Update on Results of Simple Durability Tests on Mixes from the FHWA ALF Experiment and Plans for the MnROAD-NCAT Partnership to Validate Cracking Tests

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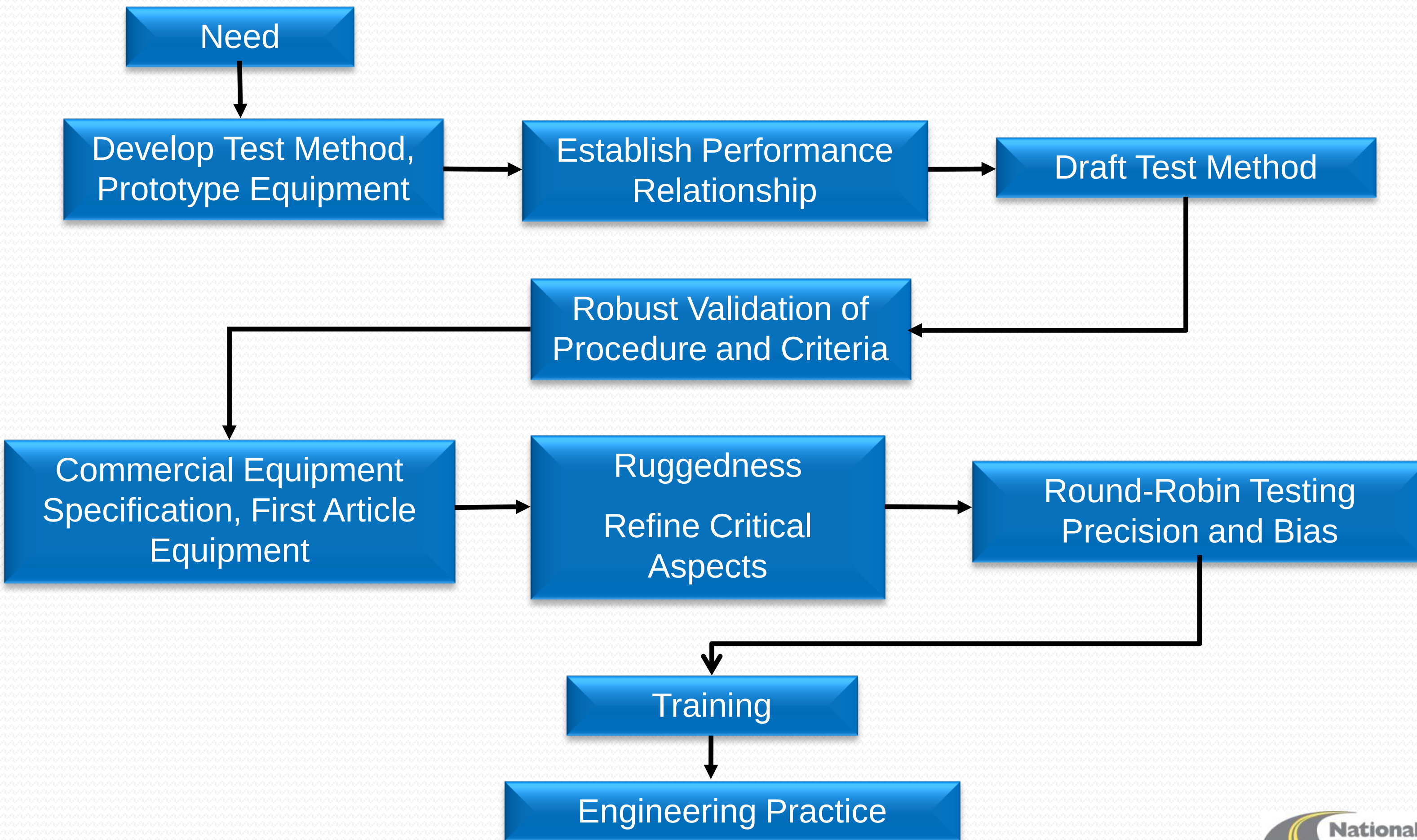
Performance Test Development



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Evaluation of Simple Mix Tests to Assess Cracking Resistance

- The objective is to determine if results of selected tests correlate with observed cracking performance using 10 mixtures from the 2013 FHWA ALF experiment.
- Cracking tests selected that are reasonably quick to conduct and could possibly used for mix design and QA testing.

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Facility Overview

ALF Loading Conditions

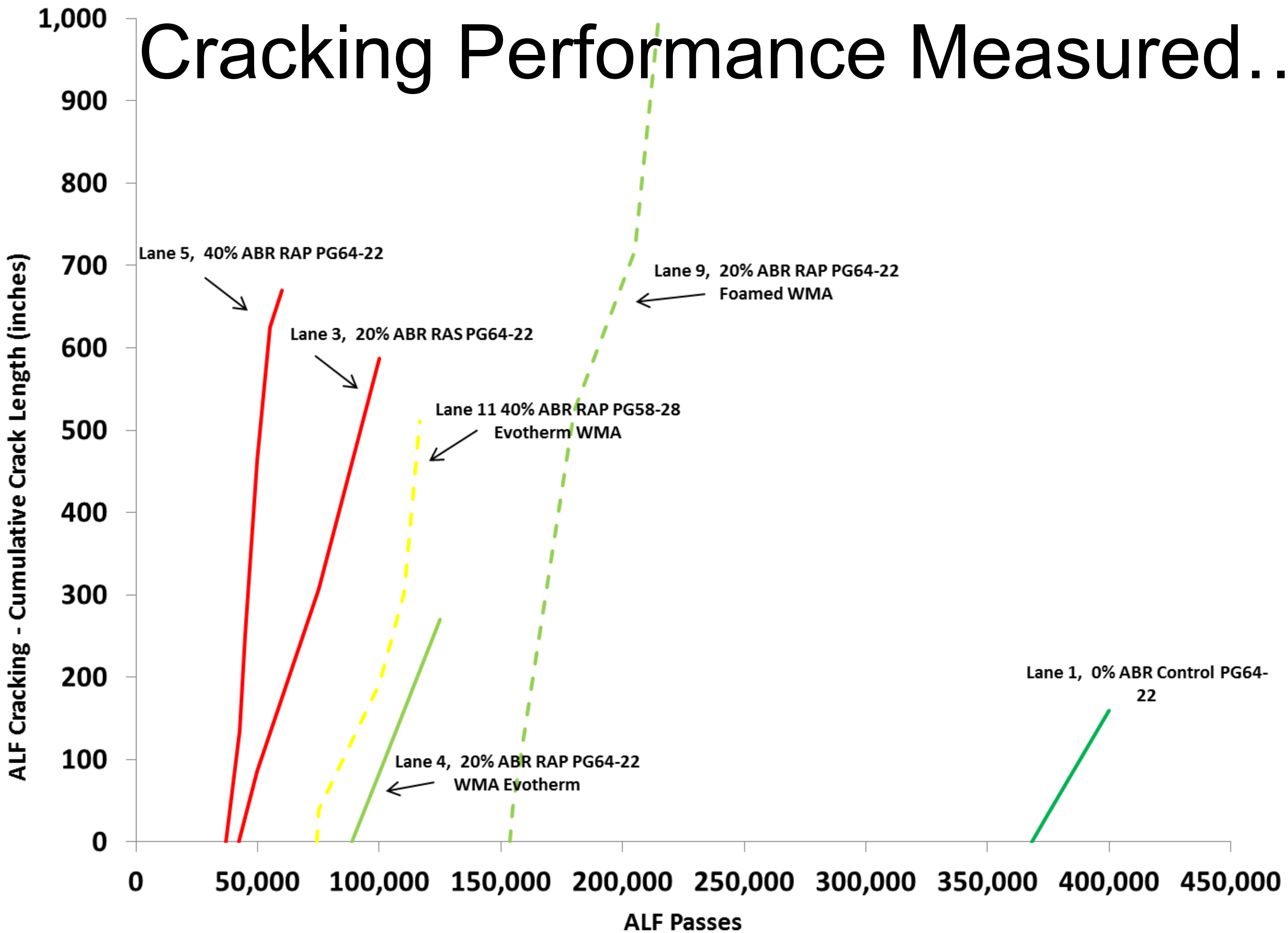
- Controlled 20ºC @ 20mm
- Loading only one direction
- Lateral Wander
- 425 Super Single Tire
- 100 psi inflation
- 14,200 lb load
- ~4-inch thick asphalt
- ~22-inch thick agg base

Mixes in Current FHWA ALF Experiment

Lane	WMA Type	RAP BR (%)	RAS BR (%)	Virgin Binder PG	Prod. Temp. (F)
1	n/a	0	0	64-22	285
2	foam	40	0	58-28	240
3	n/a	0	20	64-22	285
4	chem.	20	0	64-22	240
5	n/a	40	0	64-22	285
6	n/a	20	0	64-22	285
7	n/a	0	20	64-22	240
8	n/a	40	0	58-28	285
9	foam	20	0	64-22	240
11	chem.	40	0	58-28	240

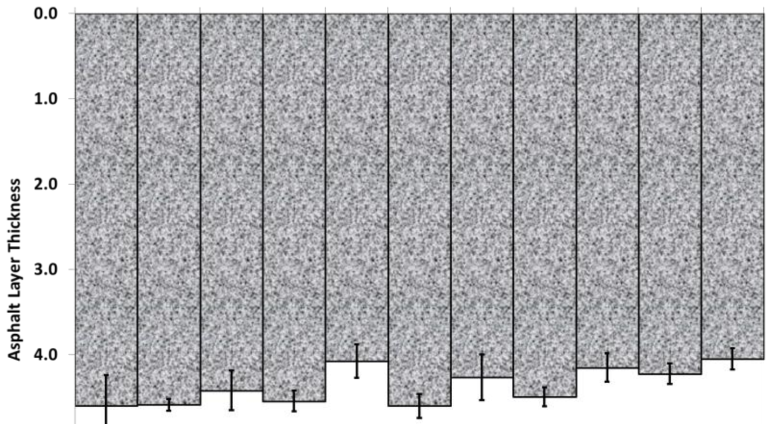
- All lanes were built to a target of 4 inches of asphalt mix. Testing of the lanes began in Fall 2013 and is expected to be completed in Fall 2015.

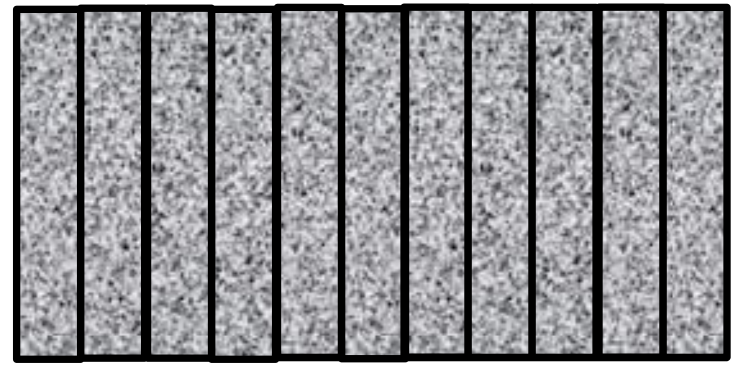
Cracking Performance Measured…



As-Built vs. Perfect Construction (thin)

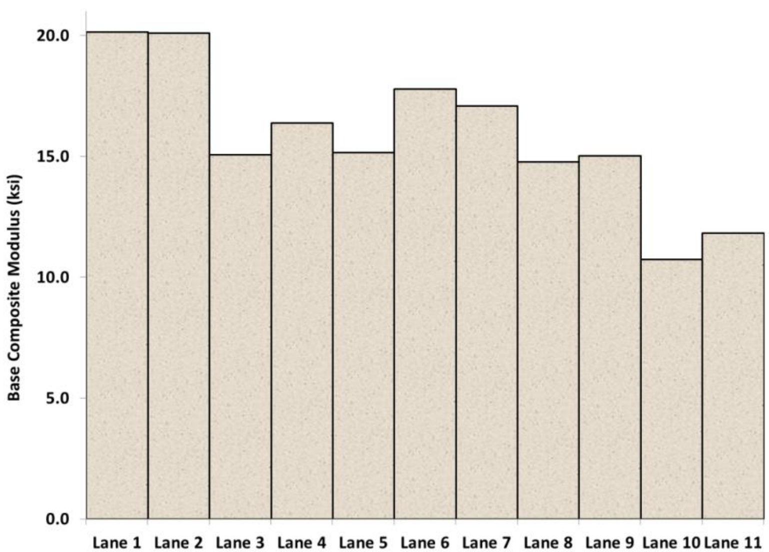
Asphalt Thickness

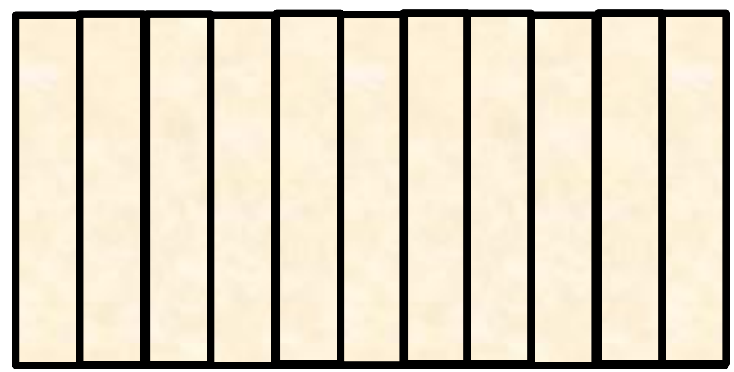




Average = “Perfect”

Base Stiffness





Tests Conducted

Test	Method
Cantabro	ASTM D7064-08
SCB	LTRC method
IDT	NCAT
Overlay Tester	Tex-248-F modified by NCAT

- Test specimens were made from SGC samples compacted to N_{design} (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.

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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
- Studies by Doyle and Howard

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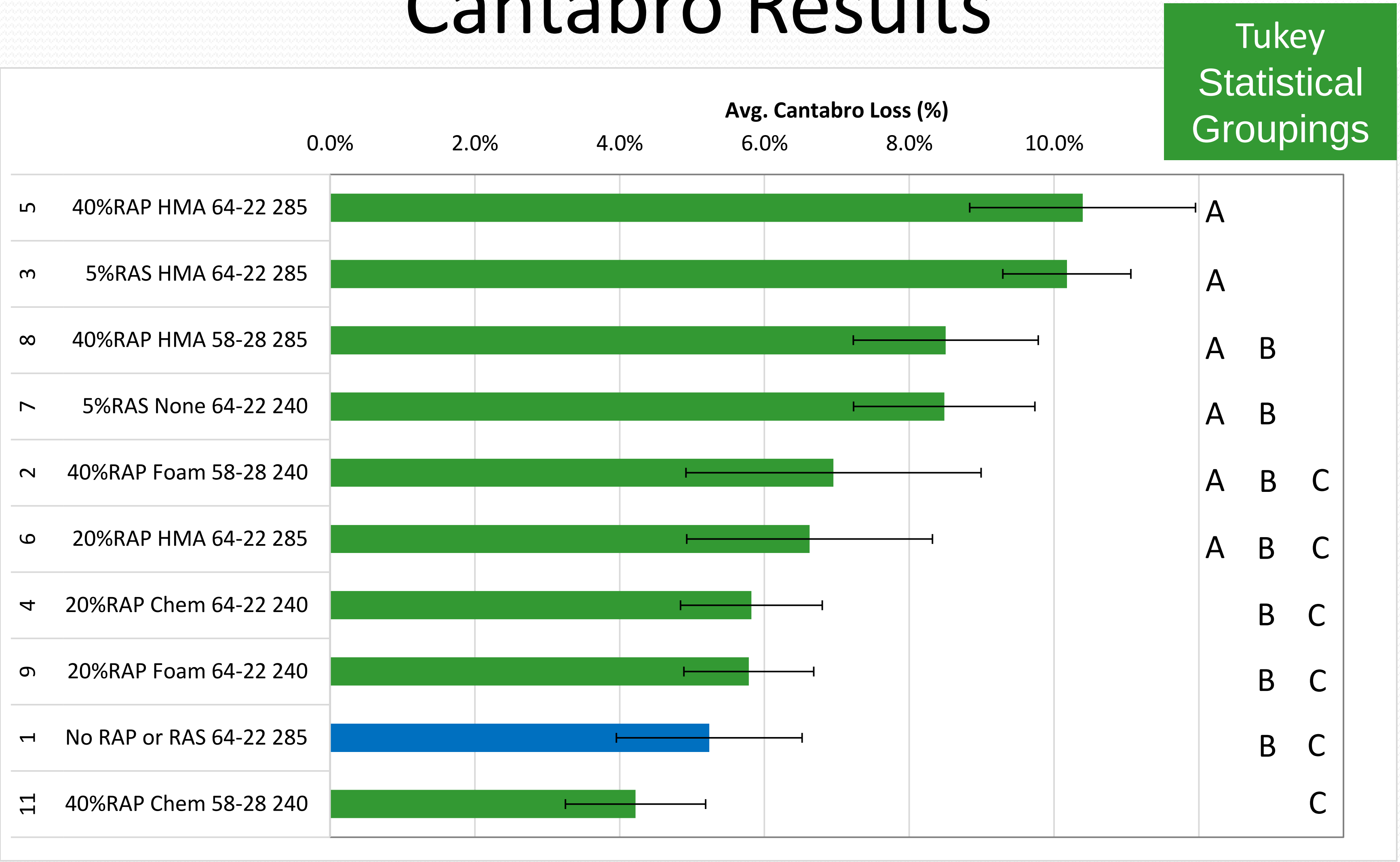
Cantabro Results



Average COV = 19%

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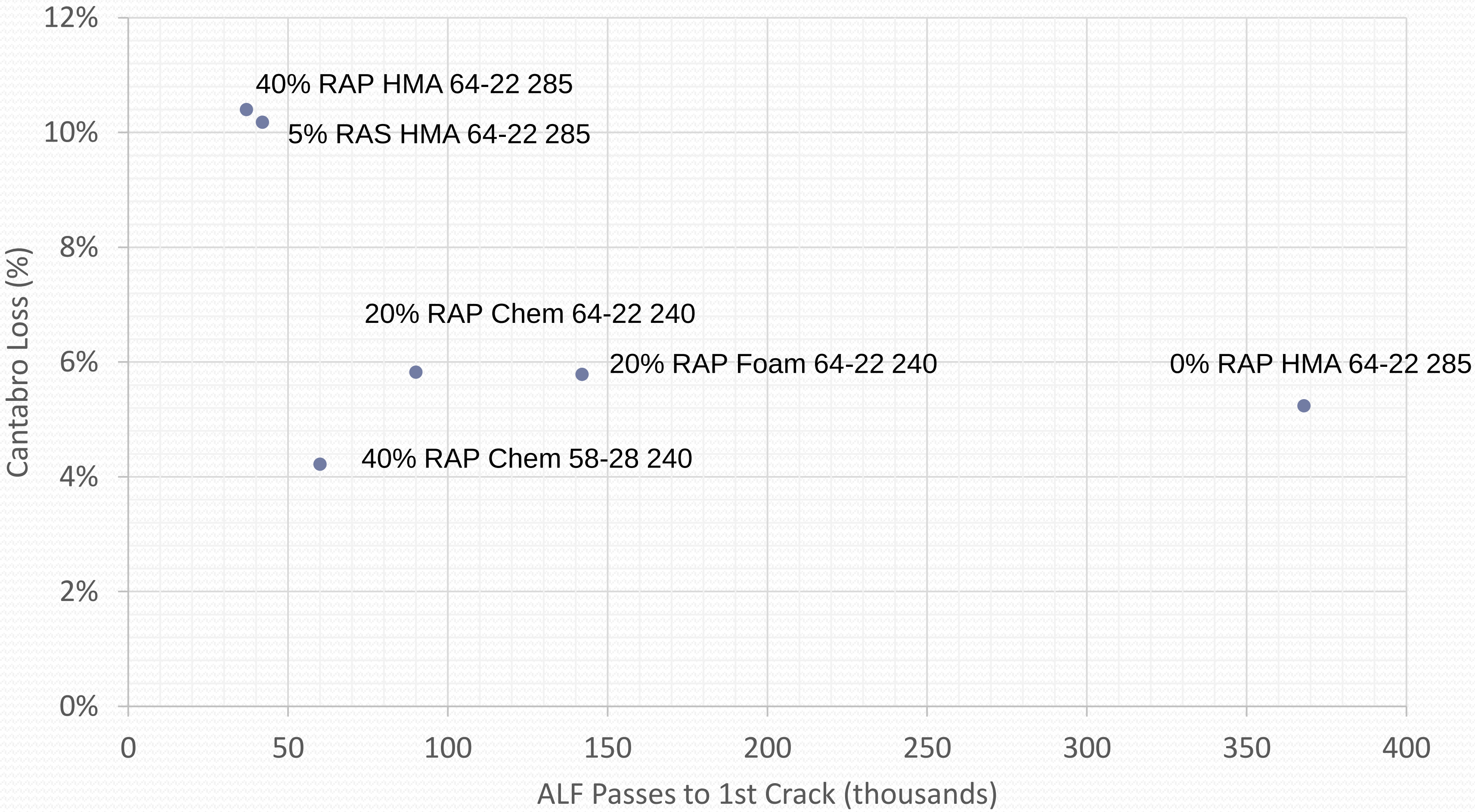
Cantabro vs ALF Cracking



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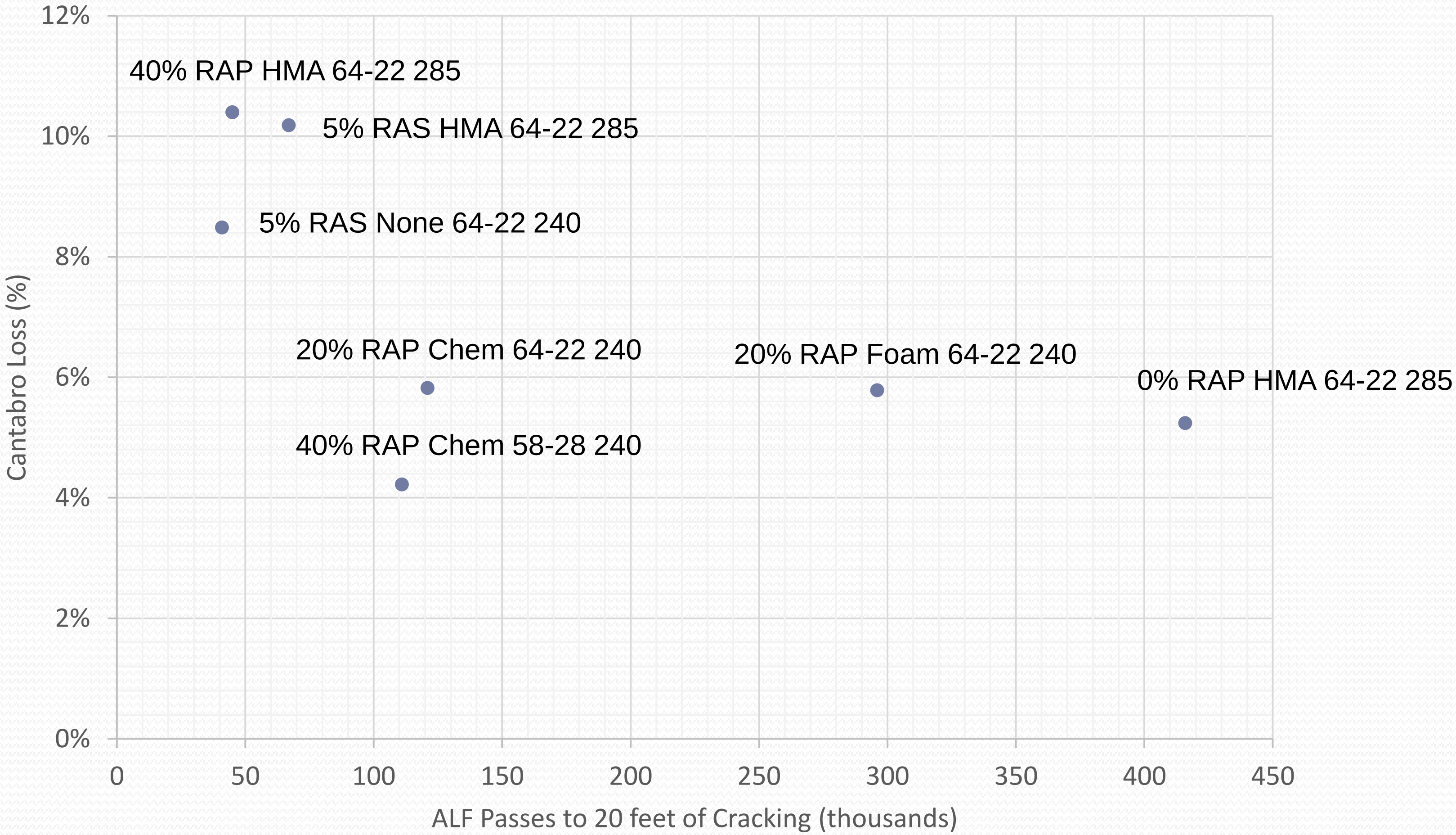

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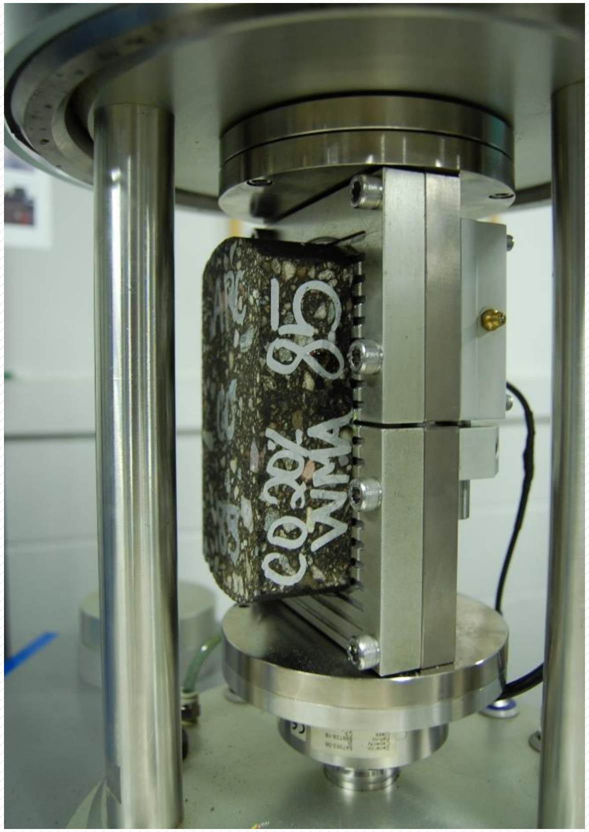
Modified Overlay Test

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



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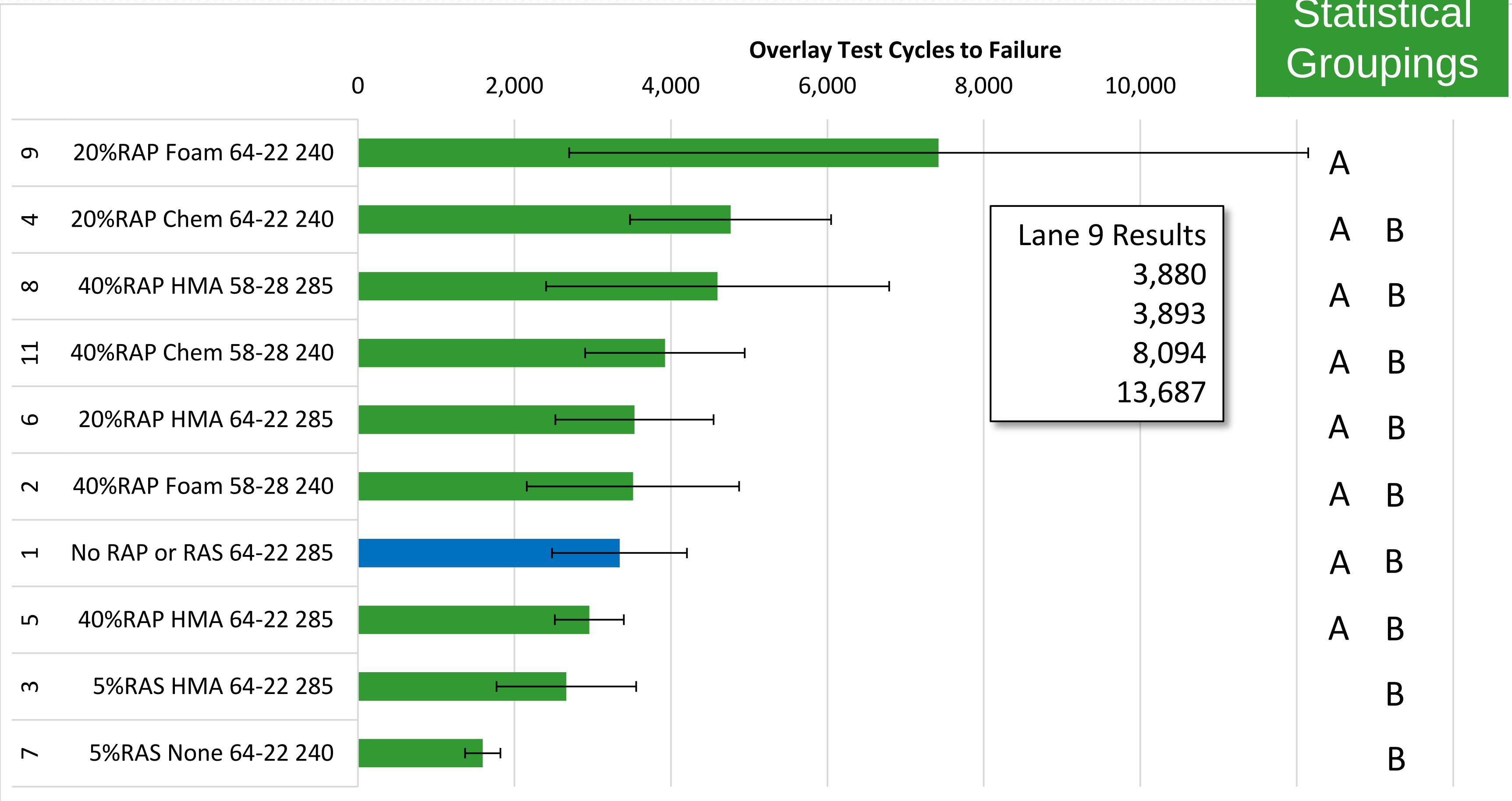
Overlay Test Results

Tukey Statistical Groupings



Average COV = 32%

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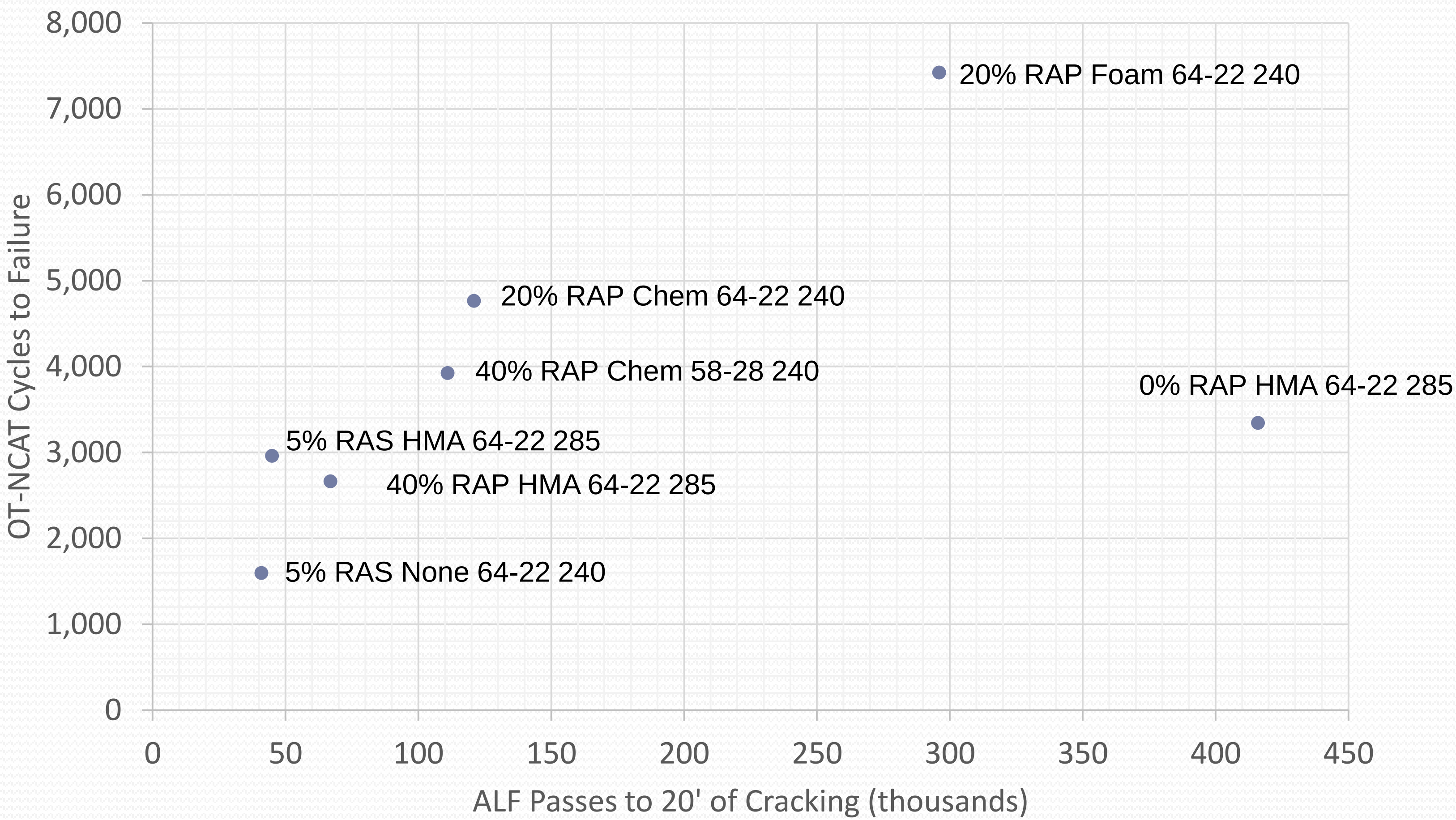
Overlay Test vs ALF Cracking



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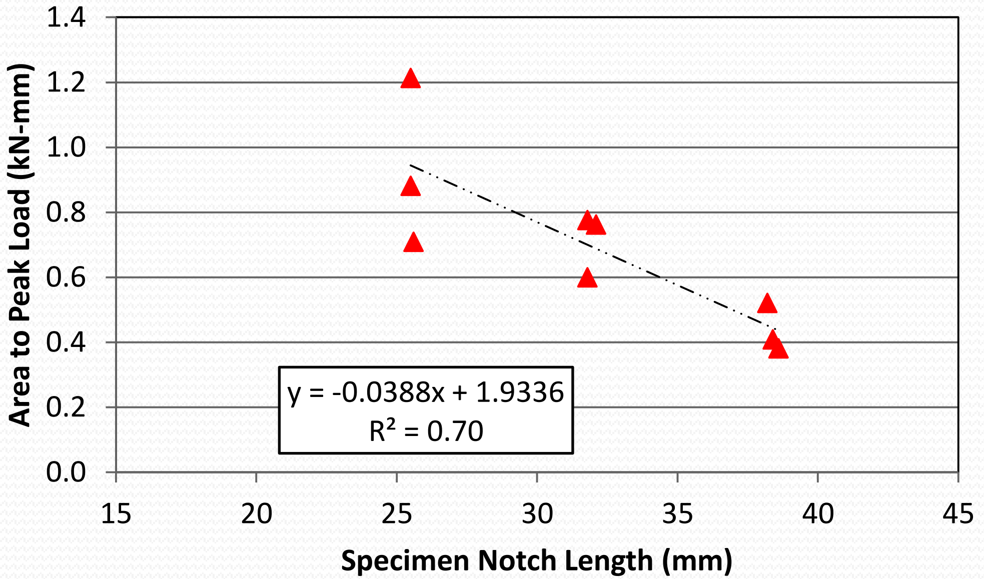
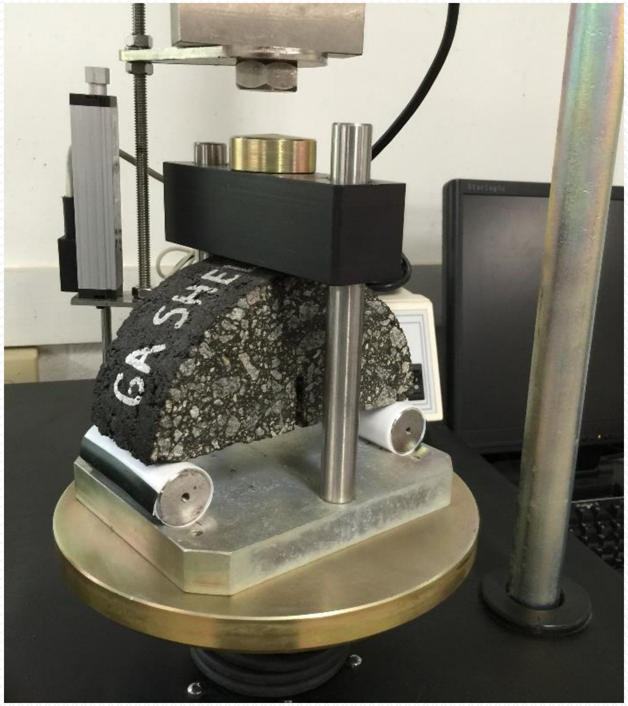
Semi-Circular Bend Test (LTRC)

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





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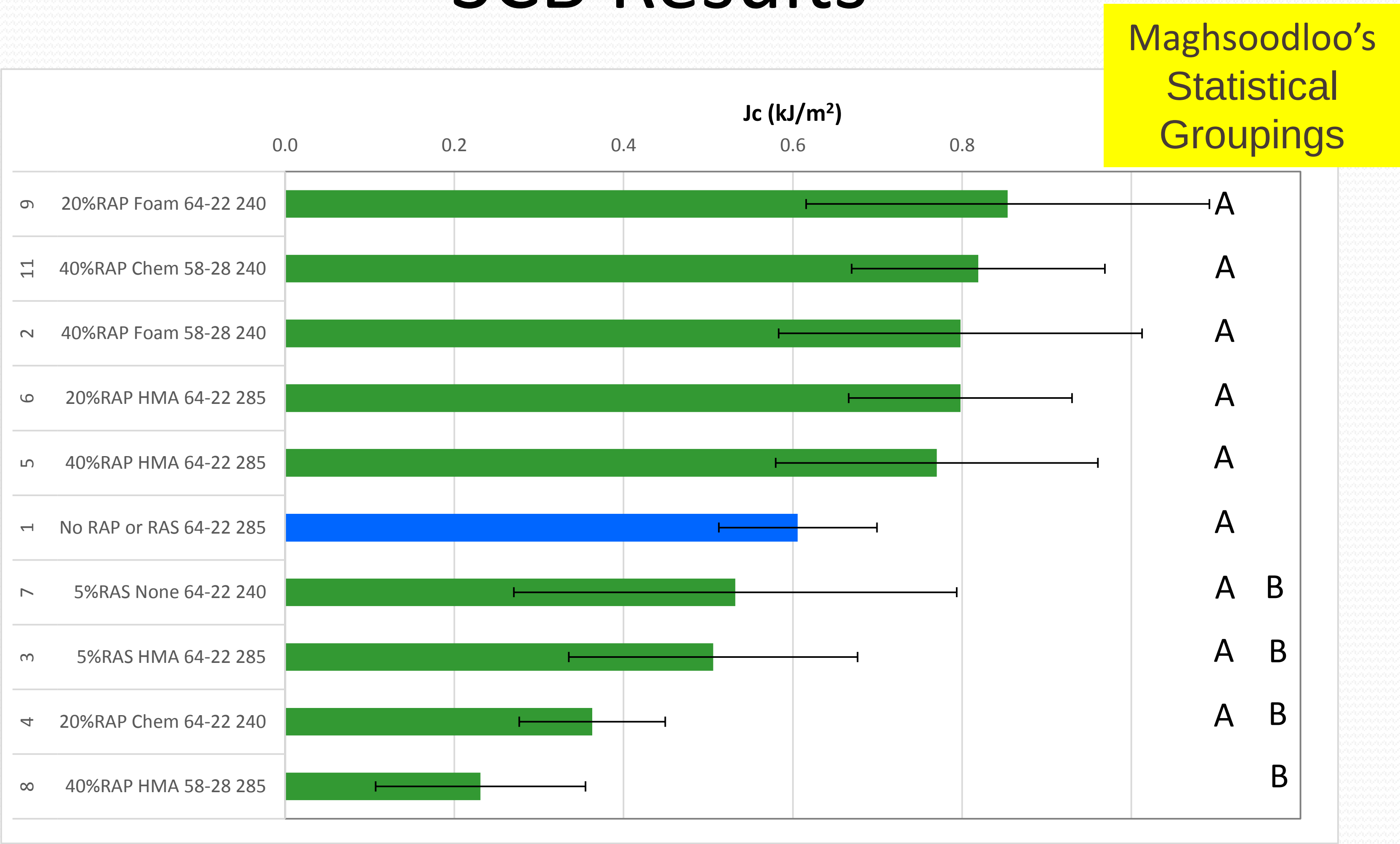
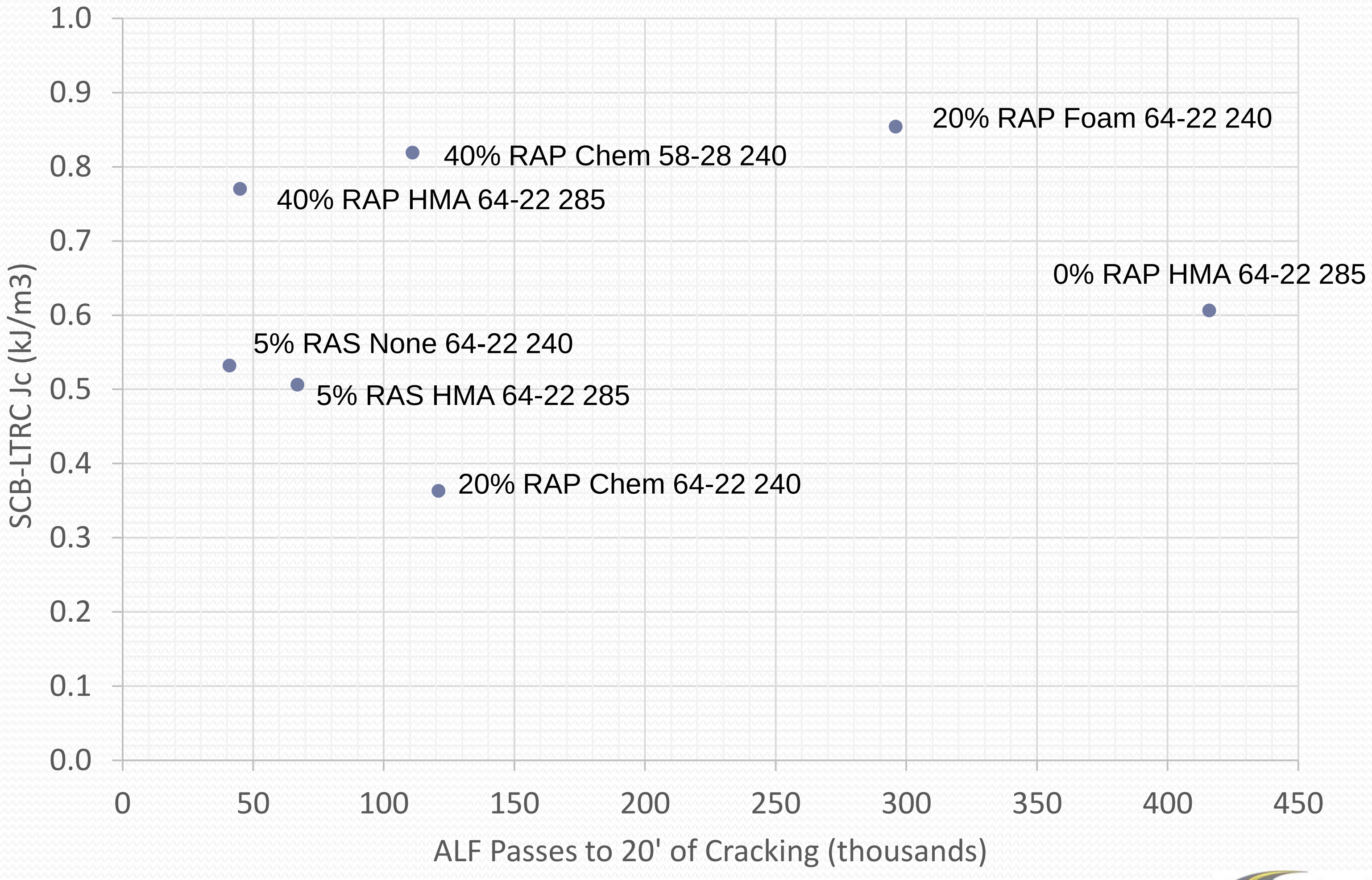
SCB Results



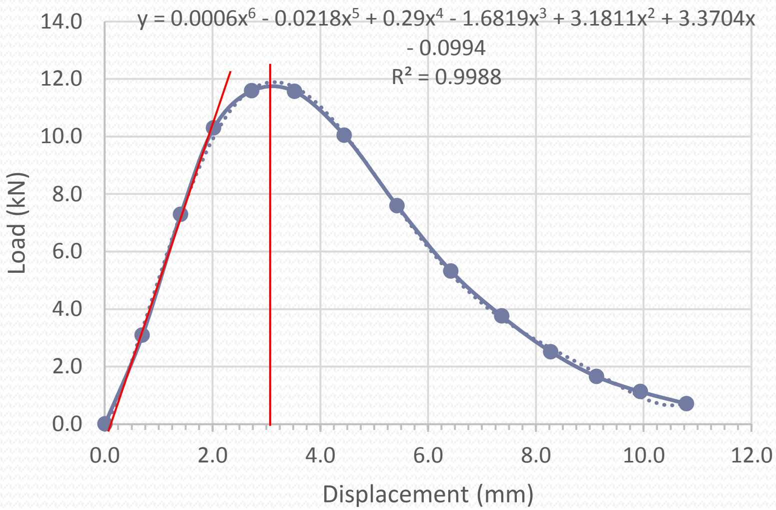
Average COV for Area to Peak Load = 27%

SCB-LTRC vs ALF Cracking

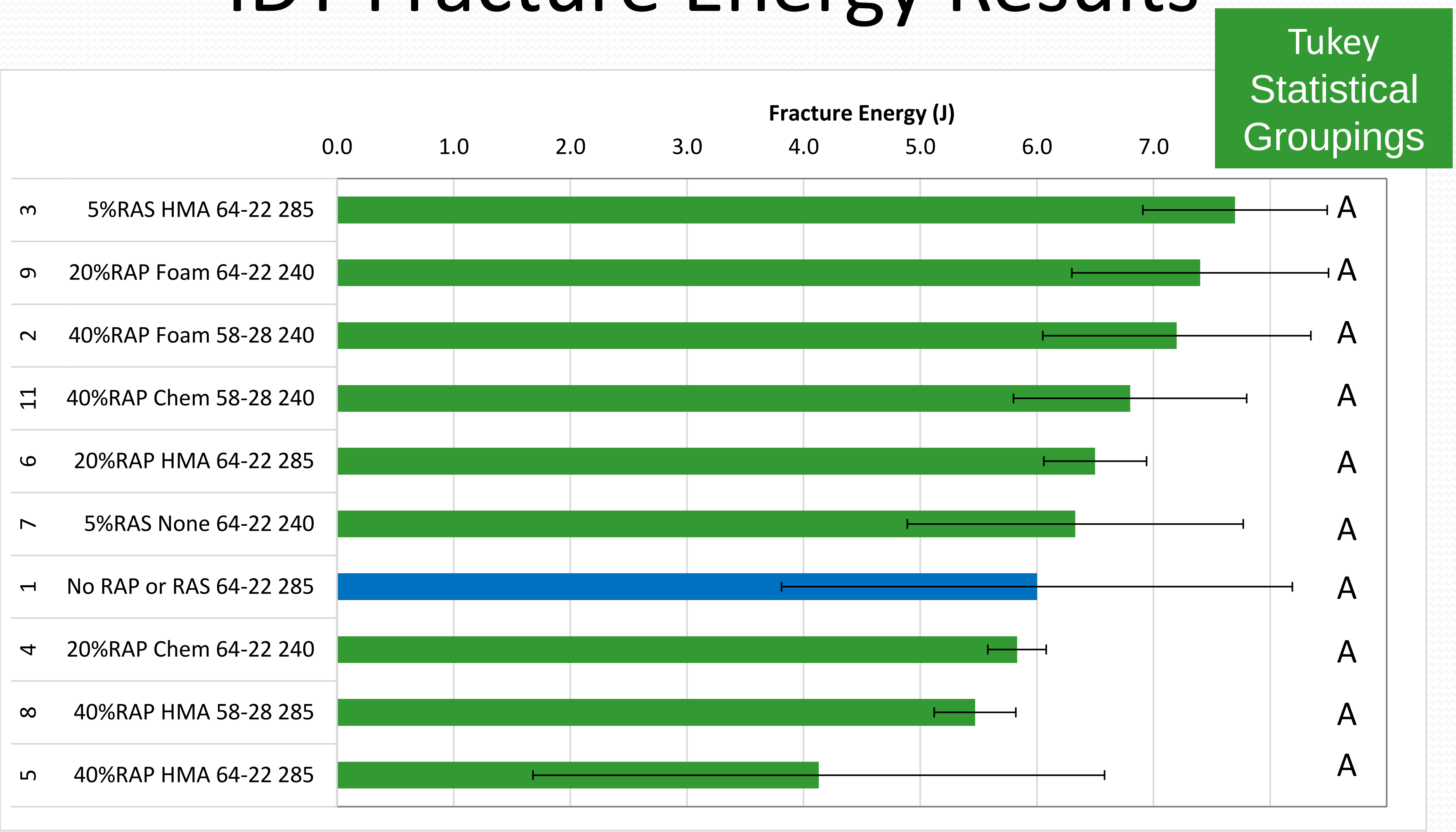


IDT Fracture Energy

- 50 mm thick specimens
- Ram rate = 50 mm/min.
- Temp. = 25°C
- Area under load vs. displ. at peak load
- Triplicates



IDT Fracture Energy Results



Average COV = 19%

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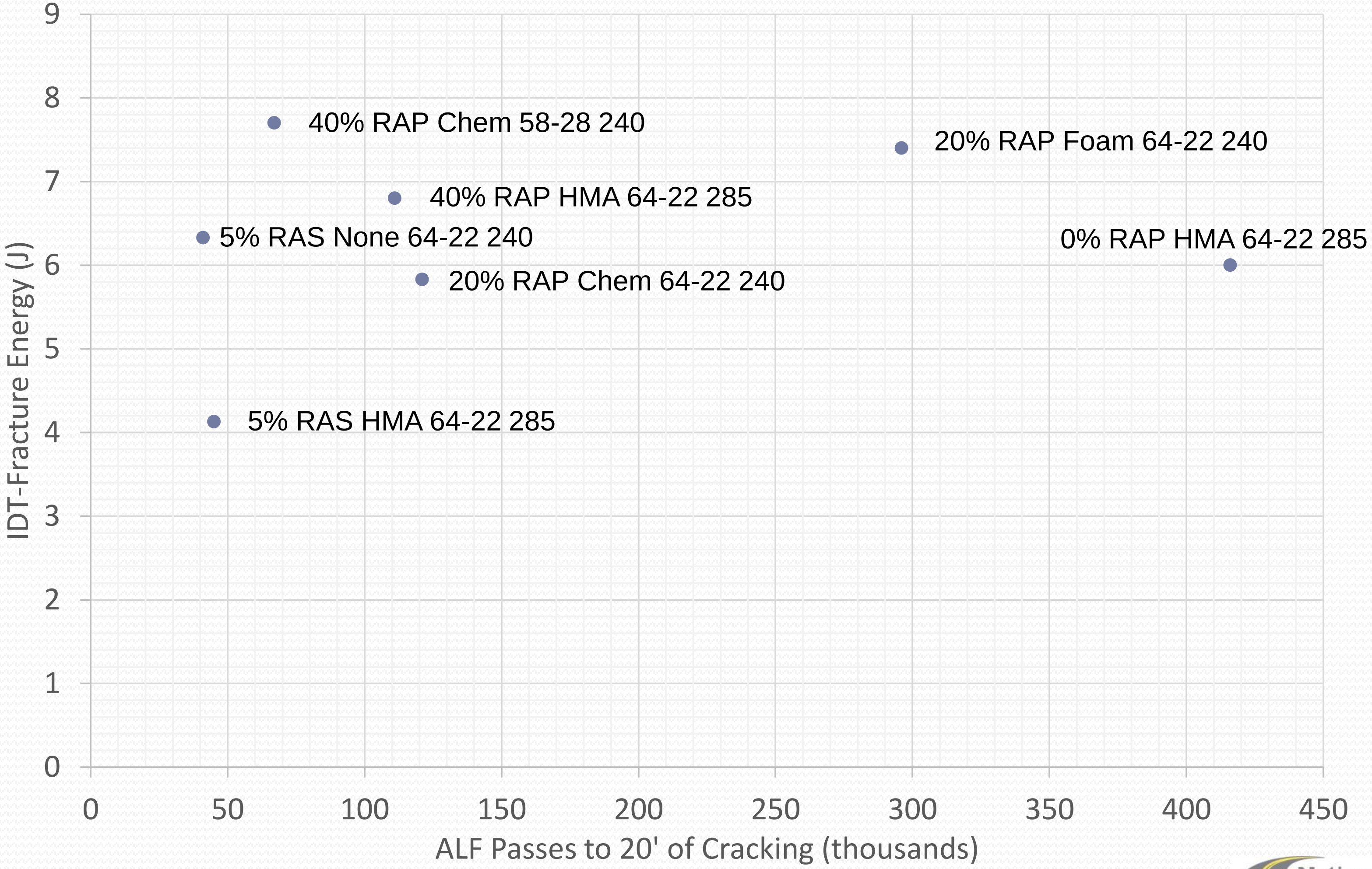
IDT Fracture Energy vs ALF Cracking



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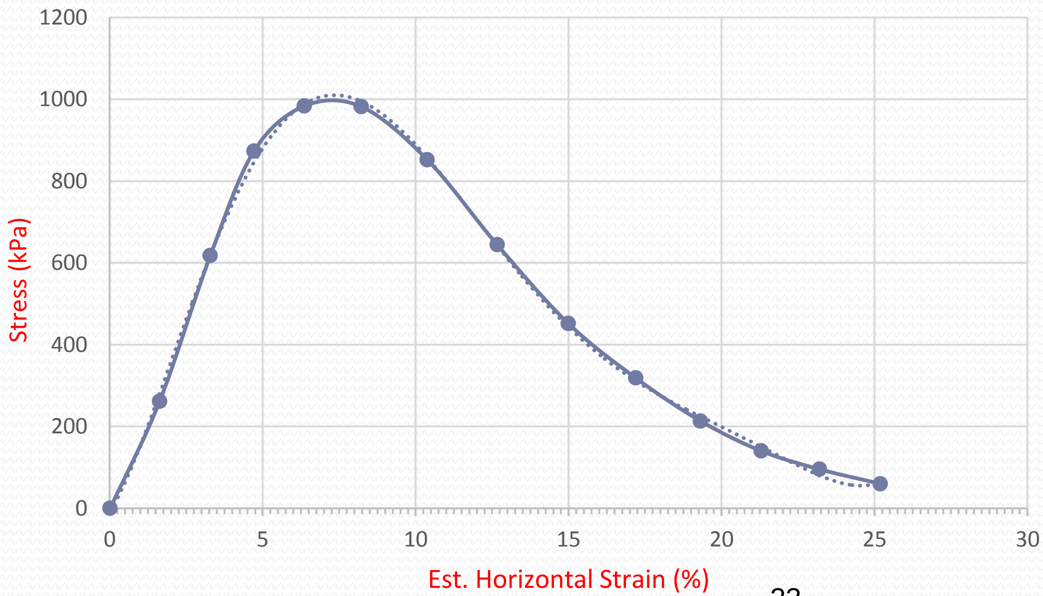
IDT FE Additional Analysis

- 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



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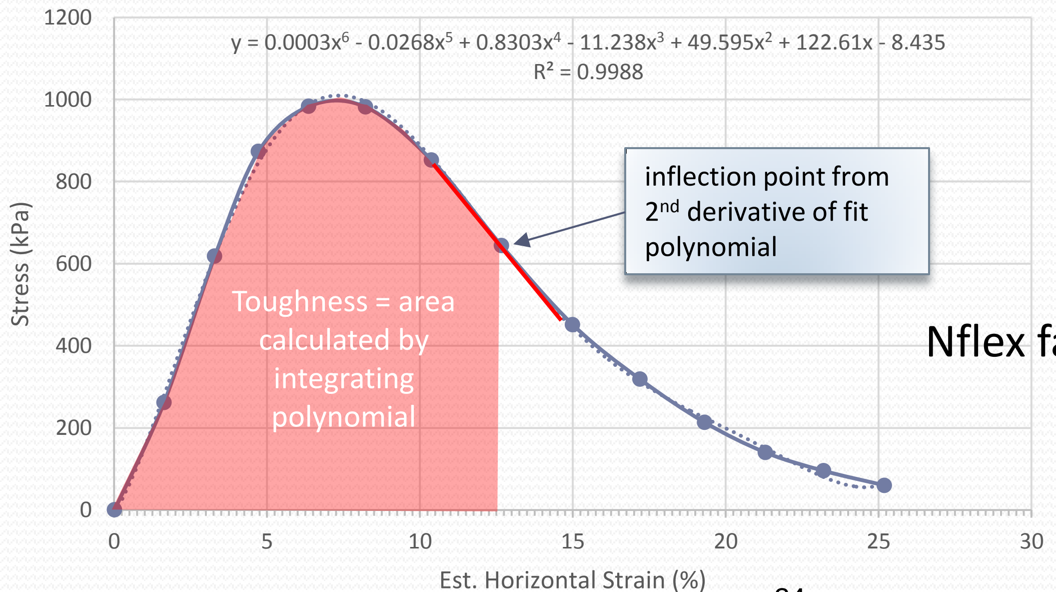

inspired by IL-SCB method

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

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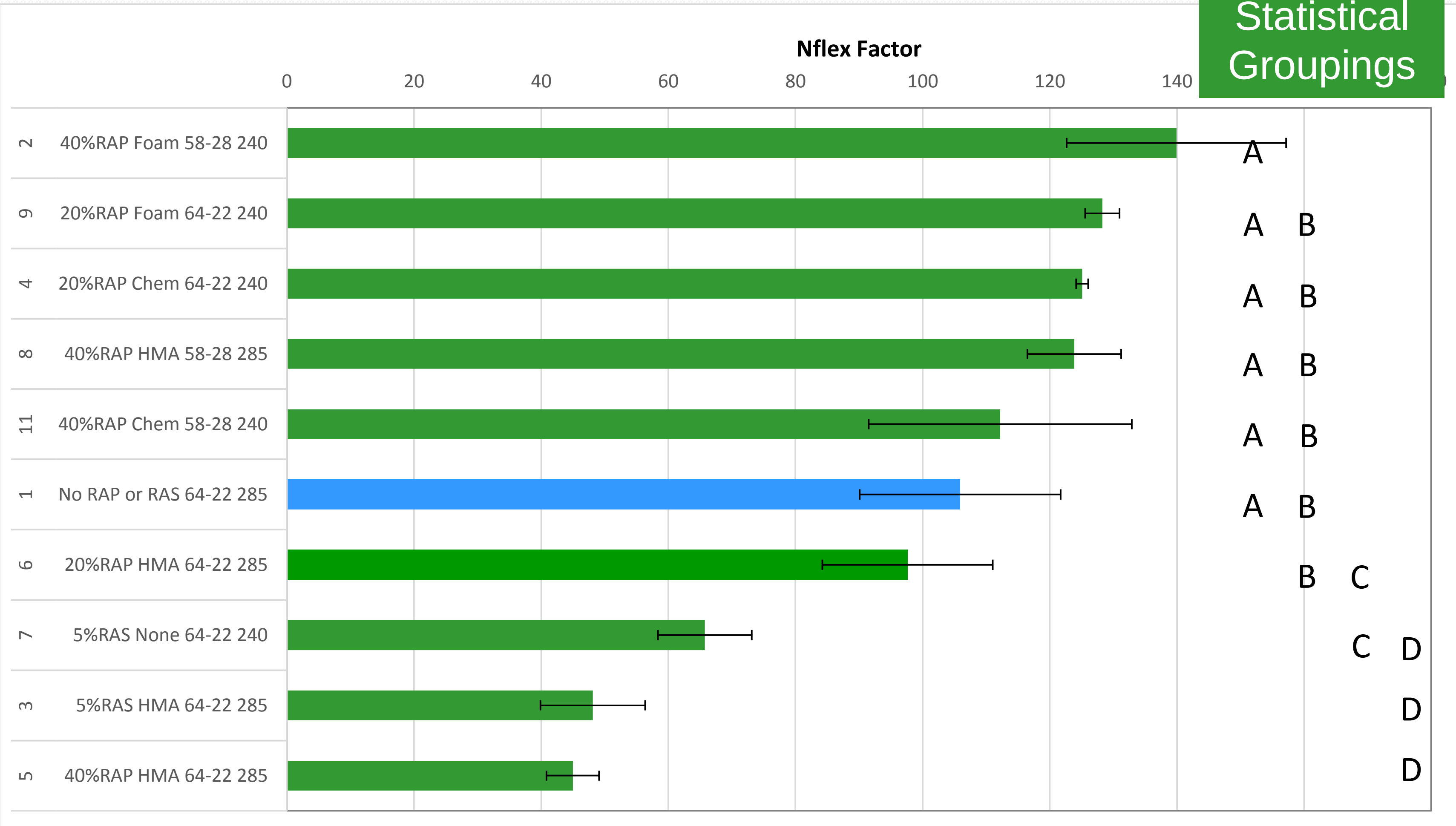
IDT Nflex factor

Tukey Statistical Groupings



Average COV = 11%

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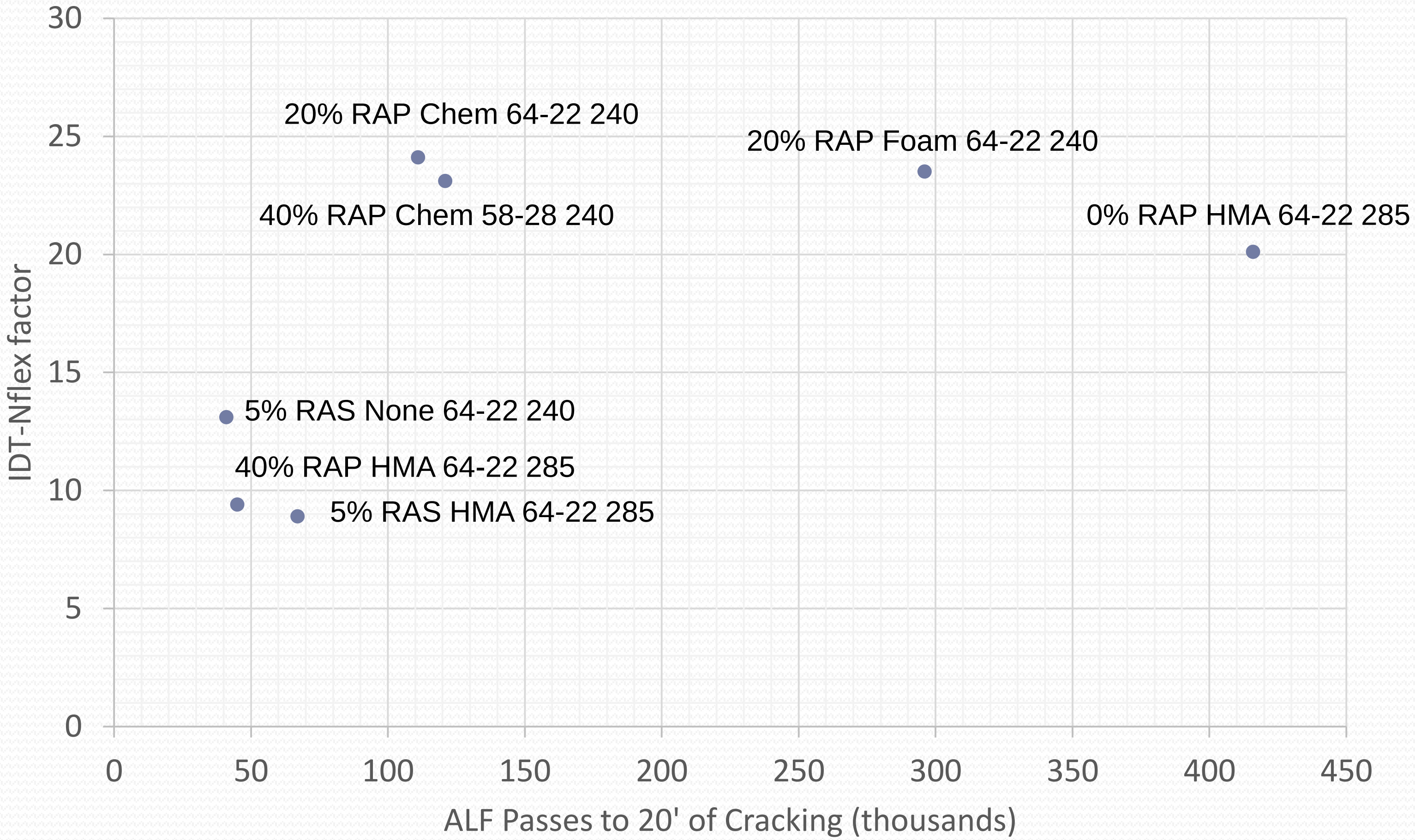
IDT Nflex factor vs ALF Cracking



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Preliminary Observations

- The performance of the ALF sections is confounded by variations in thickness, base stiffness, and age at testing.
- The ALF mixes are ranked very differently by the five tests used in this study
- The Overlay Test and the SCB test have poor repeatability.
- Nflex factor, Cantabro loss and the SCB J-intergral were able to statistically differentiate the virgin mix from some other mixes.

Preliminary Assessment

Test	Time[1]	COV	Sens.	Corr.
Cantabro	40 min.	19%	B	
Mod. OT	2 days	32%	C	
SCB-LTRC	1.5 days[2]	27%[3]	C	
IDT Nflex factor	4 hours	11%	A	

[1] once Ndes specimens are cooled
[2] requires five SGC specimens
[3] COV of Work (area under load-def. curve)

Remaining Work

- Get cracking performance of remaining ALF lanes and analyze correlations between lab and field results
- Determine if there is a way to account for variations in layer thicknesses and base moduli
- Prepare final report

NCAT+MnROAD
Cracking Group Experiments

Minnesota Department of Transportation

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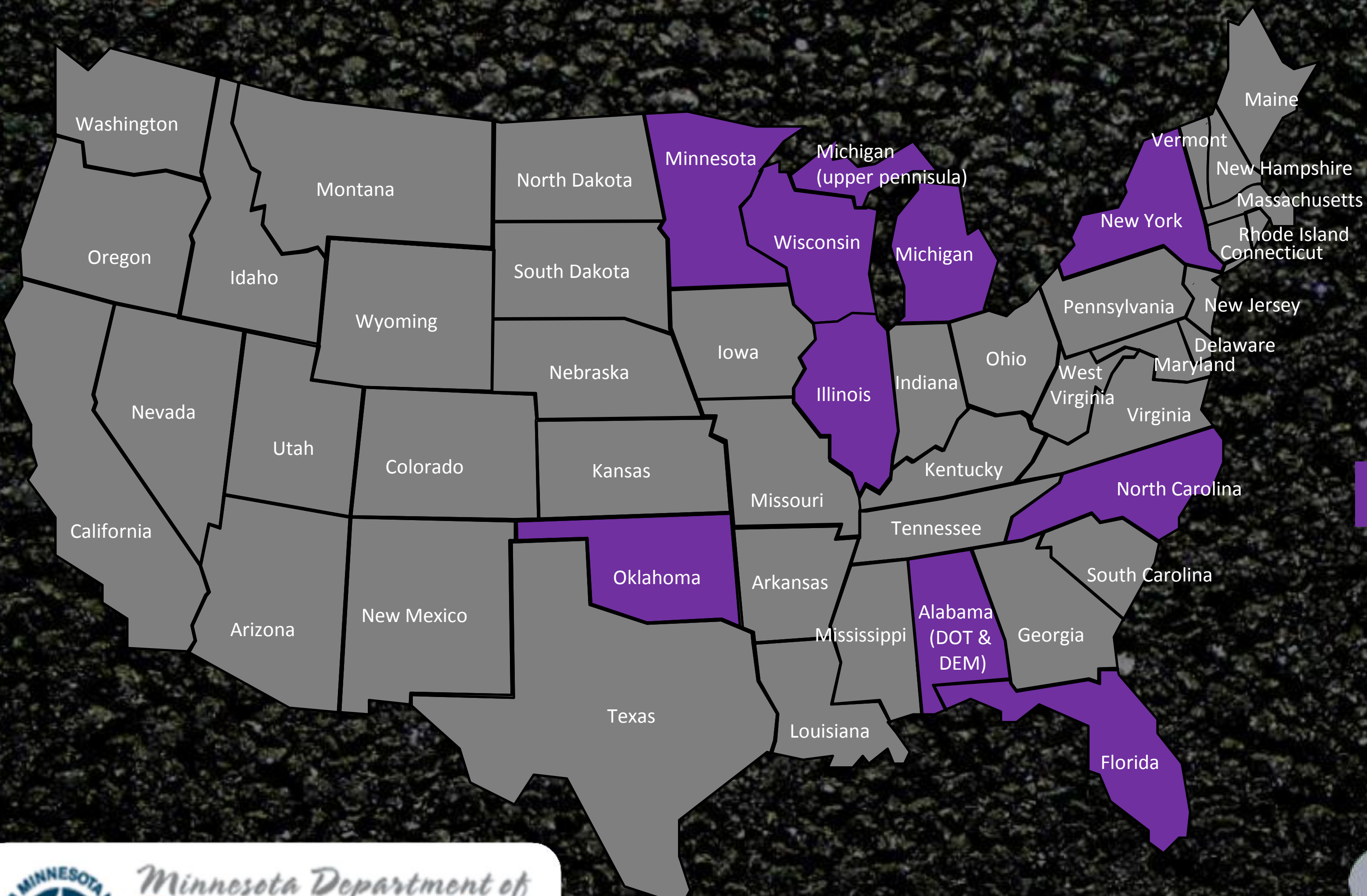
Project Objectives and Goals

- Objective: validate laboratory cracking tests by establishing correlations between the test results and measured cracking in real pavements (test sections)
- Goals: evaluate various tests based on:
  - Criteria related to field performance.
  - Practicality of the tests for mix design verification and quality control testing.
  - The ability to accommodate recycled materials, new and future additives, and mix combinations.
  - Cost-effectiveness

Cracking Group Sponsors



FHWA

Minnesota Department of Transportation

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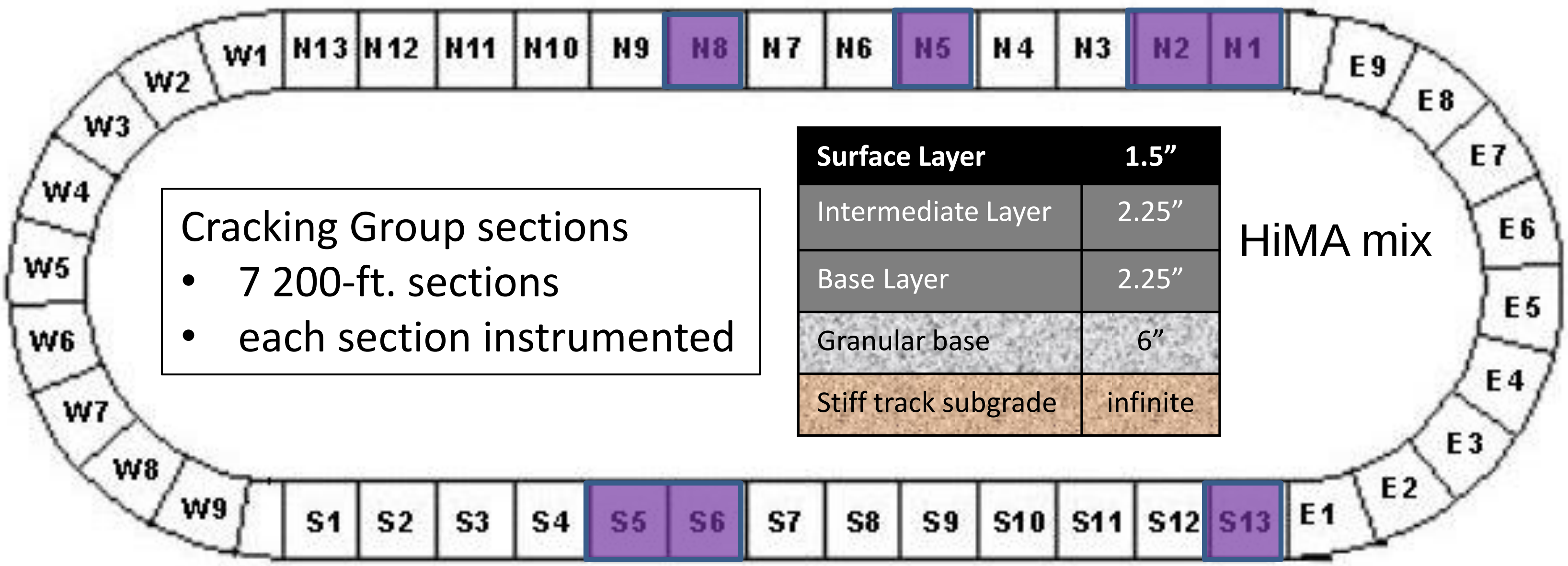
Top-Down Cracking Sections



Cracking Group sections

- 7 200-ft. sections
- each section instrumented

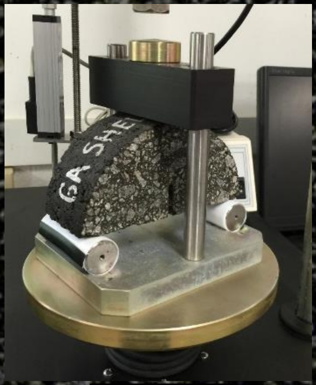
Surface Layer	1.5”
Intermediate Layer	2.25”
Base Layer	2.25”
Granular base	6”
Stiff track subgrade	infinite

HiMA mix

Tests for Assessing Cracking Resistance

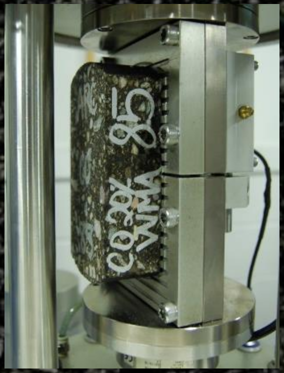
NCAT will conduct these tests on both LMLC and PMLC samples that are aged and unaged.

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.

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Cracking Group Sections

Section	Surface Mix Description
N2	Same as N1 with 95% in-place density
S5	Same as N1 with HiMA PG76-28E
S13	Arizona style asphalt-rubber mix
N1	20% RAP (0.19 binder ratio) PG 67-22
S6	35% RAP and PG 58-28
N5	Same as N1 except 0.5% low AC, low density
N8	20% RAP & 5% RAS PG 67-22

cracking expectation

low
med.
high

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Instrumentation

- Instrumentation will be installed at the bottom of the asphalt base layer to:
  - check that structures initially respond similarly to load
  - assess when surface cracking impacts structural response

NCAT CG Experiment Status

- All sections have been built
- Currently organizing construction data and establishing baseline (0-time) field data
- Trafficking to begin Oct. 1
- Mix testing to commence Oct.1
- Complete experiment within 3 year cycle

MnROAD - Cracking Group

Safer, Smarter, Sustainable Pavements through Innovative Research

Dave Van Deusen

Cracking Group Pooled Fund Meeting

Low-Temp Cracking Experiment

- Work plan developed
  - State sponsors review
  - mainline cells identified, plan to reconstruct cells
- Targeted performance property ranges
  - Nine sections proposed with varying ranges of:
    - Fracture energy
    - Binder replacement

Candidate Mixtures

(revised based on August 27, 2015 sponsor meeting)

DESCRIPTION	BINDER	POLYMER	RAP/RAS	NMAS	CRACK POTENTIAL
Mix w/ >30% RAP & softer AC	PG 52-34	Neat	30/0	12.5	Med/High
Typical surface mix	PG 58-28	Neat	20/0	12.5	Med/High
Typical surface mix	PG 58-34;	Yes	20/0	12.5	Low
Fine surface mix	PG 64-22;	Neat	0/0	9.5	Med/High
Typical surface mix	PG 64-22;	Neat	20/0	12.5	High
Mix w/ high RAP/RAS	PG 64-22;	Neat	25/5	12.5	High
Mix w/ high RAP/RAS	PG 64-28;	Yes	20/5	12.5	Med
Mix w/ cracking prone gradation	PG 64-28; Coarse; Low AC;	Yes	20/0	12.5	Med/High

Cracking Modes and Testing

- Types of cracking to be investigated
  - Low temperature is a "given"
  - Top-down very likely
  - Fatigue also possible
- Select appropriate post-construction testing
  - Low temp: SCB-IL, DCT-MN, SCB-MN
  - Top down, fatigue: Overlay Tester, BB Fatigue
  - ME Design: E*
  - Additional: BBR mix beams (related proposed study)
  - Loose mix, cores
  - Fracture energy test data analysis: both FE and FI

MnROAD Cracking Group Experiment Status

- Mix designs to commence soon, to be completed early Dec.
- Test sections to be built in 2016 construction season
- Monitoring of performance over several years using video-based automated pavement evaluation van (same as NCAT)

Thanks!