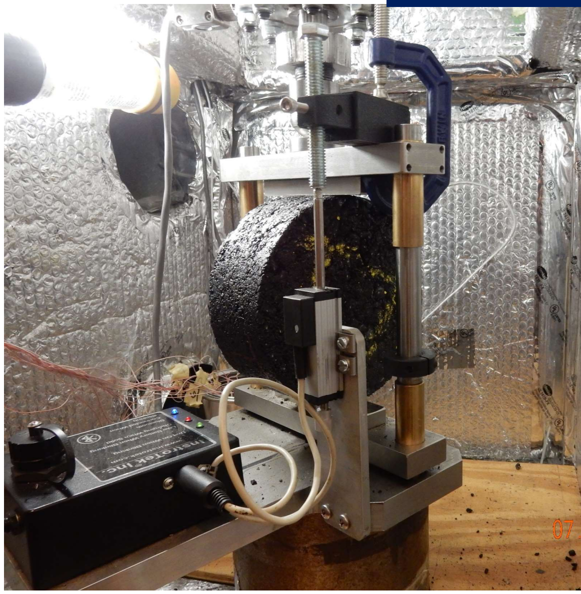
PA Initiative on Asphalt Mix Performance Tests

Pennsylvania Asphalt Pavement Association

Regional Technical Meeting

March 17, 18, 19, 2020



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and

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DISCUSSION TOPICS

1. Performance Based Testing & Long-Life Asphalt Pavements
2. PA Initiative on Performance Testing
3. Candidate Performance Tests
4. 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/BALANCED MIX DESIGN

Examples of Performance Tests

DCT

IDEAL-CT
crack

Wheel Tracking
rut

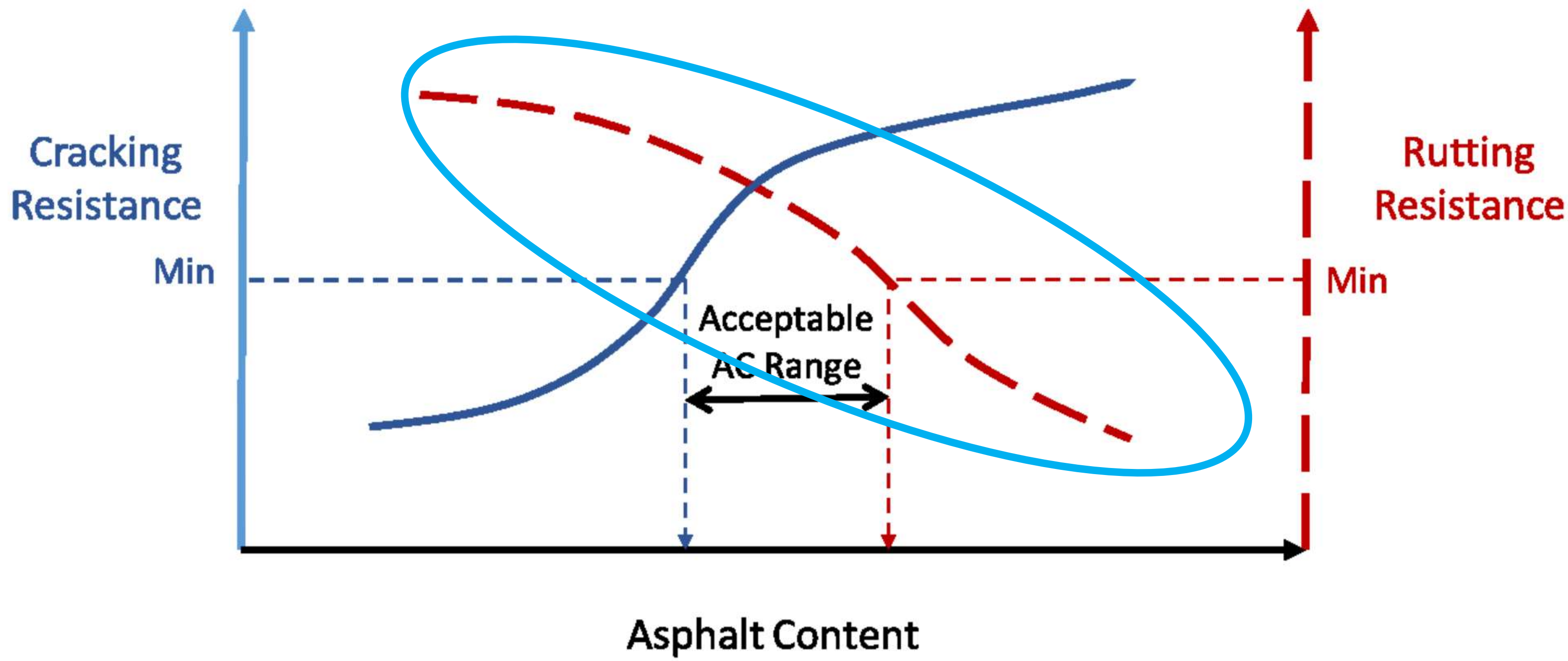
SCB

Performance Test & LLAP driven by:

- TQI

- STIC

Balanced Asphalt Mix Design



HWT testing Pilot

HWT Testing Advantages

- Well accepted nationally for rut testing

- Rutting Resistance Measure
  - Very well established track record detecting rut-prone asphalt mixtures.
  - Rules of thumb
    - 12.5mm at 20,000 cycles for polymer modified mixes
    - 12.5mm at 10,000 cycles for non-polymer modified mixes

- Moisture Susceptible Aggregate Measure
  - Can replace AASHTO T283 (TSR) eventually

HWT Standard Special Provision Status

- Standard Special previously circulated through APQIC Pro-team.
- CT 1 and CT 2 circulated
- Shooting for end of March for solicitation letter to Districts.
- Asking Districts to include the special provision on a minimum of 3 projects in the 2020 construction season with anticipated final inspection dates before October 31, 2021.
- Payment is a PDA. (about $700 per test)

HWT Standard Special Provision 2020

- HWT Testing results are for **<u>information only</u>** in 2020.
- HWT test results are not required until the final project inspection.
- No project construction delays because of testing availability or results in 2020.
- Payment to contractor for HWT testing in 2020.
- Incremental changes in future years.
  - Incidental to JMF, Testing requirment for JMF approval, Limits established…

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1. Performance Based Testing & Long-Life Asphalt Pavements
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Performance Testing

- **General agreement on the rutting test (HWT) and test protocols.**

- **The “school is still out” on the best cracking test and test protocols.**

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

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

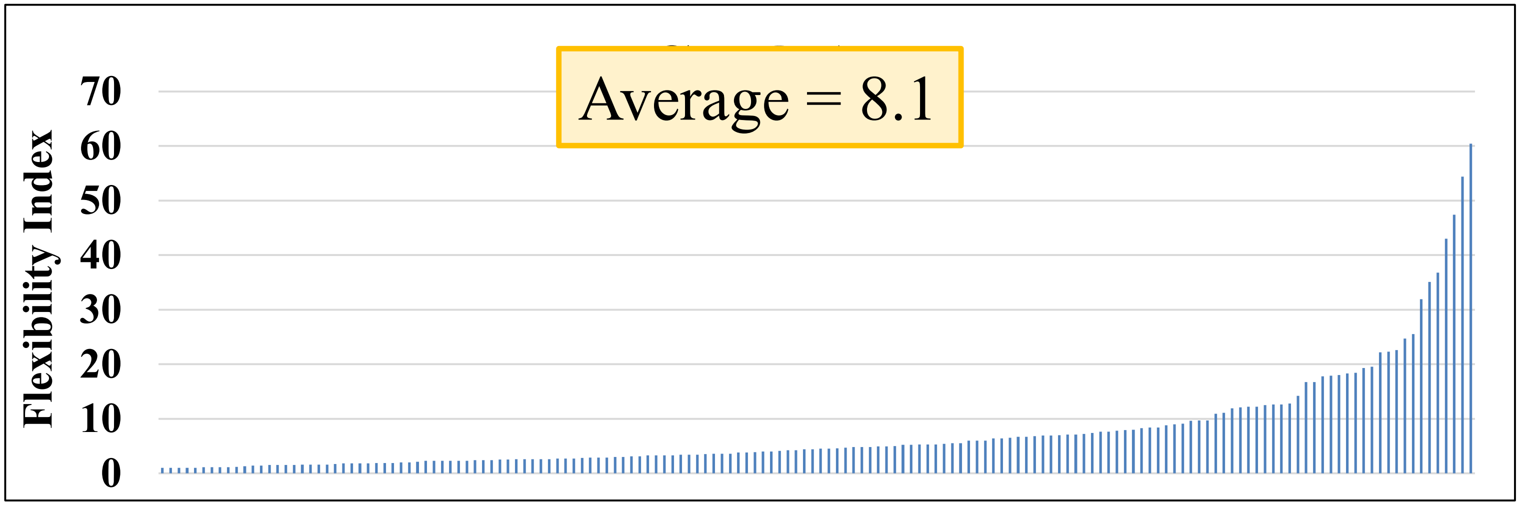
Purpose of the Effort

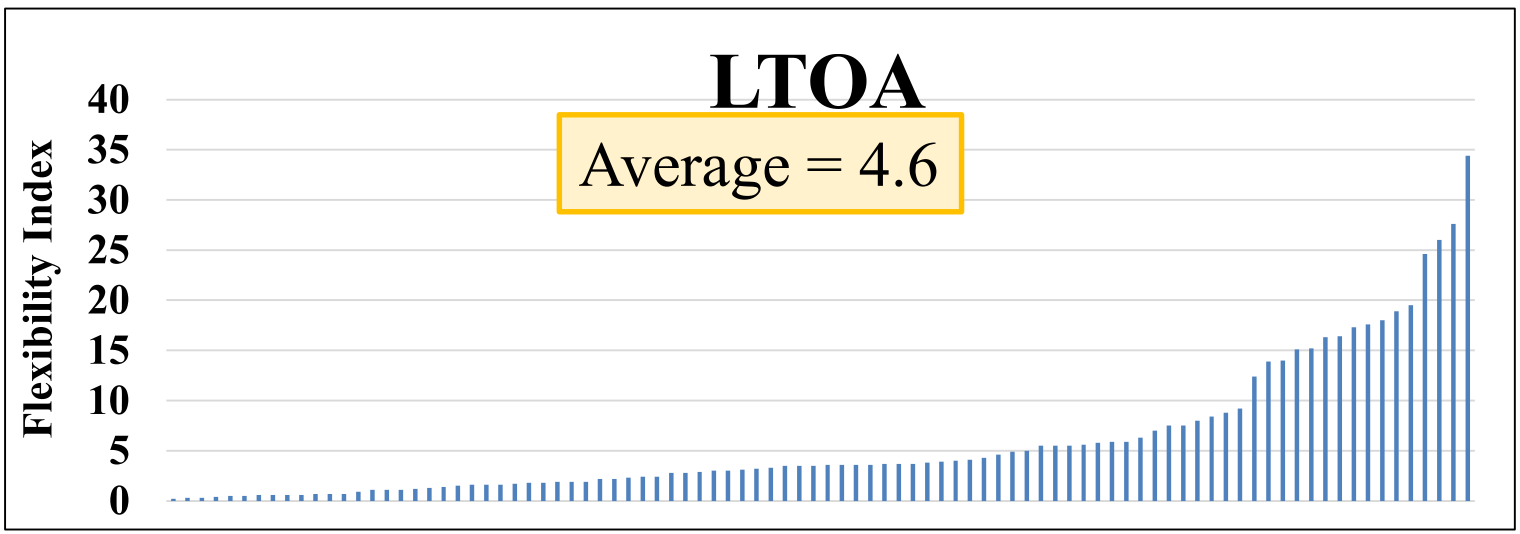
- **Bridge the Gap to Crack Performance Testing**
- **Investigate Performance of PA Mixes in SCB/IDEAL crack performance tests**
- **Develop A Database of SCB/IDEAL Test Results**
- **Evaluate Sensitivity of the PA Mixes to the Tests**
- **Evaluate Correlation with Field Performance**

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 (higher is better)





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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Performance Tests Under Consideration

- Hamburg Wheel Tracking
- IDEAL-CT Test

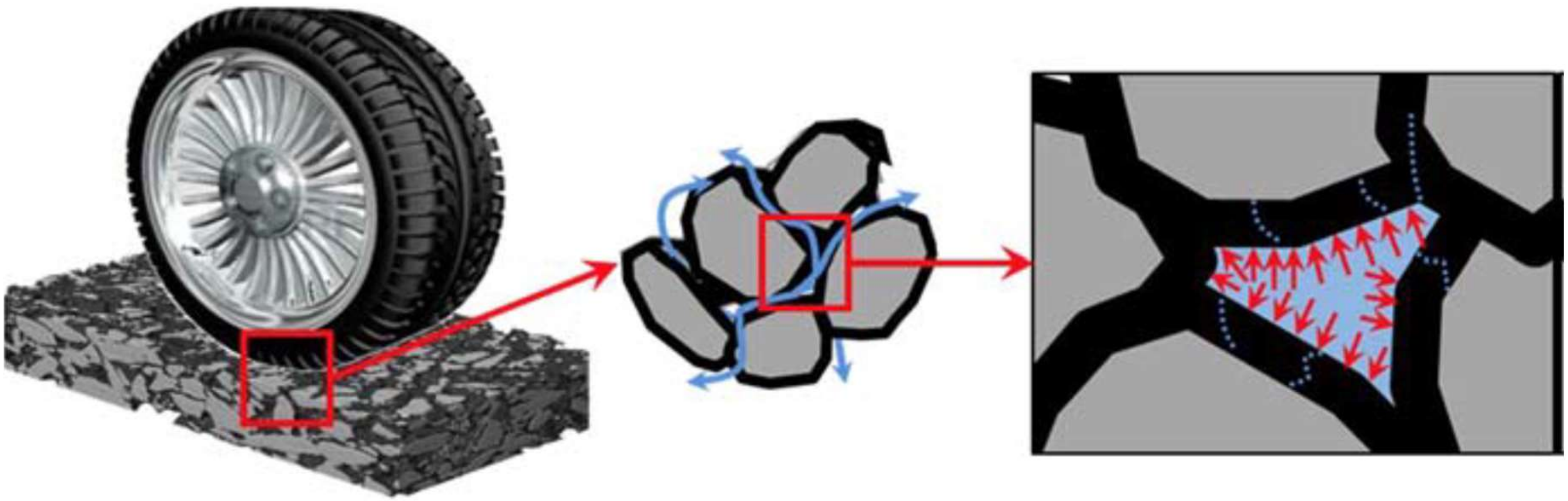
Hamburg Wheel
Tracking
(AASHTO T 324)

Hamburg Wheel Tracking Device

Moisture Conditioning
with Hydrostatic Pore Pressure
(ASMT D7870)
+ 20 Hr. Conditioning for Adhesion

MiST (Moisture Induced Stress Tester)

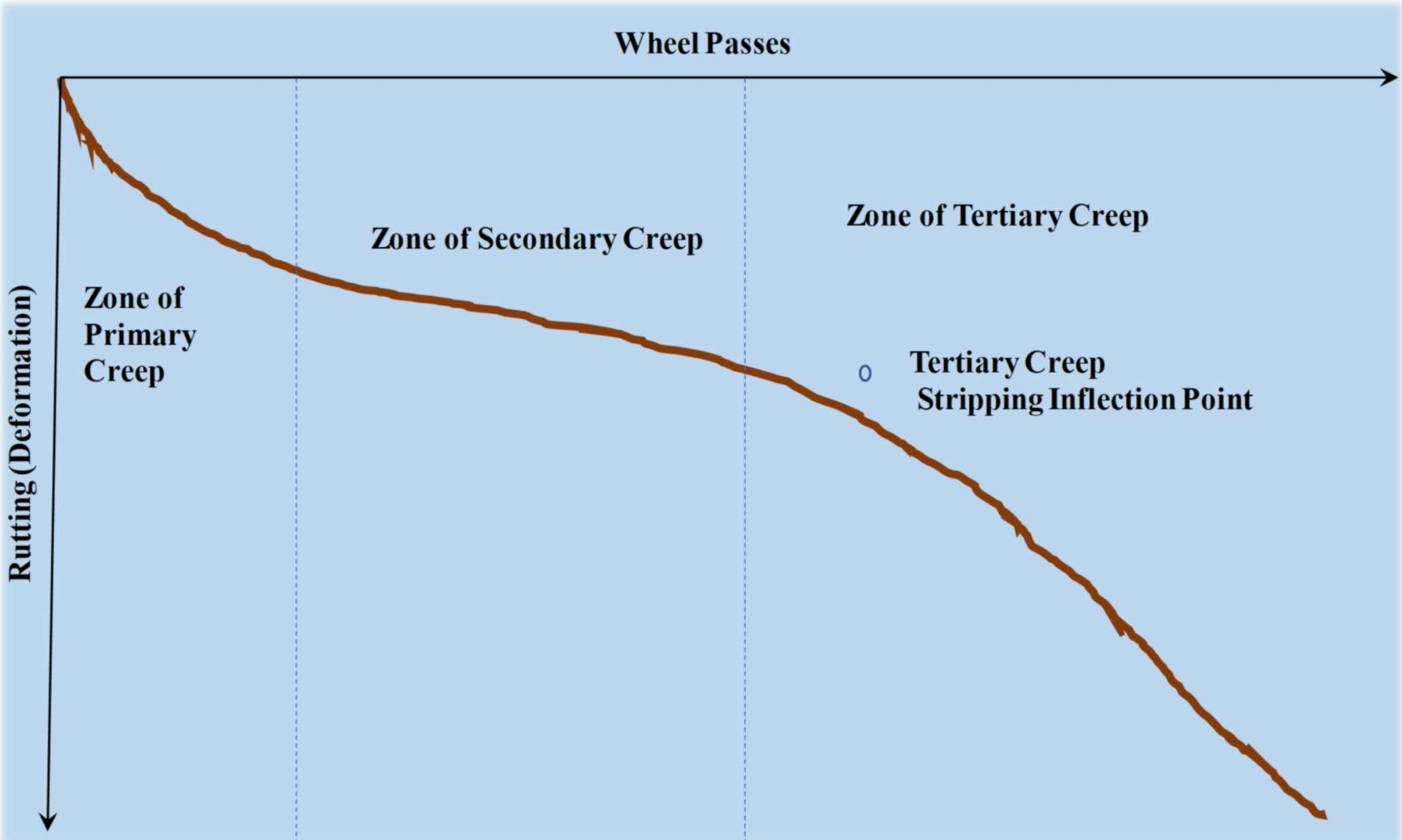
Traffic Effect on Moisture Damage



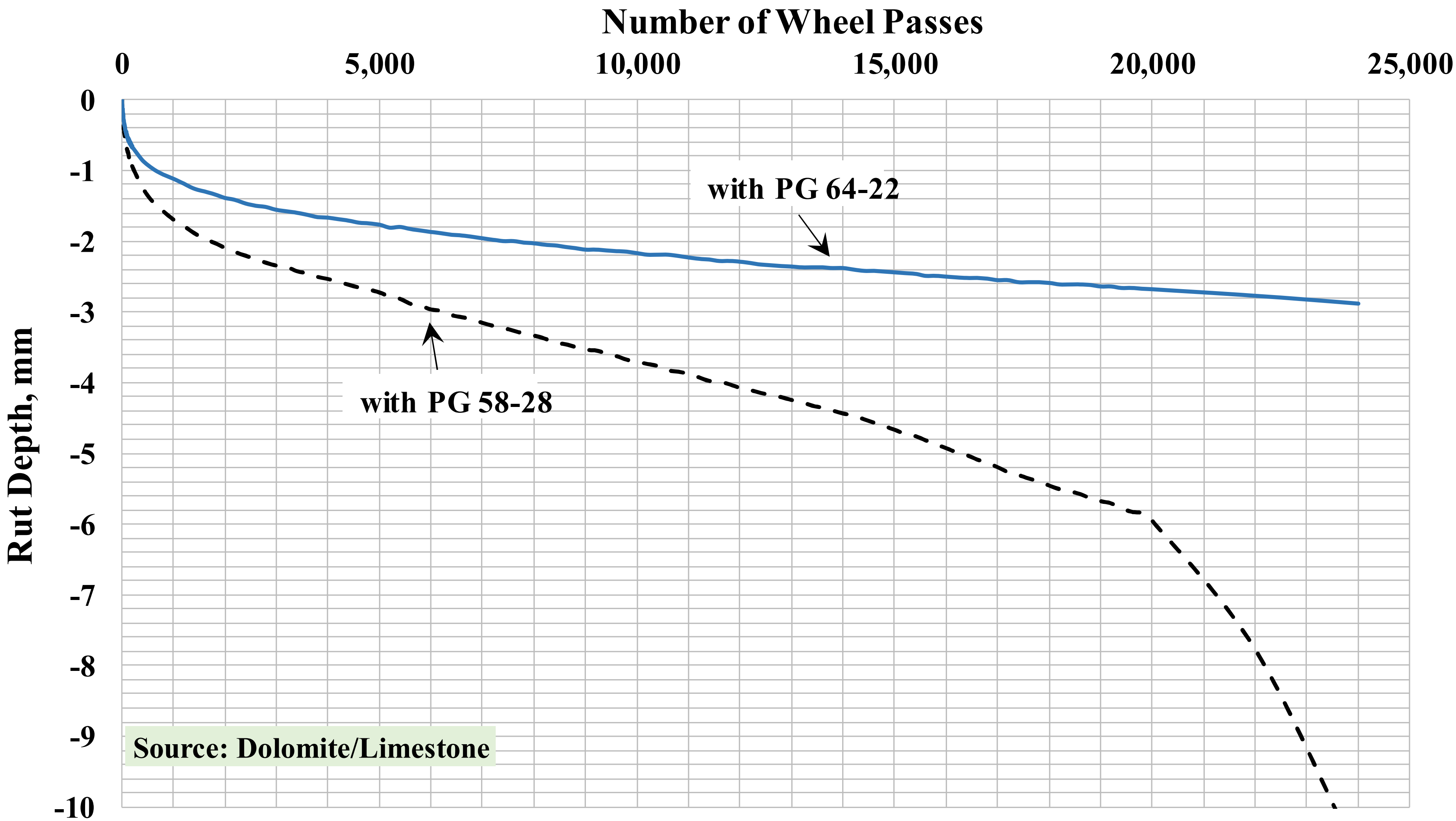
Pore Pressure Build-Up
Due to External Cyclic Stress

Compression/Tension Cycle
(Cyclic Pressure/Suction)

Wheel Tracking Test Data

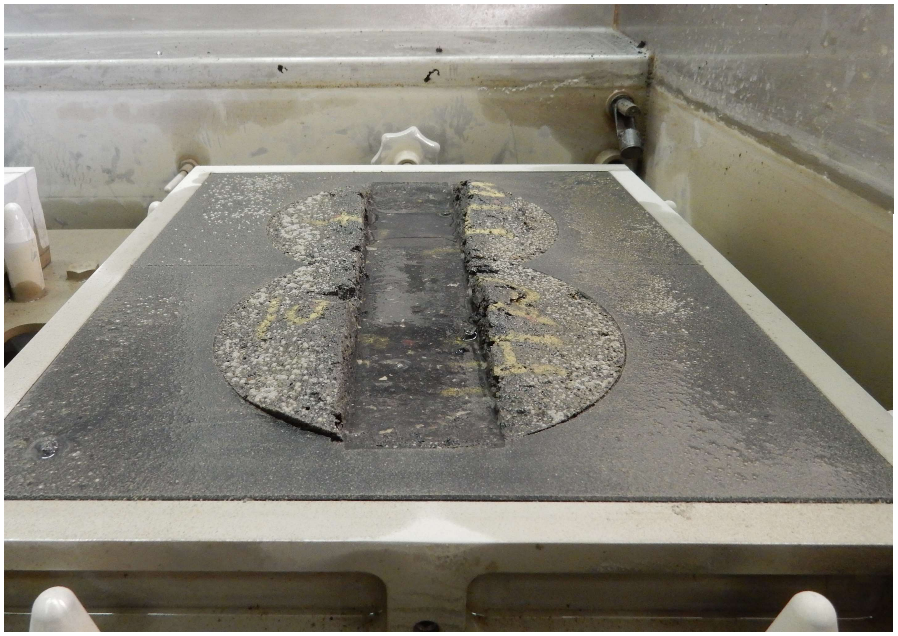


Binder Stiffness Effect

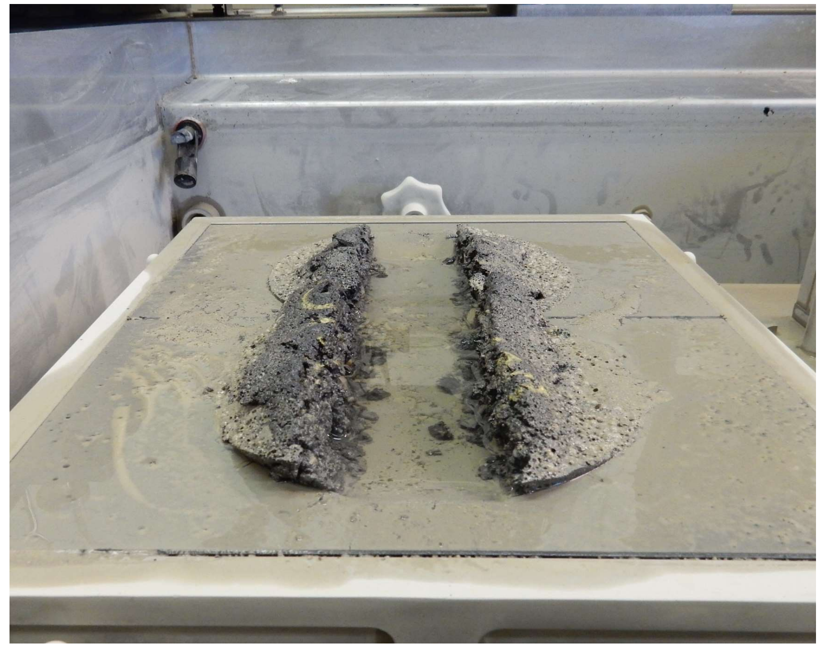


Binder Stiffness Effect

HWT - Submerged



PG 64-22



PG 58-28

SP 12.5mm – Limestone Aggregate (Aggregate 1)

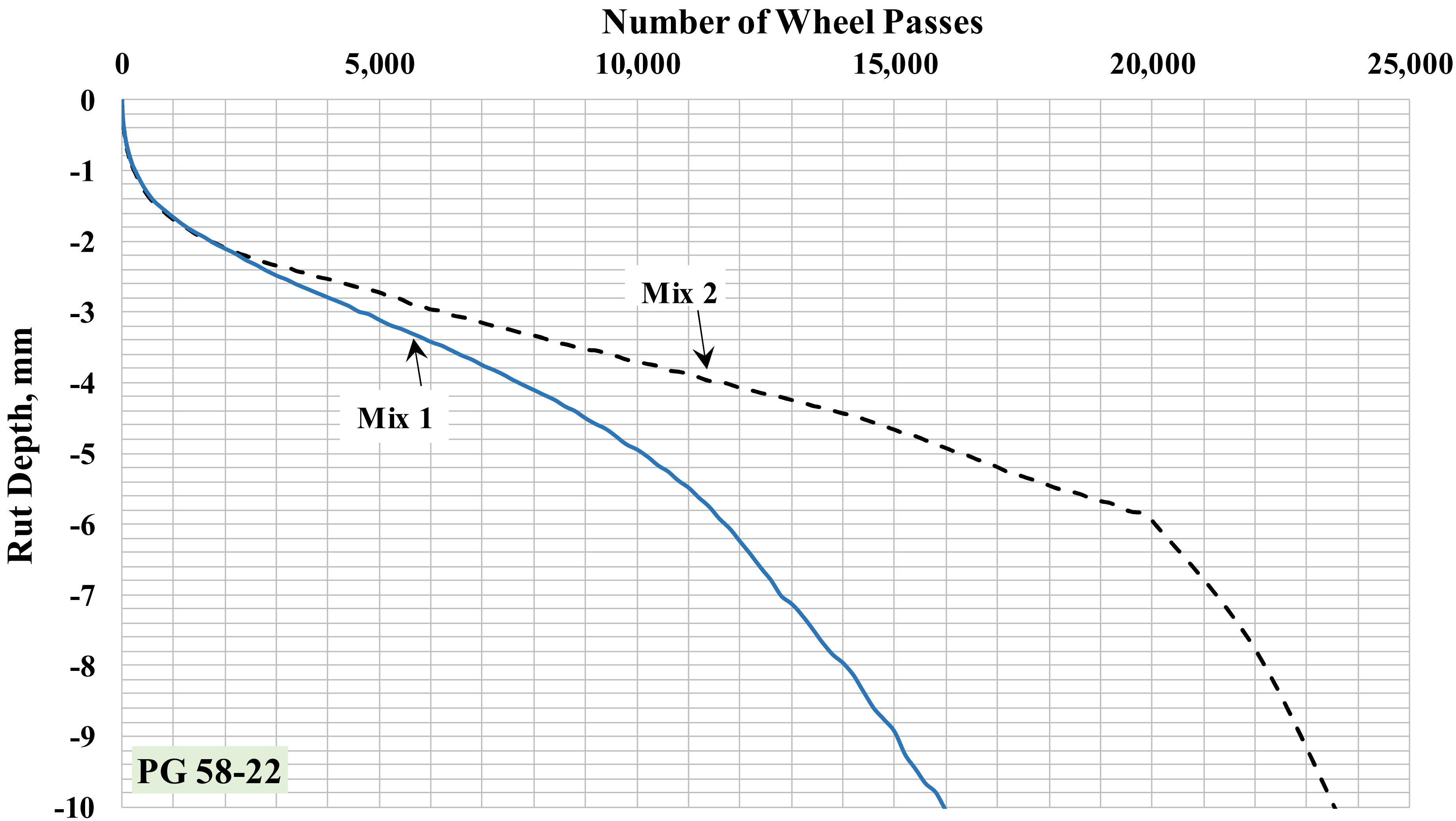
Binder Stiffness Effect

HWT - Submerged

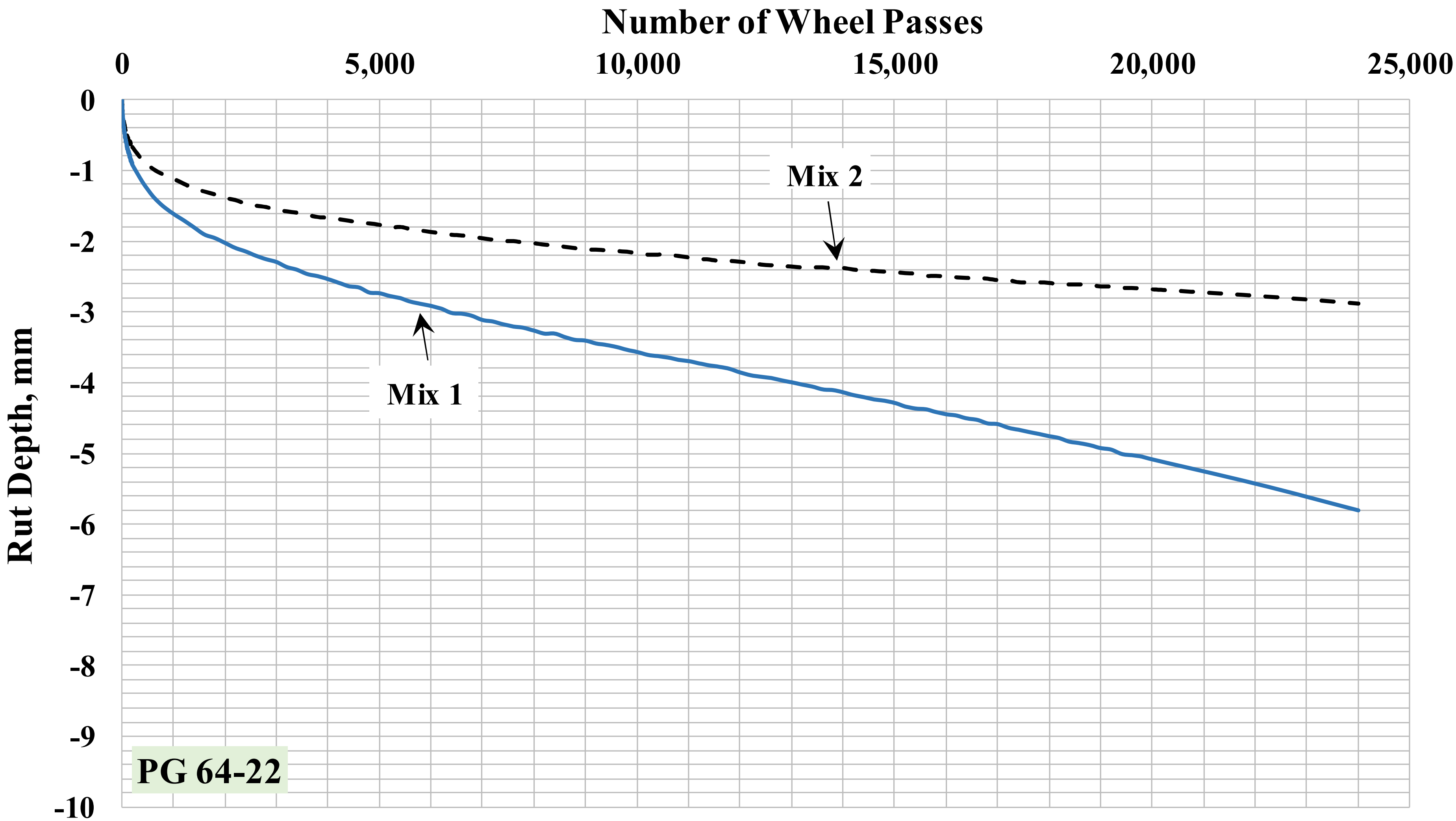
PG 64-22 **PG 58-22**

SP 9.5mm – Limestone/Dolomite Aggregate
(Aggregate 2)

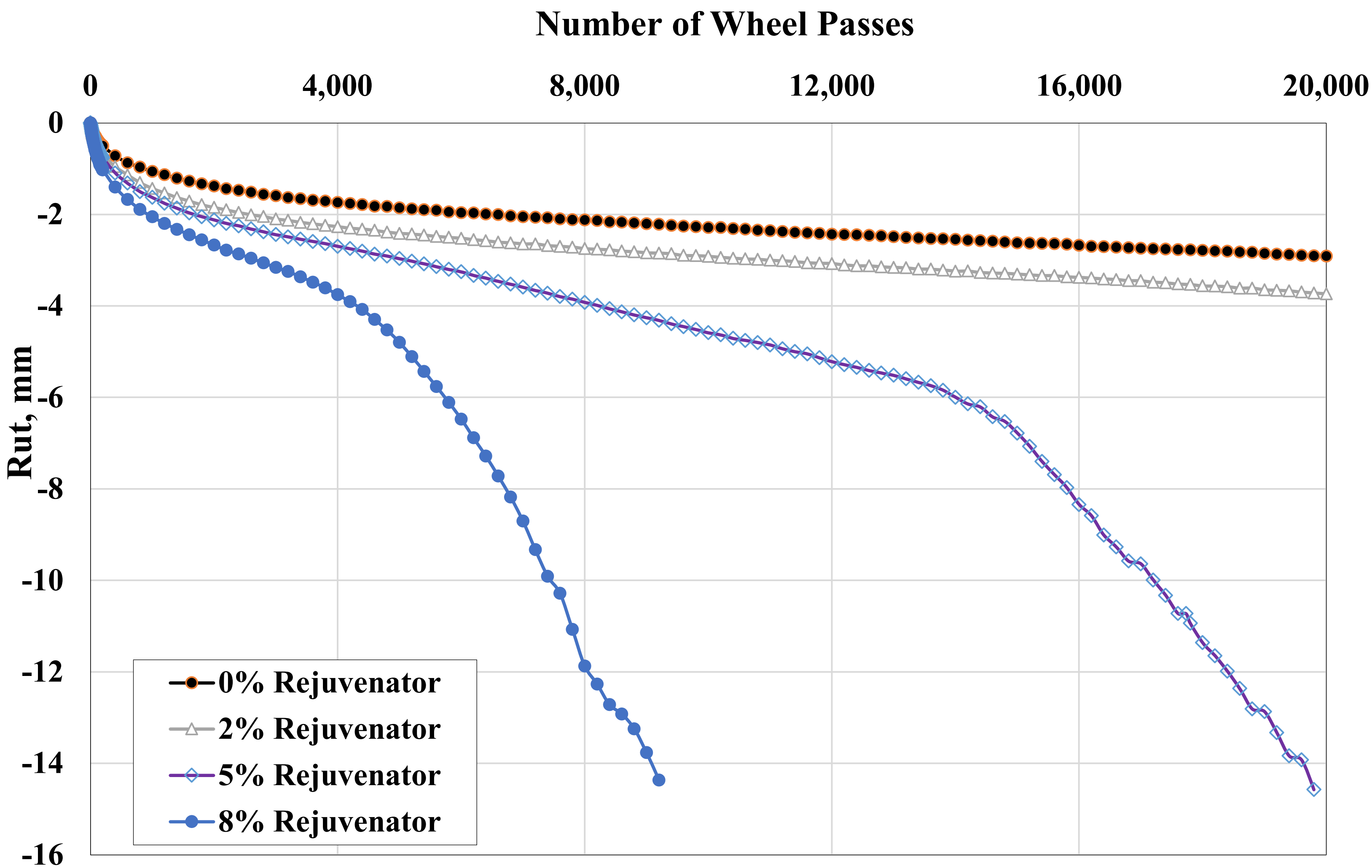
Mix/Aggregate Effect



Mix/Aggregate Effect



Rejuvenator Effect – 35% RAP Mix

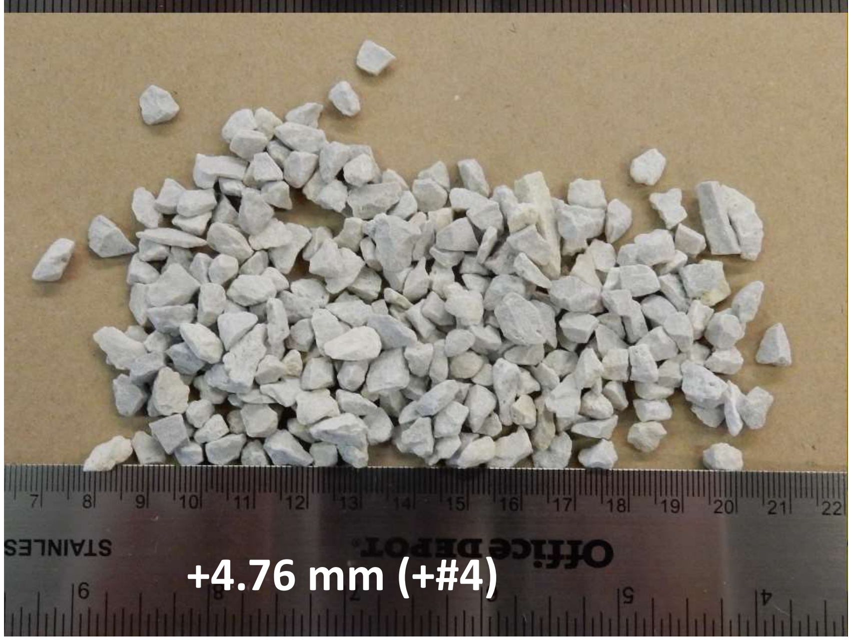


Looking at
Wheel Tracking Results for

- Submerged
- MiST Conditioned
- Dry

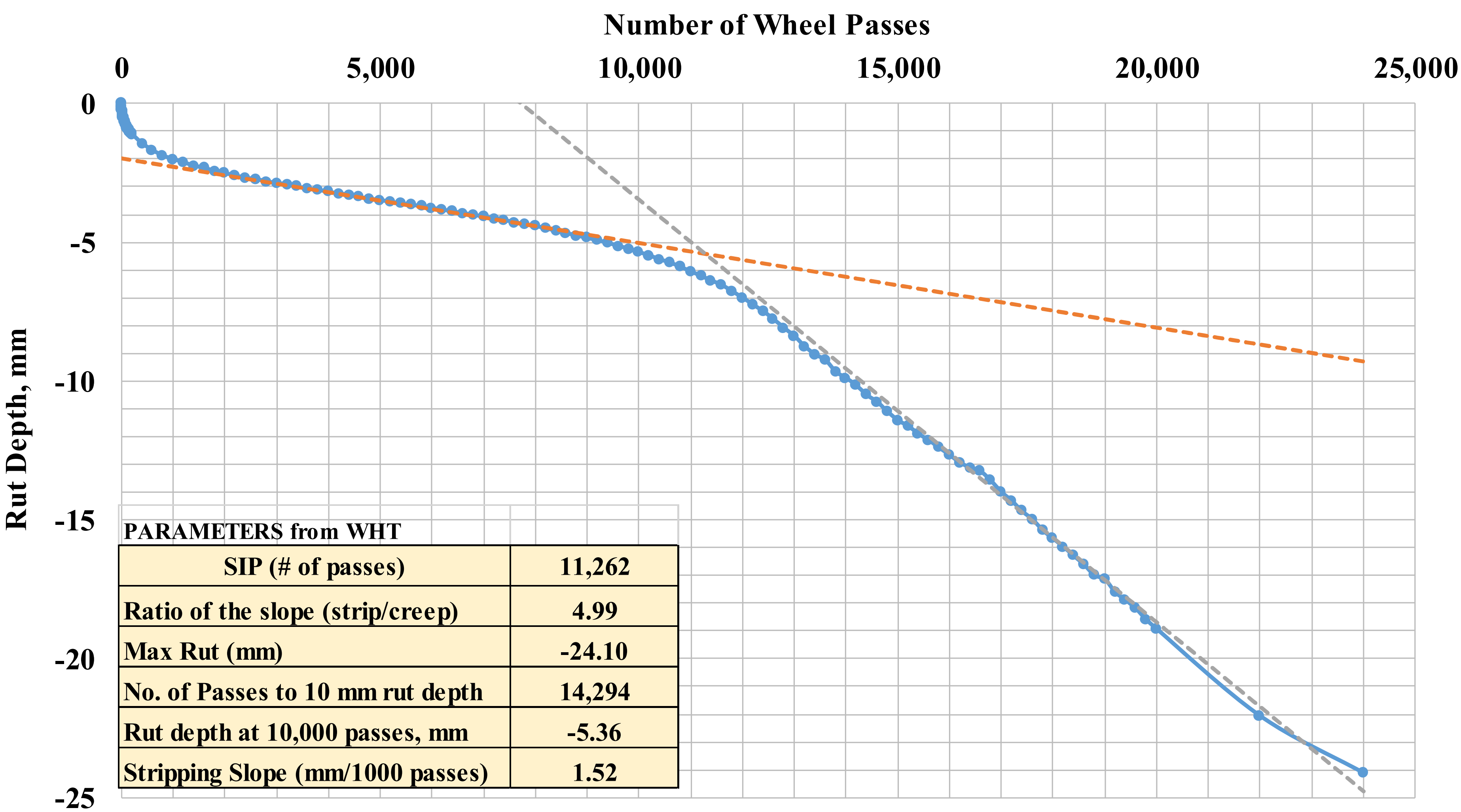
Aggregates Used in the Study

Limestone, Dolomite, and Siliceous Gravel



Dolostone shown here

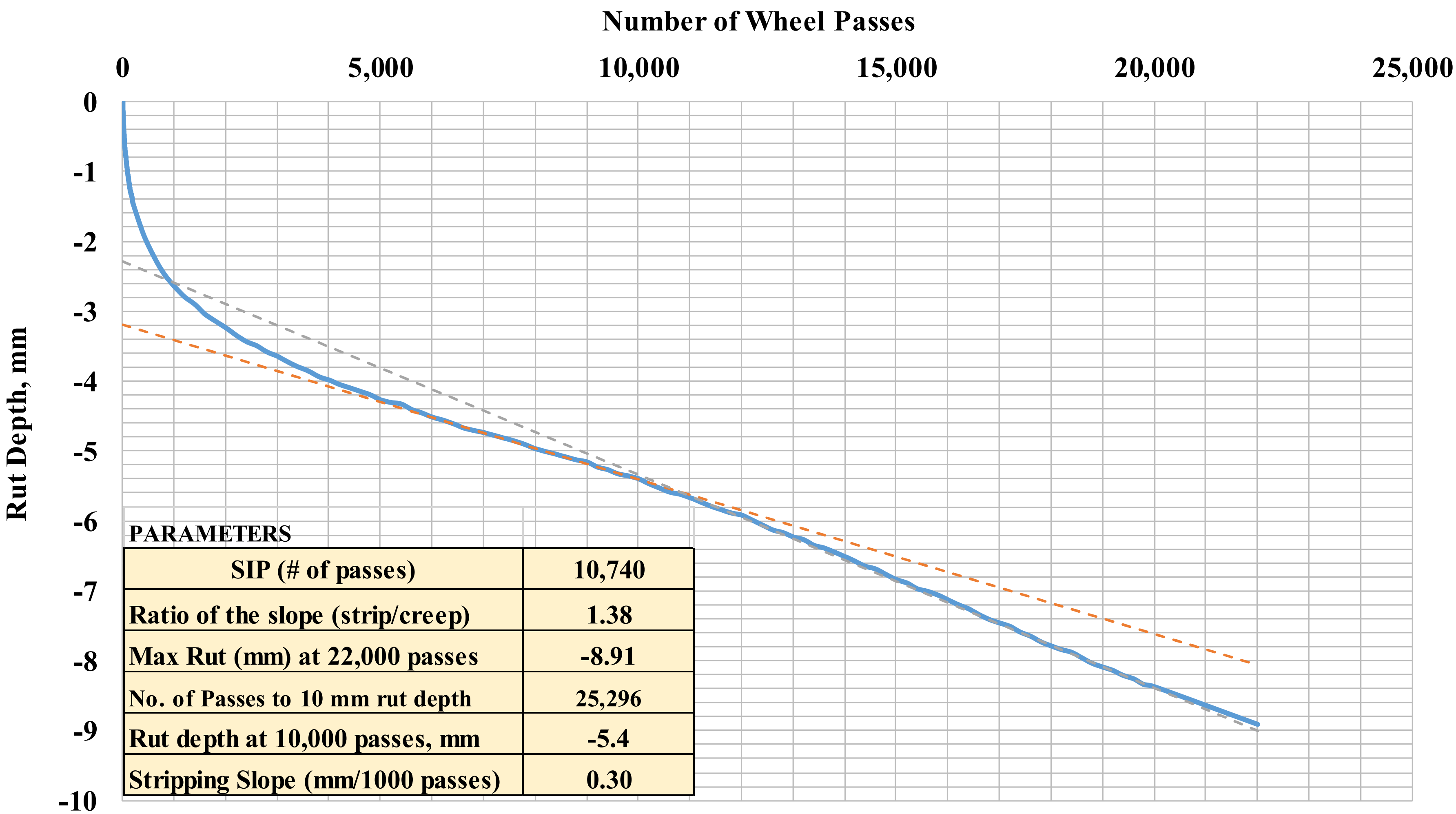
HWTD - Submerged



PARAMETERS from WHT

SIP (# of passes)	11,262
Ratio of the slope (strip/creep)	4.99
Max Rut (mm)	-24.10
No. of Passes to 10 mm rut depth	14,294
Rut depth at 10,000 passes, mm	-5.36
Stripping Slope (mm/1000 passes)	1.52

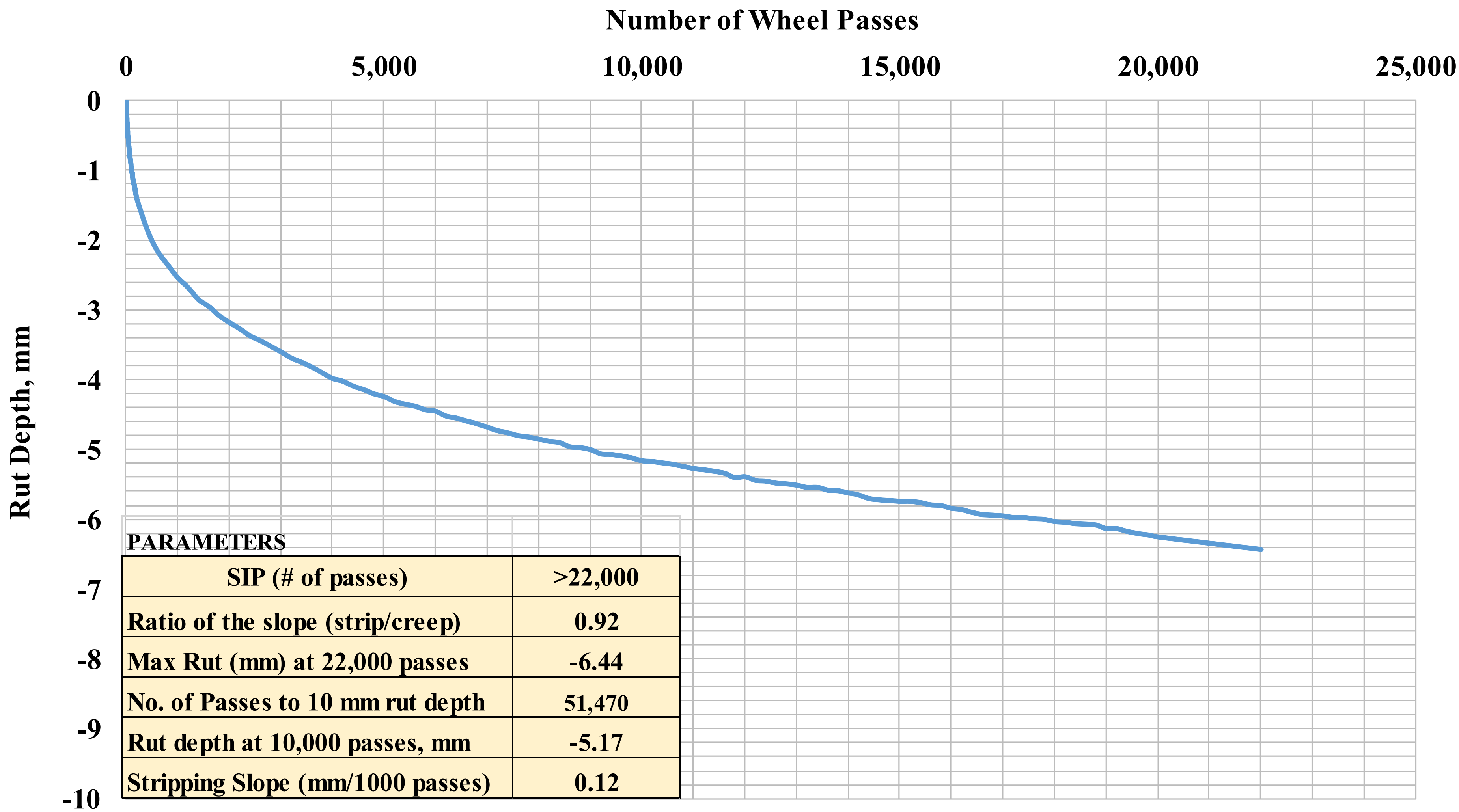
HWTD – after MiST



PARAMETERS

SIP (# of passes)	10,740
Ratio of the slope (strip/creep)	1.38
Max Rut (mm) at 22,000 passes	-8.91
No. of Passes to 10 mm rut depth	25,296
Rut depth at 10,000 passes, mm	-5.4
Stripping Slope (mm/1000 passes)	0.30

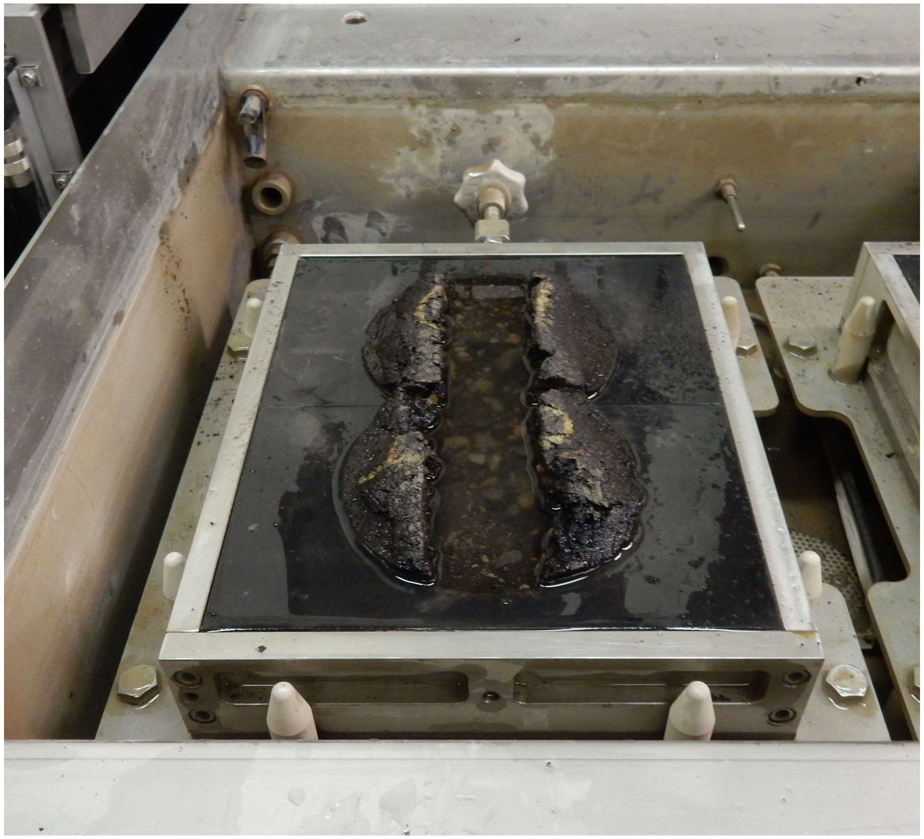
HWTD - Dry

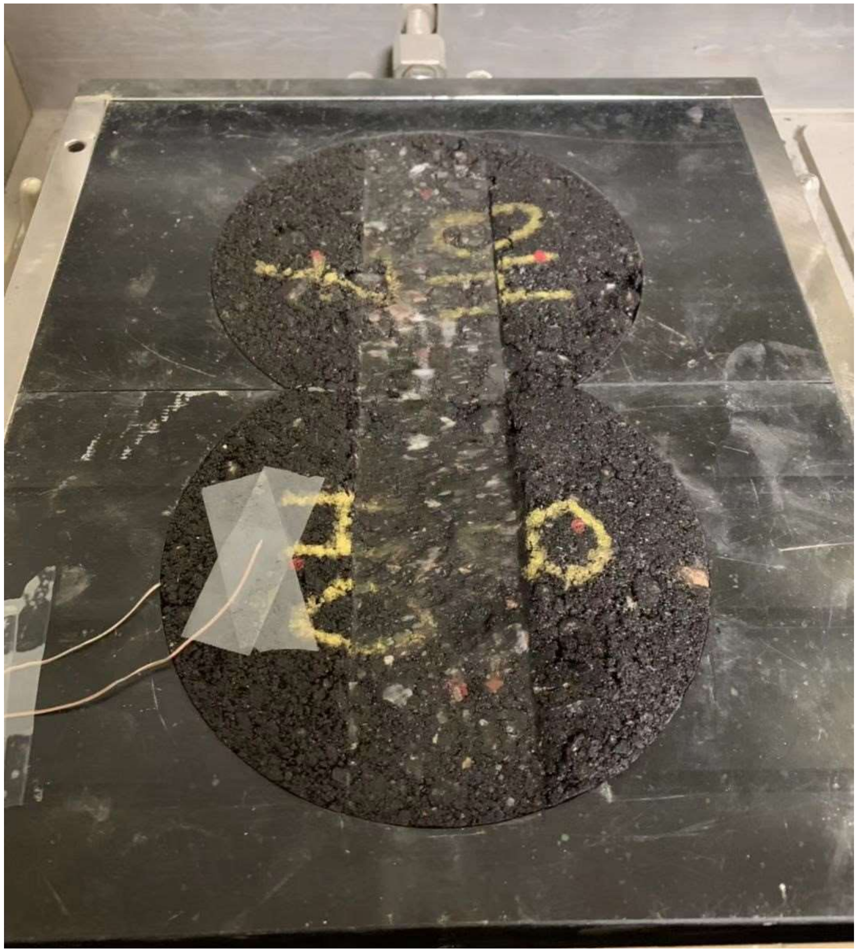


PARAMETERS

SIP (# of passes)	>22,000
Ratio of the slope (strip/creep)	0.92
Max Rut (mm) at 22,000 passes	-6.44
No. of Passes to 10 mm rut depth	51,470
Rut depth at 10,000 passes, mm	-5.17
Stripping Slope (mm/1000 passes)	0.12

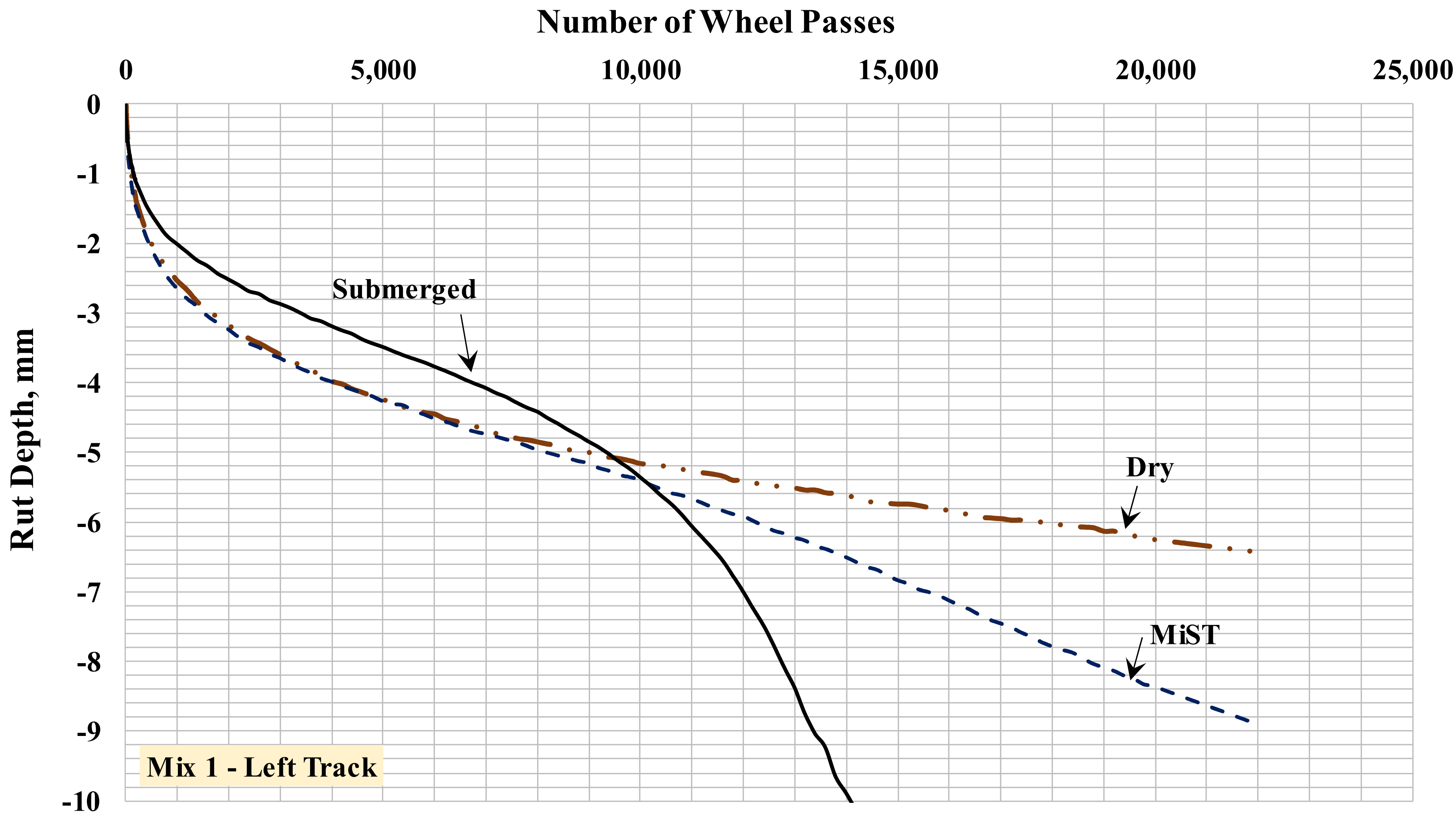
PG 58-28
Wet





PG 58-28
Dry

Dry vs. MiST vs. Submerged



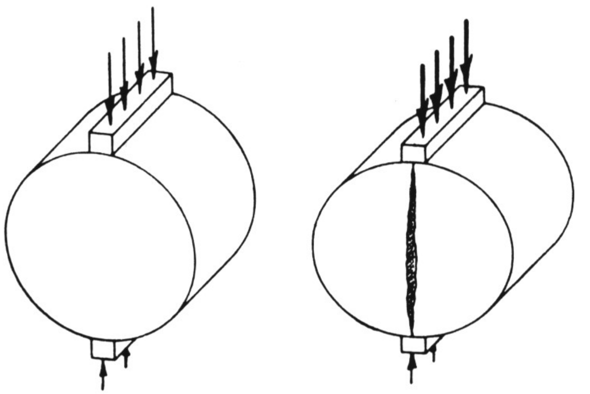
Performance Tests Under Consideration

- **Hamburg Wheel Tracking**
- **IDEAL-CT Test**

Traffic Based Criteria (HWT) - Example

Traffic Level, (Million ESALs)	Max. Rut Depth at 20,000 passes (mm)	SIP (Min.)	Strip/ Creep Ratio (Max.)	Passes to 10mm Rut (Min.)
≥ 10	10			
	15	16,000	2.0	15,000
≥ 3 and <10	10			
	15	14,000	2.0	12,000
	20	16,000	3.0	14,000
<3	15			
	20	14,000	3.0	10,000
	25	16,000	4.0	12,000

IDEAL Cracking Test for Asphalt Concrete



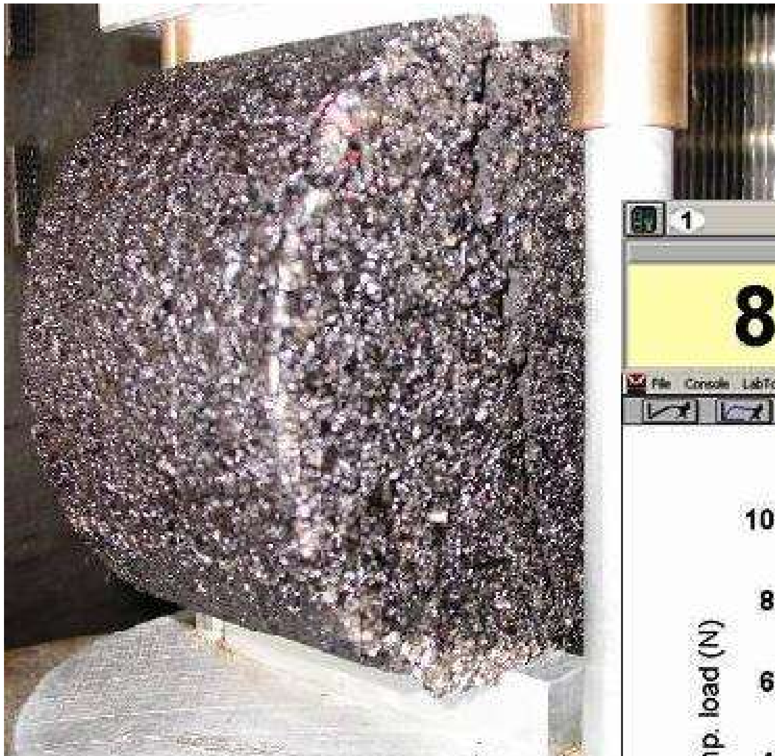
Indirect Tensile Asphalt Cracking Test

IDEAL-CT

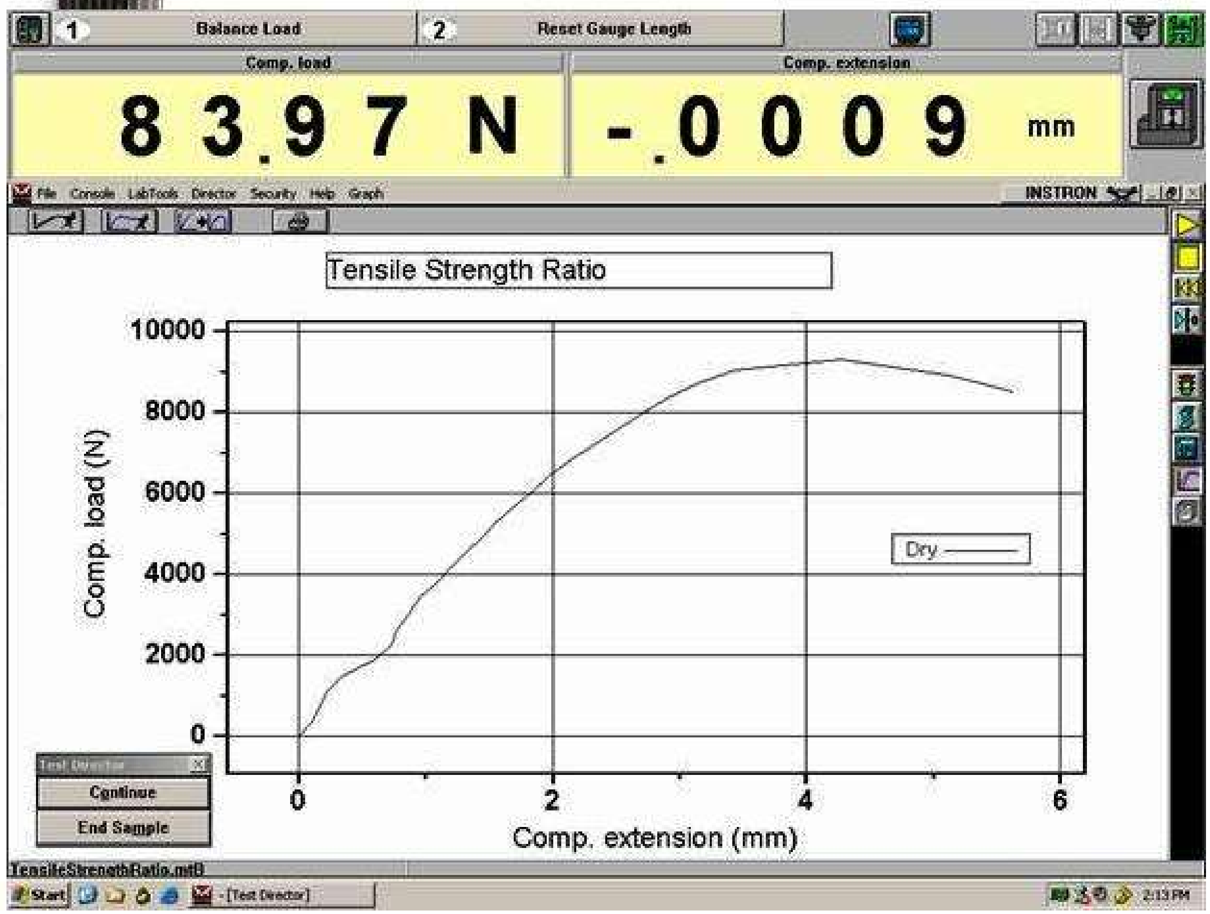
Proposed by Research at Texas Transportation Institute (TTI)

Indirect Tensile Strength Test

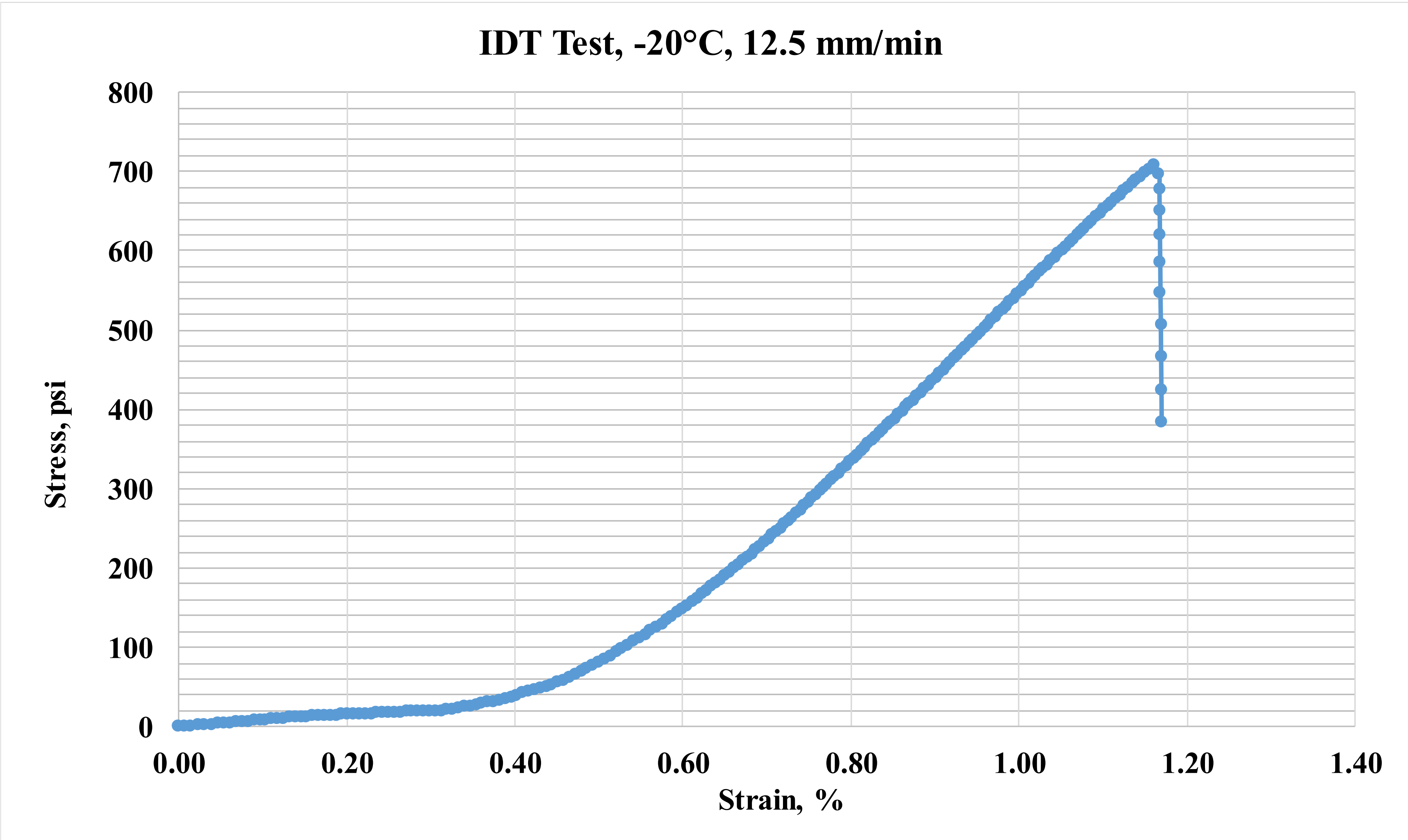
(for AASHTO T 283, Tensile Strength Ratio (TSR))



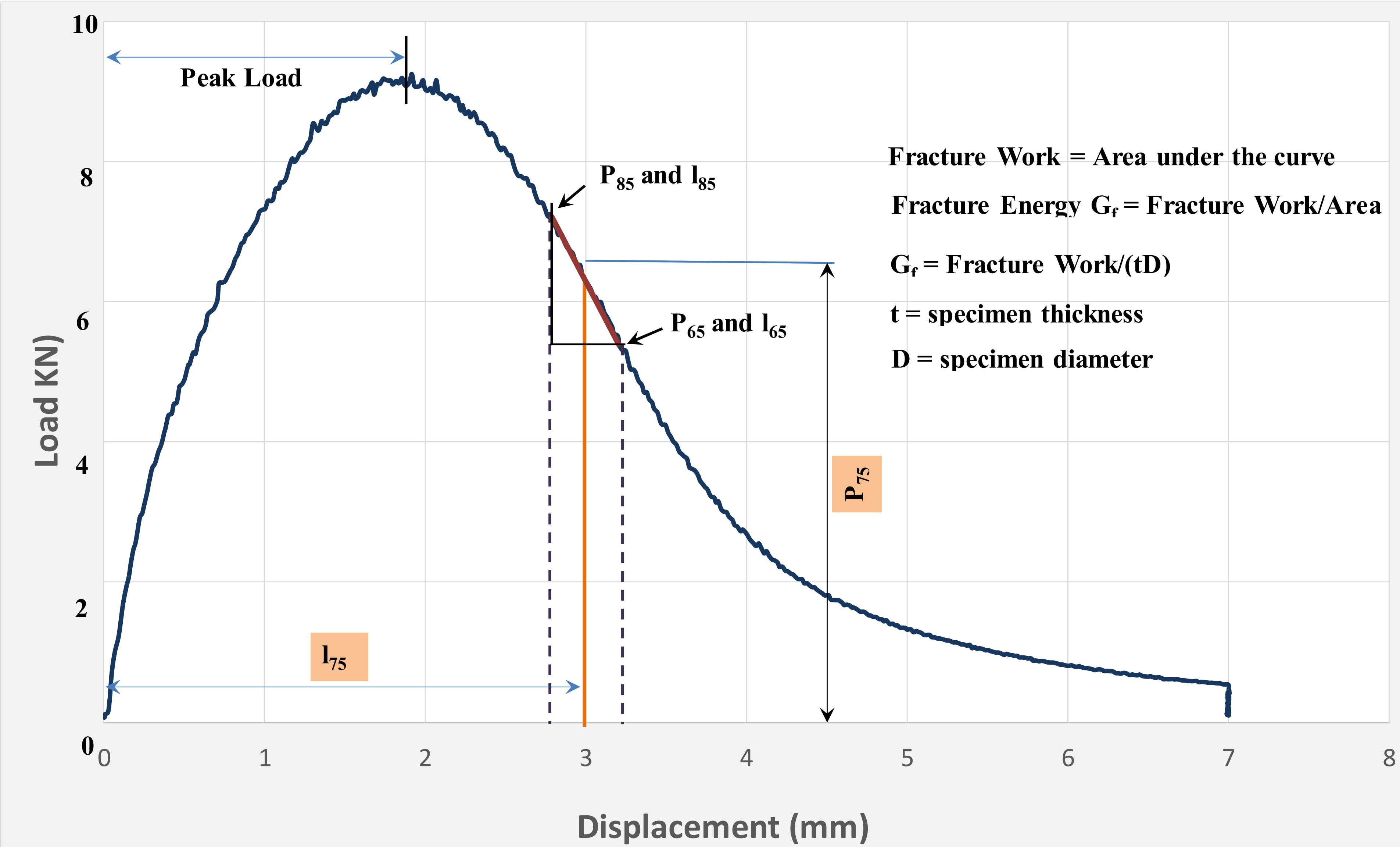
$$S_t = \frac{2P}{\pi t D}$$



Indirect Tensile Test at Low Temp.



IDEAL – Test Results



IDEAL – Test Results

Criteria established based on CT_{Index}

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

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

Source of Mixes & Conditioning

Sources 1 and 2

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

LTOA

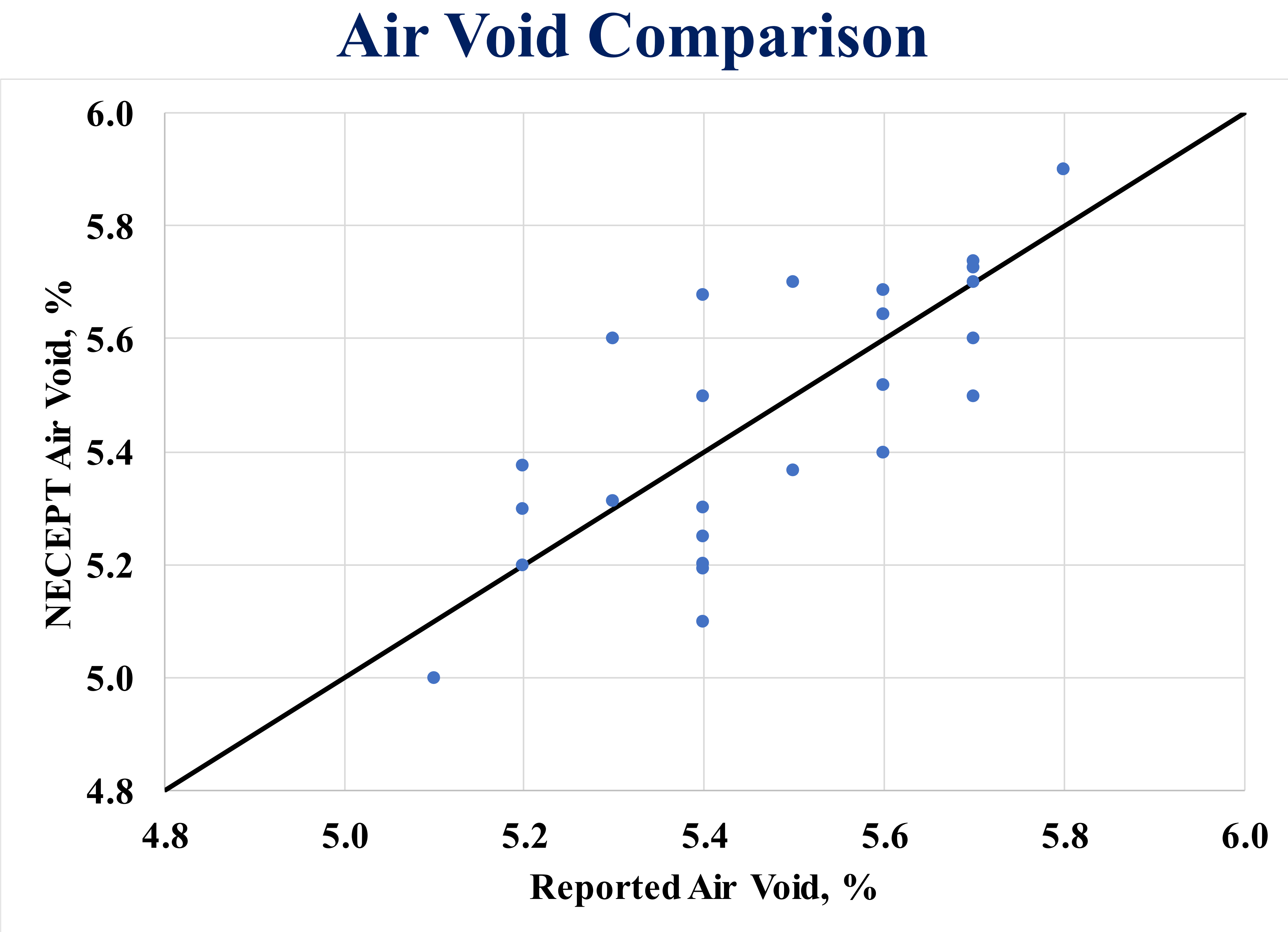
Source 3

Plant Prepared Mix → Short Term Aged

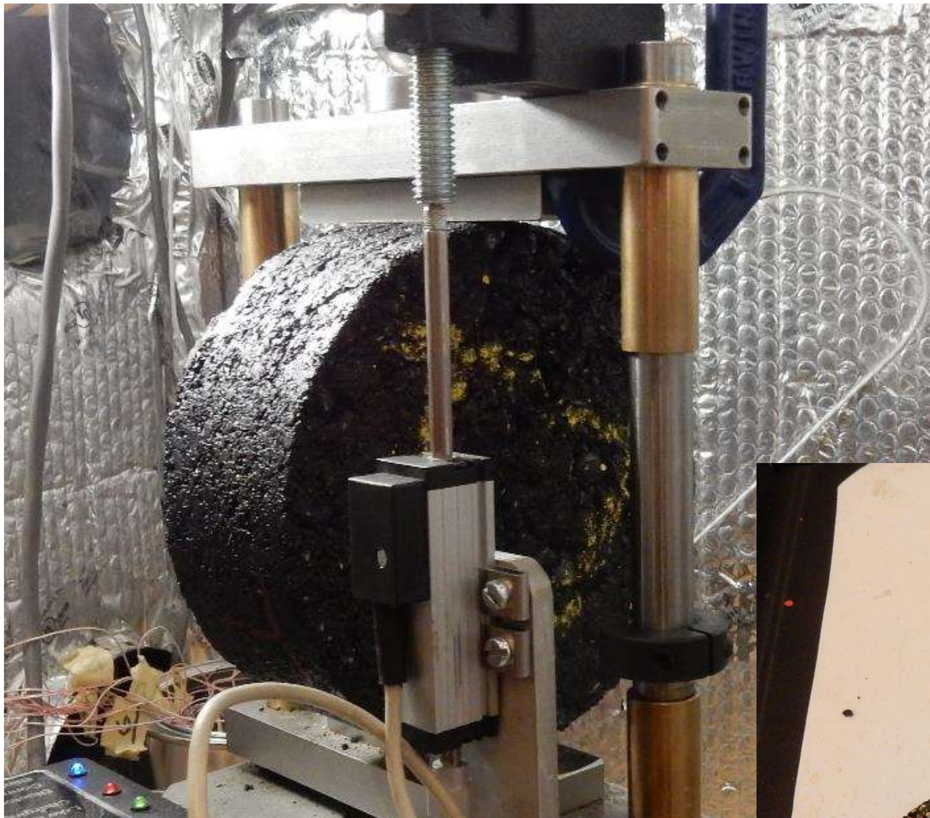
STOA

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** **64-22** **76-22**	**5.2 to 6.2**	**0, 15, 25**
02	**9**	**27**	Lab Prod.	LTOA	**9.5**	**58-28** **64-22** **76-22**	**5.1 to 6.1**	**0, 15, 25**
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
6.0
5.8
5.6
5.4
5.2
5.0
4.8
NECEPT Air Void, %
4.8
5.0
5.2
5.4
5.6
5.8
6.0
Reported Air Void, %

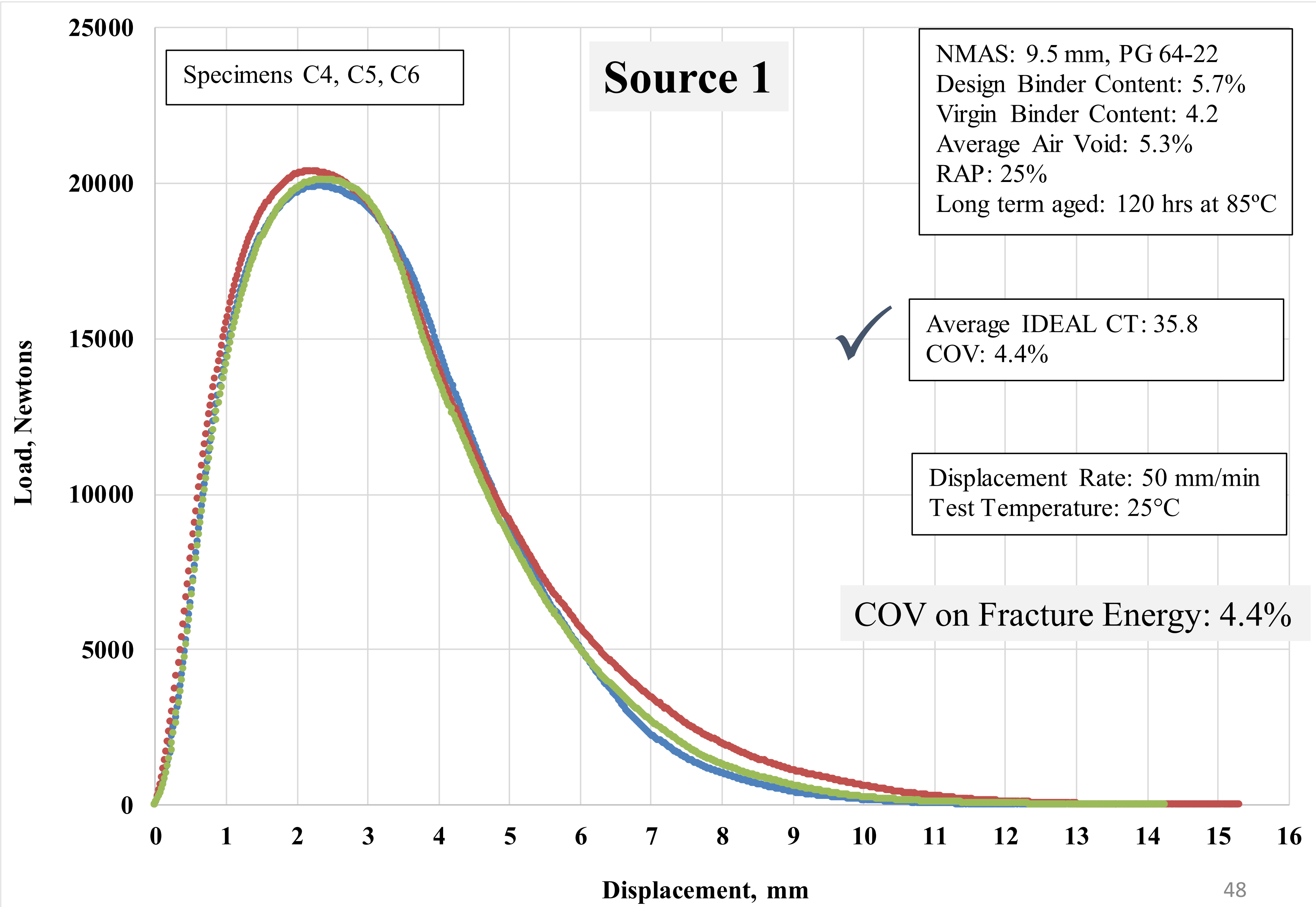
Breaking Specimens



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

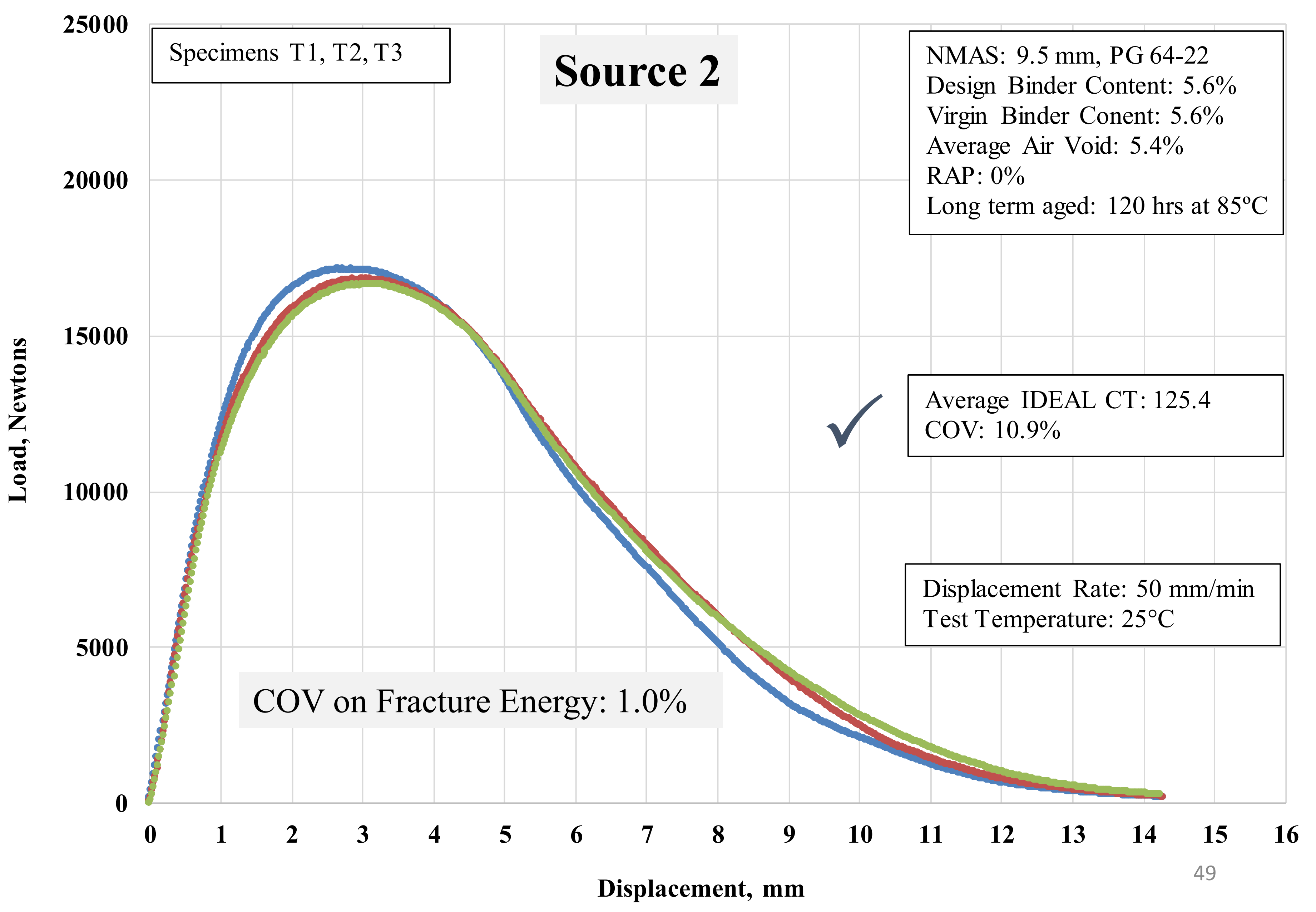
Test Repeatability

LTOA



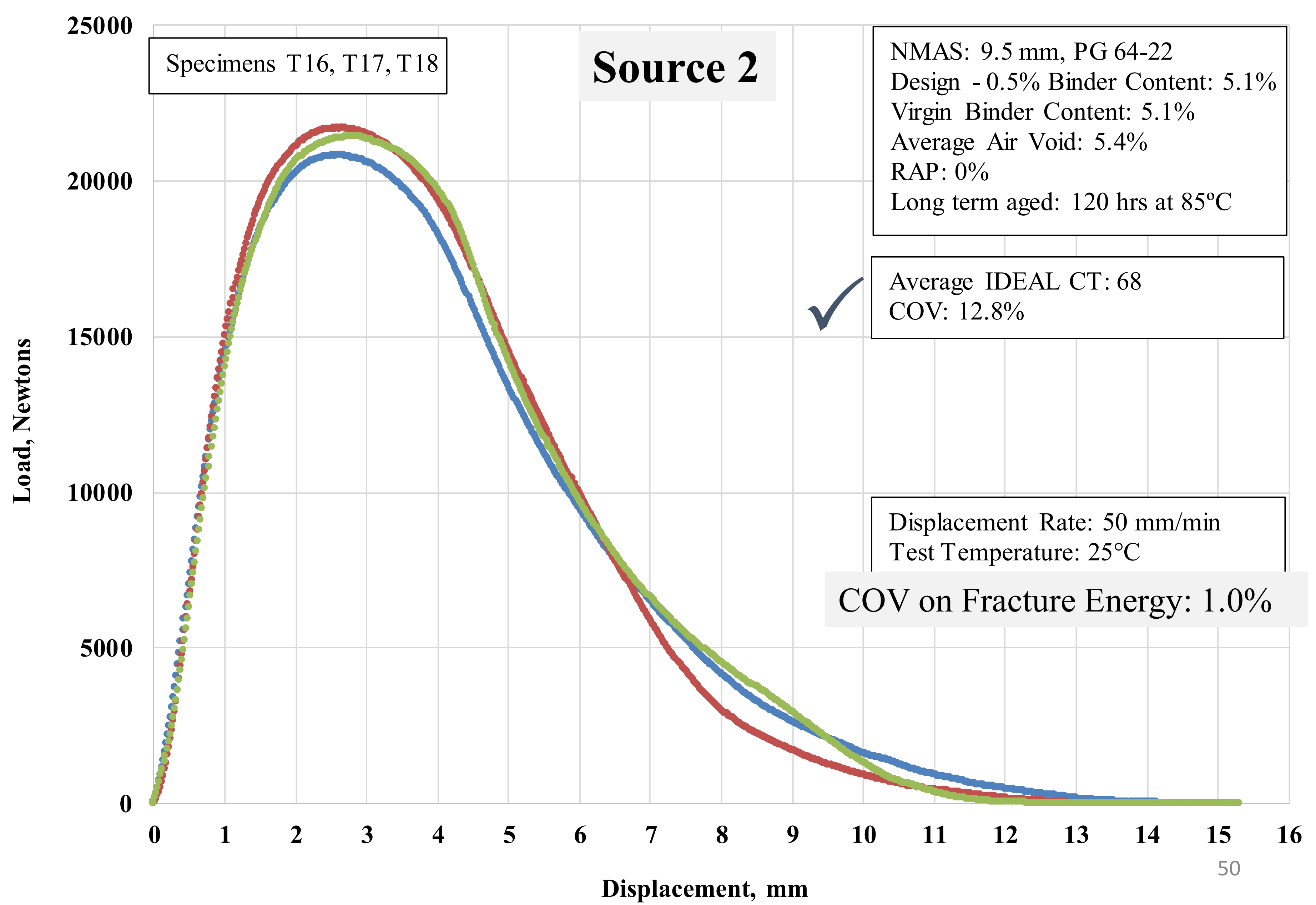
Test Repeatability

LTOA



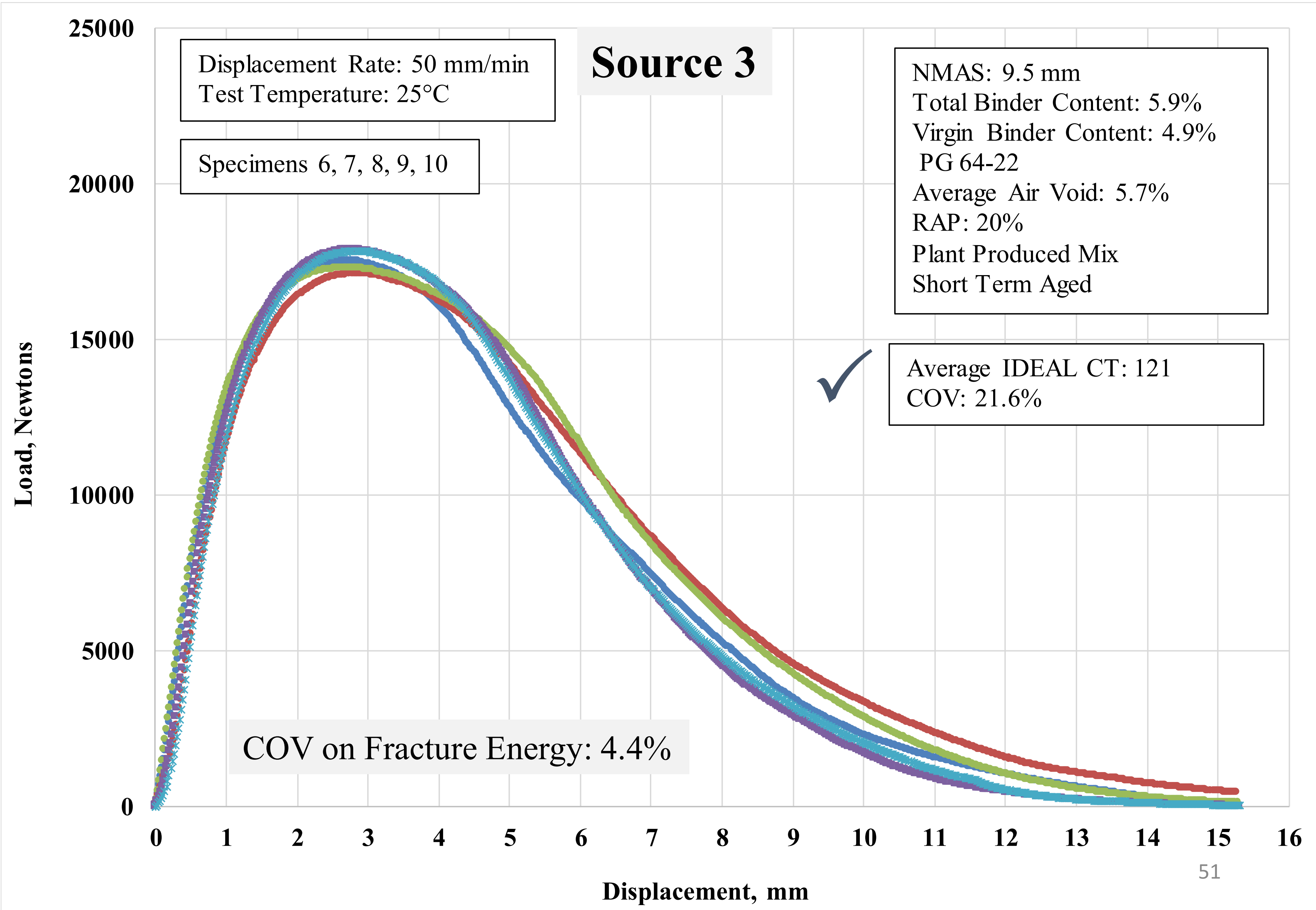
Test Repeatability

LTOA



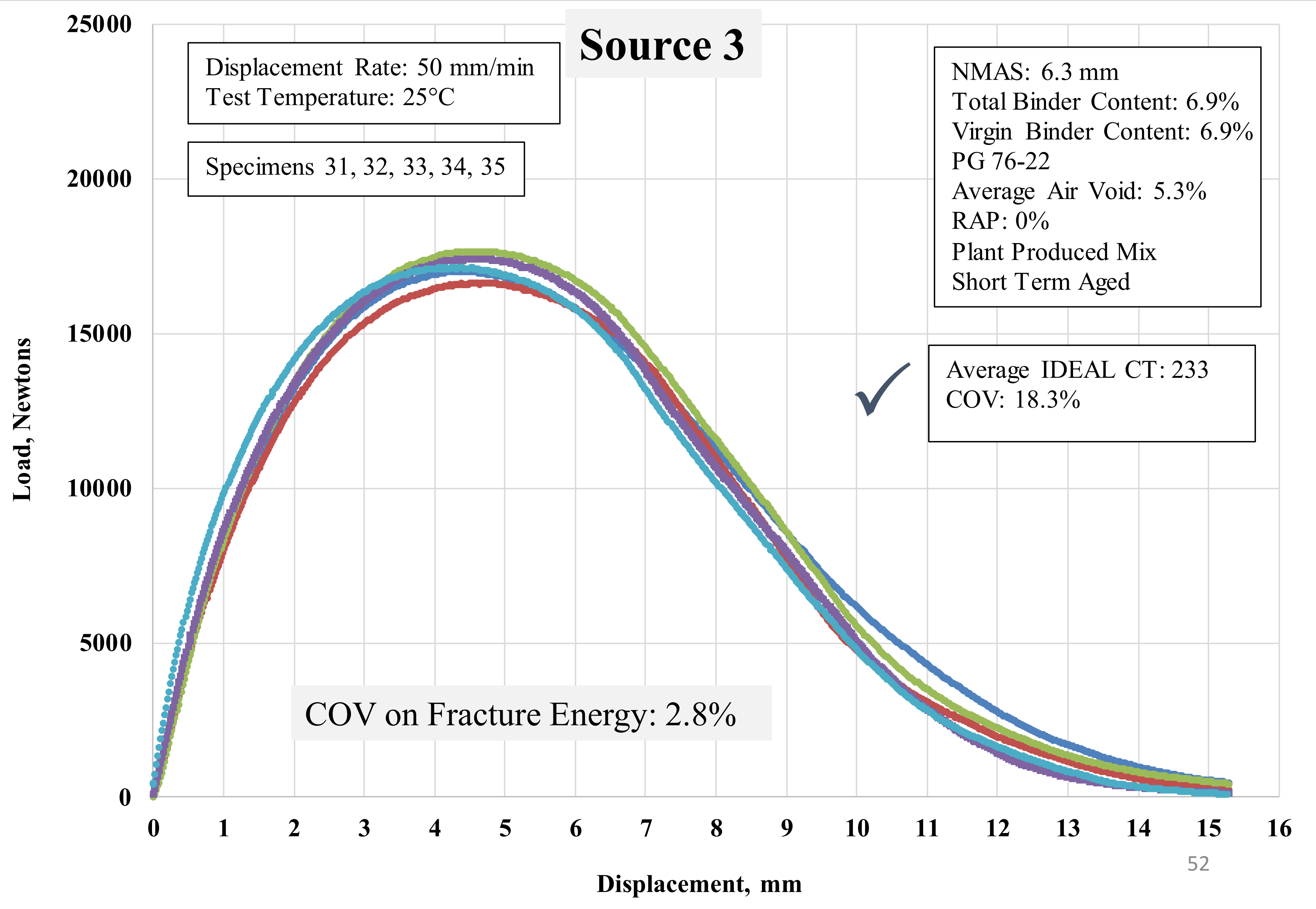
Test Repeatability

STOA

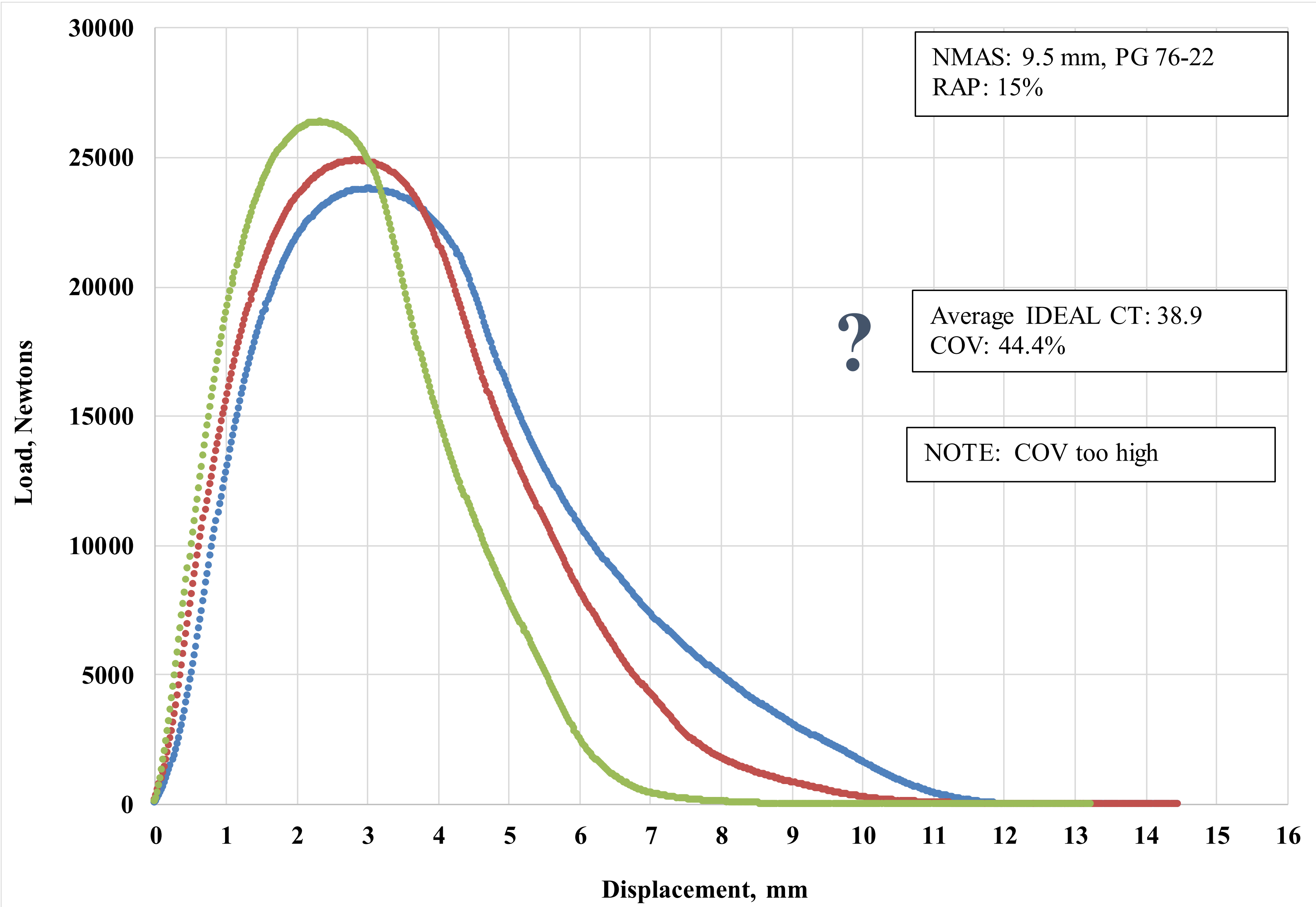


Test Repeatability

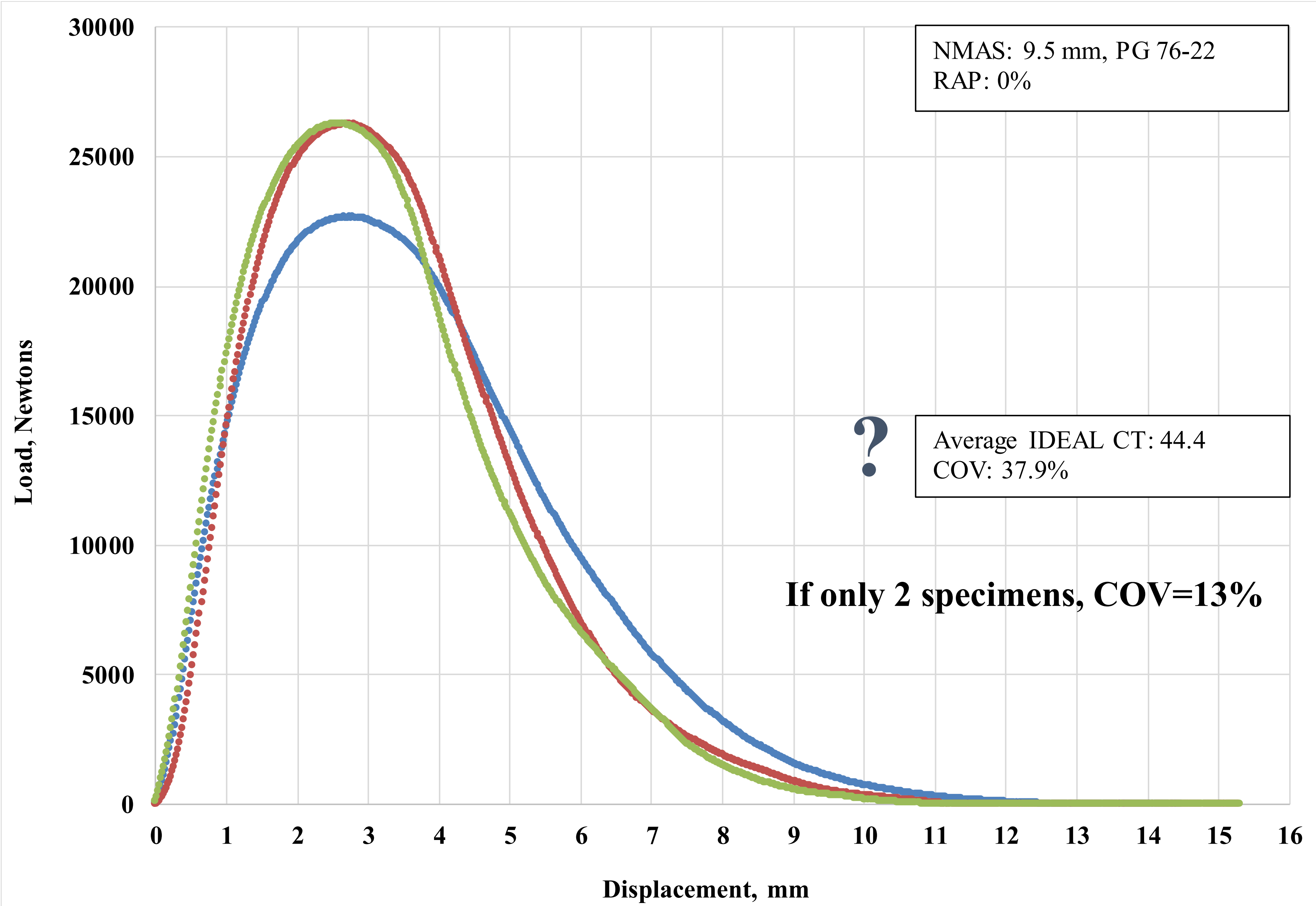
STOA



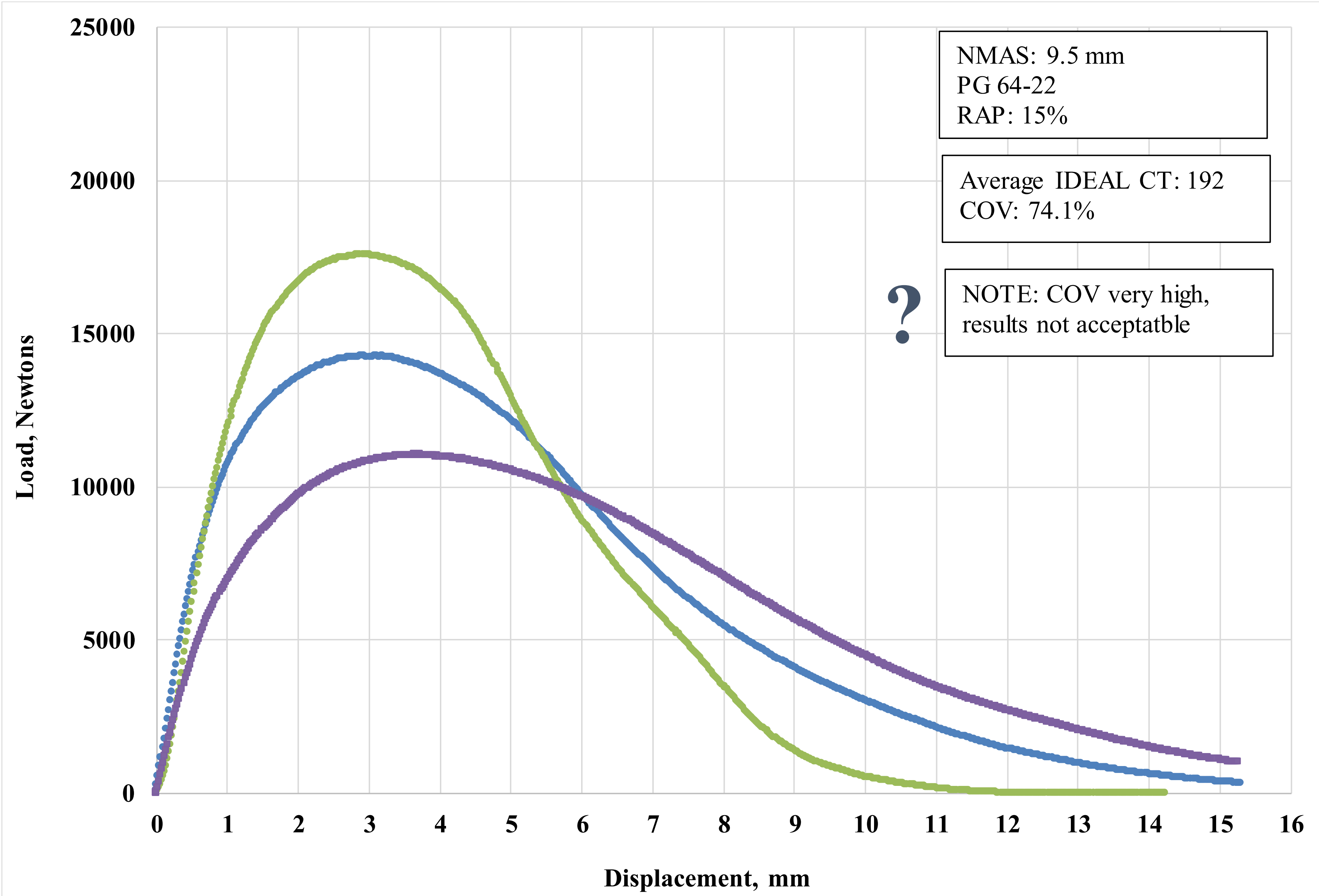
Test Repeatability



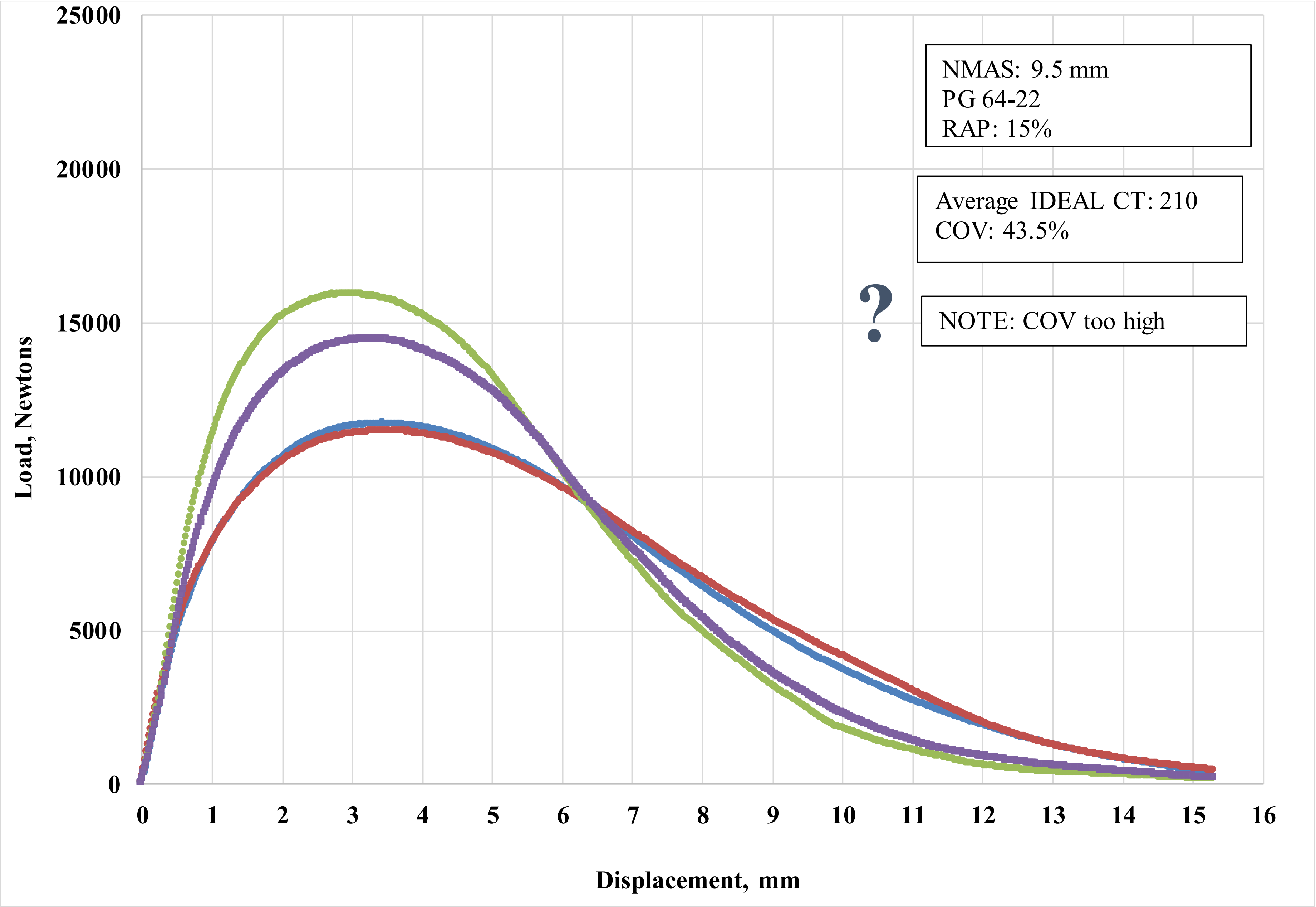
Test Repeatability



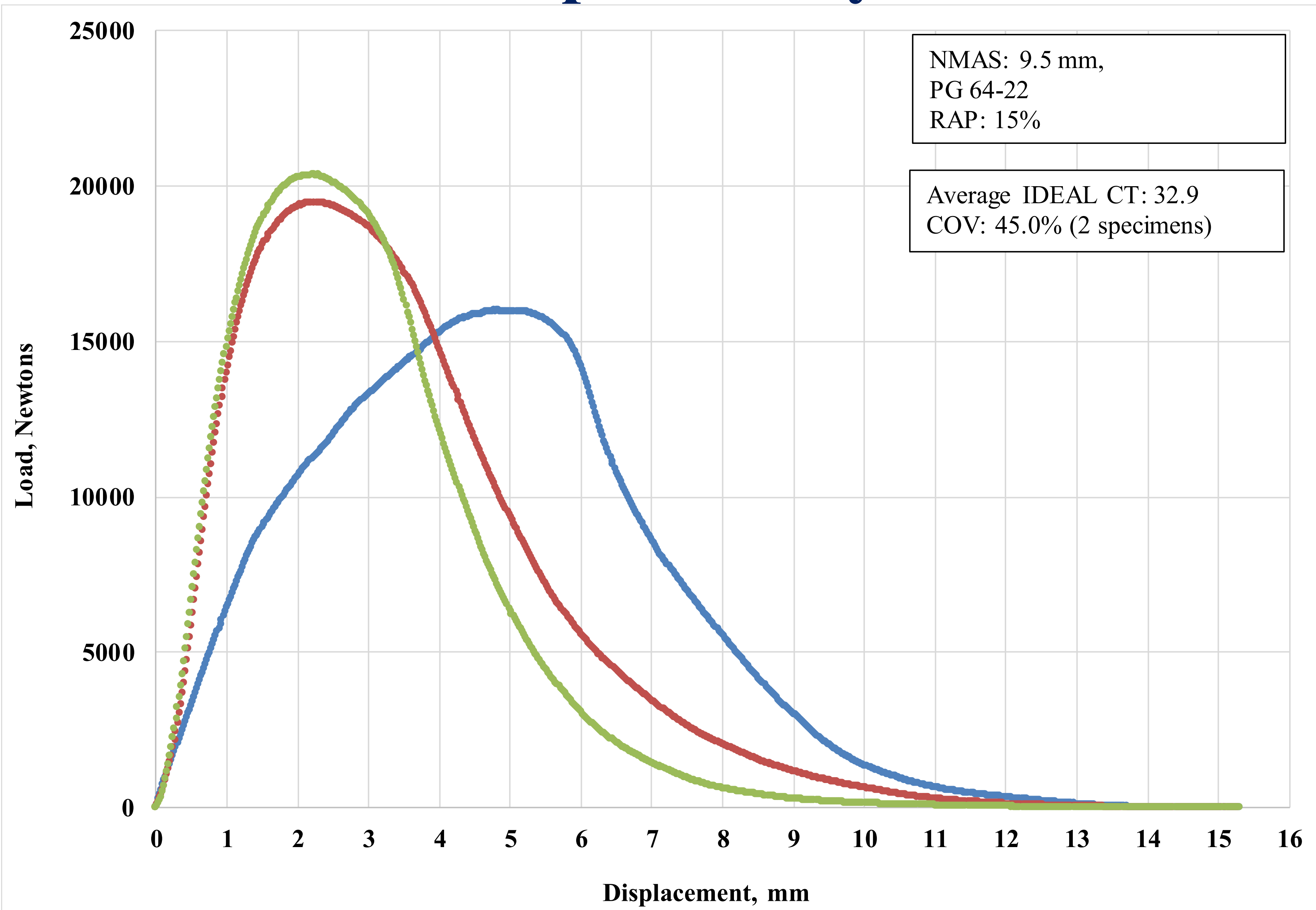
Test Repeatability



Test Repeatability



Test Repeatability



What COV should we use?

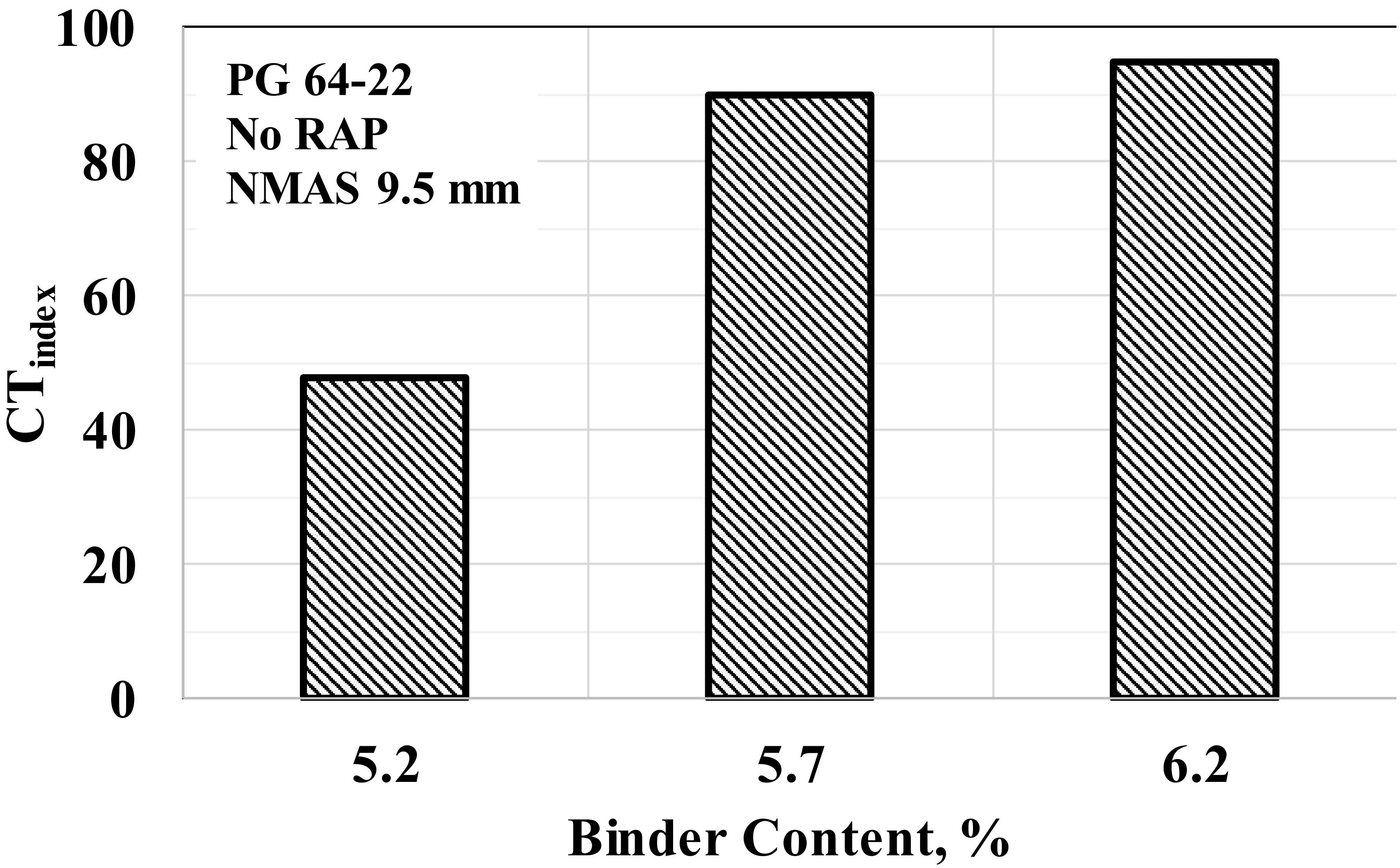
Criterion on COV	Number of Mixes
$\geq 30\%$	5
$\geq 25\%$	6
$\geq 20\%$	7
$\geq 15\%$	15
$\geq 10\%$	20

COV: Coefficient of Variation

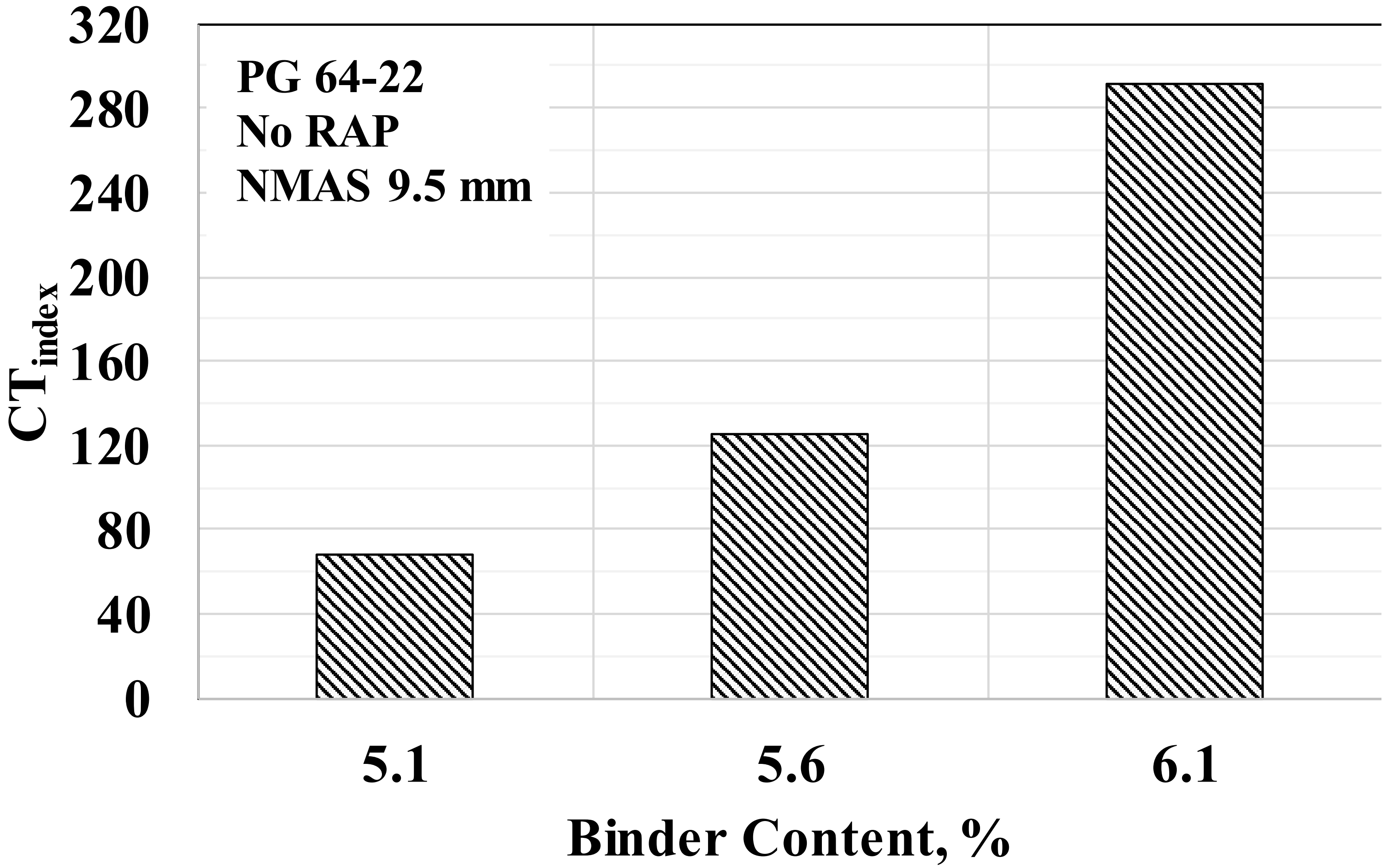
Total Number of Mixes: 23

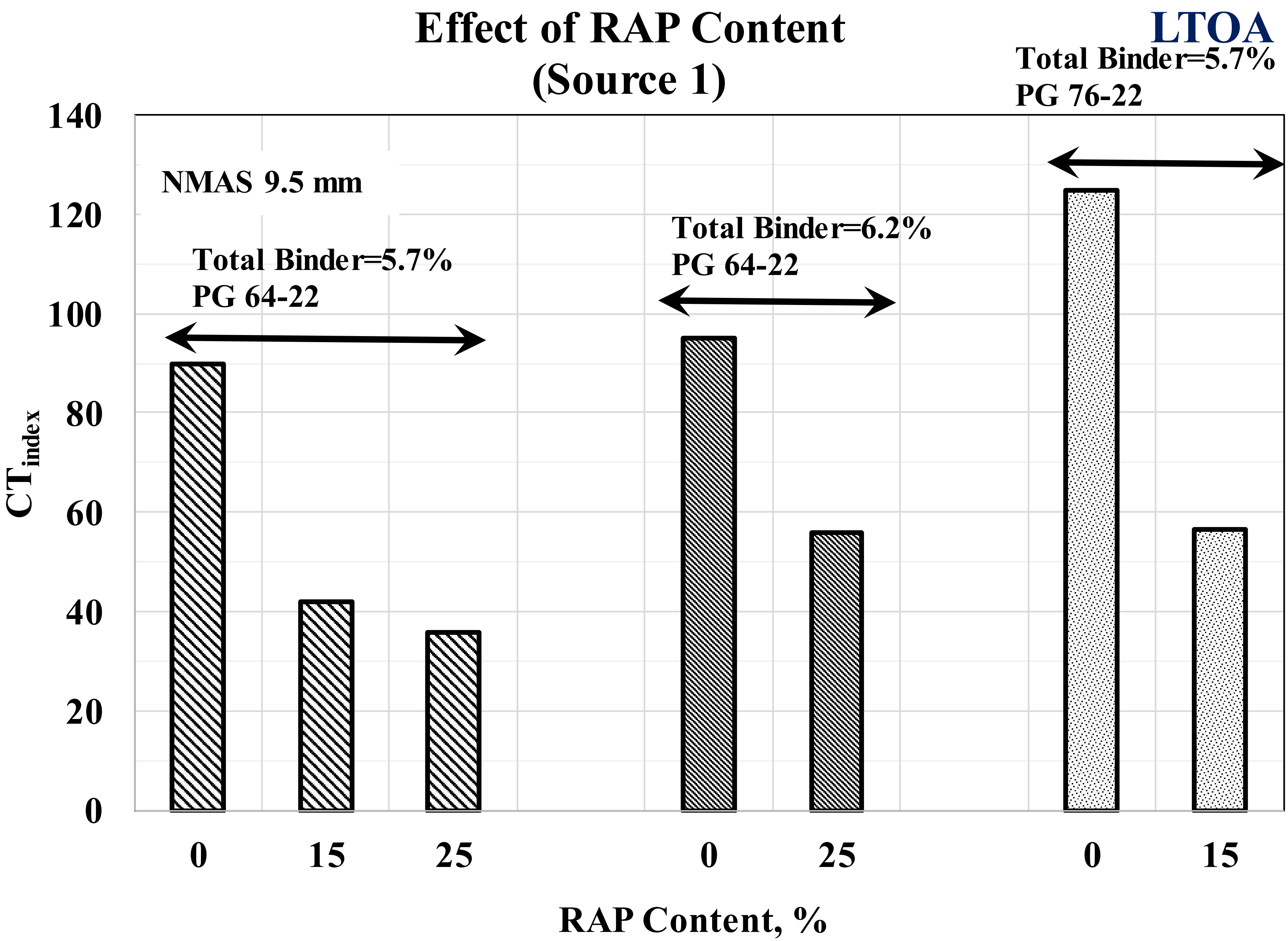
LTOA

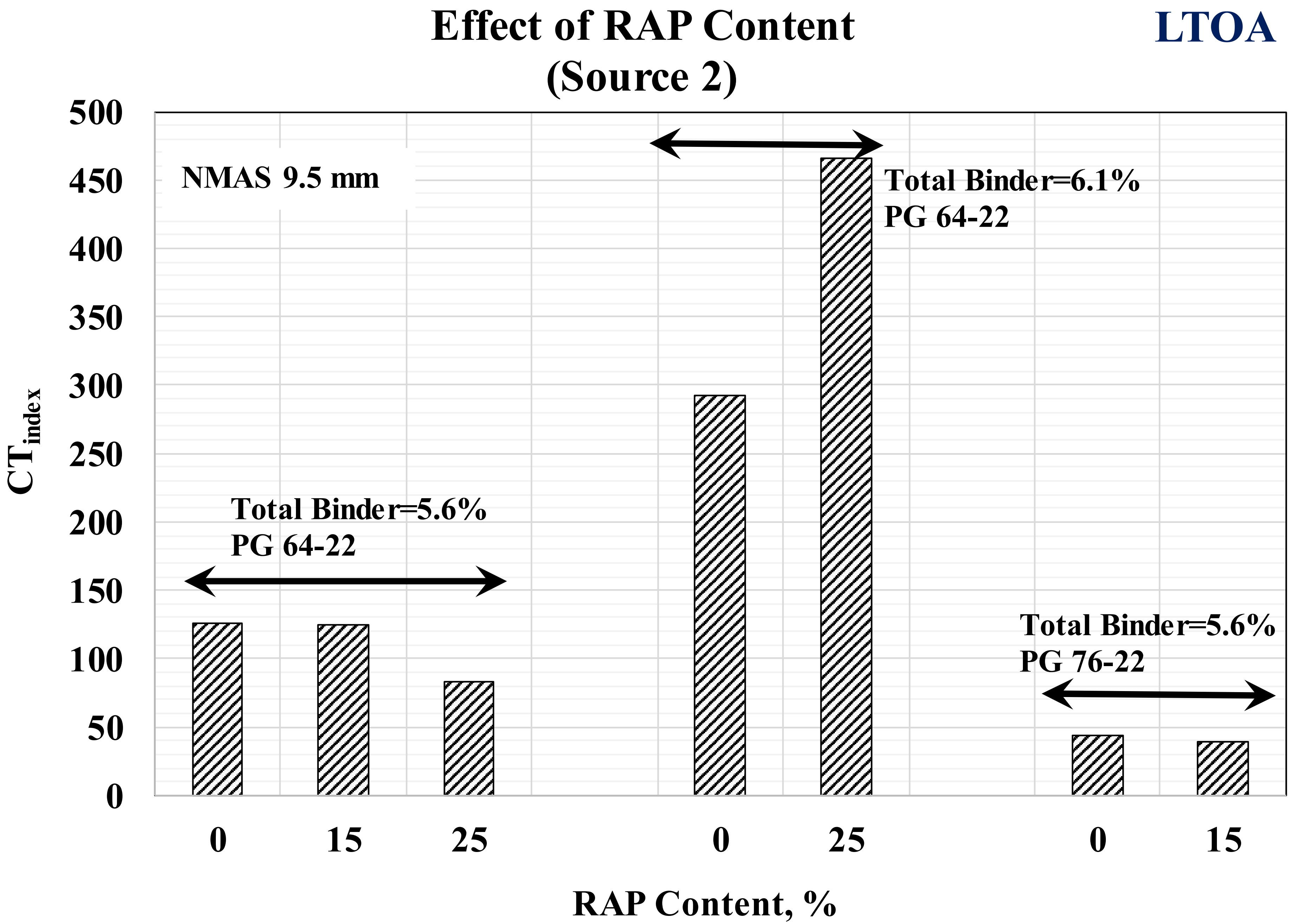
Effect of Binder Content (Source 1)

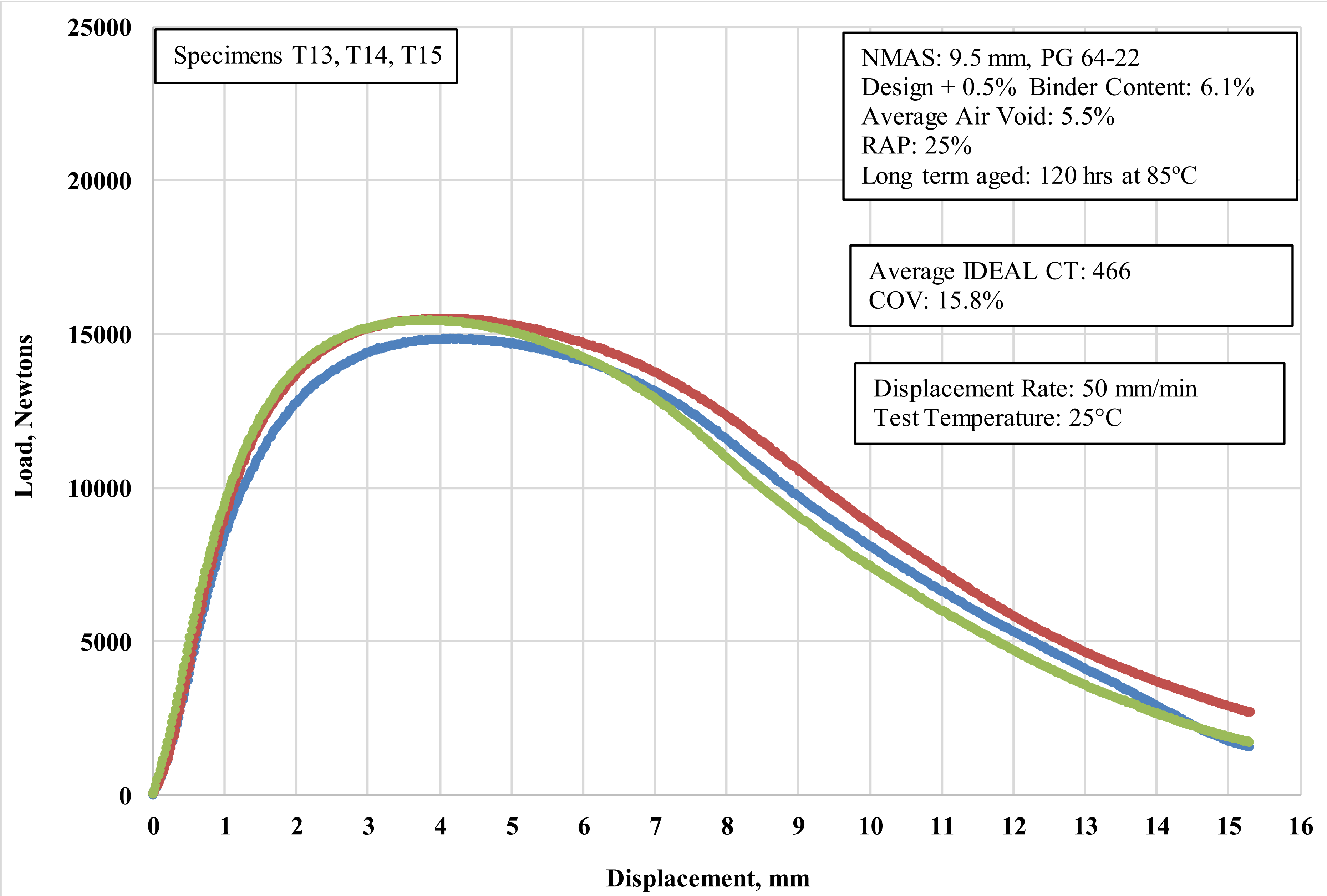


Effect of Binder Content (Source 2)

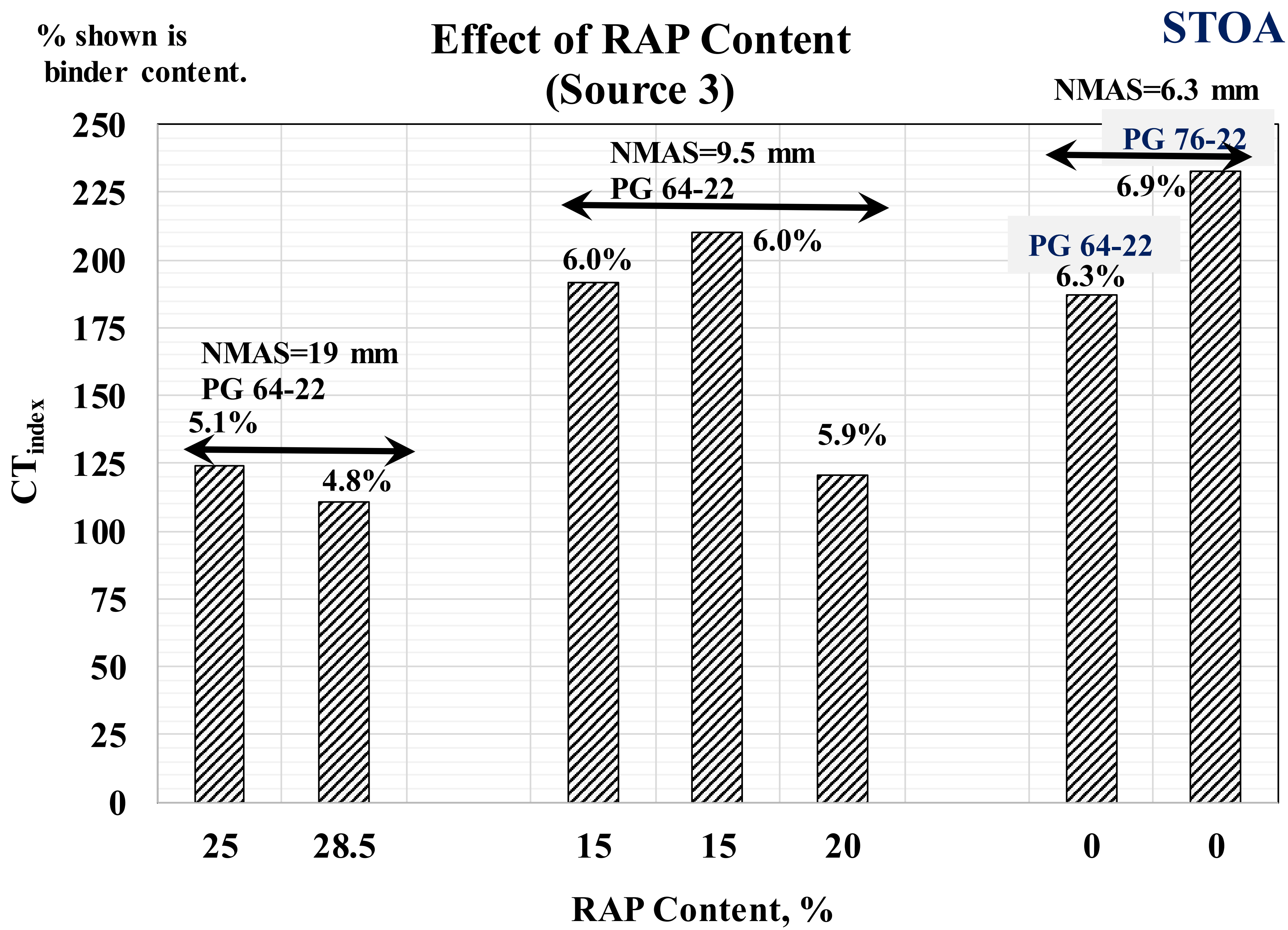


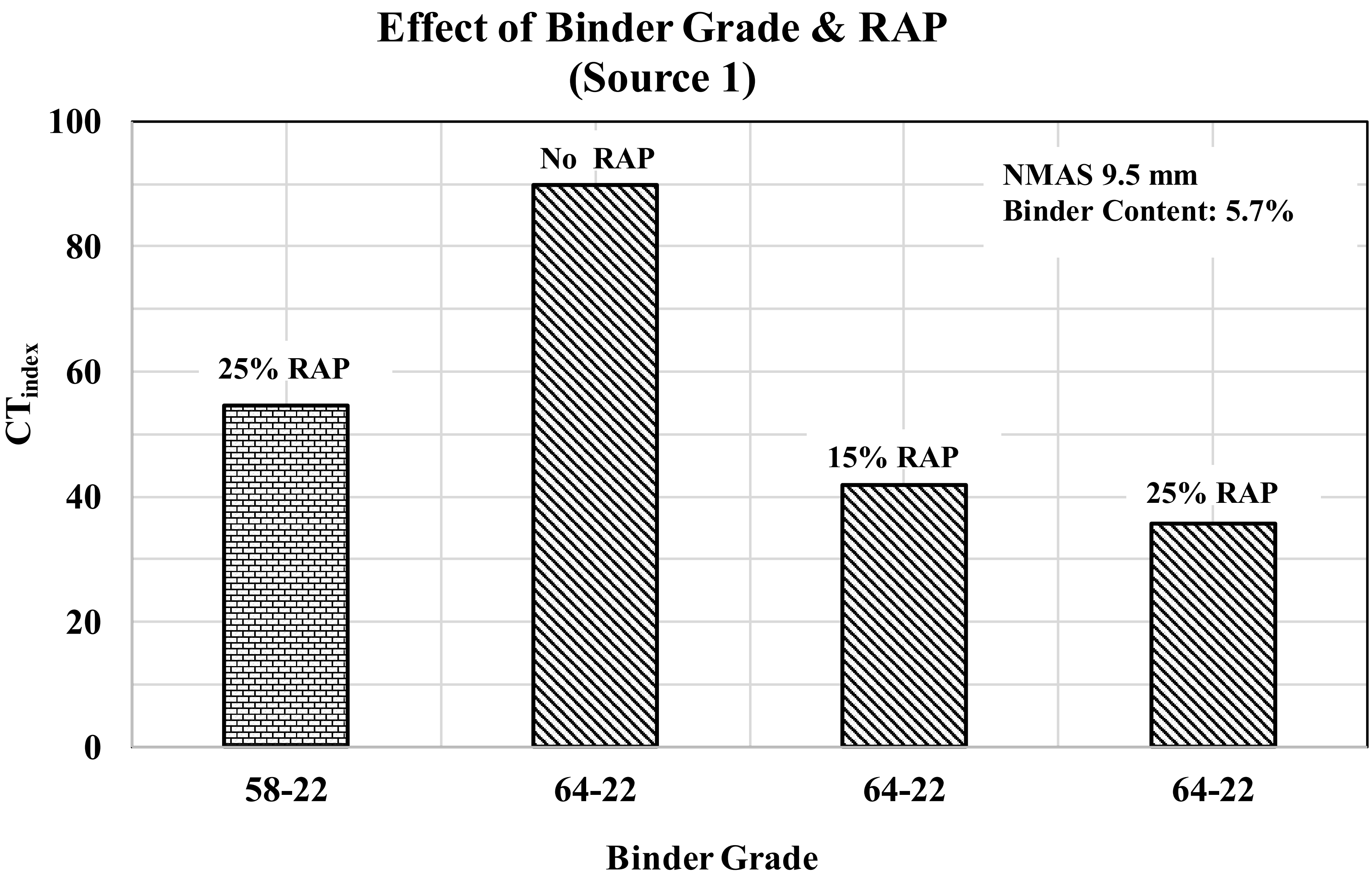

Effect of RAP Content
(Source 1)
LTOA
Total Binder=5.7%
PG 76-22
NMAS 9.5 mm
Total Binder=5.7%
PG 64-22
Total Binder=6.2%
PG 64-22
140
120
100
80
60
40
20
0
CTindex
0
15
25
0
25
0
15
RAP Content, %

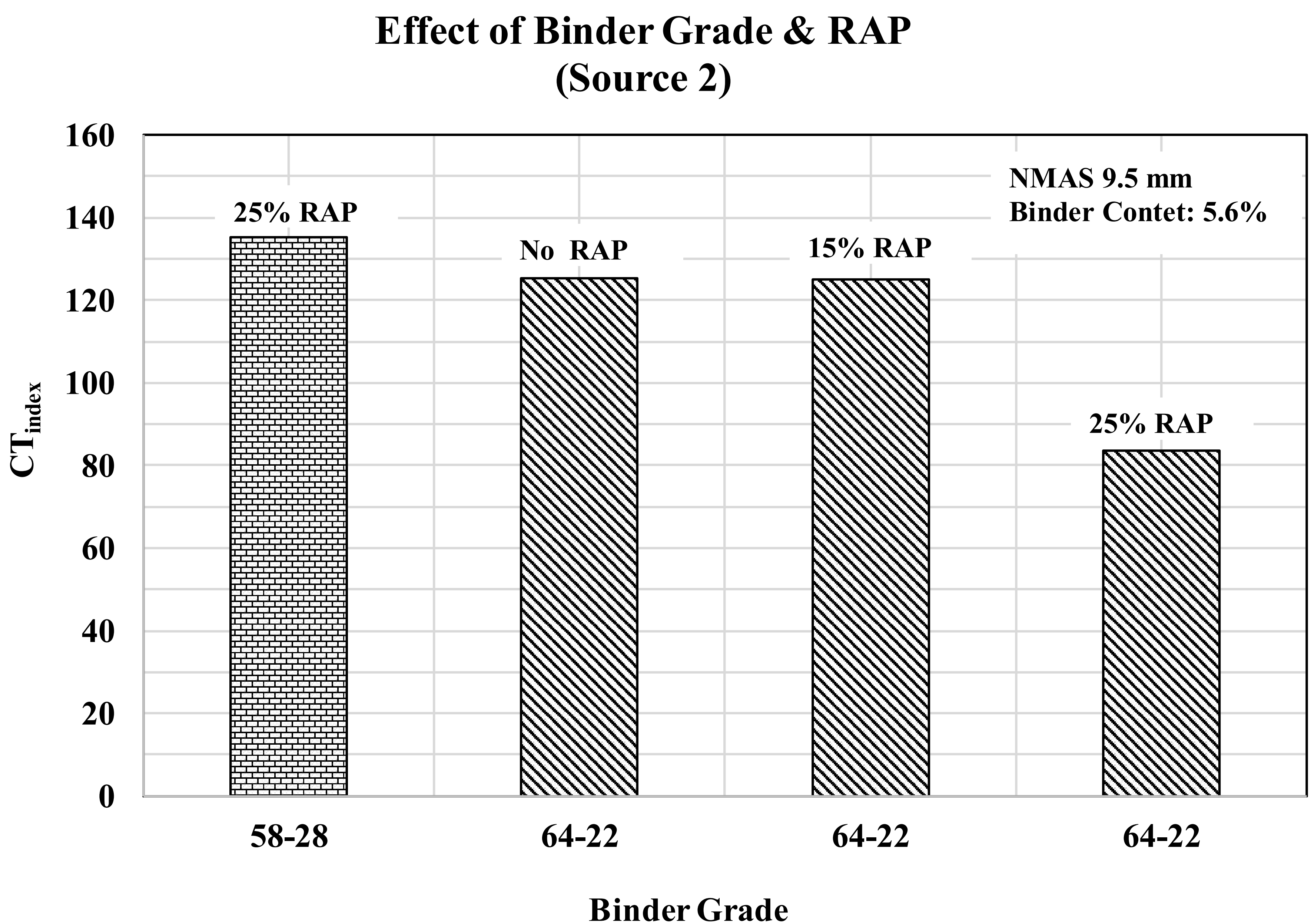

Effect of RAP Content
(Source 2)
LTOA
NMAS 9.5 mm
Total Binder=5.6%
PG 64-22
Total Binder=6.1%
PG 64-22
Total Binder=5.6%
PG 76-22
CT_{index}
0
50
100
150
200
250
300
350
400
450
500
0
15
25
0
25
0
15
RAP Content, %



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
Displacement, mm
25000
20000
15000
10000
5000
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16


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


Effect of Binder Grade & RAP
(Source 1)
100
80
60
40
20
0
CTindex
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)
NMAS 9.5 mm
Binder Contet: 5.6%
25% RAP
No RAP
15% RAP
25% RAP
160
140
120
100
80
60
40
20
0
CT_{index}
58-28
64-22
64-22
64-22
Binder Grade

DISCUSSION TOPICS

1. Performance Based Testing & Long-Life Asphalt Pavements
2. PA Initiative on Performance Testing
3. Candidate Performance Tests
4. Results, Summary, Conclusions

Summary & Recommendations (HWTD)

- HWTD effectively captures binder effect.
- HWTD effectively captures mix differences.
- Initial impact of water is **reduction** of rutting (improvement of performance).

Summary & Recommendations (HWTD)

- Damaging effect of water is manifested through increase of cycles and loading.
- Performance of mix under load significantly better than performance under water/load combination (Dry vs Wet)
- Best to establish HWTD criteria in connection with the traffic level (ESALs)

Summary & Conclusions (IDEAL-CT)

- 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 (IDEAL-CT)

- Increasing binder increases flexibility

- Increasing RAP over 20% decreases flexibility

- Use of soft binder with high RAP: mixed results (RAP binder stiffness effect?)

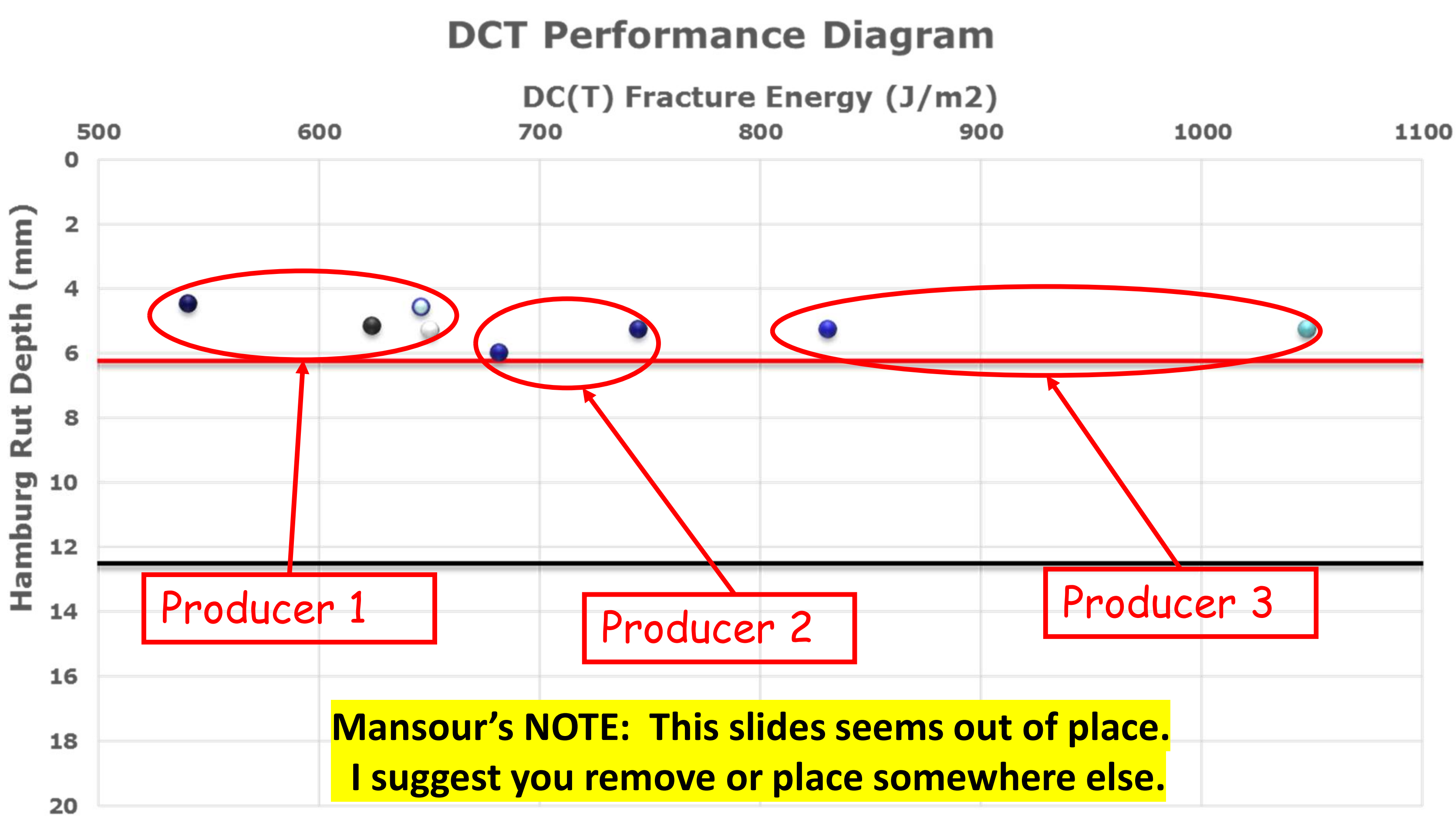
Recommendations (IDEAL-CT)

- Use four replicates

- Need a limit on COV

    - Round robin testing needed
    - Recommendation on COV: 25%

Long Life Asphalt Projects – DCT data



Mansour's NOTE: This slides seems out of place.
I suggest you remove or place somewhere else.

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**)