The “Other” HMA Test

101st THE
Matt Mueller, PE
Engineer of Tests
Illinois Department of Transportation

The "Other" HMA Test for *Flexible* Pavements

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Illinois Center for Transportation
University of Illinois at Urbana-Champaign

ICT - Testing Protocols to Ensure Mix Performance w/ High RAP and RAS


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HMA Pavement Failures

- Rutting

Solution – a Performance Test

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- The test occurs in a 50˚ C water bath.
- It takes less than a day …. to simulate 15 years……
- It's not based on a fundamental property.
- And ….

Solution – a Performance Test

It’s an Accurate Indicator, Not a Flawed Simulator

HMA Pavement Failures

- Rutting
- Cracking

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  - Reflective

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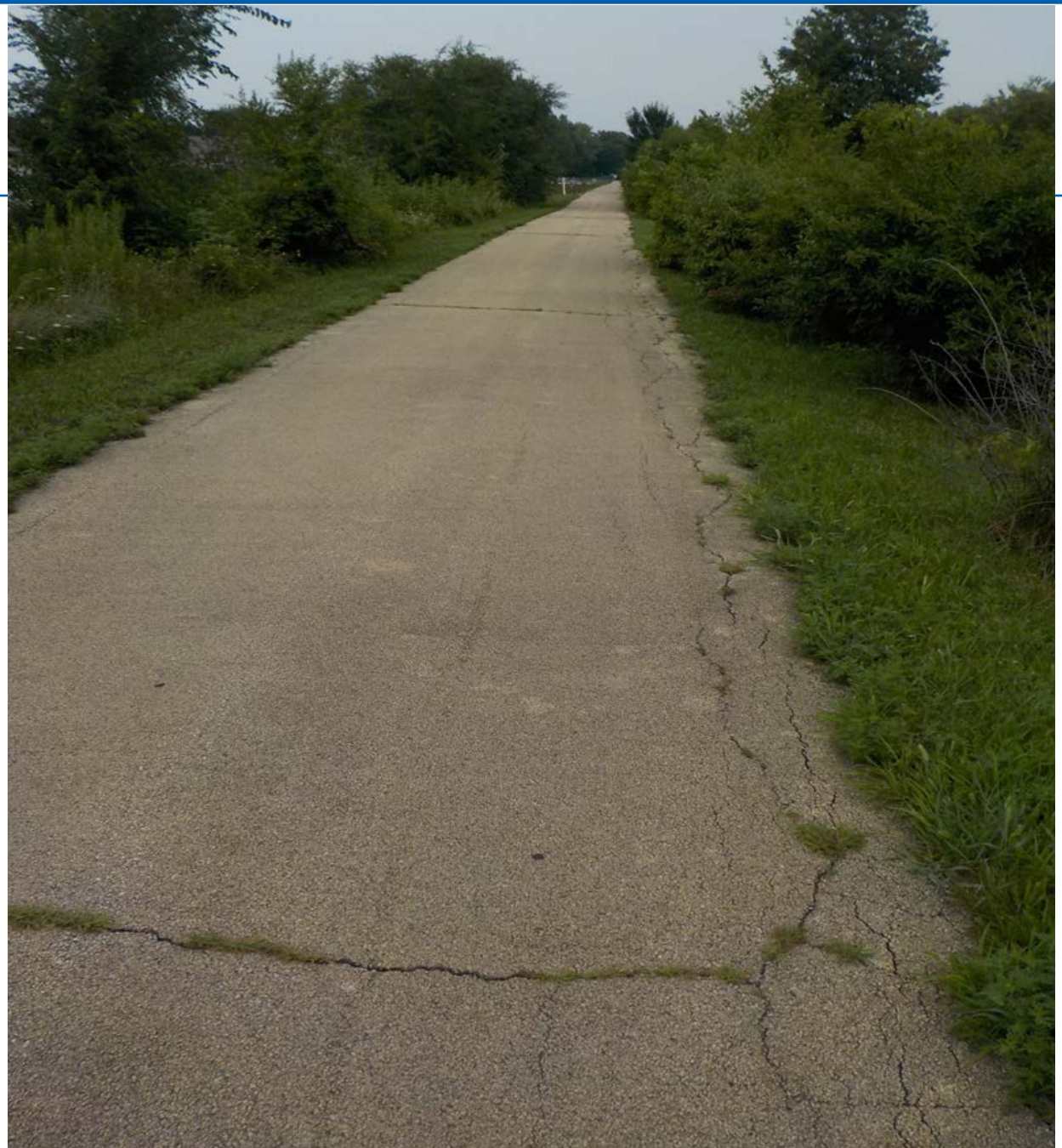
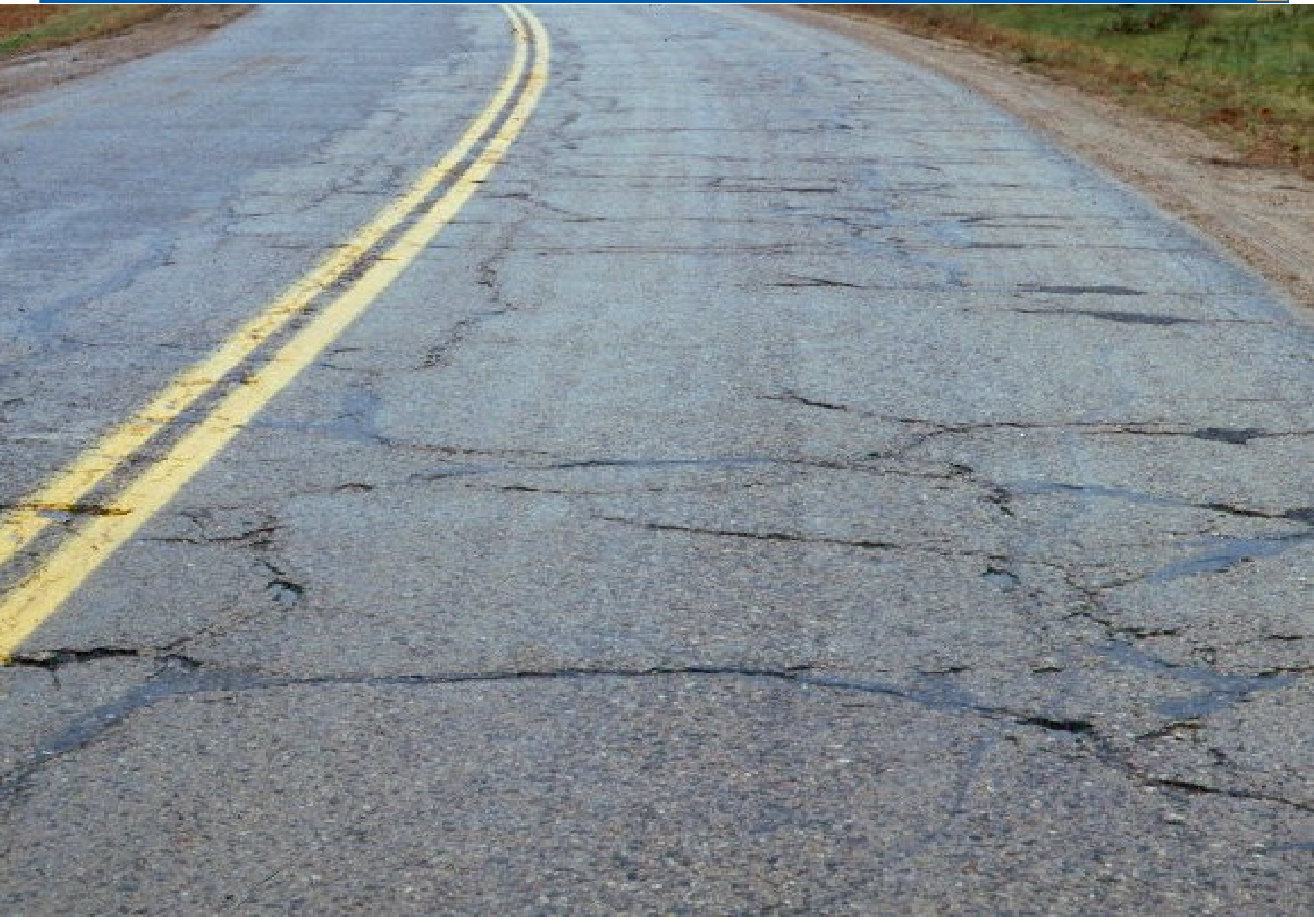
  - Thermal (Cold Weather)



HMA Pavement Failures

- Rutting
- Cracking
  - Reflective
  - Thermal (Cold Weather)
  - Fatigue



Where Do We Need to Focus?

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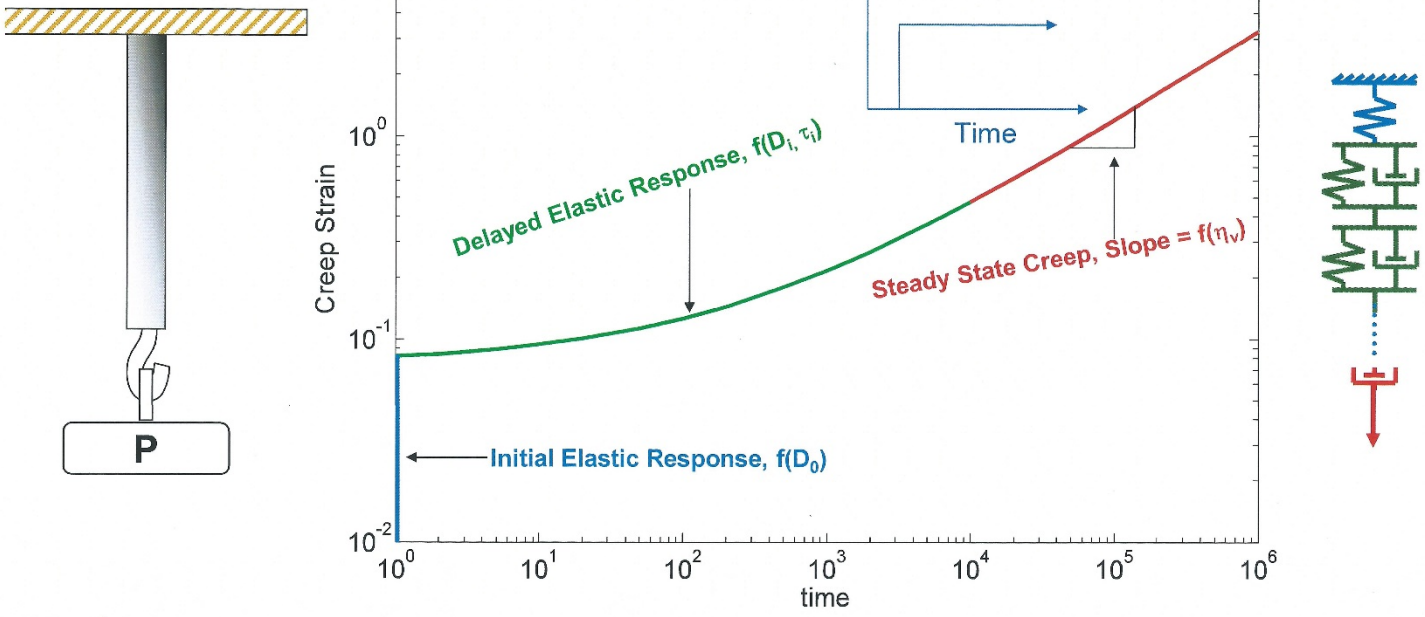
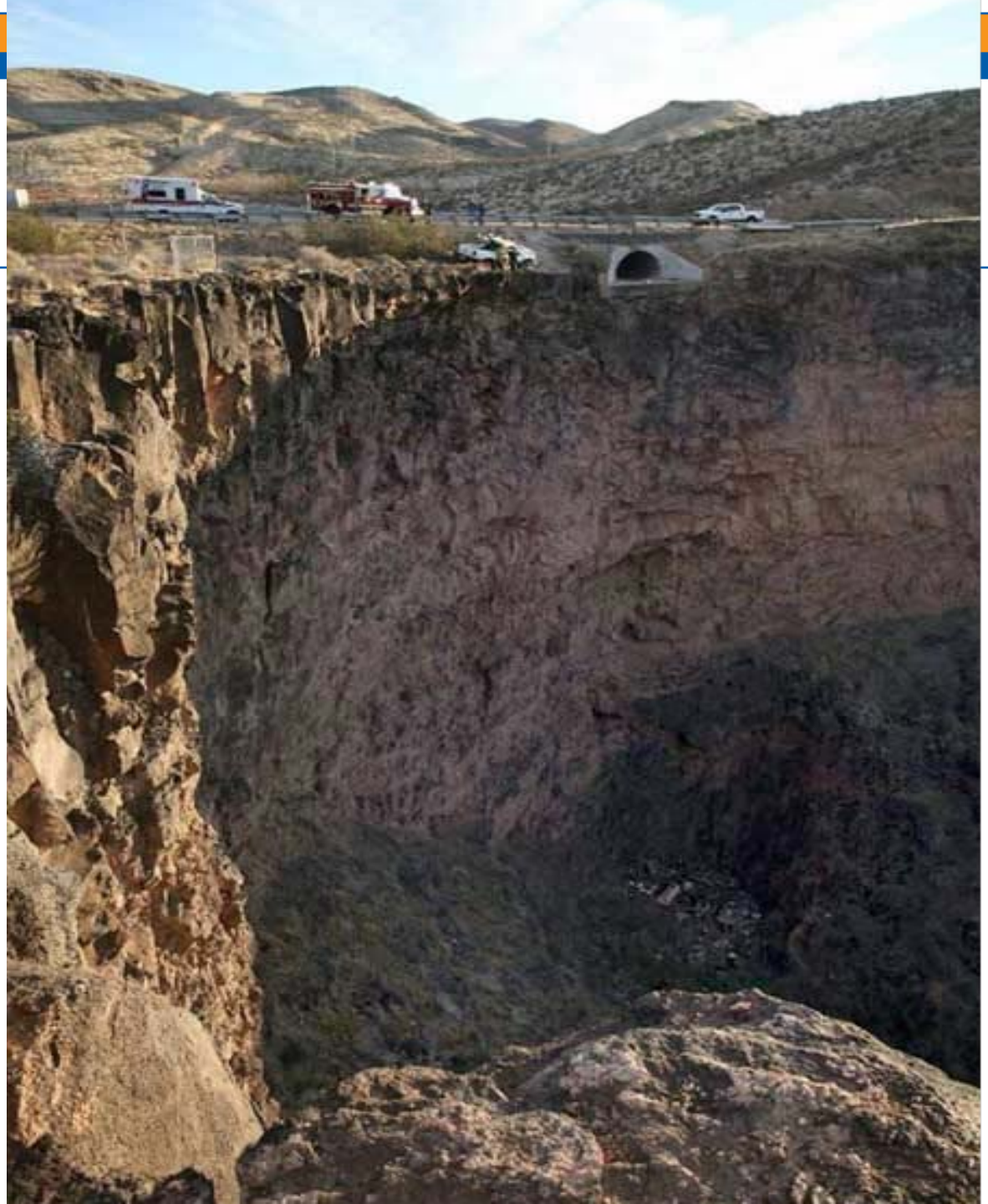
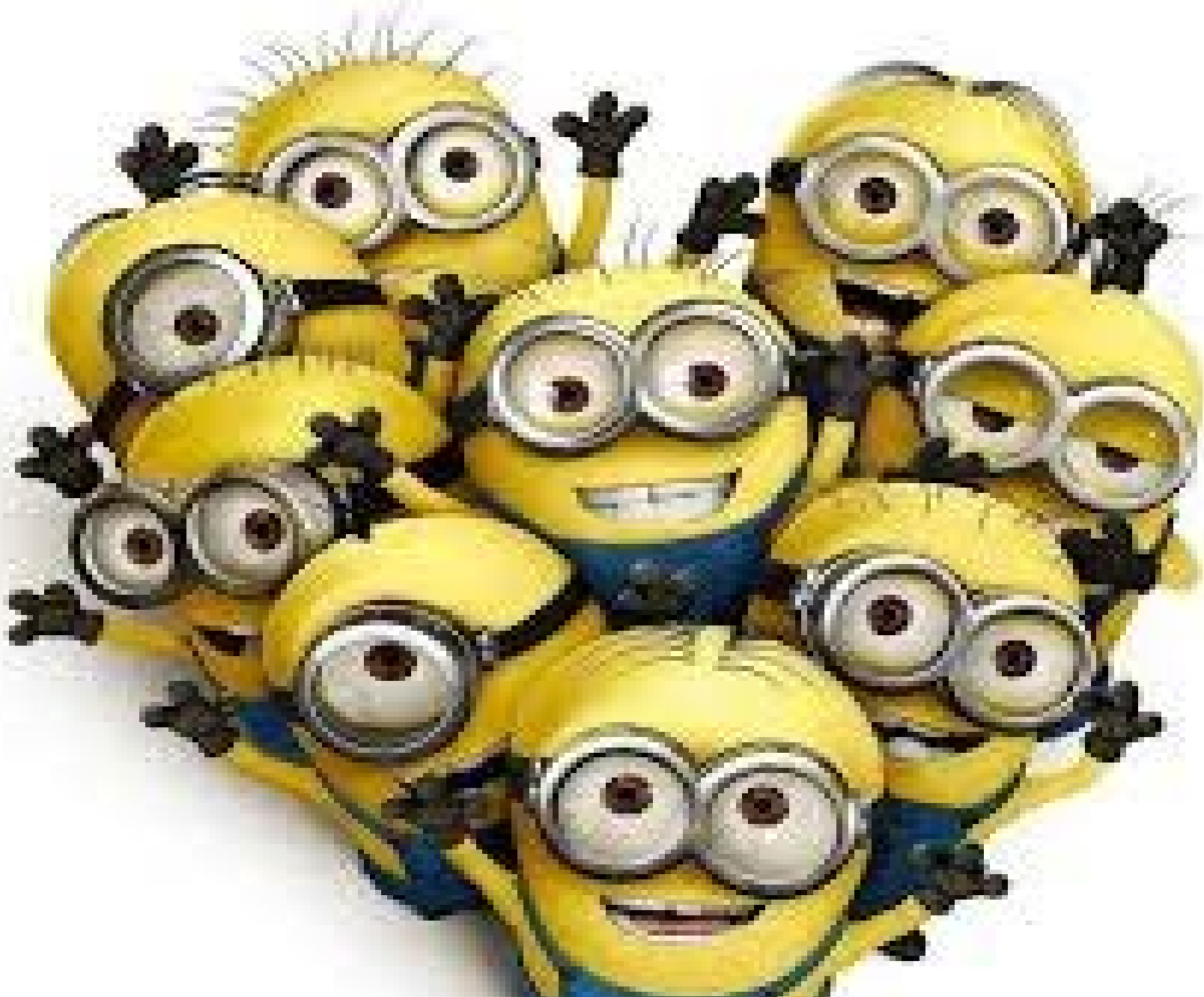
- Asphalt Binder

2. Elastic vs. Viscoelastic Response

2.2. Material Models







Could There be a Single Solution?

Challenges

- SuperPave was developed for neat materials
- More recycled materials are being used in HMA – less virgin components – especially PG asphalts in the final mix
- Currently, some recycled materials are allowed by method specifications intended to limit the risk of cracking by ABR limits and grade bumping, not actual mix performance
- Fatigue cracking issue: stiffer mixes with high ABR may exhibit early fatigue cracking
- Thermal/Block cracking issue: stiffer mixes have reduced relaxation potential

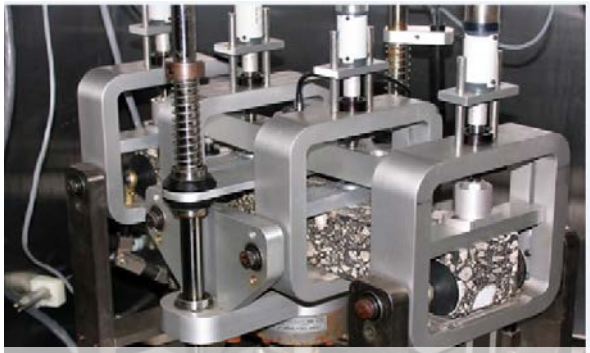
Challenges (RAP/RAS)

- RAP AC can be hard or soft – depends on project(s) milled
- RAP aggregates may be siliceous or carbonate
- Shingle asphalt (***PG 112+02***) is much harder than paving grades
- Counteracting various hard recycled binders with virgin PG binder becomes **arbitrary**
- Neat asphalt **blending** with RAP and RAS for final mix is not understood

Test Method Selection Criteria

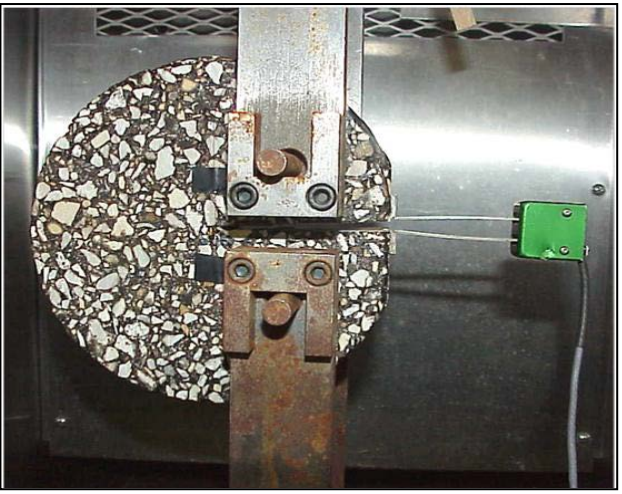
- Practical $$
- Quick turnaround
- Correlation to independent tests and engineering intuition
- Significant and meaningful spread in test output
- Correlation to field performance

Mixture Tests Available



Beam Fatigue Test

Push-pull Fatigue

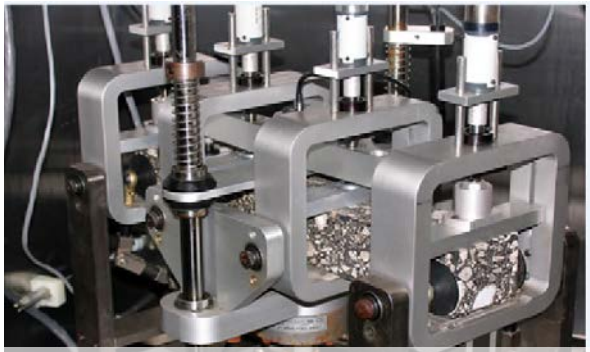


DCT (ASTM D7313)

SCB (AASHTO TP105)

Texas Overlay Test

Mixture Tests Available



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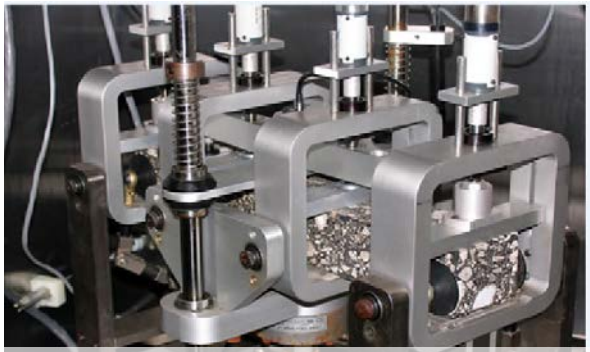

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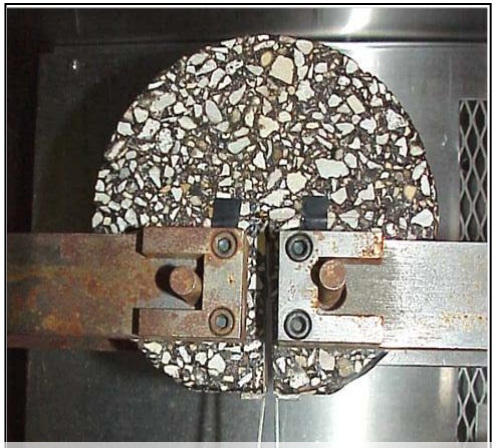


DCT (ASTM D7313)

SCB (AASHTO TP105)

Texas Overlay Test

Semi-Circular Bending Test

- Relies on simple three point bending
- Easy specimen preparation
- Can use AASHTO T283 equipment *
- Repeatable

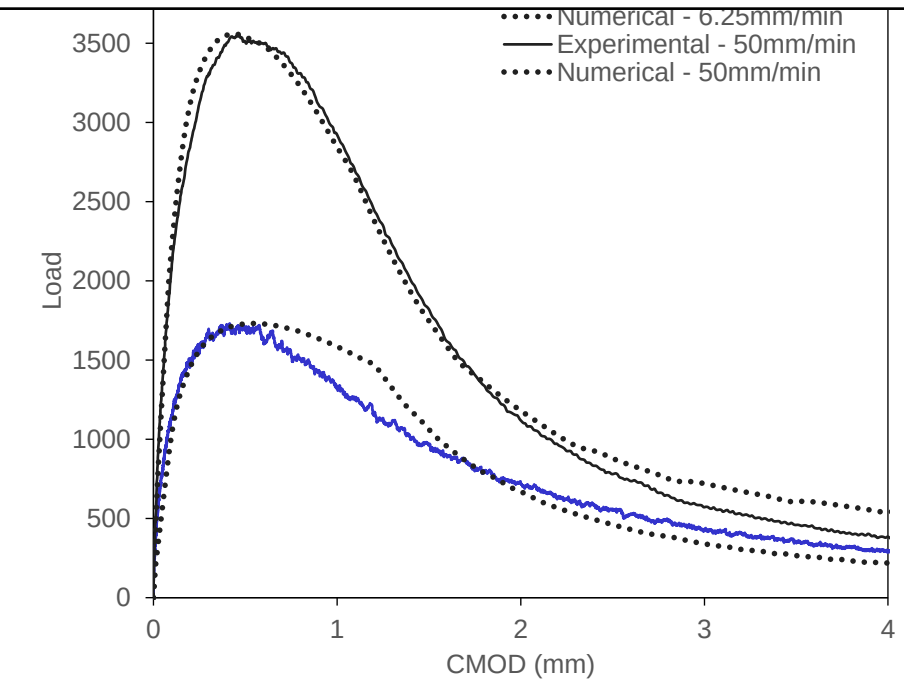
Research Approach

Parameter	Variables
Material Source	Plant Mixes, Lab-Mixes, Field Cores
N-Design	N30, N50, N70, N80, N90
Nominal Maximum Aggregate Size	4.75 mm, 9.5 mm, 12.5 mm, 19.0 mm
Asphalt Binder	PG52-28, PG58-22, PG58-28, PG64-22, PG70-22, PG70-28, PG76-22
Recycled Materials	RAP, RAS, Recycled Concrete, and Steel Slag
Asphalt Binder Ratio	0 to 60
RAP Content (%)	0 to 53
RAS Content (%)	0 to 8.5

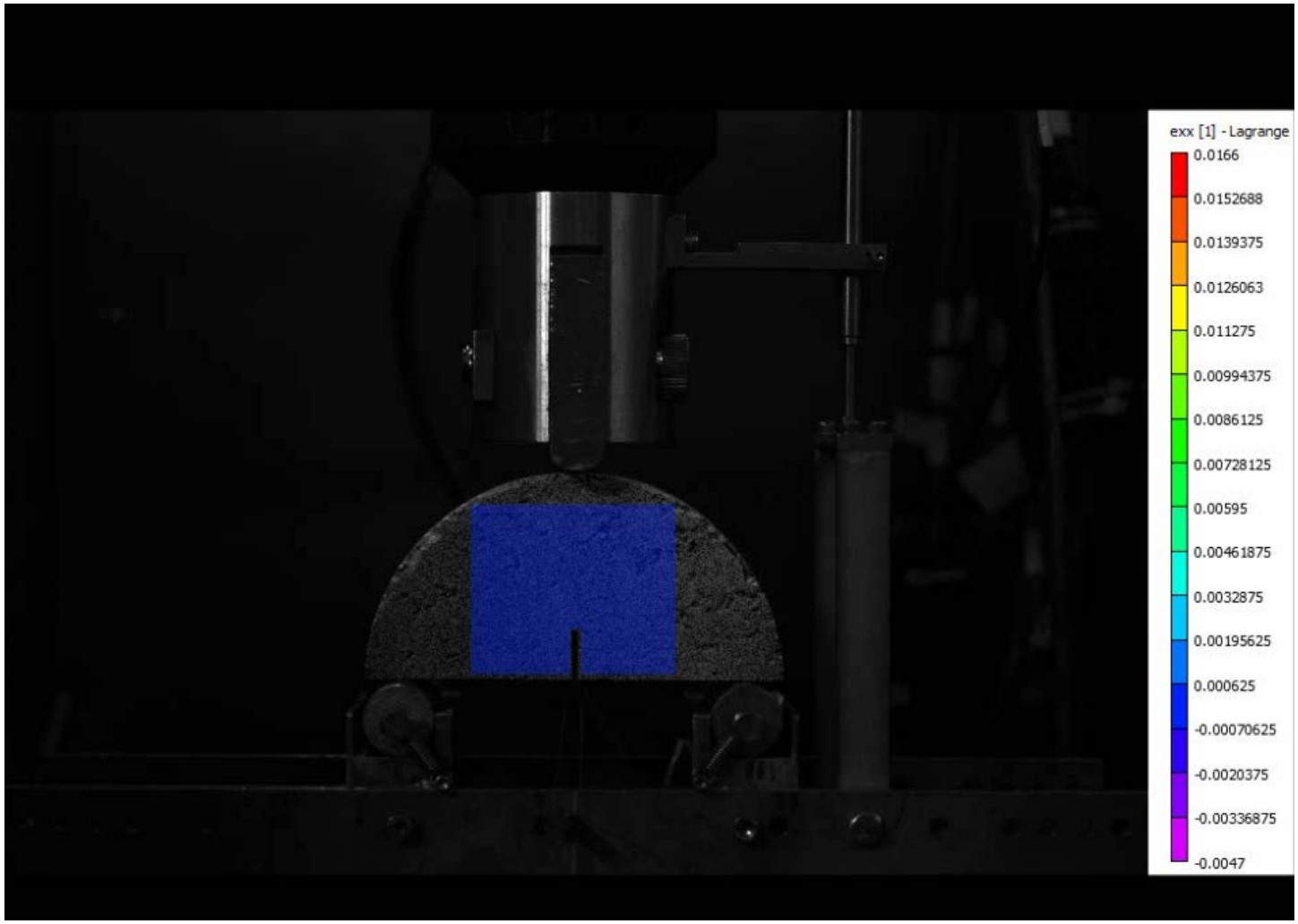
- **Assessment of variety of plant mixes, lab designed mixes, and field cores**
- **Correlation to other tests (modulus and fatigue)**
- **Theoretical and numerical evaluation**

FEM Results

- FEM simulations of N80-25 mix



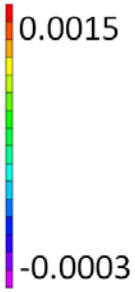
Fracture Process Zone

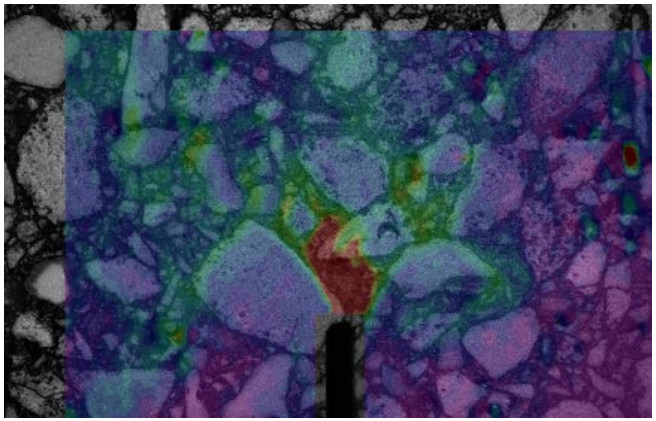


Fracture Process Zone

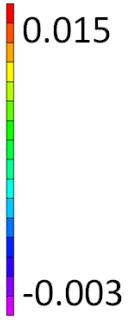
N90 Control (0% RAS)

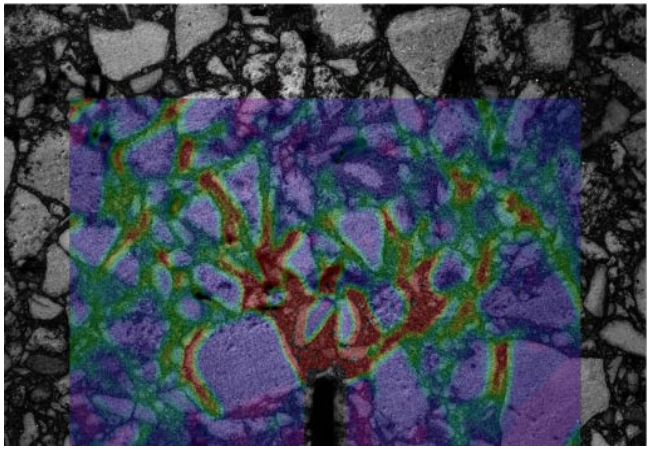
-12°C @ 0.7 mm/min





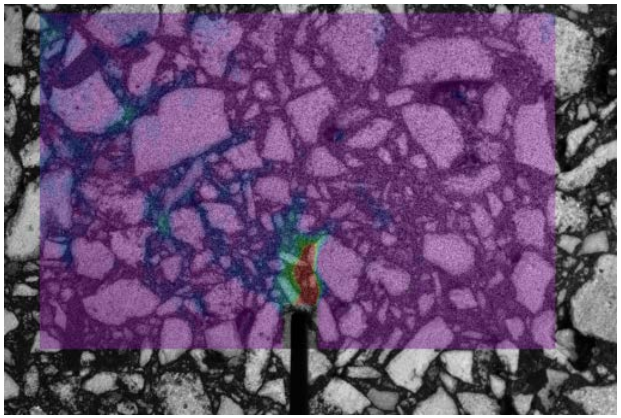
25°C @ 50mm/min



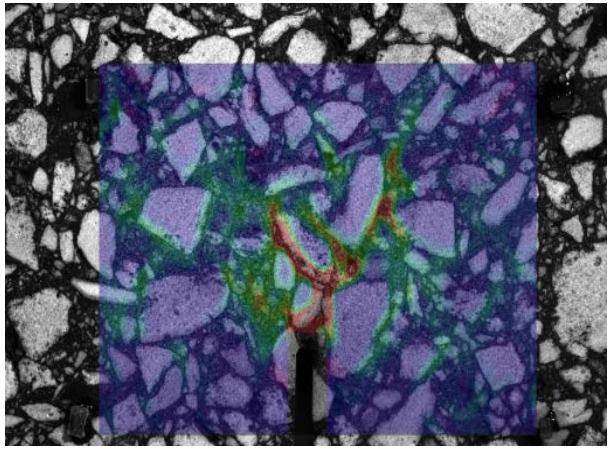


N90 30% ABR (7% RAS)

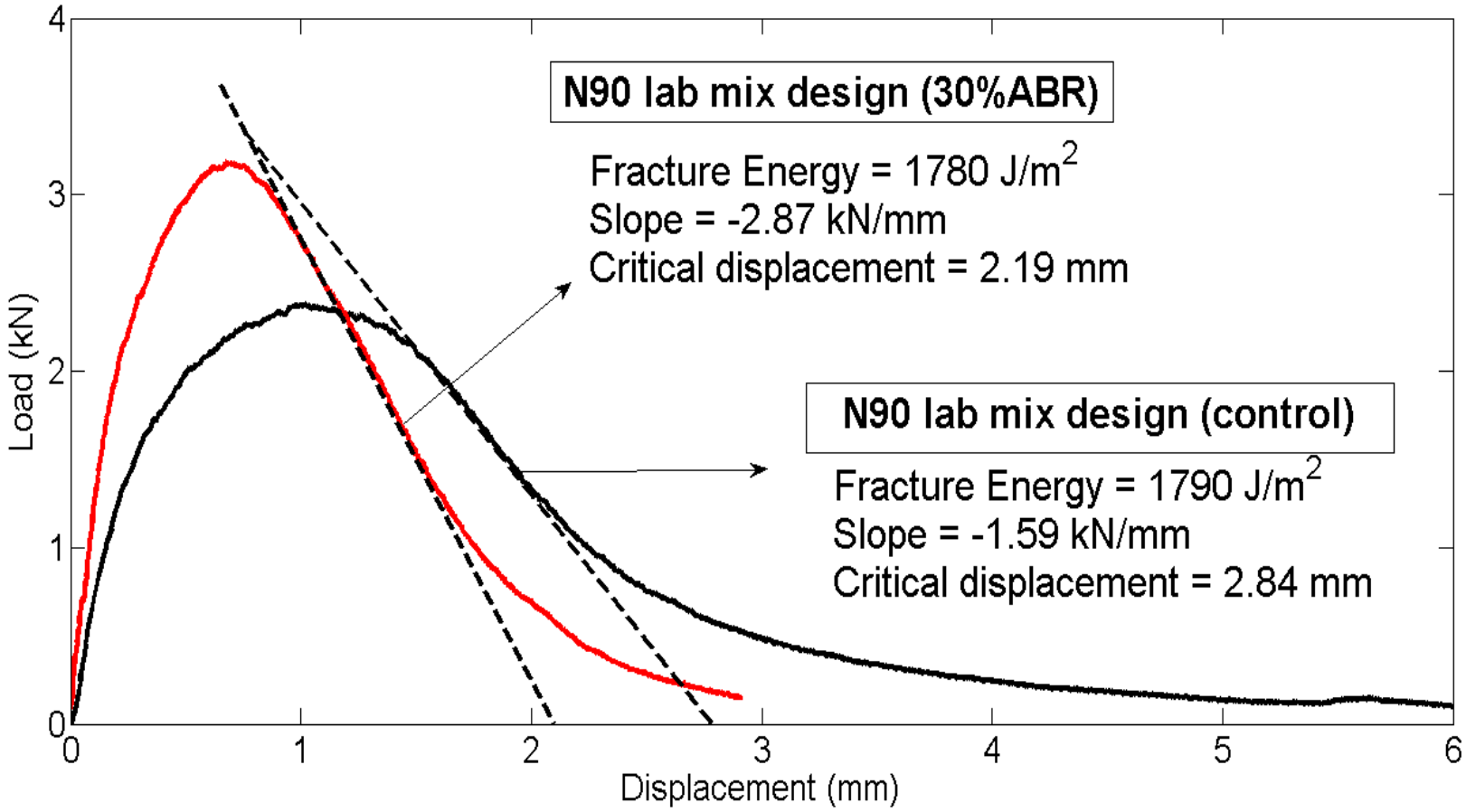
-12°C @ 0.7 mm/min



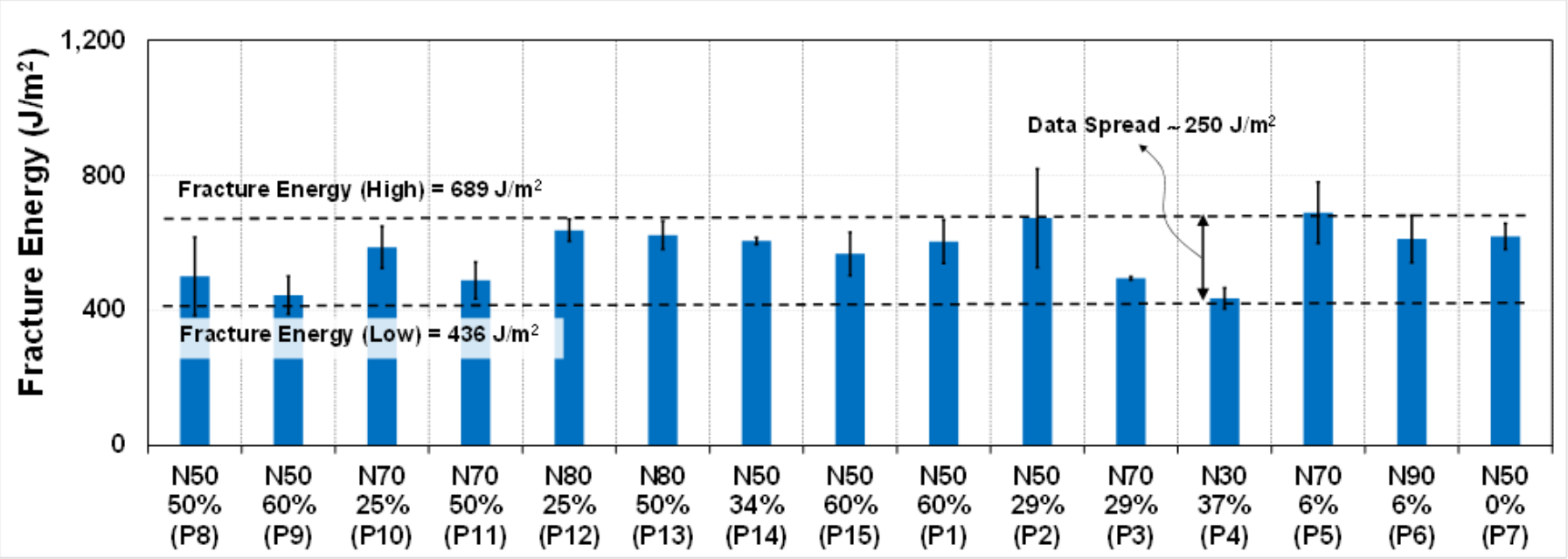
25°C @ 50mm/min



SCB Fracture Results



Establishment of Test Temperature and Loading Rate



- SCB fracture test results at -12°C
- Limited data spread

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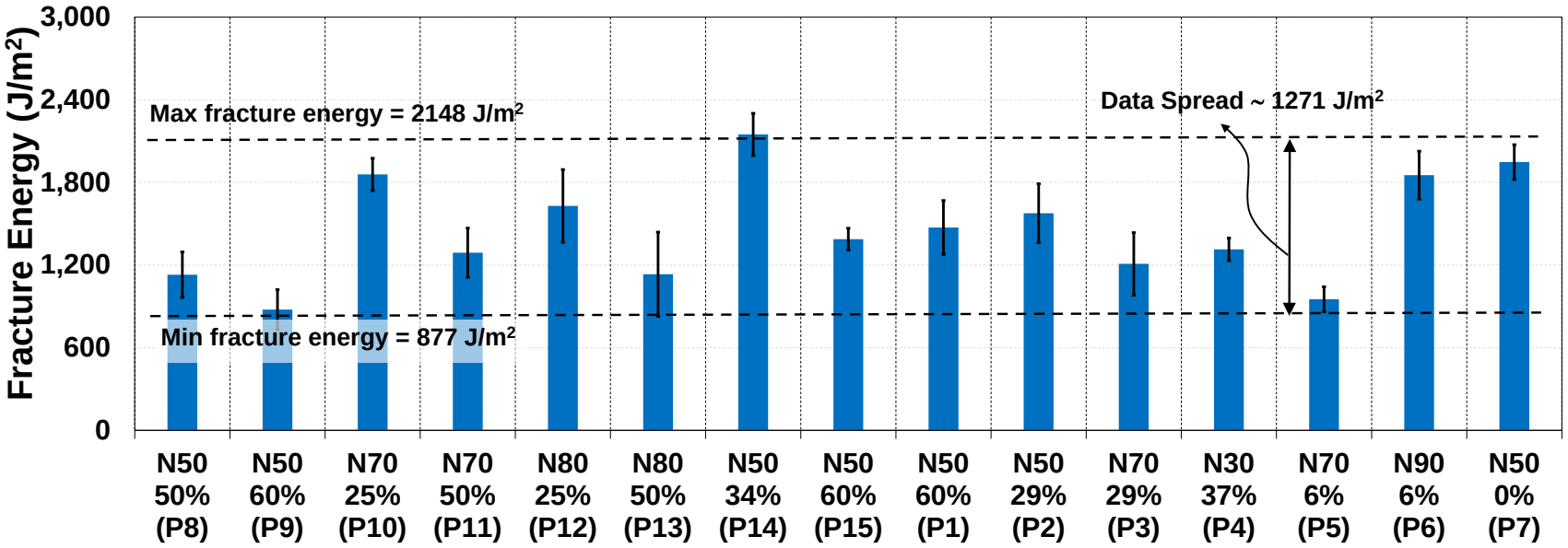

- SCB fracture energy results for the same mixes at 25 °C using displacement control at 50 mm/min
- Significant spread in fracture energy

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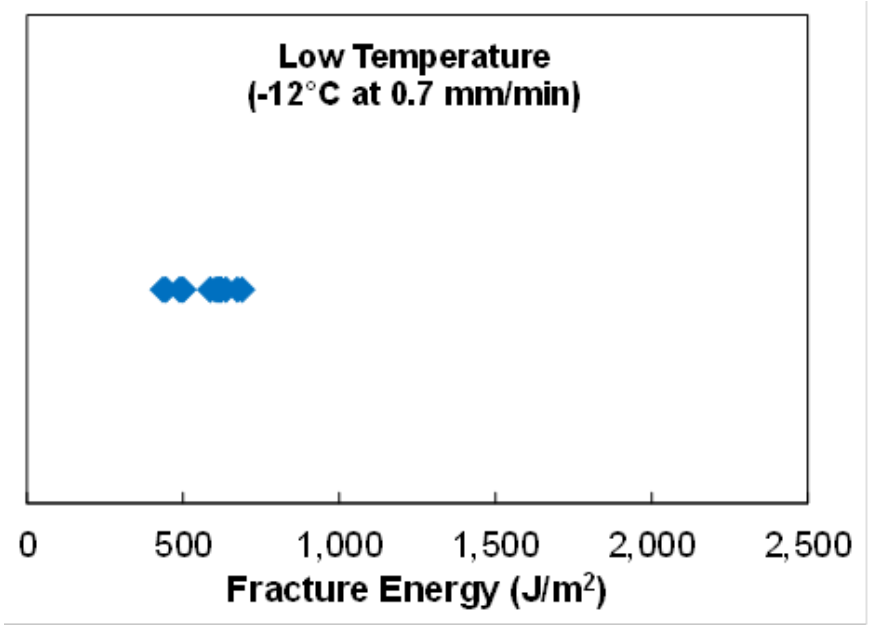
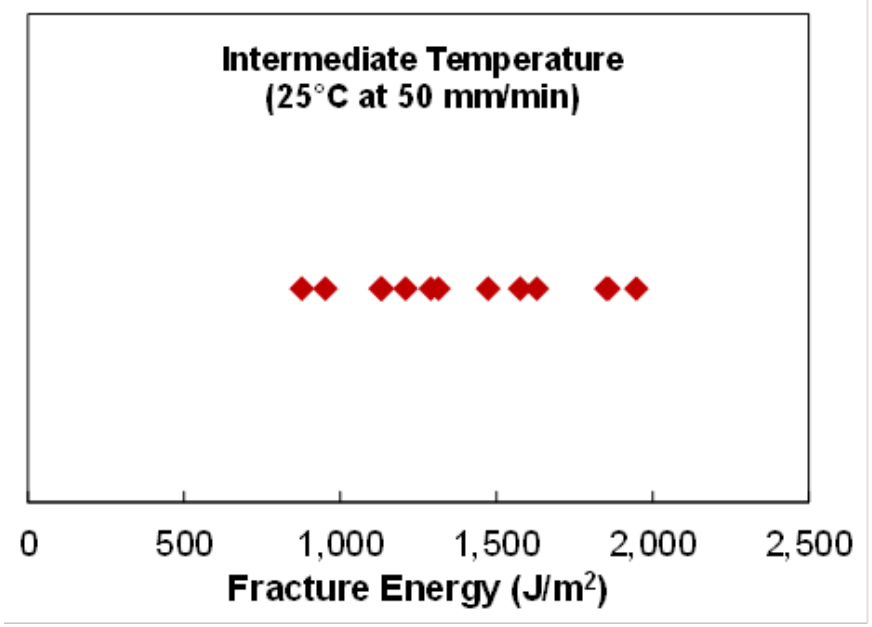


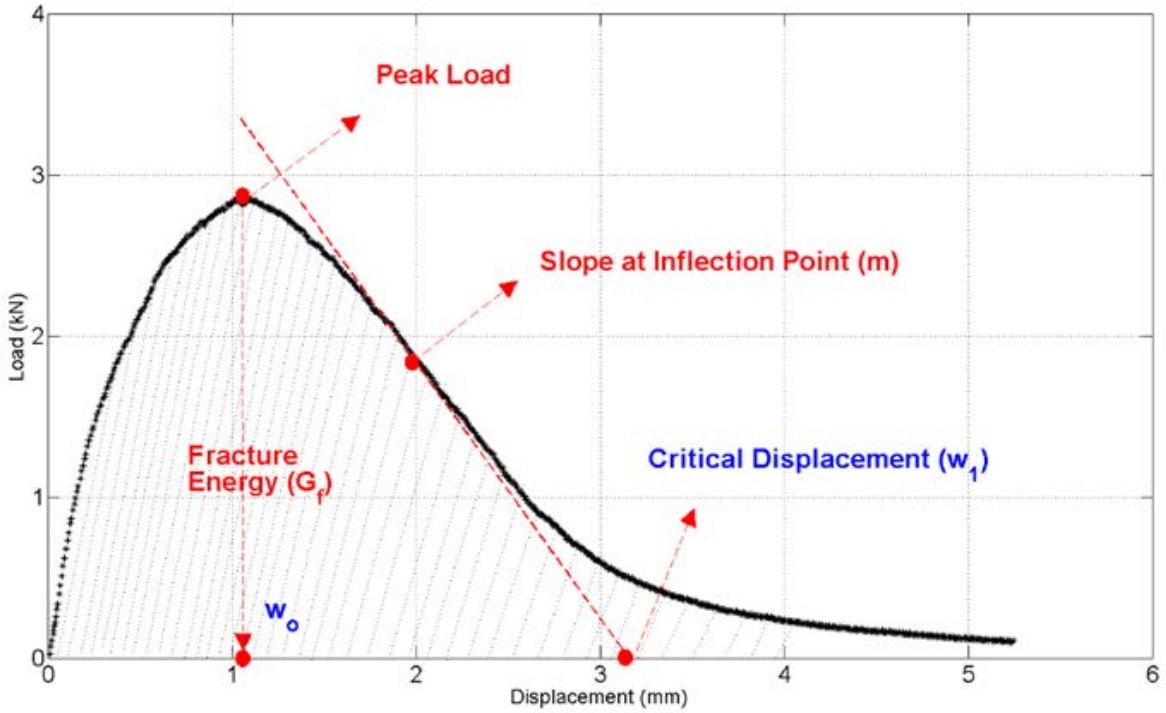


- A comparison of low temperature and intermediate temperature (25ºC) SCB test results indicate the suitability test to discriminate mixes
- 25 ºC and 50 mm/min loading rate were selected

SCB Fracture Results

- Flexibility Index calculated for two lab design (N90) mixes w/ and w/o ABR (30% ~ 7% RAS):

Flexibility Index (FI) = $A * G_F$ /m



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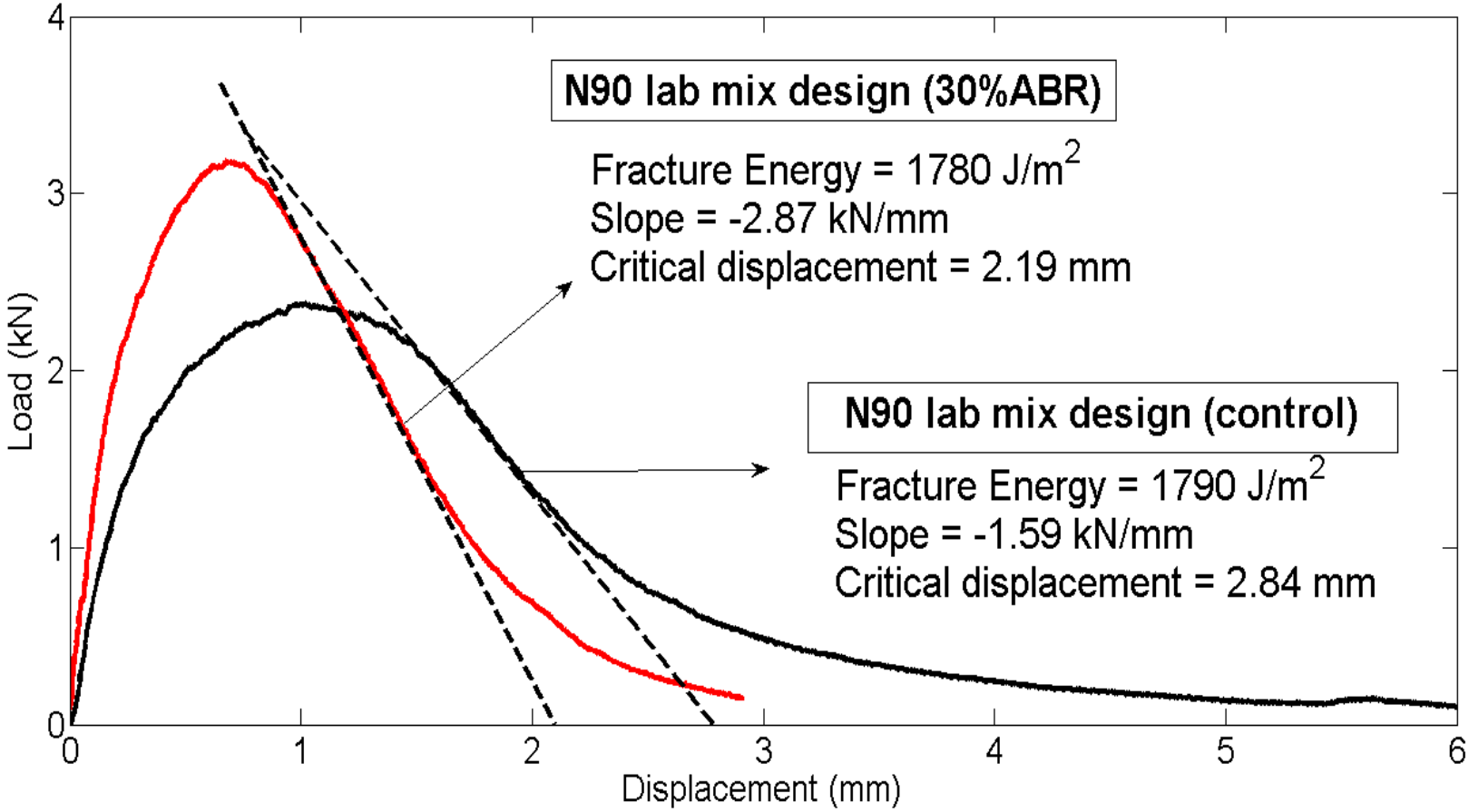
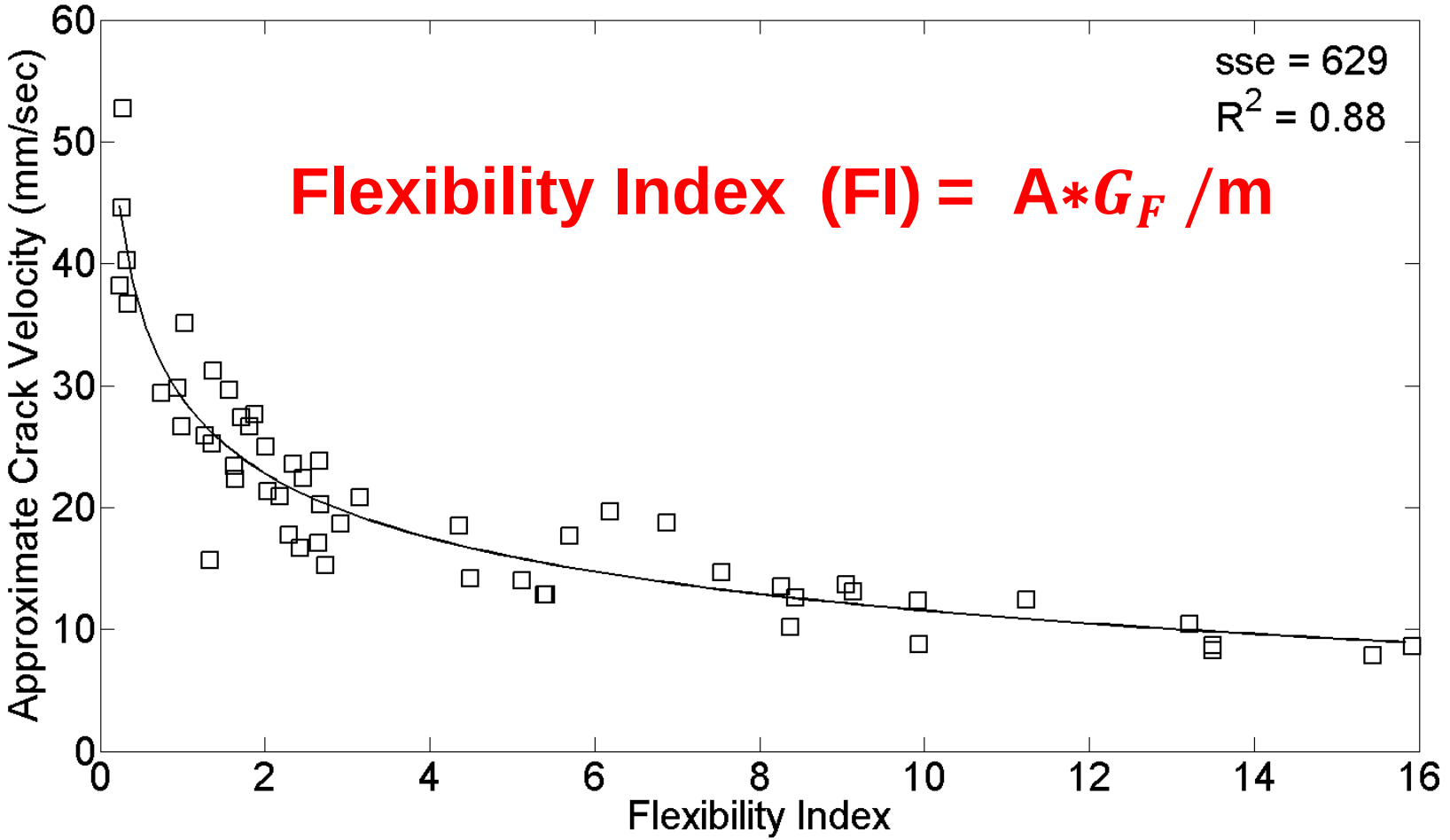


Development of Flexibility Index

- A **theoretically**-supported flexibility index (FI)



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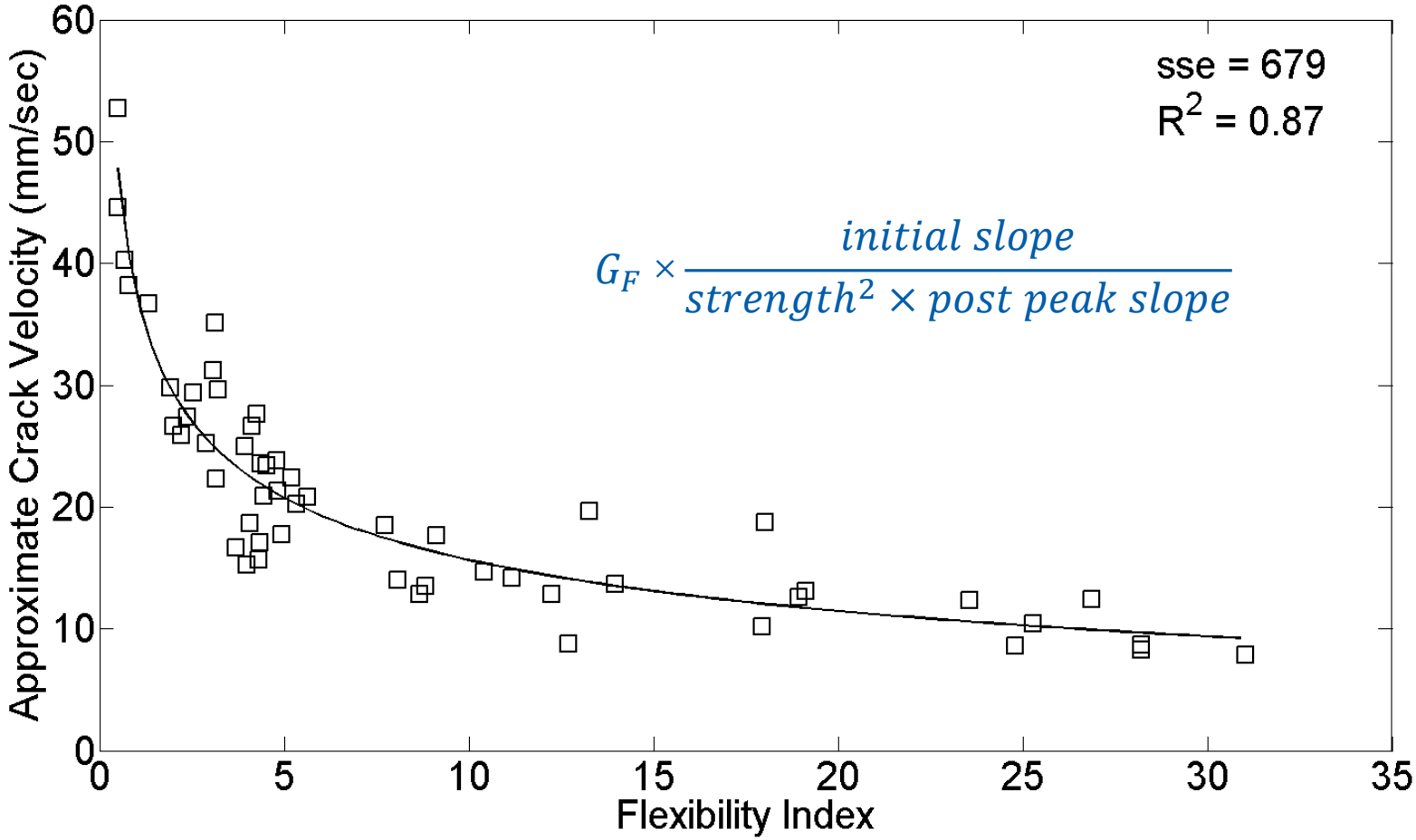

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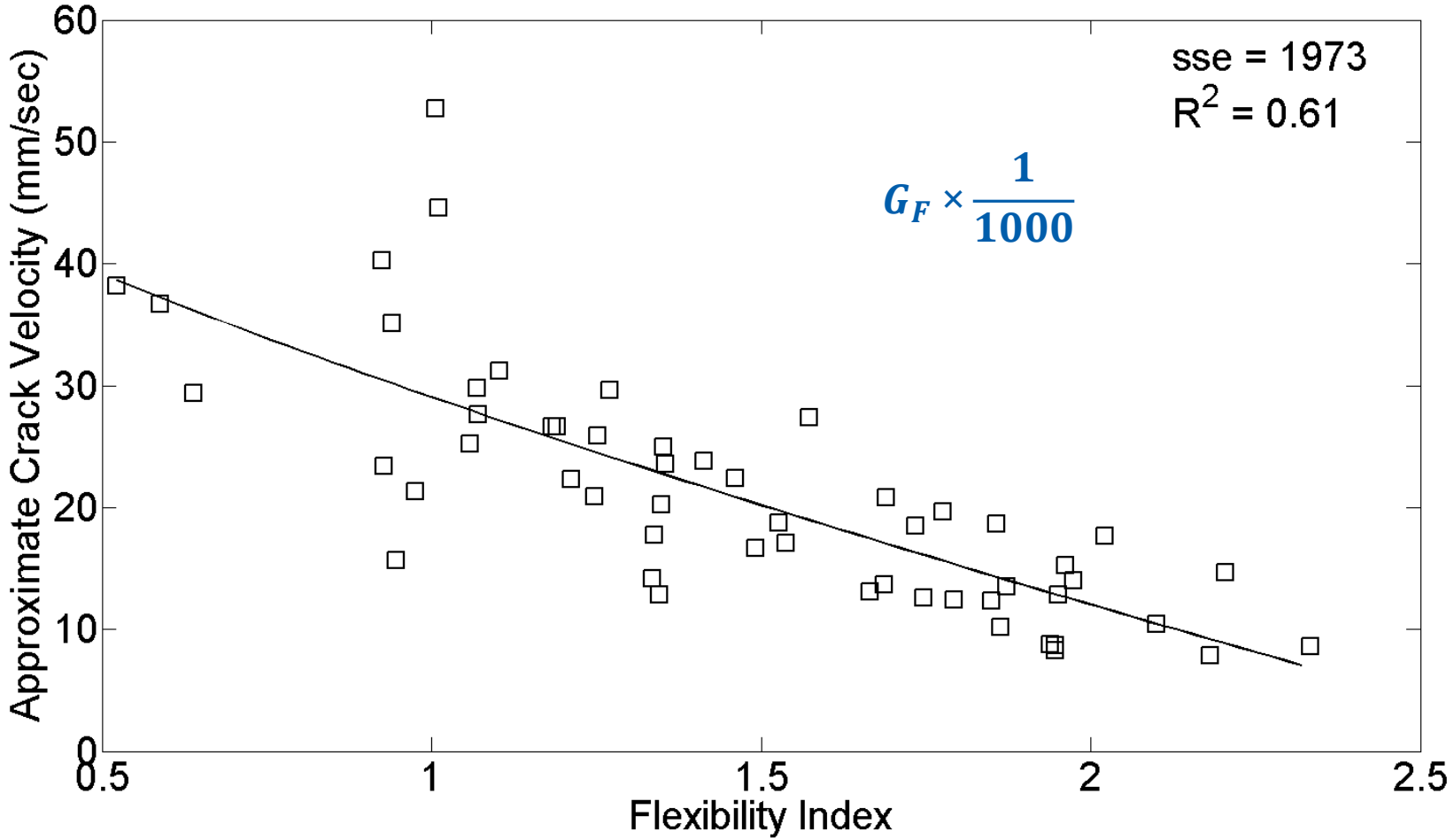
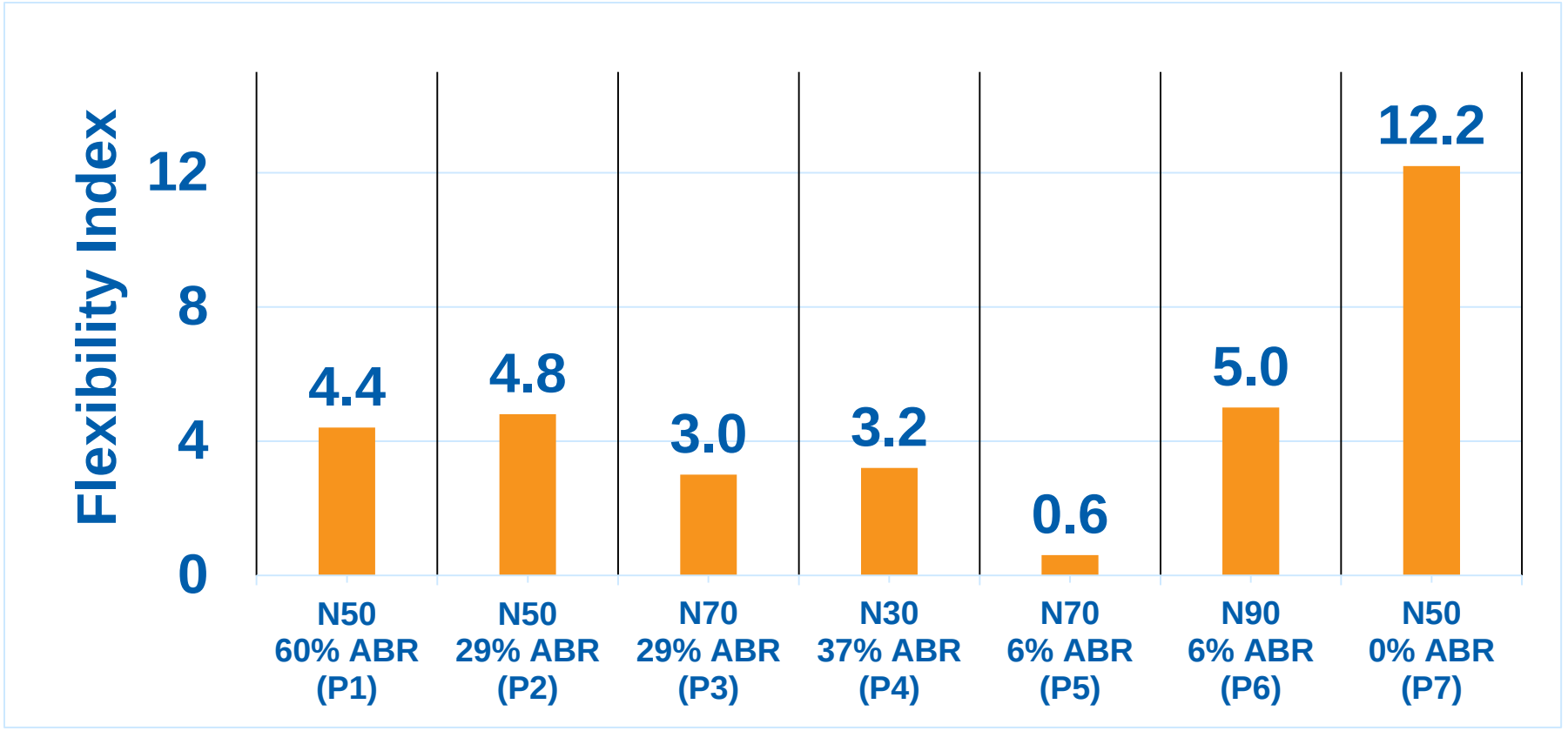
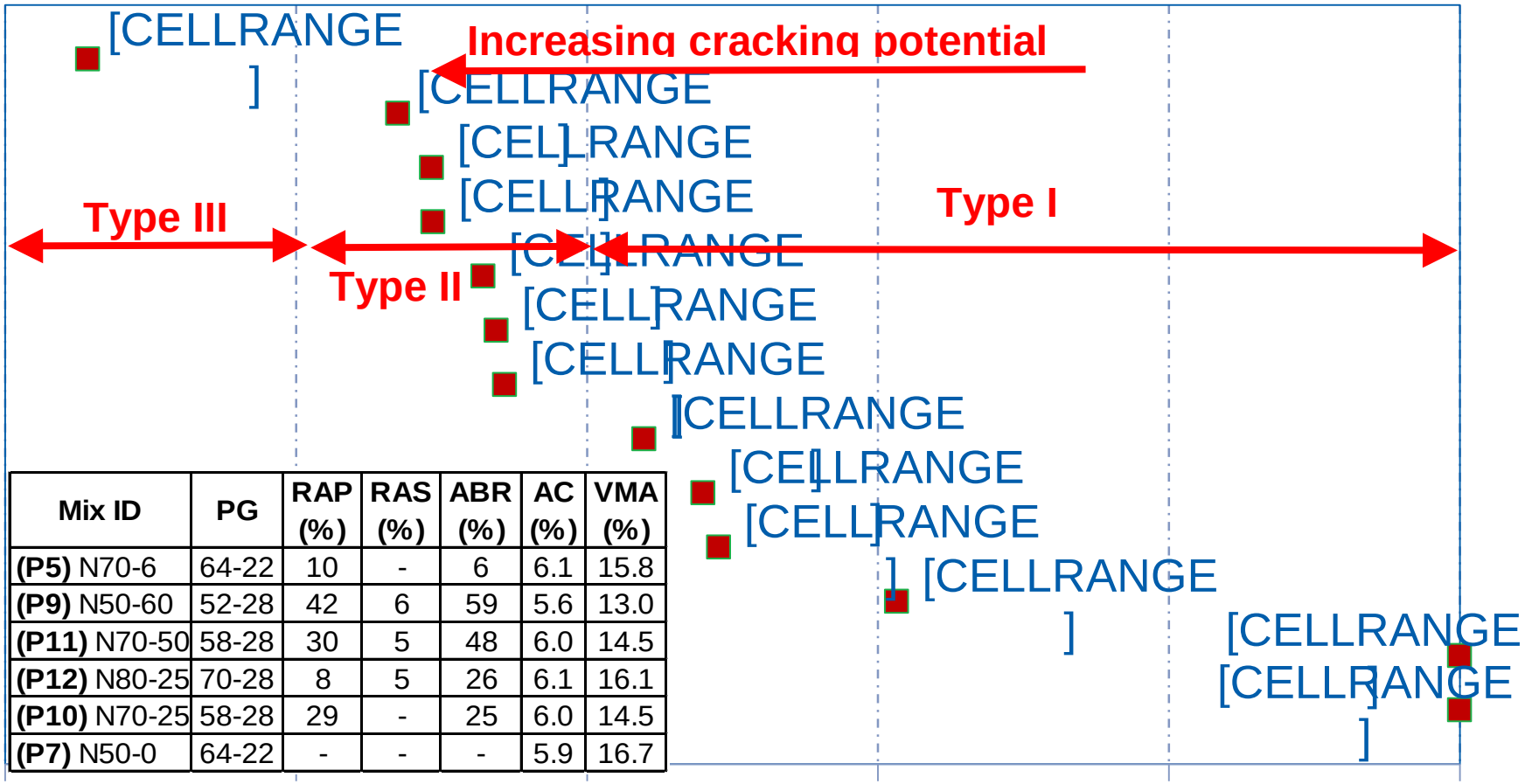


FI Results

- Flexibility index calculated for selected plant mixes

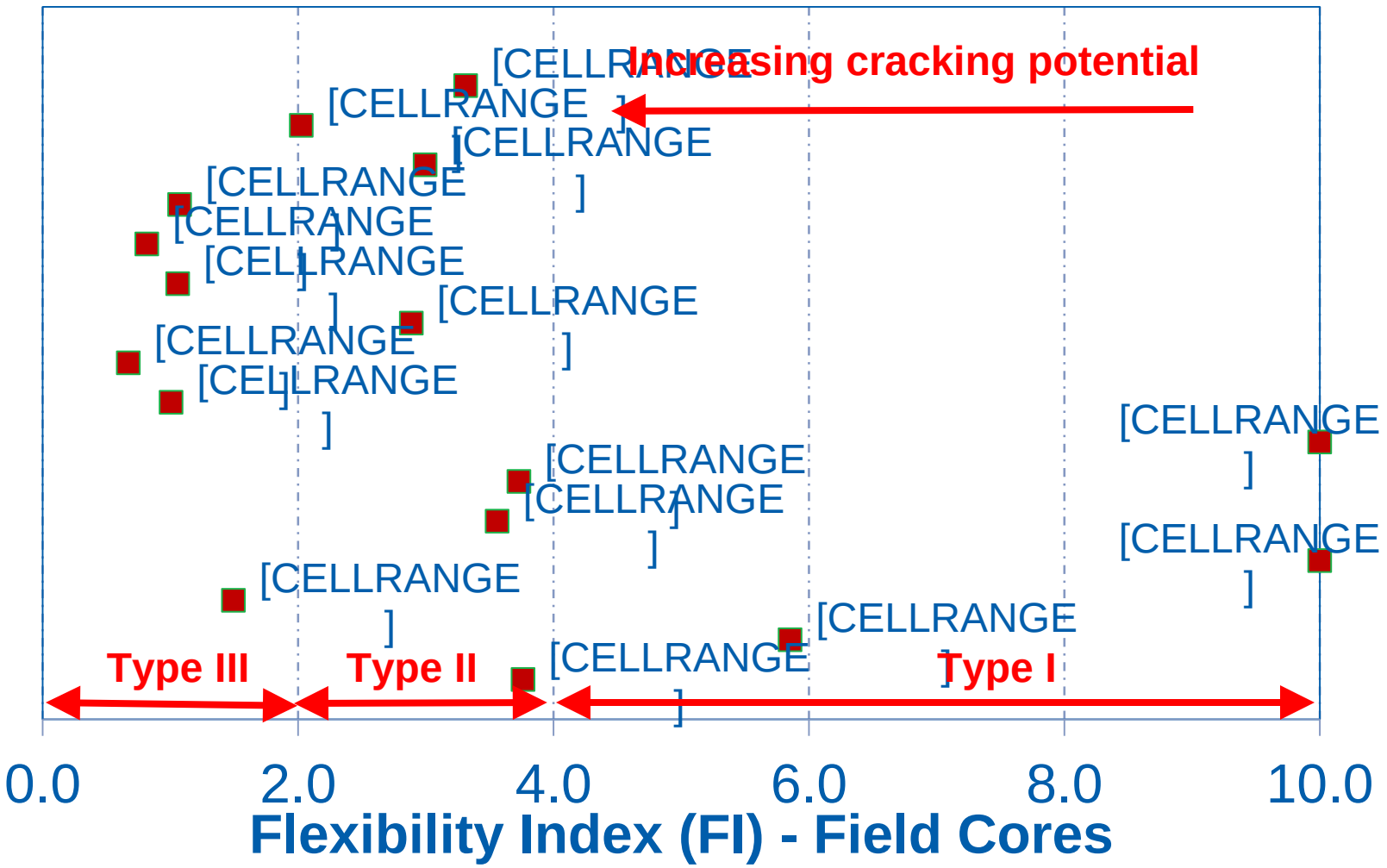


FI - Plant Mixes



Mix ID	PG	RAP (%)	RAS (%)	ABR (%)	AC (%)	VMA (%)
(P5) N70-6	64-22	10	-	6	6.1	15.8
(P9) N50-60	52-28	42	6	59	5.6	13.0
(P11) N70-50	58-28	30	5	48	6.0	14.5
(P12) N80-25	70-28	8	5	26	6.1	16.1
(P10) N70-25	58-28	29	-	25	6.0	14.5
(P7) N50-0	64-22	-	-	-	5.9	16.7

FI (with SF): Field Cores



FI Categorization & Implementation

- **Draft Categorization of Mixes Using Flexibility Index and Threshold**

Mix Category	Mix Type Based on Flexibility Index (FI)	Potential Actions and Remedies
Unacceptable Mix	Type III (<2.0)	Reject mix due to high early cracking potential. Redesign the mix.
Inferior Mix	Type II (≤2.0-4.0)	Mix susceptible to cracking. Use the mix only in temporary application or redesign.
Acceptable Mix	Type I (≤4.0-10.0[1])	Accept the mix. Mix is expected to perform adequately. Use the mix in surface overlay or typical pavement applications.

***Lab-compacted mix having FI > 10 is considered high performance mix.**

+

+

Low Temperature Cracking

Fatigue Cracking/ Service Temperature

Permanent Deformation

-40°C **-20°C** **20°C** **40°C**

Low in-service temperatures

Intermediate in-service temperatures

High Temperatures

Owner Concerns

- We don’t know where asphalts originate
- We don’t know what is added to asphalts
- We don’t know what is in recycled materials
- We don’t know what happens when sources of asphalt and aggregate change
- We don’t know what damage occurs during production in various plants
- We need a mix cracking performance test

The Other HMA Test

The Other HMA *Performance* Test

The Other HMA *Performance* Test

- With the Hamburg Wheel to minimize rutting probability ….

The Other HMA *Performance* Test

- With the Hamburg Wheel to minimize rutting probability ….
- The SCB reduces risk to the owner of premature pavement cracking
  - It is simple and scientifically sound
  - Can test gyratory specimens or field cores
  - The Flexibility Index can discriminate between good and poor performing mix
  - More validation is underway*