MTE Experiences with Performance Testing

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FHWA Mix ETG

Fall River, MA

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Discussion Points

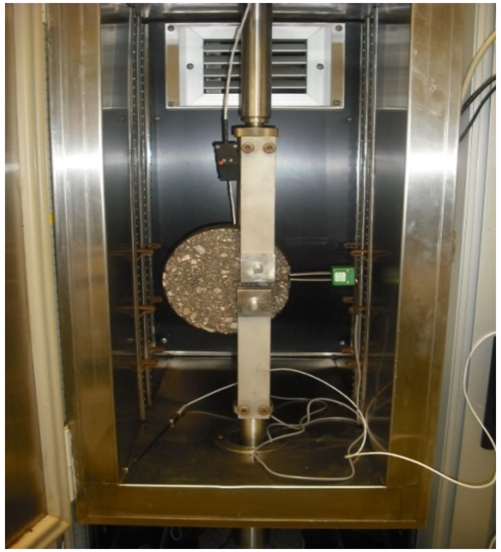
- Overview
- Summary of Performance Test Efforts
  - DCT Test
  - SCB Test: I-FIT and Jc
- Challenges
  - Standardization
  - Implementation & Setting Limits
- Next Steps

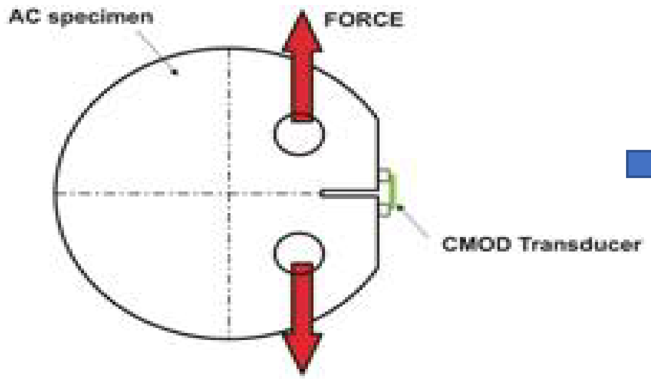
Performance Testing Experiences - MTE

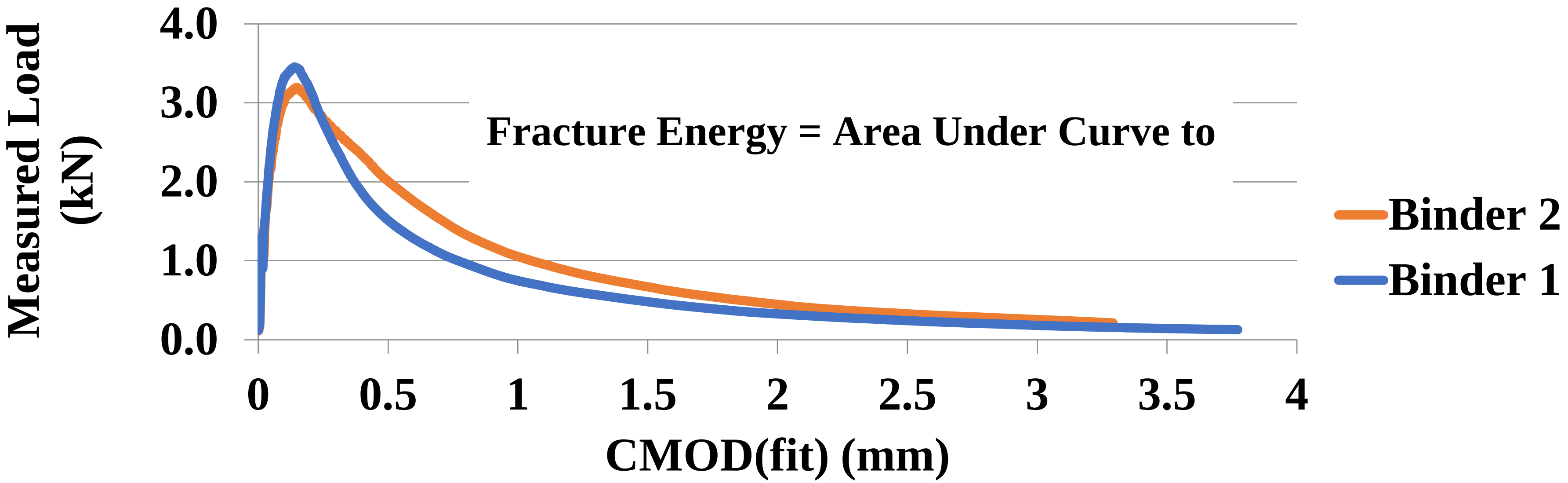
- WI & MN: High recycle projects on state highways or county roads.
  - Internally developed specification that includes Hamburg, SCB, DCT.
- Iowa: Surface mixes and Interlayer
  - State specifications for Hamburg and Beam Fatigue
- BMD Approach
  - WI & MN: Tier 3. Volumetric requirements remain, mix expected to meet or exceed the performance of a conventional mix.
  - Iowa: State sets volumetric and performance test limits.

Disc Shaped Compact Tension (DCT) Test

Thermal Cracking Resistance







Test Implementation - DCT
Procedure and Specification

Test Procedure

- Temperature: LT PG + 10°C
- Aging: AASHTO R30 Short Term
  - Long term aging done for research.
- Air voids: Design + 3%
- Detailed procedures in place for conditioning time and duration samples can be held at low temps.

Specification

Table DCT-2
Minimum Average Fracture Energy Mixture Production Requirements for Wearing Course

Traffic Level/PG Grade	Fracture Energy (J/m^2)
Traffic Level 2-3/PG XX-34	400
Traffic Level 4-5/PGXX-34	450

- Previous iterations included a min. fracture energy of 690 J/m^2
- MTE draft specification compares to a conventional mix.

Test Implementation – DCT
Evaluation #1 – Effect of Mix Design Factors

Factors Studied

- Binder Replacement (RAP): 15%, 30%, 50%
- Aging: Short Term (4 hrs @ 135C), Long Term (12 hrs @ 135C)
- Polymer Modification: PG 58S-34, PG 58V-34

Recovered Binder Data

PBR	PG 58-34 (LT Continuous Grade -34.9)
15	-32.7
30	-30.6
50	-27.7
Max Deviation from Plan Grade (°C)	**6.3**

Results

Statistic	Peak Load (kN)	Time at Peak Load (secs)	Fracture Energy (J/m^2)
Average	3.27	7.58	542
Range	0.23	0.38	43
Std Dev	0.08	0.15	15.67
COV	2.5%	2.0%	2.9%

Bahia et. al, WHRP 15-04 Study (3)

Test Implementation – DCT

Evaluation #1 – Effect of Mix Design Factors

Factor	General Trend		
	Peak Load	Time to Peak Load	Fracture Energy
Increase PBR	PG 58-28: No trend. PG 58-34: No trend.	PG 58-28: Decrease (0.70s) PG 58-34: Decrease (0.33s)	PG 58-28: Increase (31 J/m^2) PG 58-34: Decrease (42 J/m^2)
Increase Aging	PG 58-28: Increase (0.06 kN) PG 58-34: Decrease (0.05 kN)	PG 58-28: Decrease (0.15s) PG 58-34: Decrease (0.37s)	PG 58-28: Decrease (48 J/m^2) PG 58-34: Decrease (14 J/m^2)
Use of Modification	PG 58-28: Increase (0.26 kN) PG 58-34: Increase (0.08 kN)	PG 58-28: Decrease (0.60s) PG 58-34: Decrease (0.11s)	PG 58-28: Decrease (24 J/m^2) PG 58-34: Decrease (28 J/m^2)

Highlight = Inconsistent Trend Between Binder Grades

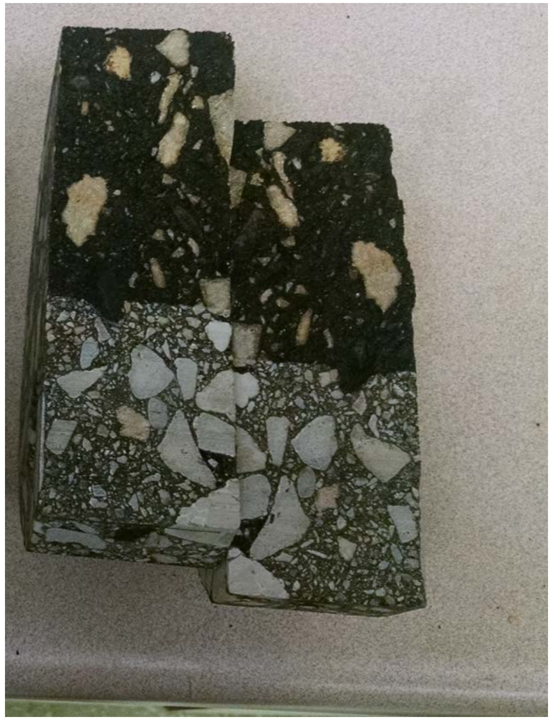
Bahia et. al, WHRP 15-04 Study (3)

Test Implementation – DCT

Evaluation #2 – Aging and Aggregate Type

Granite

- LAR @ 500 = 18.3
- Fracture Energy (12 hr) = 551 J/m2



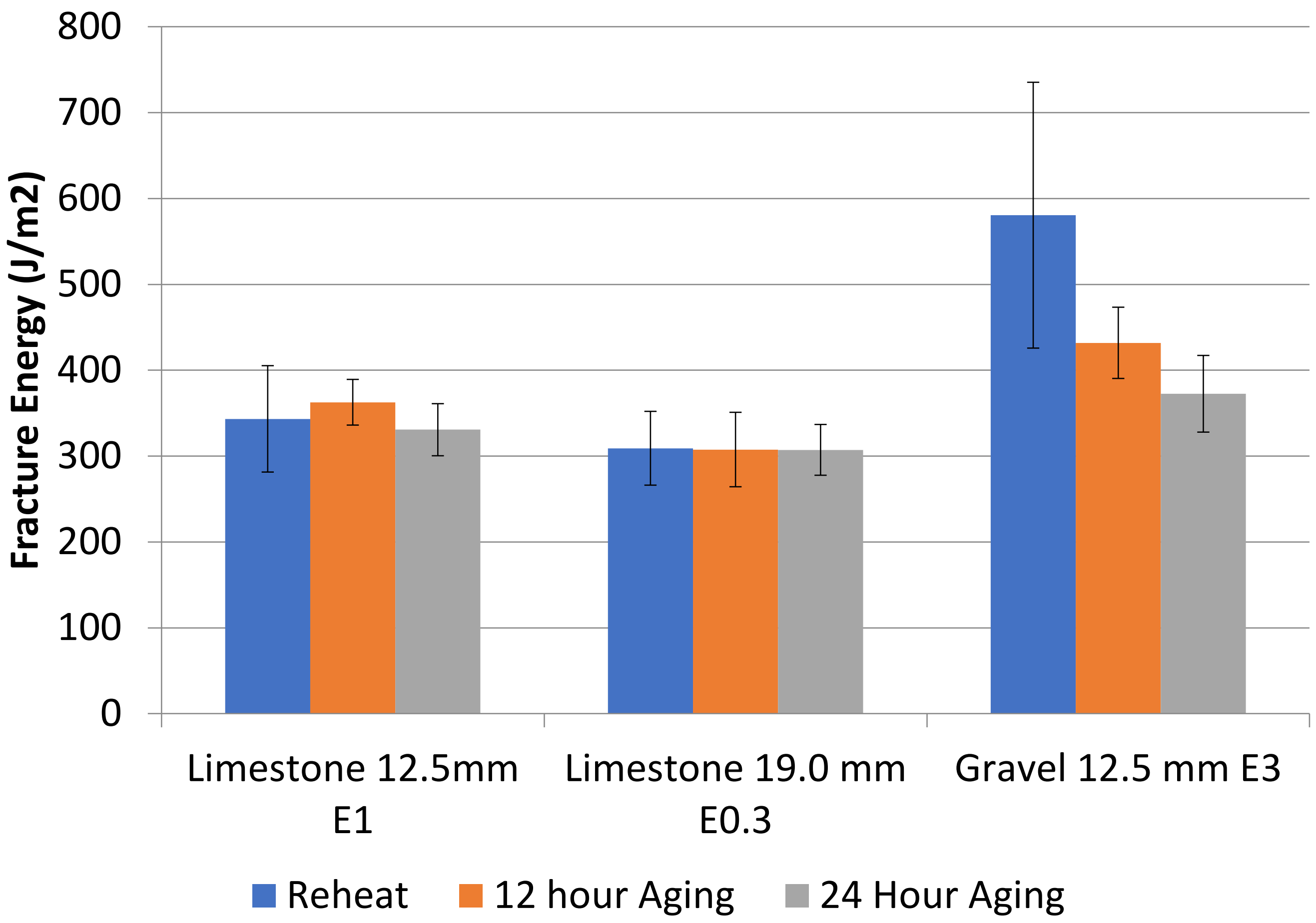
Limestone

- LAR @ 500 = 32.0
- Fracture Energy (12 hr) = 360 J/m2

- Factor driving fracture energy depends on aggregate type.
- Hard aggregate = Mastic Failure.
- Soft Aggregate = Coarse aggregate fracture.

Refer to TRB Paper by Braham (2001)

Test Implementation – DCT
Evaluation #2 – Aging and Aggregate Type



- Limestone Aggregate: LAR @ 500 = 32%
- Gravel Aggregate: LAR @ 500 = 15%
- All aging was loose mix at 135°C

Test Implementation – DCT

Evaluation #3 – MnDOT Report

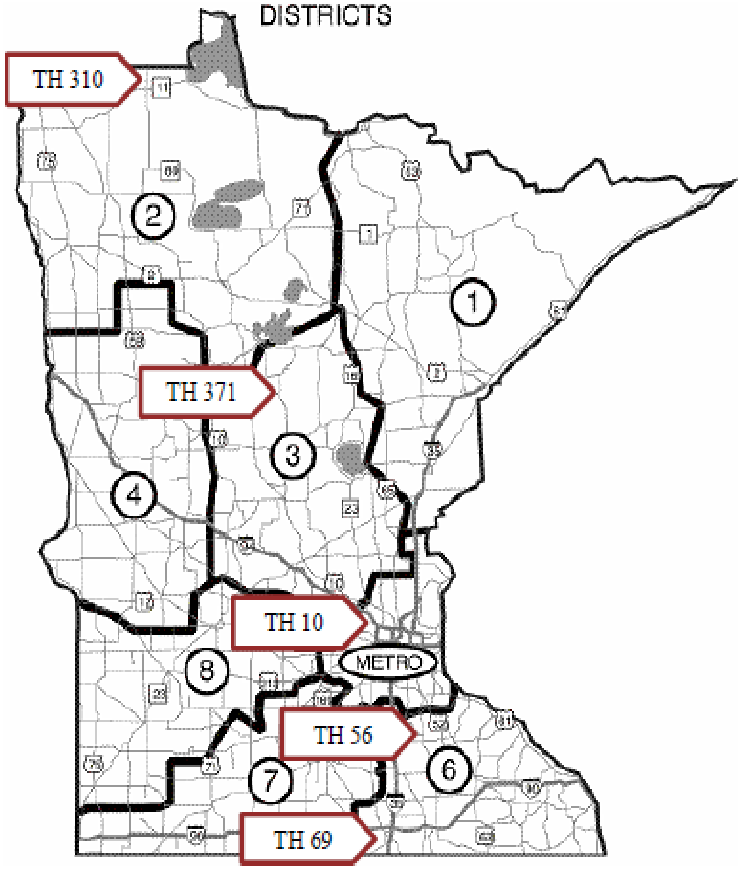
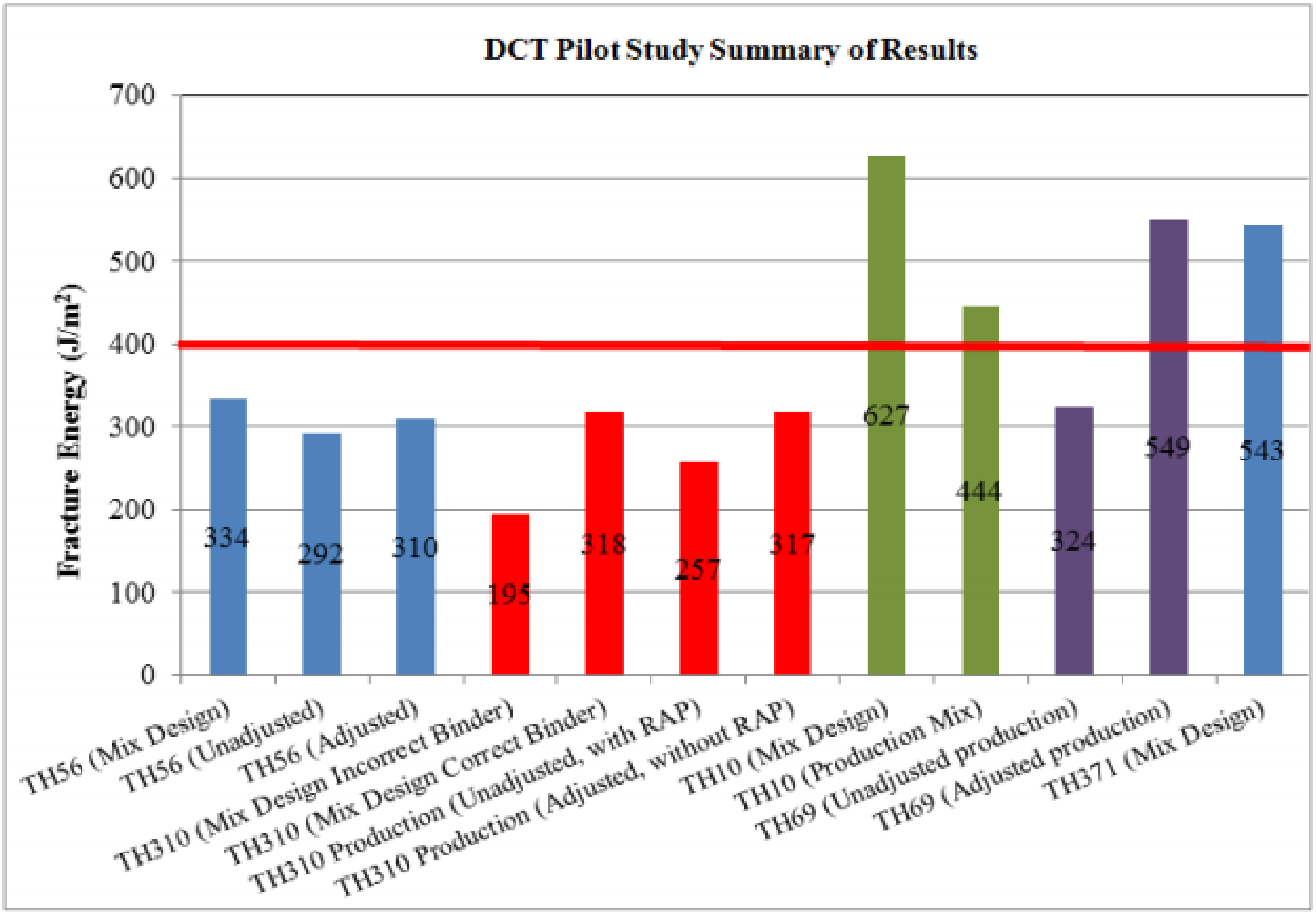


Figure 2.1: Map of project locations across Minnesota.



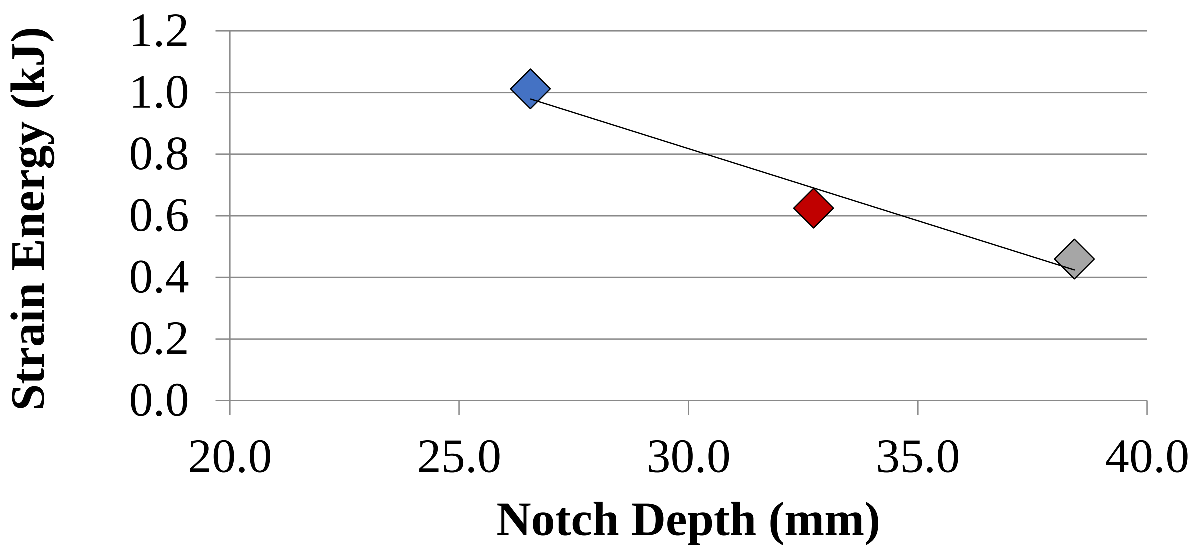
Test Implementation – DCT
Observations and Discussion

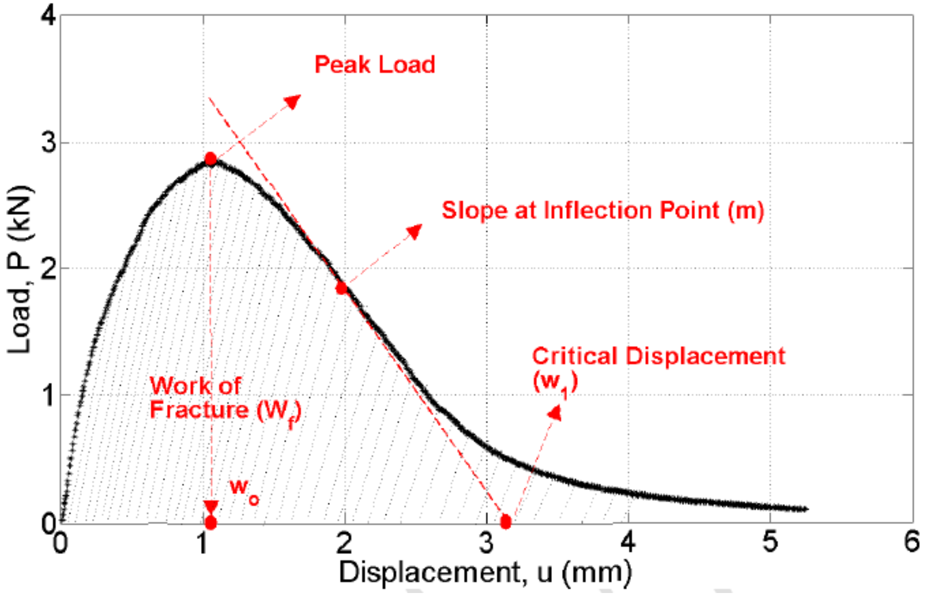
- Recent discussion has suggested reducing fracture energy requirements from initial targets:
  - Benefits: Accommodates “soft” aggregates such as limestone.
  - Risks: If hard aggregate is used there is potential that an inferior mix (i.e. high binder replacement or low binder content) would still pass specification limit.
- Implications of changing/eliminating aggregate sources.
- **Recommended Action:** Universal limit is not feasible. Compare to mixes of known performance.

SCB

Intermediate Temperature Cracking Test

- Test Methods Evaluated
  - ASTM D8044: LSU Procedure, 3 notch depths, 0.5 mm/min loading rate.
  - AASTHO TP 124: I-FIT, one notch depth, 50 mm/min loading rate.
- Factors Evaluated: Binder Replacement, Polymer Modification, Aging





SCB - LSU
Adjusting for a Northern Climate

- Test temperature was adjusted to PG Inter. Temp to account for use of softer grades in WI.
- Three independent studies:
  - WisDOT High RAM Pilot Program (AAPT 2015)
  - WHRP Performance Testing Feasibility Project (2016)
  - WHRP Durability Project – Bonaquist (2016 & 2016 AAPT Paper)
- Studies found the test was insensitive to the variables studied.
- Example of the localized development of these tests and potential complications in implementation.

SCB – D8044

ILS 1424 – Phase 1

- Three samples:

Steel Sample	
Loading Rate	0.5mm/min
Sampling Rate	10/sec
Load limit	500N, 1000N, 2500N
Gage Length	127mm (5")
Temperature	Room Temperature
Pre-load	45± 10N

Plastic Sample	
Loading Rate	0.5mm/min
Sampling Rate	10/sec
Load limit	1500N
Gage Length	127mm (5")
Temperature	Room Temperature
Pre-load	45± 10N

Plastic Sample w/notch	
Loading Rate	0.5mm/min
Sampling Rate	10/sec
Load limit	1000N
Gage Length	127mm (5")
Temperature	Room Temperature
Pre-load	45± 10N

- 12 laboratories

SCB – D8044

ILS 1424 – Phase 1

Results to date from 6 laboratories

- Testing Devices
  - 1- AMPT
  - 1- MTS
  - 2 – Brovold
  - 1 – Instron
  - 1- IPC-Global
  - 1 - Instrotek
- Testing Fixtures
  - 7 – fixed rollers
  - 3 – rollers with springs
  - 1 – 36mm roller

Material	$\bar{x}$	r-COV%	R-COV
Validator	300	24.3	57.0
Plastic with notch	58	26.6	102.1
Plastic with notch	111	45.5	122.7
	average	32.1	93.9

SCB – D8044

ILS 1424 – Phase 1

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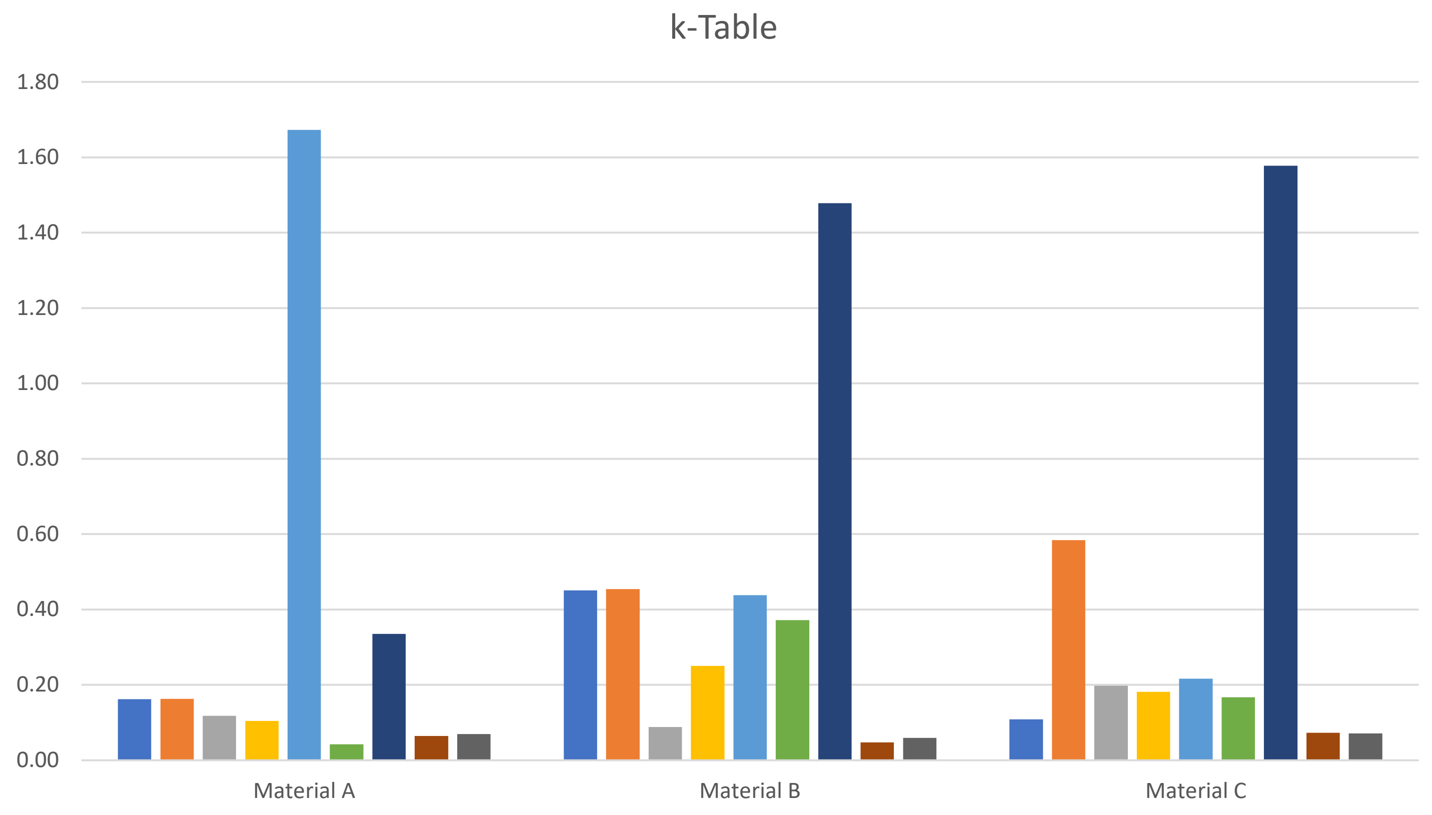


SCB-IFIT
Initial Evaluations

- Benefits
  - Identifies mixes that are too stiff.
  - Verifies design vs. production
  - Provides a relatively easy way to evaluate mix composition.
- Concerns
  - Repeatability
  - Polymer modification (Discussed in Fall 2017 meeting)
  - Aging
  - Refining limits.

SCB - IFIT

RAP/RAS Content & Volumetrics

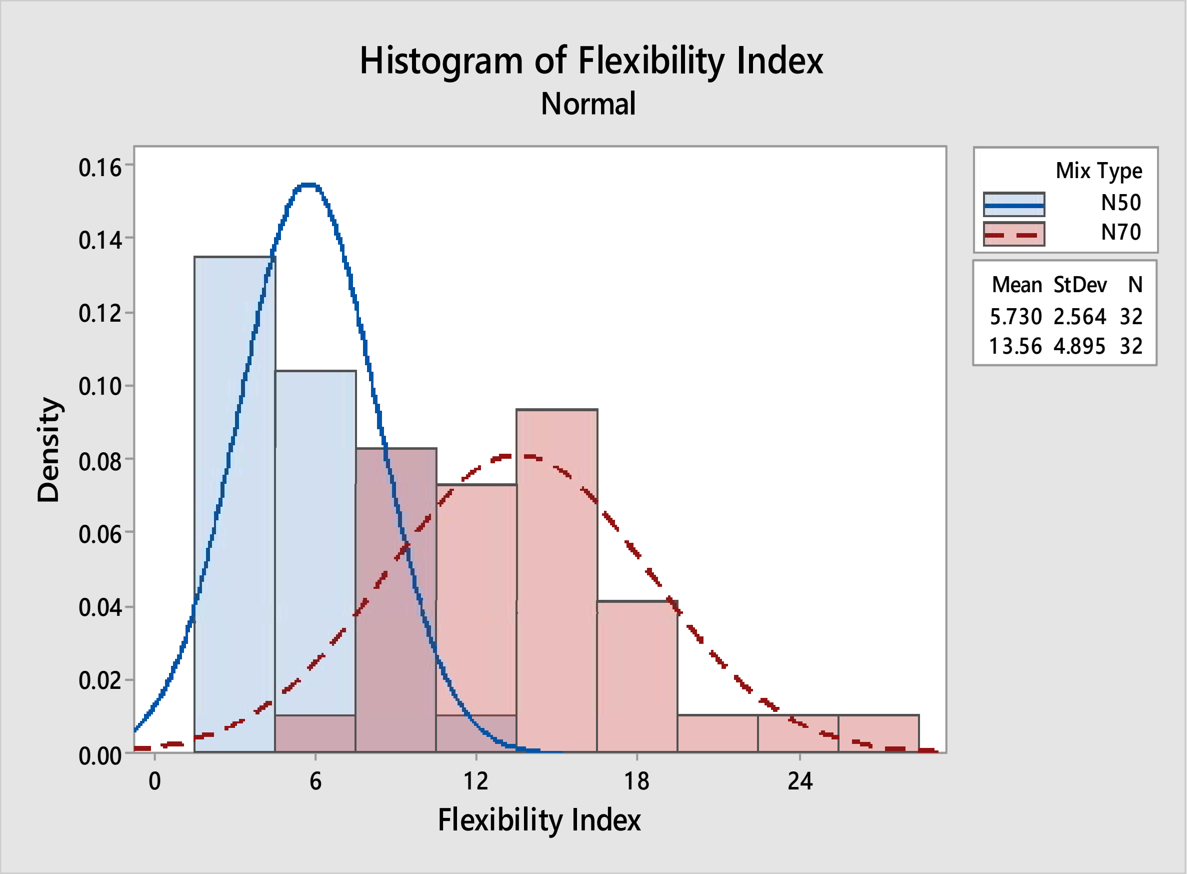
Mix Design	AB (%)	%AV at Ndes	VMA	VFA	RCY AB (%)			ABR		
					RAP	RAS	Total	RAP	RAS	Total
N50	5.8	3.6	15.1	73.5	1.2	0.8	2.00	20.3	14.0	34.3
N70	5.9	3.5	15.3	73.9	0.6	0.0	0.6	9.6	0	9.6

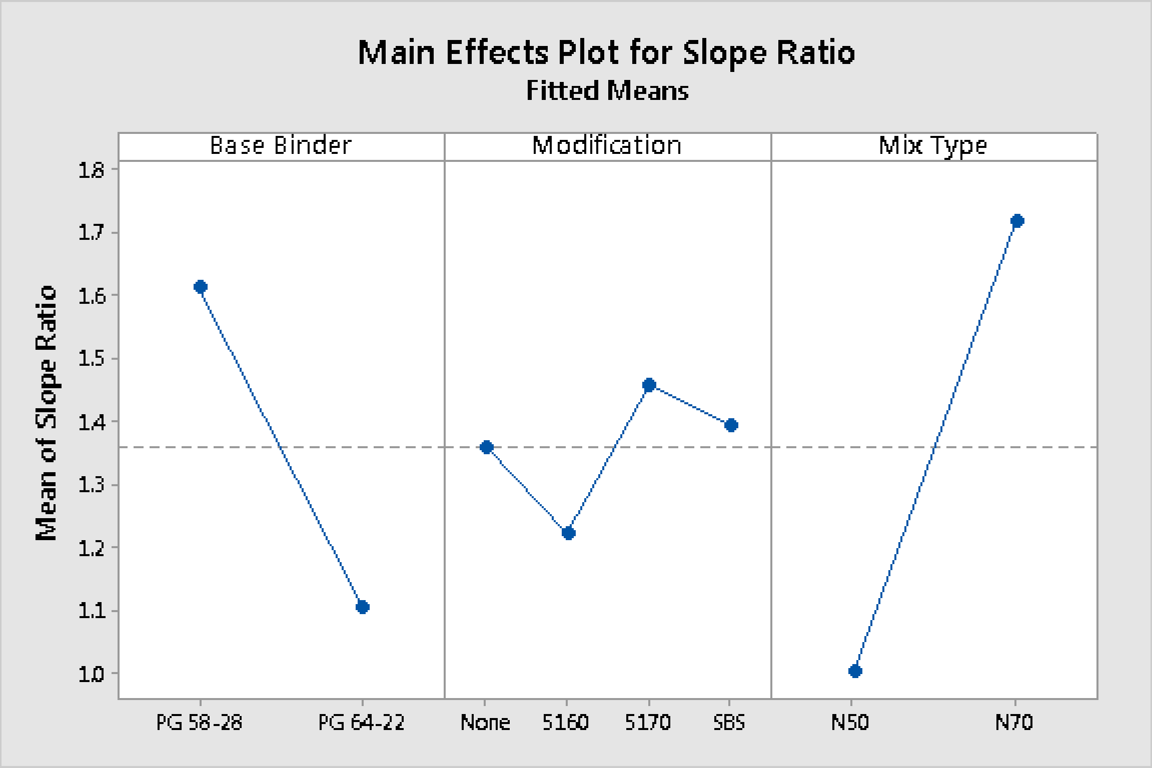
Differences

- Aggregate structure
- Recycled products and ABR values for mix designs:
  - N50 has 34% PBR, 40% of the binder replacement is from RAS.

SCB I-FIT

Effect of PBR - Flexibility Index





SCB I-Fit
Potential Benefits to Monitor Production

Factors	Levels
Mix Design Variables	
Aggregate Source:	Granite, Gravel, Limestone
Mix Traffic Level	Medium Traffic and High Traffic
Production Variables	
Asphalt Binder Content	Design – 0.3%, Design, Design + 0.3%
P200 Content	Design -2%, Design, Design + 2%

SCB I-Fit

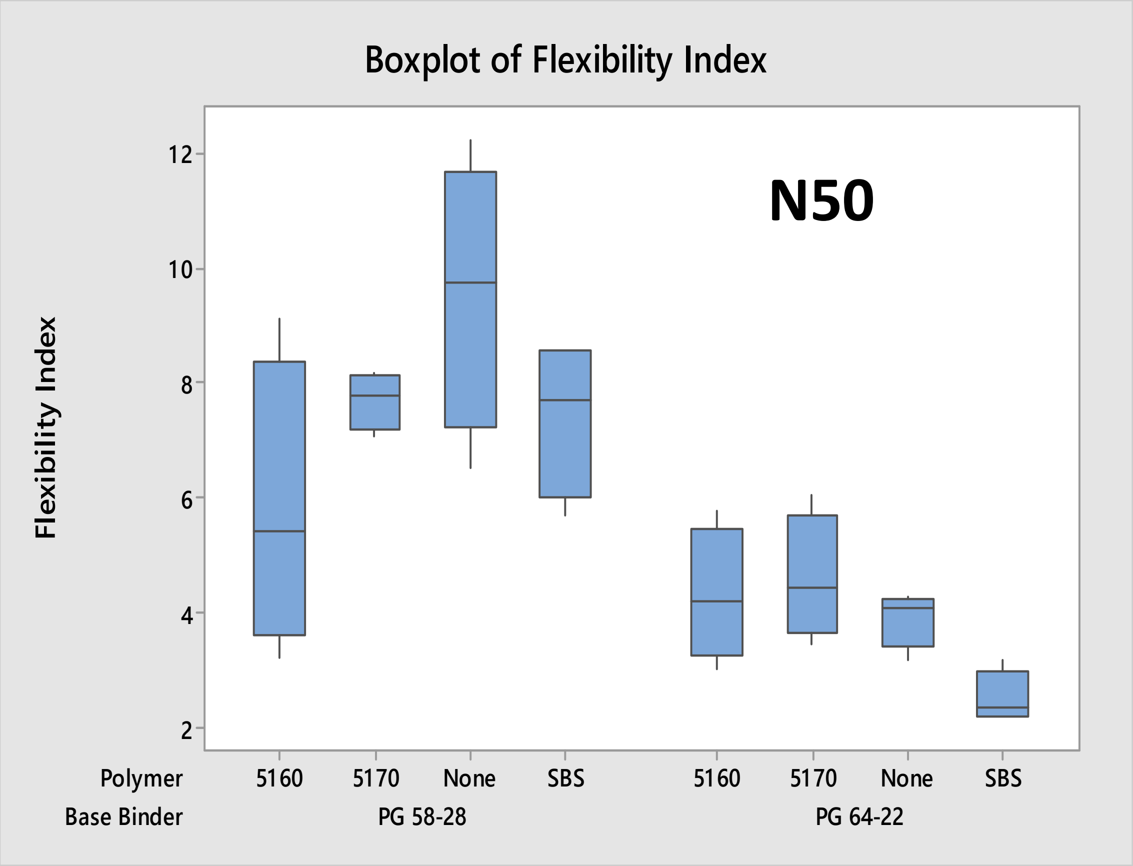
Potential Benefits to Monitor Production

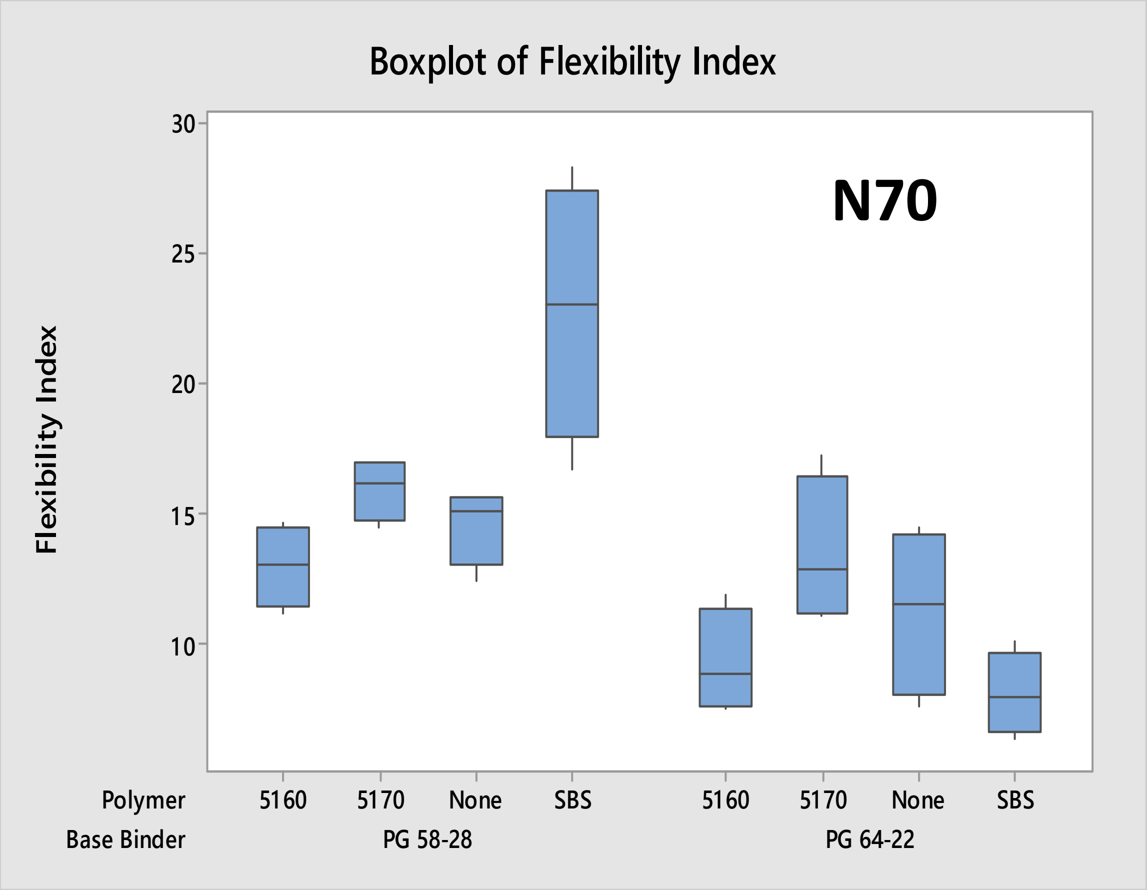
Factors	Flexibility Index		Post-Peak Slope		Fracture Energy	
Mix Type/Modification	P-value	Sig?	P-Value	Sig?	P-value	Sig?
Aggregate Source	<0.001	Yes	<0.001	Yes	0.054	No
Asphalt Binder Content	0.001	Yes	0.176	No	<0.001	Yes
P200 Content	0.124	No	0.475	No	0.001	Yes

- Results presented for HT-V-28 mix, similar for medium traffic unmodified design.

SCB I-FIT Concerns

Repeatability – Single Lab

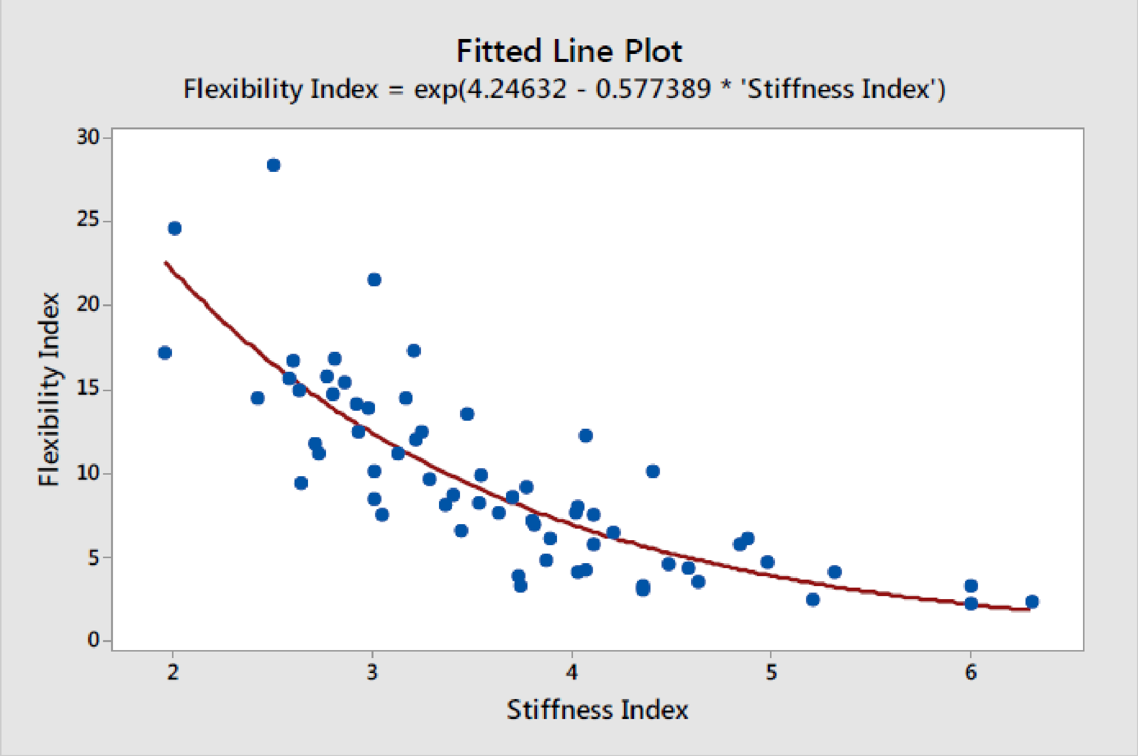


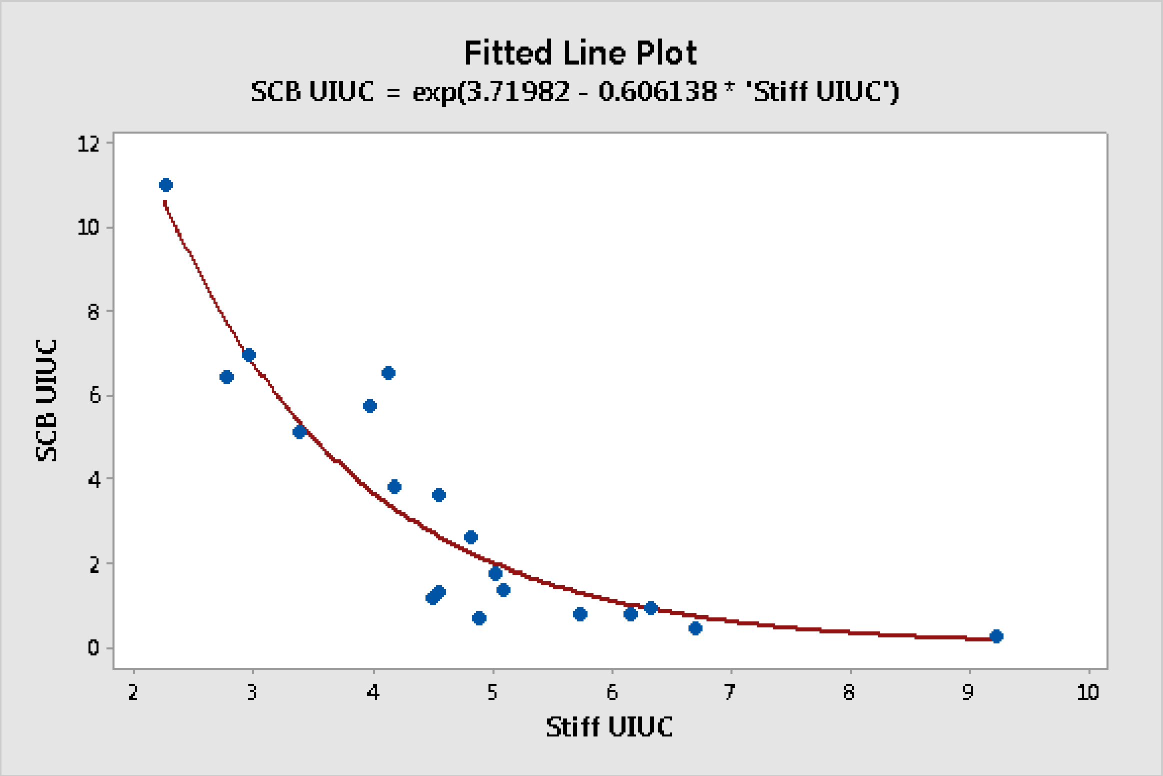


Four replicates tested for all mixes.

SCB I-FIT Concerns

Aging

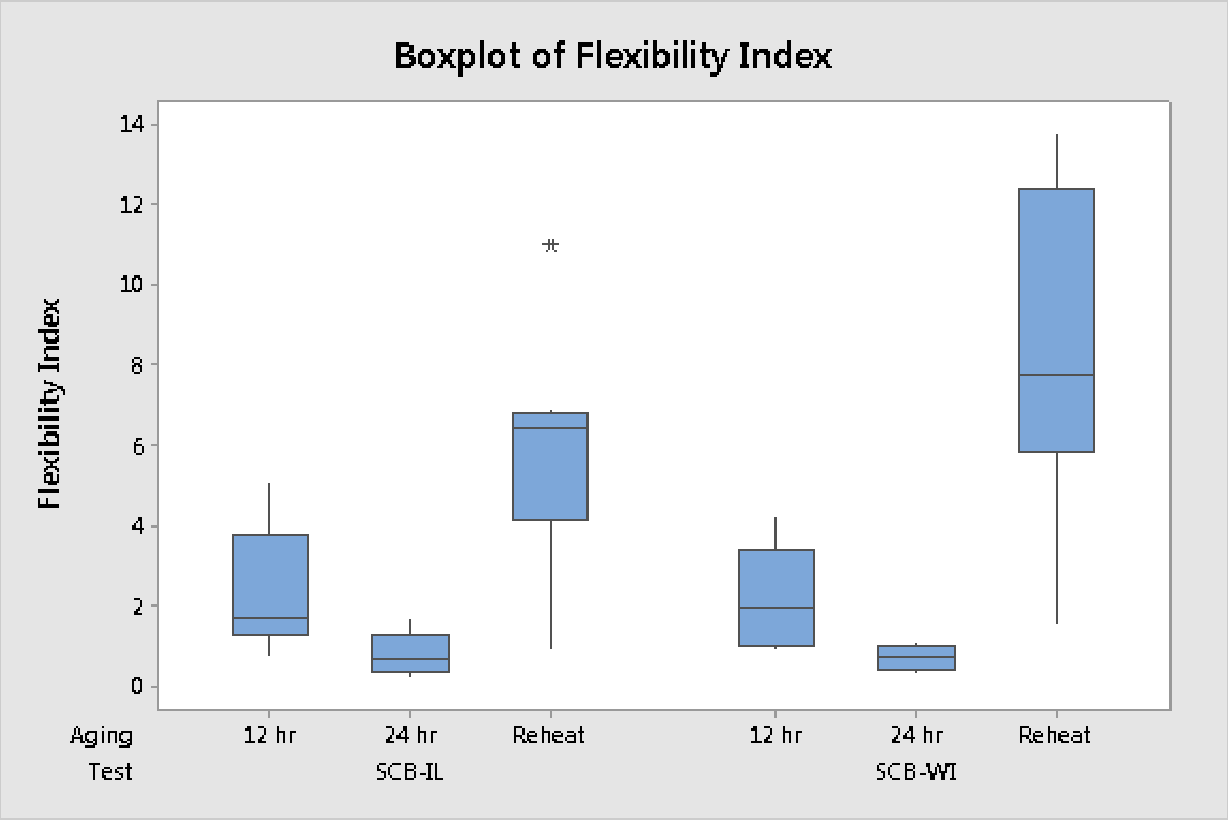




- Is Flexibility Index a discriminating property on long term aged samples?
- Data represents ~12 designs. 4% AV and 3.0% Regressed AV contents.

SCB IFIT Concerns

Effects of Loading Rate and Aging

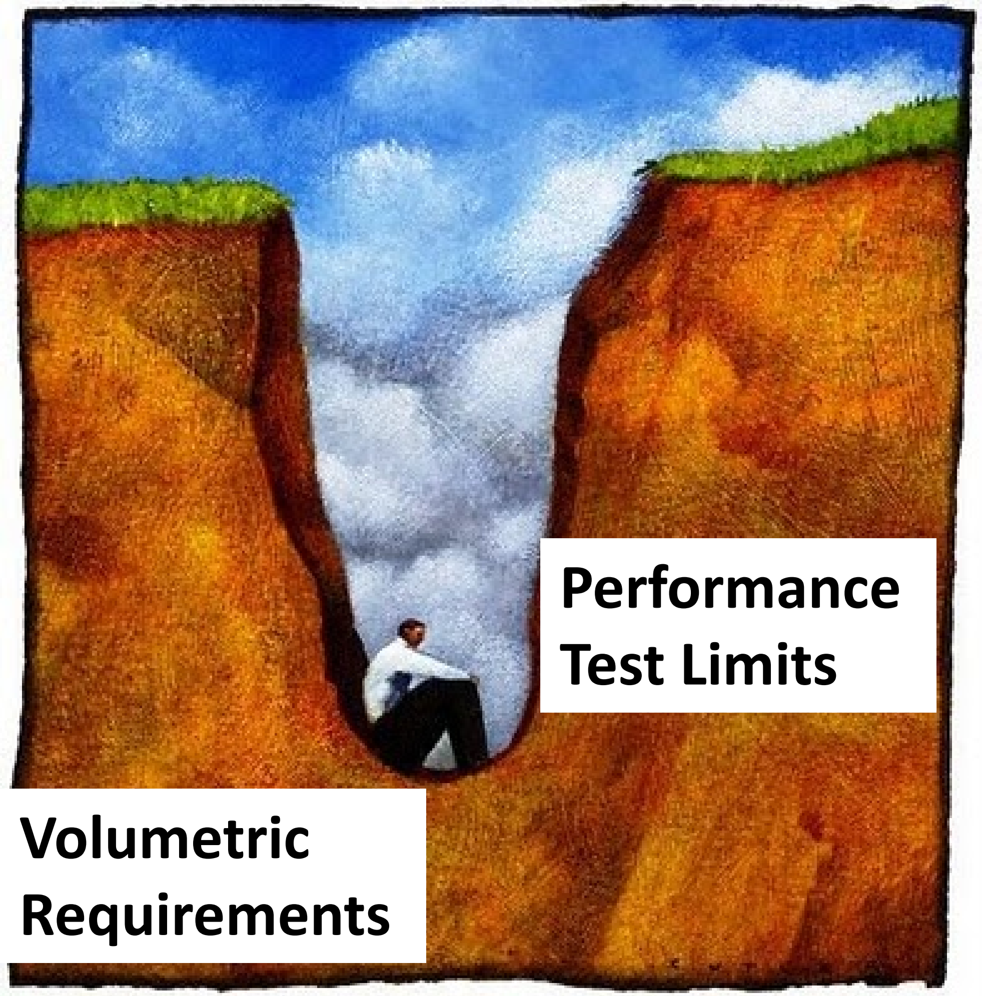


- After aging Flexibility Index values collapse due to stiffness effect.

Challenges
Standardization

- HMA acceptance based on volumetrics causes plenty of disputes due to multi-lab variability and differing practices.
- Adoption of even simple performance tests introduces more complexity.
- Have been successful in generating test procedures.
  - Need to understand precision and bias, ruggedness, etc.
- Assign testing responsibility and at what point in the process it will occur.

Challenges
Implementation Approach and Value Added



1. Maintaining current specifications and adding performance test requirements.
   a. Pro: Good for initial data gathering.
   b. Cons: Limited flexibility for mix adjustments.

Long Term Outcomes

Change in specifications based on initial performance test results.

Or

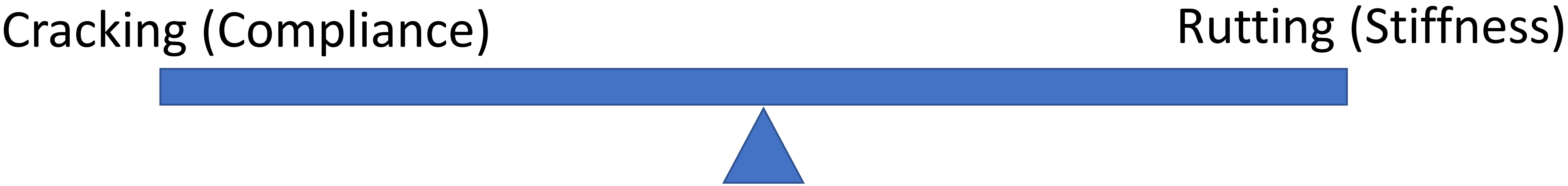
BMD Approach #2: Relax volumetric criteria and add performance test requirements.

Challenges
One Size Does Not Fit All – Setting Limits

- **Dense Graded Mixes**
  - Surface Layers vs. Lower Layers
  - Mix Traffic Level
  - Should effects of load/moisture be combined?
- **Specialty Mixes**
  - Interlayer, Thinlay, SMA
- **Example**
  - Flexibility Index = 7.0 (Dense Graded Mix) or 20.0 (SMA).
- **Different Tests may be better suited for different applications.**

Next Steps
Ideal Process

1. Selection of Binder Grade and Binder Content



2. Quality Assessment

Aging Protocol?
Aging Evaluation – Mixture or Binder?

Moisture Damage
Which test?

Next Steps
Quality Assessment - Gaps

- **Moisture Damage**
  - Combined with Rutting by using wet Hamburg with very high # of passes.
  - Is specification promoting dry/stiff mixes?
  - Should effects of load/moisture be combined?
- **Aging/Durability**
  - Significant debate on which aging method to use and aging binder or mix.
  - Many index cracking tests have not been developed at the levels of aging currently under consideration.
  - Interim solution? Binder properties (i.e. ΔT_c, G-R) have shown good correlation to field performance.

Remarks/Discussion Points

- There are benefits to single loading rate/single temperature tests, but they cannot solve all problems.
  - Evaluates the mix as a system & Provides a control for mix stiffness.
- A solution for aging resistance is still a major research need.
  - Accelerated load correlations indicate load associated cracking.
- States are looking for guidance on how to incorporate these tests into practice.

Thank You!

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References

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