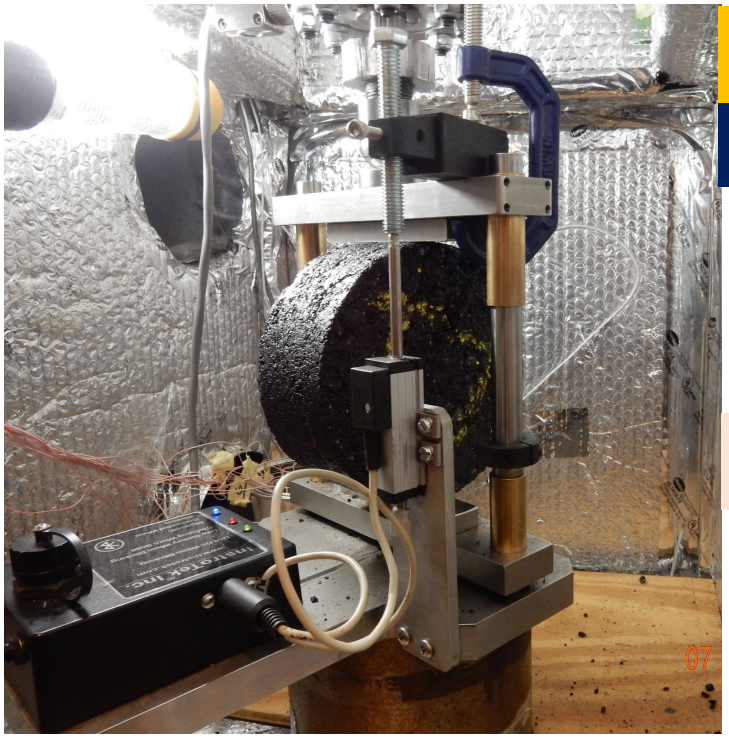
PA Initiative on
IDEAL AND SCB CRACK TESTS



Pennsylvania Asphalt Paving Association

60th Annual Meeting

January 22, 2020

Gary Hoffman, PAPA
and
Mansour Solaimanian, Penn State

DISCUSSION TOPICS

1. Performance Based Testing & Long Life Asphalt Pavements
2. Initiative on SCB/IDEAL-CT Testing in PA
3. Background on IDEAL-CT Tests
4. Discussion of Results, Summary & Conclusions

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LLAP Best Practices

- SMA Wearing
- WMA/Antistrip
- MTV Required
- Longitudinal Joint Density Specification
- Ride Specification Optional
- Tack Coat Every Layer (New Section 460)
- % Within Tolerance (PWT) Acceptance
- Incentivize Critical Elements (i.e. Mat Density)
- **PERFORMANCE TESTS**

Examples of Performance Tests

DCT

IDEAL-CT

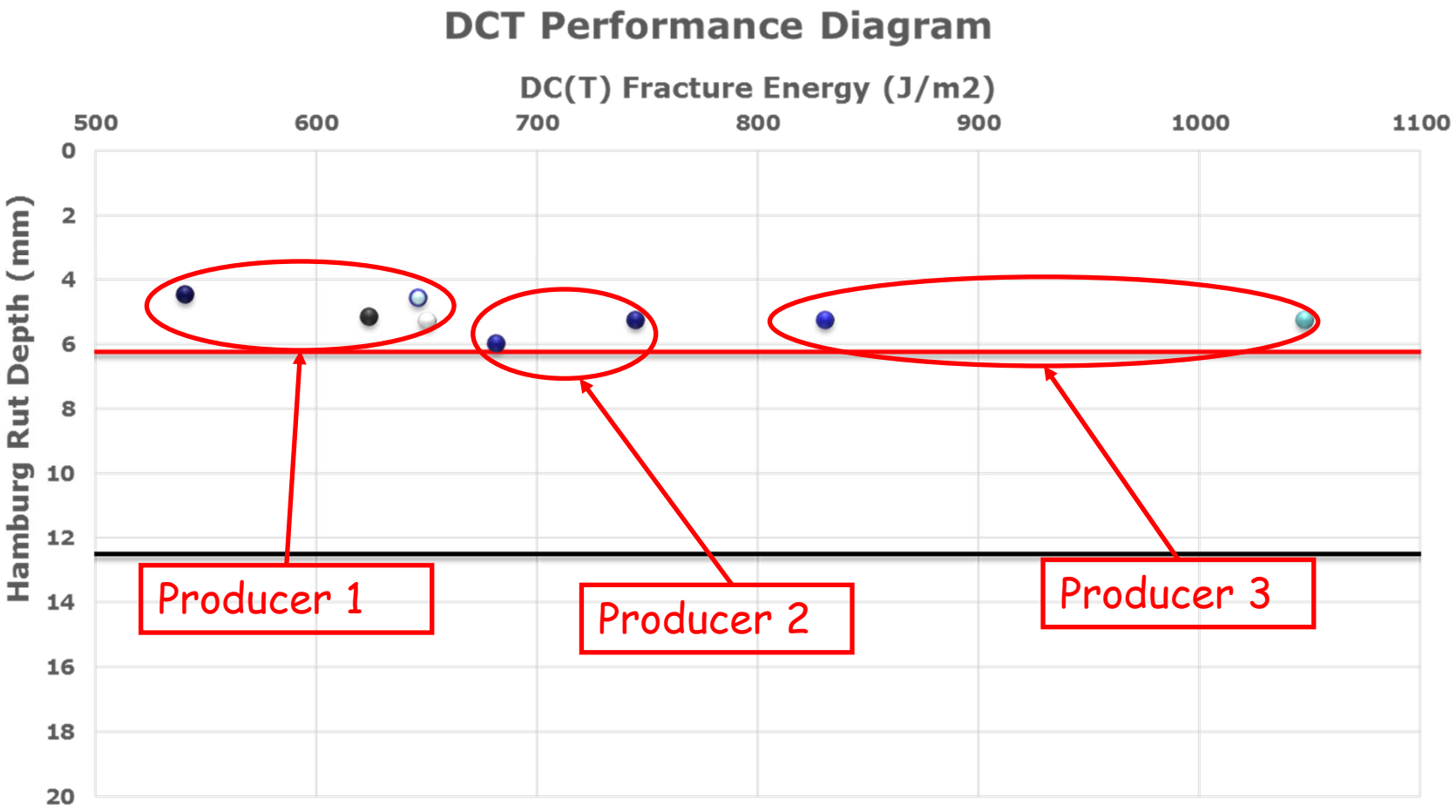
Wheel Tracking

SCB

Performance Test & LLAP driven by:

- TQI
- STIC

Long Life Asphalt Projects – DCT data



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Industry SCB/IDEAL CRACK Testing: How Did It Start?

- **Move to Performance Testing**
- **Initiated by Asphalt Quality Improvement Committee and PAPA**
- **Industry Interested in Accelerating Move to Performance Testing**

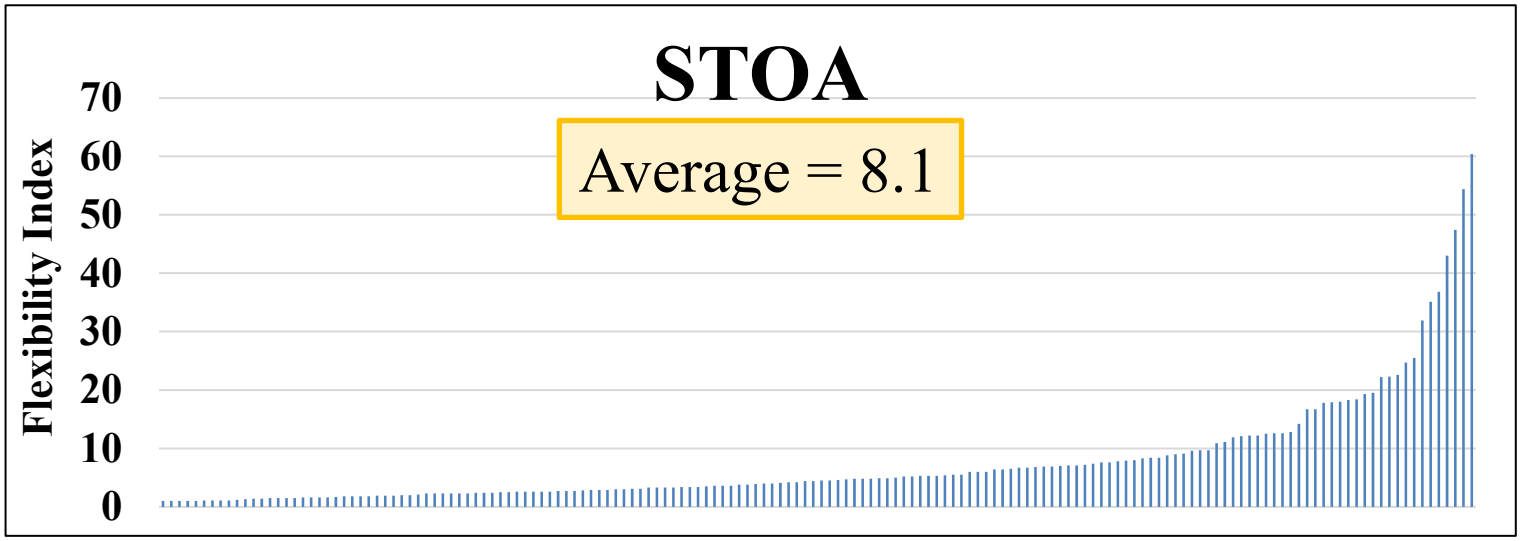
Purpose of the Effort

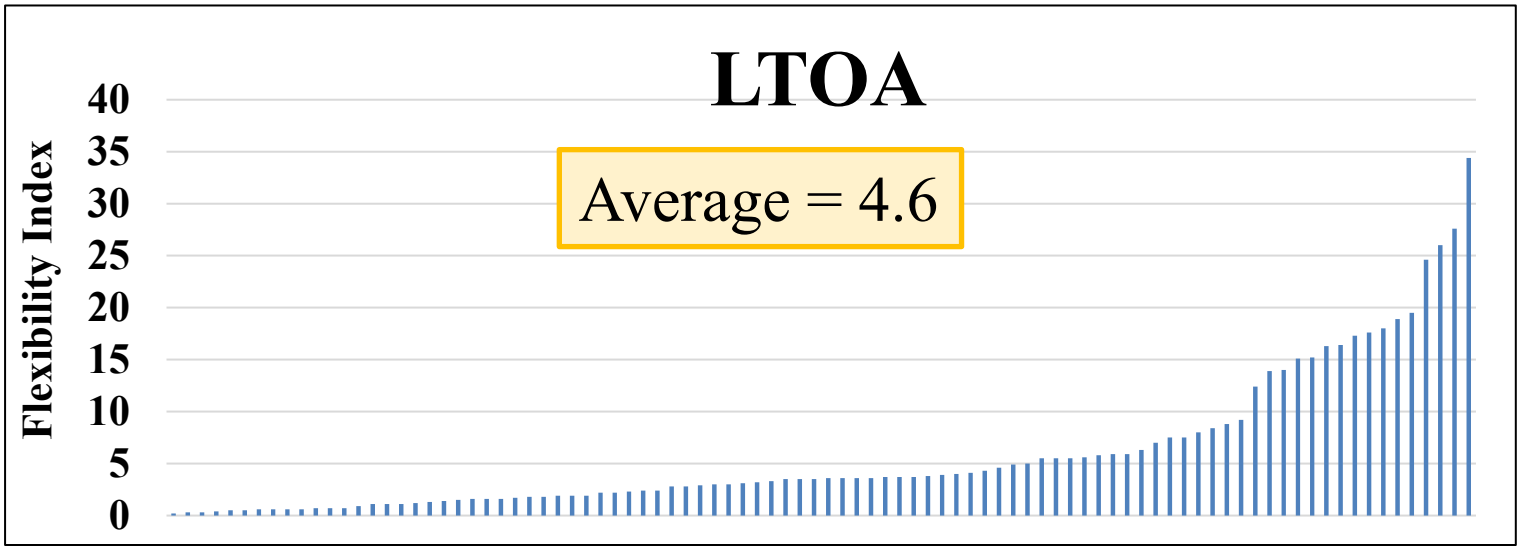
- **Bridge the Gap to Performance Testing**
- **Investigate Performance of PA Mixes in IDEAL as a follow-up to previous study**
- **Develop A Database of SCB/IDEAL Test Results**
- **Evaluate Sensitivity of the PA Mixes to the Test**
- **Evaluate Correlation with Field Performance**

SCB
Mix Criteria and Variables

- **Air Void: 5.5% (Final SCB Specimen)**
- **Design Binder Content (and +0.5%)**
- **Mixes with 15% RAP at Design BC and at 0.5% Higher Binder Content**
- **Mixes at higher RAP Contents**
- **NMAS: 4.75, 9.5mm, 12.5mm, 19mm, 25mm**
- **Lab vs Plant Produced**
- **Short term vs Long Term Aging**

Data Range: Flexibility Index





General Observations

1. **Higher AC Content → higher F.I.**
2. **Higher RAP content lower F.I.**
3. **Longer aging → lower F.I.**
4. **Plant mix has higher F.I. than lab mix**
5. **Higher voids → higher F.I.**
6. **SMA mix delivers higher F.I.**
7. **Finer mix with high BC → higher F.I.**

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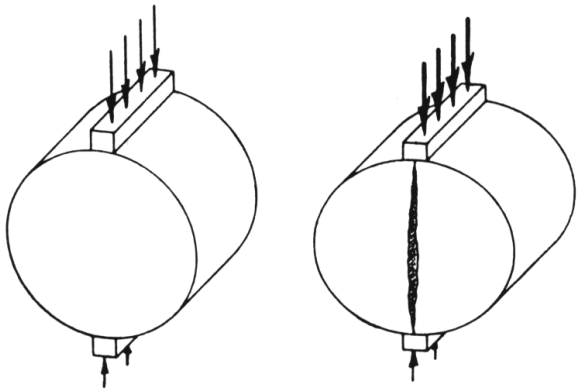
Research Team

Dr. Xuan Chen

Mr. Scott Milander
NECEPT Lab Coordinator

IDEAL Cracking Test for Asphalt Concrete



In**d**irect T**e**nsile **A**spha**l**t
Cracking **T**est

IDEAL-CT

Proposed by Research at Texas Transportation Institute (TTI)

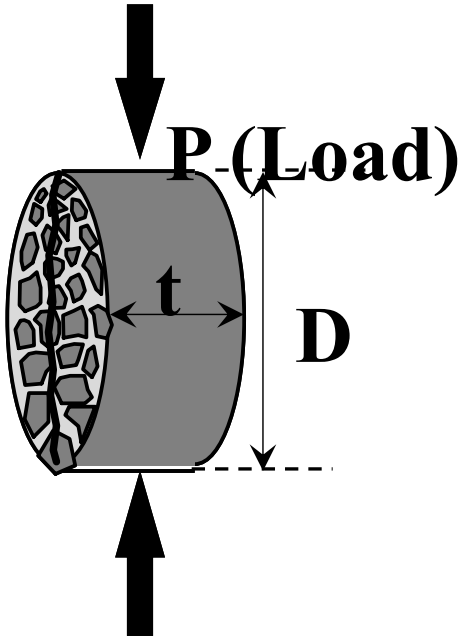
The Brazilian Test
(The Split Test or Indirect Tensile Test)

- Tensile Strength of Concrete (Carneiro, **1943**)
- Tensile Strength of Stabilized Materials (Hudson, Kennedy, **1967**)
- Tensile Strength of Asphalt (Kennedy et al., **1969**)
- Tensile Strength of Rocks (ISRM, **1978**)

Resilient Modulus, ASTM D7369
Repeated Haversine Loading

$$\mu = \frac{3.588 + 0.2699\dfrac{\Delta V}{\Delta H}}{0.0627 - \dfrac{\Delta V}{\Delta H}}$$

ΔV = recoverable vertical deformation
ΔH= recoverable horizontal deformation
μ = Poisson's ratio

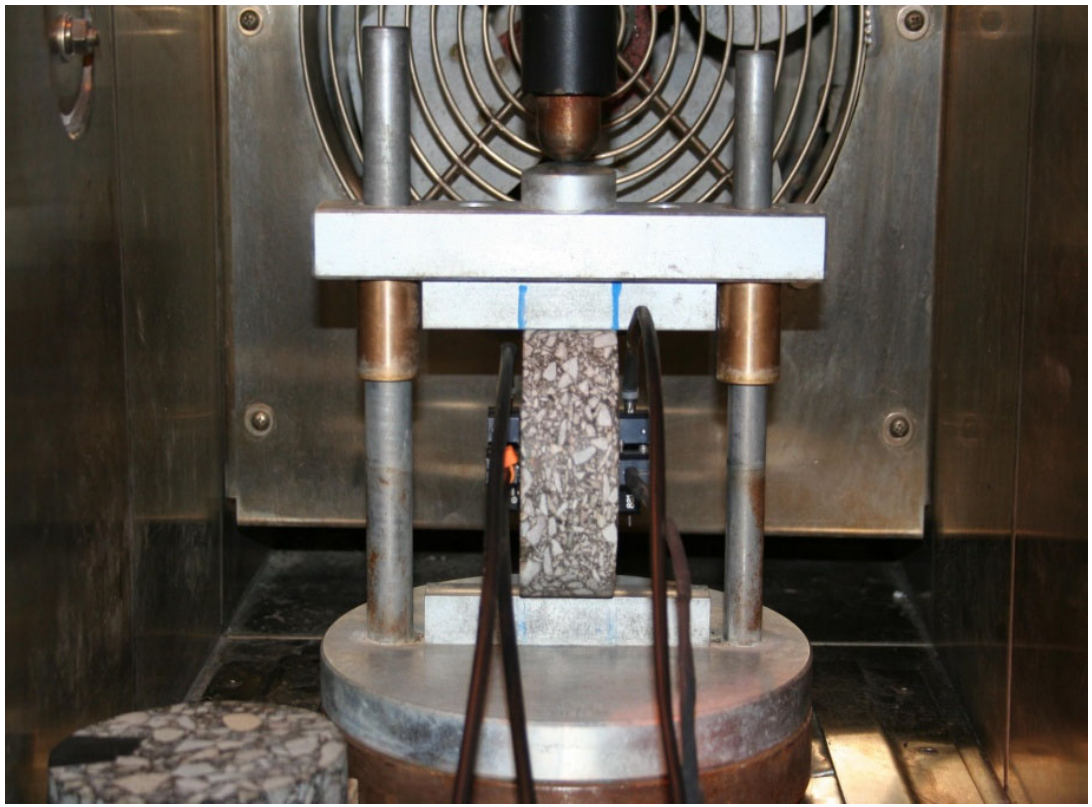


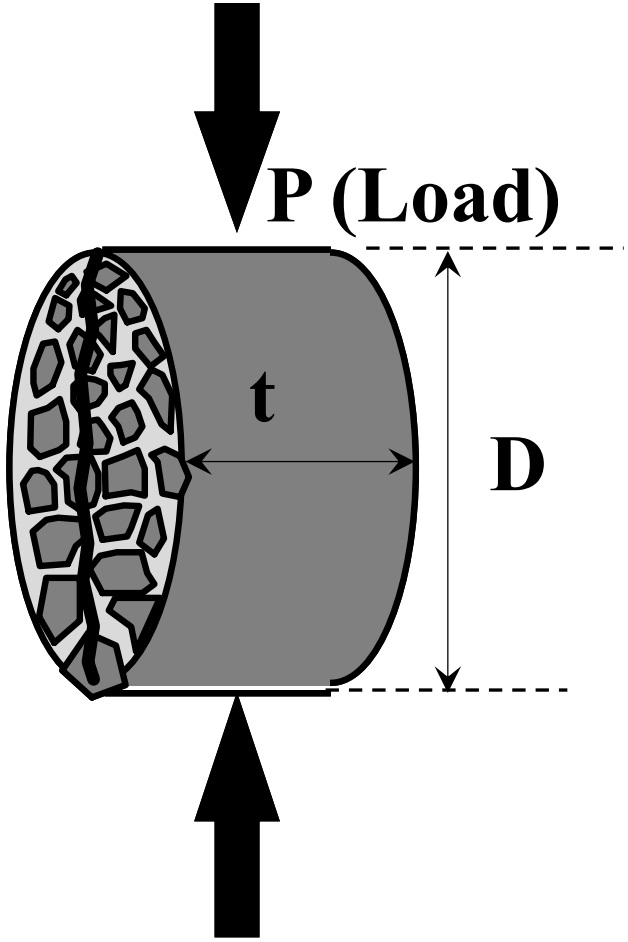
P = load
t = thickness
M_r = Resilient Modulus

$$M_r = \frac{P}{(\Delta H)xt}(0.2699 + \mu)$$

Asphalt Concrete
Creep & Strength Test at Low Temperature
(for example, as input for Pavement ME)

Indirect Tensile Test

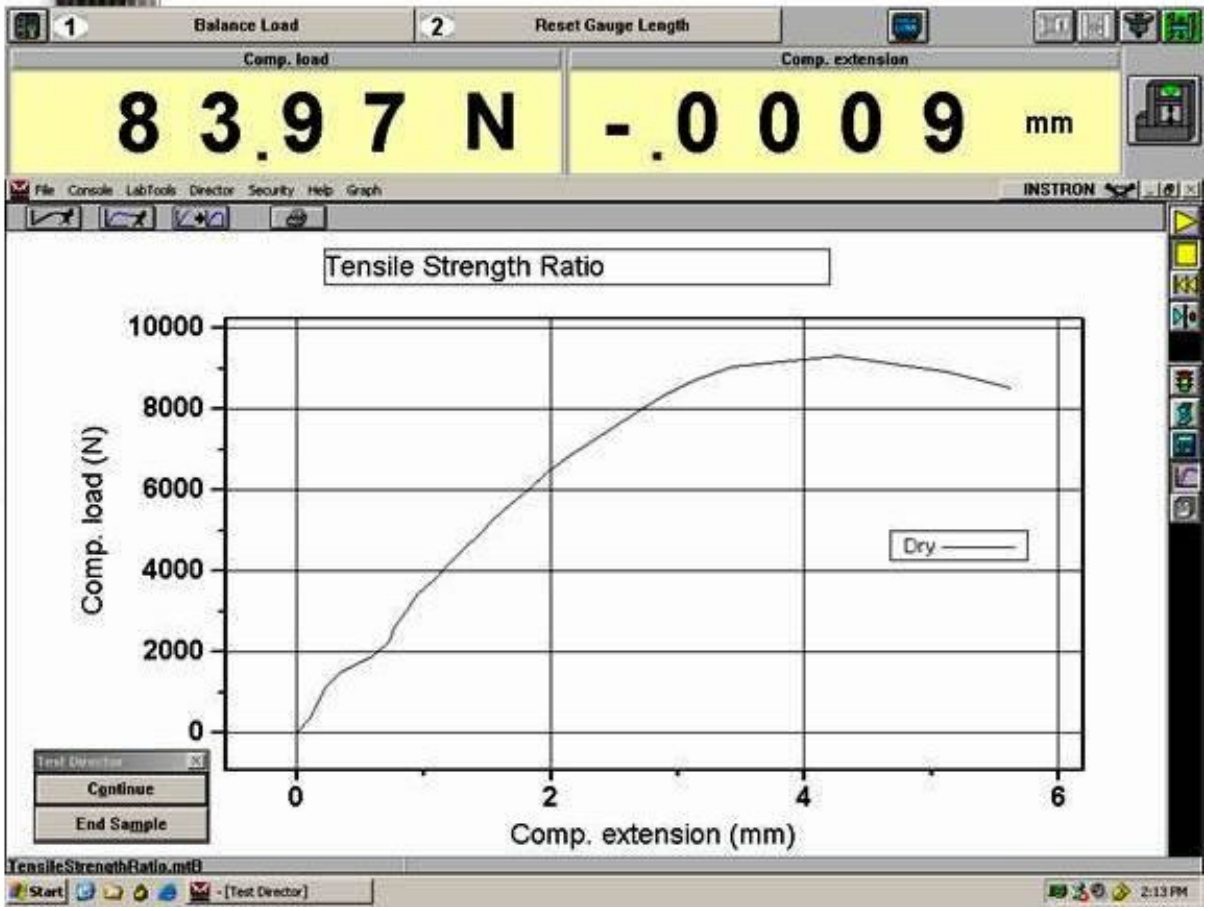




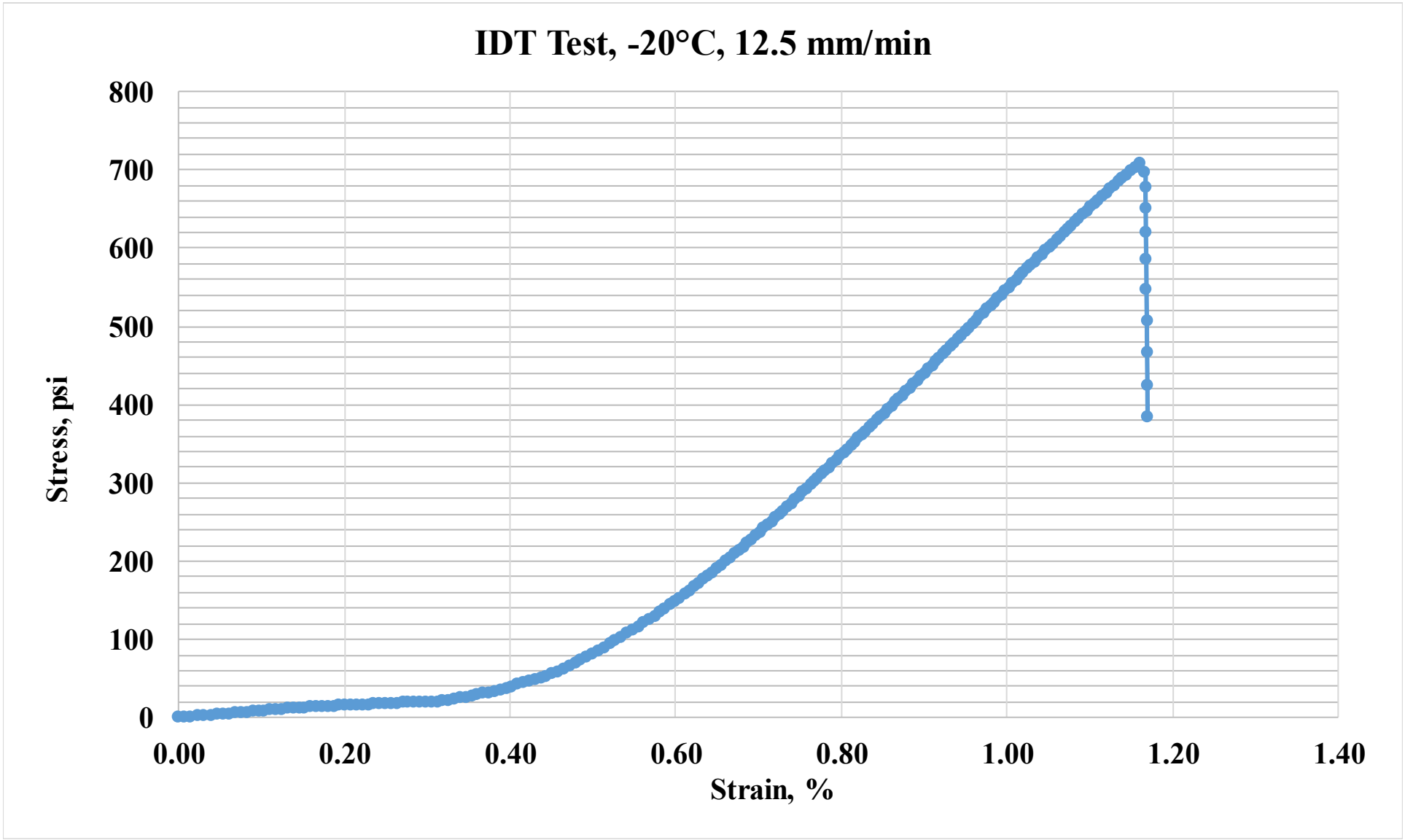
Indirect Tensile Strength Test

(for AASHTO T 283, Tensile Strength Ratio (TSR)

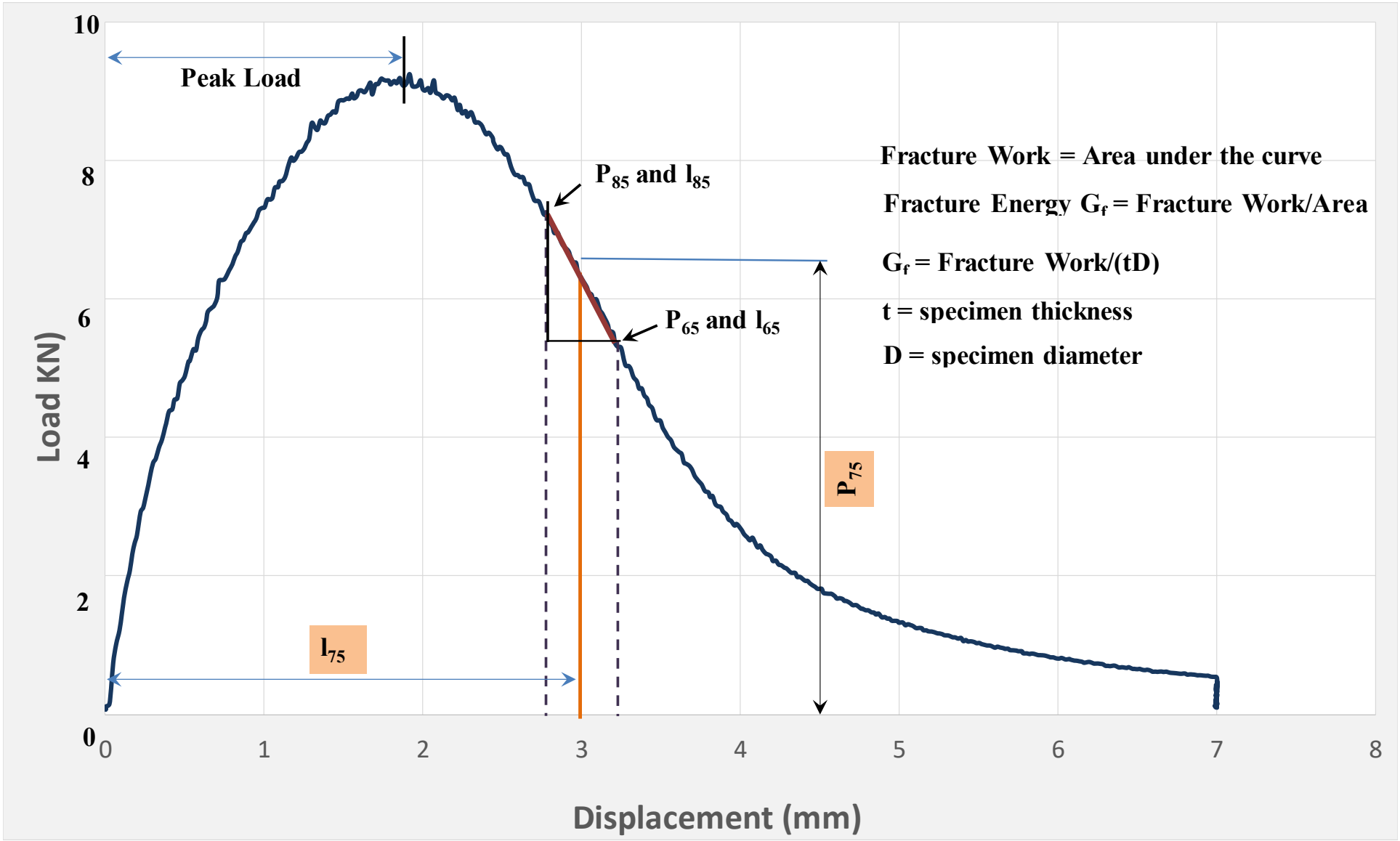
$$S_t = \frac{2P}{\pi t D}$$



Indirect Tensile Test at Low Temp.



IDEAL – Test Results

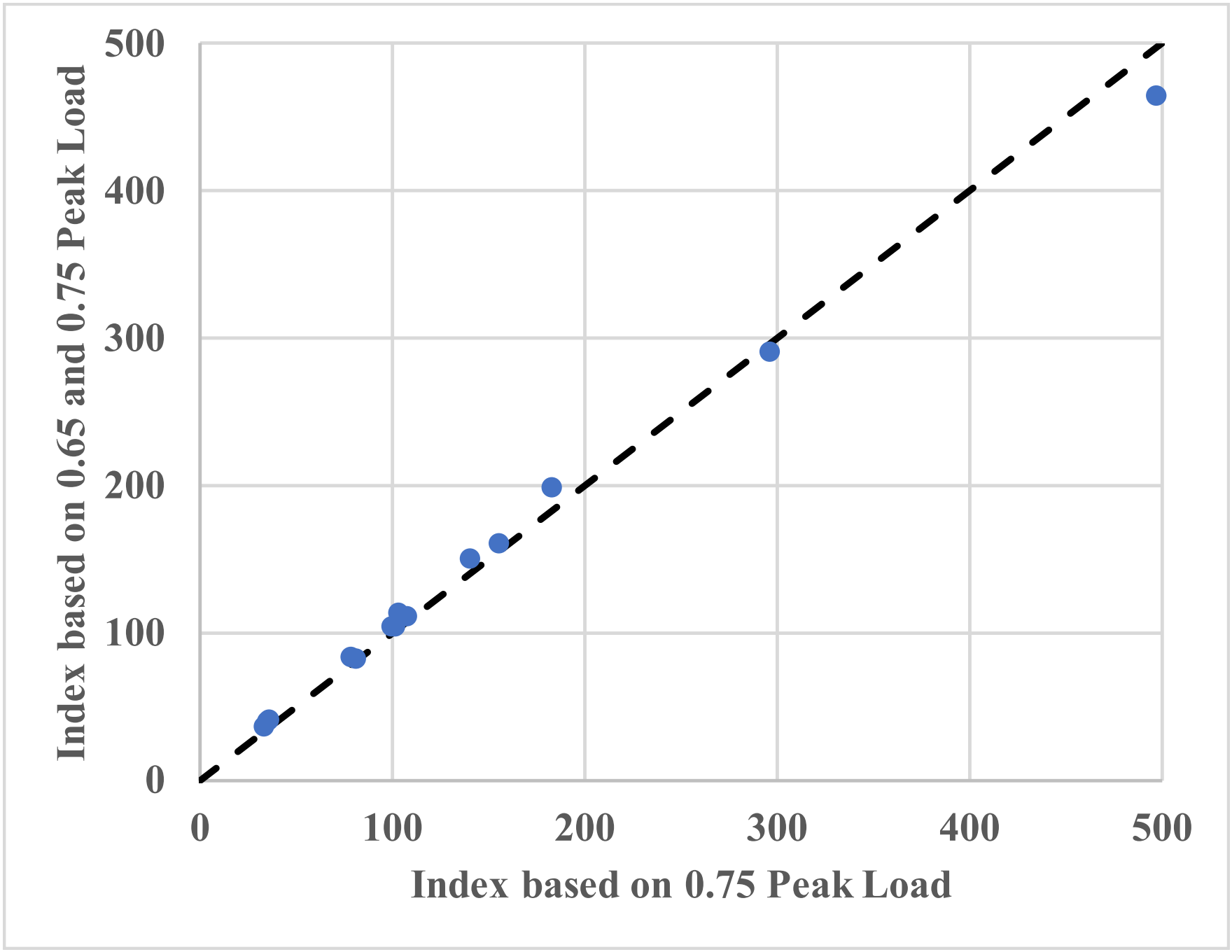


IDEAL – Test Results

Criteria established based on CT_{Index}

$$CT_{Index} = \frac{G_f}{\frac{P}{l}} \times \left(\frac{l_{75}}{D}\right)$$

$$\frac{P}{l} = |m_{75}| = \frac{P_{85} - P_{65}}{l_{85} - l_{65}}$$


Index based on 0.65 and 0.75 Peak Load
500
400
300
200
100
0
0
100
200
300
400
500
Index based on 0.75 Peak Load

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Source of Mixes & Conditioning

Sources 1 and 2

Lab Prepared Mix → **Long Term Aged (5 days @ 185°F)**

LTOA

Source 3

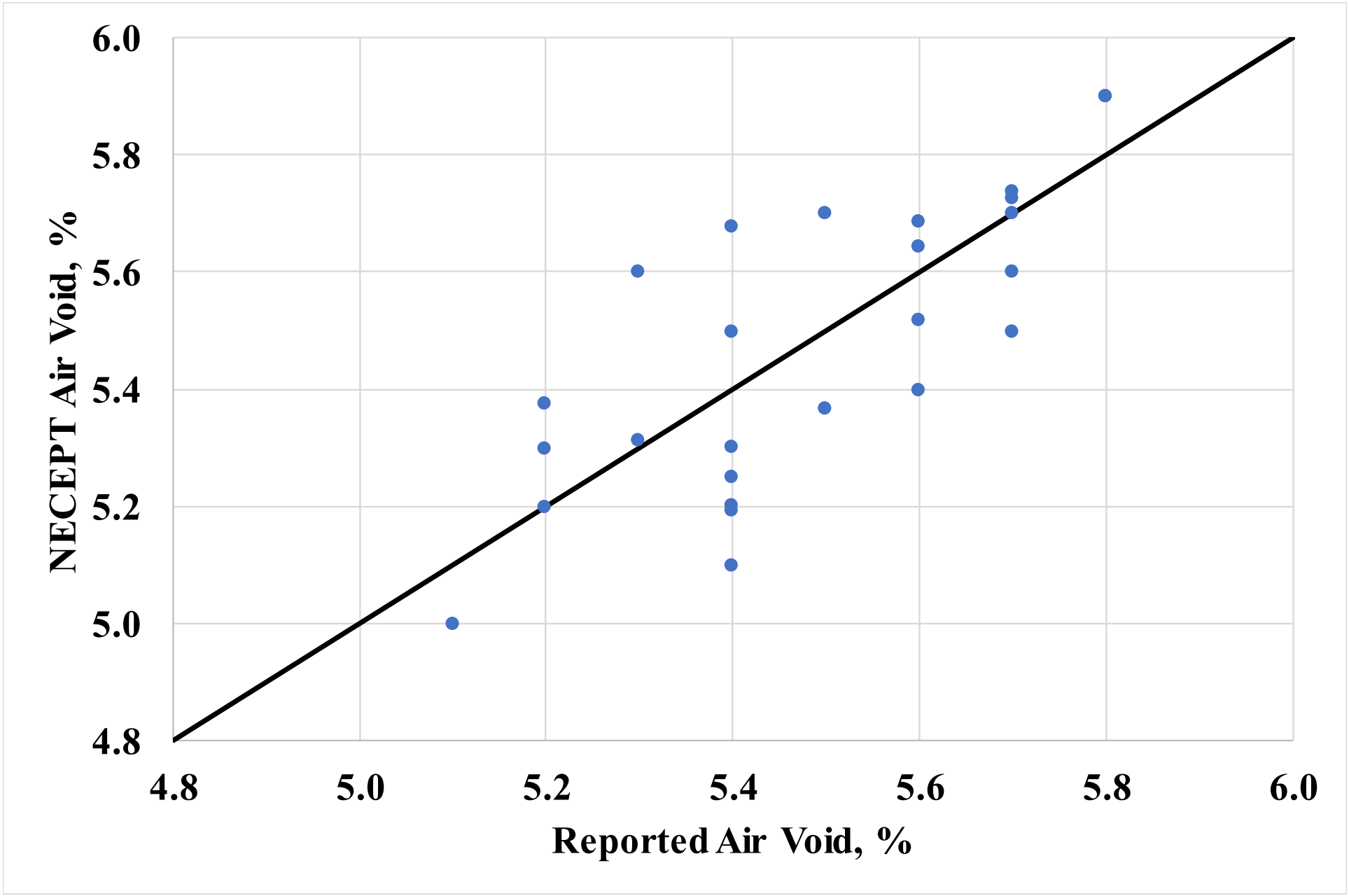
Plant Prepared Mix → **Short Term Aged**

STOA

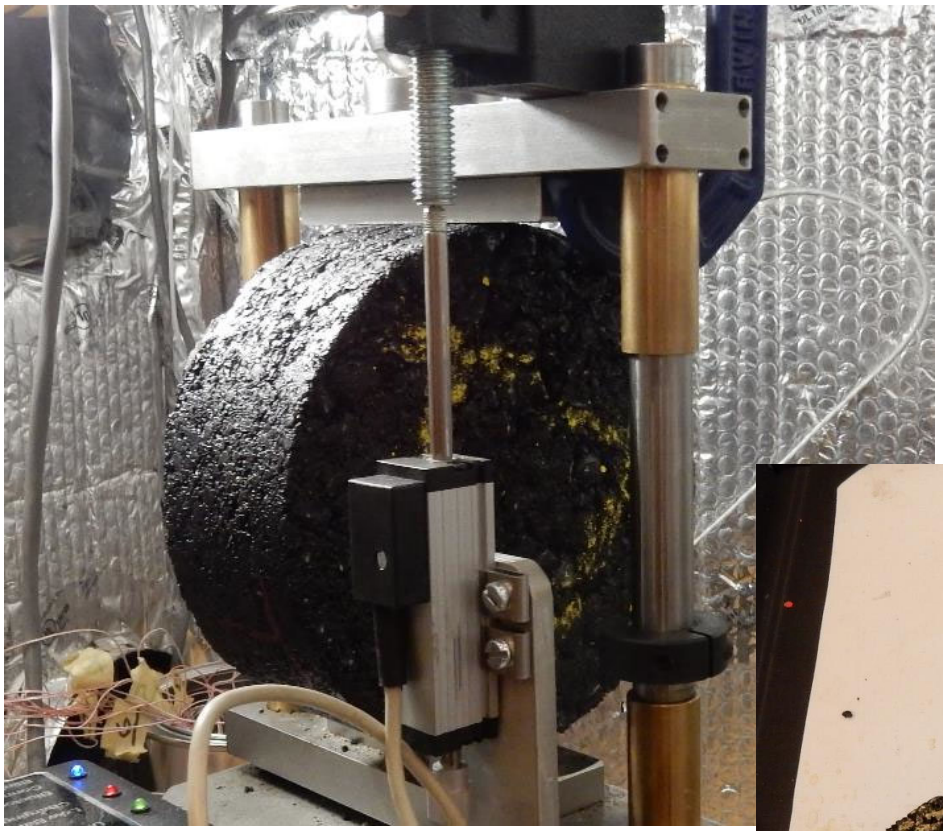
Types of Mixes Tested (25 Mixes)

Source	# of Mixes	# of Plugs	Mix Origin	Mix Condition	NMAS, mm	Binder Grade	Binder Content	RAP
01	**9**	**27**	Lab Prod.	LTOA	**9.5**	**58-28**	**5.2 to 6.2**	**0, 15, 25**
						64-22		
						76-22		
02	**9**	**27**	Lab Prod.	LTOA	**9.5**	**58-28**	**5.1 to 6.1**	**0, 15, 25**
						64-22		
						76-22		
03	**7**	**35**	Plant Prod.	STOA	**6.3**	**64-22**	**6.3**	**0**
					6.3	**76-22**	**6.9**	**0**
					9.5 (3)	**64-22**	**5.9 & 6.0**	**15.0, 20.0**
					19 (2)	**64-22**	**4.8 & 5.1**	**25.0, 28.5**

Air Void Comparison



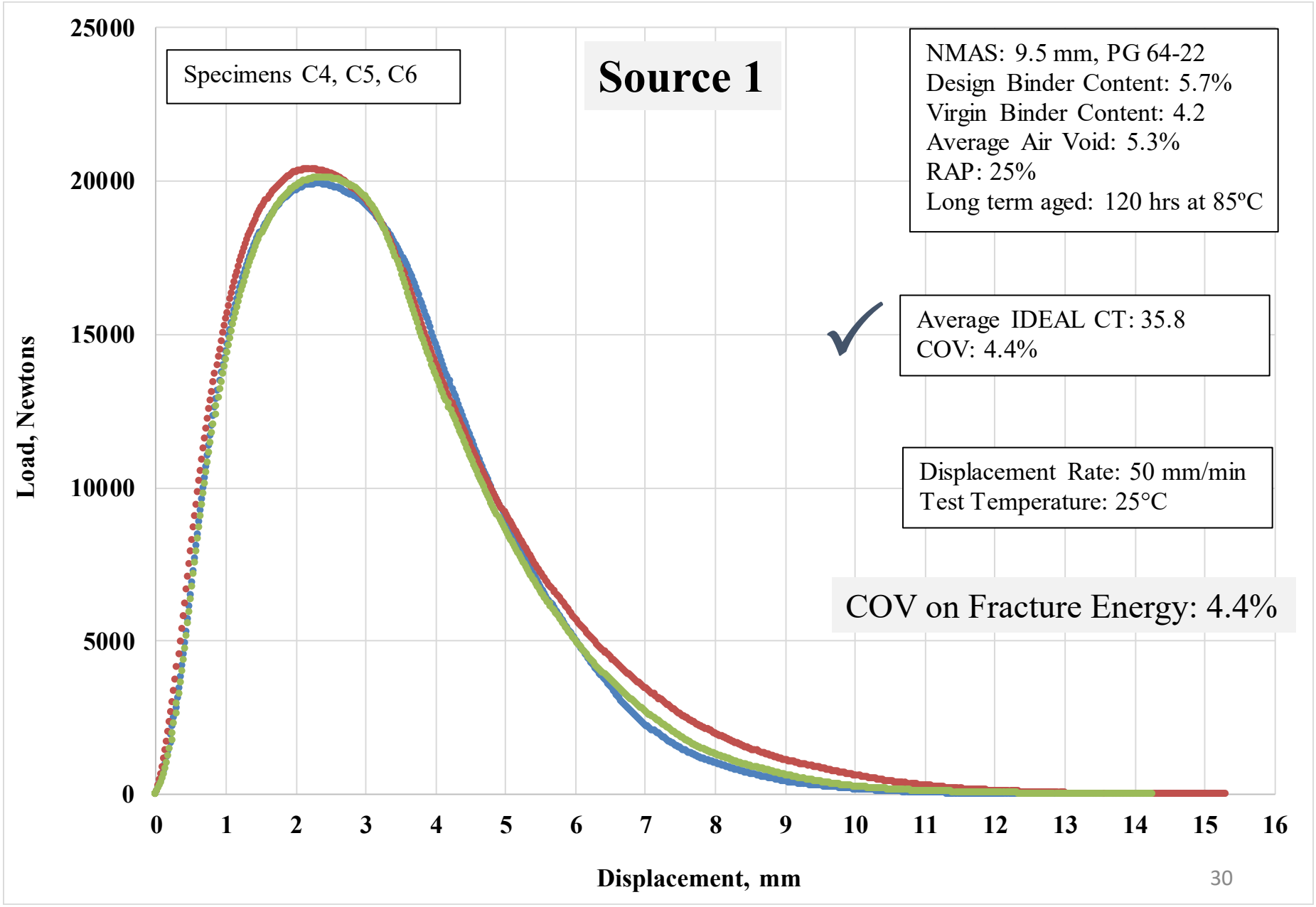
Breaking Specimens



Test Temperature: 25◦C
Displacement Rate: 50 mm/min

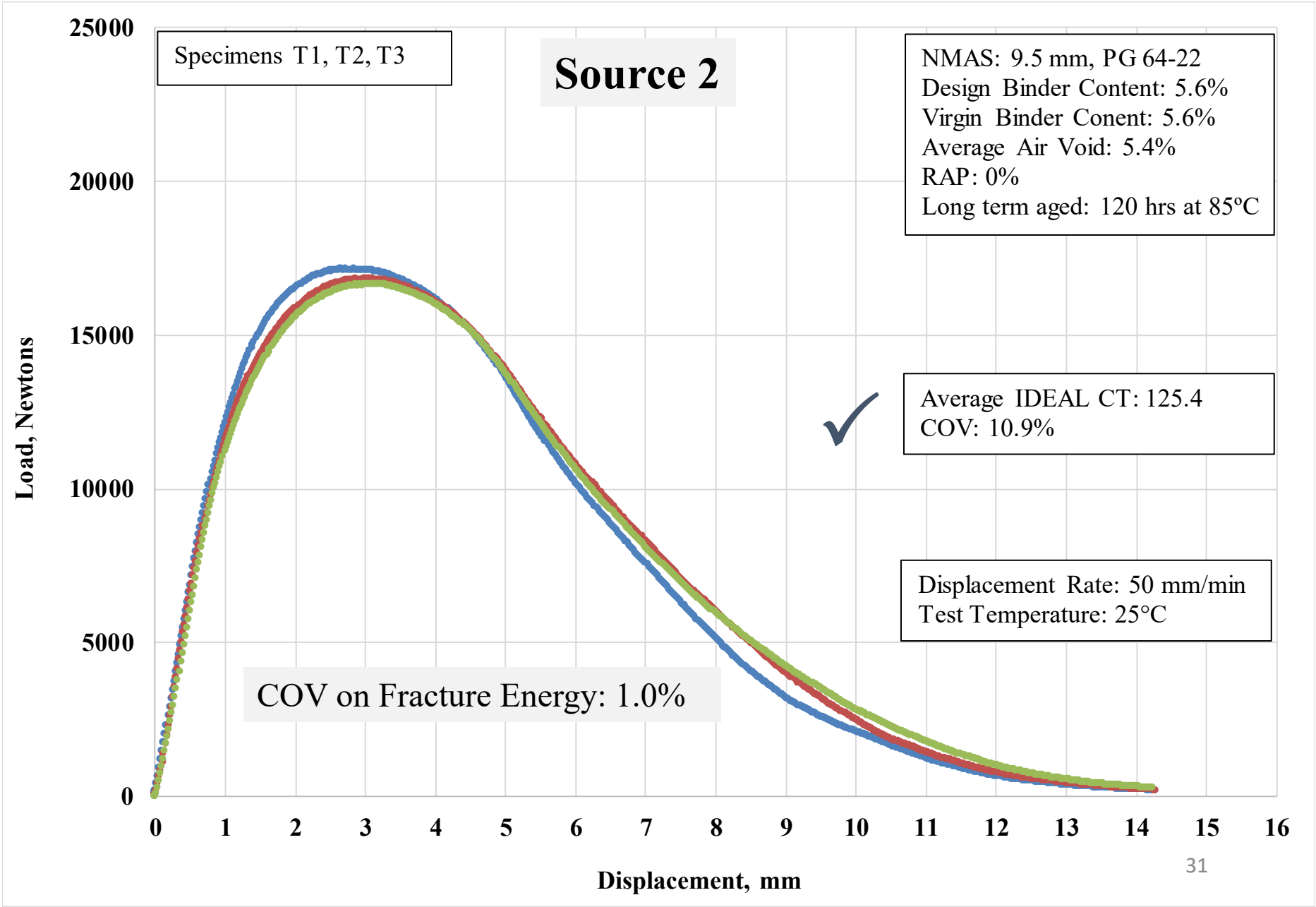
Test Repeatability

LTOA



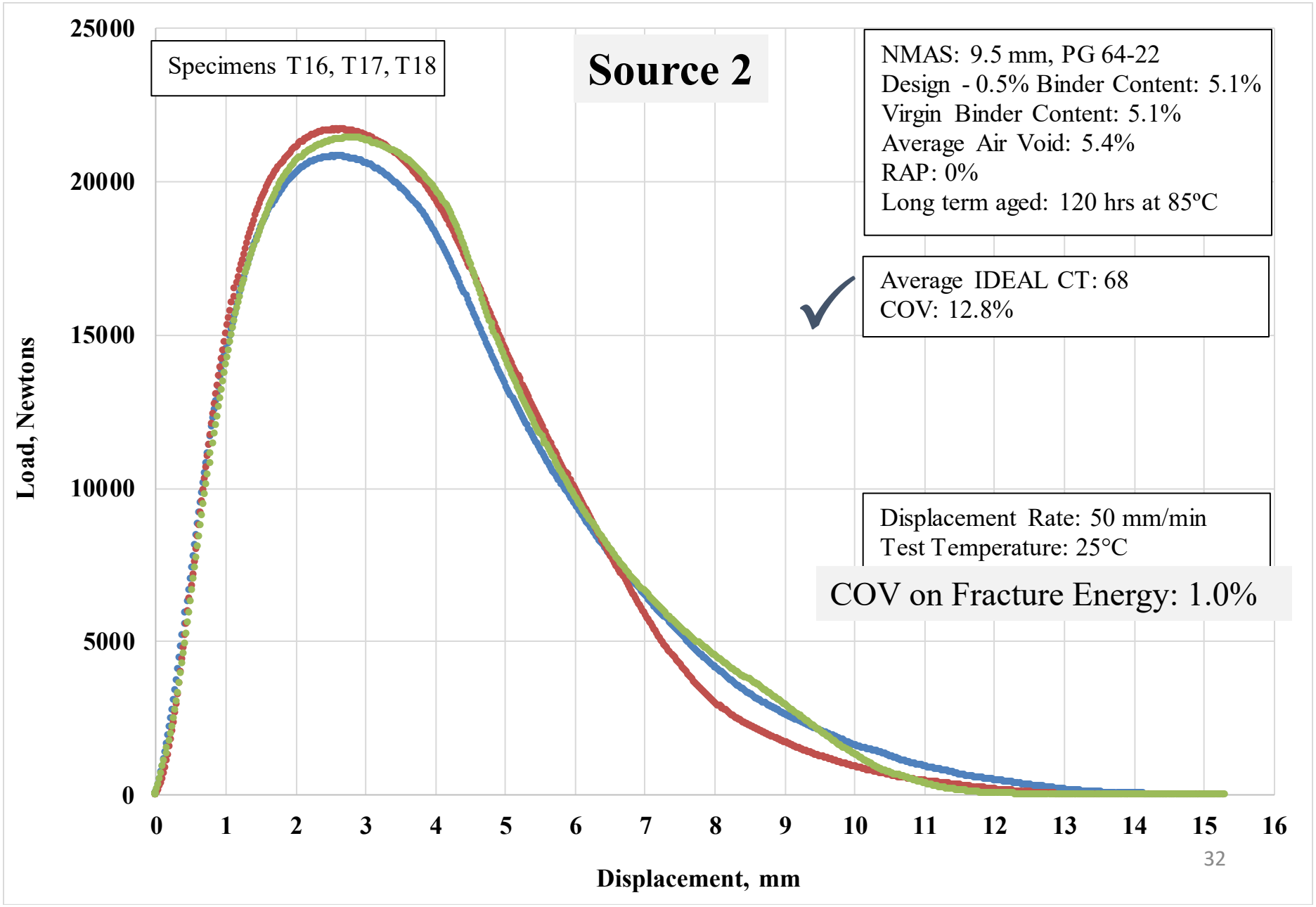
Test Repeatability

LTOA



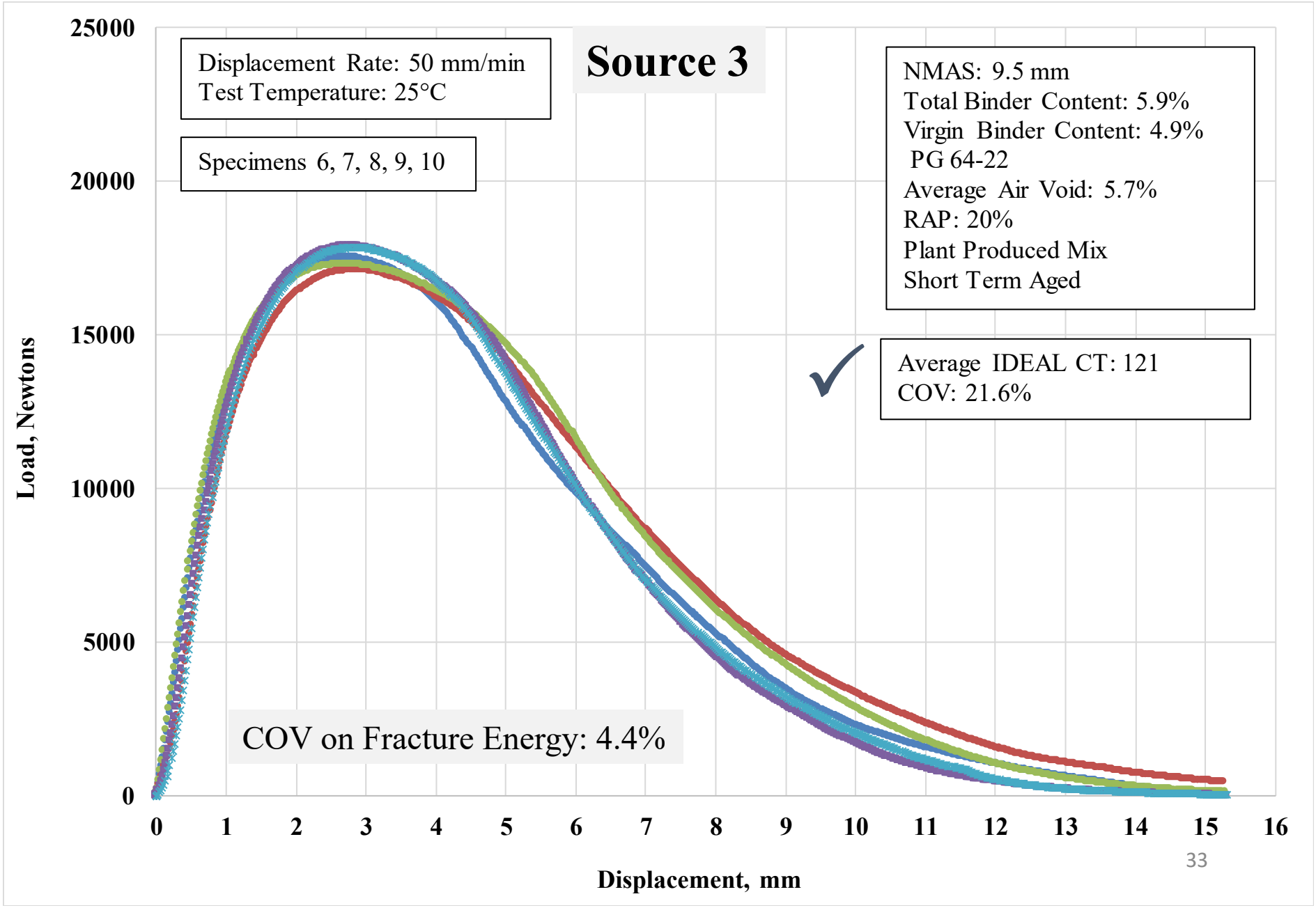
Test Repeatability

LTOA



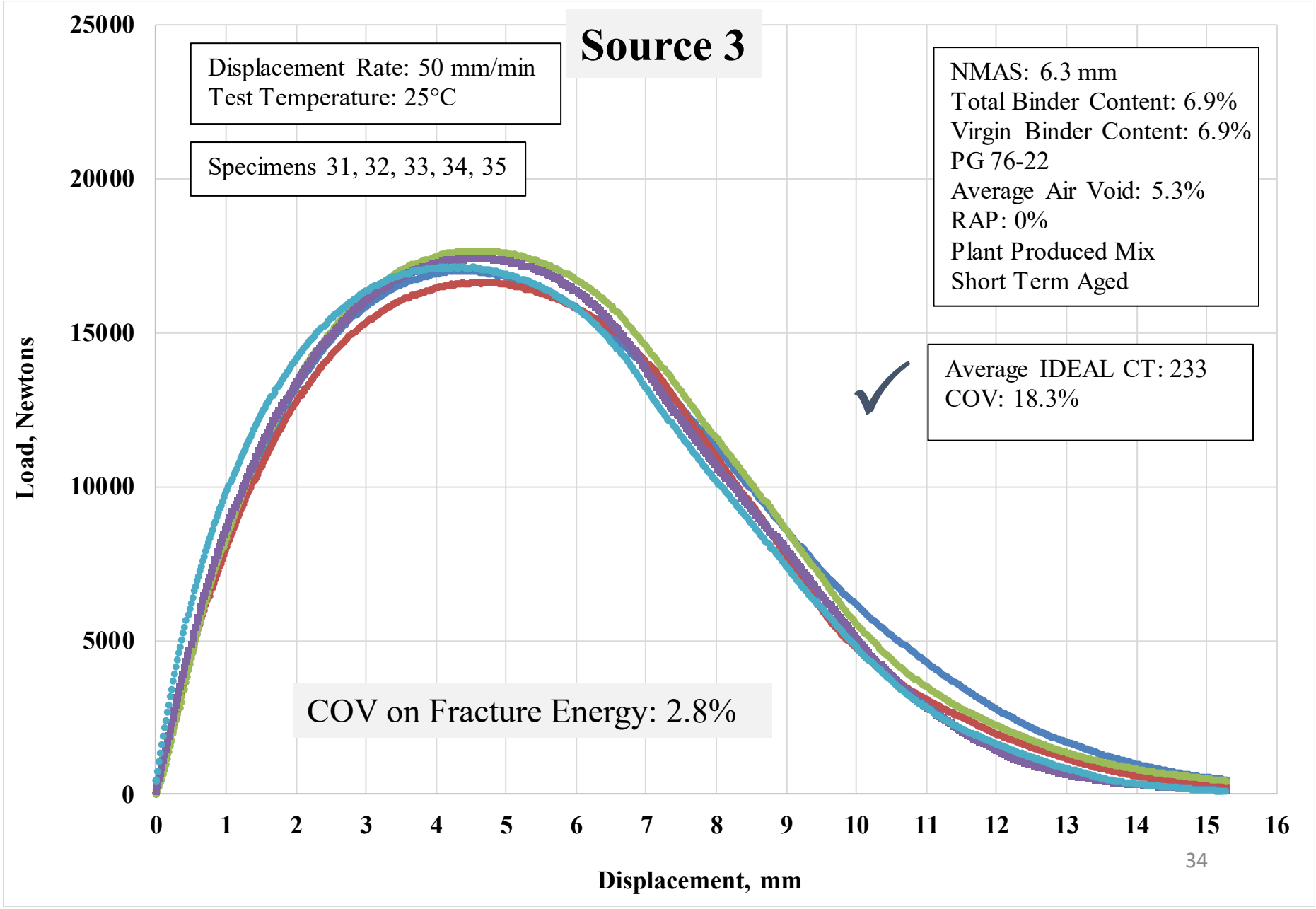
Test Repeatability

STOA

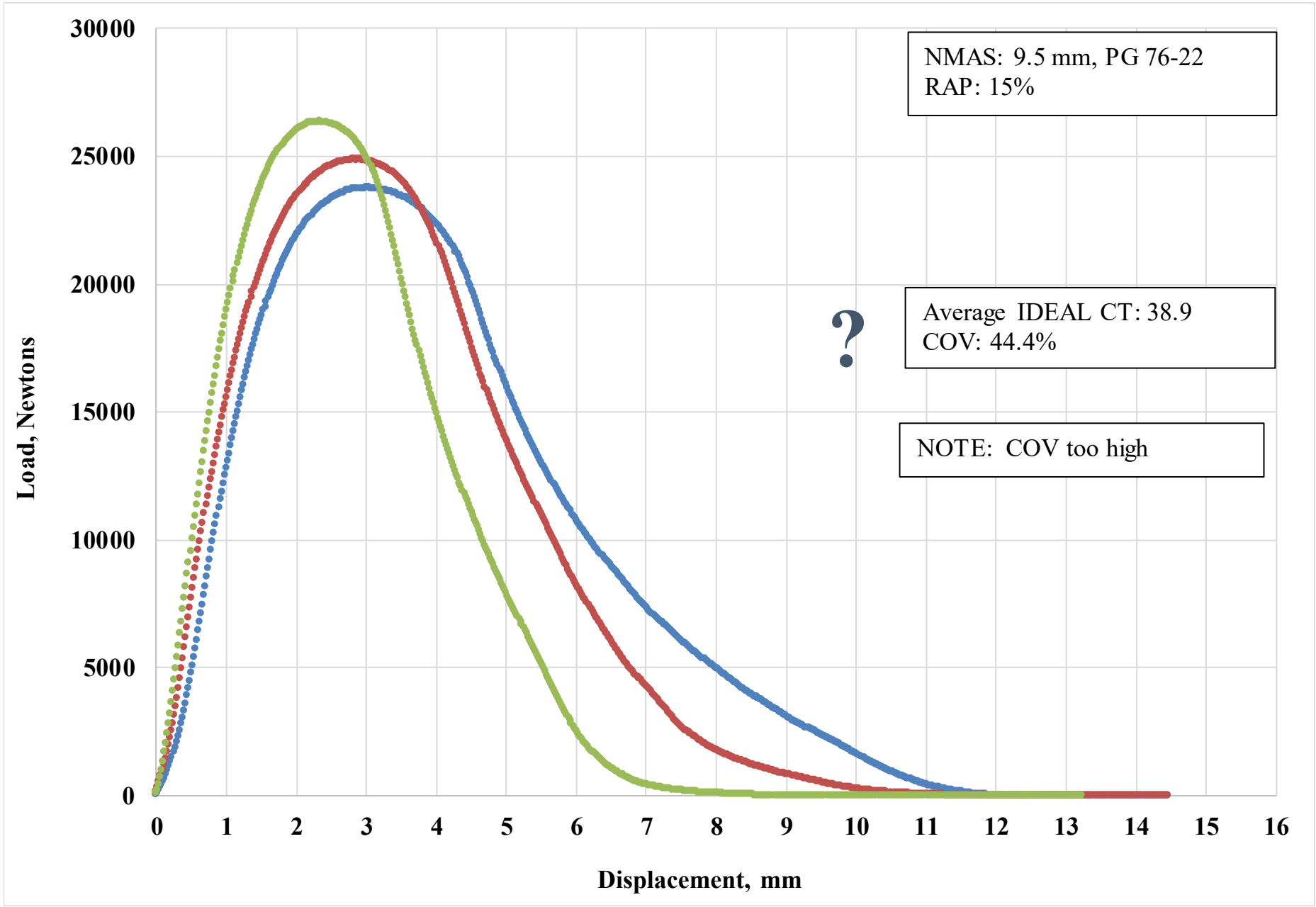


Test Repeatability

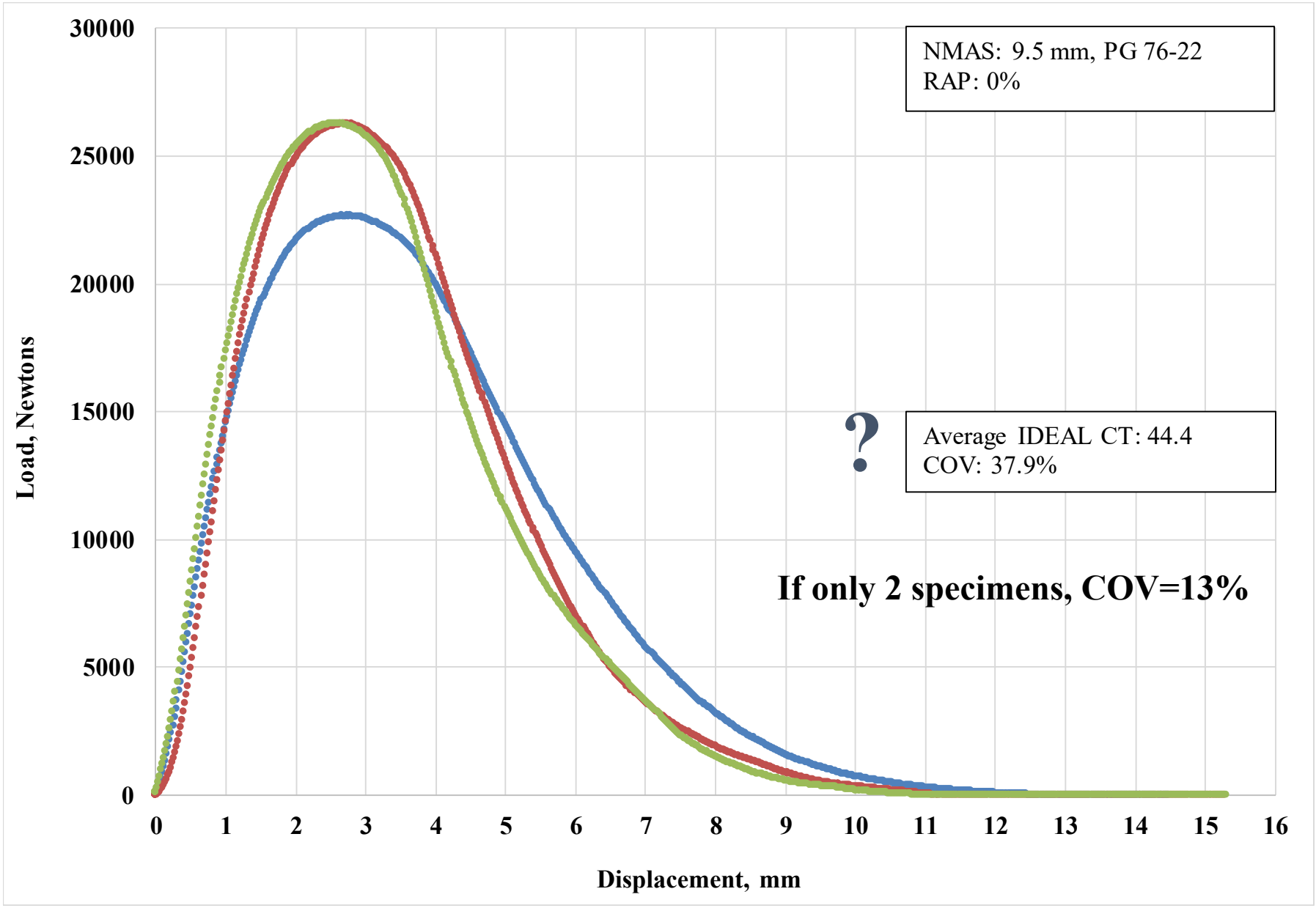
STOA



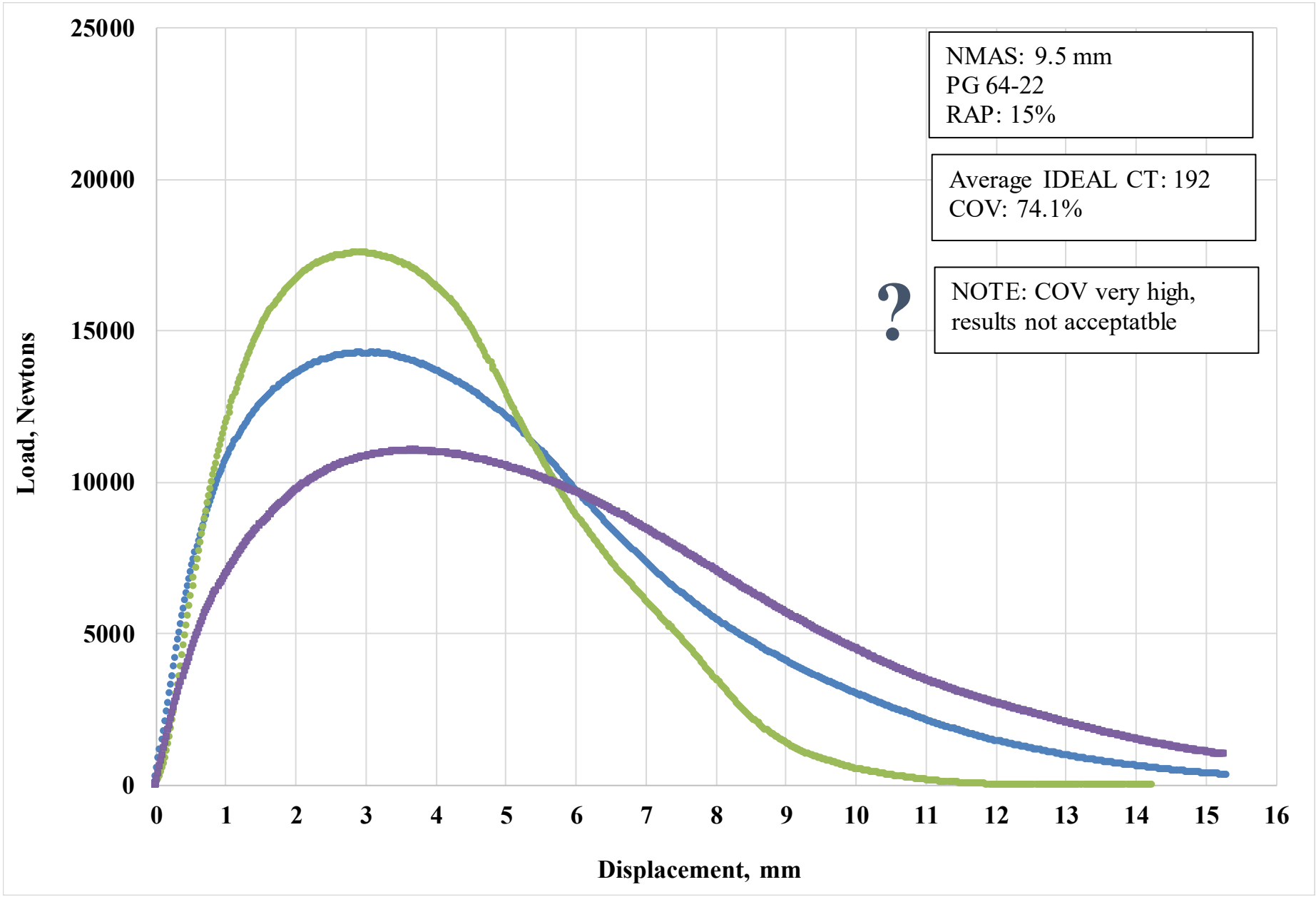
Test Repeatability



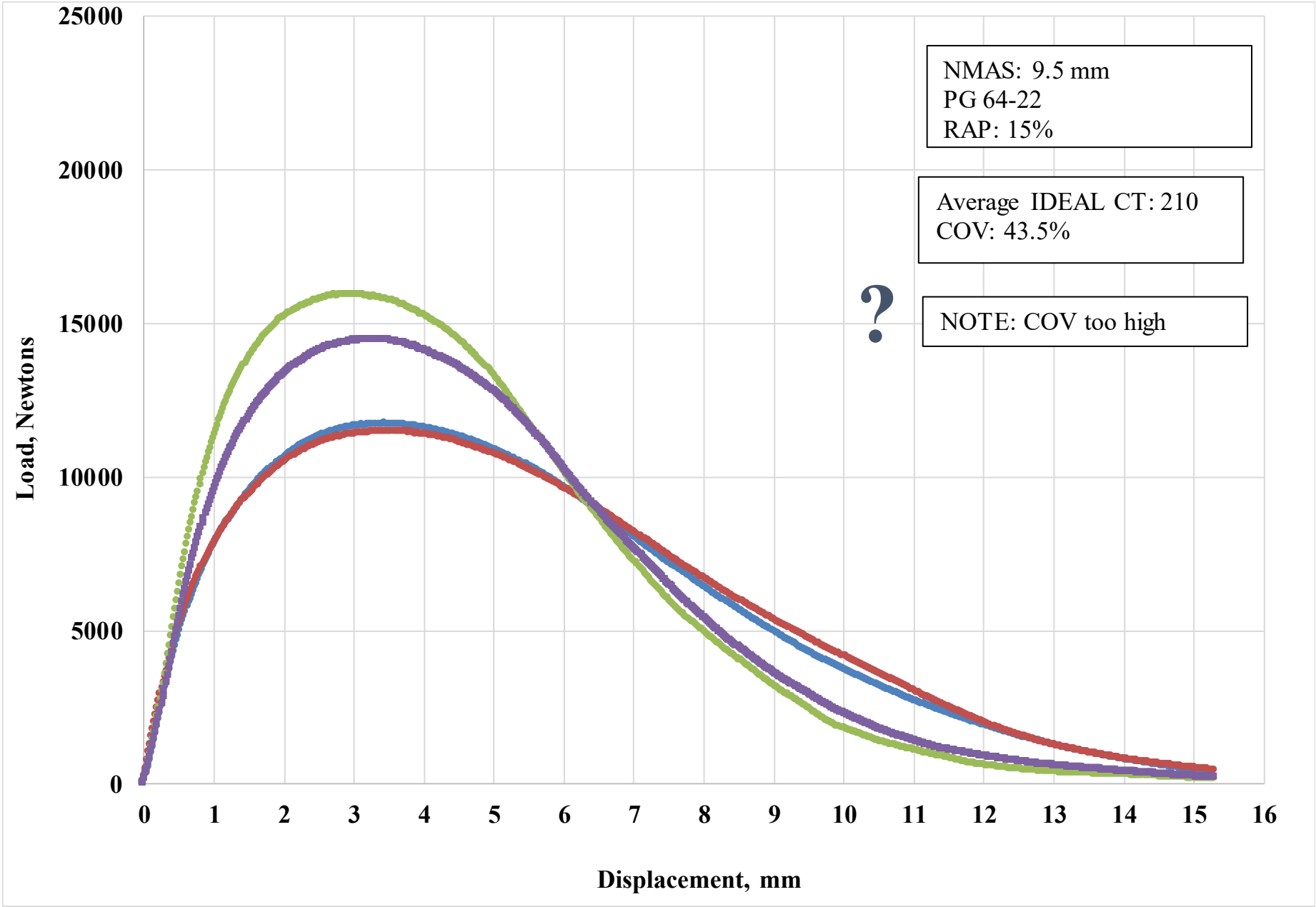
Test Repeatability



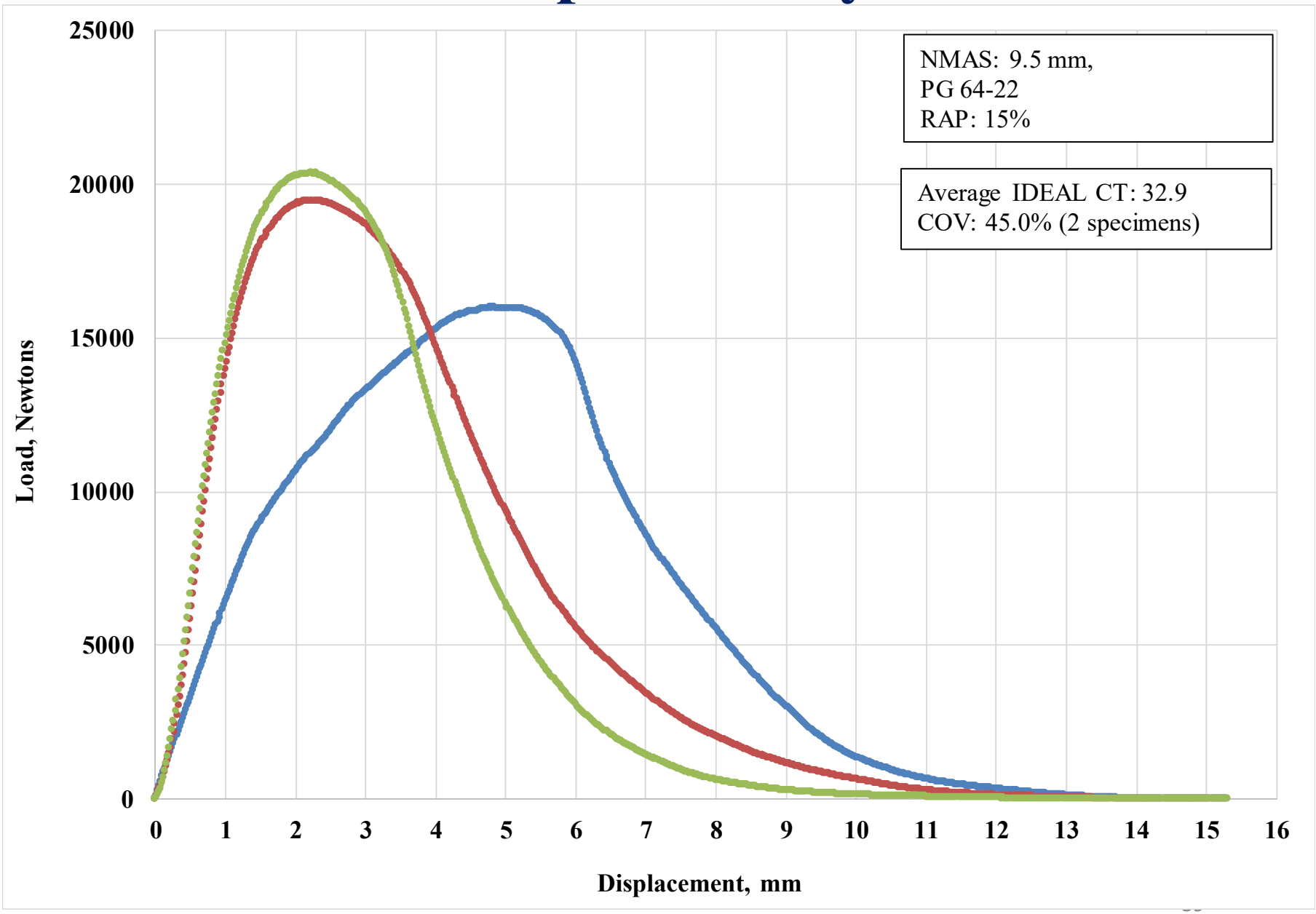
Test Repeatability



Test Repeatability



Test Repeatability



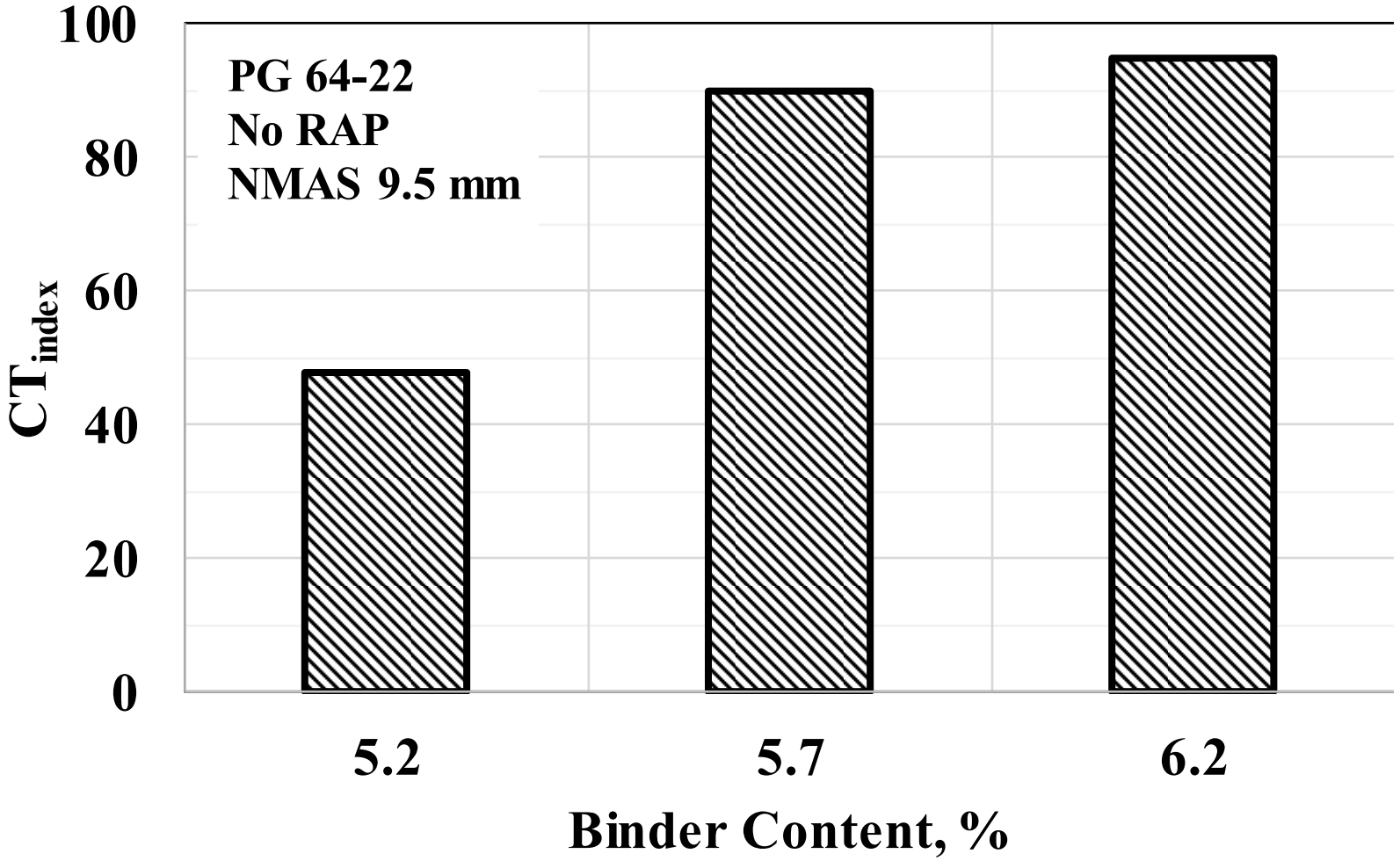
What COV should we use?

Criterion on COV	Number of Mixes
≥ 30%	5
≥ 25%	6
≥ 20%	7
≥ 15%	15
≥ 10%	20

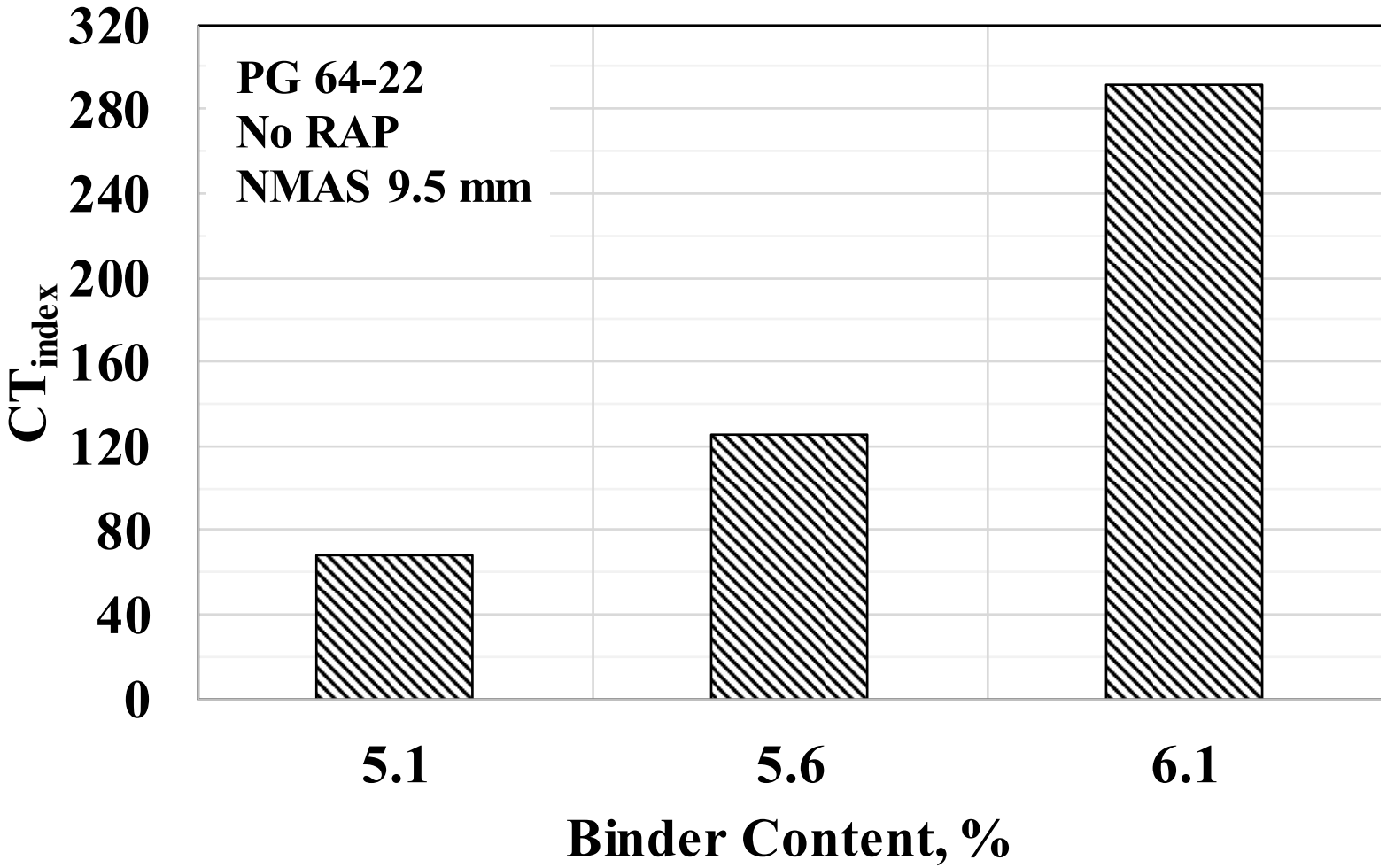
COV: Coefficient of Variation

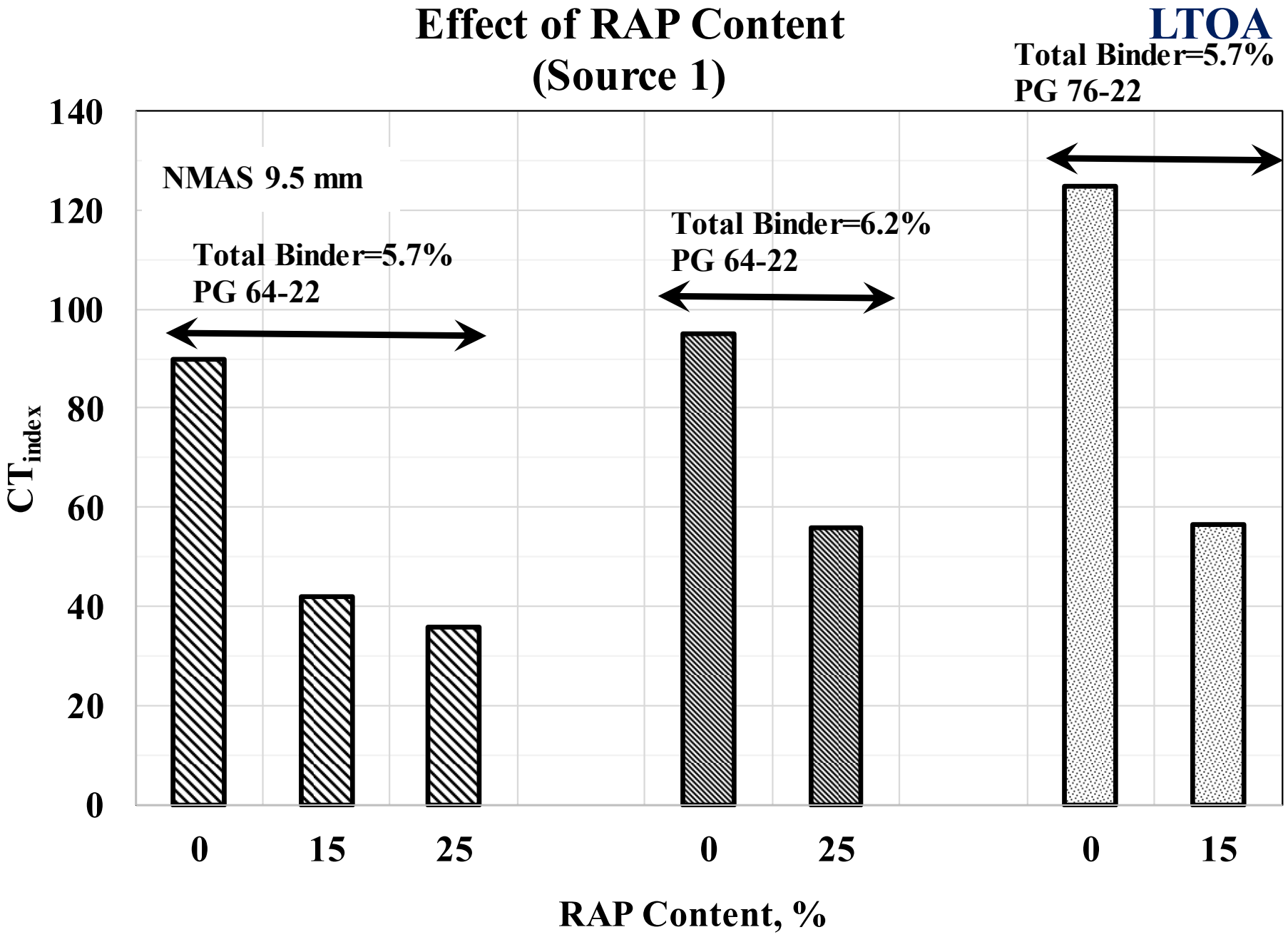
Total Number of Mixes: 23

Effect of Binder Content (Source 1)



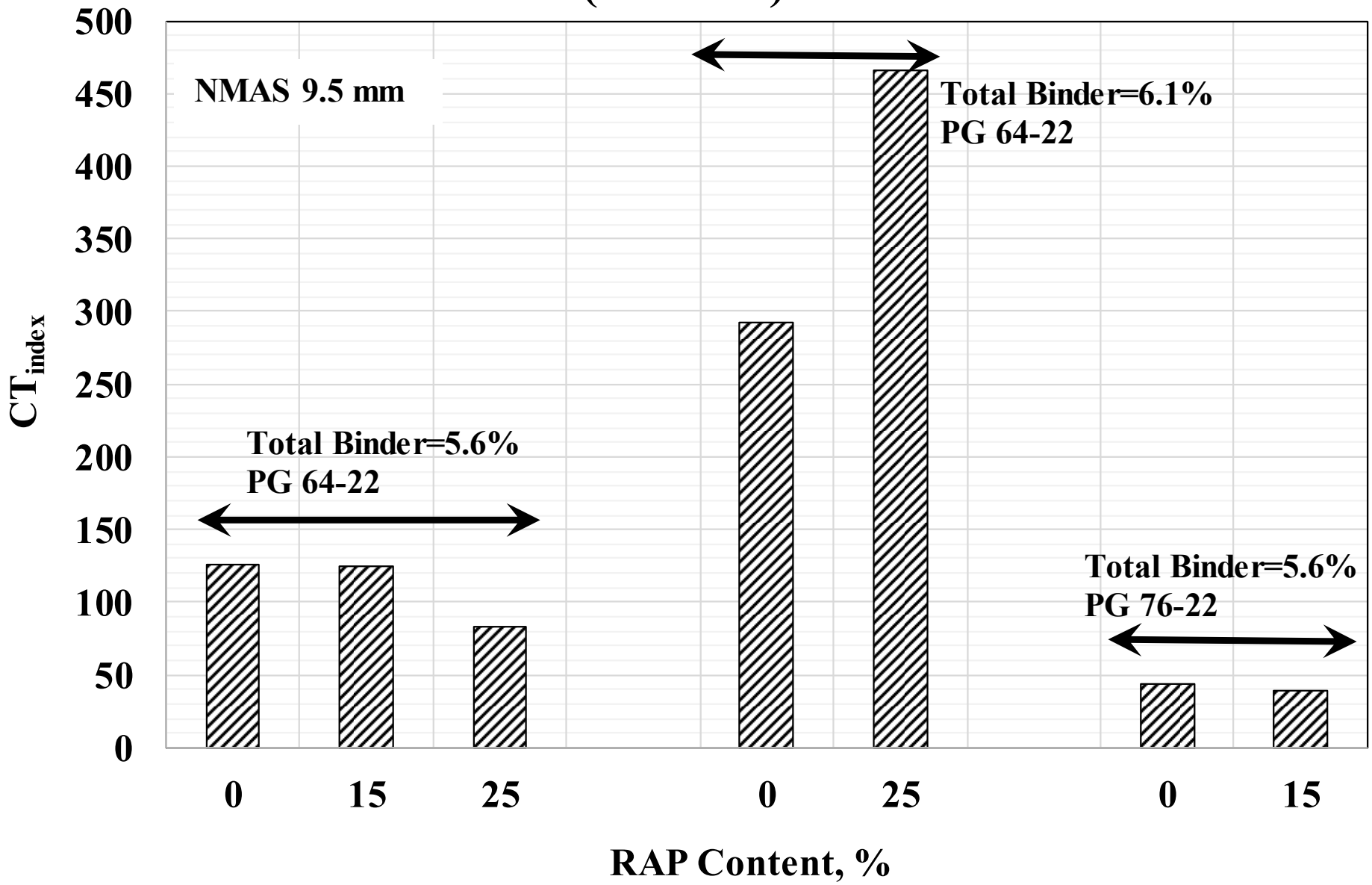
Effect of Binder Content (Source 2)

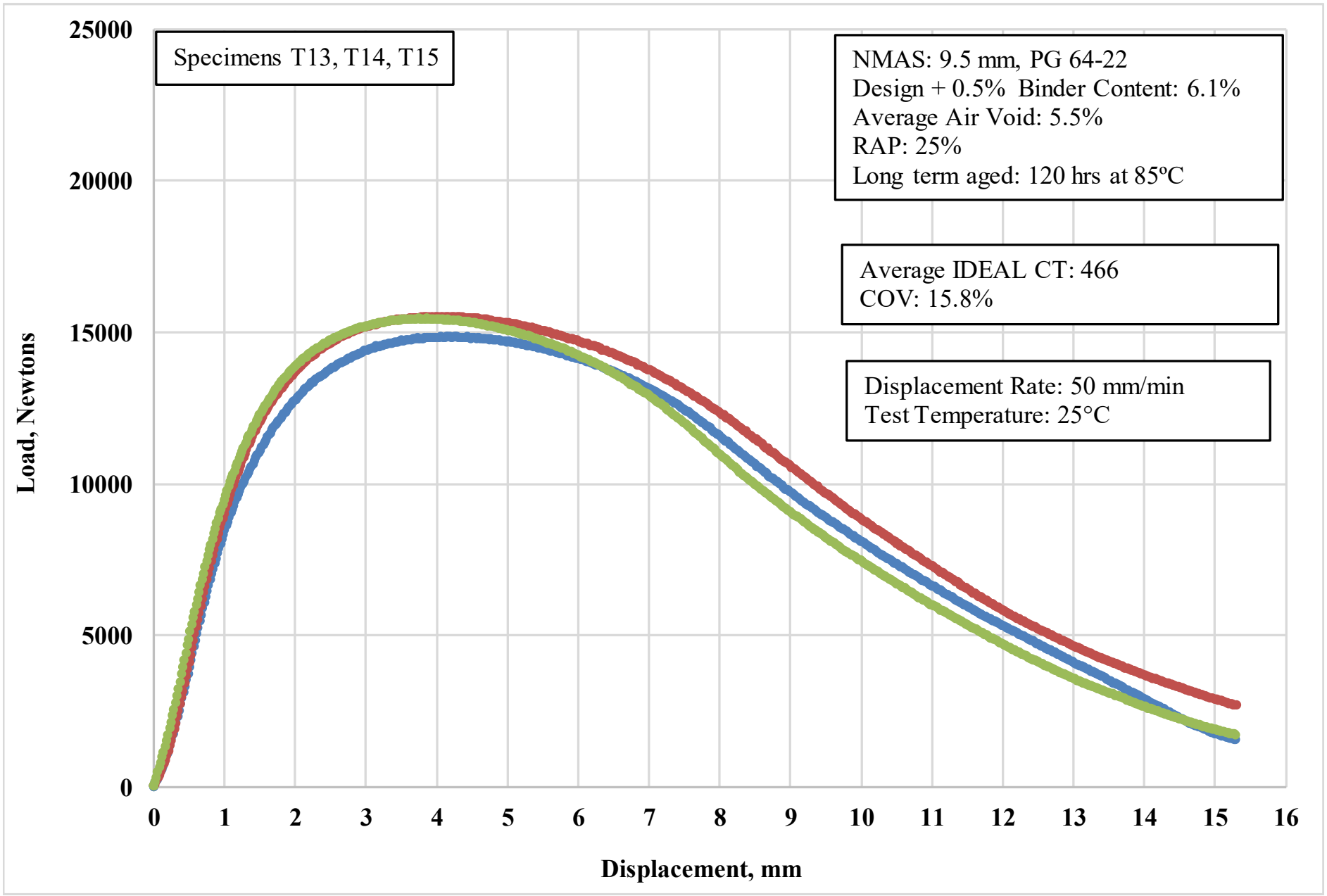


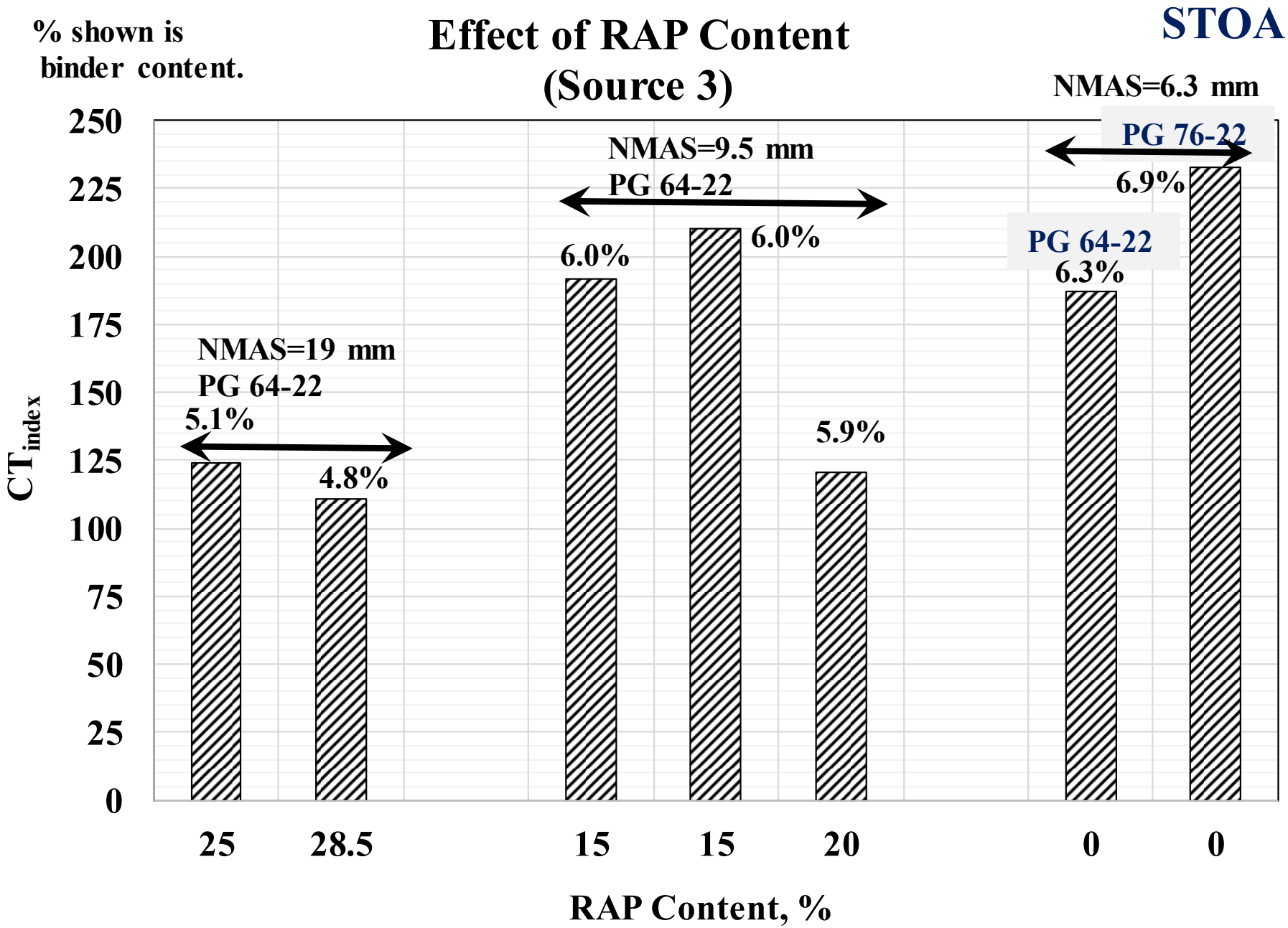

Effect of RAP Content
(Source 1)
LTOA
Total Binder=5.7%
PG 76-22
NMAS 9.5 mm
Total Binder=5.7%
PG 64-22
Total Binder=6.2%
PG 64-22
140
120
100
80
60
40
20
0
CT index
0
15
25
0
25
0
15
RAP Content, %

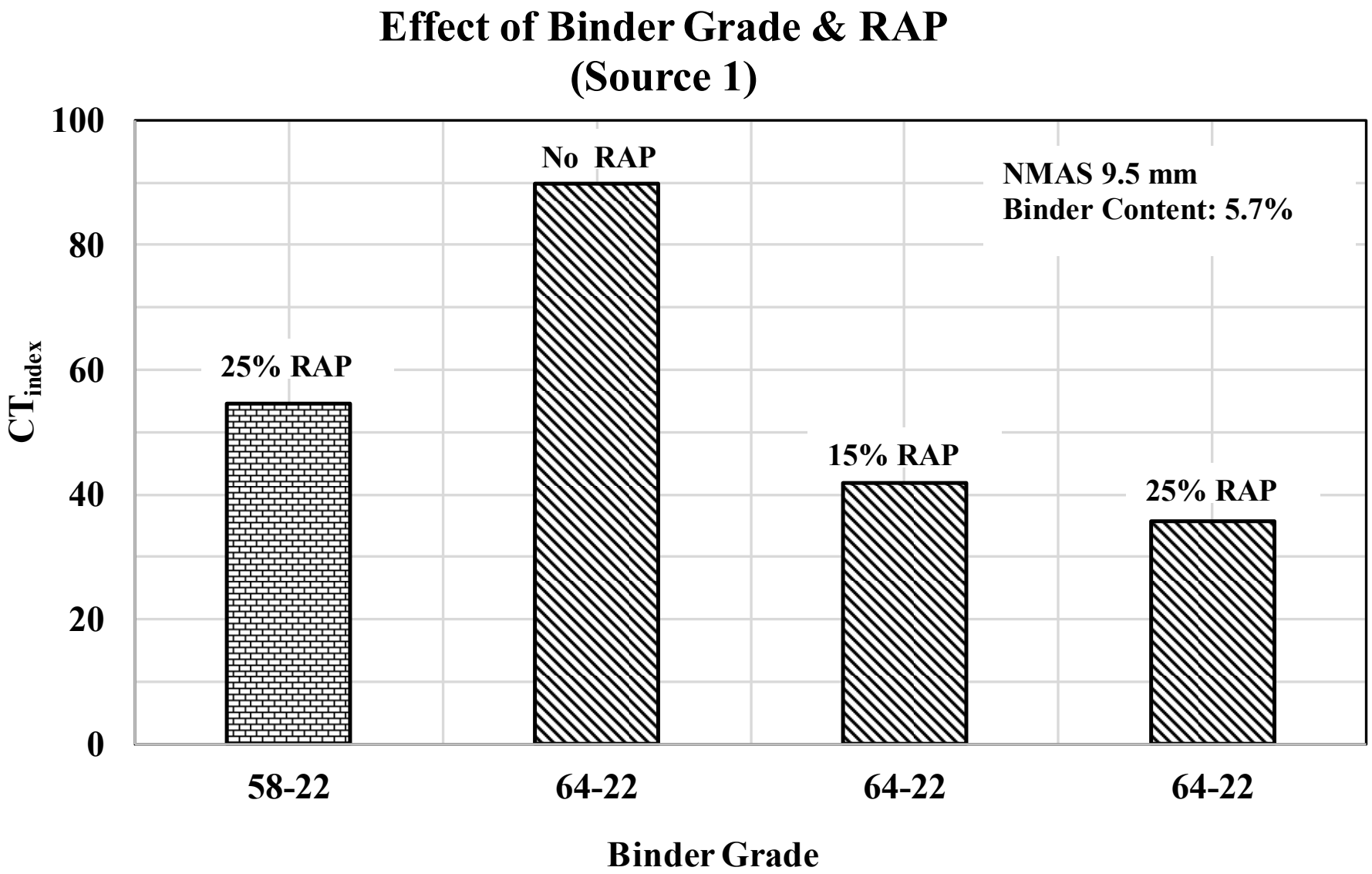
Effect of RAP Content (Source 2)

LTOA

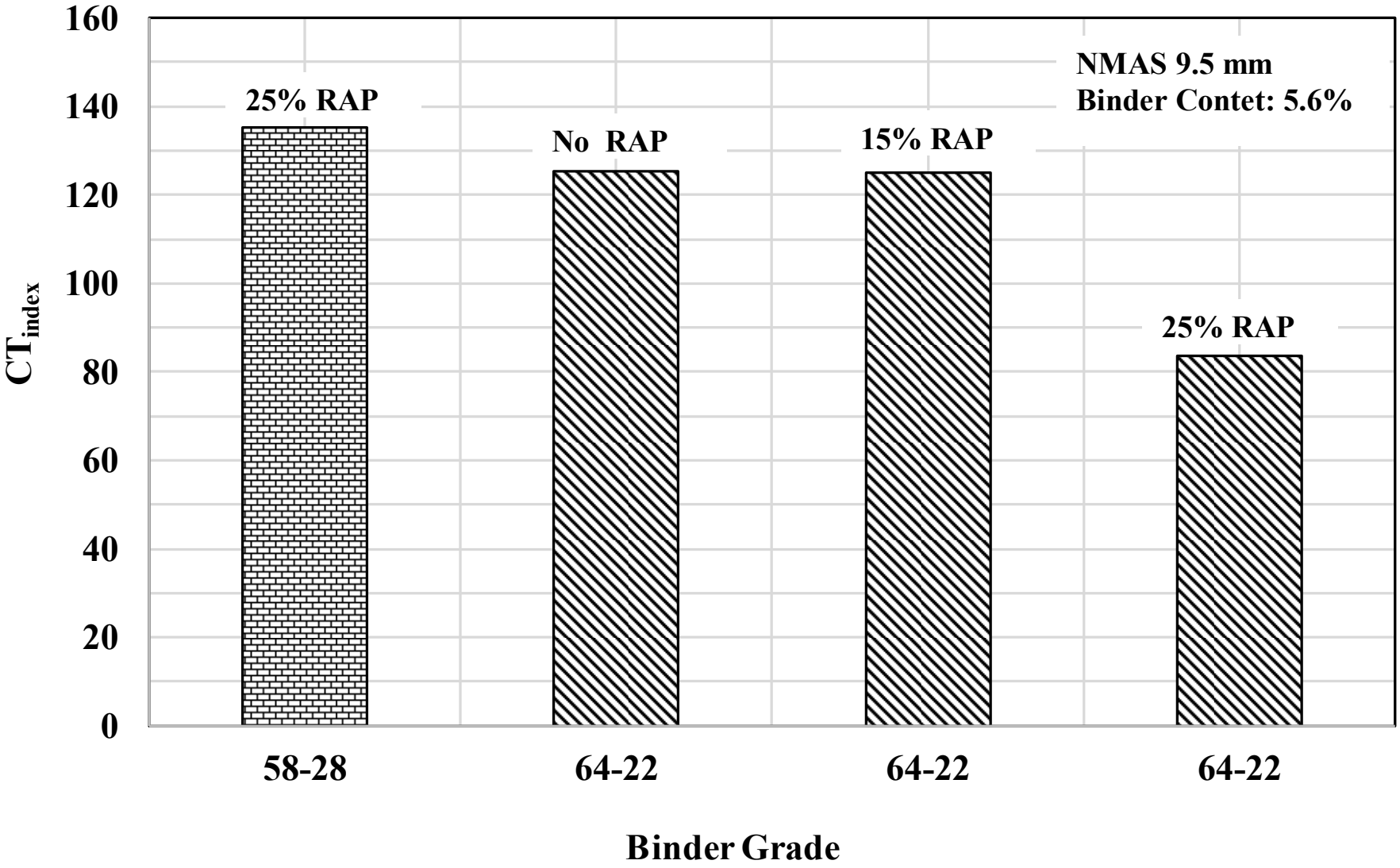



Specimens T13, T14, T15
NMAS: 9.5 mm, PG 64-22
Design + 0.5% Binder Content: 6.1%
Average Air Void: 5.5%
RAP: 25%
Long term aged: 120 hrs at 85ºC
Average IDEAL CT: 466
COV: 15.8%
Displacement Rate: 50 mm/min
Test Temperature: 25°C
Load, Newtons
25000
20000
15000
10000
5000
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Displacement, mm


% shown is binder content.
Effect of RAP Content (Source 3)
STOA
NMAS=6.3 mm
PG 76-22
6.9%
NMAS=9.5 mm
PG 64-22
6.0%
6.0%
PG 64-22
6.3%
NMAS=19 mm
PG 64-22
5.1%
4.8%
5.9%
250
225
200
175
150
125
100
75
50
25
0
CT index
25
28.5
15
15
20
0
0
RAP Content, %


Effect of Binder Grade & RAP
(Source 1)
100
80
60
40
20
0
CT_{index}
No RAP
NMAS 9.5 mm
Binder Content: 5.7%
25% RAP
15% RAP
25% RAP
58-22
64-22
64-22
64-22
Binder Grade

Effect of Binder Grade & RAP (Source 2)



Summary & Conclusions

- Trend of Data very similar to SCB
- IDEAL-CT Range: **33 to 460**
- **In most cases, the test is very repeatable**
- COV mostly under 25%

Summary & Conclusions

- Increasing binder increases flexibility
- Increasing RAP over 20% decreases flexibility
- Use of soft binder with high RAP: mixed results (RAP binder stiffness effect?)

Recommendations

- Use four replicates
- Need a limit on COV
  - Round robin testing needed
  - Recommendation: 20% to 25%


Thank You!