Asphalt Mix Performance Testing for PA
An Update

2019 PAPA REGIONAL TECHNICAL MEETINGS

March 19, 20 and 21, 2019

Gary Hoffman, PAPA

and

Mansour Solaimanian, Penn State

DISCUSSION TOPICS

1 Performance Based Testing/SCB Initiative

2 A Summary of SCB Test Results

3 Long Life Asphalt Pavements (SMA)

4 RAP/RAS With Rejuvenators

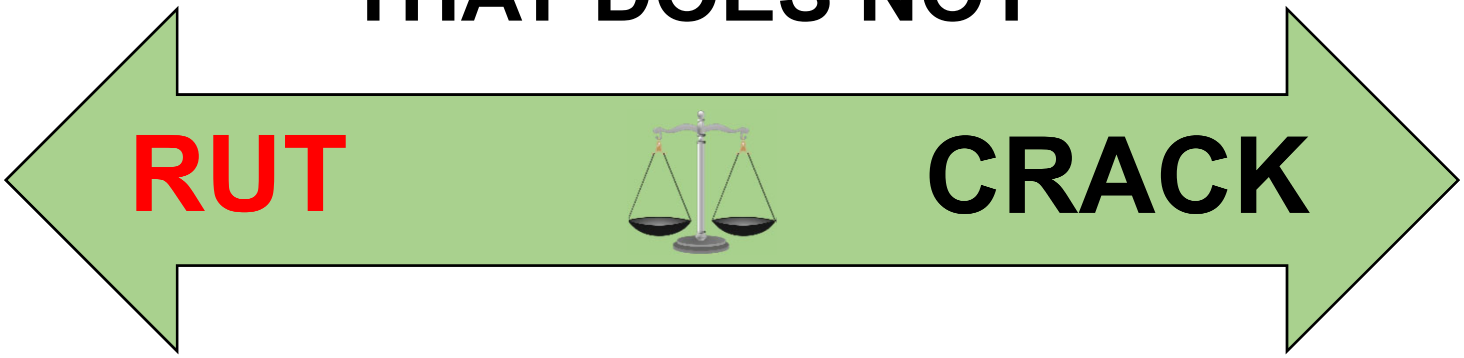
5 IDEAL Test Initiative

DISCUSSION TOPICS

1. Performance Based Testing/SCB Initiative

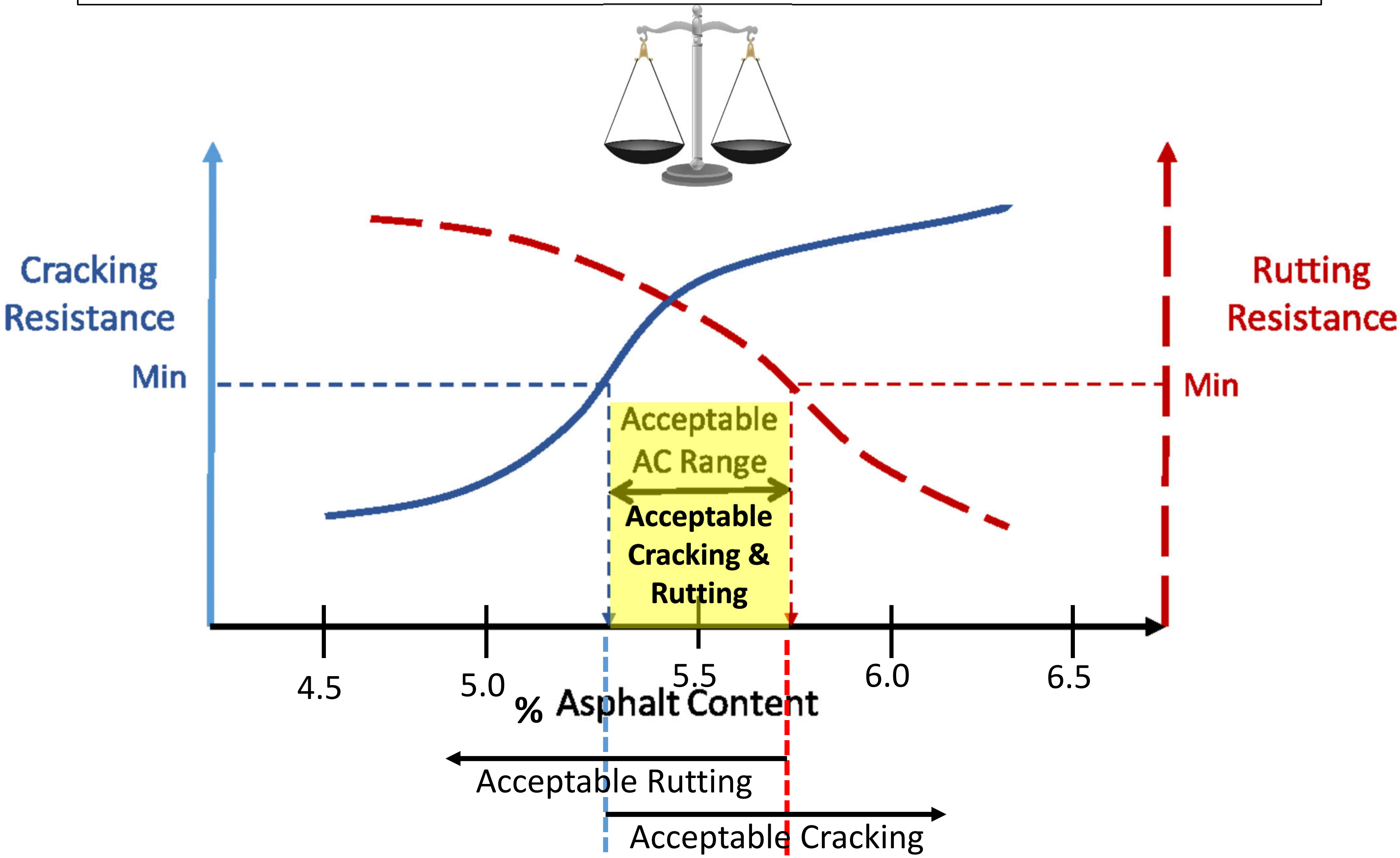
BALANCED ASPHALT MIX DESIGN

GOAL: DESIGN/PLACE AN ASPHALT MIX THAT DOES NOT



BALANCED ASPHALT MIX DESIGN



Need Proper Performance Test for Balanced Mix Design

- Important Considerations:
  - **Need Right Test**
  - **Appropriate Test Protocols**
  - **Right Acceptance Thresholds**

Examples of Performance Tests

DCT

Wheel Tracking

SCB

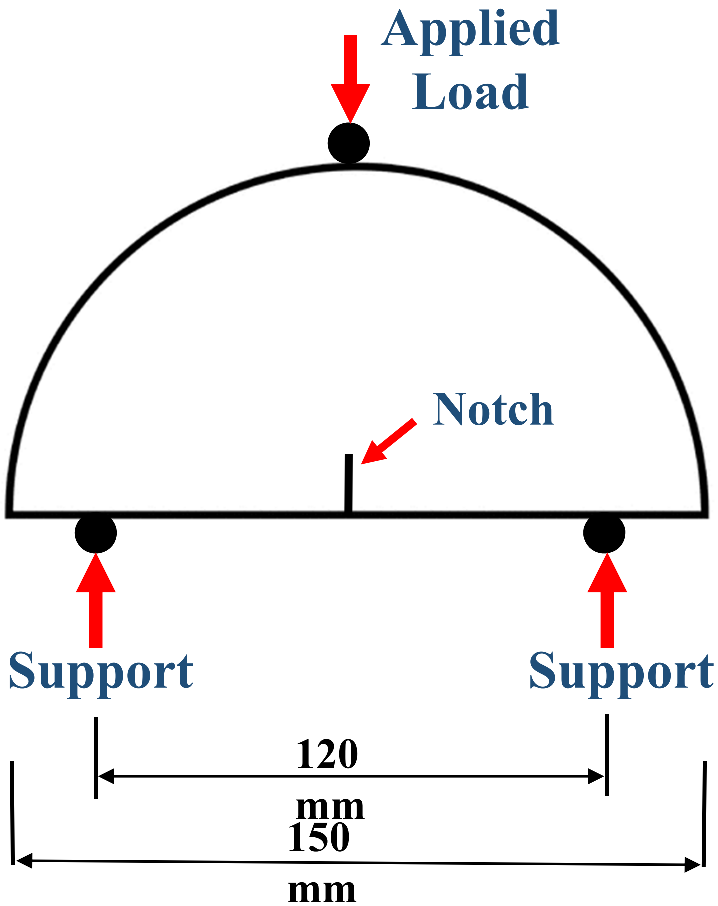
Industry SCB Testing:
How Did It Start?

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

Purpose of the Effort

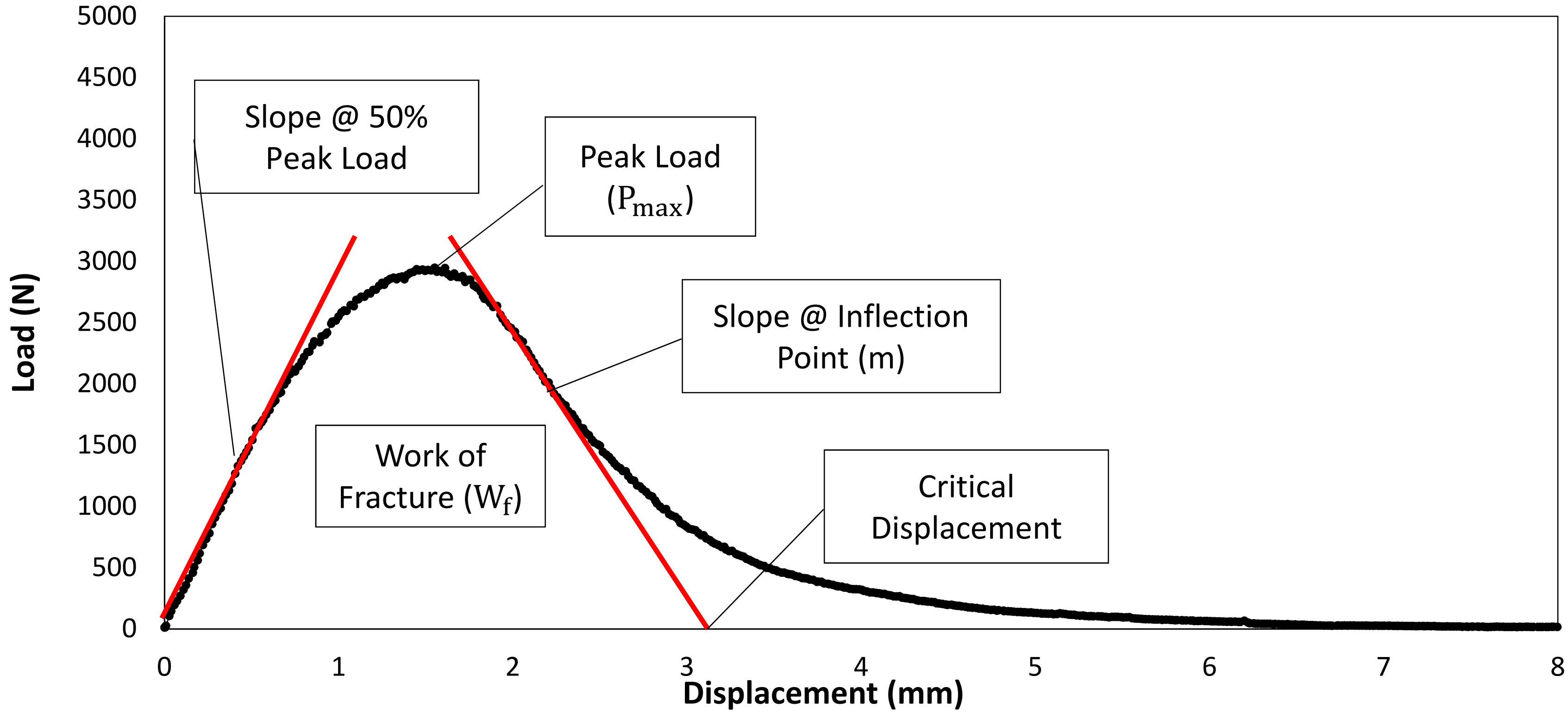
- Bridge the Gap to Performance Testing
- Investigate Performance of PA Mixes in SCB
- Develop A Database of SCB Test Results
- Evaluate Sensitivity of the PA Mixes to the Test
- Evaluate Correlation with Field Performance

SCB Test Setup



Specimen Thickness: 50 mm
Notch Depth: 15 mm
Notch Width: 1.5 mm

Parameters Used For Evaluation



Fracture Energy

$$G_f = \frac{W_f}{B \cdot L}$$

B: Specimen Thickness
L: Ligament Length

Flexibility Index

$$FI = A \times \frac{G_f}{abs(m)}$$

A: Constant

Stiffness Index

Slope @ 50% Peak Load in Pre-Peak Curve

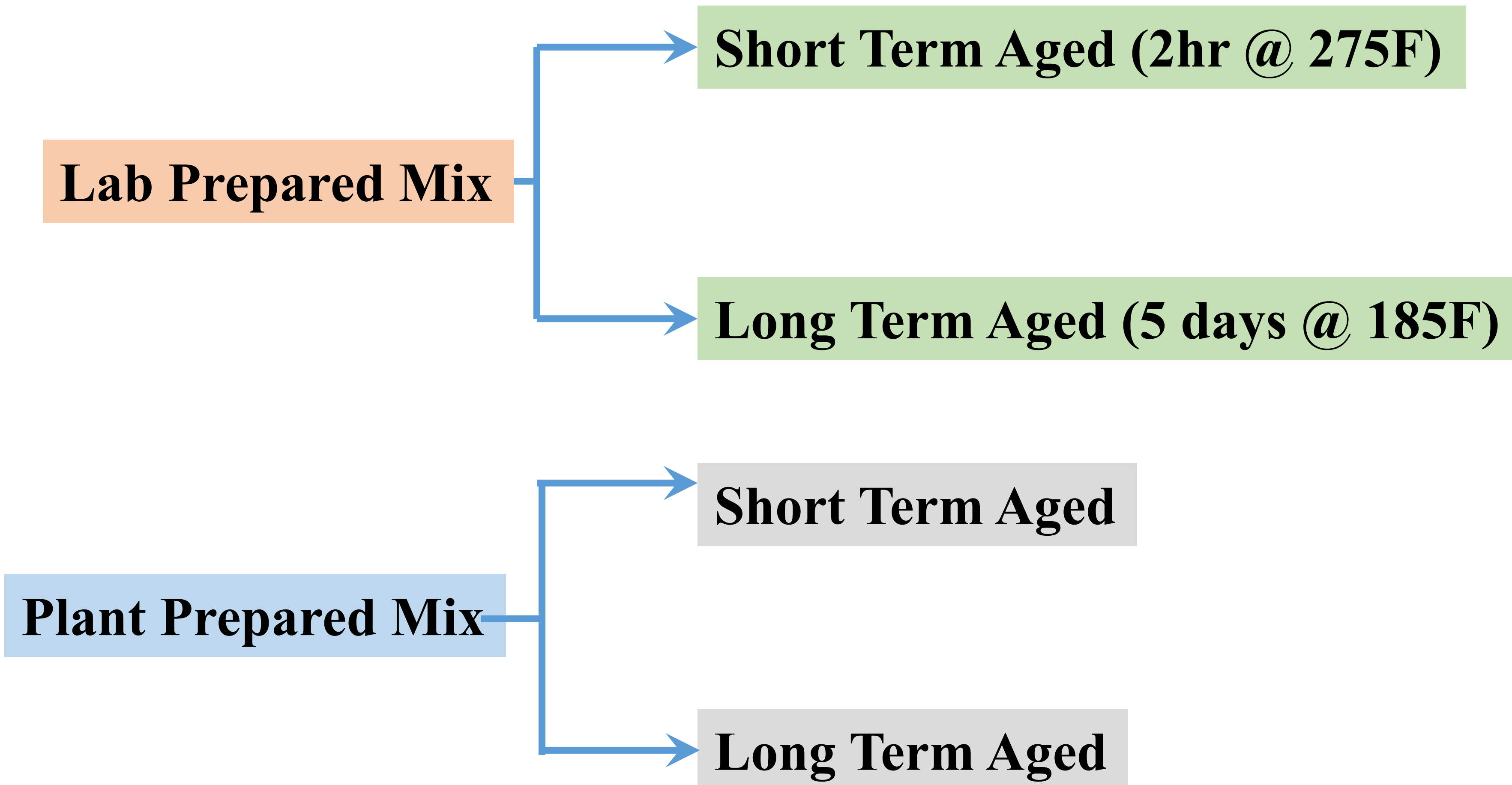
DISCUSSION TOPICS

2 A Summary of SCB Test Results

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

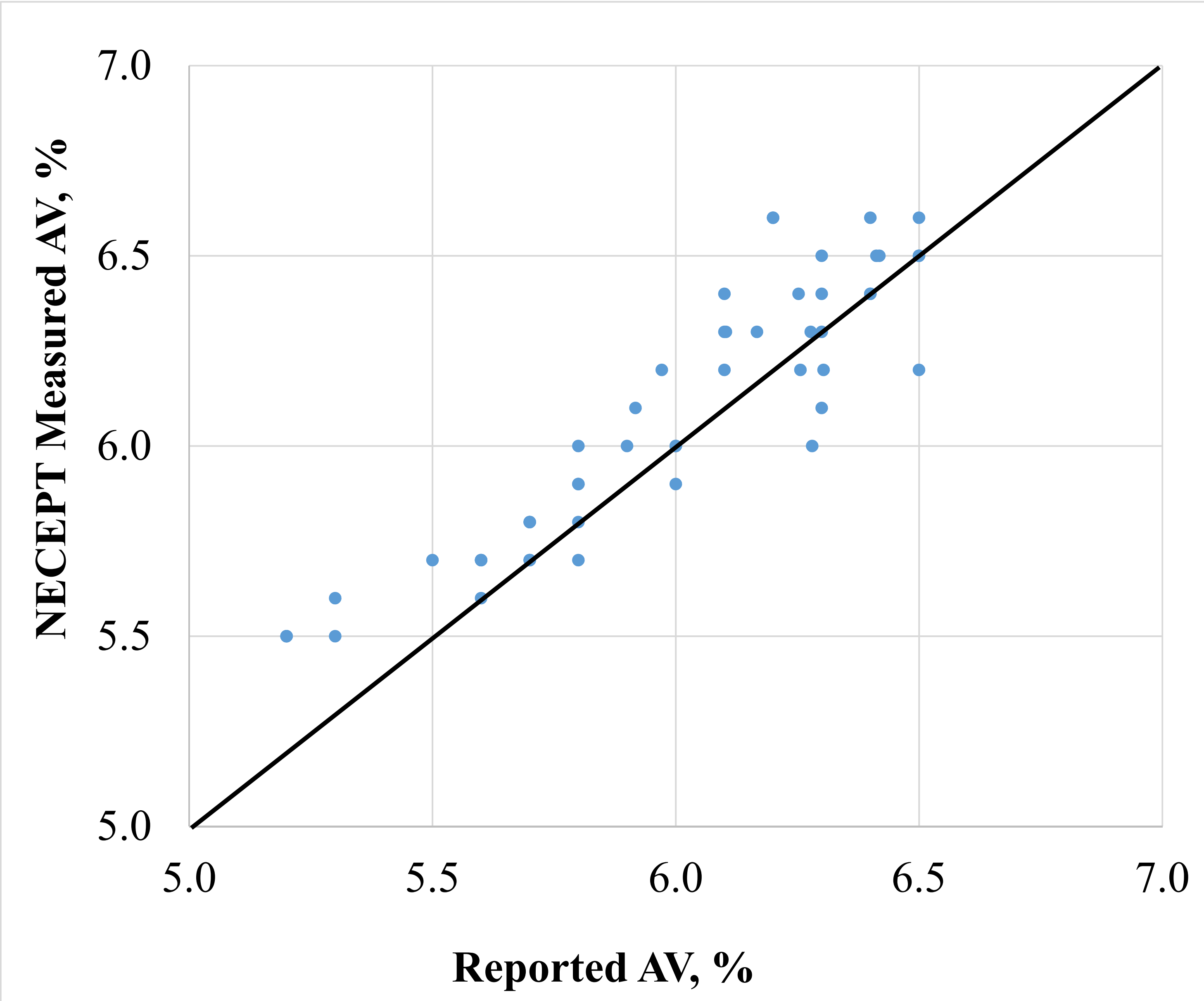
Plant vs Lab, and Aging Effect



Summary of SGC Plugs Tested (85)

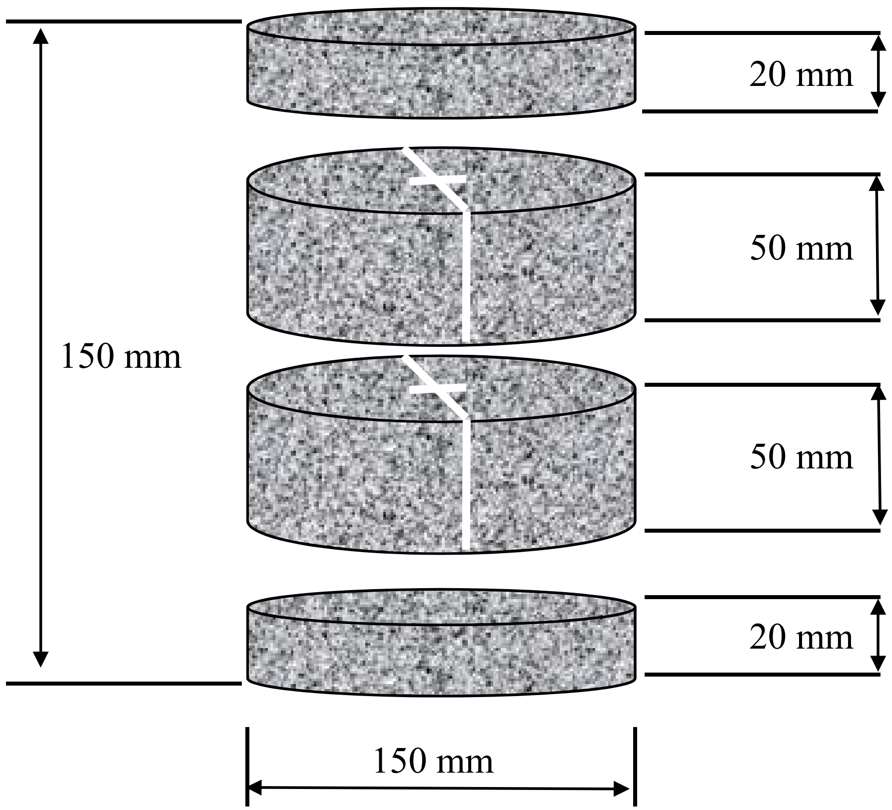
Source	Mix Origin	Mix Condition	NMAS, mm	Binder Grade	# of Binder Contents	RAP
01	Plant	Long	9.5	64-22	1	15
02	Plant/Lab	**Short/Long**	9.5	64-22	6	0
03	Plant	**Short/Long**	9.5	64-22	2	0
04	Plant/Lab	Long	9.5	64-22	1	0
05	Plant/Lab	Short	4.75, 9.5, 25	64-22 76-22	4	0, 15, 30
06	Plant/Lab	**Short/Long**	9.5	64-22	6	15
07	Lab	Long			2	0, 15
08	Lab	Short	9.5, 19	64-22	4	10, 15
09	Lab	Long	9.5	64-22 76-22	1	15, 20
10	Lab	**Short/Long**	9.5	64-22 76-22	2	15, 20
11	Lab	Long	9.5	64-22	1	0, 15

Air Void Comparison



Specimen Preparation

- SGC Specimen or Field Cores
- Cut to Ensure Minimum AV Gradient
- Obtain Density
- Condition Specimens at Test Temperature
- Conduct Test

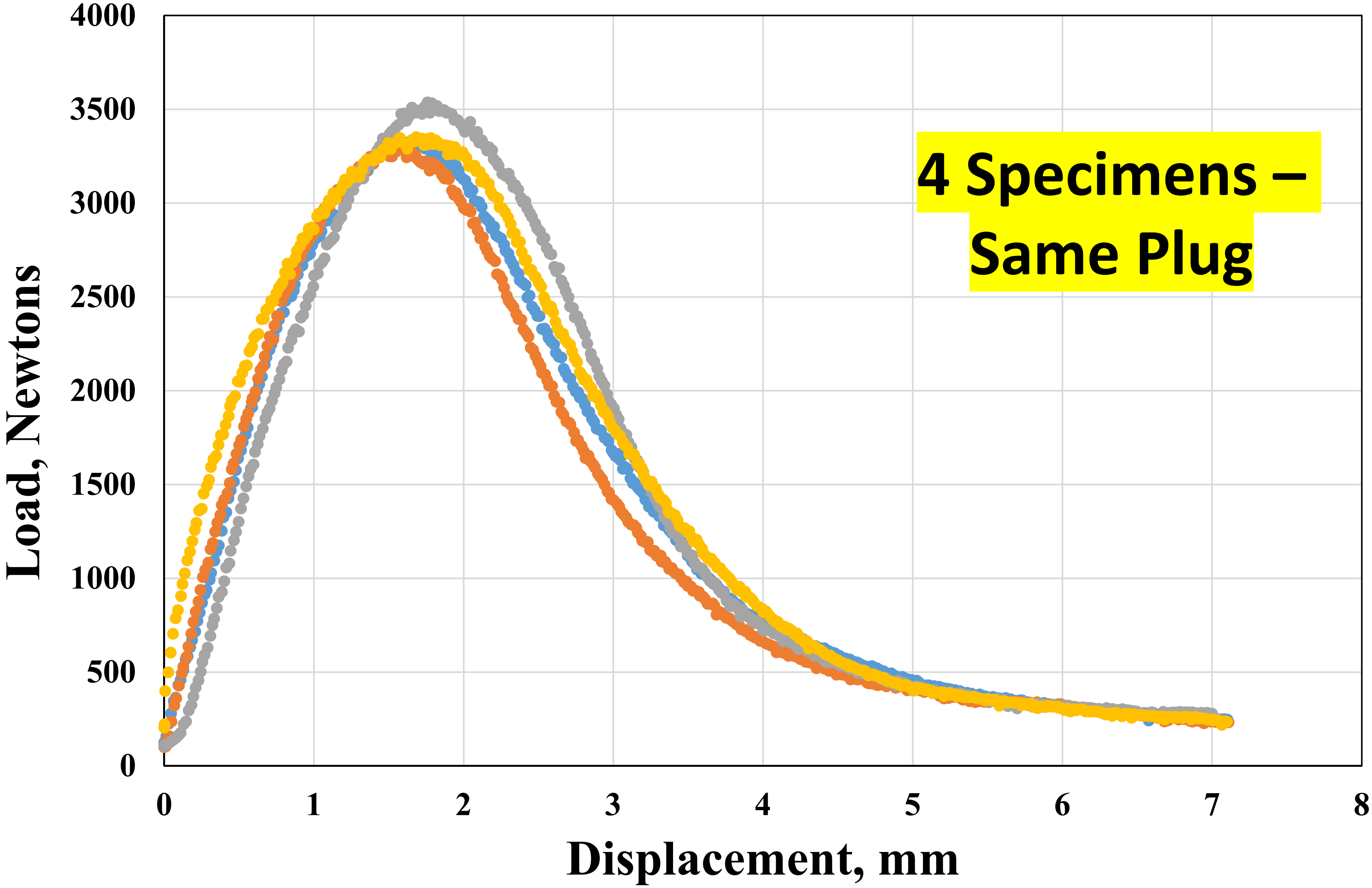


340 TEST SCB Specimens

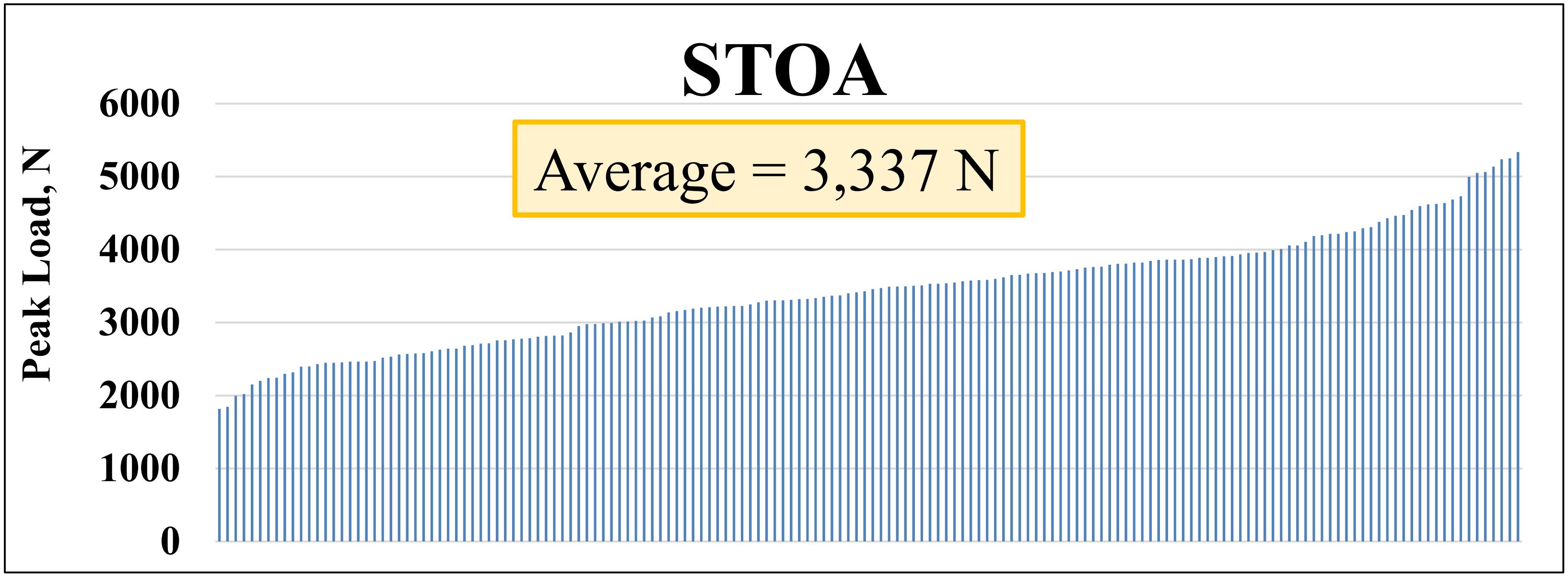
Specimens After Cutting
Ready for Testing

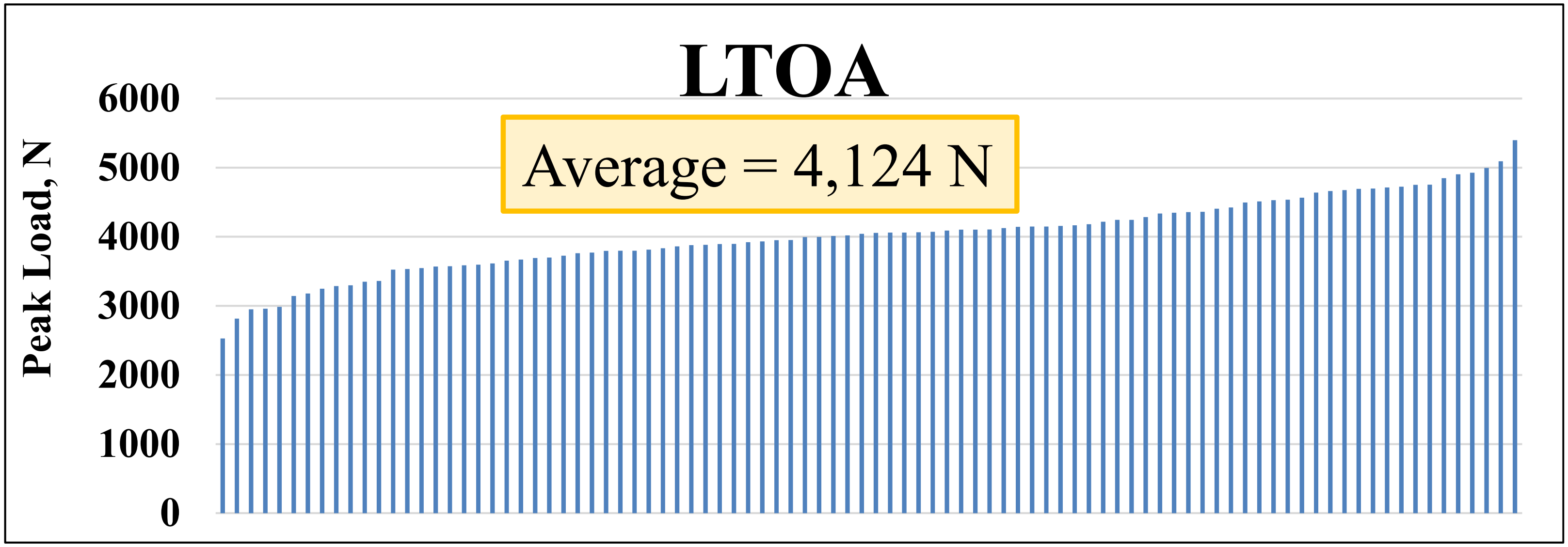
Specimens Before (L) / After (R) Testing

A Typical High Quality Test Result

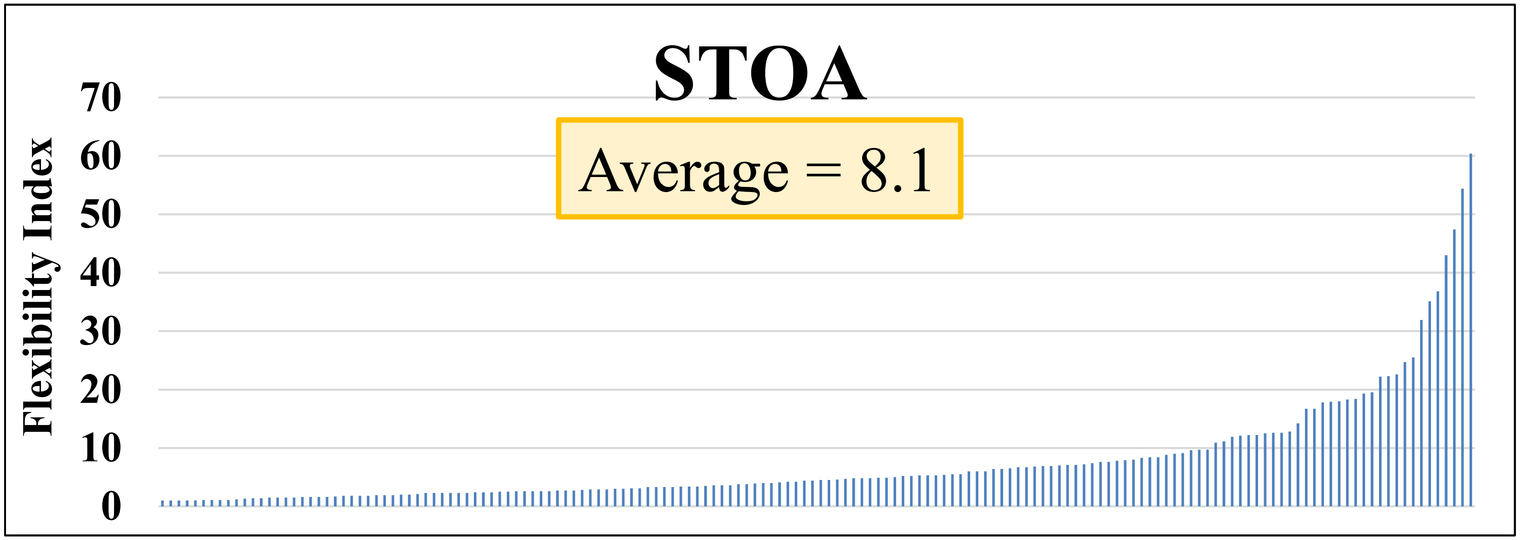


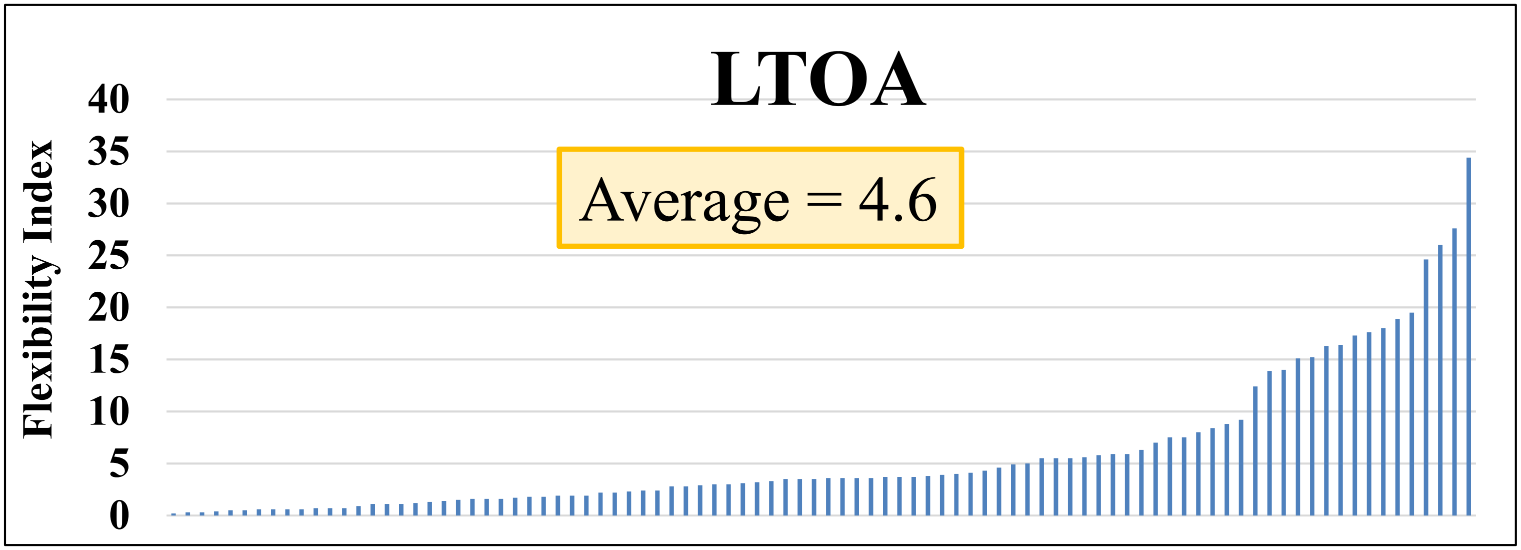
Data Range: Peak Load





Data Range: Flexibility Index

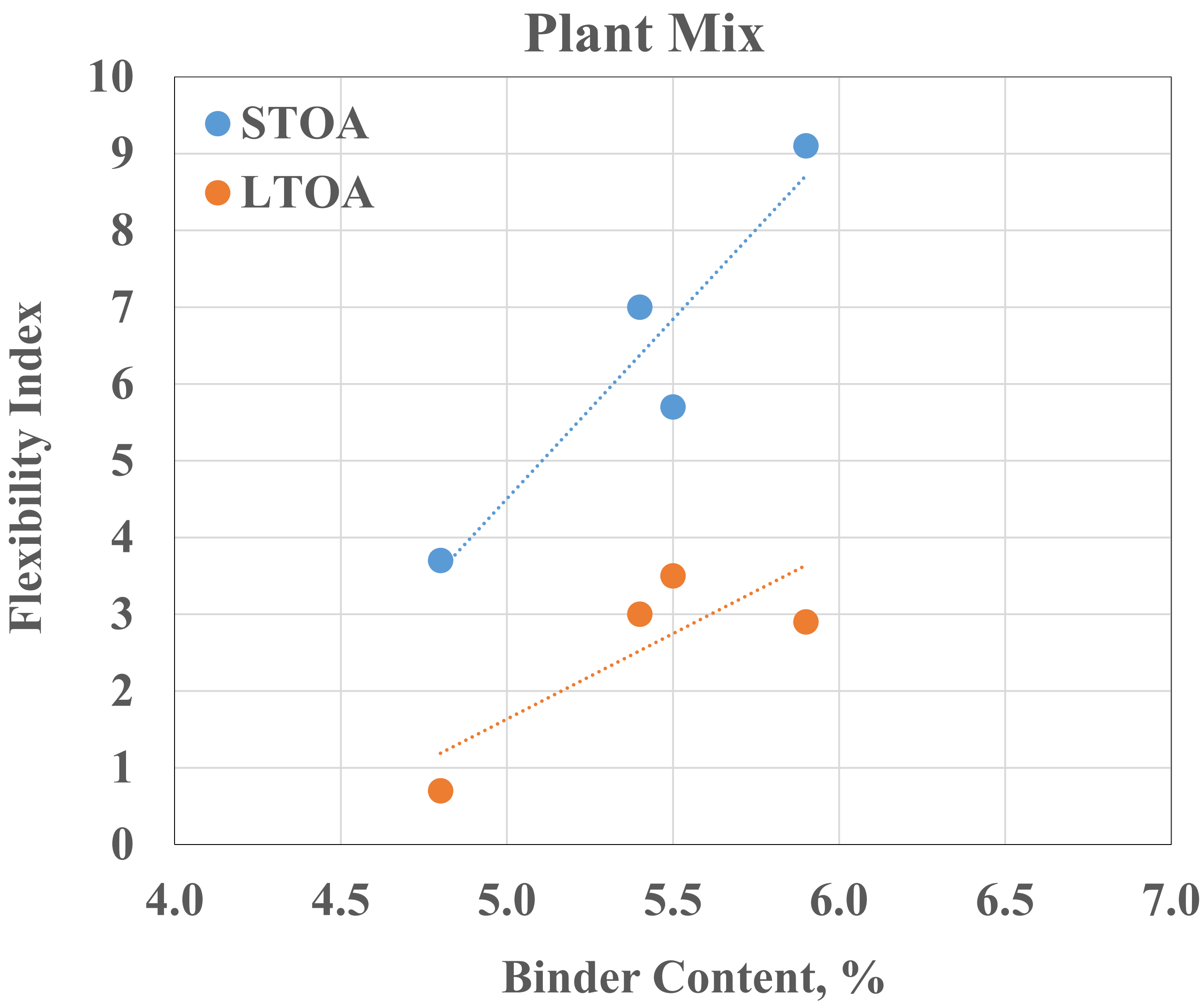




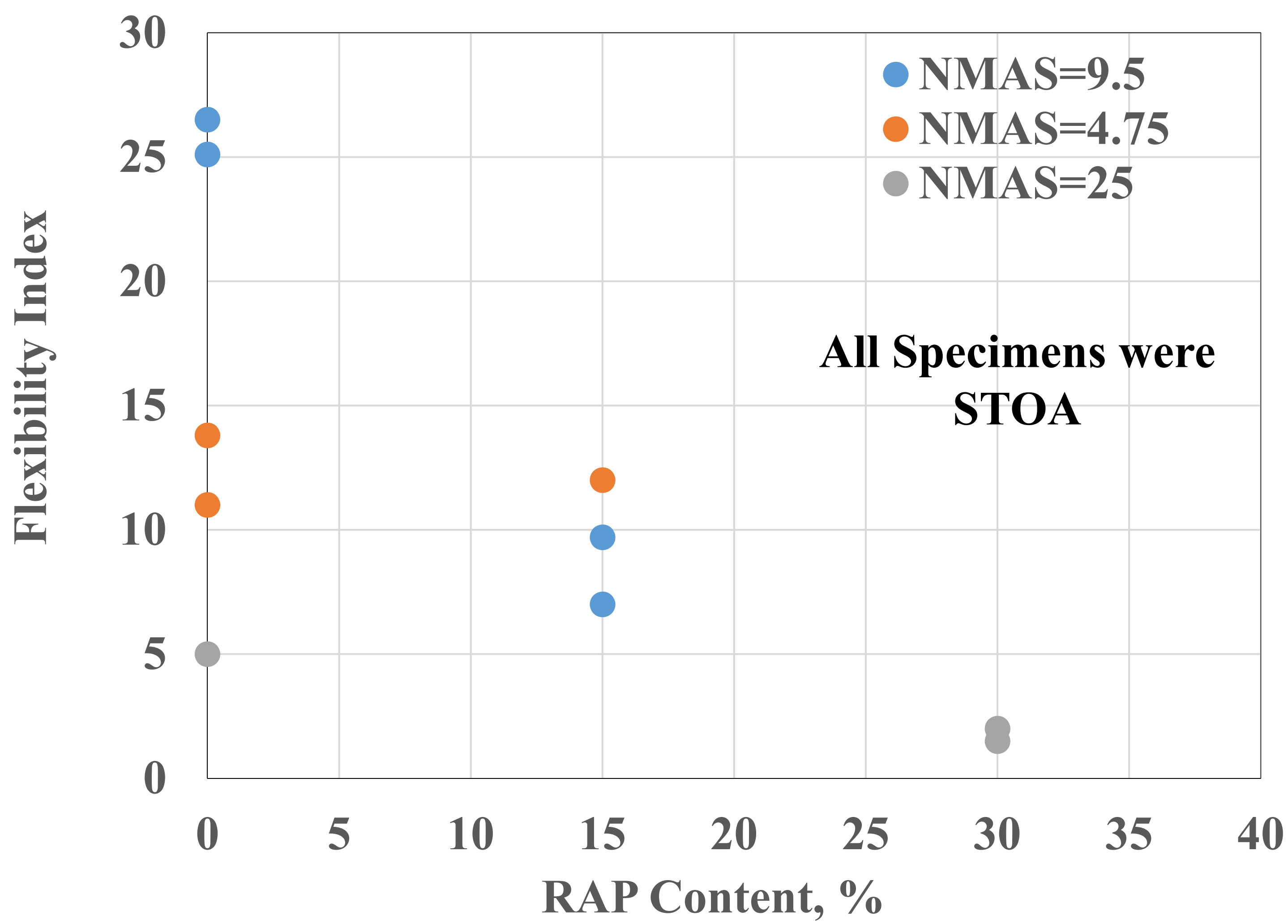
General Observations

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.

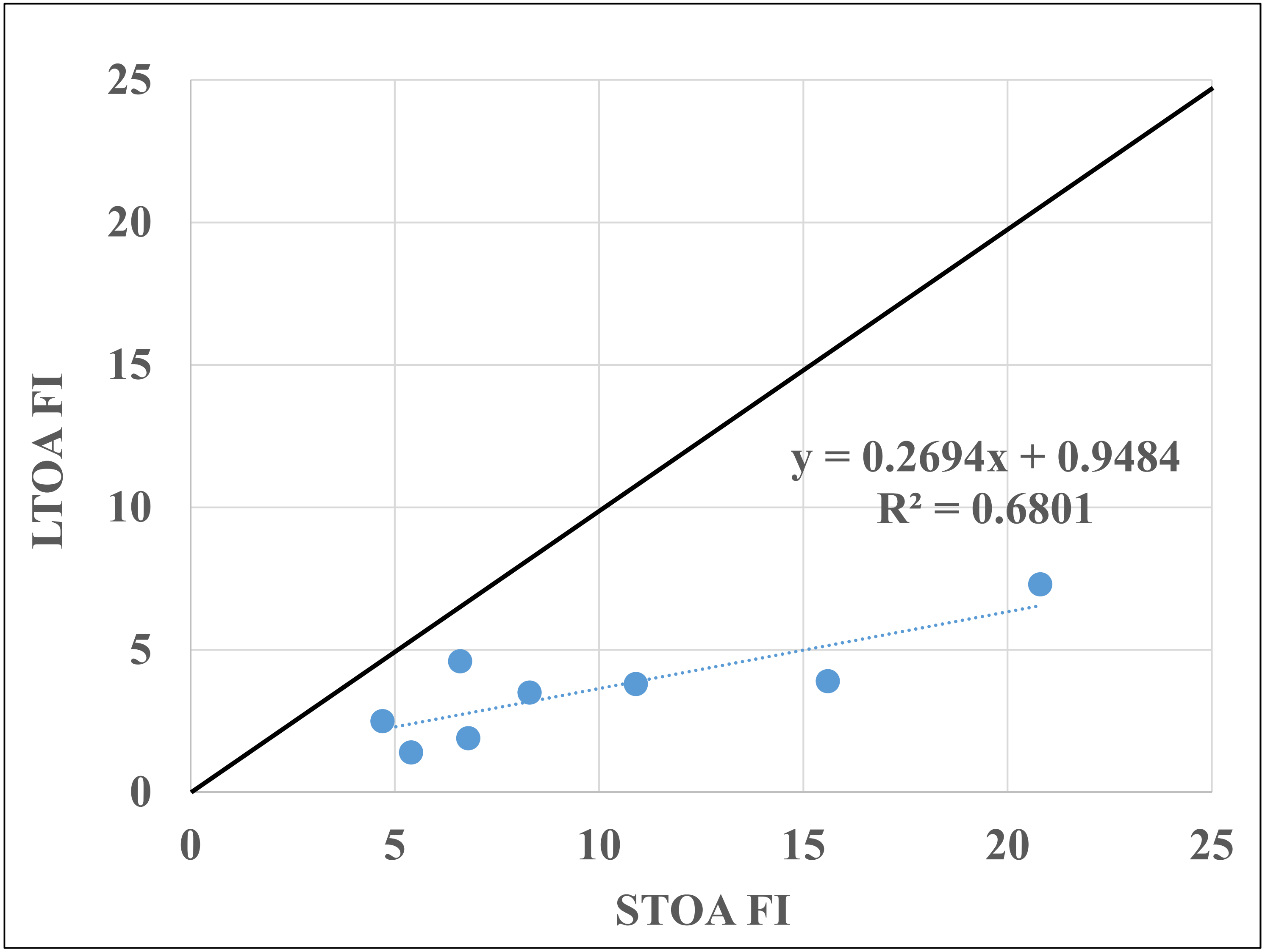
Binder Content Effect



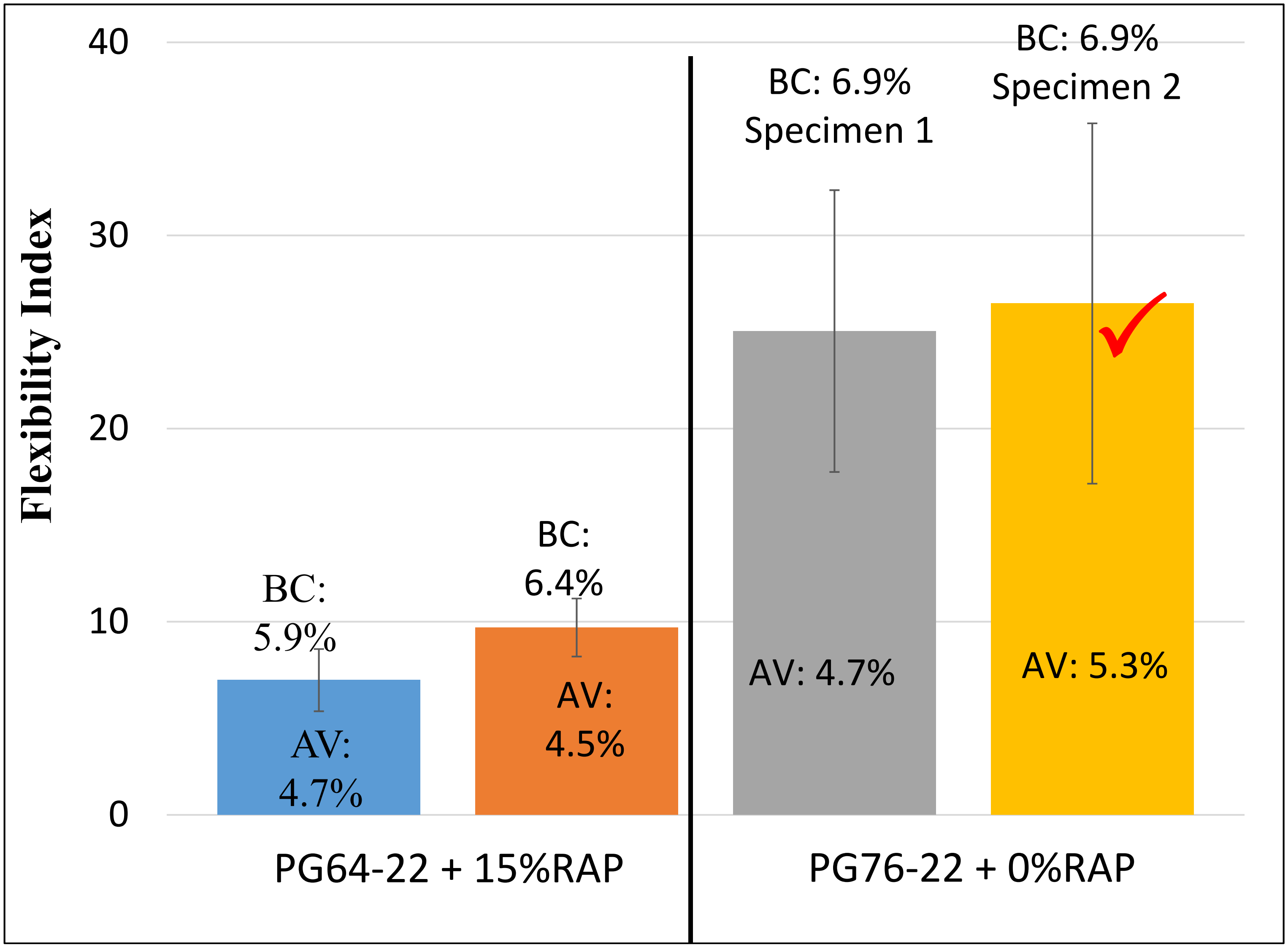
RAP Content Effect



Aging Effect



SMA vs Conventional Mix



Where should we go next?

1. Test mix(es) with proven good long term performance.

2. Track mix performance in the field to verify lab predictions.

DISCUSSION TOPICS

3 **Long Life Asphalt Pavements (SMA)**

Performance Test & LLAP driven by:

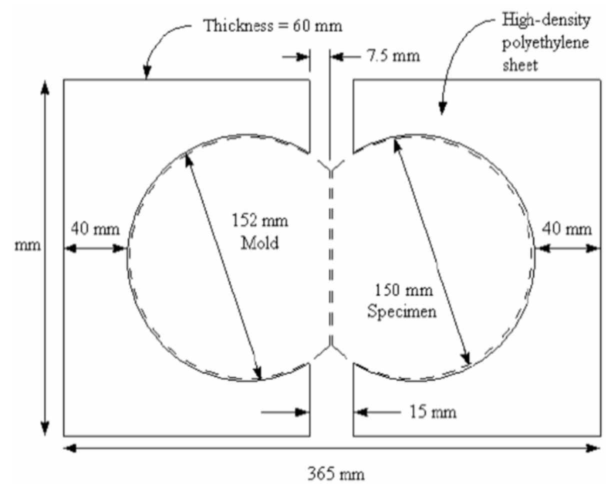
- TQI
- STIC

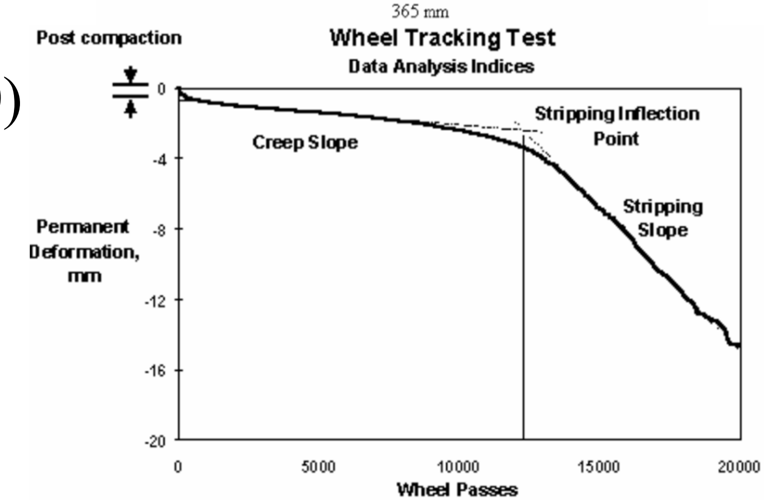
LLAP Best Practices

- 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

Rutting Test

- **Hamburg Wheel Tacking Test.** (AASHTO T 324)
  - Measures rutting potential and gives an indication of moisture sensitivity.
  - Gyratory samples %7.0 (+/- %1.0) air voids
  - Test run at 131^0 F (55^0 C)
  - 12.5mm (0.5 inch) rut at 20,000 cycles general rule of thumb for limit on superpave.





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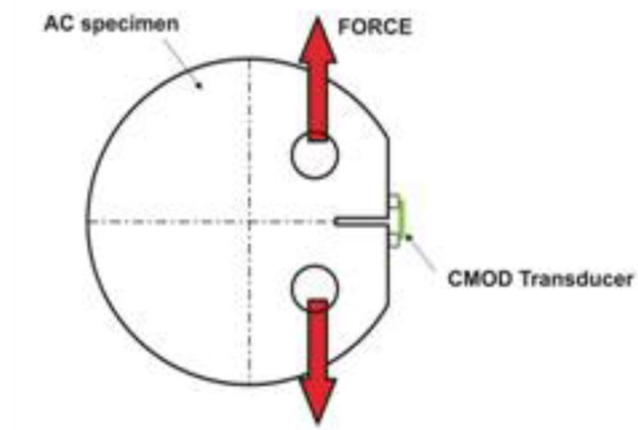
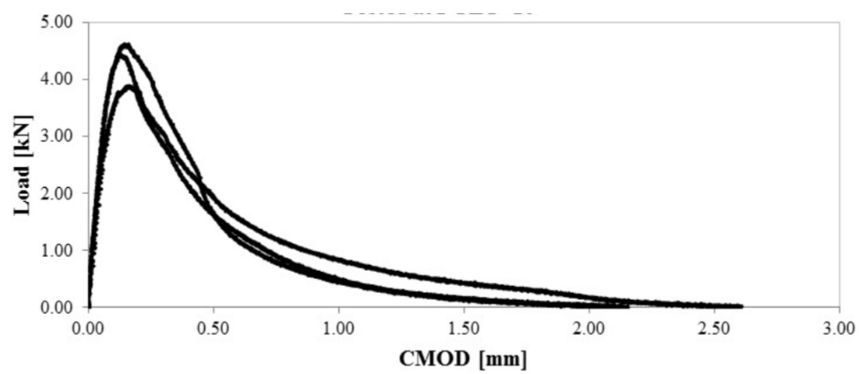
Cracking Test

- **Disk-Shaped Compact Tension** (DCT) testing. (ASTM D7313)
  - Measures fracture energy
  - Gyratory samples %7.0 (+/- %1.0) air voids.
  - Test run at 10^0 C above the low PG mix designation. (-12^0C (10.4^0 F) for PG64-22)
  - Fracture energy requirements vary depending on mix type (SMA) and layer (wearing, binder)





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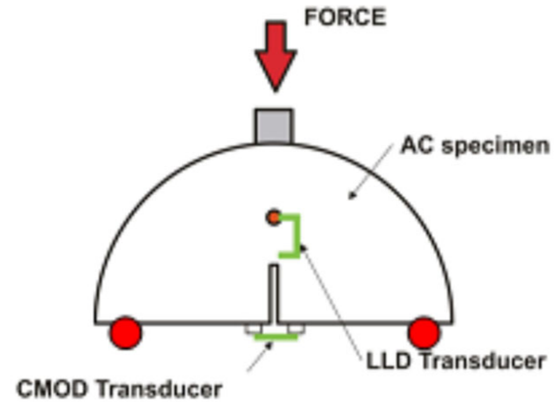
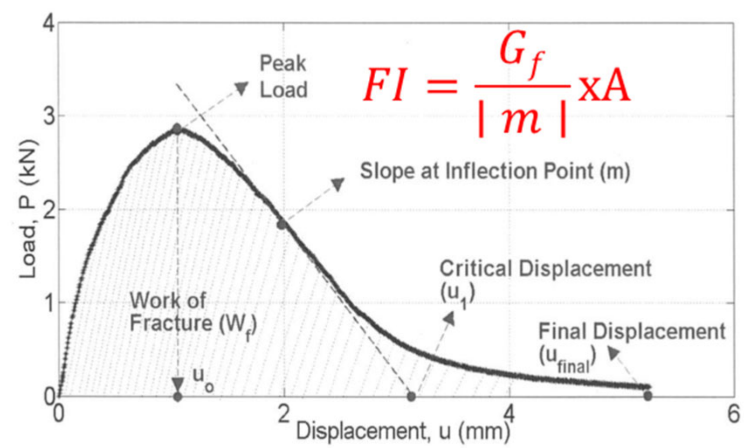
c1 cgoodhart, 1/11/2017

Cracking Test

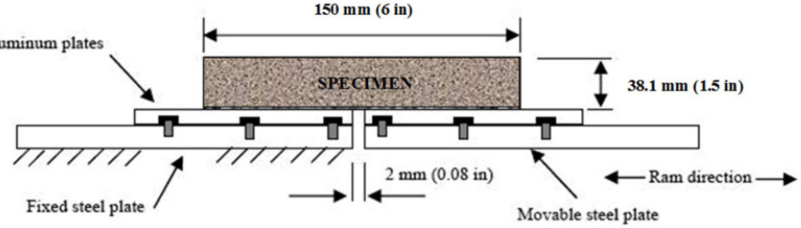
- **Illinois Flexibility Index** Test (IFIT) (AASHTO TP 124) (SCB TEST)
  - Measures fracture energy and post peek slope.
  - Uses fracture energy and load/displacement slope to compute Flexibility Index.
  - Gyratory samples %7.0 +/- %1.0 air voids
  - Test run at 25^0 C +/- 0.5^0C (77^0F).
  - Flexibility Index requirements vary depending on mix type (SMA) and layer (wearing, binder)

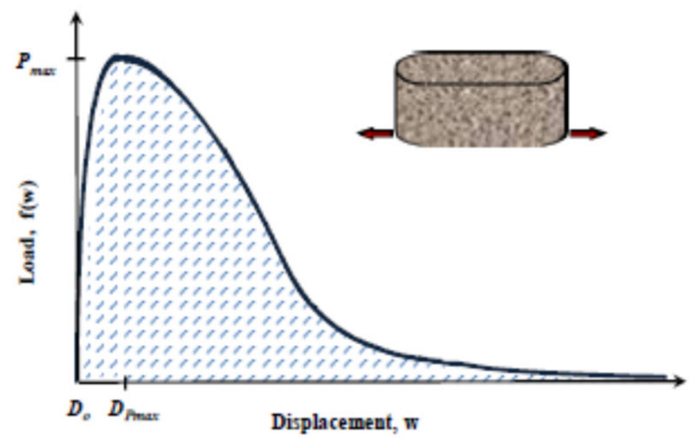




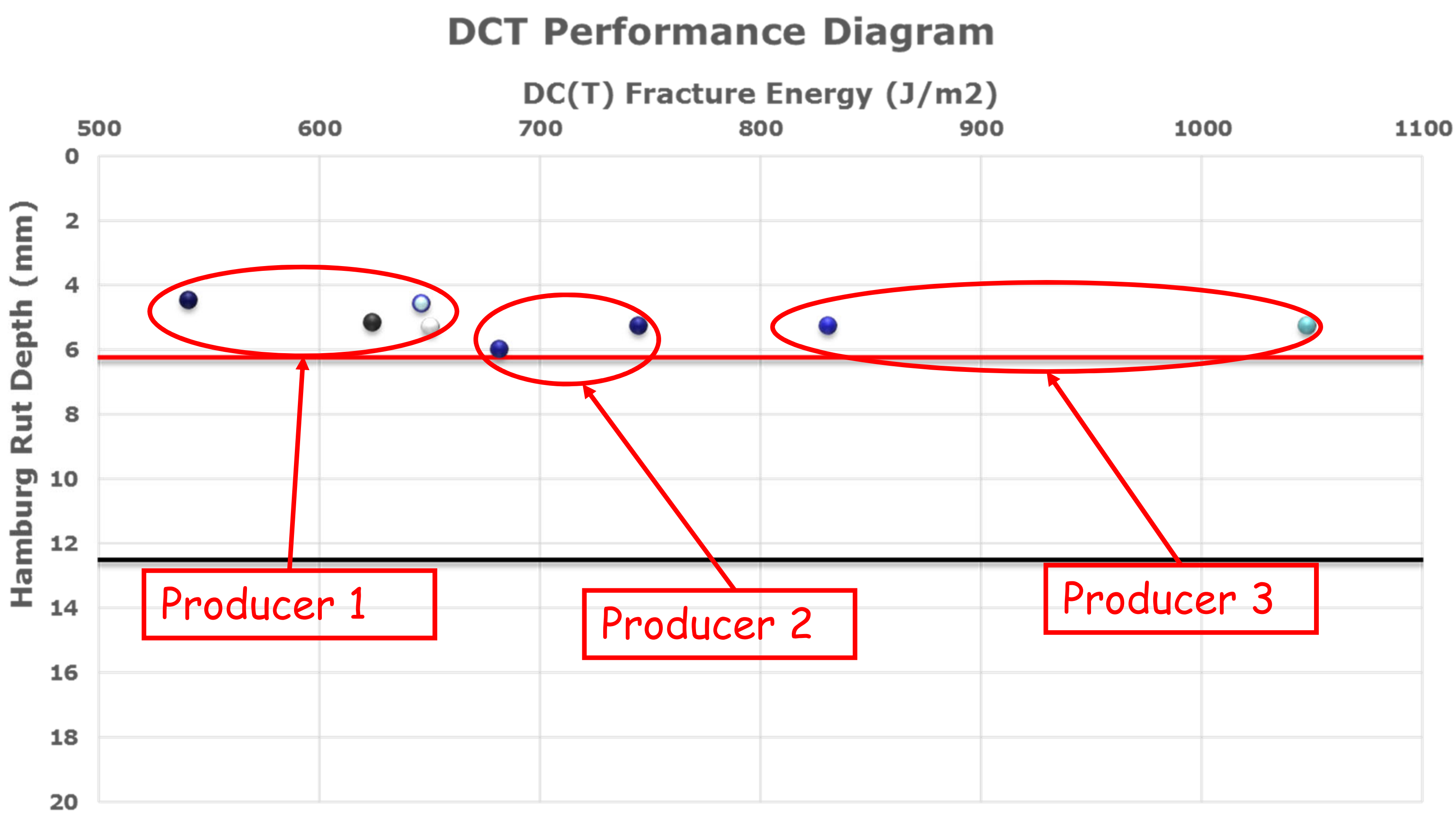
Cracking Test

- **Overlay Test** (OT). (TEX-248-F)
  - Measures fatigue or reflective cracking potential.
  - Gyratory samples %7.0 +/- %1.0 air voids.
  - Test run at 25^0 C (77°F).
  - Applies load to induce 0.025 (3/128ths) inches displacement.
  - Number of cycles to failure is reported along with percent decline in load.

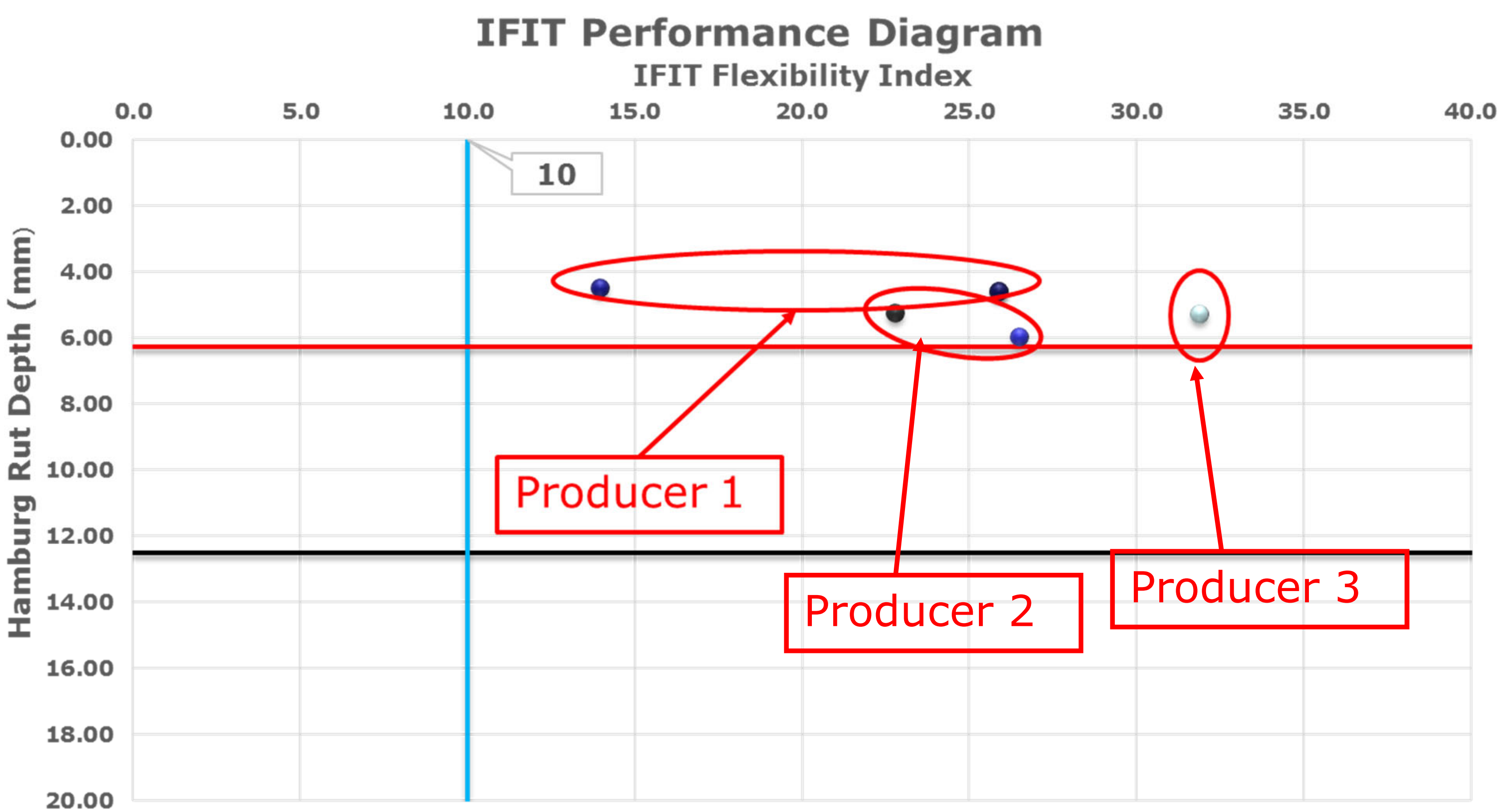




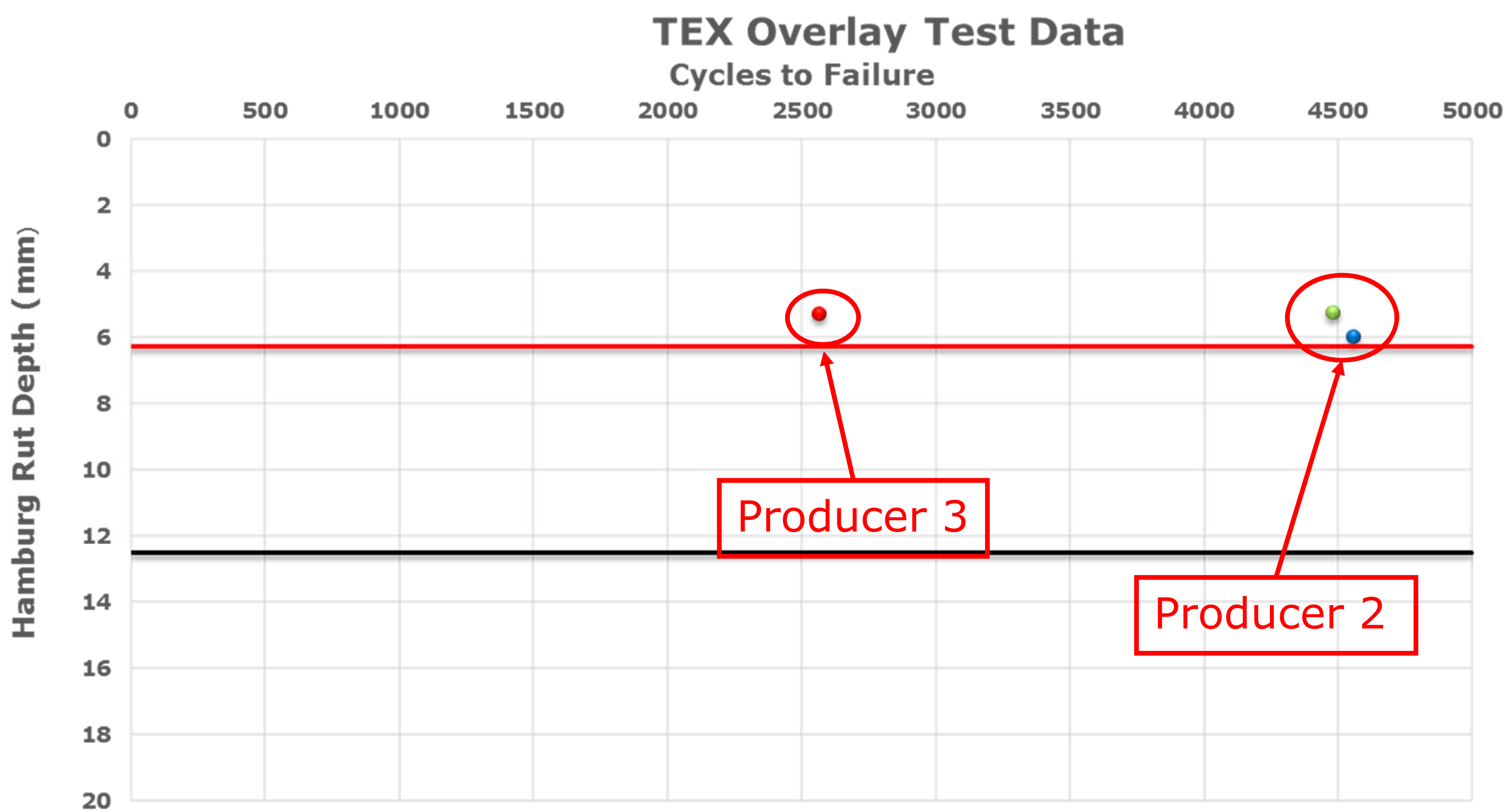
Long Life Asphalt Projects – DCT data



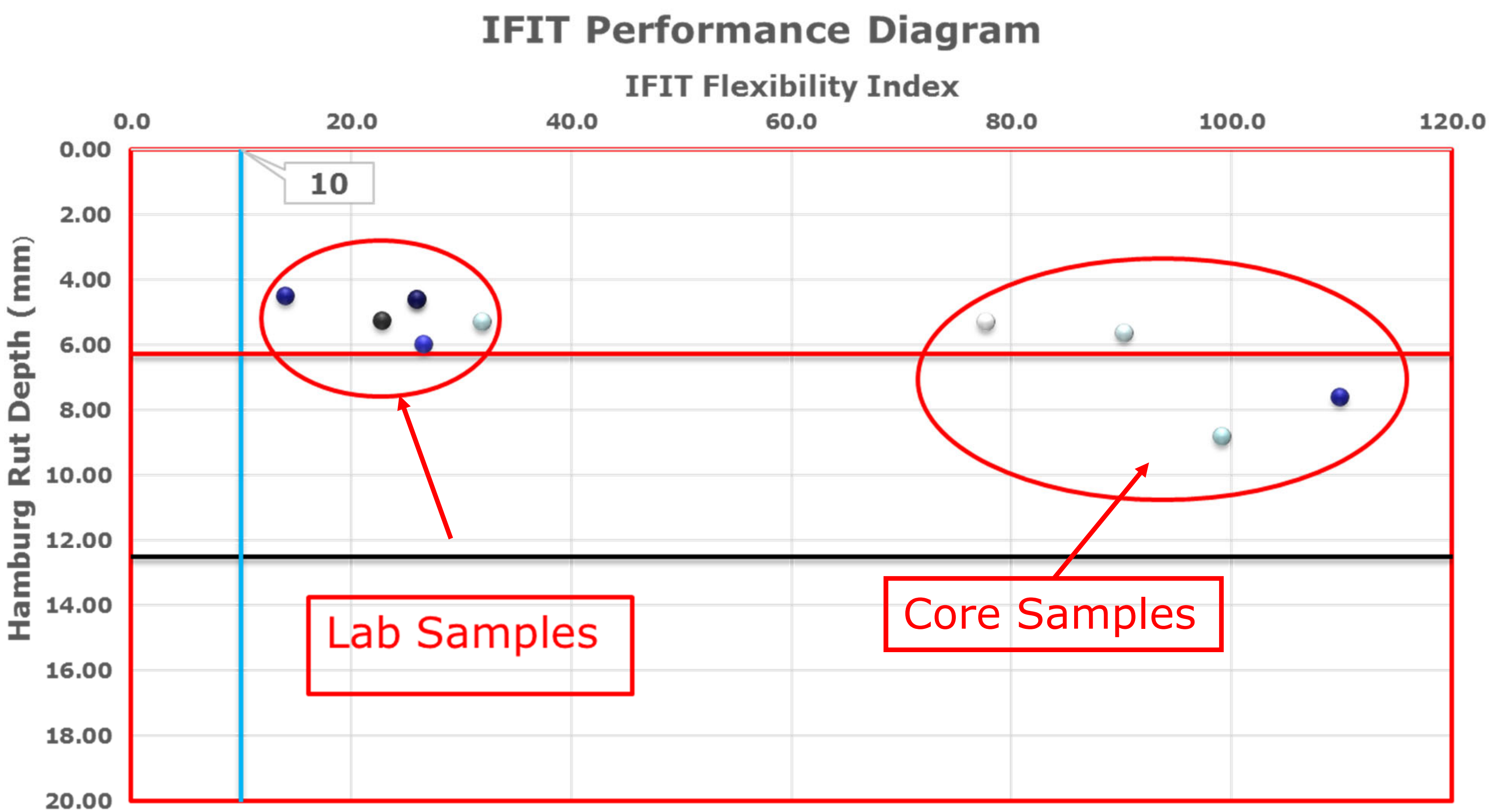
Long Life Asphalt Projects – IFIT Data



Long Life Asphalt Projects – Overlay Test Data



Long Life Asphalt Paving Project - IFIT



Implementation Challenges

- **Implementation will not be quick or simple**
  - Pick performance test(s)
  - Decide on test protocols.
  - Specification pilot(s).
  - Who will be doing testing and how large of an investment is the equipment?
    - Contractors / Producers
    - Special Testing Labs
  - Enough lead time between project bid and paving?
  - Trained technicians to run testing?
  - After the initial rush to get testing done will there be enough tests run to sustain an industry?

DISCUSSION TOPICS

4 RAP/RAS With Rejuvenators

Objectives of the Study

- Evaluate performance-based BMD for mixes with **recycled materials and rejuvenators** via binder tests and mixture mechanical tests.

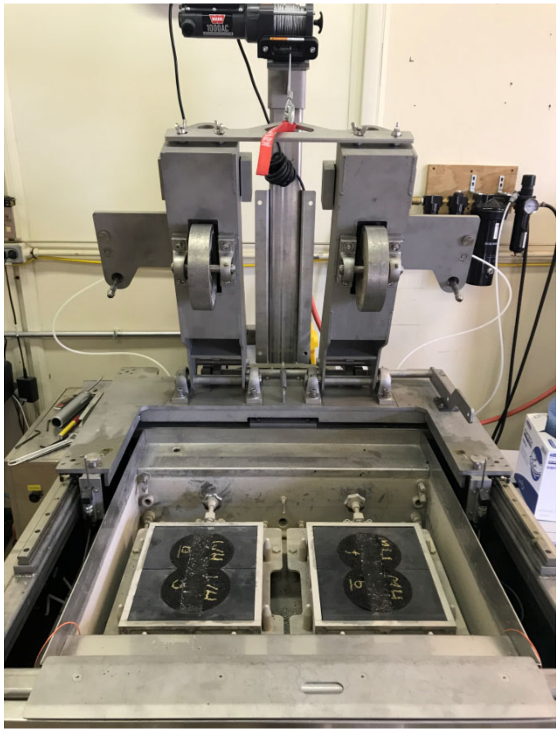
Focus on
intermediate and **high temperature performance**

Test Program – SCB Fracture Test

- ❖ **Followed IFIT with two modifications**
- ❖ **Displacement Rate**: **5** mm/min
- ❖ **Test Temperature**: **20**℃ [Using Effective Temperature (*El-Basyouny and Jeong 2009*)]

Semi-Circular Bend (SCB) Test Setup

Test Program – Hamburg Test



Hamburg Wheel Tracking Device Used in the Study

- Evaluate Resistance to Permanent Deformation
- Following AASHTO T 324
- Test Temperature 50°C
- Two Replicates

Test Program – Binder Tests

Intermediate Temp Performance

- Glower Rowe (**G-R**) Damage Parameter
  - ✓ Temp/Frequency Sweep Test
  - ✓ Extrapolated [$G^* \cdot \cos(\delta)^2 / \sin \delta$] at 15°C and 0.005 rad/s
- G* at 20°C and 10 rad/s
  - ✓ Direct Measurement

High Temp Performance

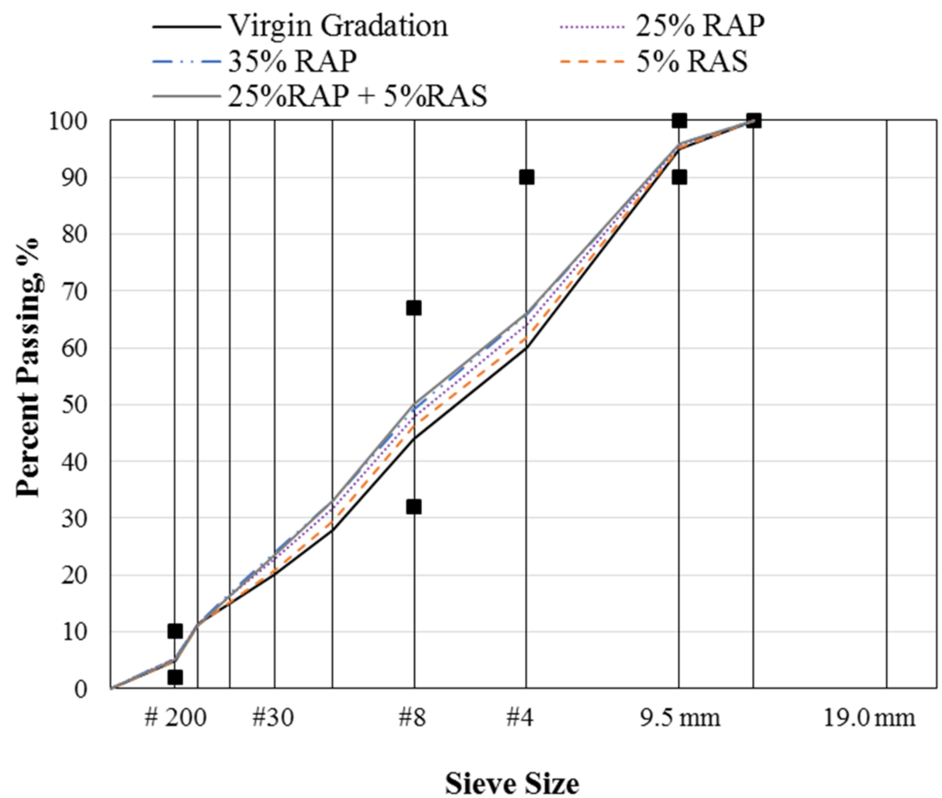
- High Temperature Continuous Grade
- Multiple Stress Creep Recovery (MSCR)
  - ✓ Non-recoverable creep compliance (**J_{nr}**)
  - ✓ 100 Pa and 3,200 Pa Stress levels

Benchmark Work – Materials

➤ ***Six* Benchmark Mixes**

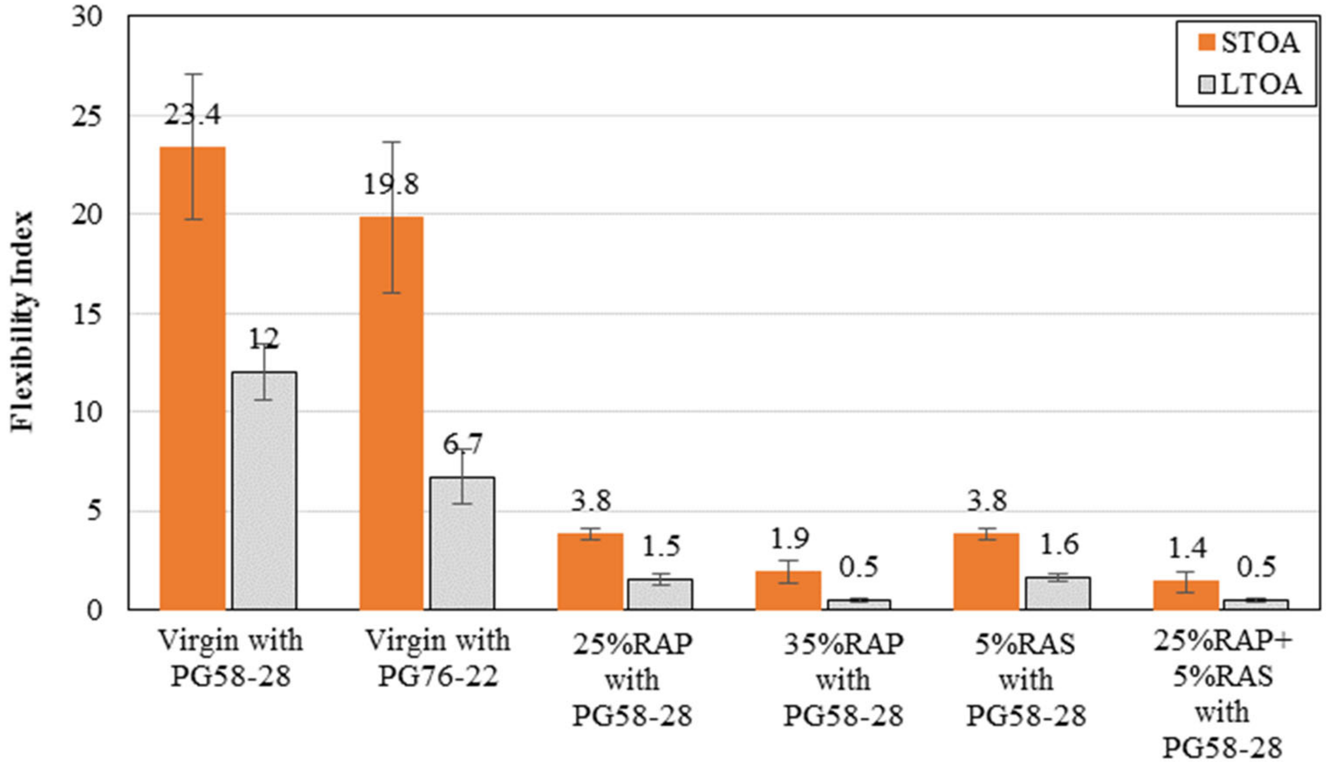
- Dolomite/limestone aggregate
- 9.5 mm Superpave gradation
- PG58-28 and PG76-22

- RAP (6.4% residual binder) – two Levels
- RAS (21% residual binder)



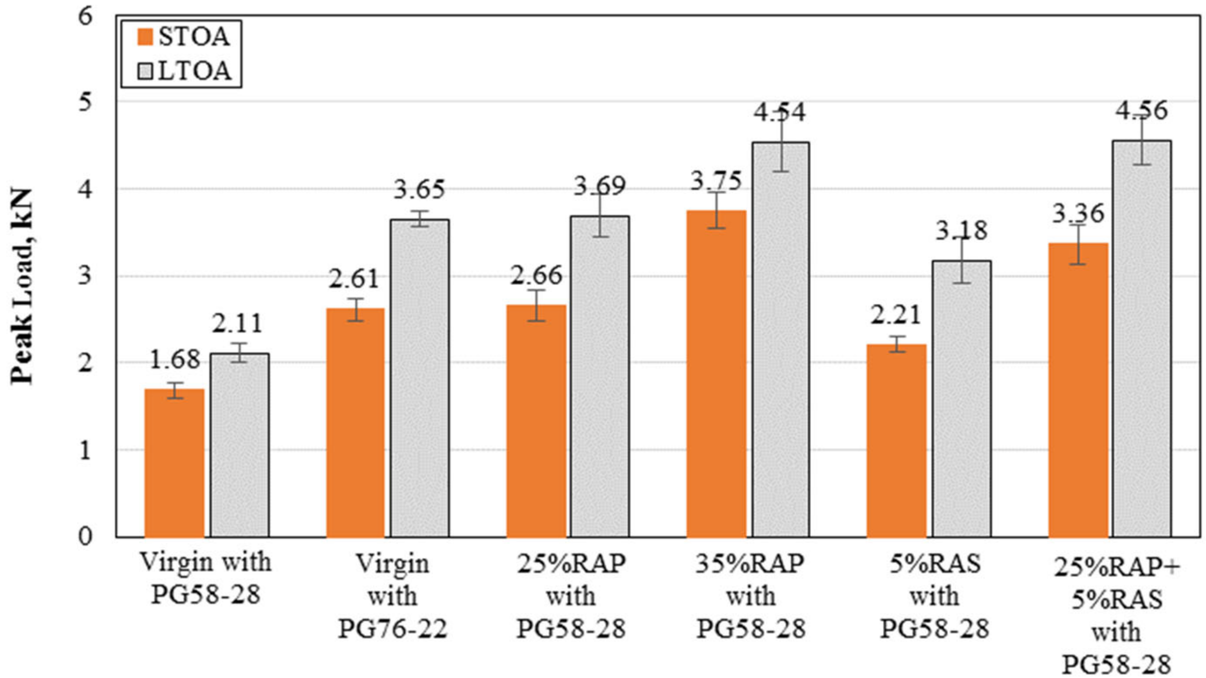
Gradation of All Benchmark Mixes

SCB Test Results – Flexibility Index (FI)



- Higher Aging → Lower FI
- Higher RAP/RAS → Lower FI

SCB Test Results – Peak Load (PL)



- Higher Aging ➡ Higher Strength
- Higher RAP/RAS ➡ Higher Strength

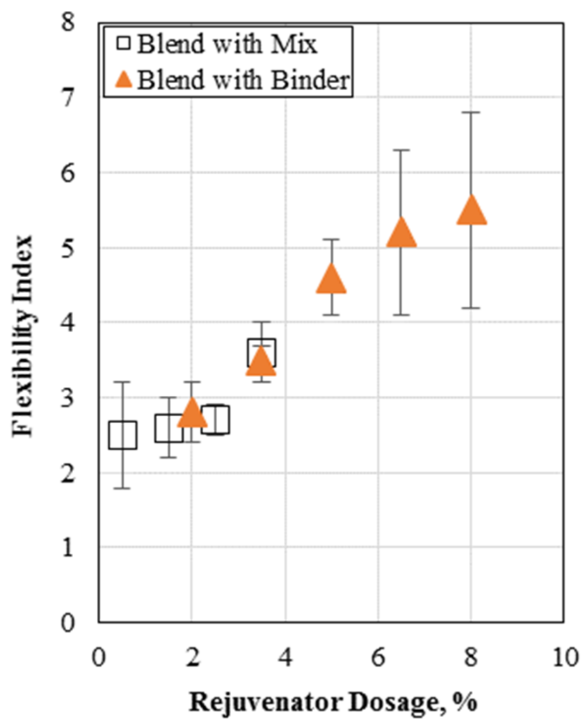
Rejuvenator Effect – Materials

- Dolomite/limestone aggregate
- 9.5 mm Superpave gradation
- **PG58-28**

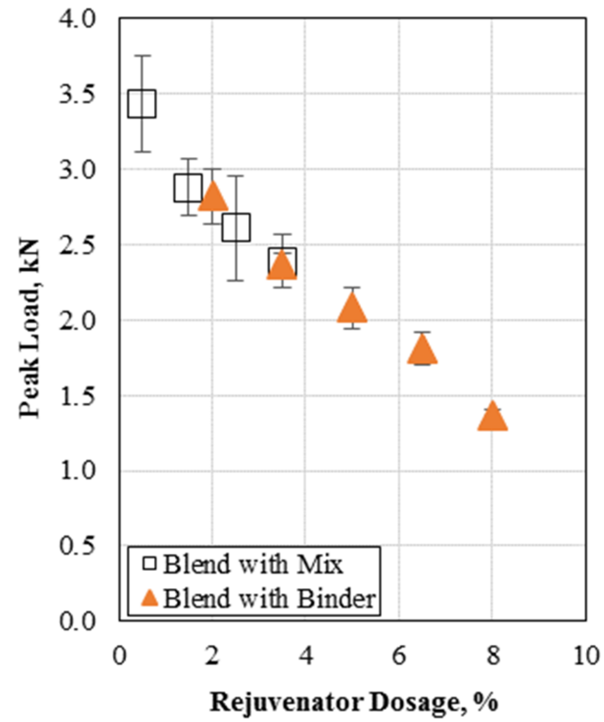
- **35%** RAP (6.4% residual binder, **45% RBR**)

- Rejuvenator **A** (**Modified vegetable oil**, multiple dosages)

Effect of Rejuvenator Content & Blending Methods



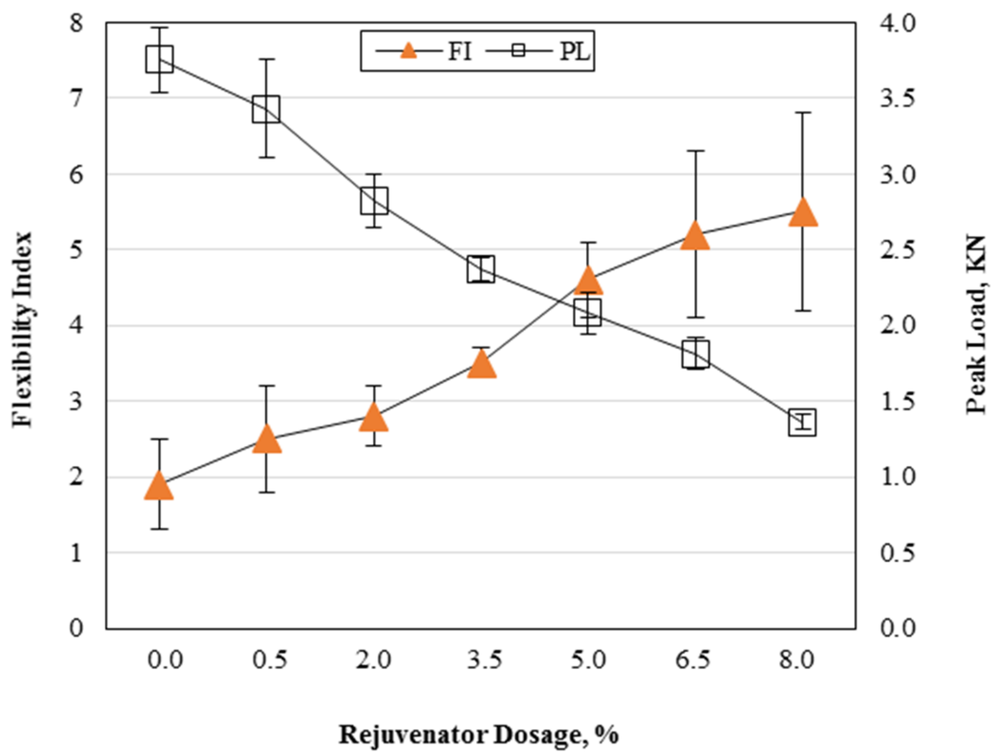
FI Distribution



Peak Load Distribution

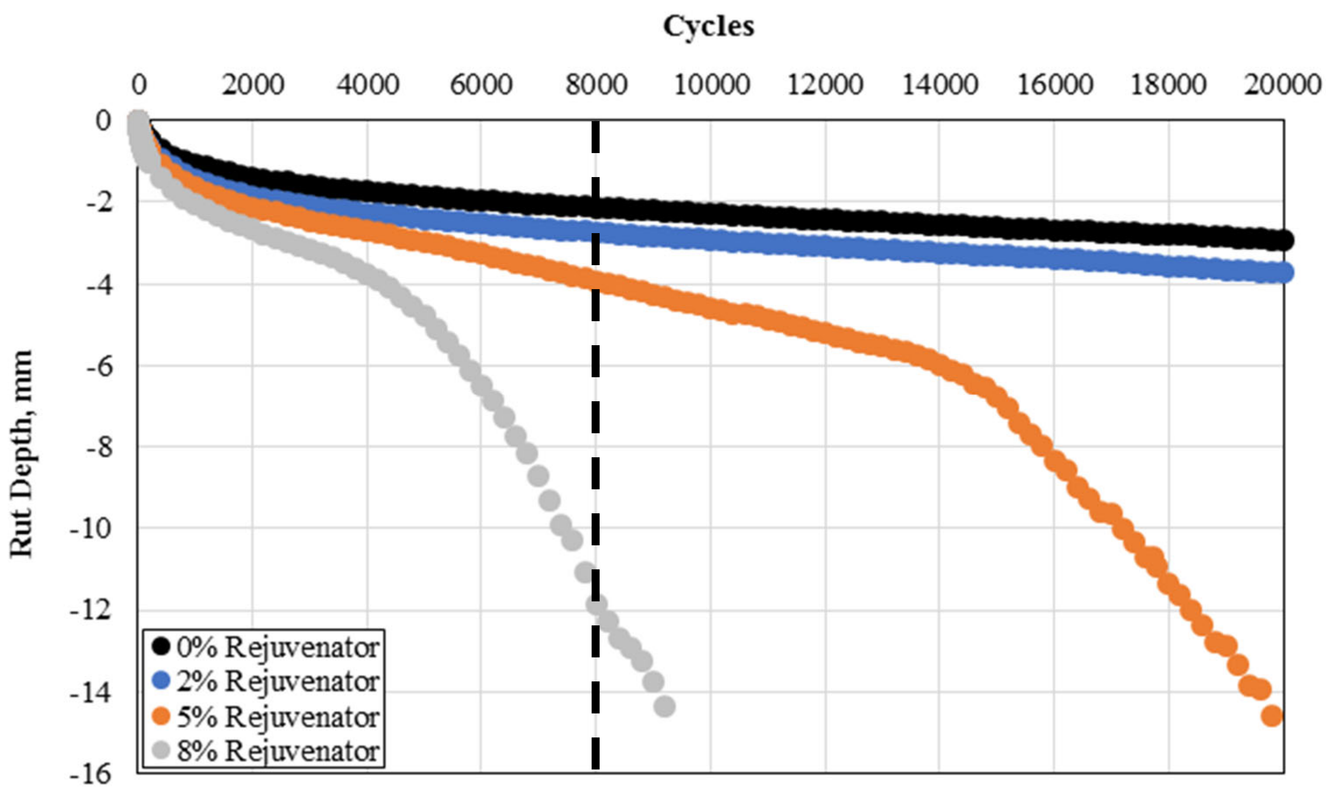
- Higher Rej Content → Higher FI
- Higher Rej Content → Lower Strength

Effect of Rejuvenator Dosage



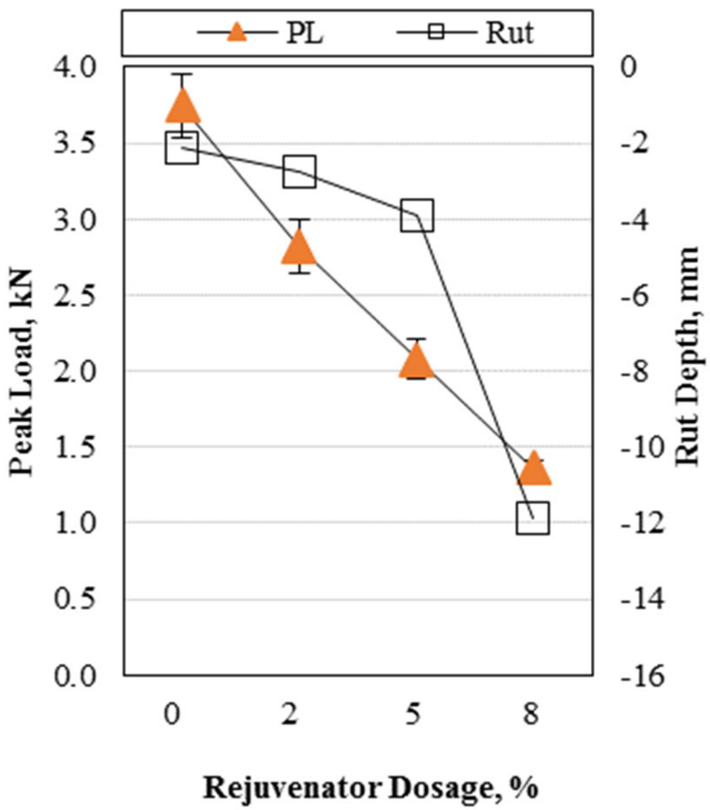
- resembles typical balanced mix design plot
- Threshold Values on FI and Load?

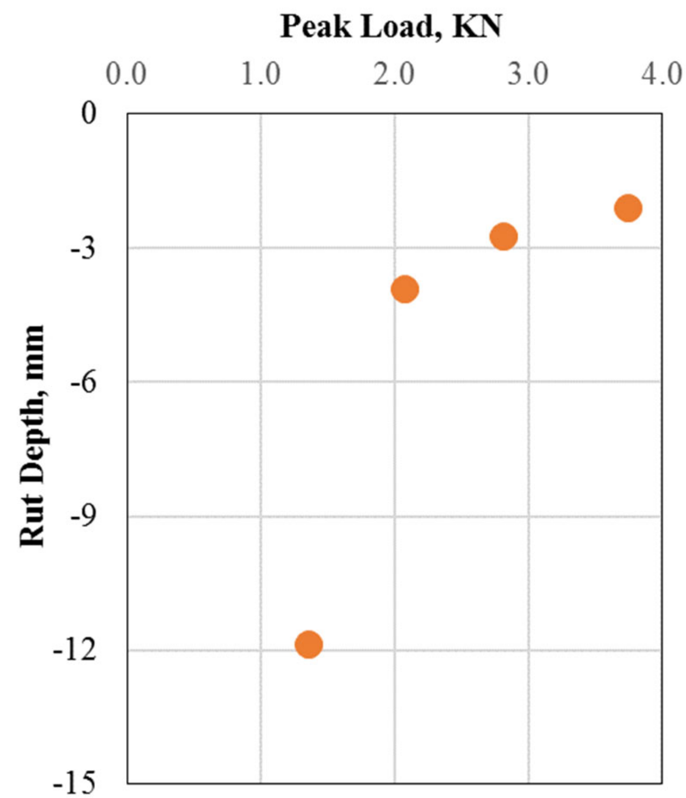
Hamburg Test Results – Rut Depth



Rut Depth (RD) Under Different Rejuvenator Dosages

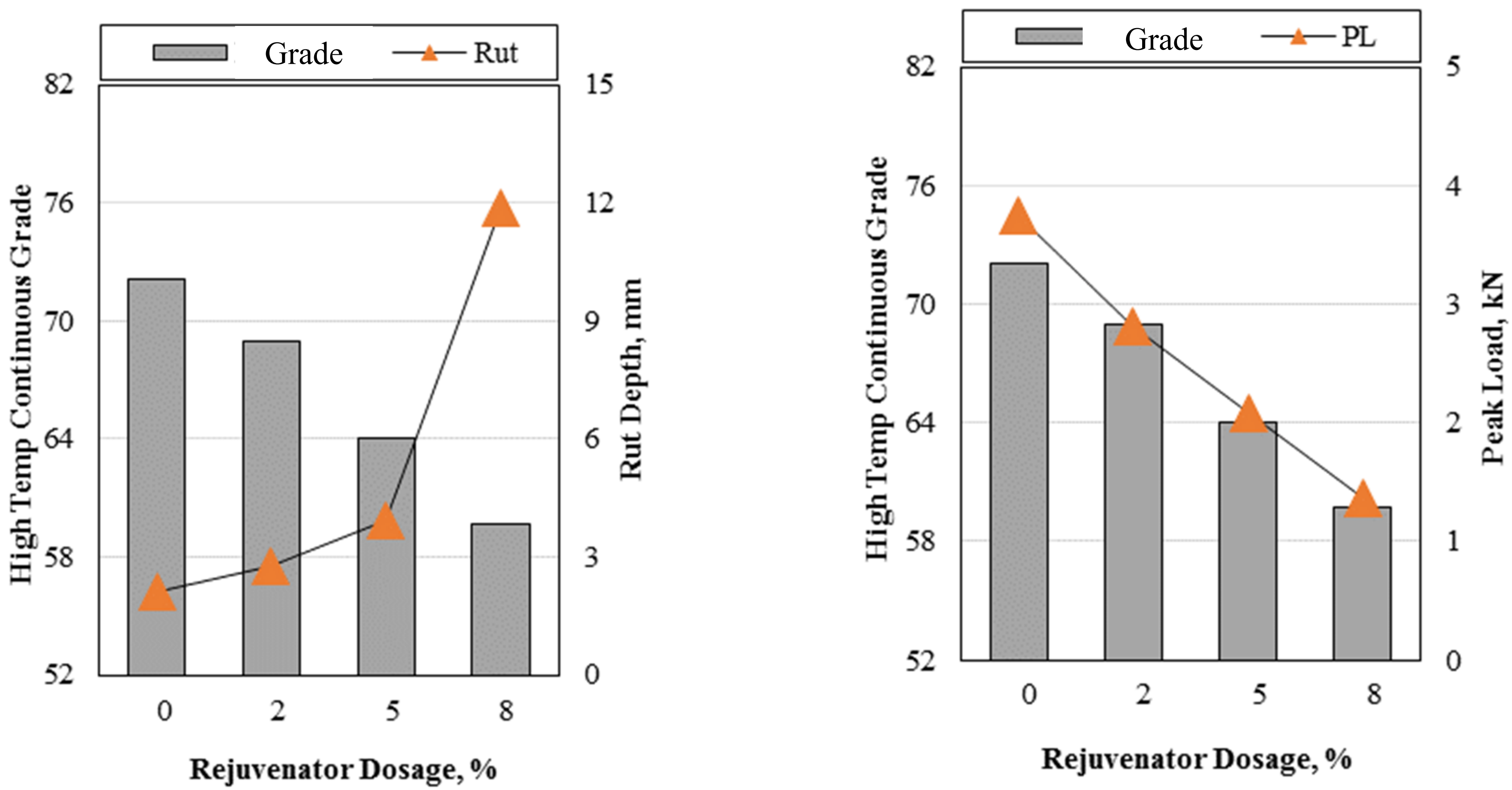
Cross Comparison – Rut Depth vs. Peak Load





(All mixes with 35% RAP)

Cross Comparison – Binder to Mix



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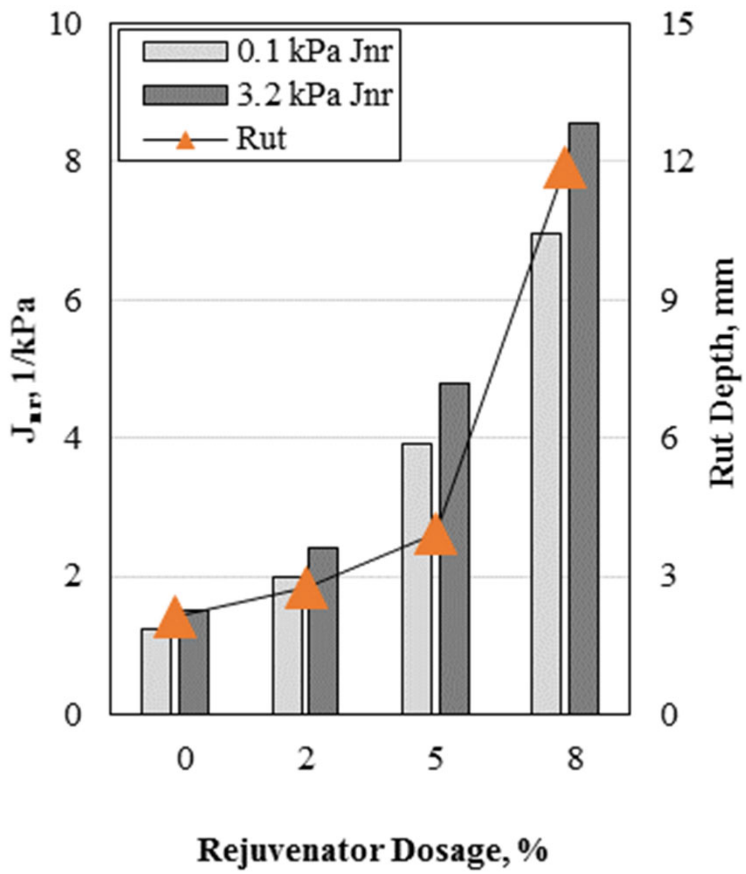
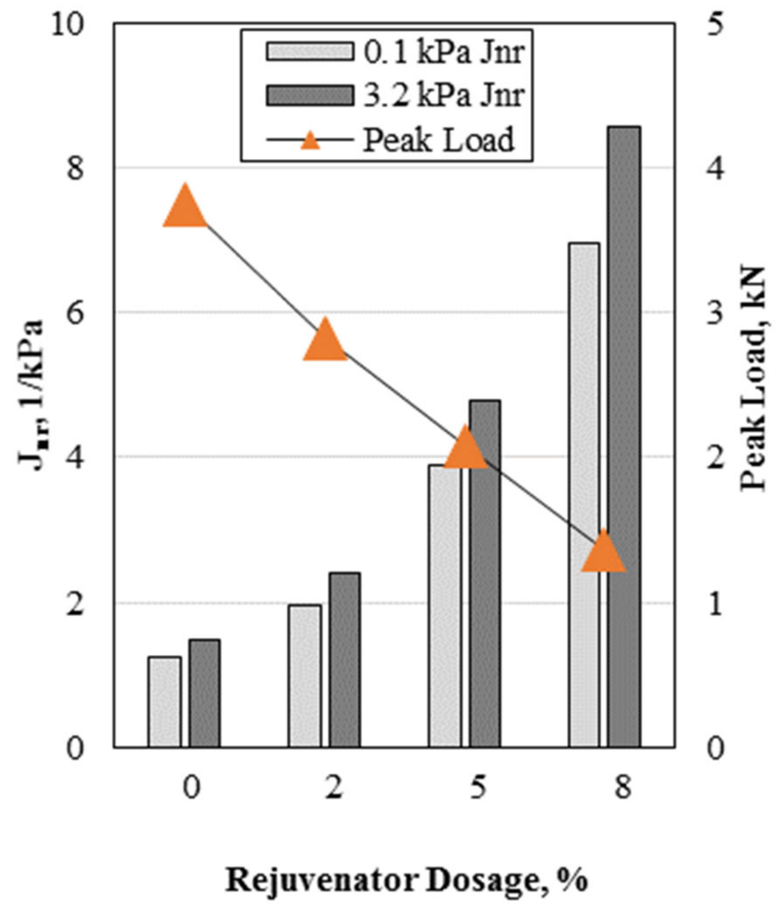
Cross Comparison – Binder to Mix





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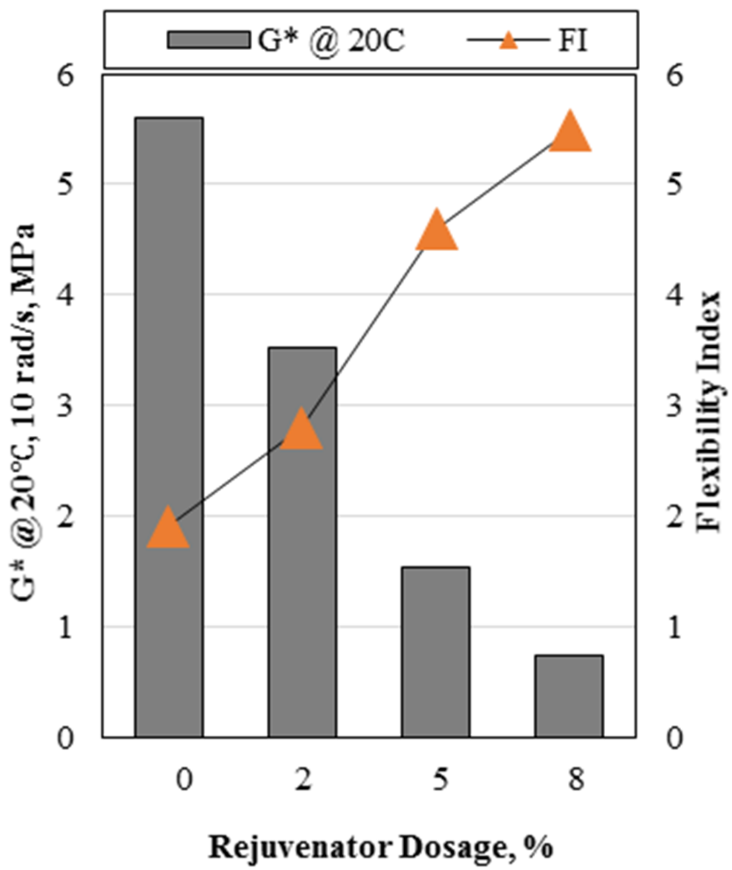
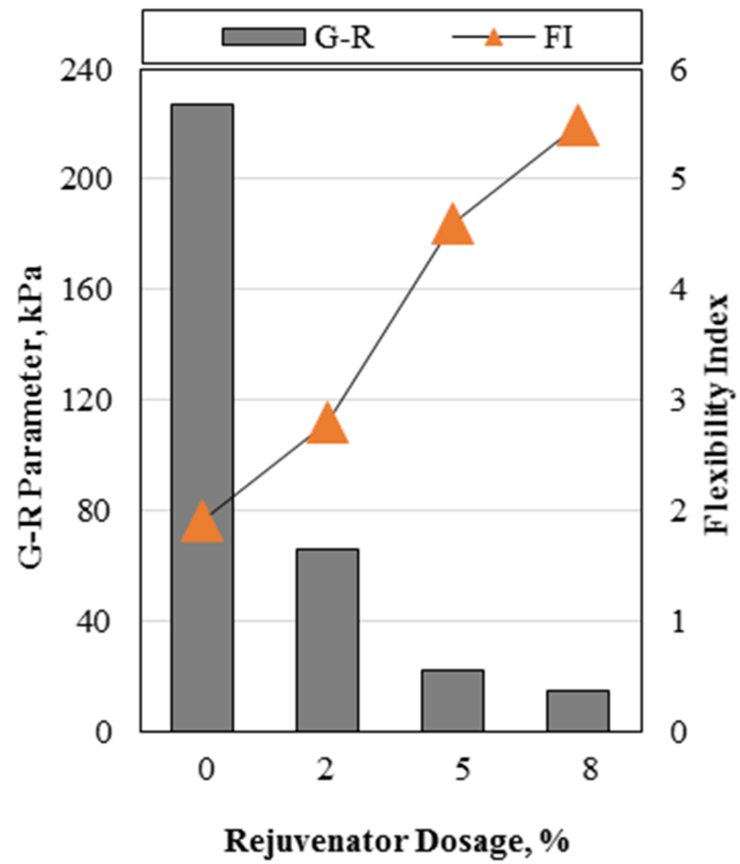
Cross Comparison – Binder to Mix





Expanded Study – Materials

- PG58-28/**PG64-22/PG76-22**

Virgin Binder & Mix

- RAP (6.4% residual binder, 25%&35%)
- RAS (21% residual binder, 5%)
- All Blended with PG58-28

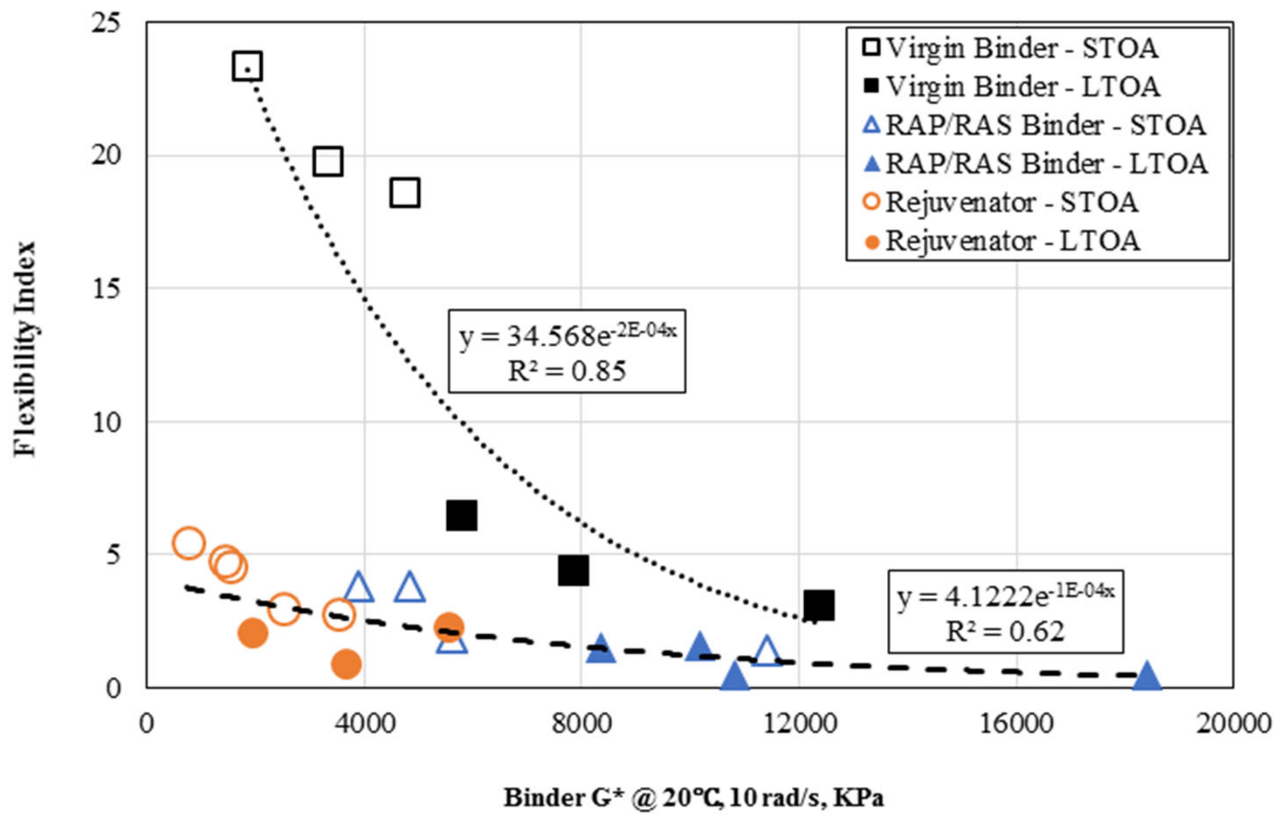
RAP/RAS Binder & Mix

- Rejuvenator A (Modified vegetable oil, up to 8% to binder)
- **Rejuvenator B (bio-based agent, 8% to binder)**
- **Rejuvenator C (hydrolene product, 8% to binder)**
- All Blended with PG58-28 and 35%RAP (45%RBR)

Rejuvenator Binder & Mix

Cross Comparison with More Mixes

- LTOA/RAP/RAS reduces FI
- Rejuvenator increases FI
- Mixes with/without RAP/RAS form two distinct patterns



Conclusions

- Blending methods **do not** affect effectiveness of rejuvenators
- Optimizing Rejuvenator
  - **Increases FI**, **Decreases PL** (mix strength), and; **Increases Rutting**
- Rejuvenator decreases high temp continuous grade and raises J_{nr}.

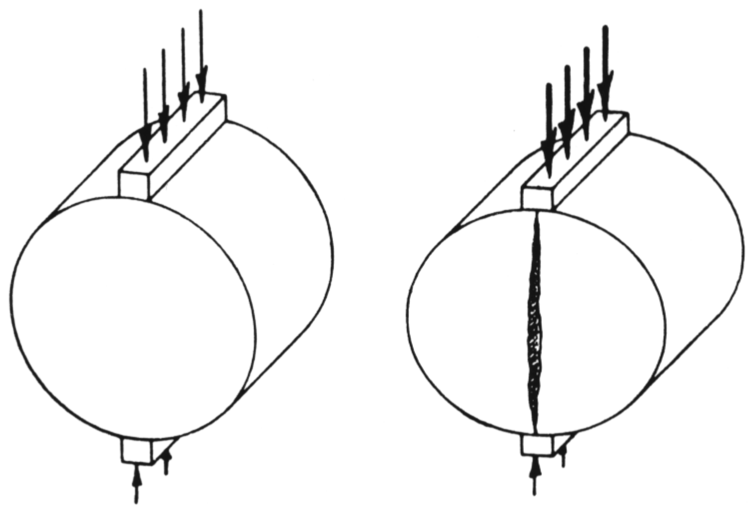
- Adding rejuvenator decreases G* and G-R at intermediate temp.

DISCUSSION TOPICS

5 IDEAL Test Initiative

IDEAL Cracking Test for Asphalt Concrete

Indirect Tensile Test



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

IDEAL-CT

Proposed by Research at Texas Transportation Institute (TTI)

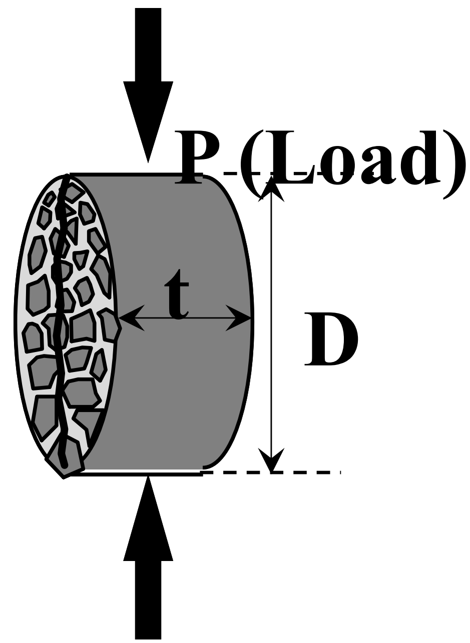
The Brazilian Test
(The Split Test or Indirect Tensile Test)

- 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

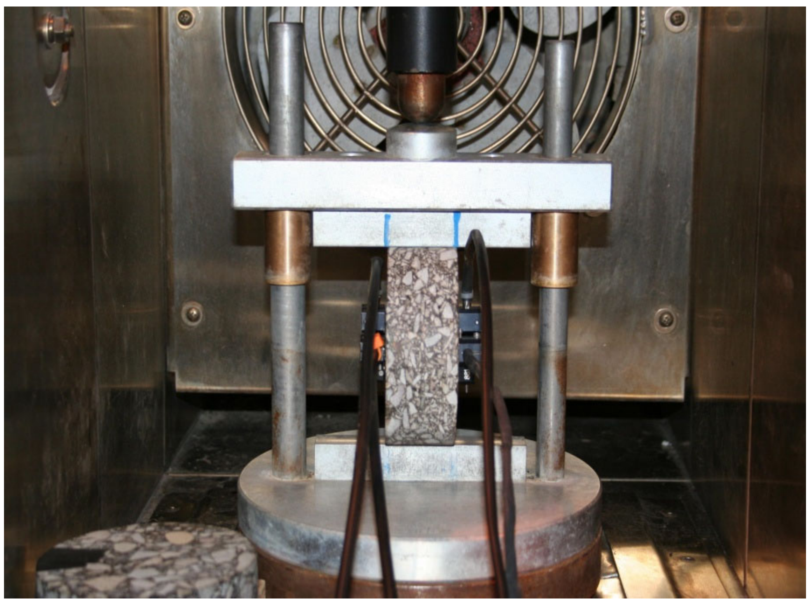


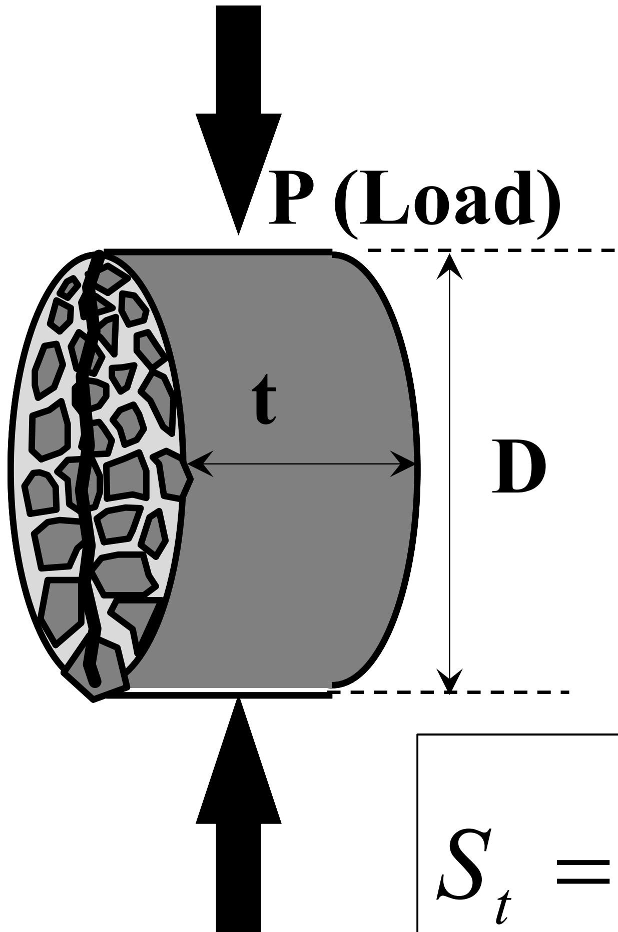
P = load
t = thickness
M_r = Resilient Modulus

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

Asphalt Concrete
Creep & Strength Test

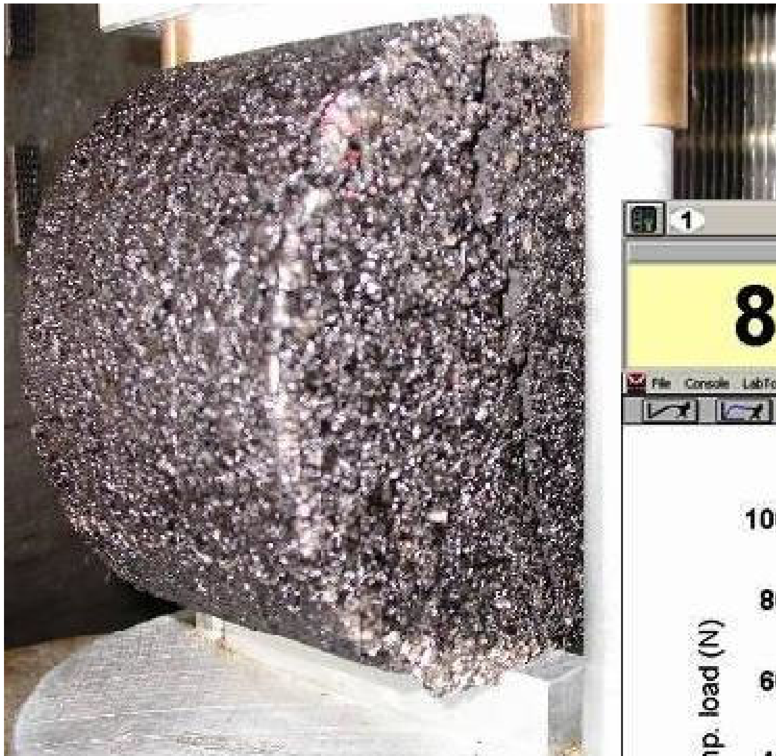
Indirect Tensile Test

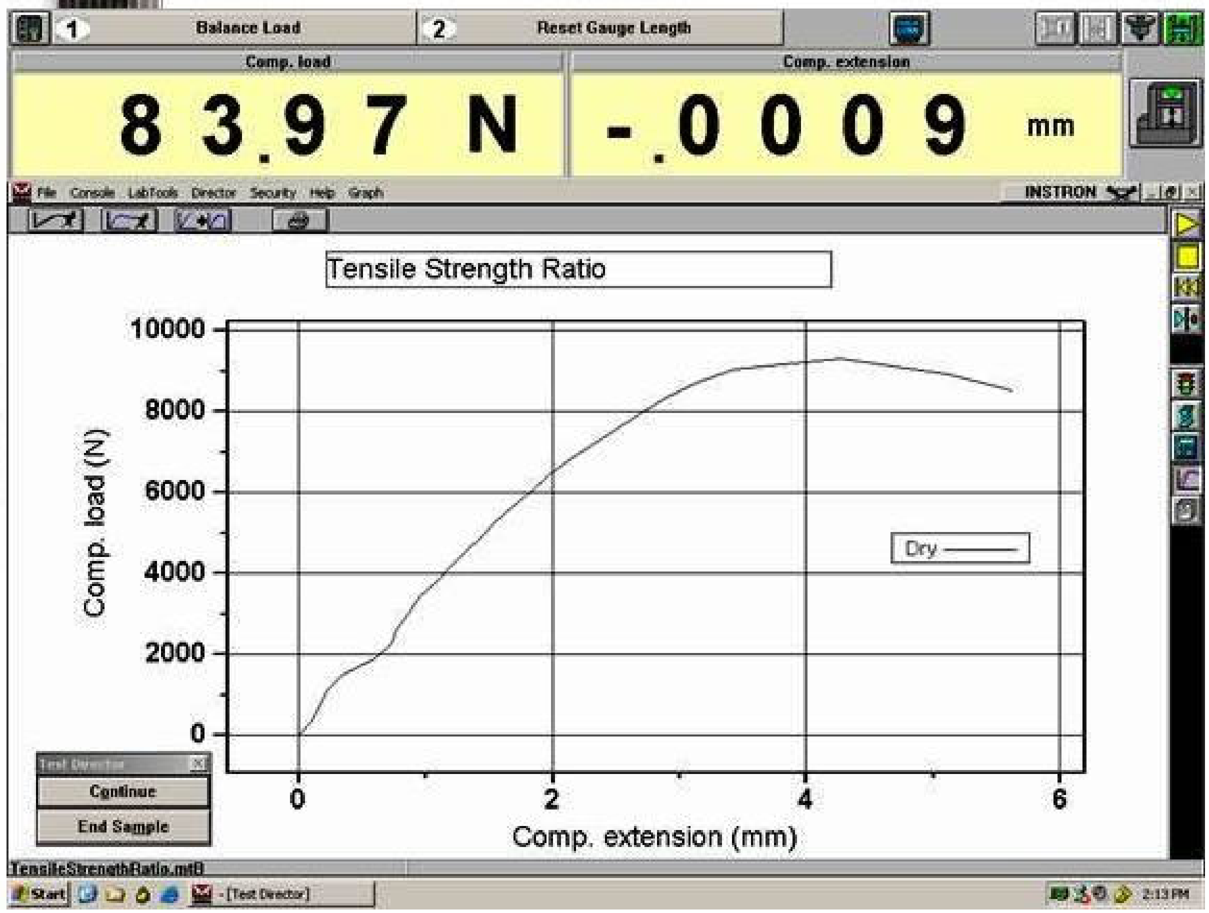




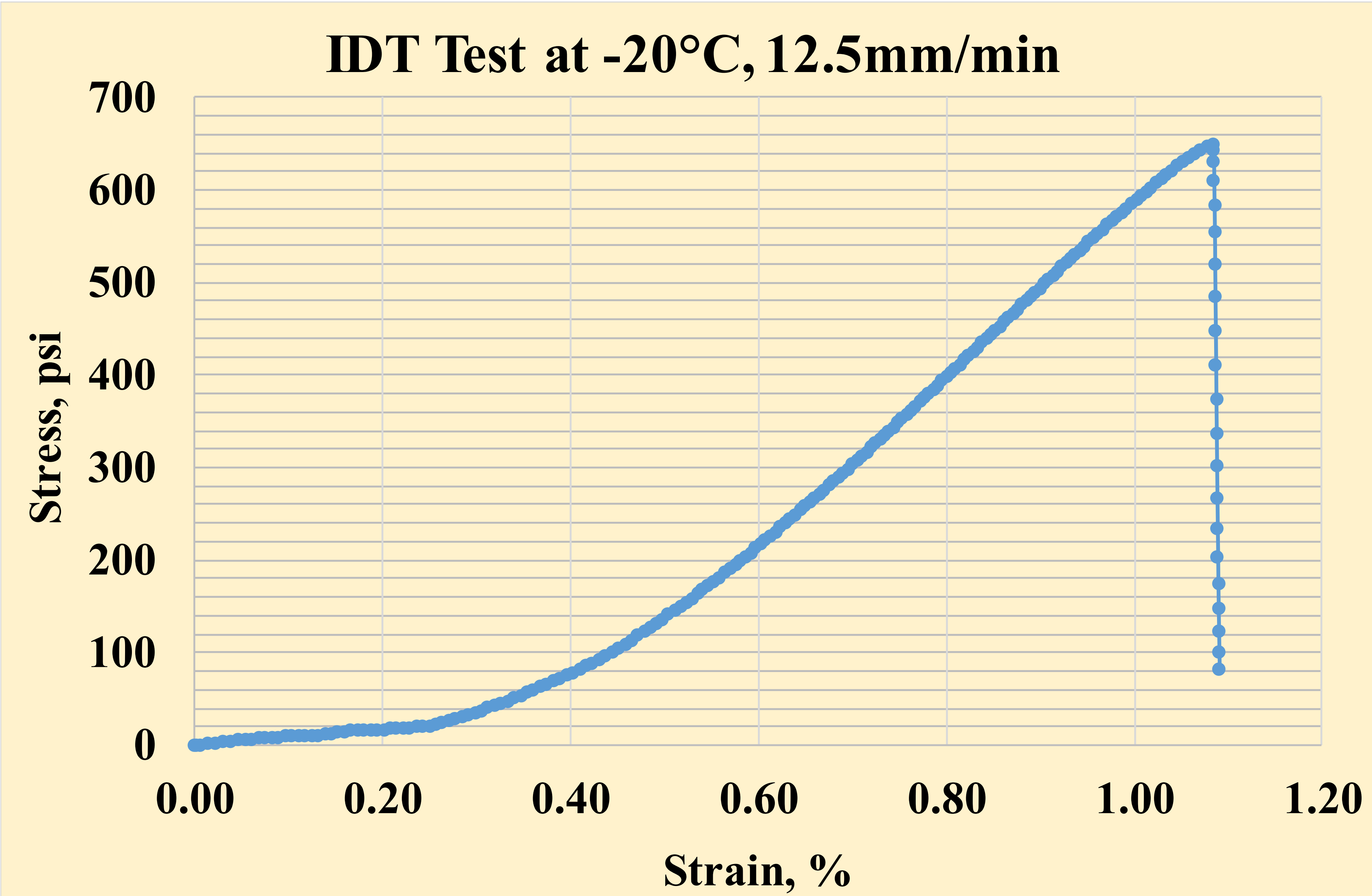
$$S_t = \frac{2P}{\pi t D}$$

Indirect Tensile Test (for TSR)

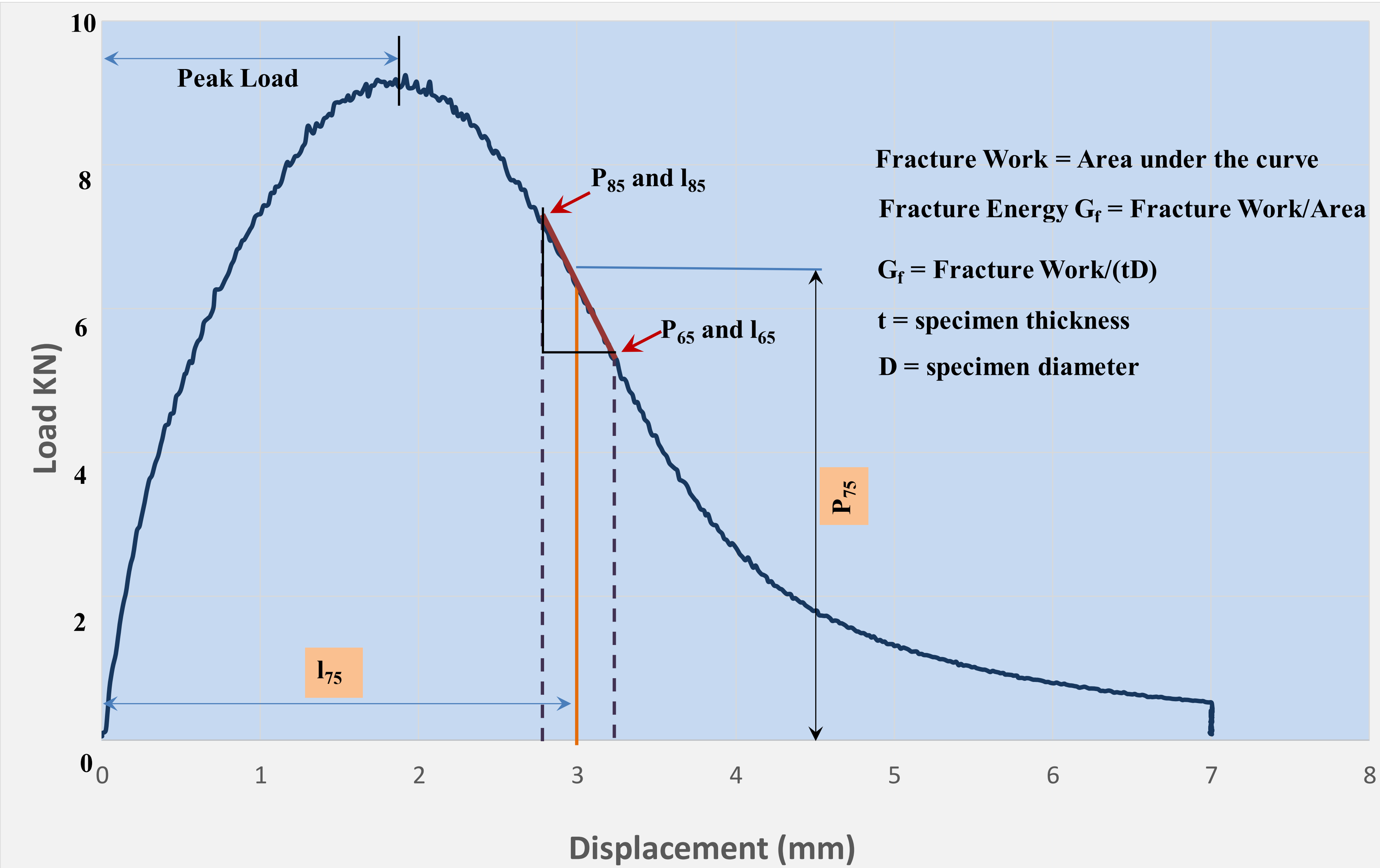




Indirect Tensile Test (for TSR)



IDEAL – Test Results (Similar to SCB)



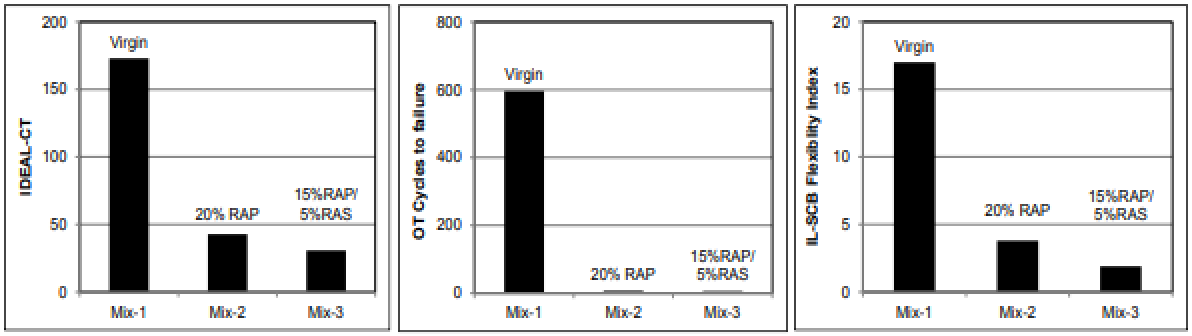
IDEAL – Test Results

Criteria established based on CT_{Index}

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

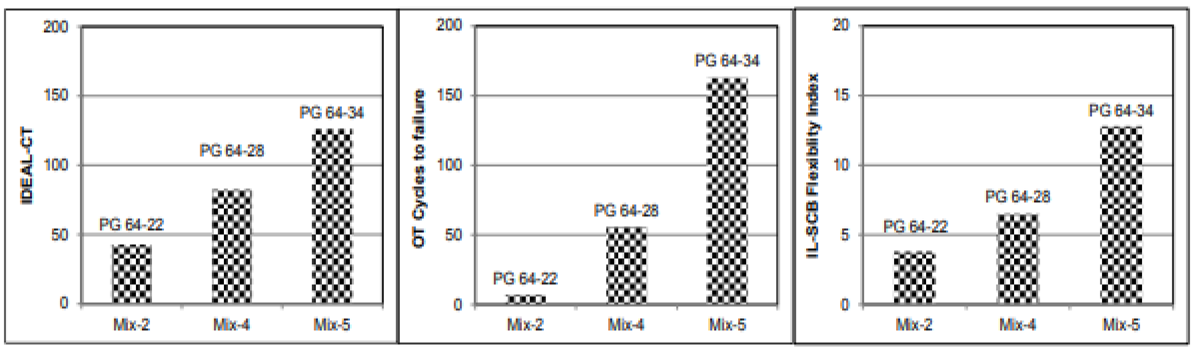
$$\frac{P}{l} = |m_{75}| = \frac{P_{85} - P_{65}}{l_{85} - l_{65}}$$

IDEAL – Test Results – An Example



(a) IDEAL-CT test (b) OT test (c) I-FIT test

FIGURE 11 RAP and RAS sensitivity identified by different cracking methods.



(a) IDEAL-CT test (b) OT test (c) I-FIT test

FIGURE 12 Binder type sensitivity identified by different cracking methods.

Source of Graph: *Final Report, NCHRP IDEA Project 195*
Fujie Zhou, Texas A &M Transportation Institute,
January 2019

Should We Look at IDEAL-CT for PA mixes?

- Need a crack test and this looks good.
- Test has potential for both design and QC
- Easy to do
- Correlates well with SCB
- Use with both cores and lab specimens
- Could use to catalog PA mixes


Thank You!