Update on Work on Simple Mixture Durability Tests and Plans for the MnROAD-NCAT Partnership to Validate Cracking Tests

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FHWA Accelerated Loading Facility

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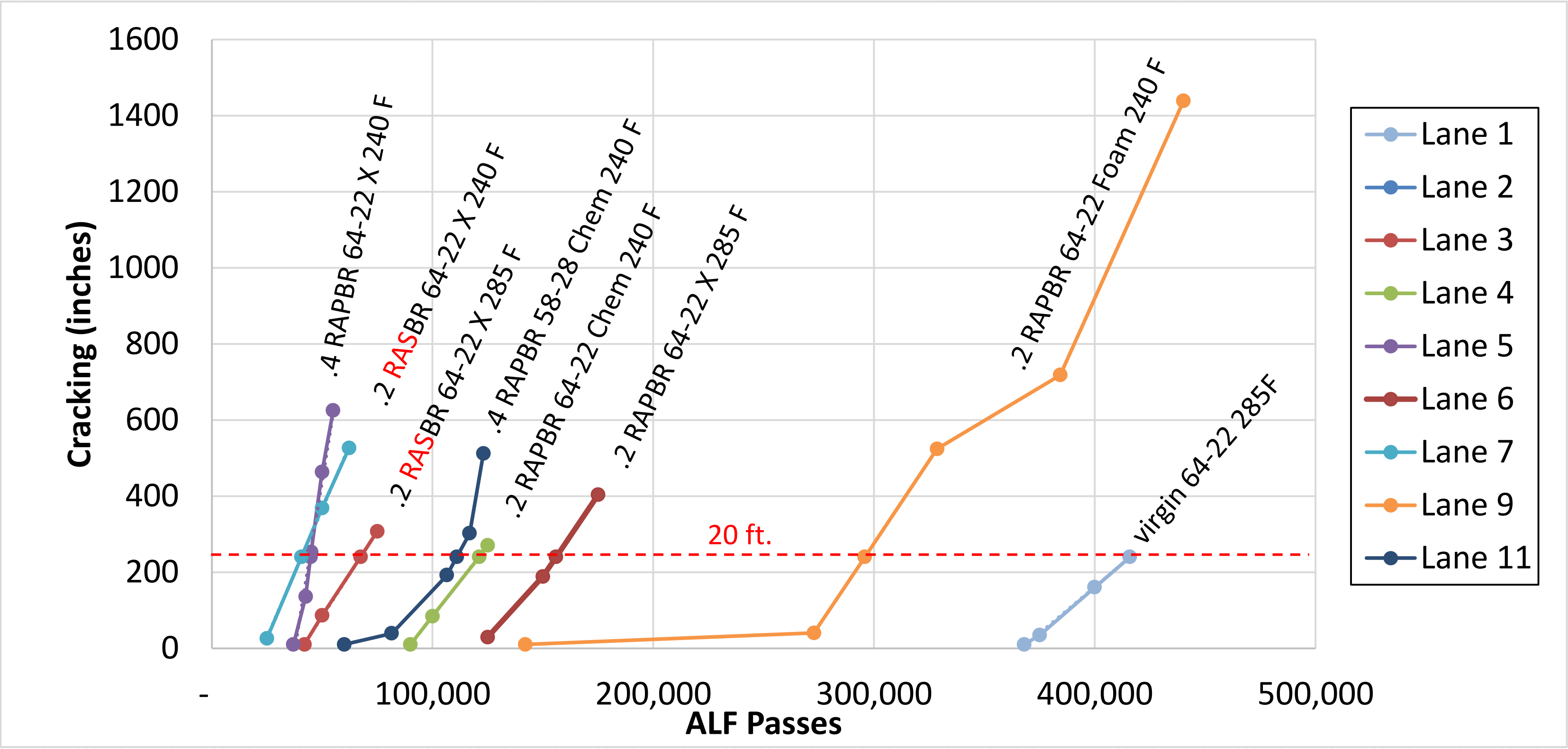
Tests Conducted

Test	Method
Overlay Tester	Tex-248-F modified by NCAT
SCB Louisiana	LTRC method, draft AASHTO
IDT Nflex Factor	NCAT, draft AASHTO
Cantabro	AASHTO TP 108-14
I-FIT (tested by UIUC)	AASHTO TP 105-13

- Test specimens were made from SGC samples compacted to 65 gyrations
- Using N_{design} specimens provides the quickest and simplest path to implementation for any of these durability “performance” tests.
- Sealed buckets of mix were reheated, weighed out, then brought back to the compaction temperature before SGC compaction.

Cracking Performance Measured…



Issues with Loading of Lane 8 and 10

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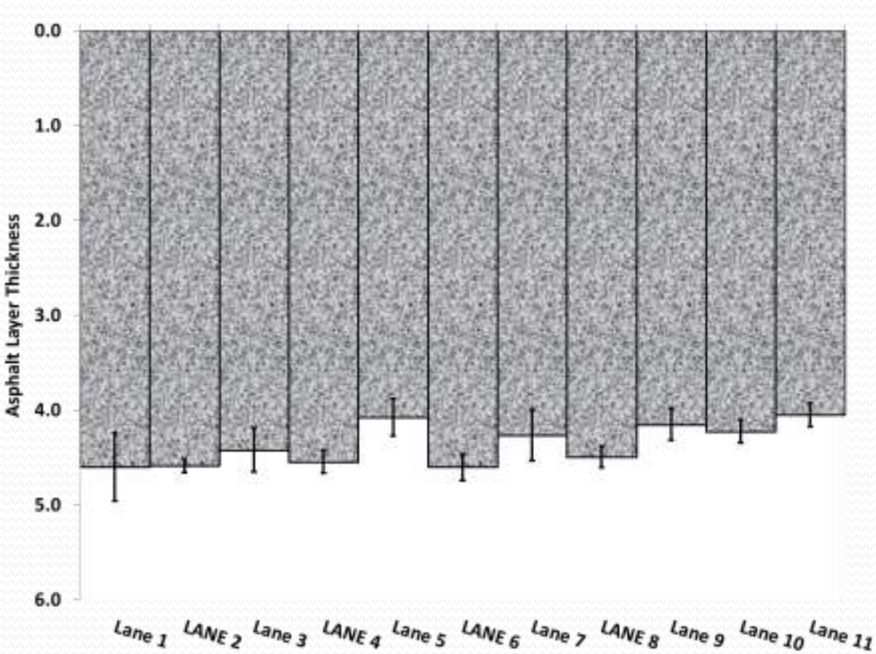
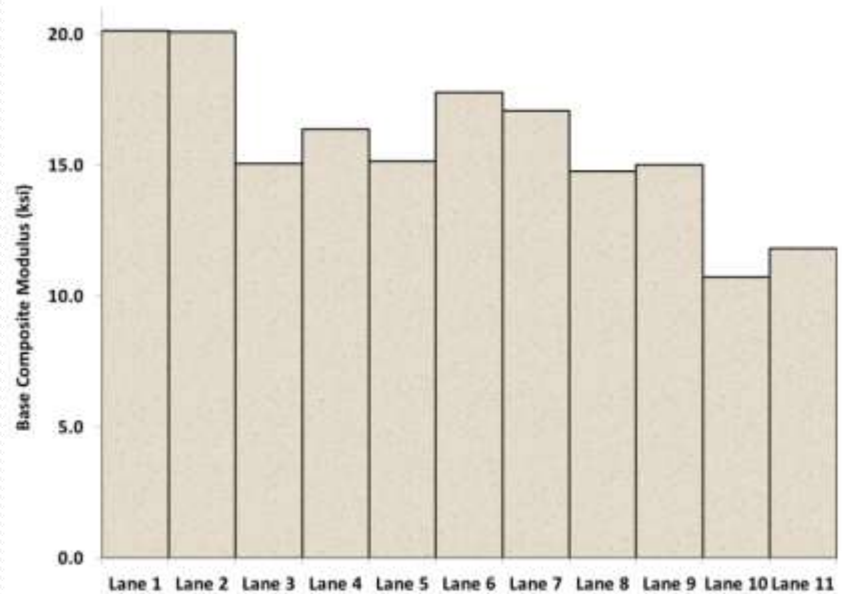
As-Built Construction

Asphalt Thickness



Base Stiffness



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1. Calculate Max. Tensile Strain

Input	Value
Load	14,200 lbs.
Tire Pressure	100 psi
AC Modulus	761 ksi
Subgrade Modulus	8 ksi
Agg. Base Thickness	22 in.
Poisson's ratios	AC = 0.35 Base = 0.40 Subgrade = 0.45

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2. Calculate Max. Tensile Strain

Lane	Asphalt Thickness (in.)	Base Modulus (ksi)	Maximum tensile strain	Strain Ratio
1	4.56	20.1	321	1.0
2	4.57	20.1	320	1.0
3	4.42	15.3	364	1.13
4	4.53	16.5	346	1.08
5	4.03	15.4	397	1.24
6	4.6	17.9	332	1.03
7	4.28	17.2	360	1.12
8	4.5	15.1	359	1.12
9	4.14	15.3	387	1.21
10	4.23	10.9	424	1.32
11	4.04	12.1	430	1.34

3. Relationship between fatigue life and tensile strain

$$N_f = \alpha_1 \left[\frac{1}{\epsilon_T}\right]^{\alpha_2}$$

N_f = cycles to failure
ϵ_T = strain level at the reference test temperature
α_1, α_2 = transfer function regression constants

set $\alpha_2 = 5.21$ *Average of TT Group Exp. mixes, range 4.2 to 6.5*

Lane 1 N_f = 416,000 passes to 20' of cracking

Solve for α_1: $\alpha_1 = 4.7641$ E18

4. Est. N_f for Each Strain

Lane	Asphalt Thickness (in.)	Base Modulus (ksi)	Maximum tensile strain	Est. *Nf*	Ratio to Lane 1
1	4.56	20.1	321	416,000	1.00
2	4.57	20.1	320	422,818	0.98
3	4.42	15.3	364	216,096	1.93
4	4.53	16.5	346	281,448	1.48
5	4.03	15.4	397	137,495	3.03
6	4.60	17.9	332	349,024	1.19
7	4.28	17.2	360	228,901	1.82
8	4.50	15.1	359	232,243	1.79
9	4.14	15.3	387	157,040	2.65
10	4.23	10.9	424	97,591	4.26
11	4.04	12.1	430	90,701	4.59

5. Adjust Measured ALF Passes to 20 ft. of Cracking

Lane	Ratio to Lane 1	Measured Passes to 20 ft. of Cracking	Adjusted Passes to 20 ft. of Cracking
1	1.00	416,000	416,000
2	0.98	--	
3	1.93	67,000	128,980
4	1.48	121,000	178,847
5	3.03	45,000	136,151
6	1.19	156,000	185,936
7	1.82	41,000	74,512
8	1.79	--	--
9	2.65	296,000	784,106
10	4.26	--	--
11	4.59	111,000	509,099

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Cantabro Test

- Primarily used for OGFC mixes
- One compacted specimen placed in LA Abrasion drum at a time
- No Steel Balls
- 300 drum revolutions
- Calculate mass loss

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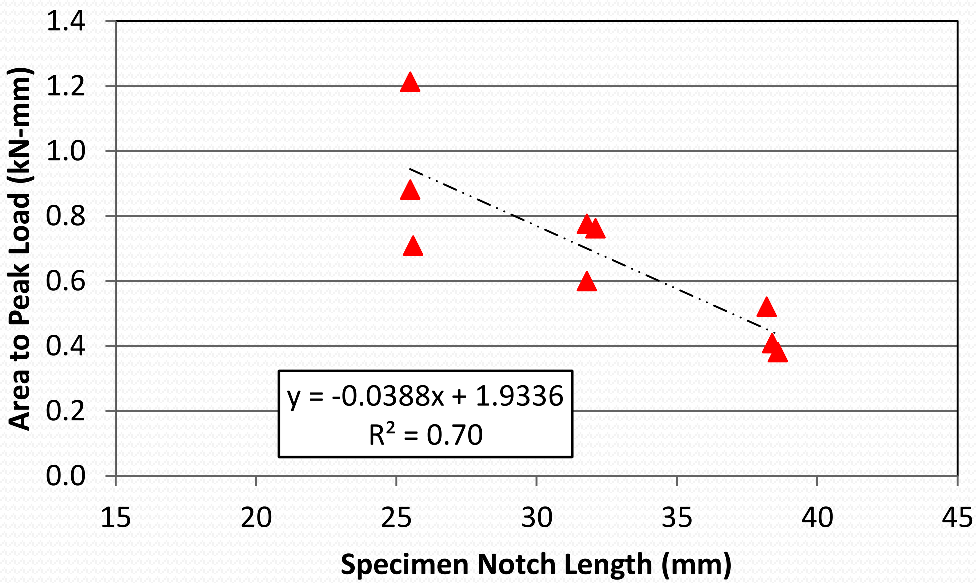
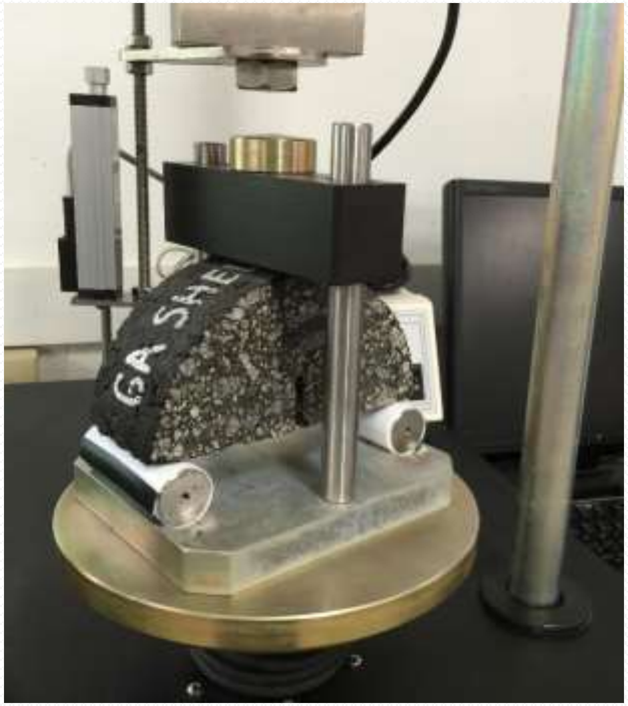
Modified Overlay Test

- Method modified by NCAT
  - Displacement = 0.381 mm
  - Cycle = 1 Hz
  - Failure = peak of normalized load x cycle
- Conducted in AMPT @ 25°C
- Triplicates

Semi-Circular Bend Test (LTRC)

- 50 mm thick specimens
- Ram rate = 0.5 mm/min.
- Notch depths of 38.1, 31.8, 25.4 mm
- Triplicates





Illinois Flexibility Index Test (I-FIT)

- Tests conducted by Univ. of Illinois
- Reheated mix, no aging
- Specimens compacted to 7 ± 0.5% air voids
  - 4 SCB specimens per SGC pill
  - 50 mm thick SCB specimens
  - Notch 1.5 mm wide, 15 mm deep
- Loading Rate = 50 mm/min.
- Test Temp. = 25°C

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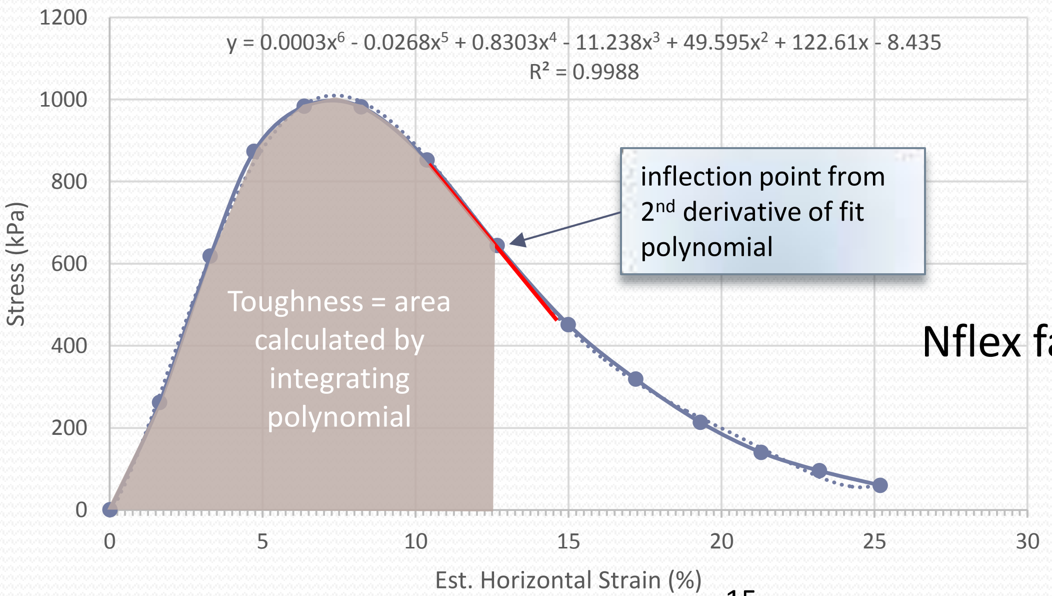
IDT Nflex Factor

- 50 mm thick specimens
- Ram rate = 50 mm/min.
- Temp. = 25°C
- Area under σ vs. έ to post peak inflection point divided by slope at that point



inspired by IL-SCB method

$$\text{Nflex factor} = \frac{\text{Toughness at inflection pt.}}{\text{slope at inflection pt.}}$$

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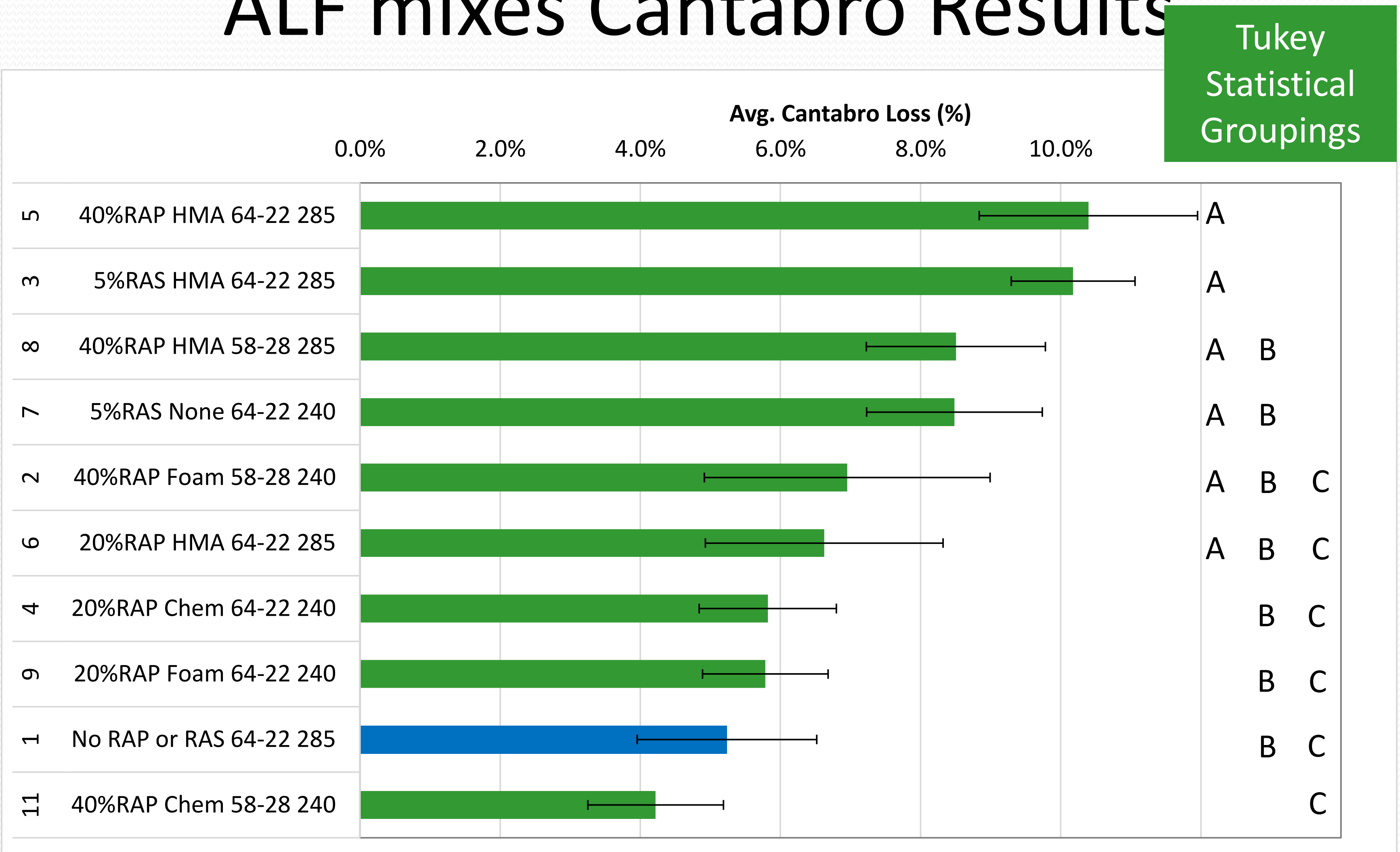
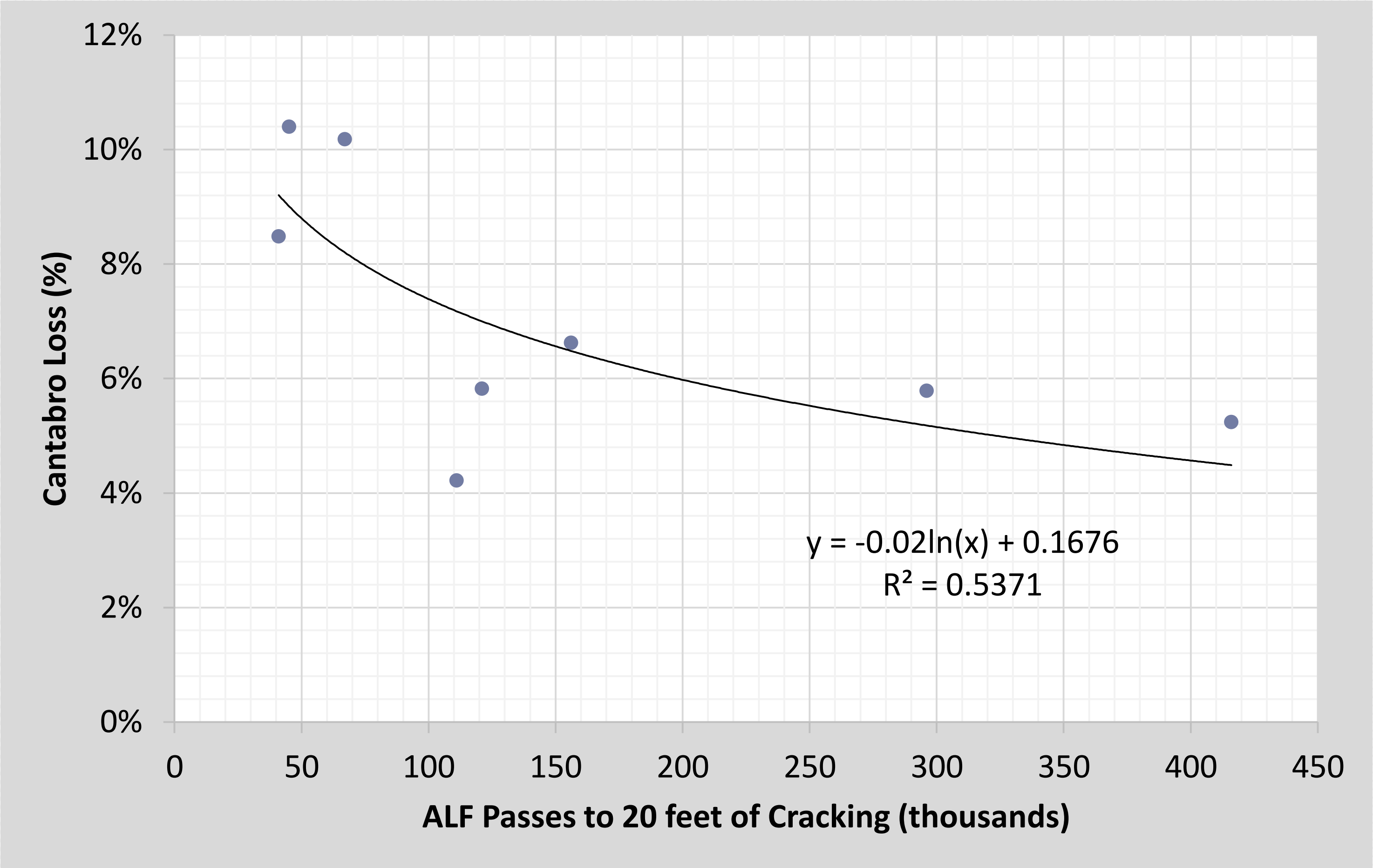
ALF mixes Cantabro Results



Average COV = 19%

Cantabro ALF Correlation



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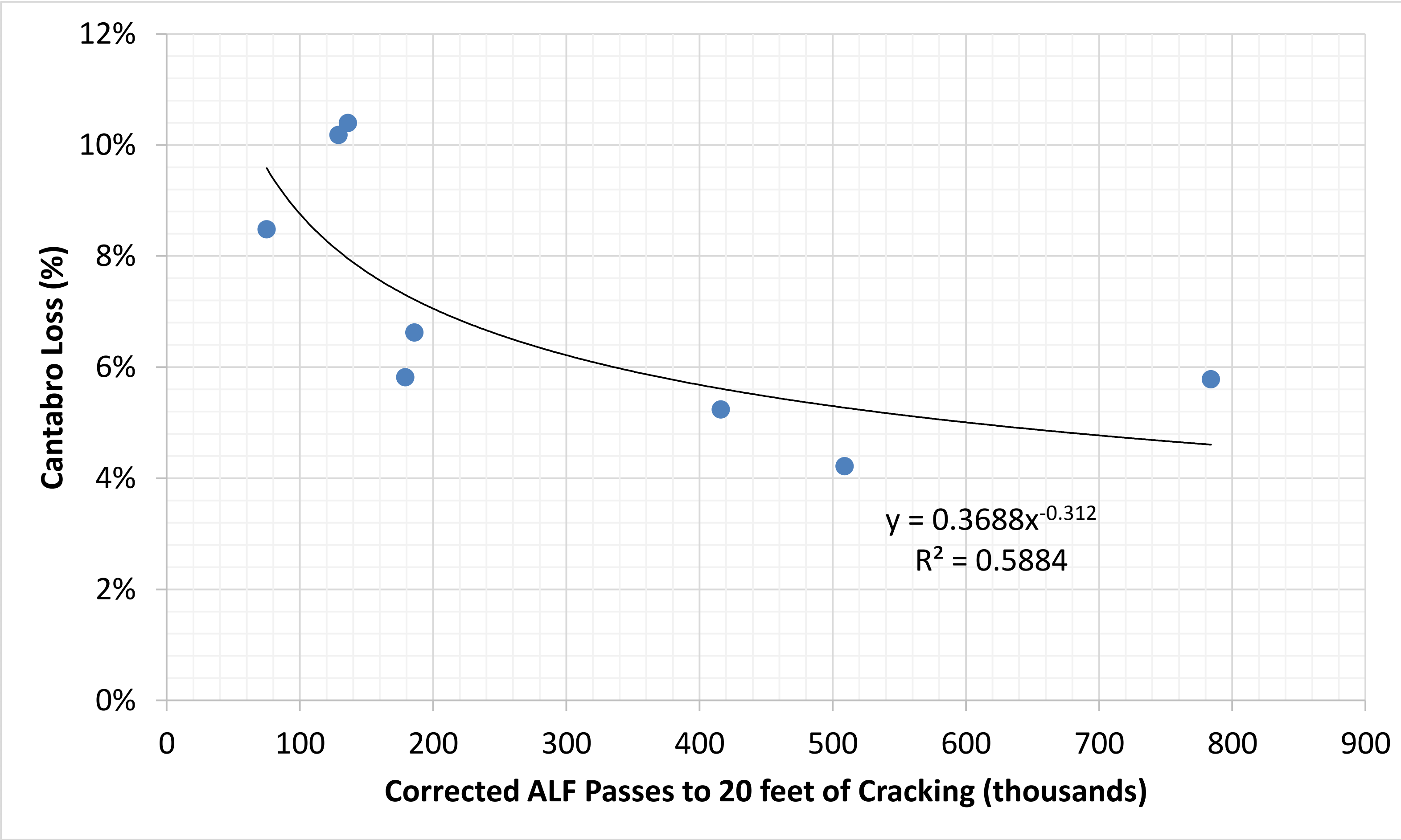
Cantabro Corrected ALF Correlation



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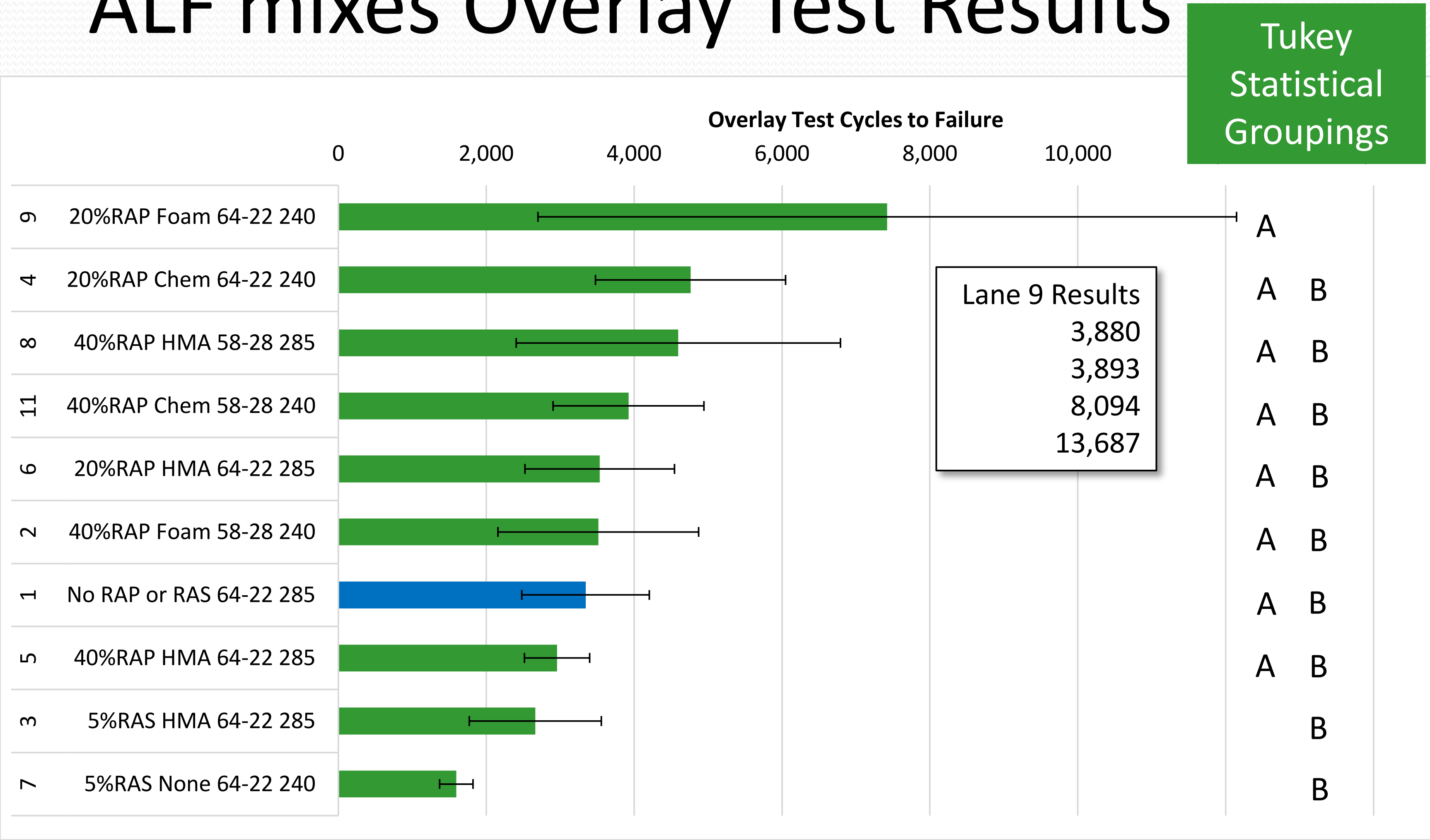
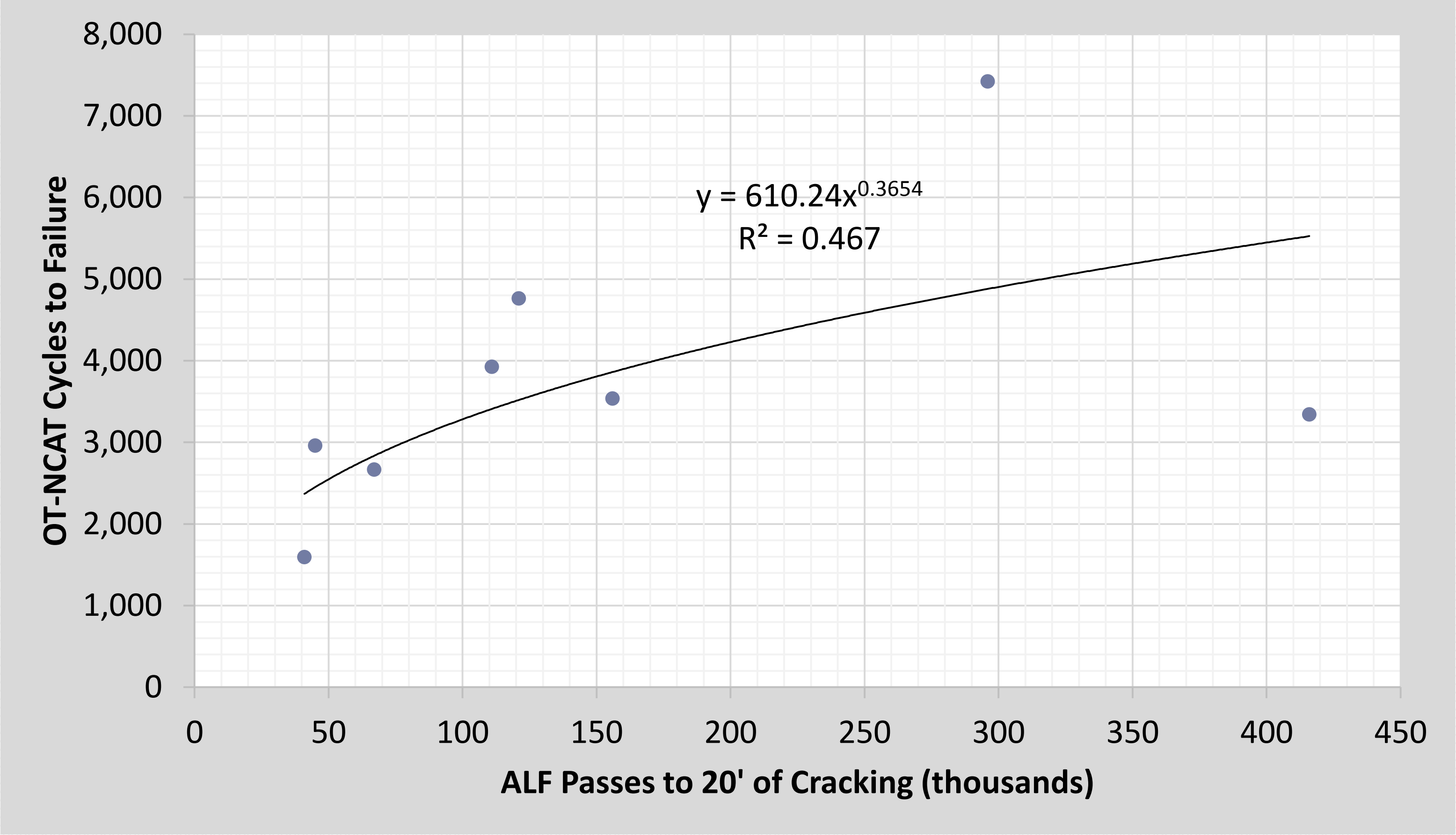
ALF mixes Overlay Test Results

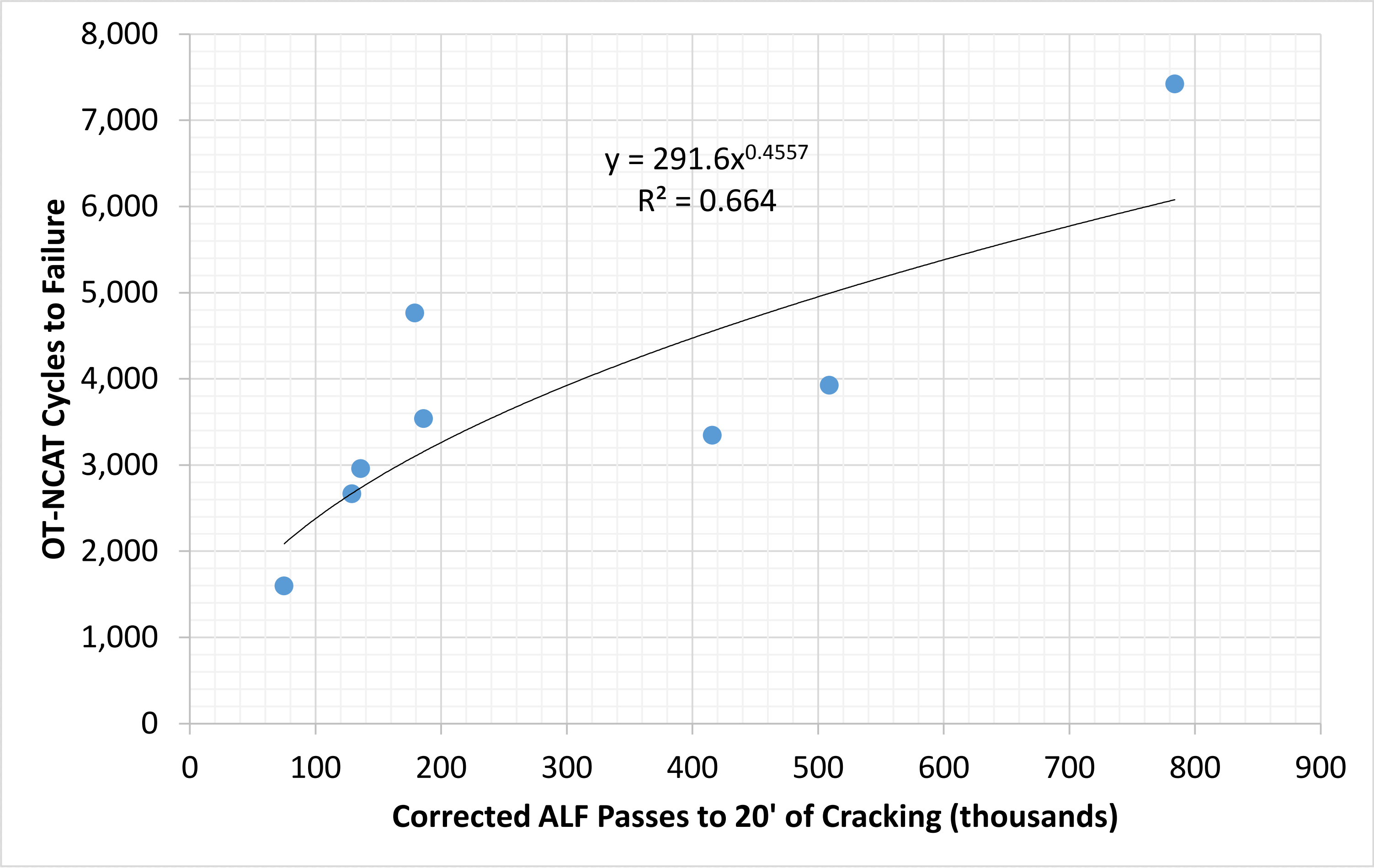


Average COV = 32%

OT-NCAT ALF Correlation



OT-NCAT Corrected ALF Correlation



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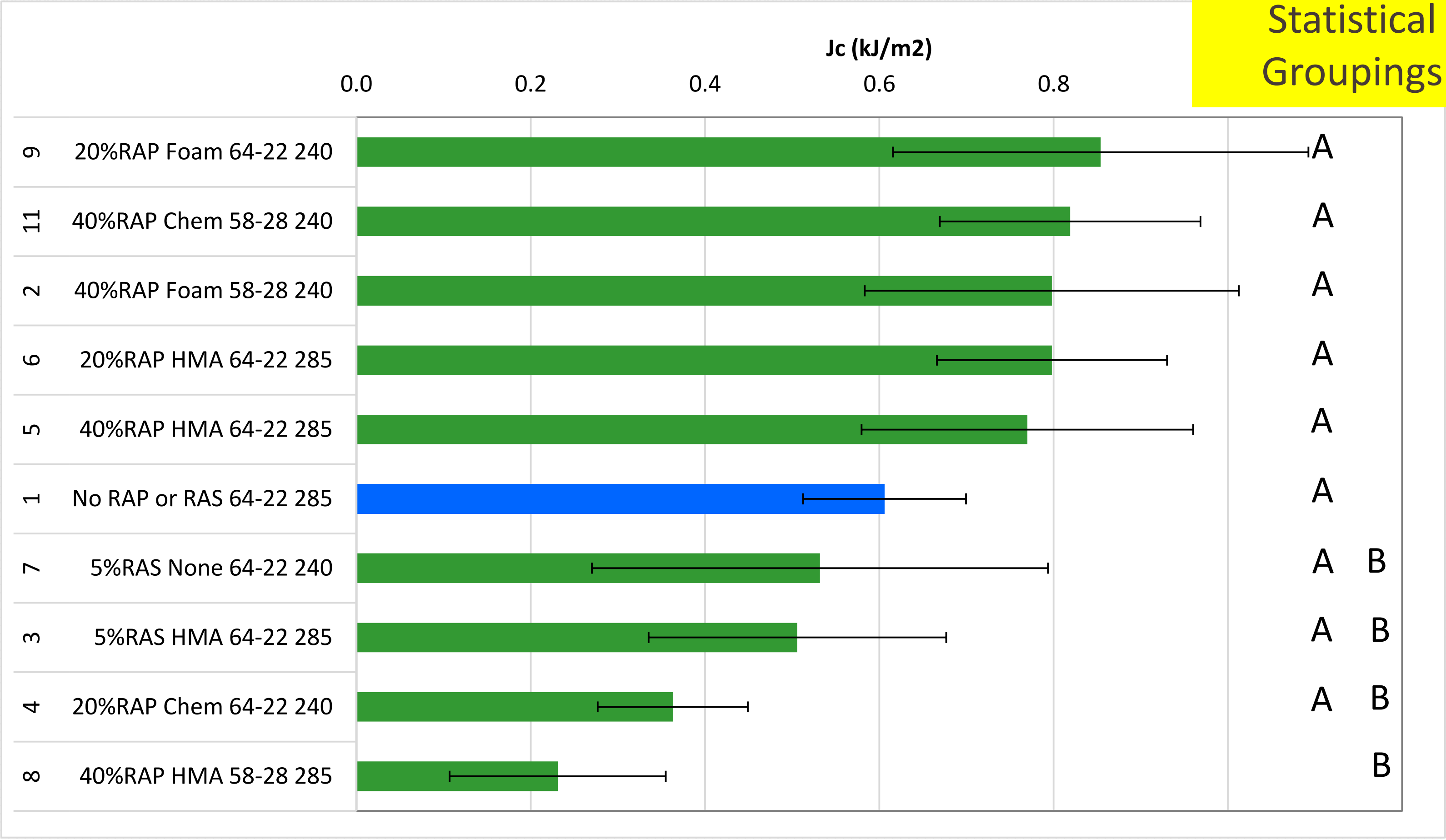
ALF Mixes SCB-LTRC Results

Maghsoodloo's Statistical Groupings



Average COV for Area to Peak Load = 27%

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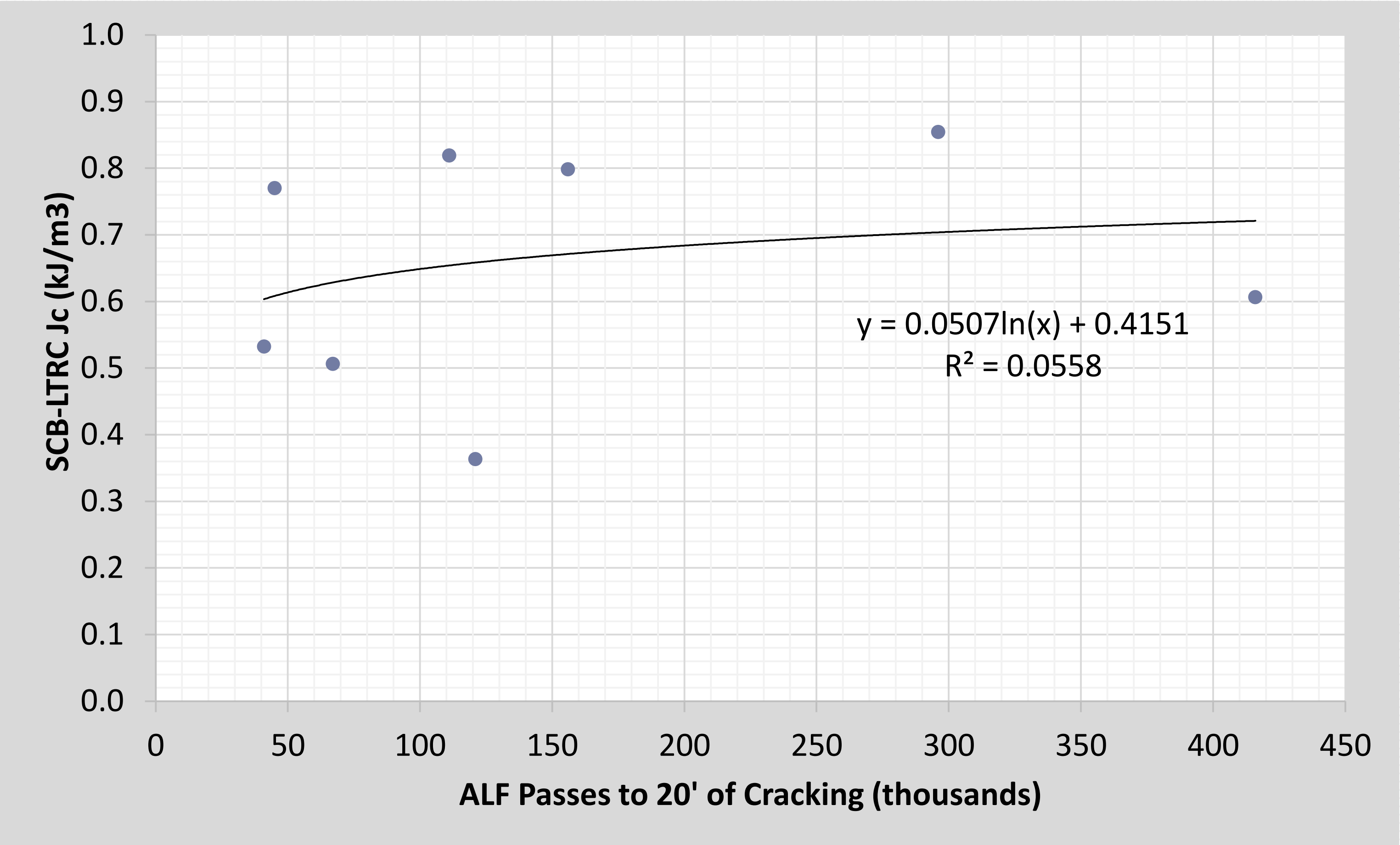
SCB-LTRC ALF Correlation



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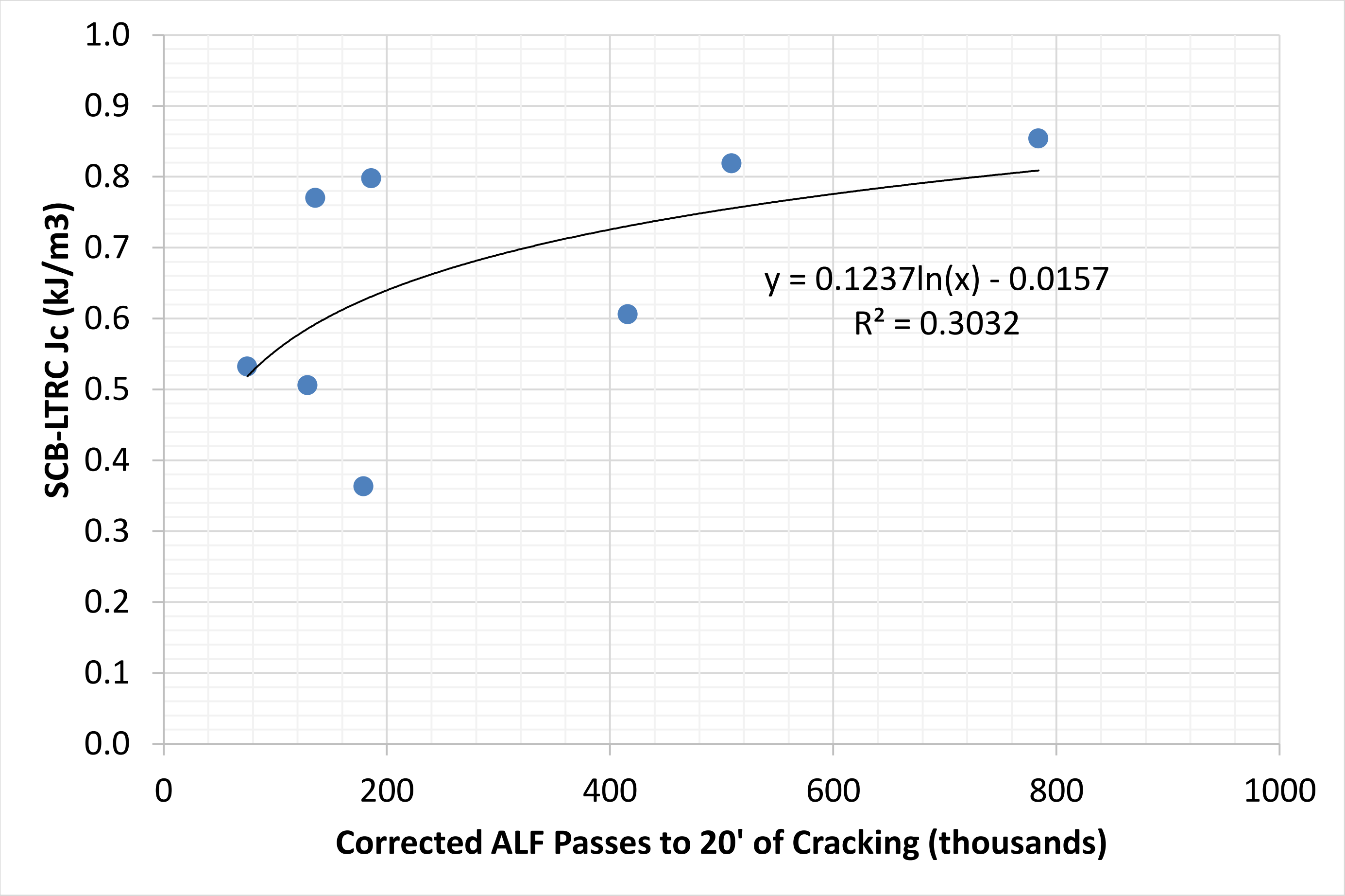
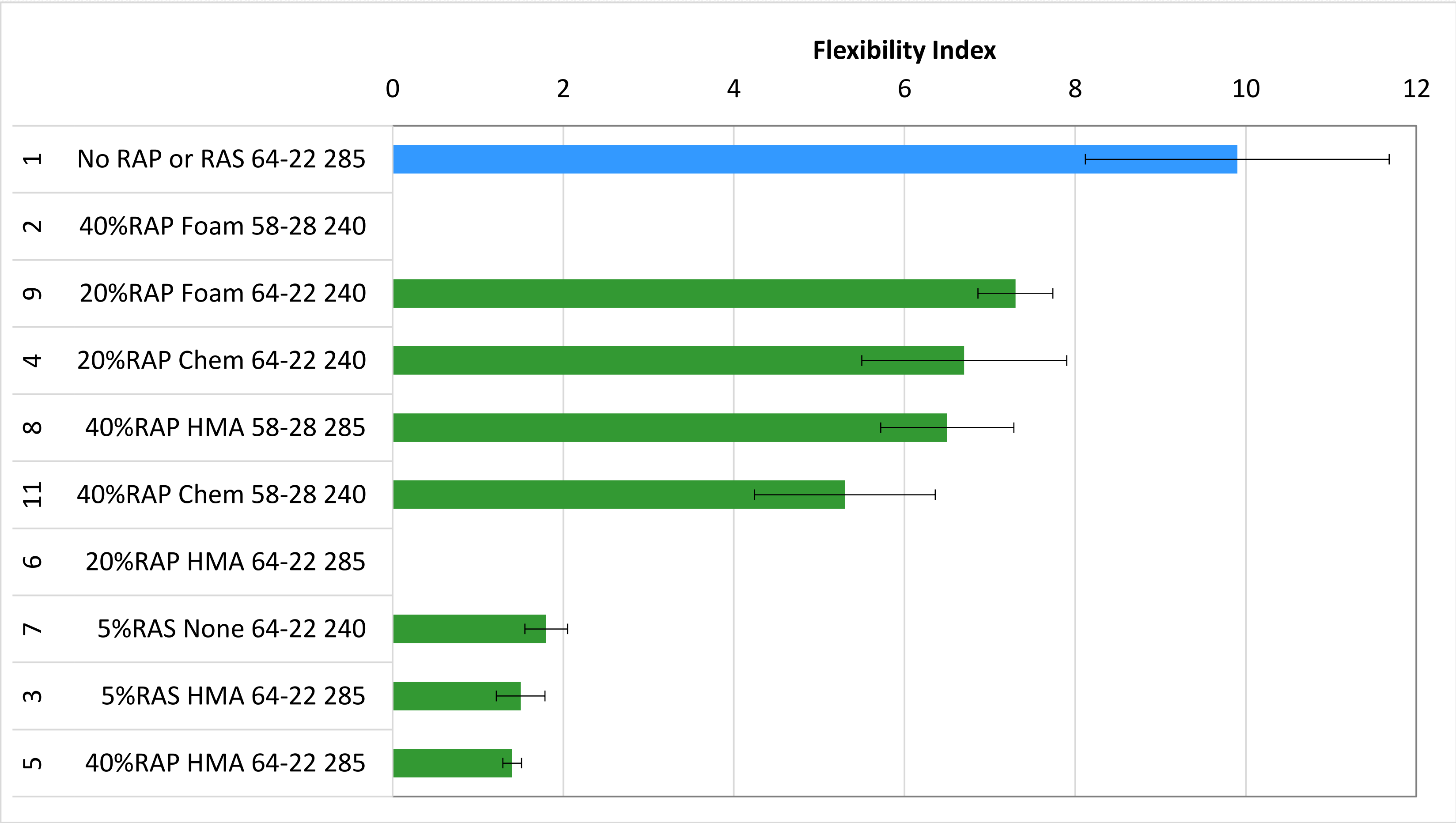
SCB-LTRC Corrected ALF Correlation

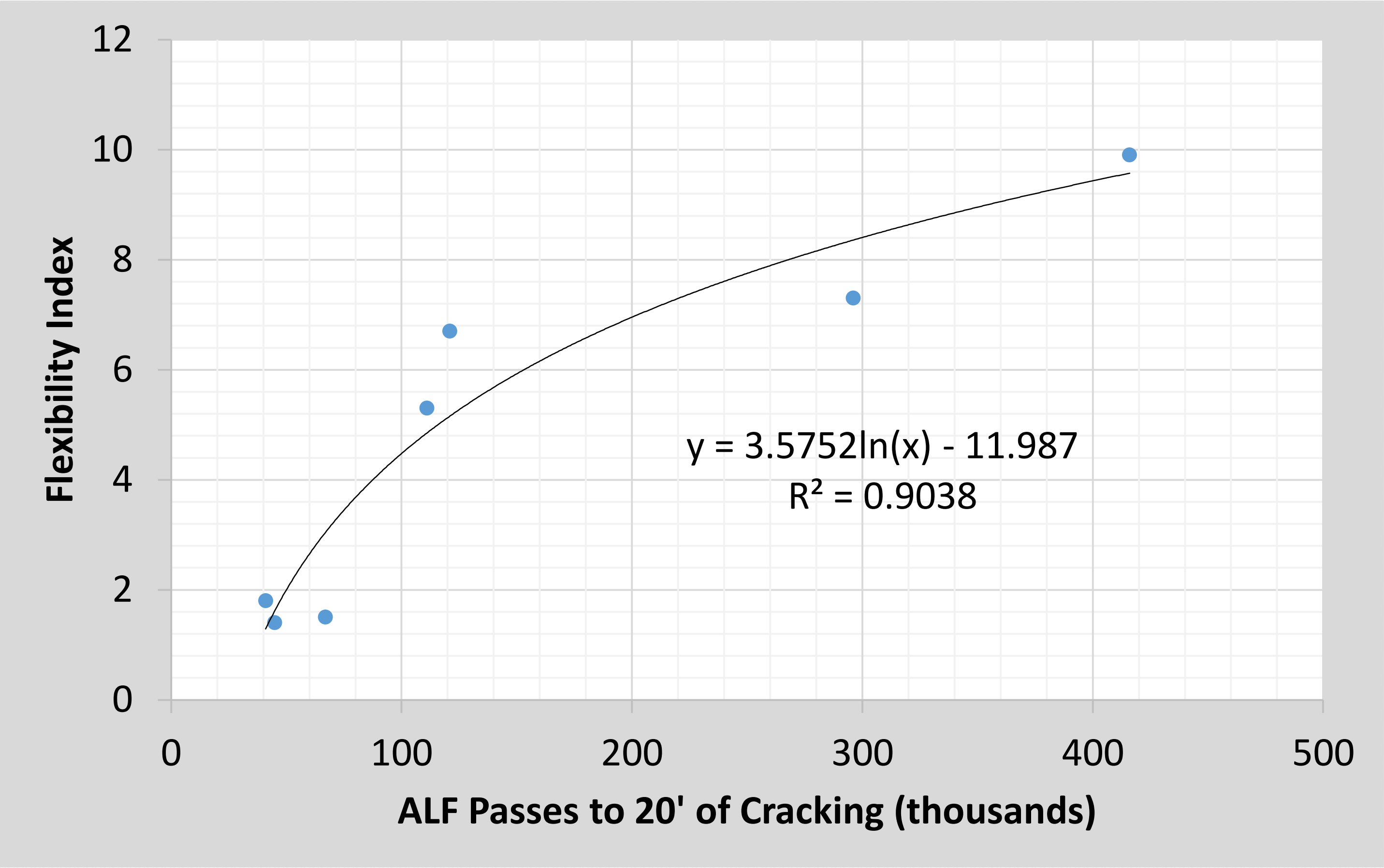


ALF mixes IFIT Flexibility Index

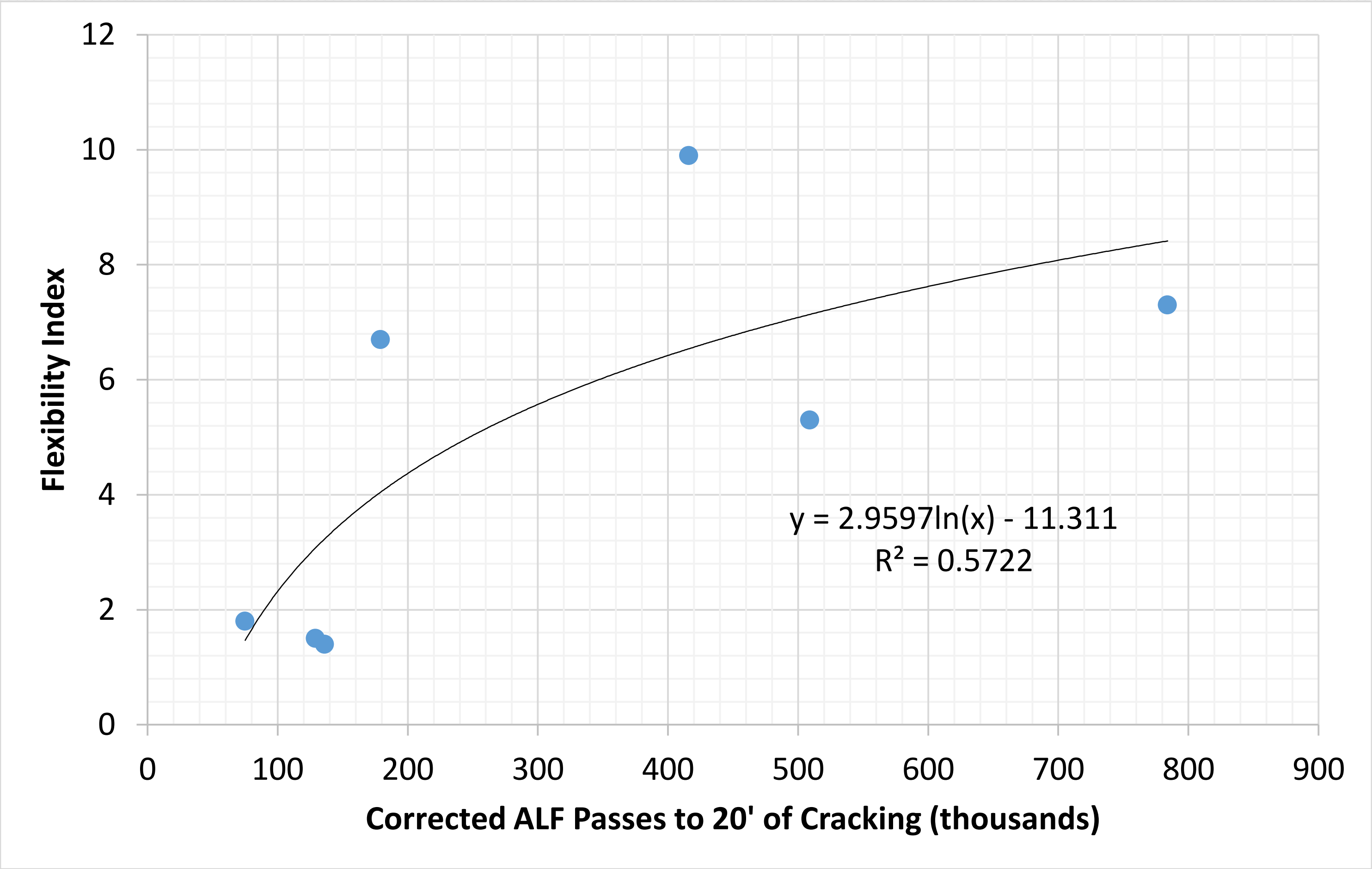


Average COV = 16%

Flexibility Index ALF Correlation



Flexibility Index Corr. ALF Correlation



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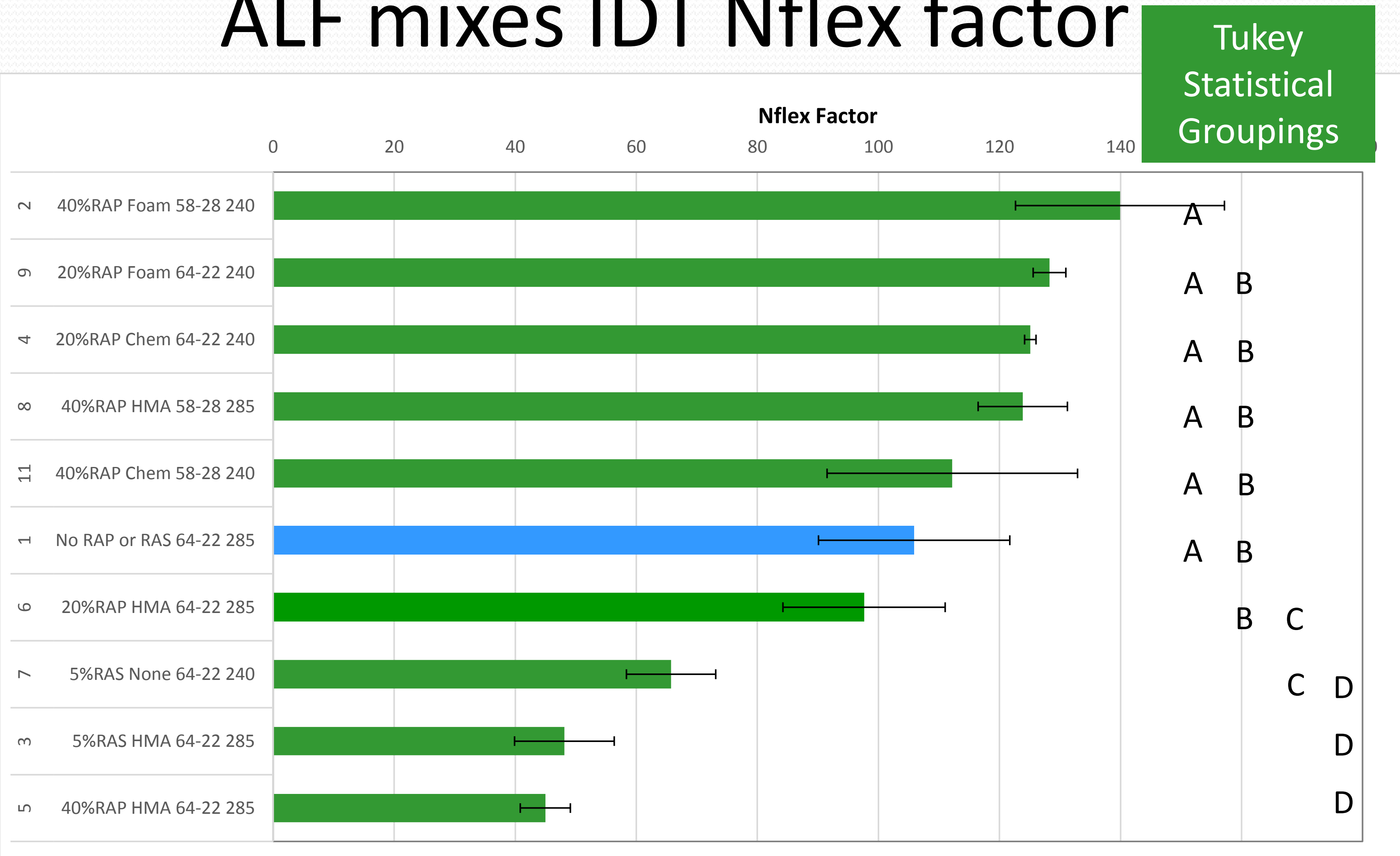
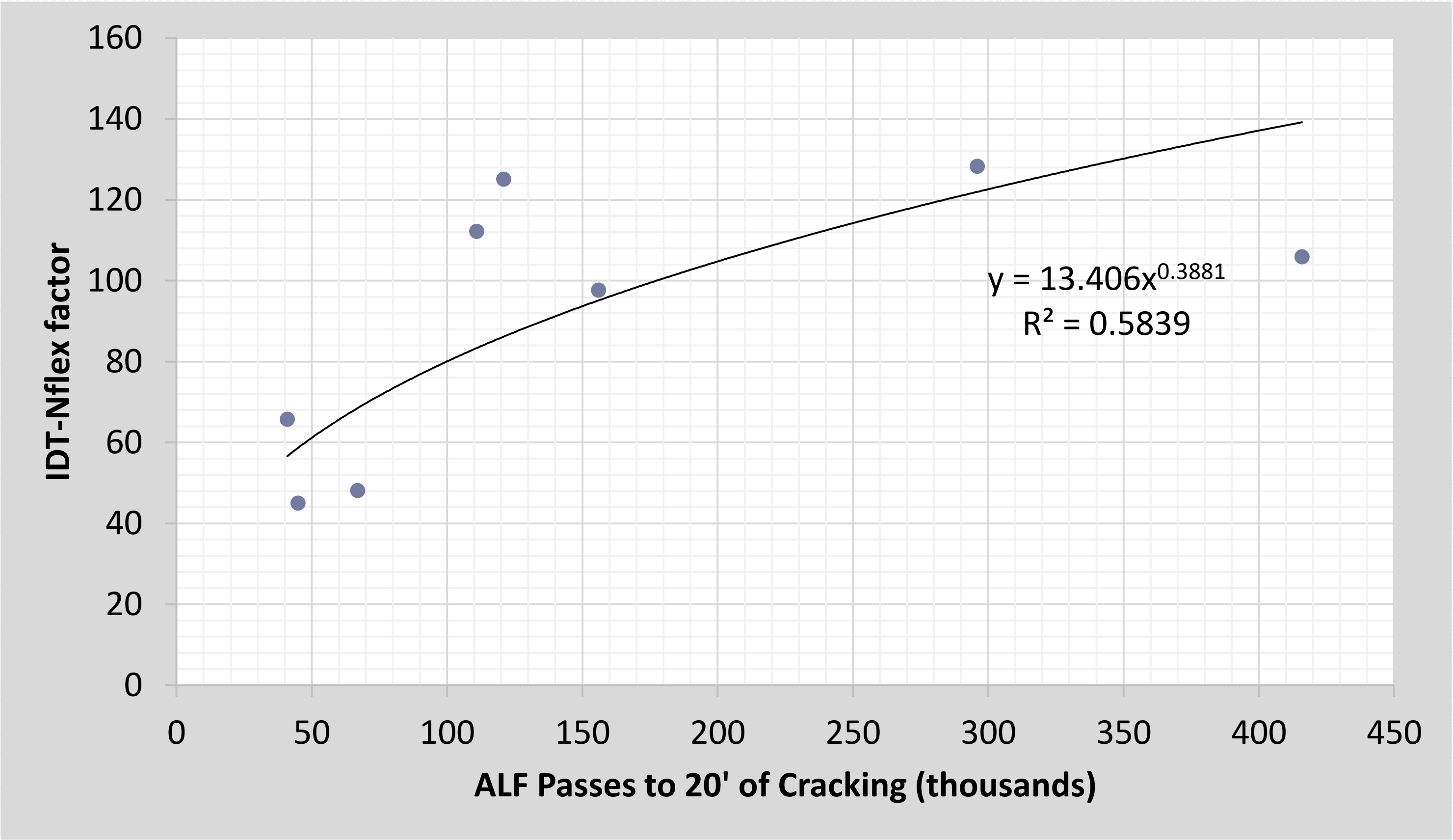
ALF mixes IDT Nflex factor



Average COV = 11%

Nflex Factor ALF Correlation



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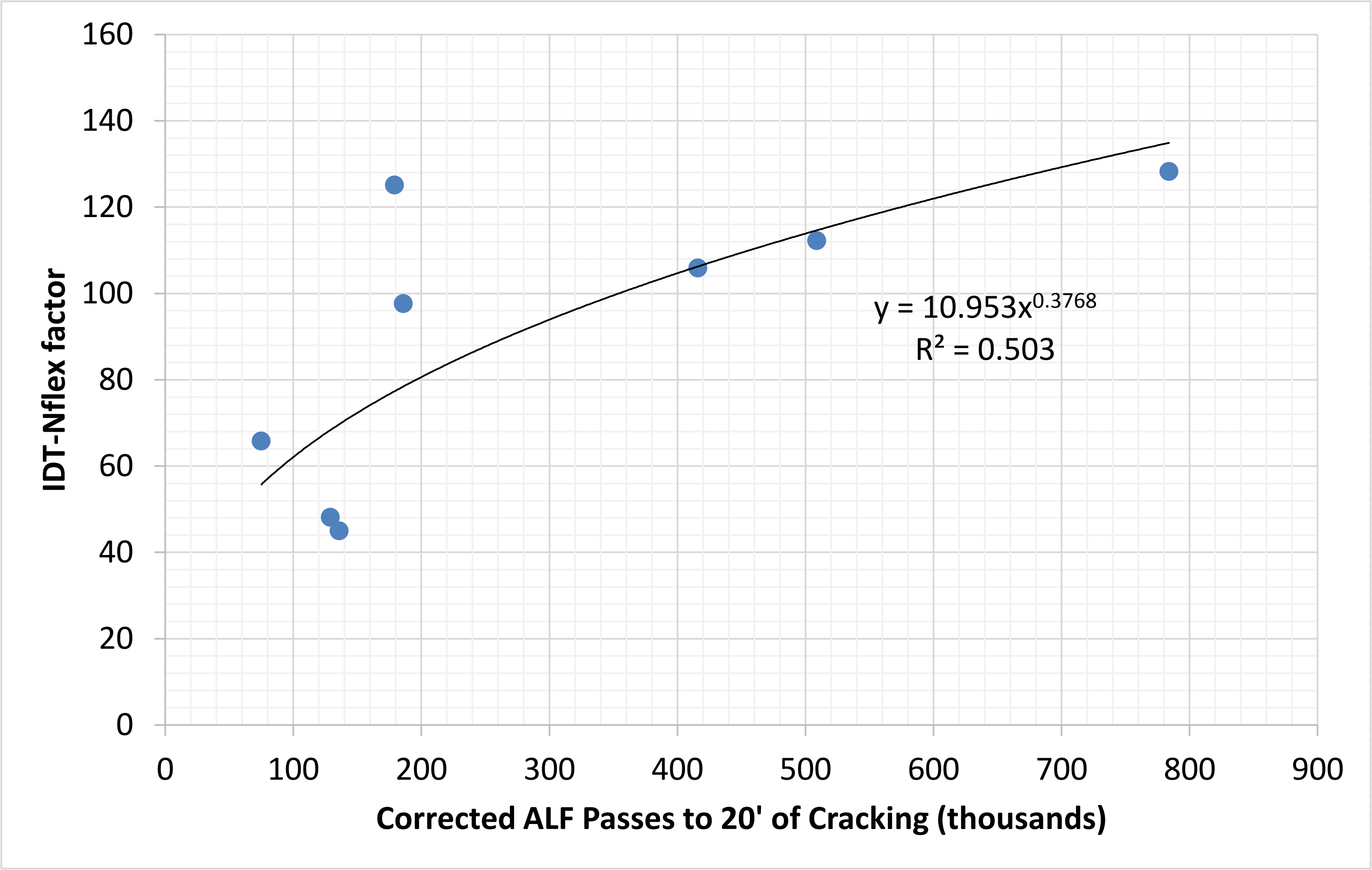
Nflex Factor ALF Correlation



Preliminary Assessment

Test	Time[1]	COV	Sens.	Corr. R^2
Cantabro	40 min.	19%	B	0.59
Mod. OT	2 days	32%	C	0.66
SCB-LTRC	1.5 days[2]	27%[3]	C	0.30
I-FIT	5 hours	11%		0.57
IDT Nflex factor	4 hours	11%	A	0.50

[1] once Ndes specimens are cooled. No aging.

[2] requires five SGC specimens

[3] COV of Work (area under load-def. curve)

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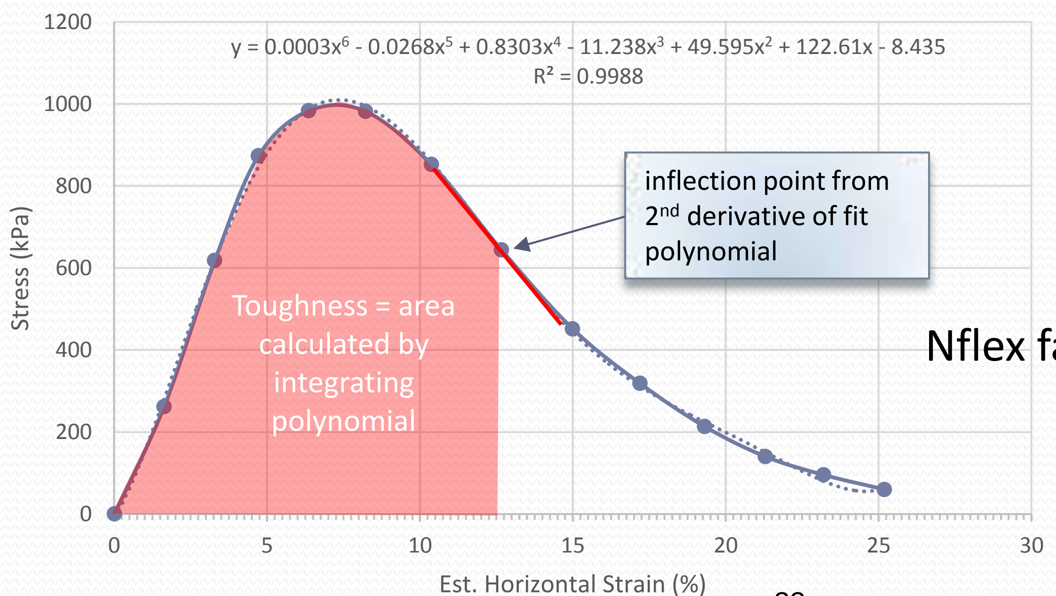
IDT Nflex factor

- 50 mm thick specimens
- Ram rate = 50 mm/min.
- Temp. = 25°C
- Area under σ vs. έ to post peak inflection point divided by slope at that point



inspired by IL-SCB method

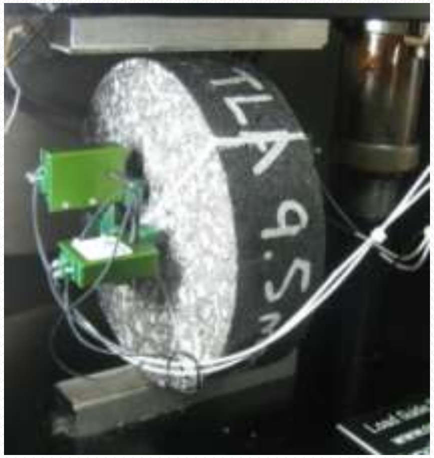
$$\text{Nflex factor} = \frac{\text{Toughness at inflection pt.}}{\text{slope at inflection pt.}}$$

Refining Nflex Factor

- Draft test method, AASHTO format
- Phase 1 Experiment
  - Effect of temperature - completed
  - Effect of loading rate
- Phase 2 Experiment
  - Effect of asphalt content
  - Effect of air voids
  - Effect of PG grade

PMLC Mixes from TT
- E7B – virgin mix, hybrid binder
- E8B – RAP & RAS, PG 76-22

LMLC Mixes
- virgin mixes
- Short & Long Term Aged



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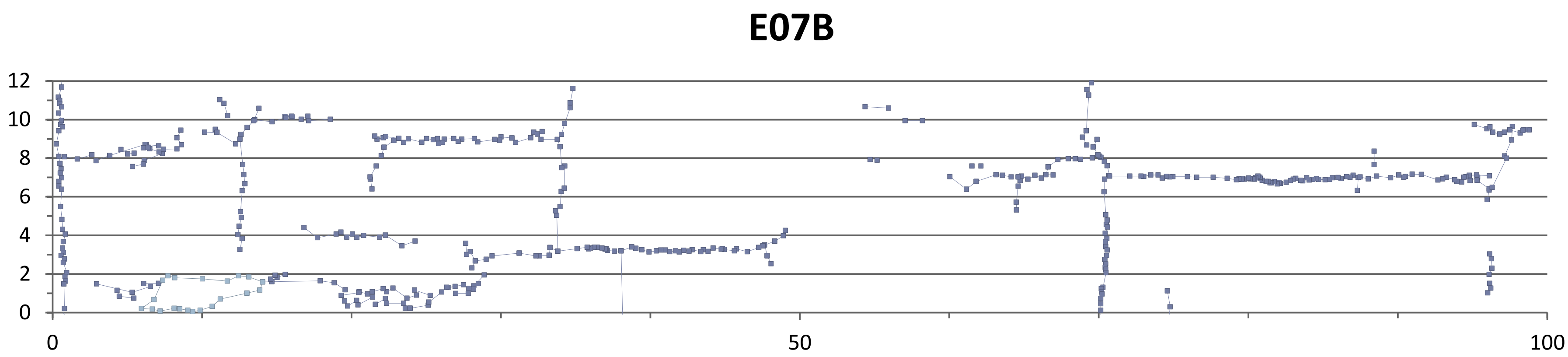
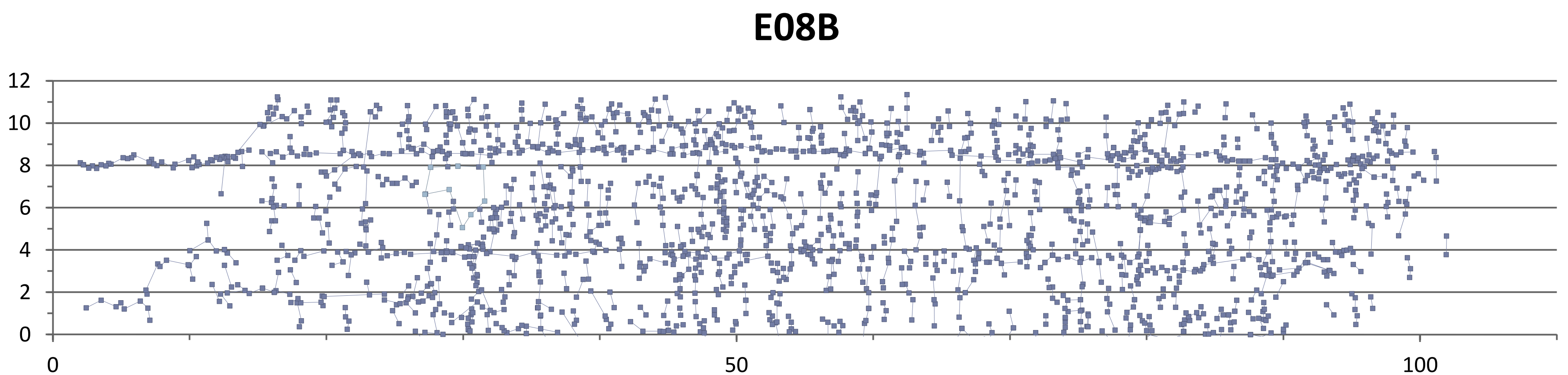


Virgin mix, Hybrid 76-22 binder

15% of Lane Area Cracking



20% RAP 5% RAS, SBS 76-22 virgin binder

73.4% of Lane Area Cracking

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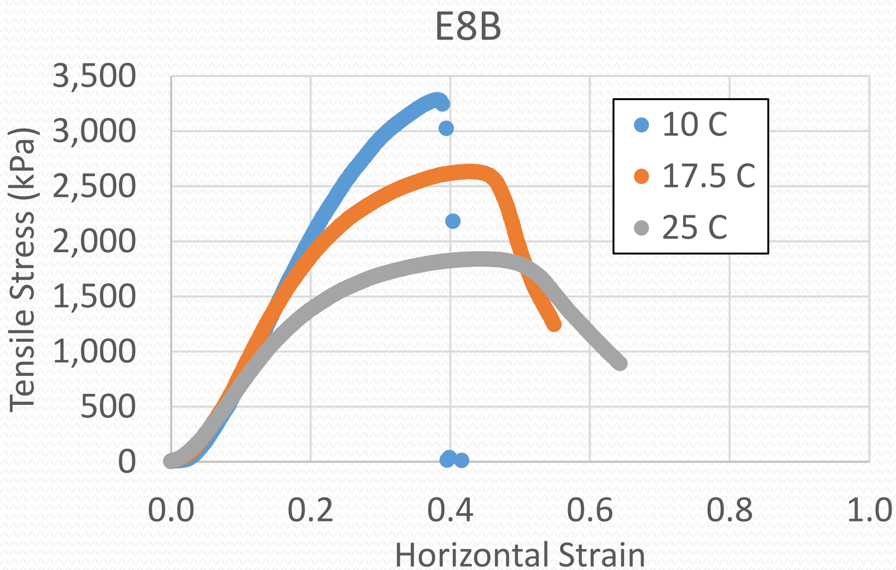
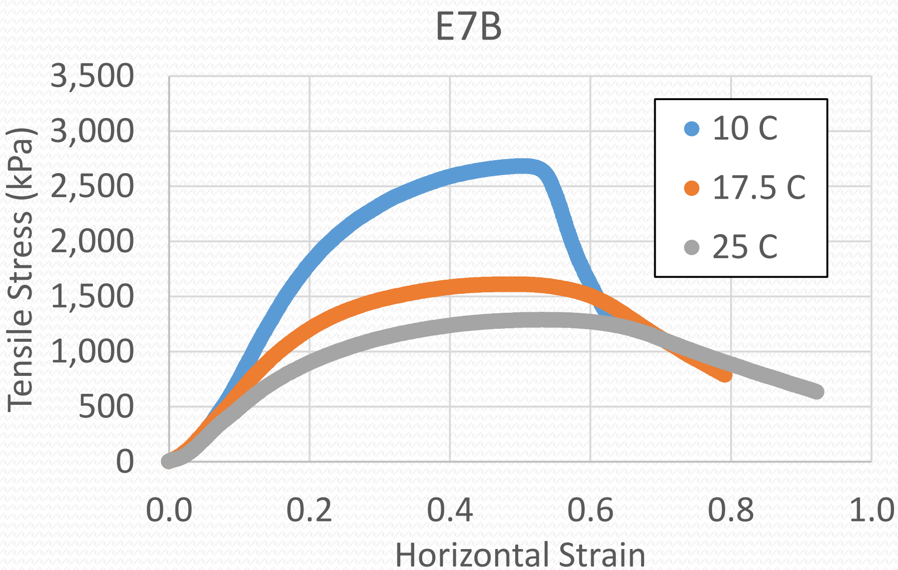
Refining Nflex Factor





Mix	E8B (brittle)			E7B (ductile)		
Test Temp.	10	17.5	25	10	17.5	25
Poisson's ratio	0.21	0.23	0.32	0.21	0.30	0.28
Toughness	755	813	799	1114	954	720
Brittleness slope	-48,855	-27,434	-10,104	-15,583	-4,099	-2,273
Nflex Factor	14.3	37.8	82.2	73.8	235.9	316.5

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NCAT + MnROAD
Cracking Group Experiments

Minnesota Department of Transportation

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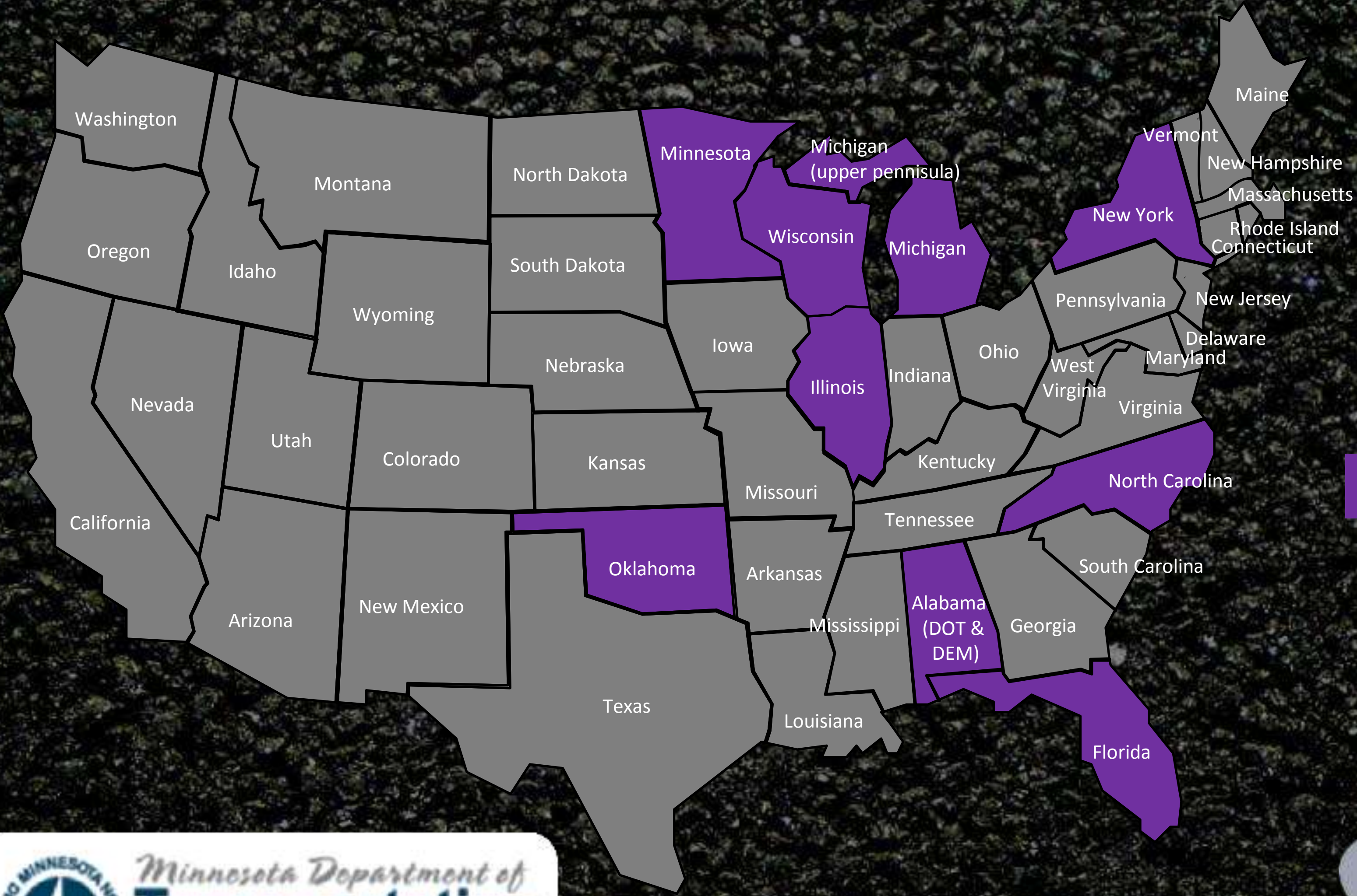
Objectives and Goals

- Objective: validate laboratory cracking tests by establishing correlations between the test results and measured cracking in real pavements using real loading conditions
- Goals: evaluate various tests based on:
  - Relatability to field performance.
  - Practicality of the tests for mix design verification and quality control testing.
  - Ability to accommodate recycled materials, new and future additives, and mix combinations.

Cracking Group Sponsors



FHWA

Minnesota Department of Transportation

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Scope

NCAT Test Track

- Top-down cracking

MnROAD

- Low-temperature cracking

Minnesota Department of Transportation

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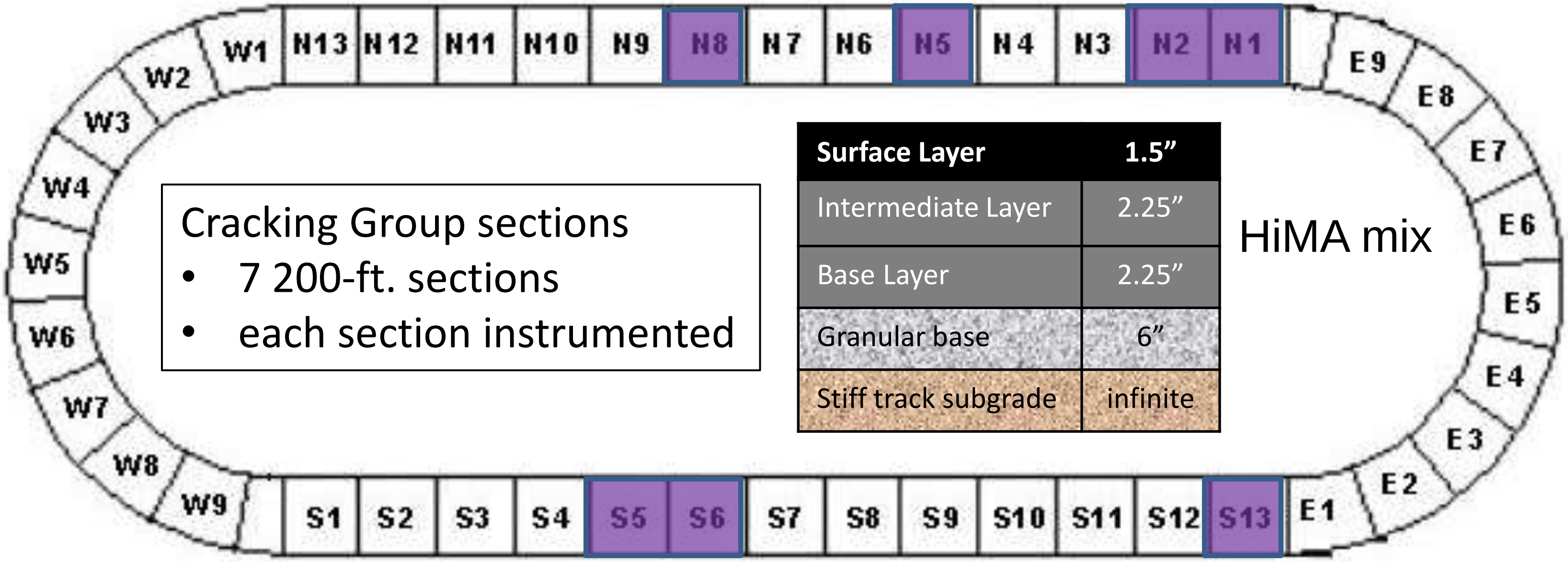
Top-Down Cracking Sections



Cracking Group sections

- 7 200-ft. sections
- each section instrumented

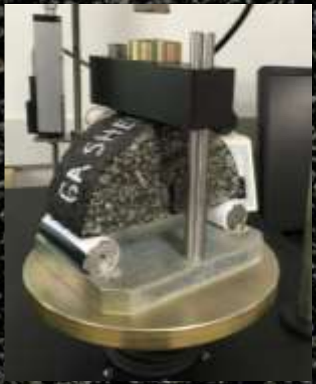
Surface Layer	1.5"
Intermediate Layer	2.25"
Base Layer	2.25"
Granular base	6"
Stiff track subgrade	infinite

HiMA mix

Tests for Top-Down Cracking Resistance

NCAT is conducting these tests on both LMLC and PMLC samples that are aged and unaged.


SCB-LA


SCB-IL


OT-TX


OT-NCAT


Energy Ratio


Nflex Factor

Cantabro

Materials were sampled for complementary studies funded by sponsoring agencies. 99 buckets of mix sampled per test section.

NCAT Cracking Group Sections

Section	Surface Mix Description
N1	20% RAP (0.20 binder ratio) PG 67-22
N2	Same as N1 with 96% in-place density
N5	Same as N1 except 0.5% low AC, low density
N8	20% RAP & 5% RAS with PG 67-22
S5	35% RAP with PG 58-28
S6	Same as N1 with HiMA PG76-28E
S13	Arizona style asphalt-rubber mix

cracking expectation

low

med.

high

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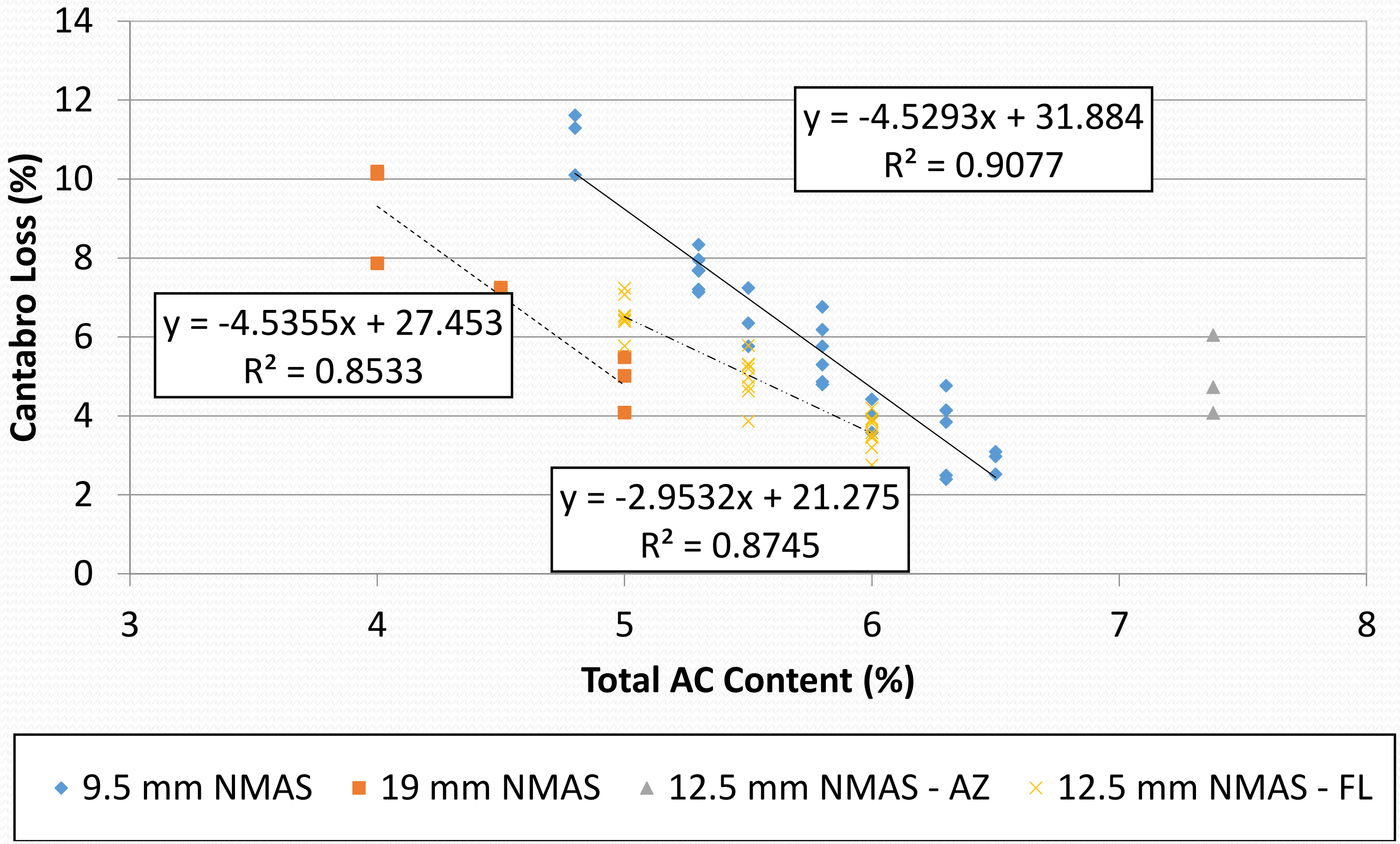
NCAT CG Experiment Status

- Test sections built in August 2015
- Const. QC data & baseline field data summarized
- Trafficking began Oct. 8, 2015
  - 2.5 million ESALs, no cracking yet
  - FWD testing and response data
- PMLC testing began Oct.1, 2015
  - Energy Ratio testing completed
- Complete experiment in 3 year cycle

Cantabro – Cracking Group Mix Designs



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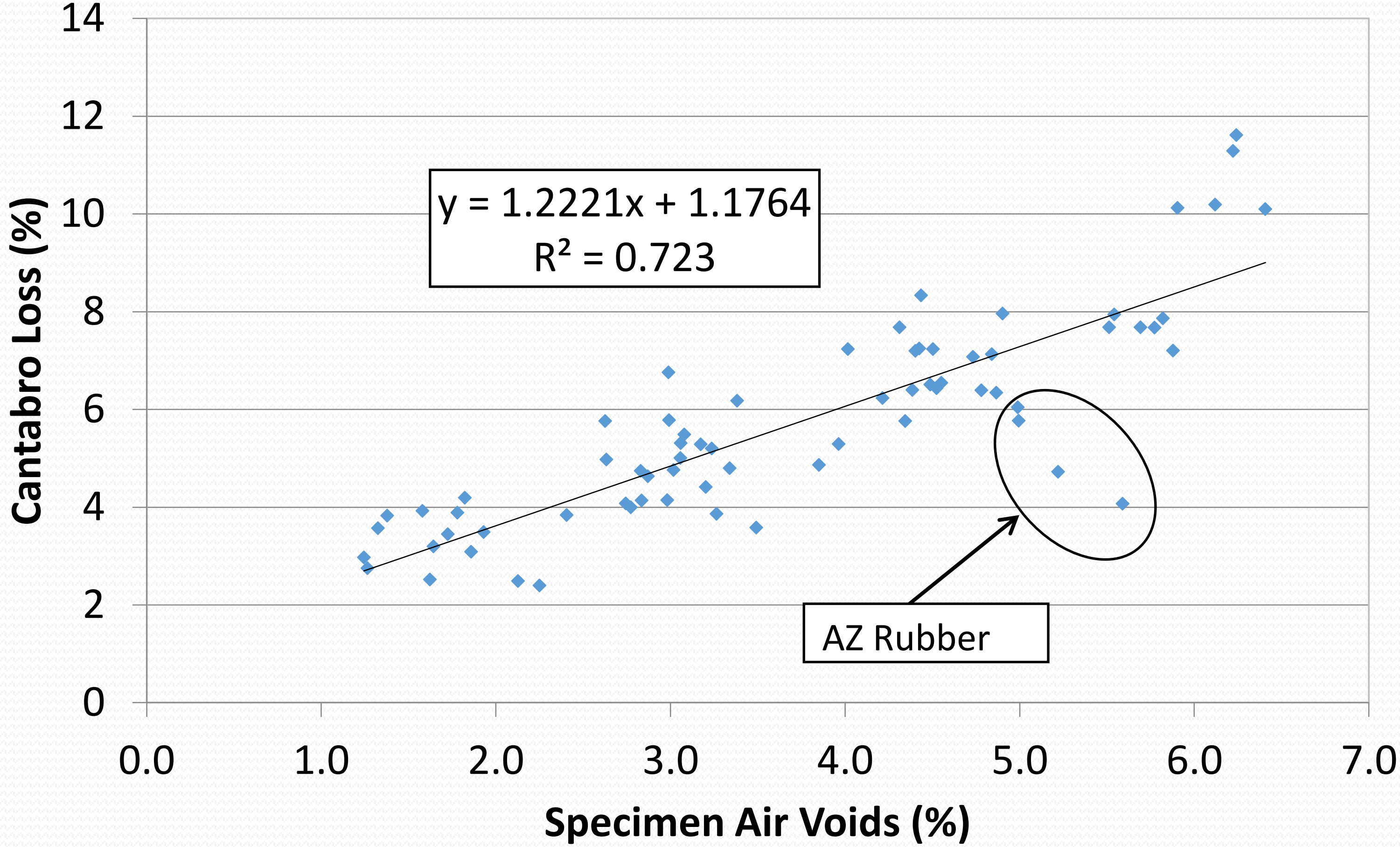
Cantabro – Cracking Group Mix Designs



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NCAT/MnDOT Partnership Cracking Group Experiment

MnROAD Test Section Update
National Center for Asphalt Technology

Auburn, Alabama
December 9, 2015

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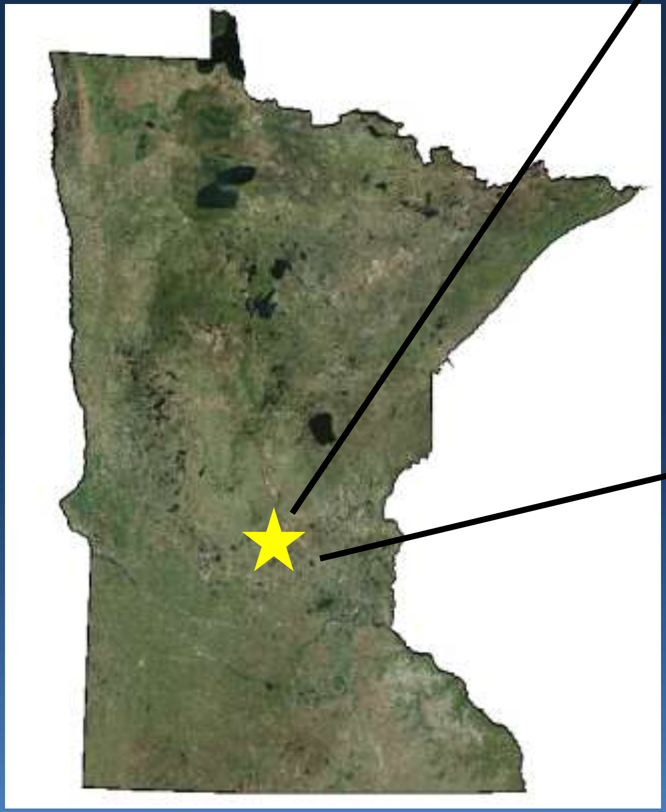
NCAT
at AUBURN UNIVERSITY

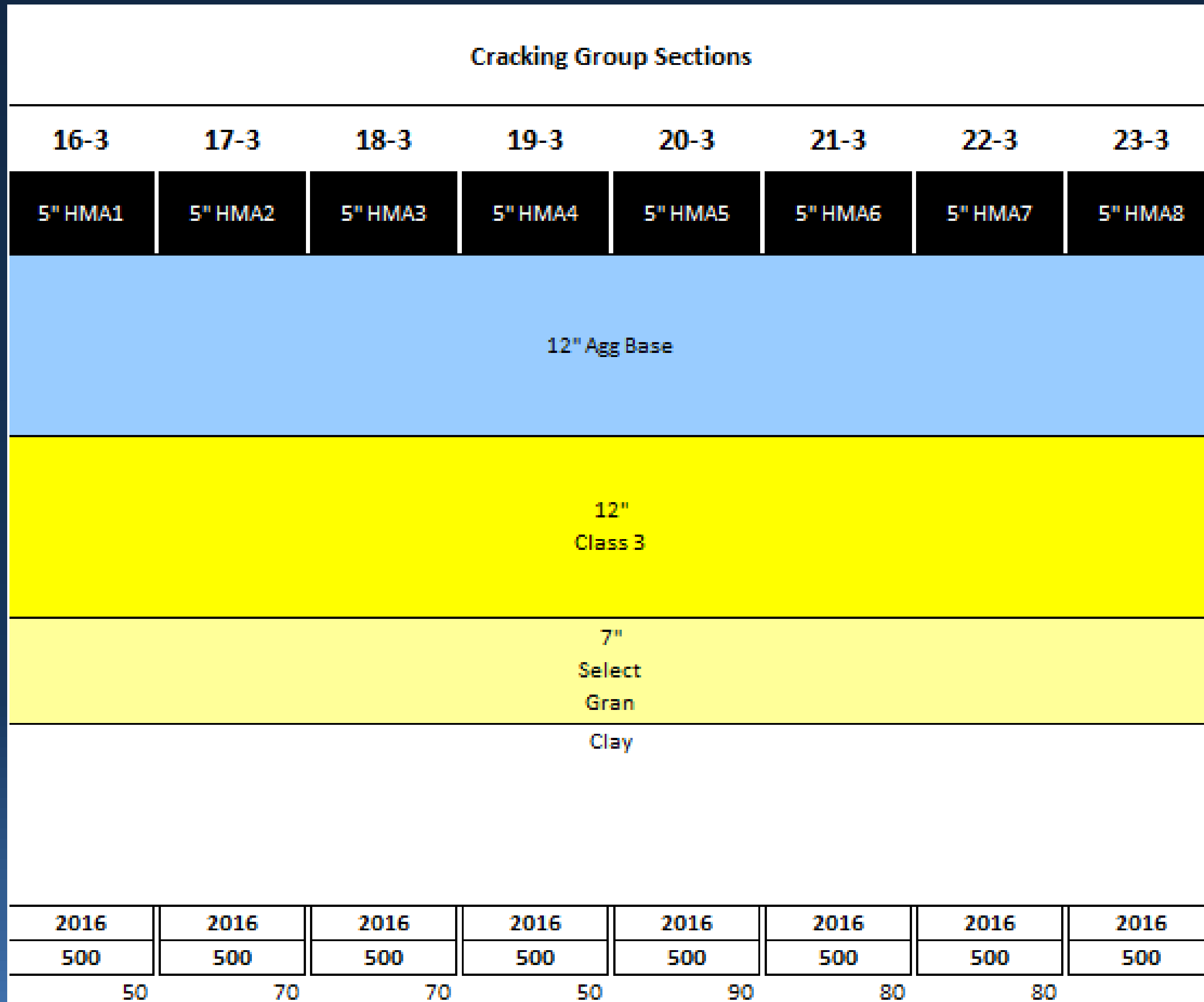
MnROAD
Safer, Smarter, Sustainable Pavements Through Innovative Research

Site Location



Test Section Layout

Proposed Pavement Sections



Asphalt Mixtures

CELL NO	MIX DESIGNATION	MAX AGG SIZE (mm)	ABR % (1)	RAP % (2)	RAS % (3)	Air voids at N_{design}	N_{design}	BINDER GRADE	COMMENTS
16	SPWEB540L SPECIAL	12.5	65	30	5	4.0	80	PG 64S-22	
17	SPWEB540L SPECIAL-1	12.5	77	20	3	4.0	80	PG 64S-22	
18	SPWEA540L SPECIAL-2	12.5	80	20	-	4.0	80	PG 64S-22	
19	SPWEB530L SPECIAL-3	12.5	80	20	-	3.0	100	PG 64S-22	
20	SPWEB540A SPECIAL	12.5	70	30	-	4.0	80	PG 52S-34	
21	SPWEB540C SPECIAL	12.5	80	20	-	4.0	80	PG 58H-34	
22	SPWEB540C SPECIAL-1	12.5	80	20	-	4.0	80	PG 58H-34	3139 modified for limestone
23	SPWEB540I SPECIAL	12.5	85	15	-	4.0	80	PG 64E-34	Highly modified asphalt binder

Cracking Modes and Testing

- Types of cracking to be investigated
  - Low temperature a given
  - Top-down likely
  - Fatigue also possible
- Select appropriate post-construction testing
  - Low temp: DCT-MN and SCB-MN
  - Intermediate temp: I-FIT (SCB-IL)
  - Top down, fatigue: Overlay Tester, BB Fatigue
  - ME Design: E*
  - Loose mix, cores
- Additional: BBR mix beams (related study, separate funding)

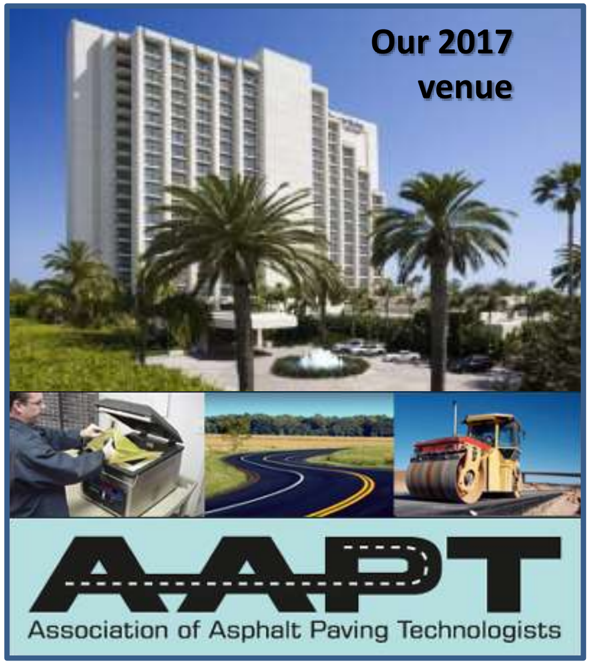
Schedule

- Pre-bid meeting – May 4
- Letting - May 20
- Mix Designs – July & August
- Construction - September

92nd AAPT Annual Meeting and Technical Sessions

The 2017 Annual Meeting will be held March 19-22, 2017

The Island Hotel, Newport Beach, California USA



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2017 Call for Papers

The Association of Asphalt Paving Technologists is actively soliciting paper offers for its 2017 Annual Meeting and Technical Sessions. Papers reporting on studies concerning any aspect of asphalt paving technology or related fields are considered. These can include research, design, construction and maintenance issues dealing with all types of asphalt binders, asphalt mixtures, and pavement applications – including innovative ideas and improvements to current practice. Papers will be considered for presentation at the Annual Meeting which is attended by specialists from academia, research organizations, material producers, contractors, national and state authorities, and consultants from around the world. Papers offered for the 2017 Annual Meeting must be submitted through the AAPT website.

Important dates

May 1, 2016 web site open for paper submission
August 15, 2016 - deadline for submitting papers
November 4, 2016 - notification of paper acceptance
December 2016 - registration open
March 19 to 22, 2017 - annual meeting and technical sessions

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