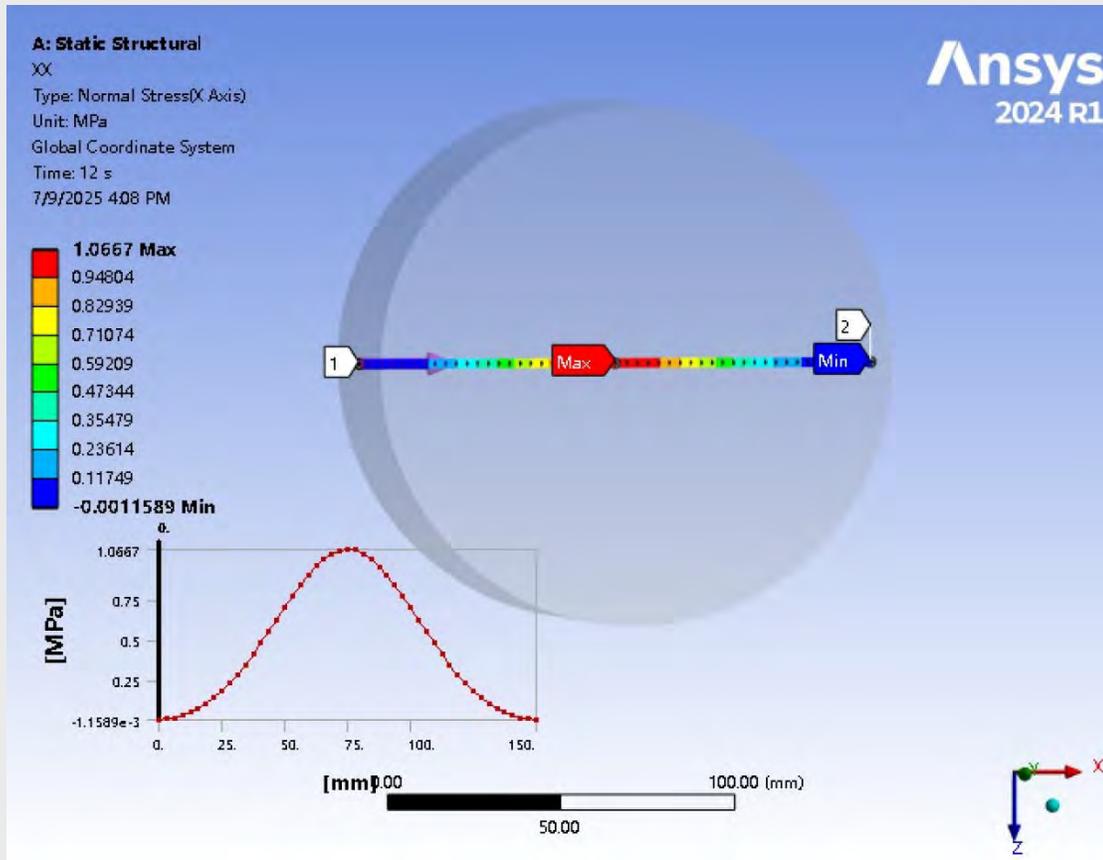


Equivalent Stress Distribution (von Mises)
from FEM Simulation

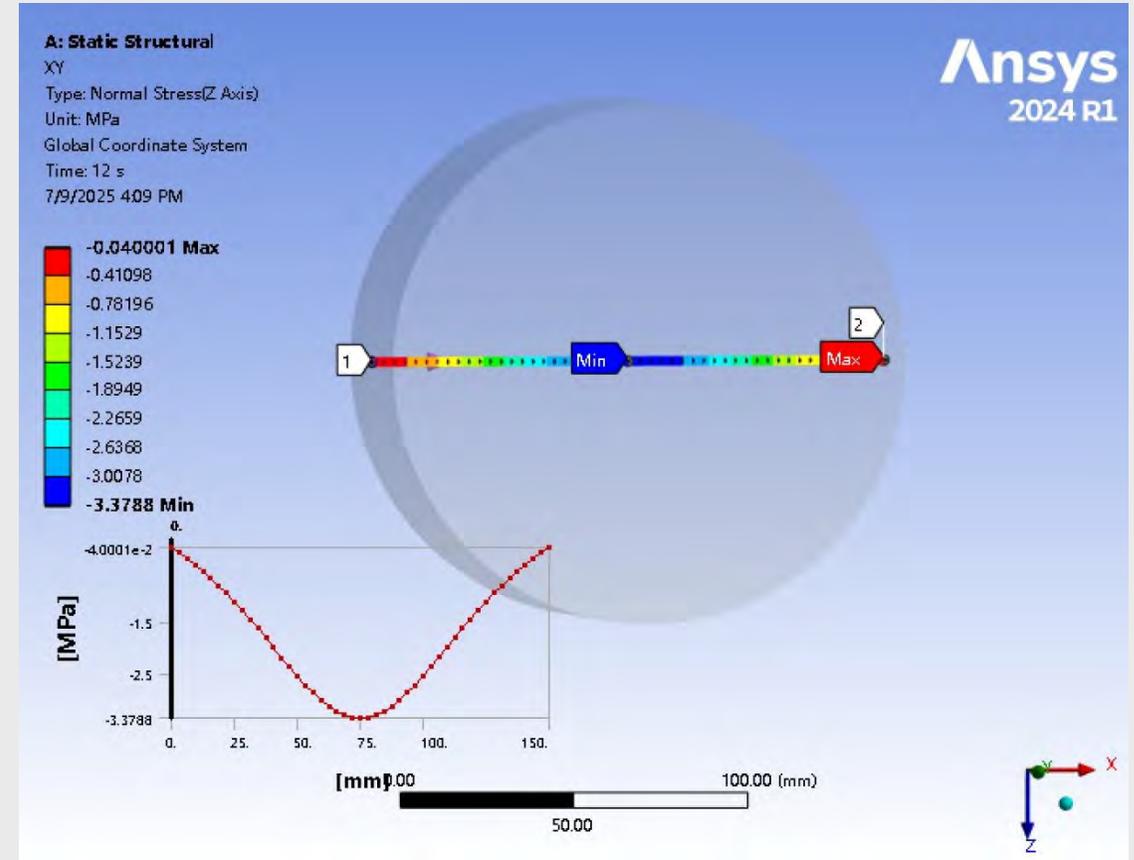


Stress Distribution

FEM vs. Theoretical Calculation



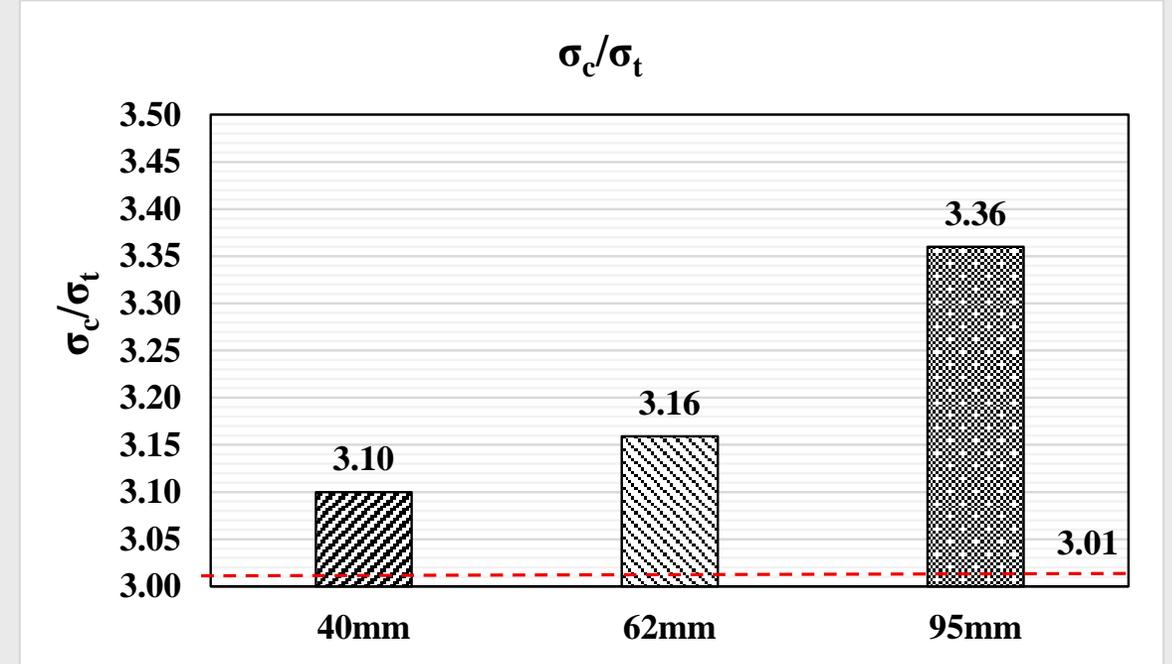
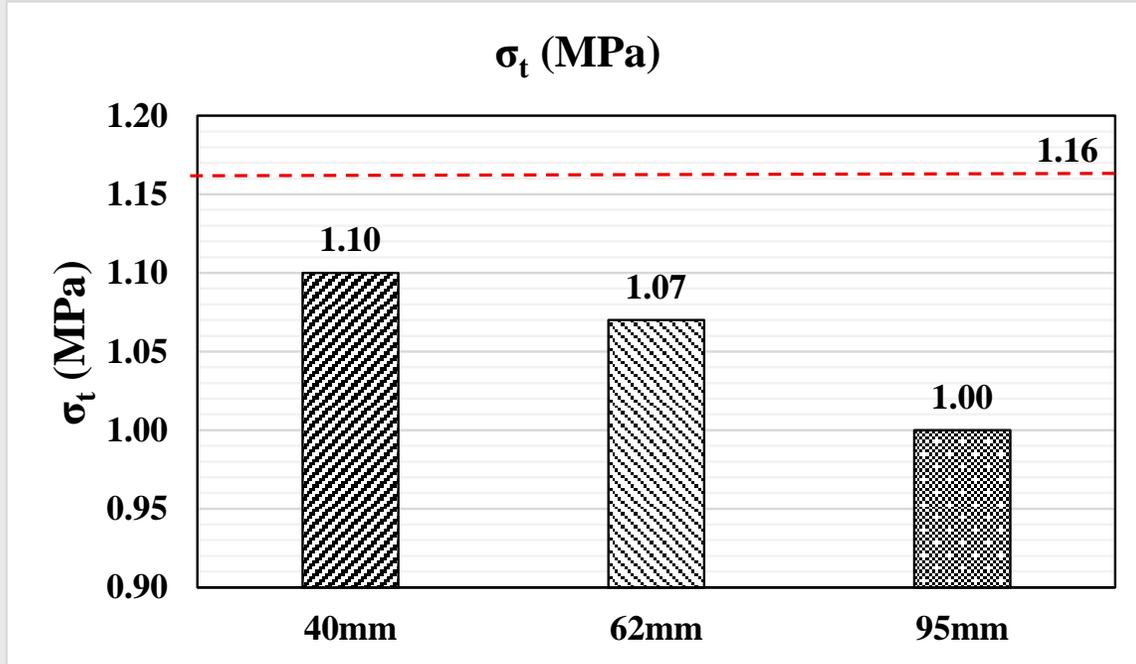
X-direction Stress along the Horizontal Axis



Y-direction Stress along the Horizontal Axis



FEM vs. Theoretical Calculation



Comparison of Tensile Stress and Compressive-to-Tensile Stress Ratio at Specimen Center across Different Specimen Thicknesses

$$\sigma_t = \frac{2 \times 17000}{\pi \times 0.062 \times 0.15} = 1.16 \text{ MPa}$$

$$\sigma_c = -\frac{6 \times 17000}{\pi \times 0.062 \times 0.15} = -3.49 \text{ MPa}$$

*Thicknesses (40 mm, 62 mm, 95 mm) ; Peak load (10.97 KN, 17.00 KN, 26.05 KN) ; Modulus (4 GPa)



OUTLINE



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Lab/Plant/Field: IDEAL-CT



Summary & Conclusions

Summary and Conclusions

- ❖ **Possible to establish options to check variability in HWT**
- ❖ **Use of COV a good option with IDEAL-CT and using 4 to 6 specimens**
- ❖ **Limited thickness of cores is a challenge for Performance Testing**
- ❖ **In some cases, significant difference between Lab/Plant/Field Performance Test results**
- ❖ **Not possible to use the same accept/reject threshold values for Lab/Plant/Field test results**

Thank You!

