Impact of ICT Research on the HMA Industry

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ICT, Director

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Test Protocols for High Asphalt Binder Replacement

Sponsor: Illinois Dept. of Transportation/
Federal Highway Administration

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Sustainable Asphalt Mixtures

- ***High-performance and durable mixes*** **to reduce frequency of maintenance and rehabilitation treatments and provide smooth riding surface**
- ***Lower environmental footprint*** **with replacement of virgin constituents (aggregate and binder) with recycled materials, industrial by-products, and non-petroleum products**
  - **Warm-mix asphalt technology**
  - **RAP, RAS, RCA, steel slag, etc.**
  - **Bio-binder alternatives**

Testing Program for High ABR Mixes





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

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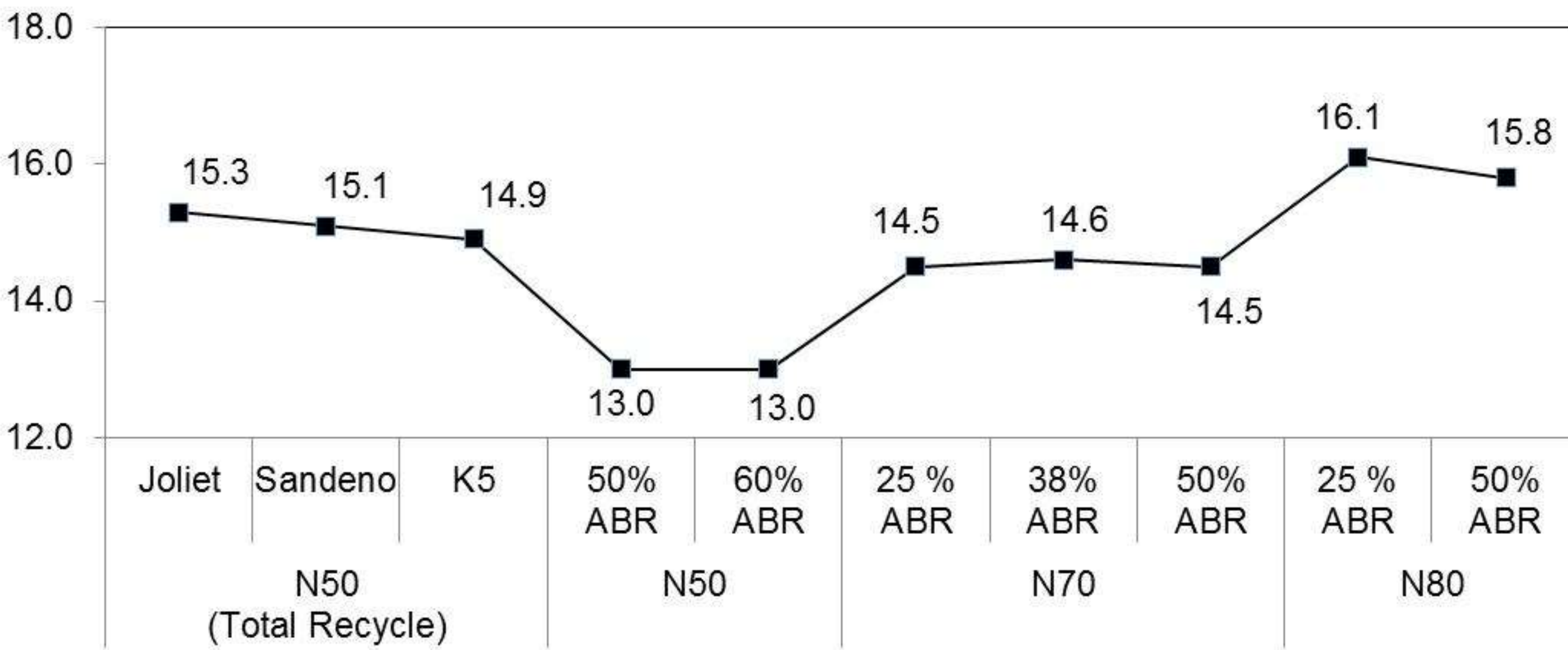
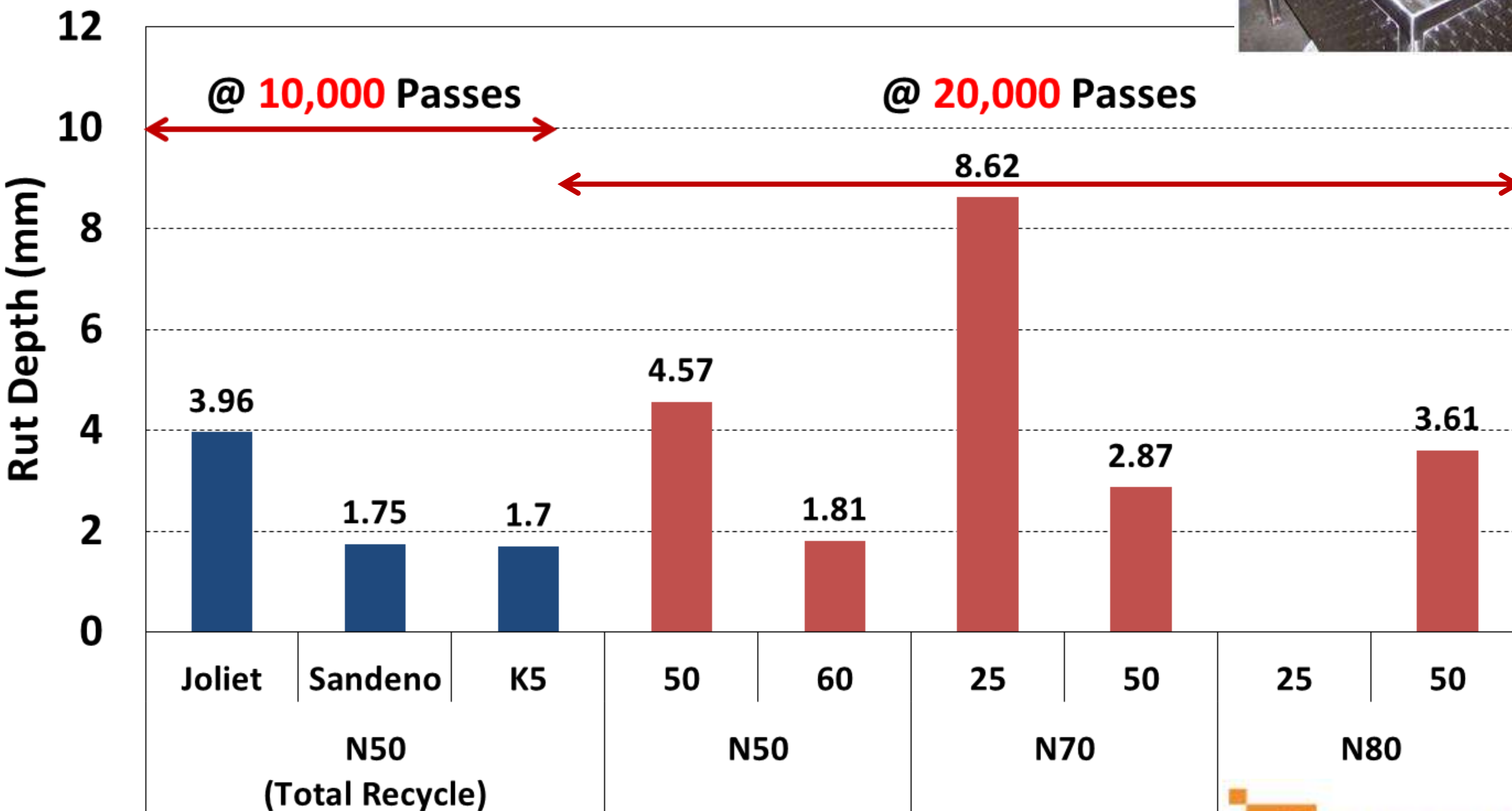
High ABR* Mixes

Mix Type	%ABR	%RAP	%RAS	Slag	RCA
IL-19 mm N50	50	42	4	-	-
IL-9.5 mm TR-Sandeno	57	52	3.5	15	30



Part of the ICT R27-128, Performance of High Asphalt Binder Replacement Mixes Using RAP & RAS

Rut Resistance



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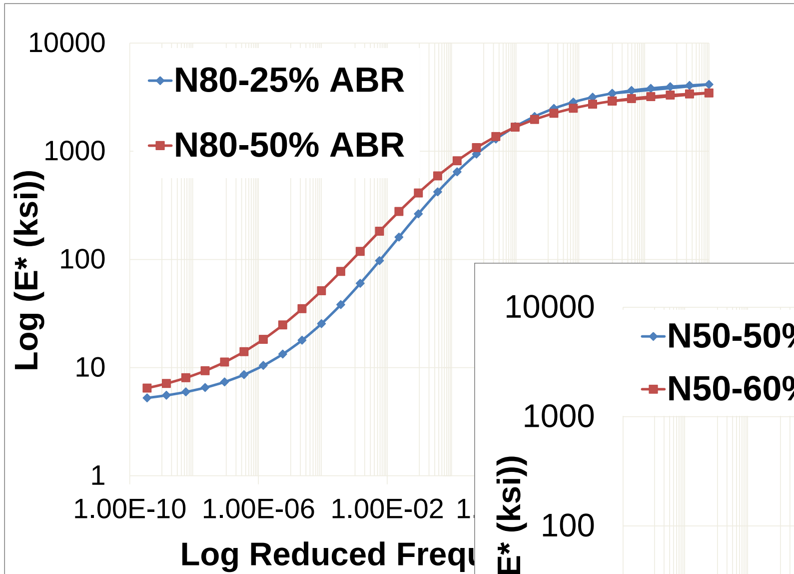
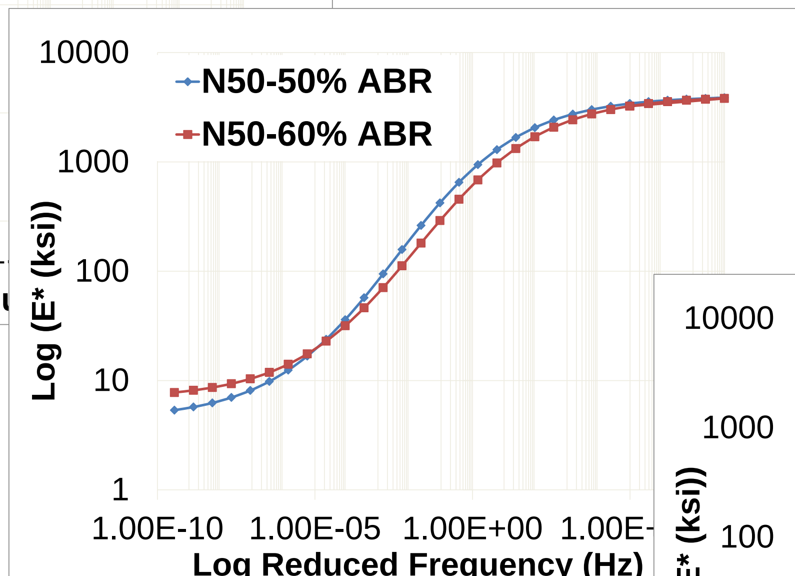
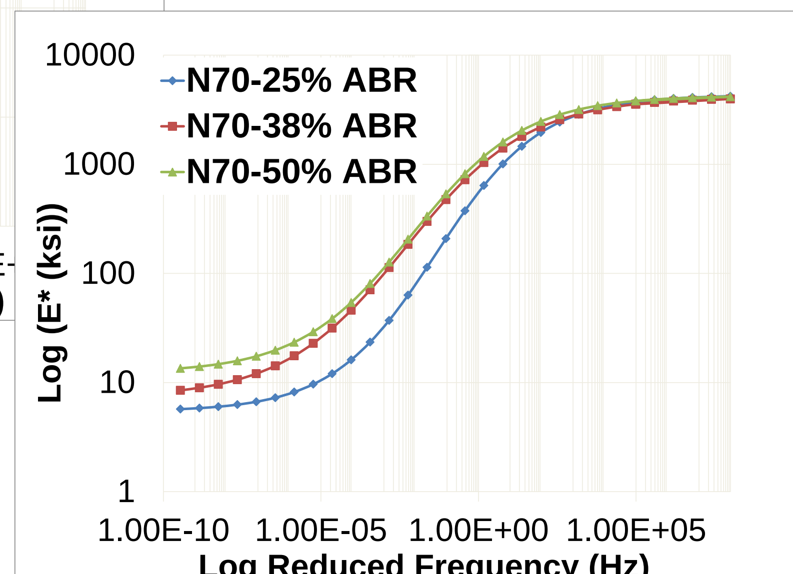
Modulus of High ABR Mixes



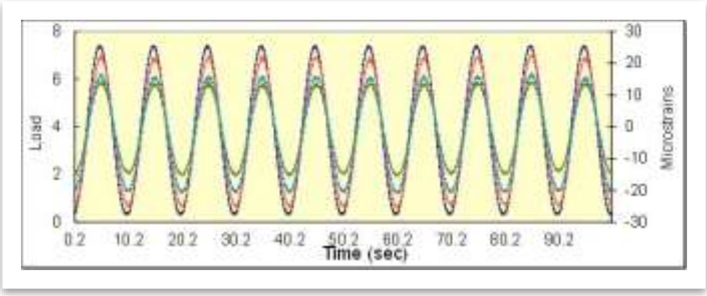




- As ABR increases, increase in modulus with slow loading and high temperatures

Fatigue Test - Push-Pull Test

- Characterize damage with repeated load applications
- Uniaxial tension and compression
- Temperature @ 21ºC
- Strain Controlled: 200 & 300 micro-strains



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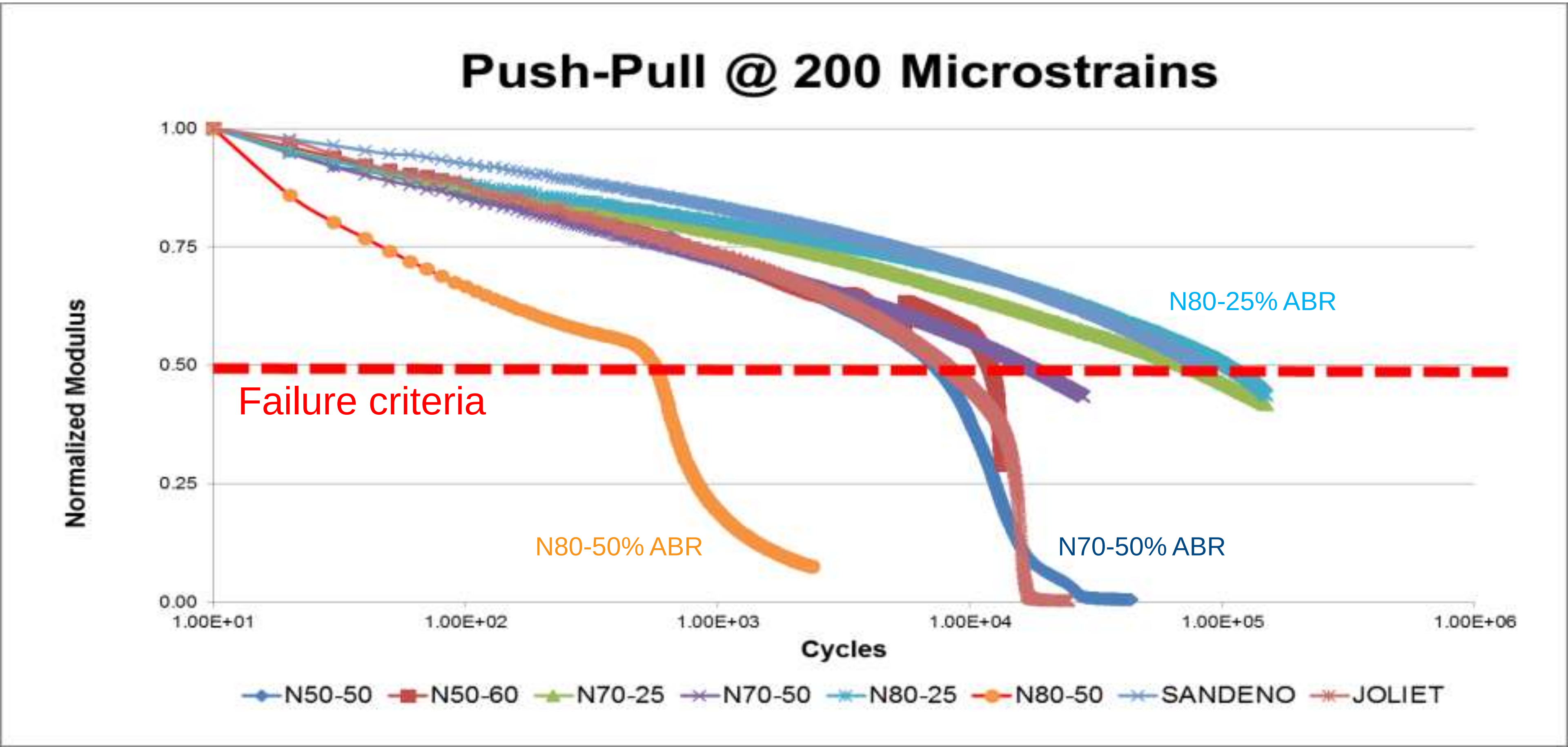
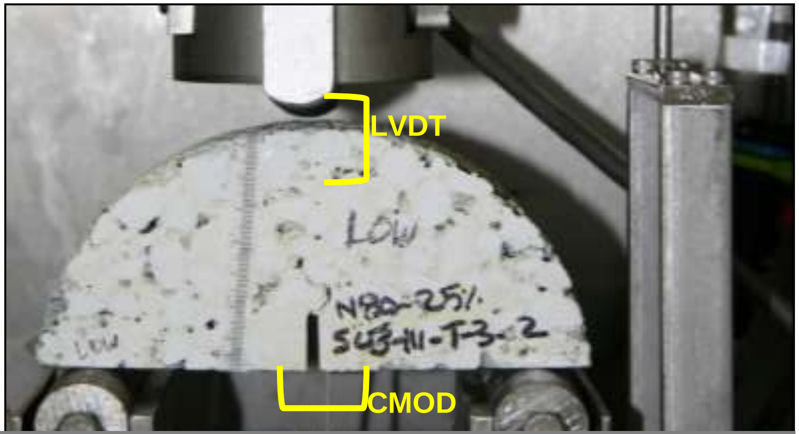
Fatigue Results

- 50% reduction in modulus value is used as failure criteria
- Change of ABR in N80 mixes appear to be very significant



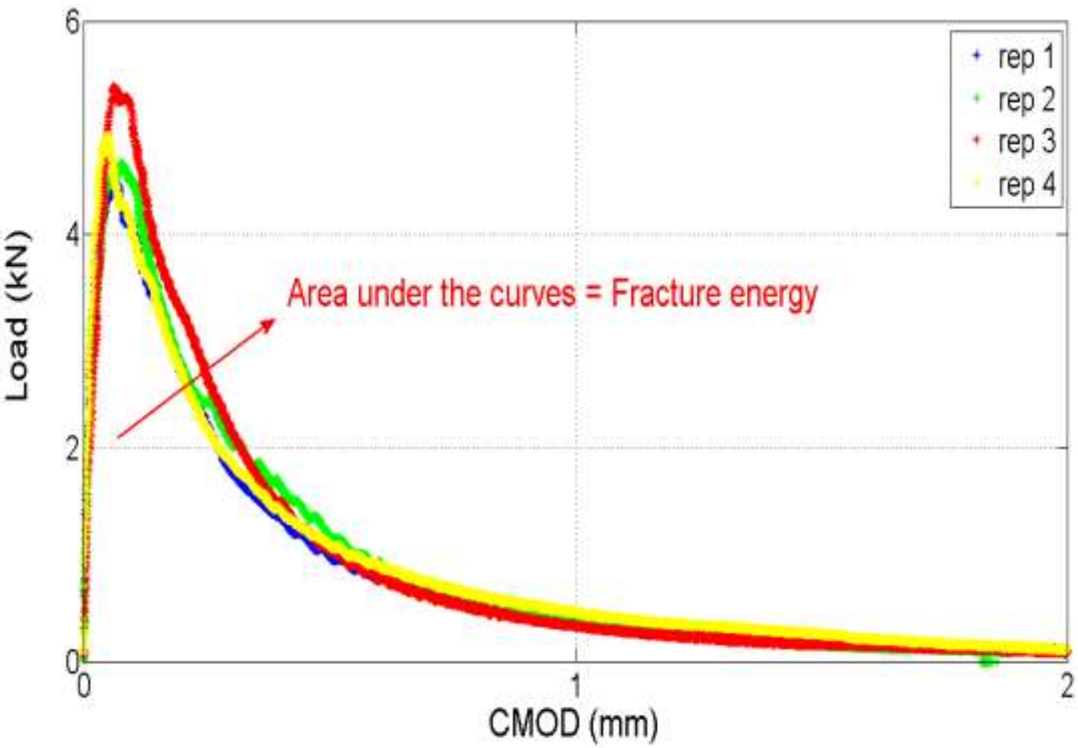
Conventional Fracture Tests



Semi-Circular Bending (SCB)
@ Loading Rate = 0.7mm/min

Disc Compact Tension (DCT)
@ Loading Rate = 1.0 mm/min

Test Temperature= -12ºC



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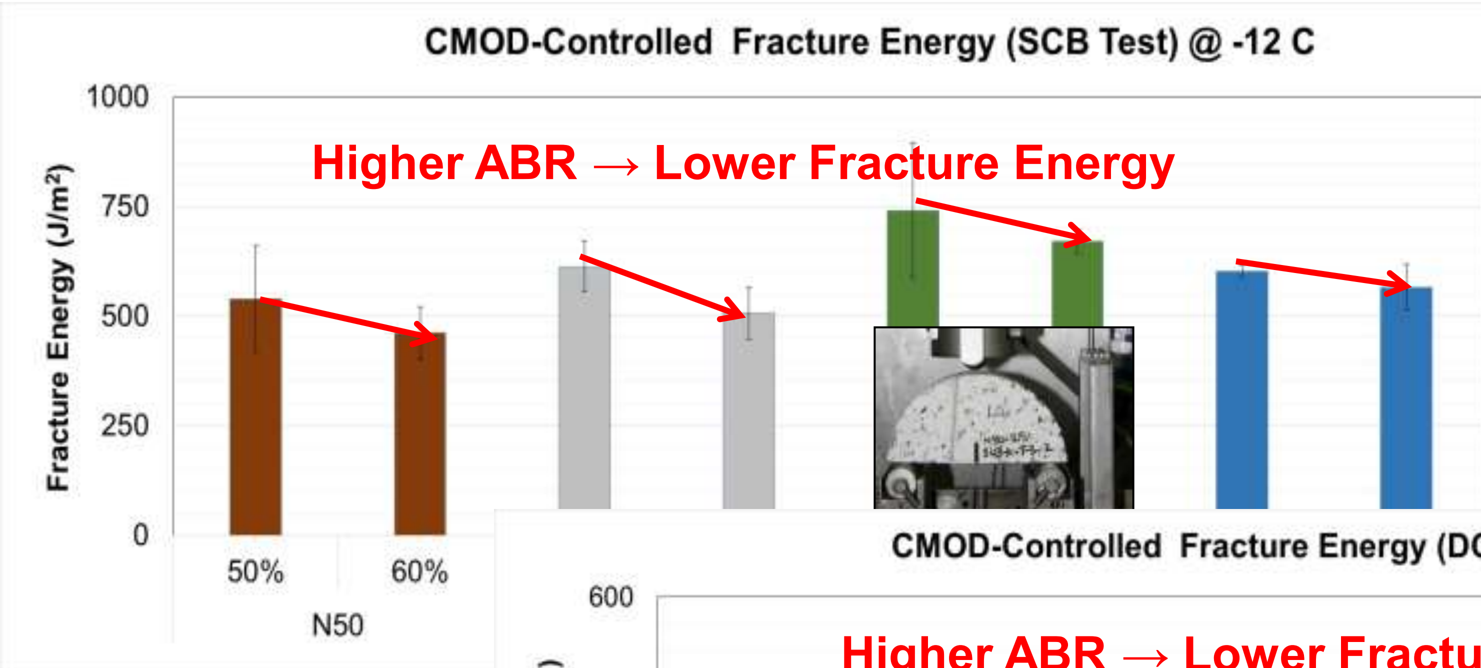
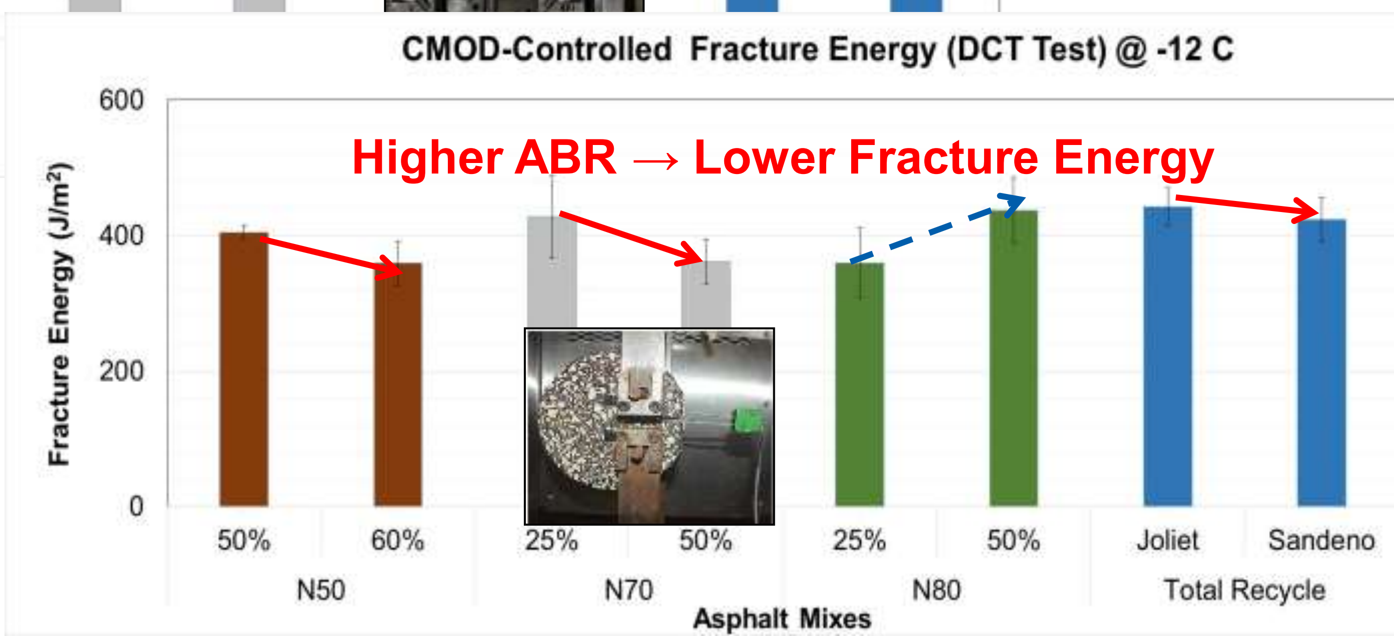
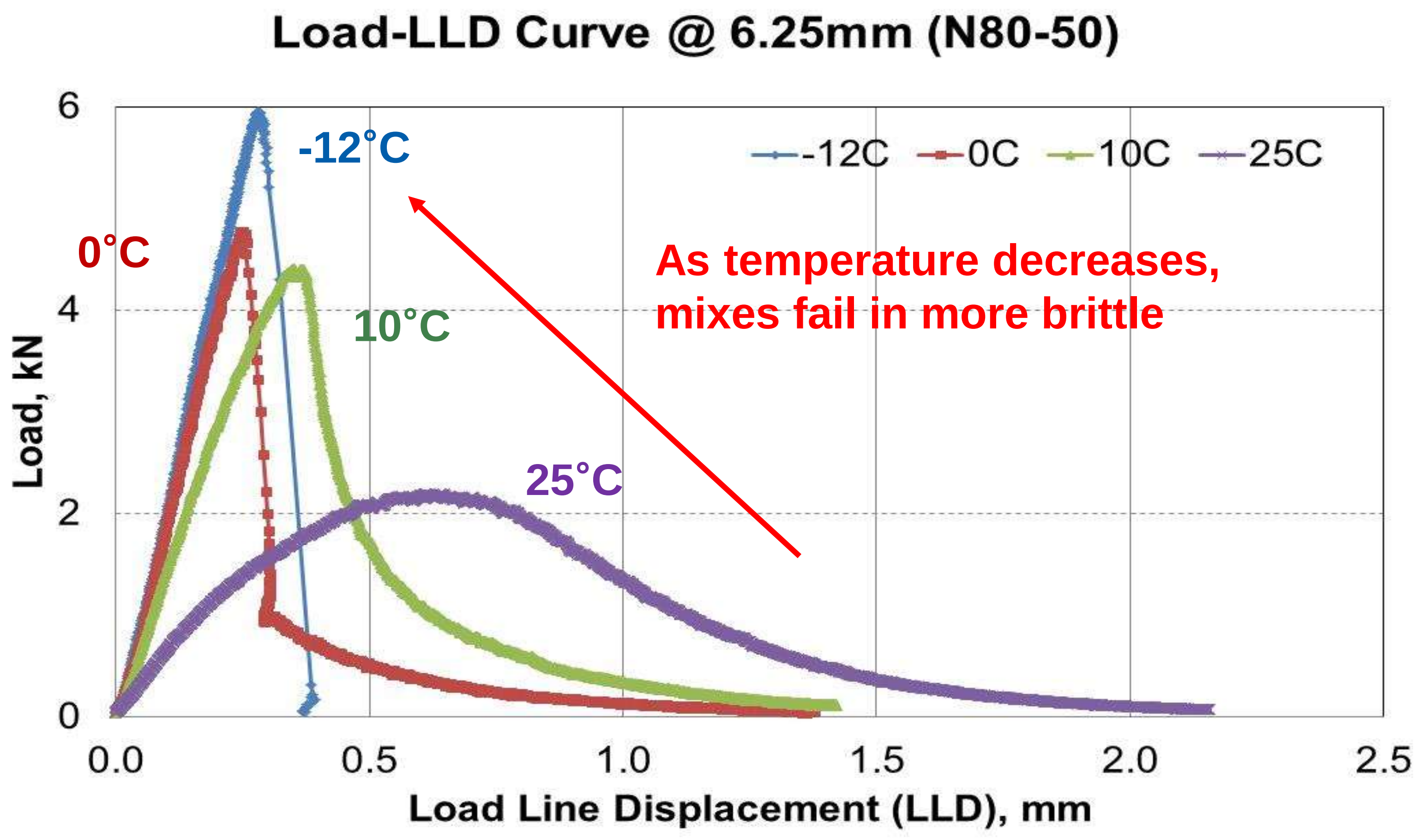
SCB/DCT Test Results





Temperature and Rate Dependency

- Fracture experiments were conducted at a sweep of temperatures and loading rates



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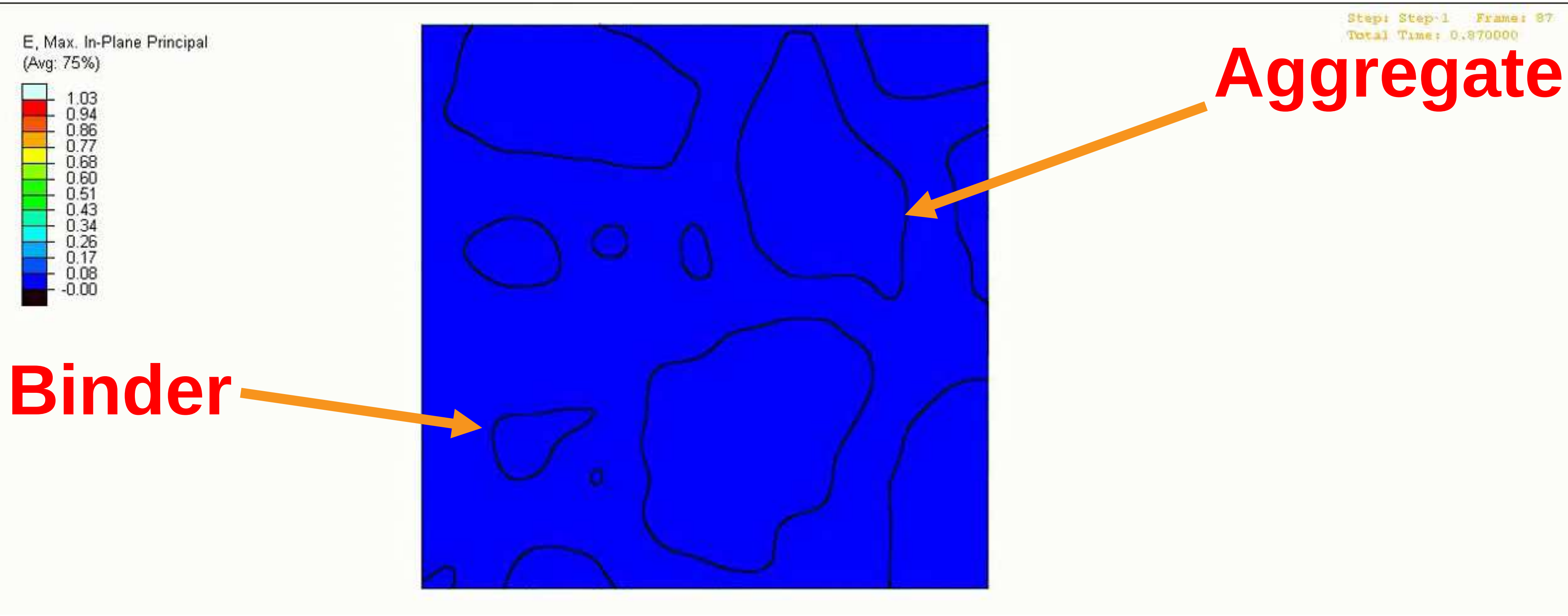
Asphalt Concrete

- Response to loading

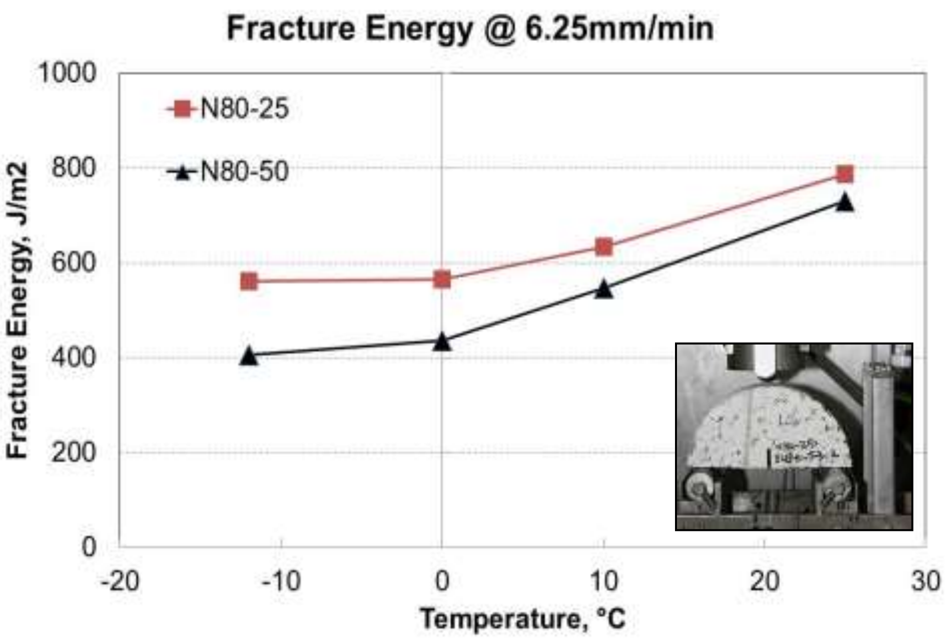


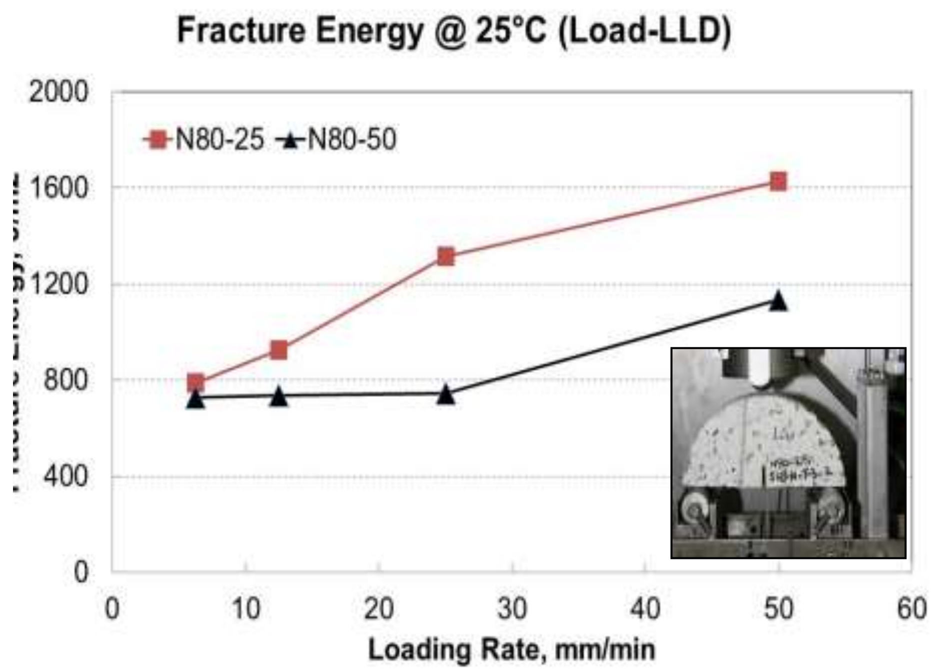
Fracture Path

SCB Fracture Test at
Low Temperature (-12C)
Rate (6.25mm/min)

SCB Fracture Test at
High Temperature (25C)
Rate (6.25mm/min)

Temperature and Rate Dependency





- Fracture energy changes with **temperature**
- Fracture energy change with **loading rate** is sensitive to ABR

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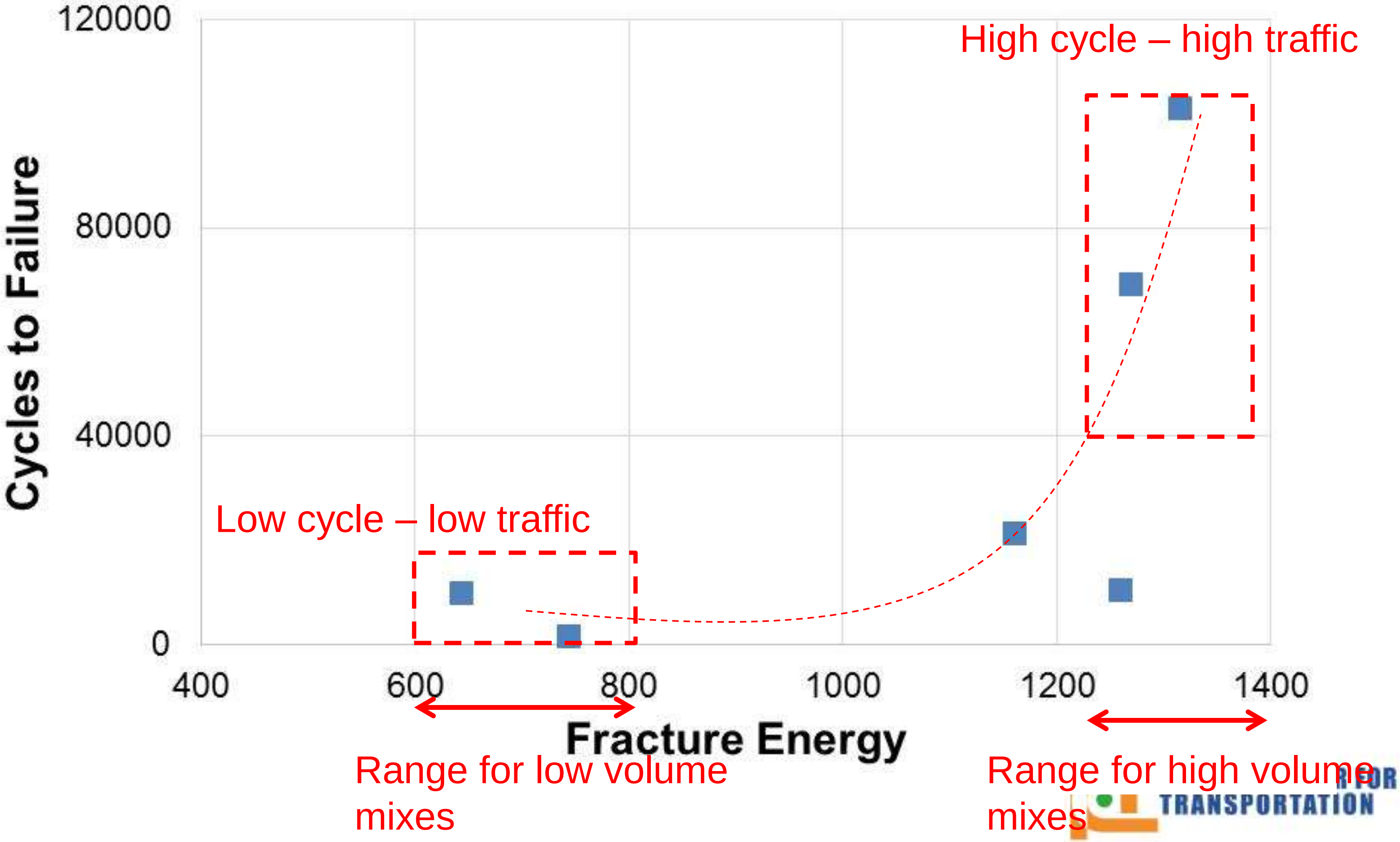
SCB Thresholds at 25 C

25 mm/min



Implementation Potential

- A simple and affordable test protocol to screen mixes for crack-susceptibility
- Performance based mix-design specifications considering rutting and cracking simultaneously

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Development of Roadway/ Roadside LCA Tool

Sponsor: Illinois Tollway

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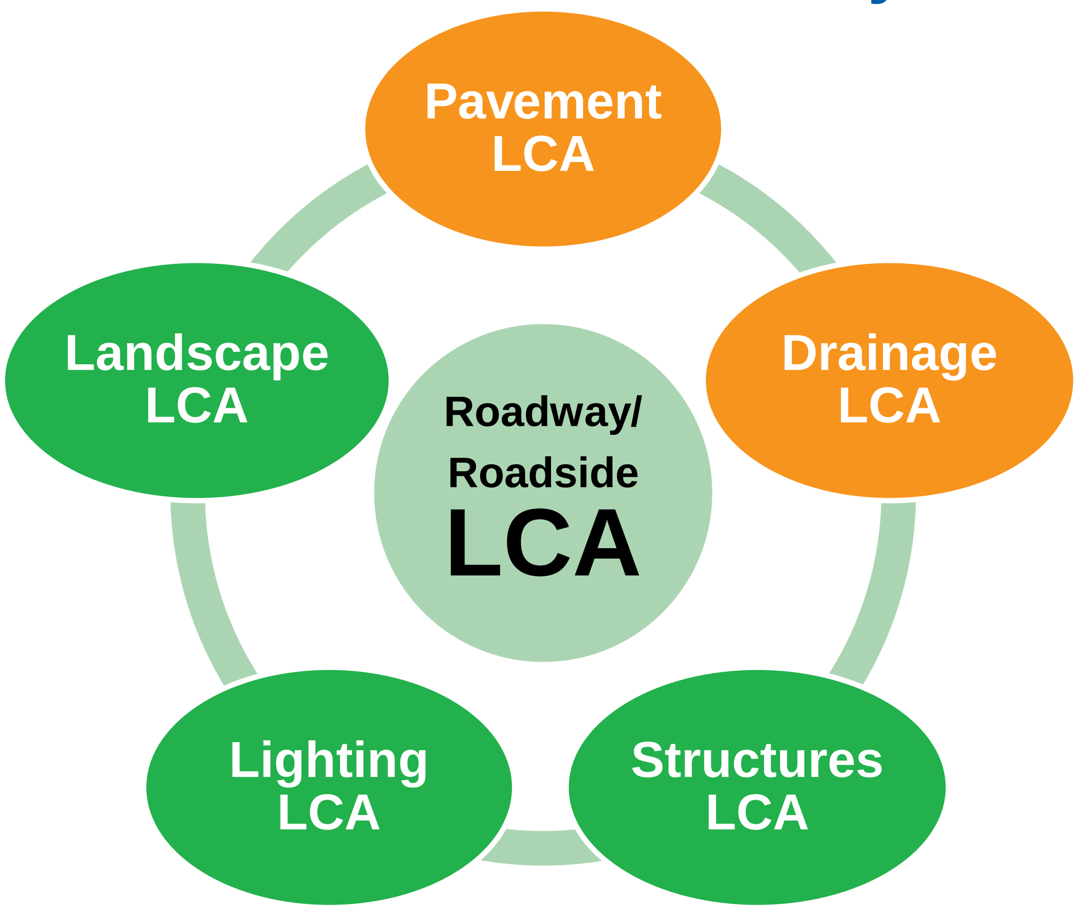
Research Motivation & Background

- The U.S. pavement industry, recognizing the **need to strive toward sustainability**, has implemented design practices to reduce emissions and energy consumption
- **Life cycle assessment (LCA)** is a strategy that can systematically and holistically assess the environmental performance of pavements

Research Approach

- Complete roadway/roadside LCA
- Pavement sustainability rating system



INVEST
ECONOMIC • SOCIAL • ENVIRONMENTAL

Certified Sustainable (Tollway Green)

Certified Bronze

Certified Gold

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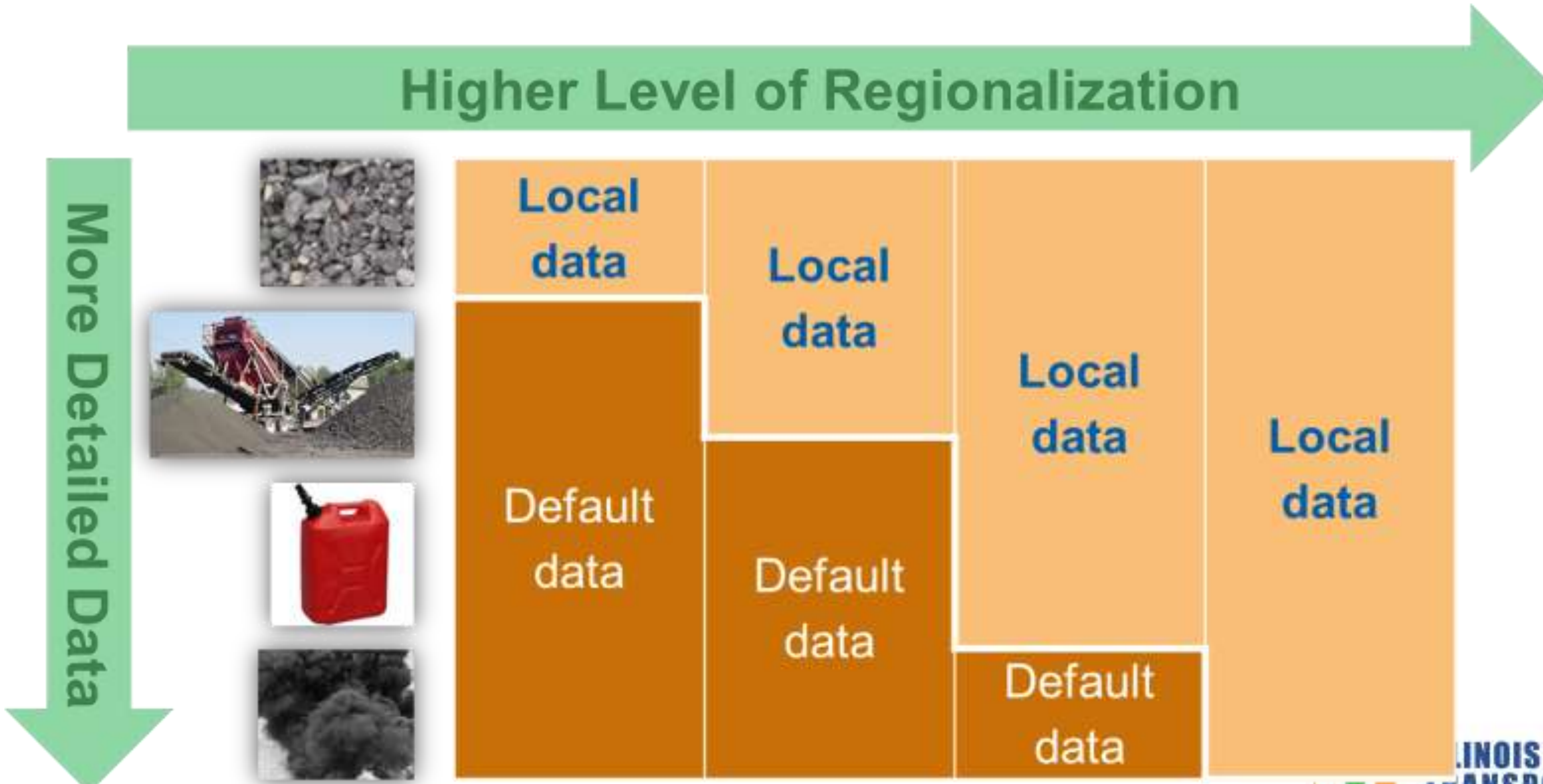
Scope

- **Regionalized inventory database for energy and emissions in material and fuel production**
  - **Questionnaires, literature, commercial LCI database**



LCA Tool

- Preliminary Pavement LCA tool
  - Project information, materials, construction and maintenance inputs from the user

Pavements LCA v.1.0

Mix Designs

Surface	Mix 21	Seal 1
To AC/PCC	To Agg. (Sub)base/Subgrade	To Surface Seal

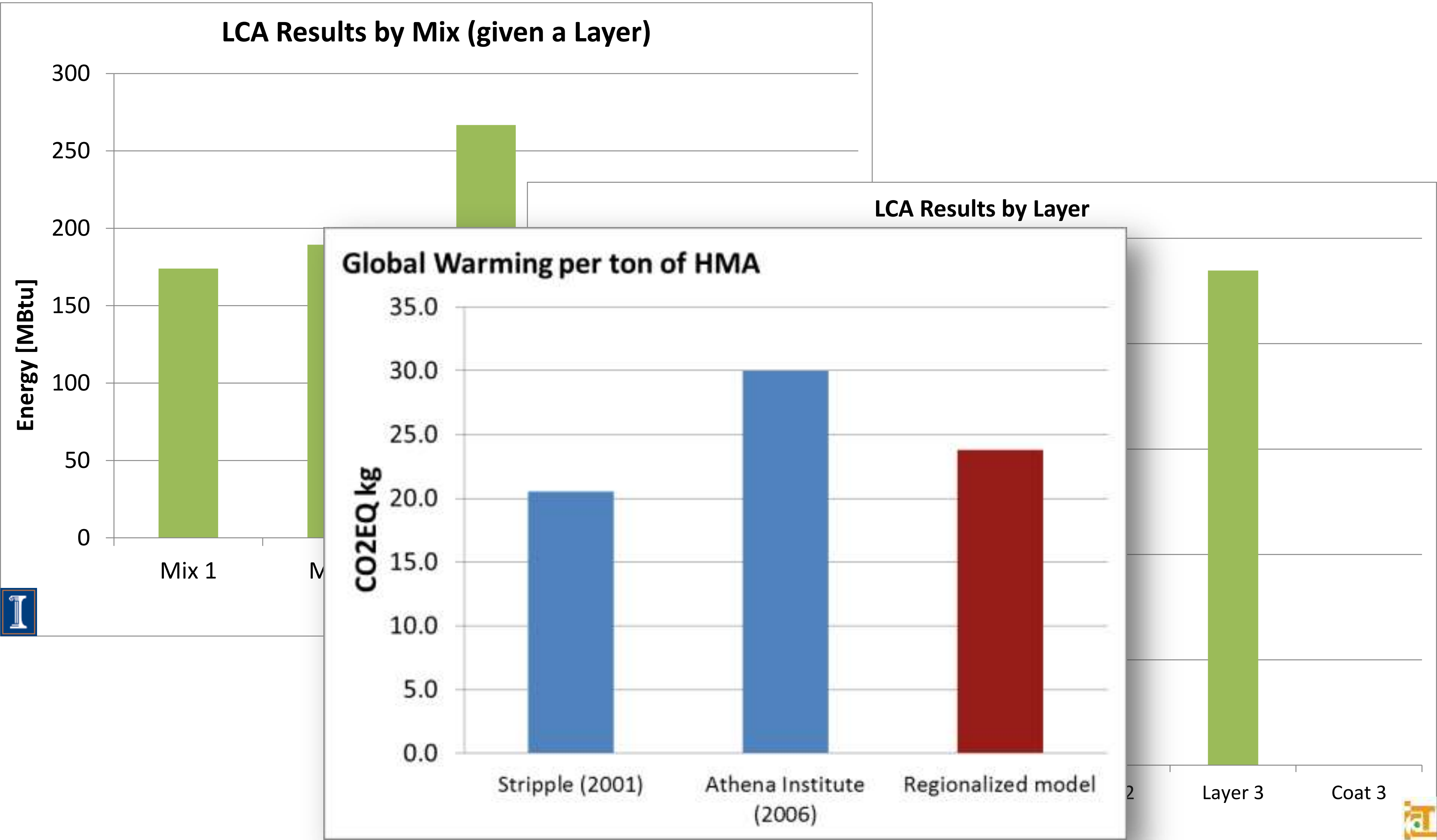
To Materials | To Navigation

AC/PCC MIX DESIGN 1

Mix Design ID	Surface	**Asphalt Mix Volumetrics**	
Type	Asphalt mix	Gmb, design (g/cm3)	2.541
Plant Location		Gmm (g/cm3)	2.625
Plant-to-Site Distance (mi)		Voids (%)	4
Process	HMA Plant	Gmb, in place (g/cm3)	2.520
Material Wasted (%)	1.0	Asphalt Content (%)	5.6

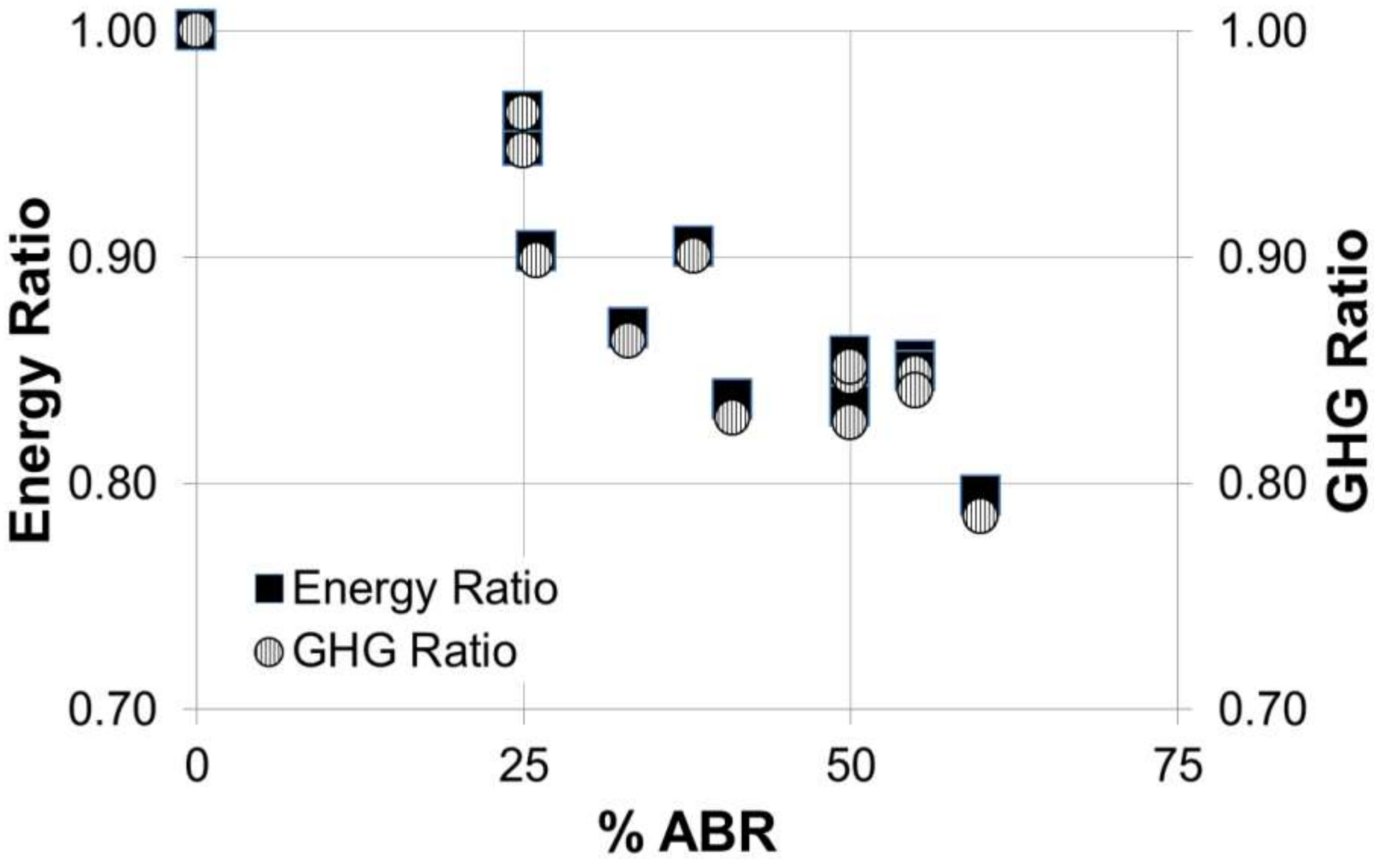
Material	Description (optional)	Recycled Binder (%)	Amount (%Mix)	Acquistion Location (optional, for dist.)	Transportation Mode	Acquisition-to-Plant Distance (mi)	Amount (lb/CY)
Crushed Aggregate			50.7				2053
Crushed Aggregate			31				1255
Mineral Filler			6.3				255
Recycled Asphalt Pavement		6	12				486
Straight Binder			5.6				227
							0
							0
							0
							0
							0
							0
							0
							0
							0

Sample Results: By Mix



Impact of ABR Using LCA

- A clear trend in the reduction of energy and GHG emissions with increasing ABR



Implementation Potential

- A **project- or network-level tool** to assess environmental sustainability performance
- Implementation of LCA promotes a **holistic understanding of sustainability** that can be used in decision making
- **Integrated sustainability architecture** with a pavement management system with cost, performance, and environment to promote more sustainable infrastructure
- An **objective measure of sustainability** whose results can be disseminated to public

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Effects of Various Asphalt Binder Additives/Modifiers on Moisture-Susceptible Asphaltic Mixtures

Sponsor: Illinois Department of Transportation/ Federal Highway Administration

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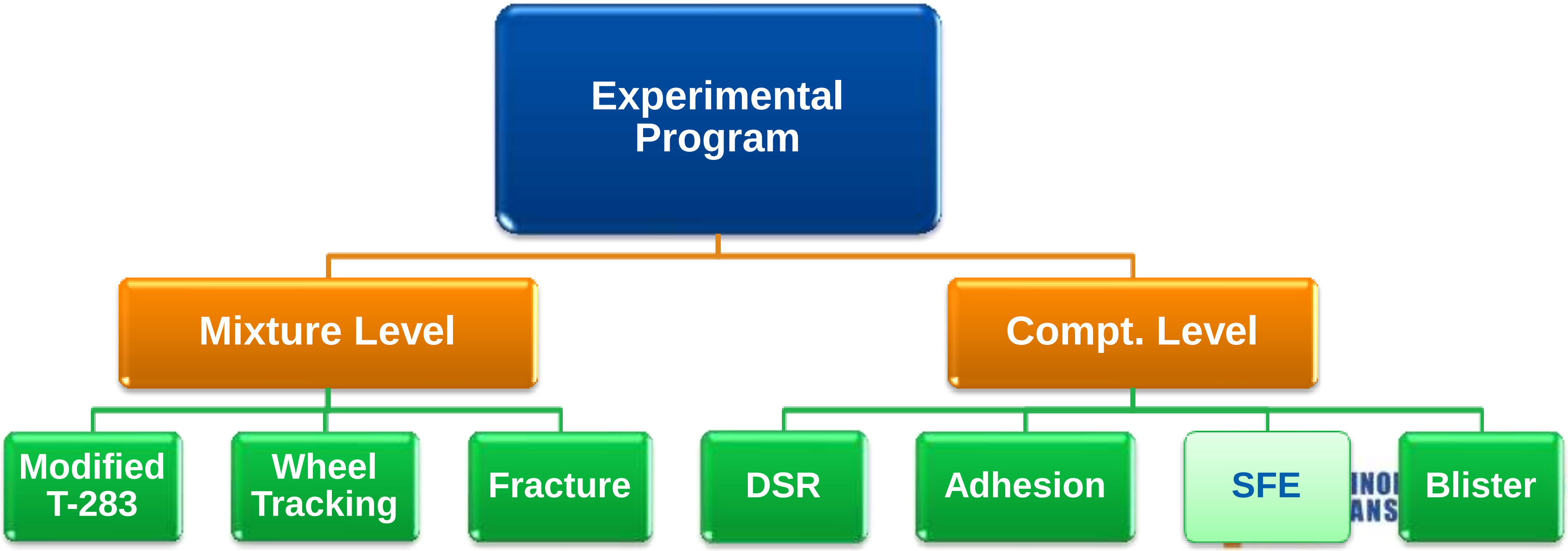
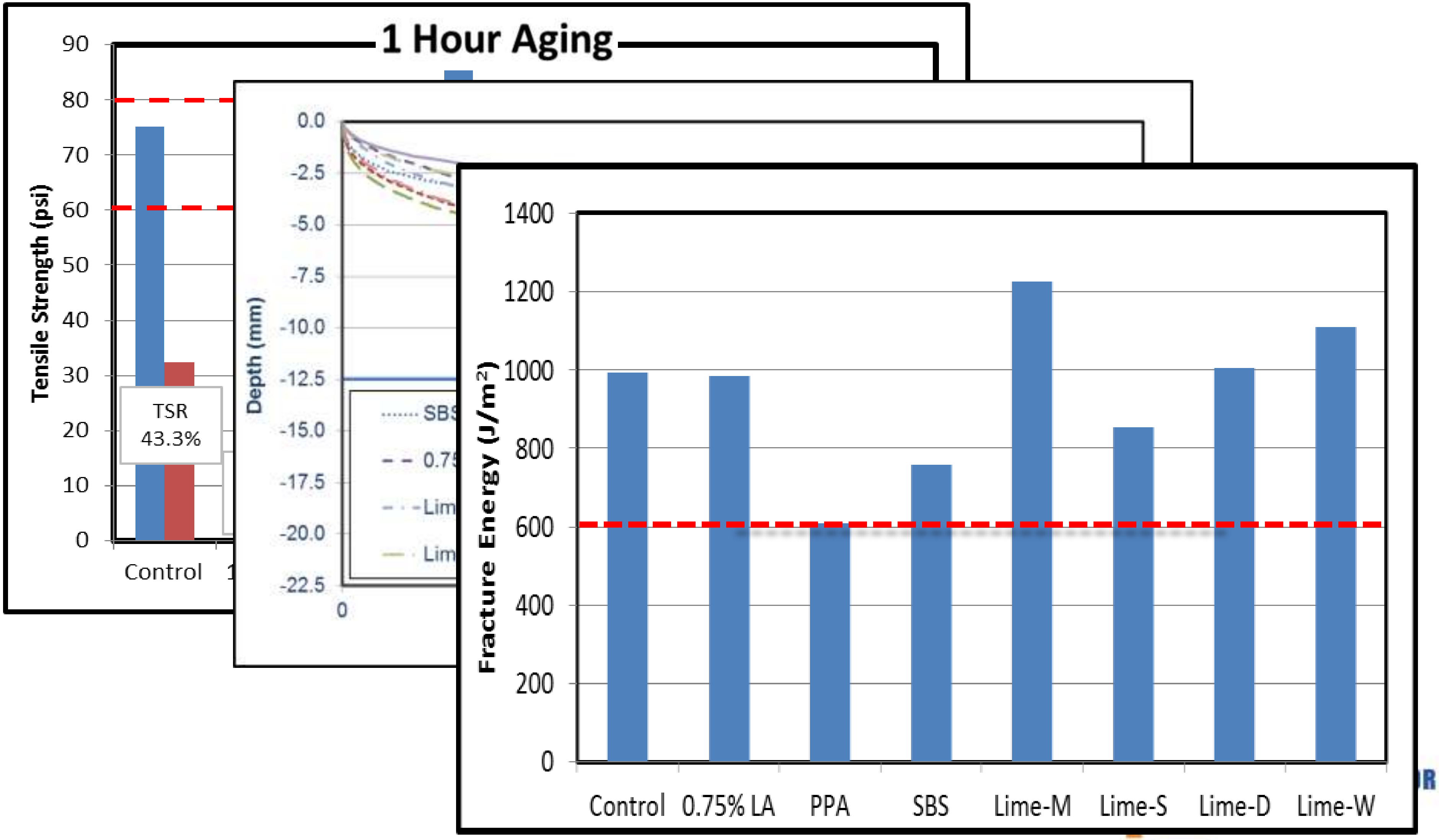
Research Objective and Approach

- Determine **short-** and **long-term effects** of selected **additives/modifiers** on controlling moisture damage of typical Illinois mixes
  - Liquid antistrip, hydrated lime, SBS, poly-phosphoric acid (PPA), foamed binder



Typical Results



Findings

- LAS appears to be an efficient additive improving tensile strength ratio
- Lime addition improves overall strength
- PPA does not improve moisture resistance of mixes evaluated
- Aging time, type, and duration of conditioning cycles are significantly altering the overall strength of mixes

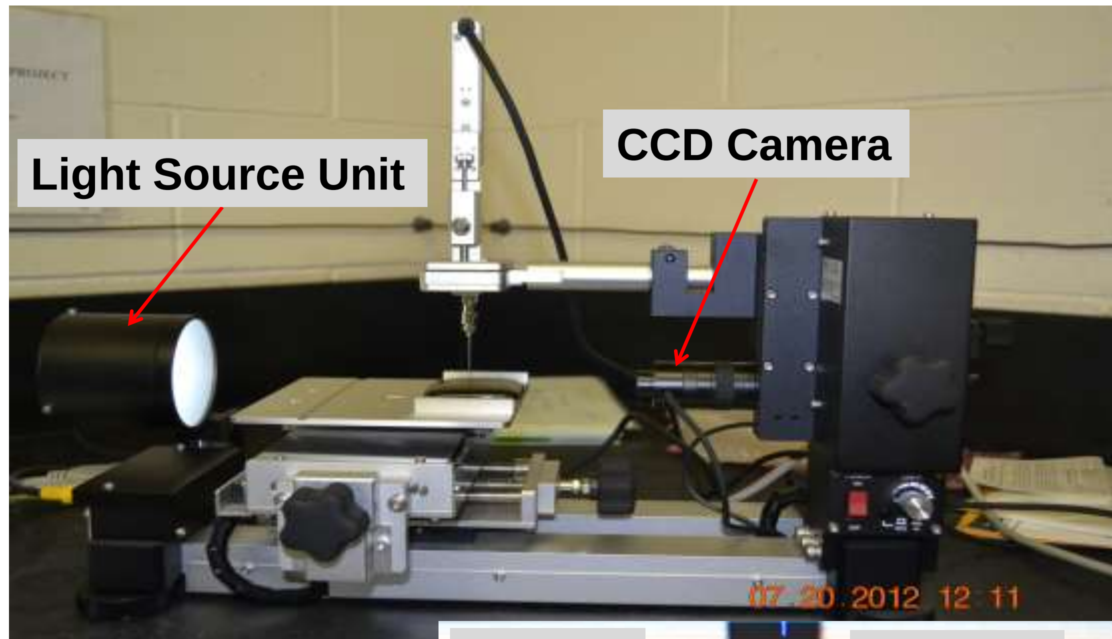
Implementation Potential

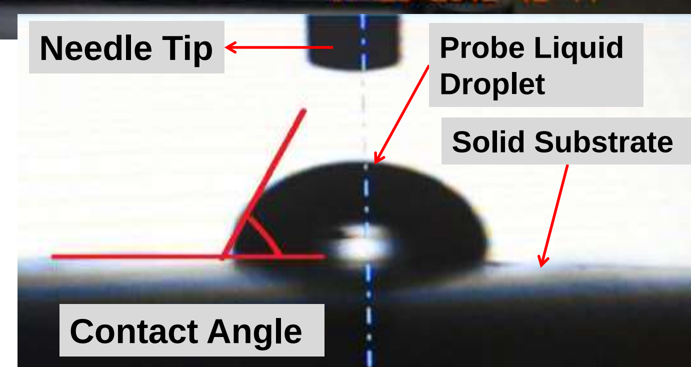
- Quantify the effectiveness of selected additives/modifiers in controlling moisture damage of asphaltic mixtures
- Recommendations and guidelines on use of the most appropriate additive(s)/ modifier(s) for typical mixes in Illinois
- Cost-effectiveness impact of using selected additives/ modifiers

Do We Need to Test Each Product?

- Predict moisture susceptibility of a particular asphalt mixture using **sessile-drop methodology**
- **Contact angle** between a probe liquid and substrate (aggregate or binder) defines the surface tension

Sessile Drop Device

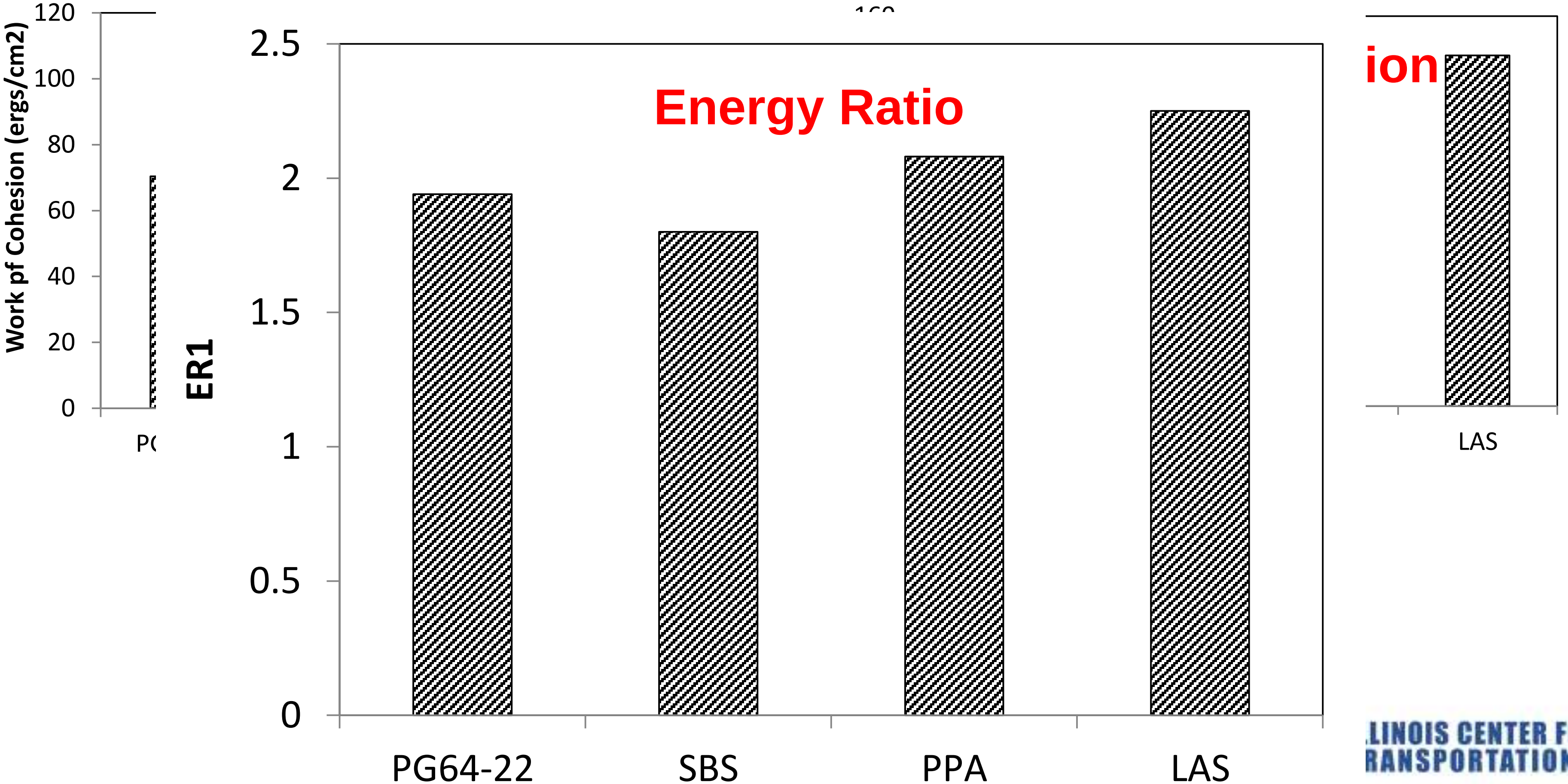




Contact Angle

Typical Results

- Tests were conducted on PG 64-22 binder, PG 64-22 with SBS, PG 64-22 with PPA, PG 64-22 with LAS, limestone aggregate

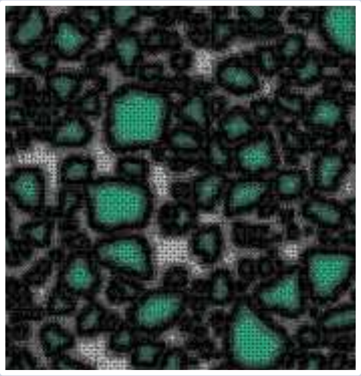


Micromechanical Computational Model

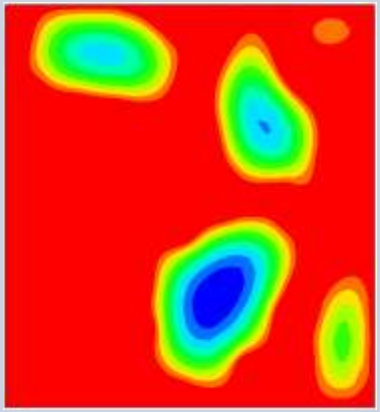
Micromechanical Modeling

Xray CT Data Acquisition & Image Processing

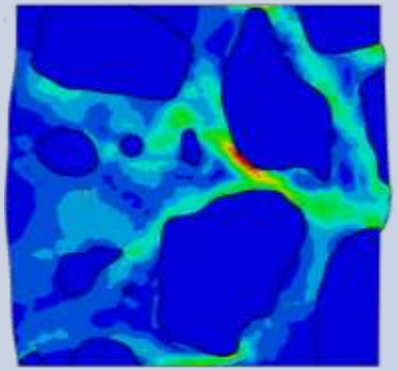
Micromechanical Computational Models



Moisture Transport



Mechanical Relaxation



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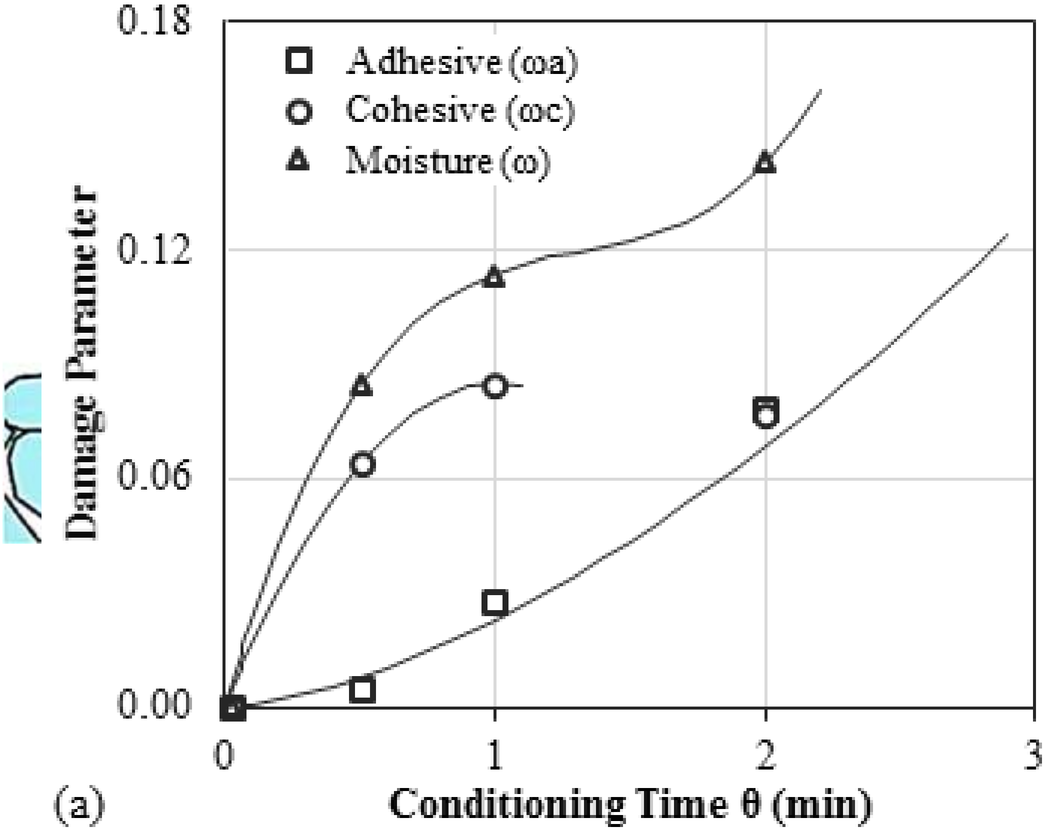
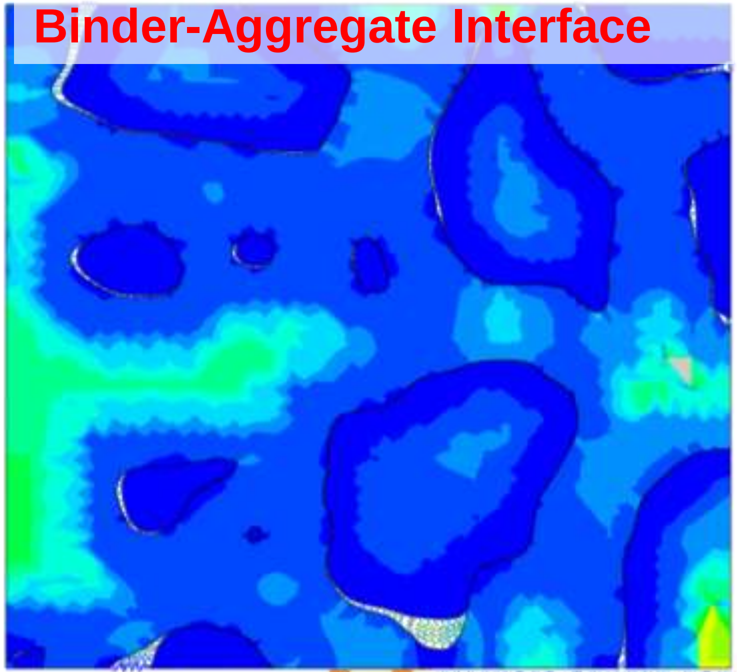
Moisture Damage

- Adhesive and cohesive damage potential of asphalt concrete mixtures can be identified using microstructural simulations





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Field Experience and Lab Testing of Fine-Graded Mixes

Sponsor: Illinois Department of Transportation/ Federal Highway Administration

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Project Objective and Scope

- ✓ Use fine graded (F-G) HMA as an alternative to coarse-graded (C-G) HMA in Illinois for binder/ surface courses
- F-G mixtures: gradation curve passes over the max. density line at the critical control sieve -> Easier to compact (esp. in thin lifts), less permeable
- ✓ The project focused on binder-course mixtures (19mm NMAS, N90), produced with local aggregates (D5).
- ✓ The research study includes mix design, lab performance testing, APT testing, and field permeability testing.

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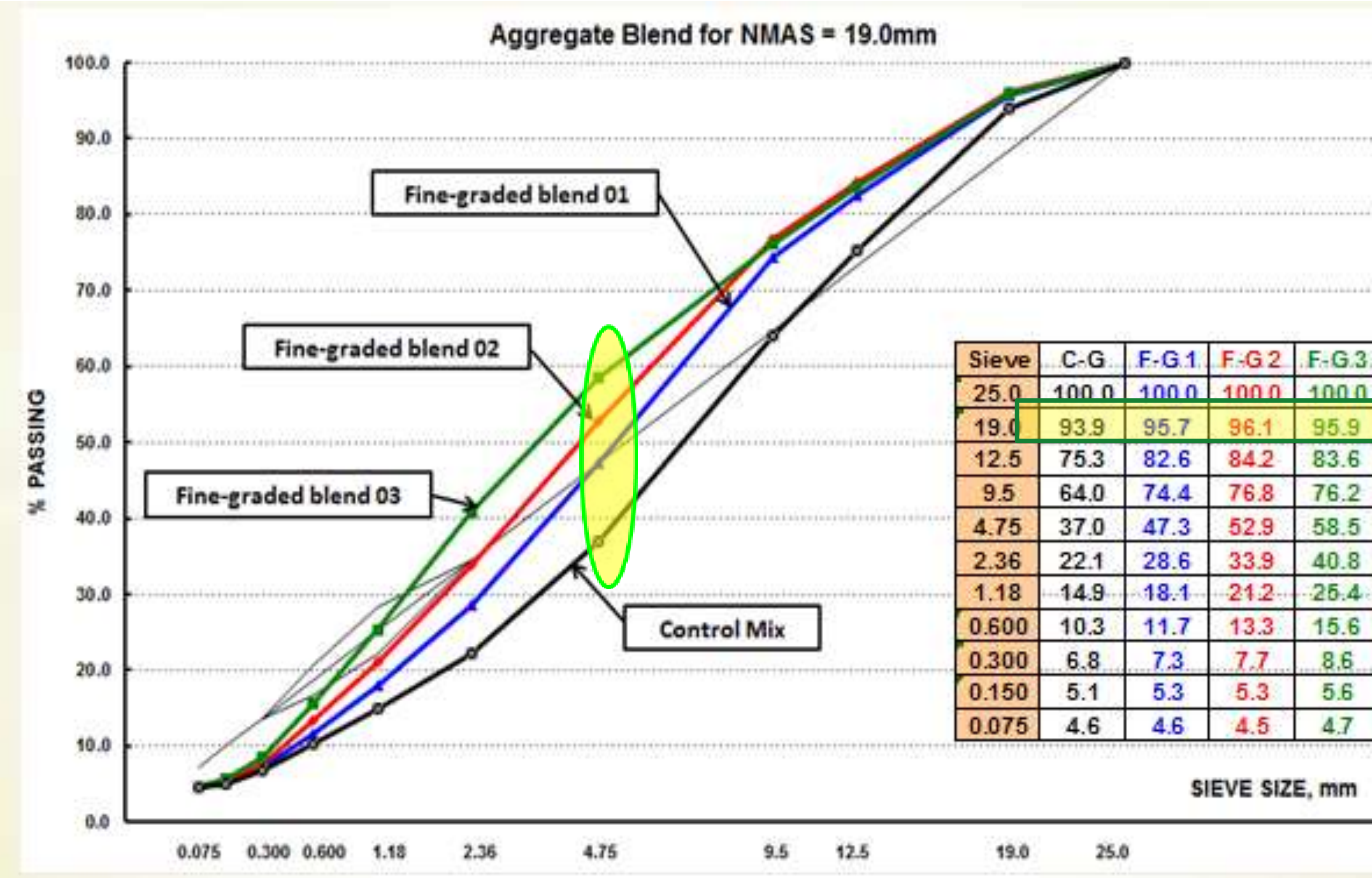
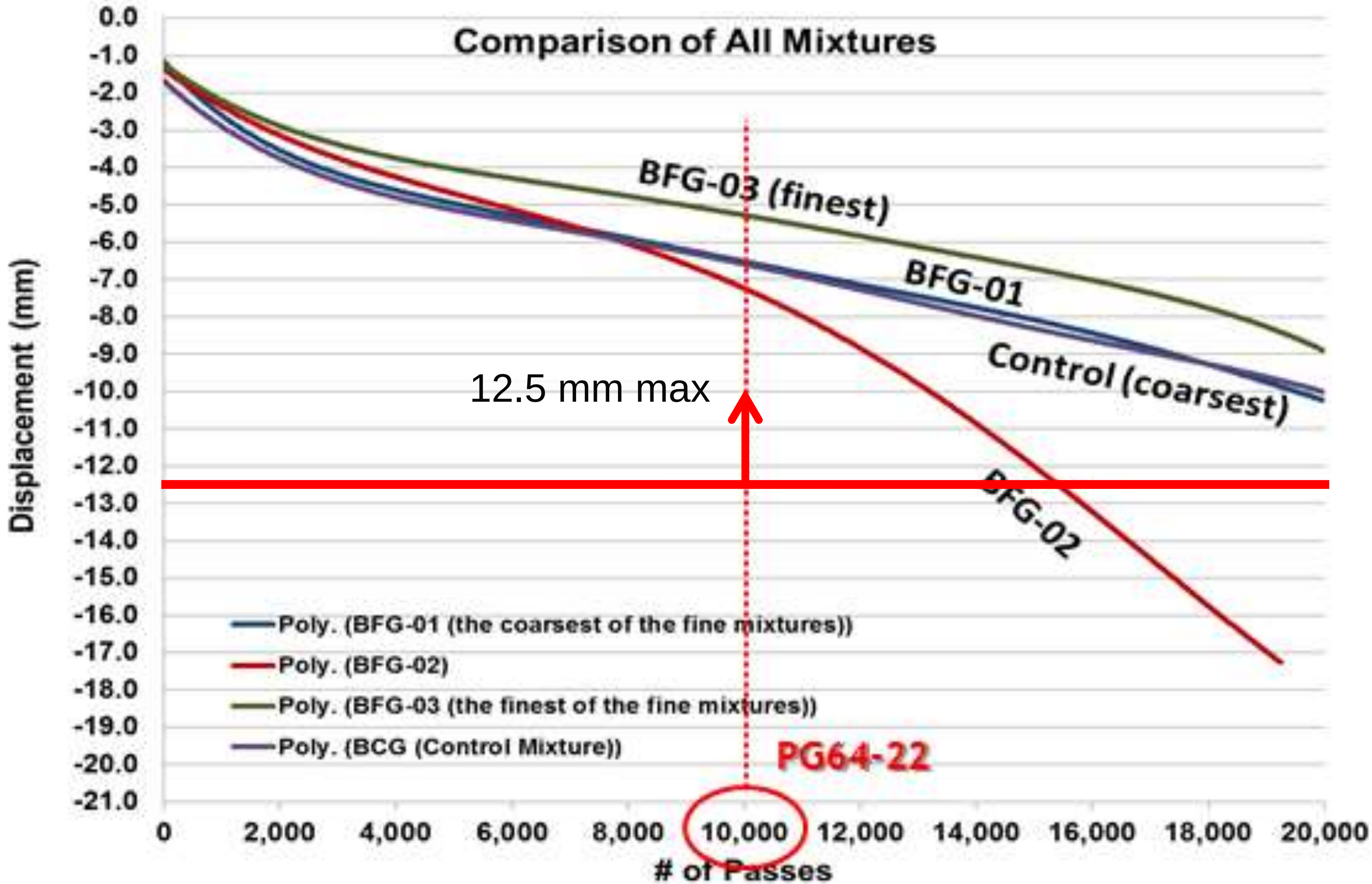
Aggregate Structure



Sieve	C-G	F-G 1	F-G 2	F-G 3
25.0	100.0	100.0	100.0	100.0
19.0	93.9	95.7	96.1	95.9
12.5	75.3	82.6	84.2	83.6
9.5	64.0	74.4	76.8	76.2
4.75	37.0	47.3	52.9	58.5
2.36	22.1	28.6	33.9	40.8
1.18	14.9	18.1	21.2	25.4
0.600	10.3	11.7	13.3	15.6
0.300	6.8	7.3	7.7	8.6
0.150	5.1	5.3	5.3	5.6
0.075	4.6	4.6	4.5	4.7



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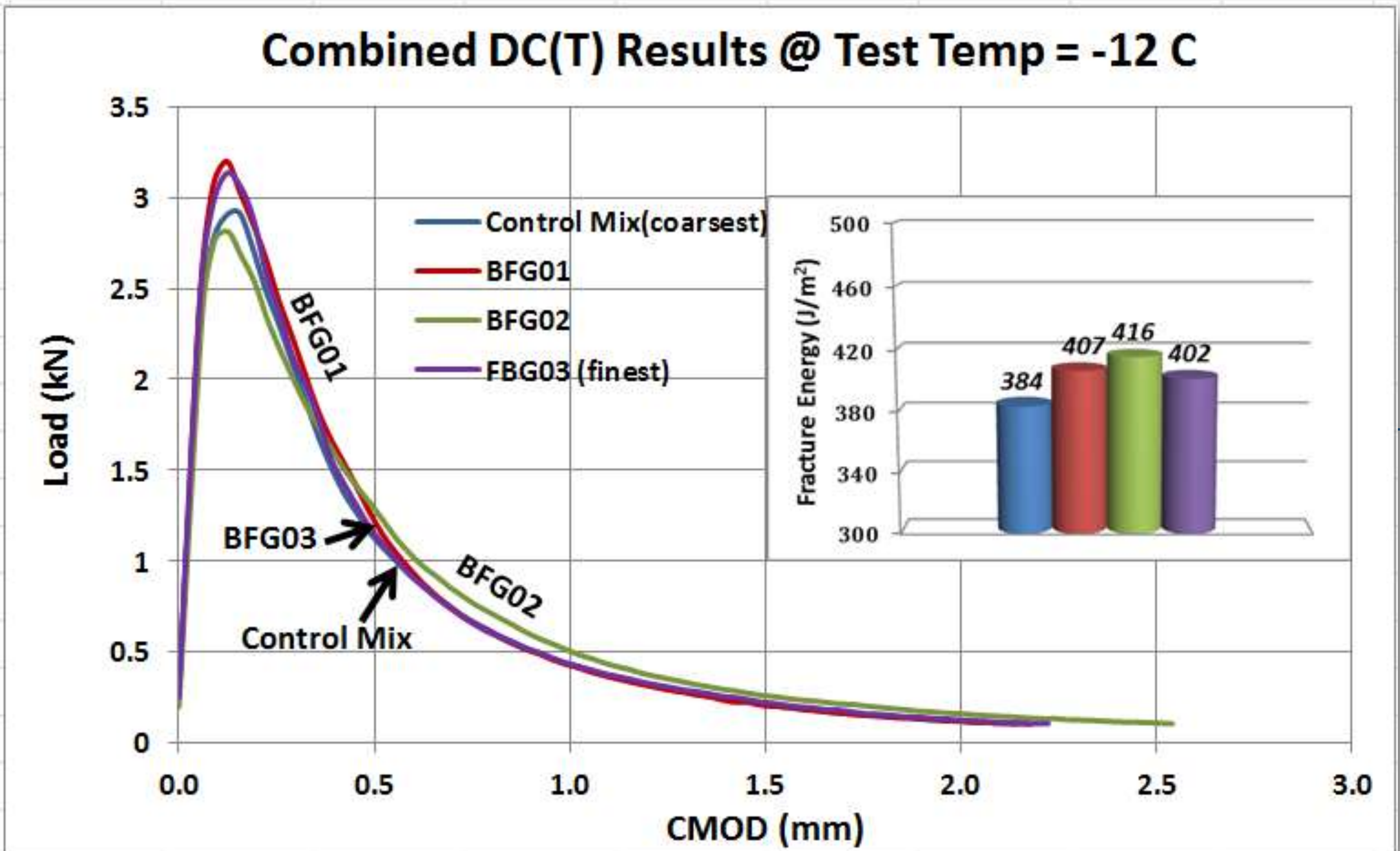

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FG Study Findings

- FG mixes are as good or superior to CG. Limited ATLAS testing confirmed this result.
- Significant permeability reduction
- Easier to compact and can result in higher density PFP
- Project TRP has developed a new IL 19mm binder spec that raises and broadens gradation bands to accommodate FG mixes.

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Thank You
Questions ?

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