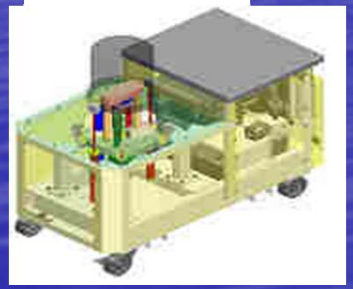

Thin HMA Overlays for Pavement Preservation

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Nelson Gibson

Turner-Fairbank Highway Research Center

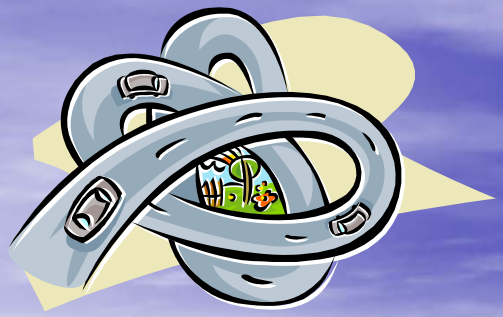
US Federal Highway Administration

www.TFHRC.gov

MATERIALS & CONSTRUCTION TEAM, R&D

Acknowledgments

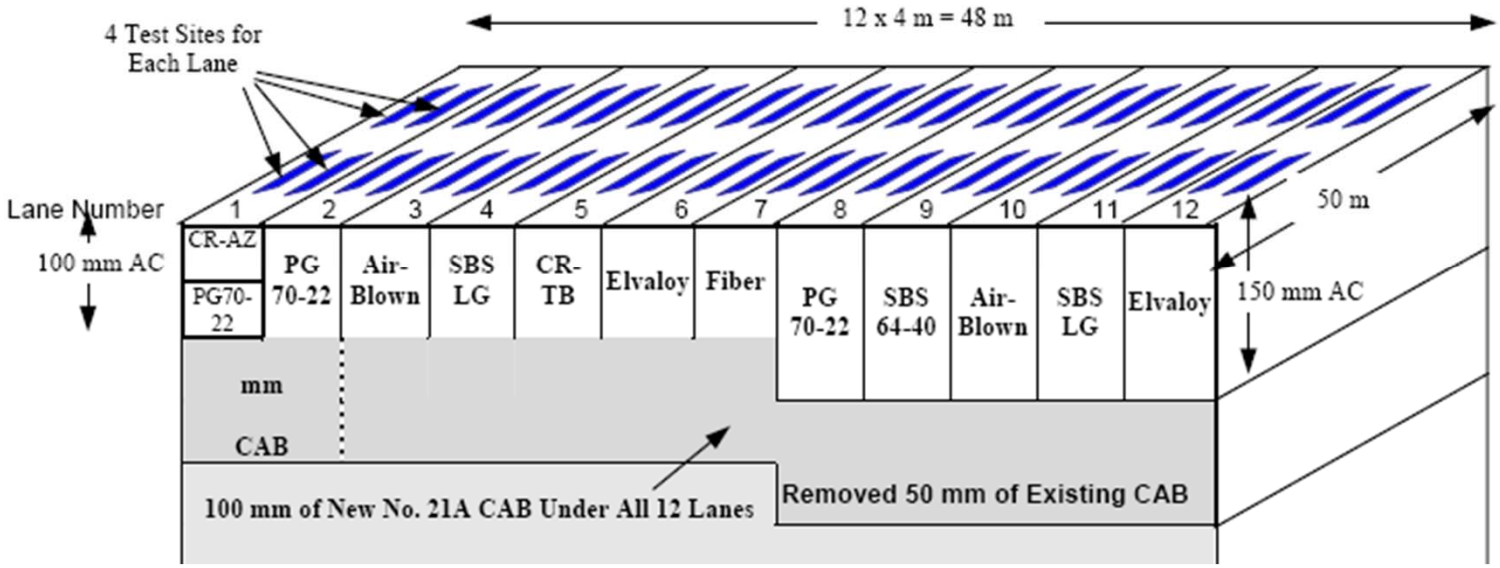
- Thank Virginia DOT and Superior Paving whose cooperation and assistance were vital to the thin HMA overlay study.
- Also thank laboratory staff at ALF, Mix, and Binder labs at the FHWA Tuner-Fairbank Highway Research Center for their lab tests and data collection.



Outline

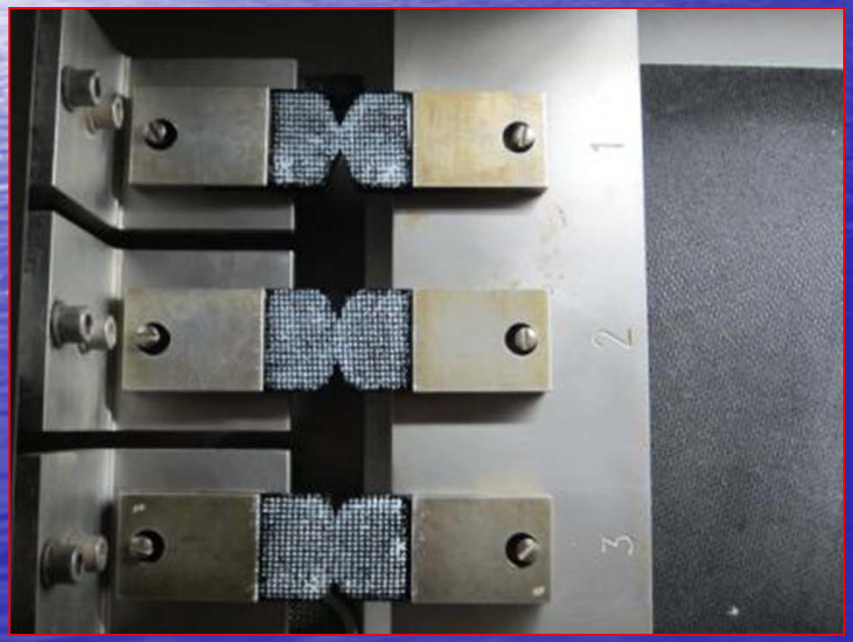
1. Project Background
   - Preceding research study at the Accelerated Load Facility (ALF)
   - Motivation for the thin overlay study
2. Thin Overlay Construction
3. ALF Testing and Results
4. Summary and Conclusions

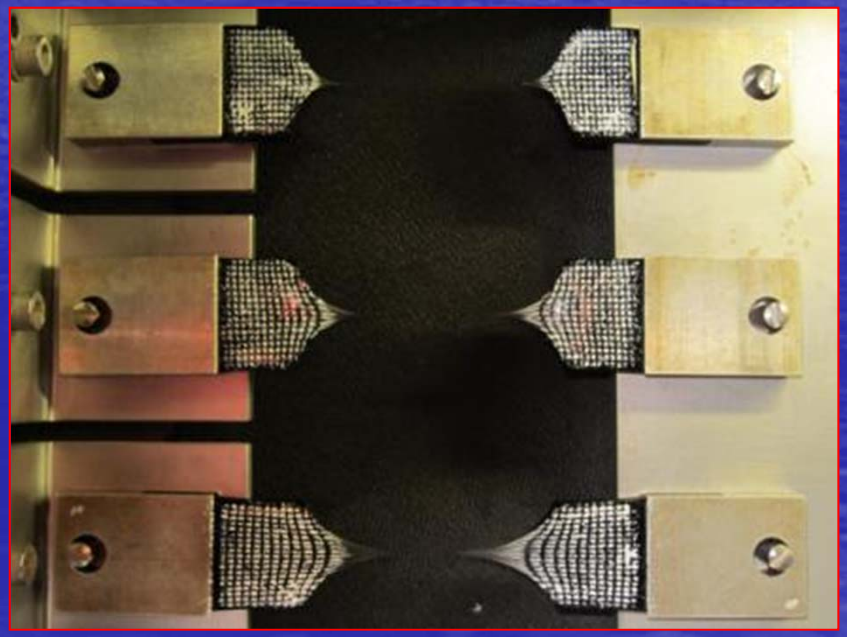
Project Background


12 x 4 m = 48 m
4 Test Sites for Each Lane
Lane Number
1
2
3
4
5
6
7
8
9
10
11
12
50 m
100 mm AC
CR-AZ
PG70-22
PG 70-22
Air-Blown
SBS LG
CR-TB
Elvaloy
Fiber
PG 70-22
SBS 64-40
Air-Blown
SBS LG
Elvaloy
150 mm AC
mm
CAB
100 mm of New No. 21A CAB Under All 12 Lanes
Removed 50 mm of Existing CAB

FHWA Recommendation to Replace $|G^*|\sin\delta$ for Fatigue Cracking

- Calculated Crack Tip Opening Displacement (CTOD), a notched direct tension test





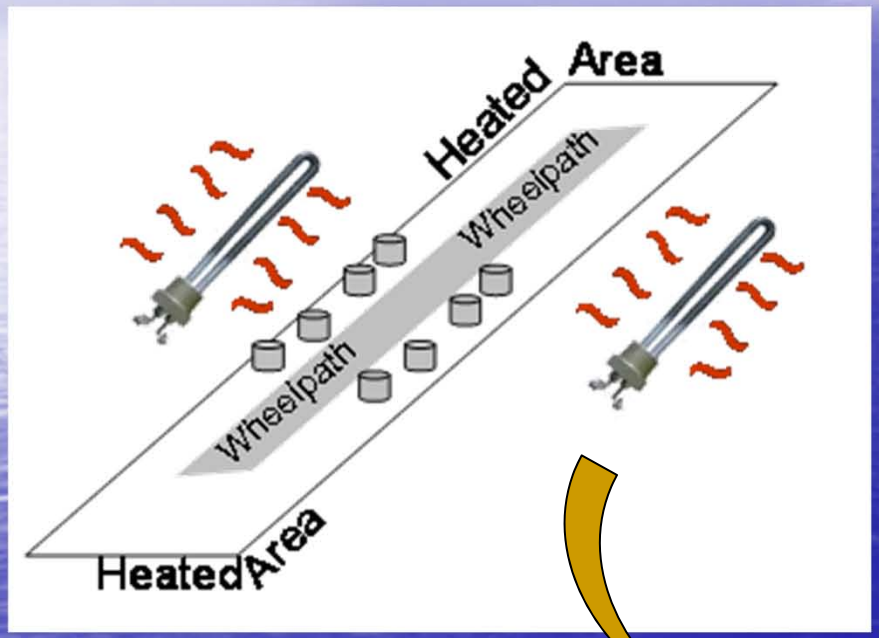
FHWA Recommendation to Replace $|G^*|\sin\delta$ for Fatigue Cracking

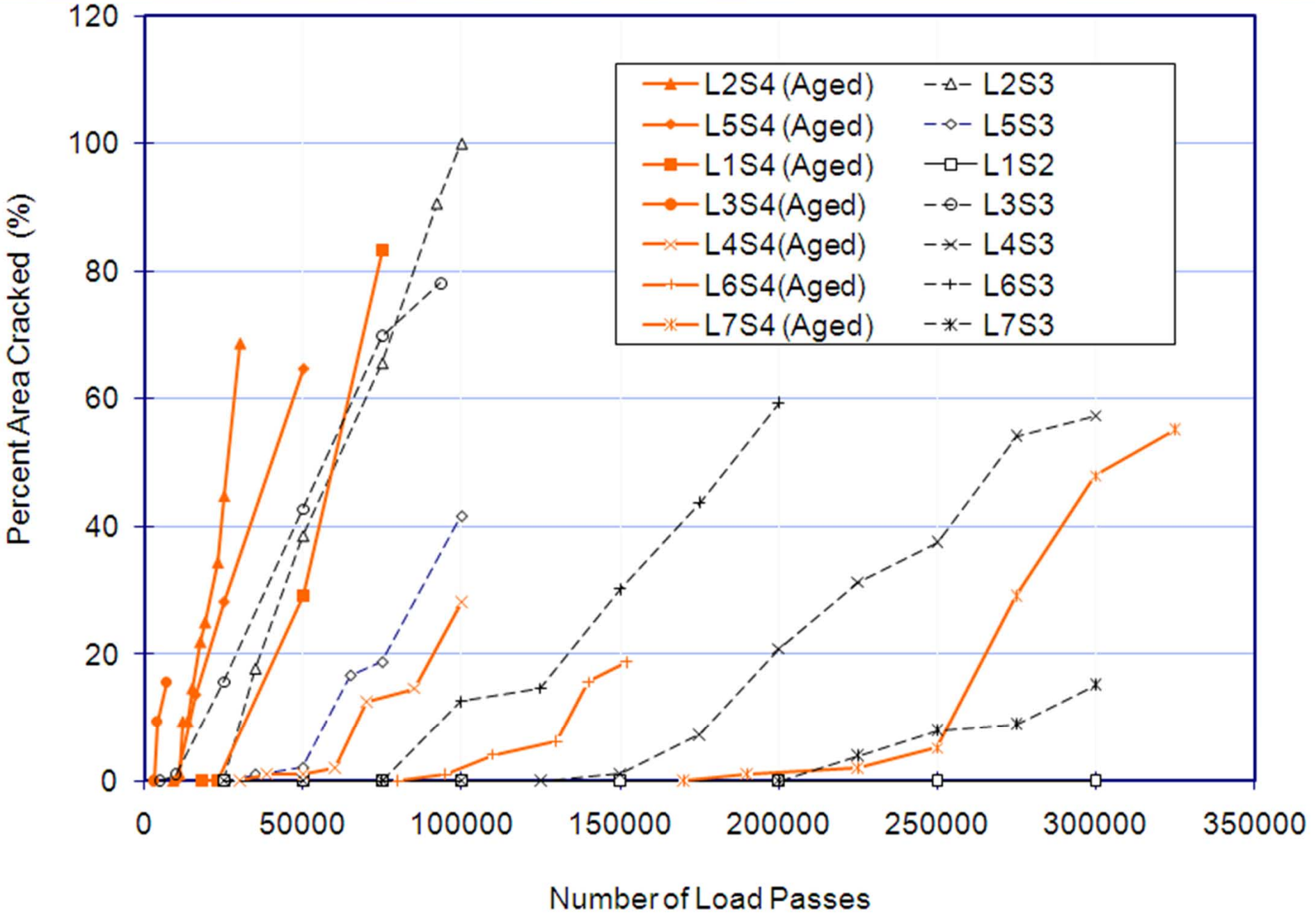
- Calculated Crack Tip Opening Displacement (CTOD), a notched direct tension test
- ***Primarily based*** on fatigue cracking in un-aged full scale accelerated pavement tests

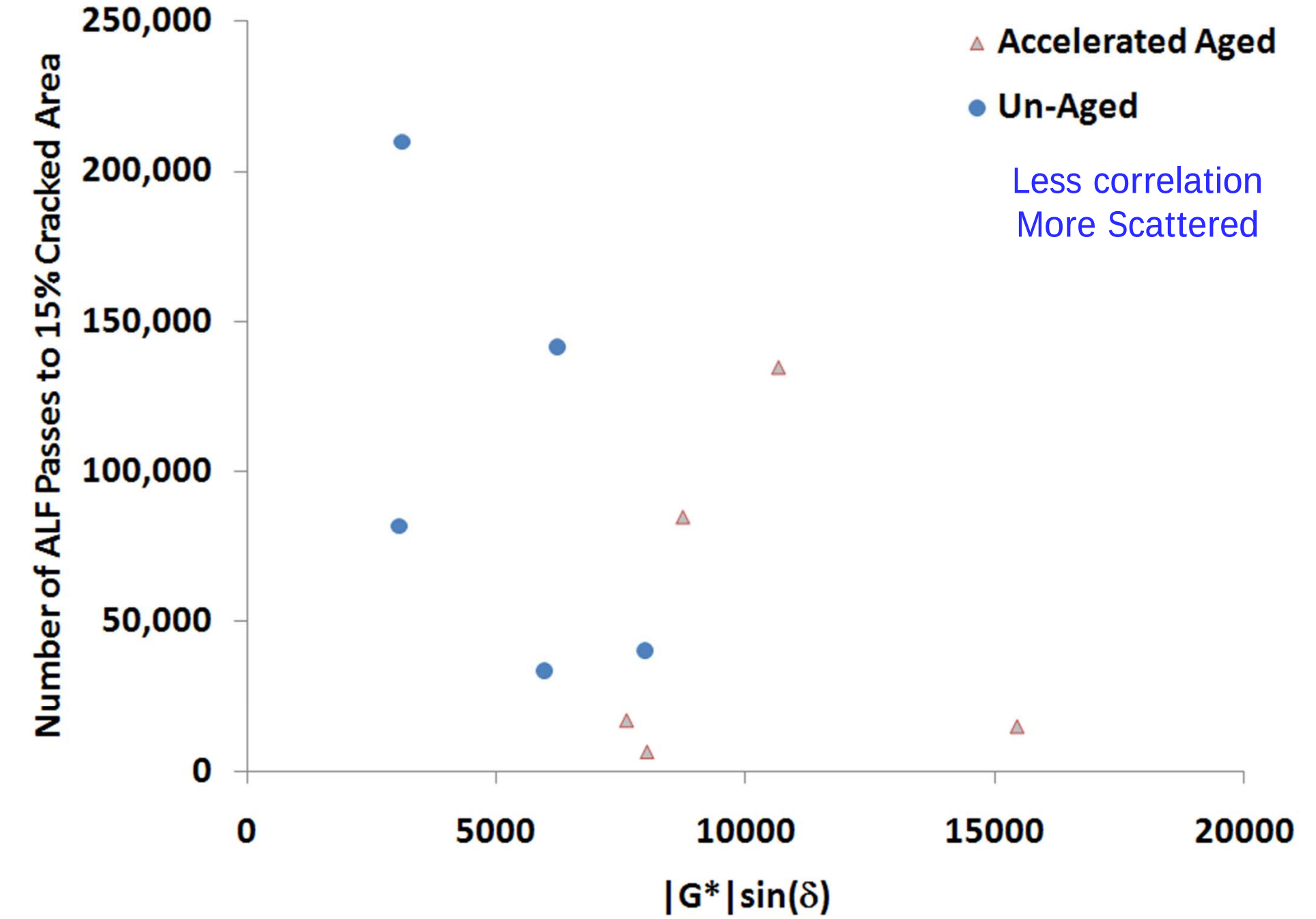
PLUS

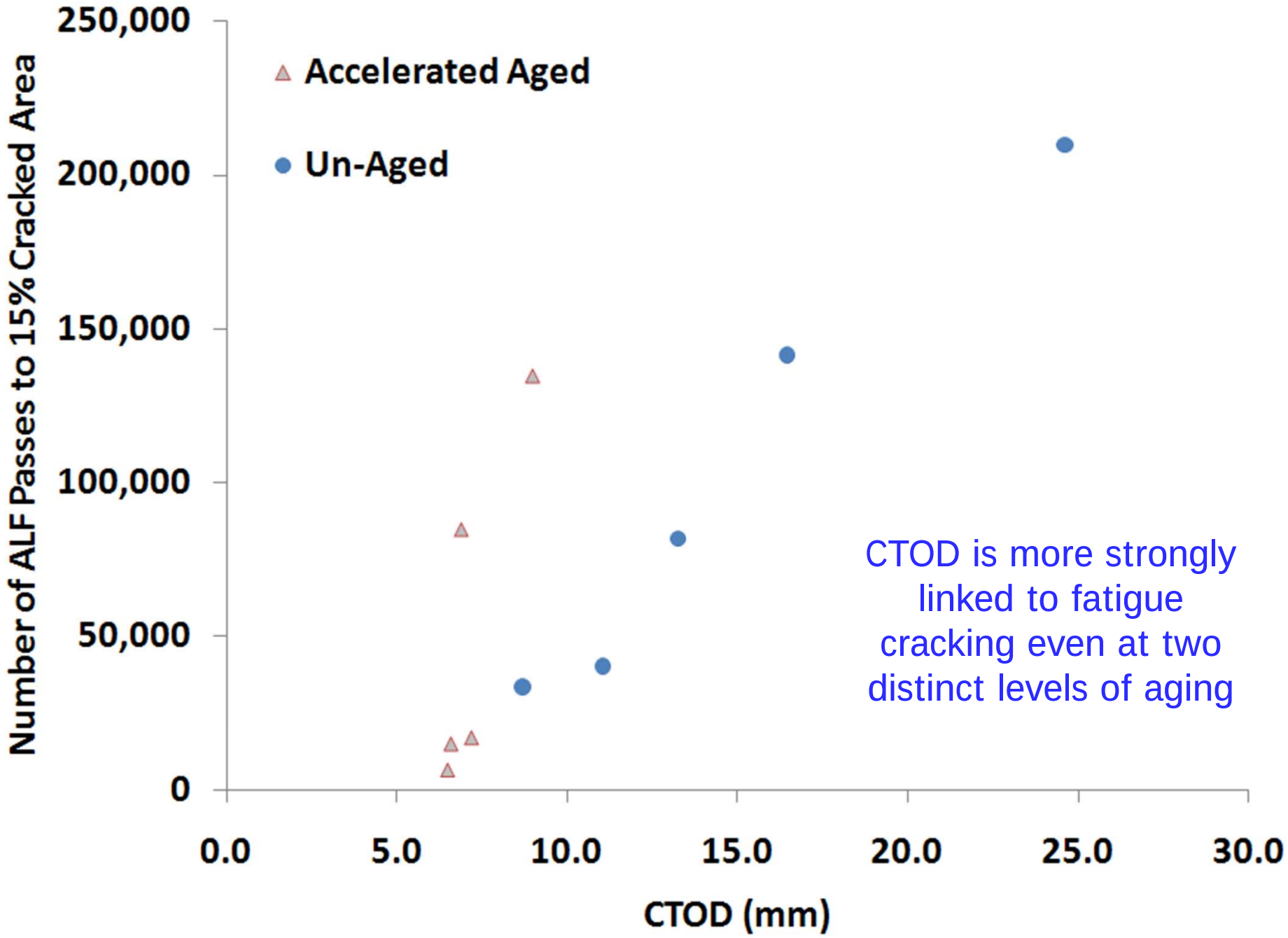
- ***Validated and Strengthened*** with full scale accelerated aged test sections

Accelerated Aging via Radiant Heaters used for Temperature Control

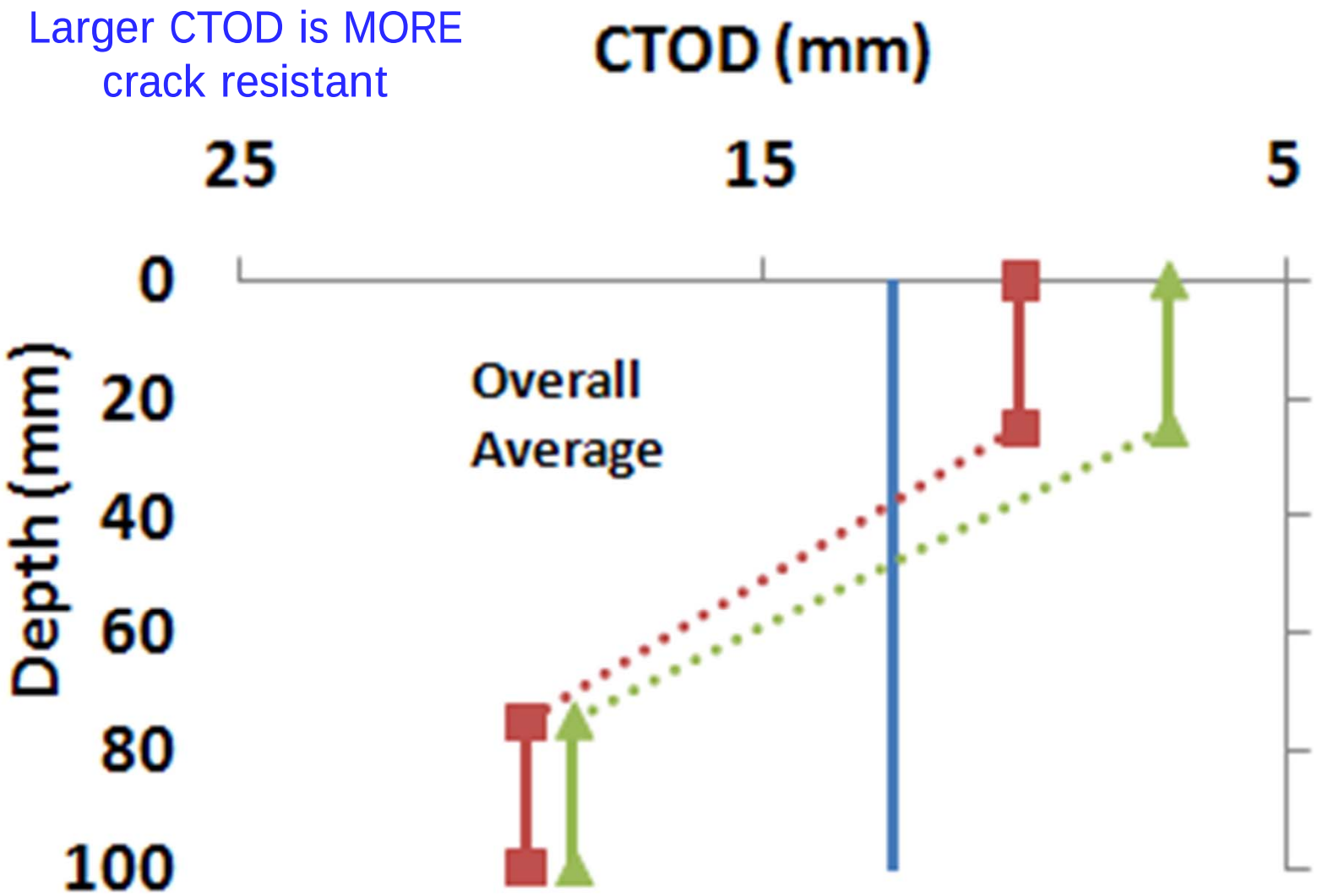



120
100
80
60
40
20
0
Percent Area Cracked (%)
0
50000
100000
150000
200000
250000
300000
350000
Number of Load Passes
L2S4 (Aged)
L5S4 (Aged)
L1S4 (Aged)
L3S4(Aged)
L4S4(Aged)
L6S4(Aged)
L7S4 (Aged)
L2S3
L5S3
L1S2
L3S3
L4S3
L6S3
L7S3

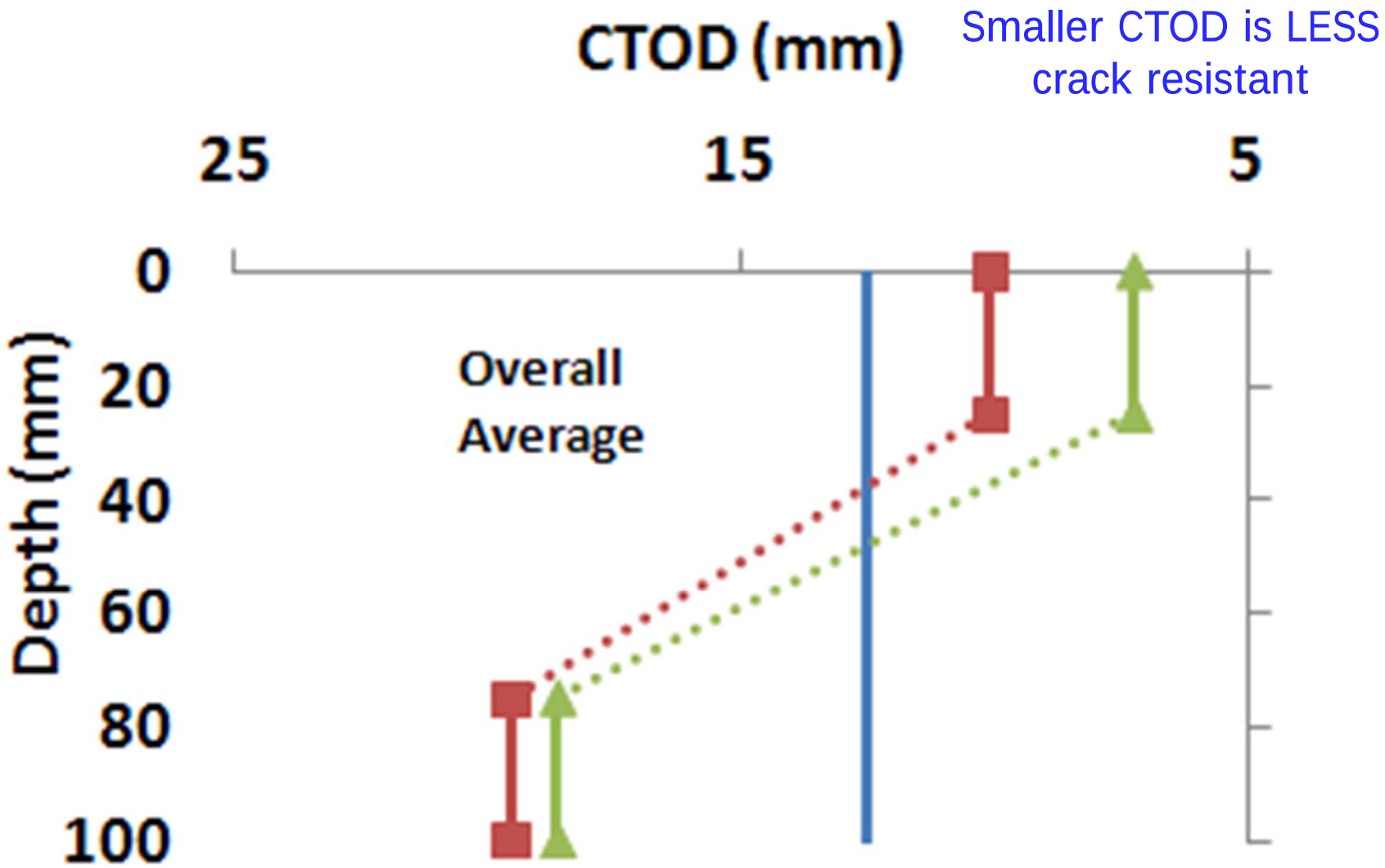

Number of ALF Passes to 15% Cracked Area
250,000
200,000
150,000
100,000
50,000
0
0
5000
10000
15000
20000
|G*|sin(δ)
Accelerated Aged
Un-Aged
Less correlation
More Scattered


Number of ALF Passes to 15% Cracked Area
250,000
200,000
150,000
100,000
50,000
0
Accelerated Aged
Un-Aged
0.0
5.0
10.0
15.0
20.0
25.0
30.0
CTOD (mm)
CTOD is more strongly linked to fatigue cracking even at two distinct levels of aging

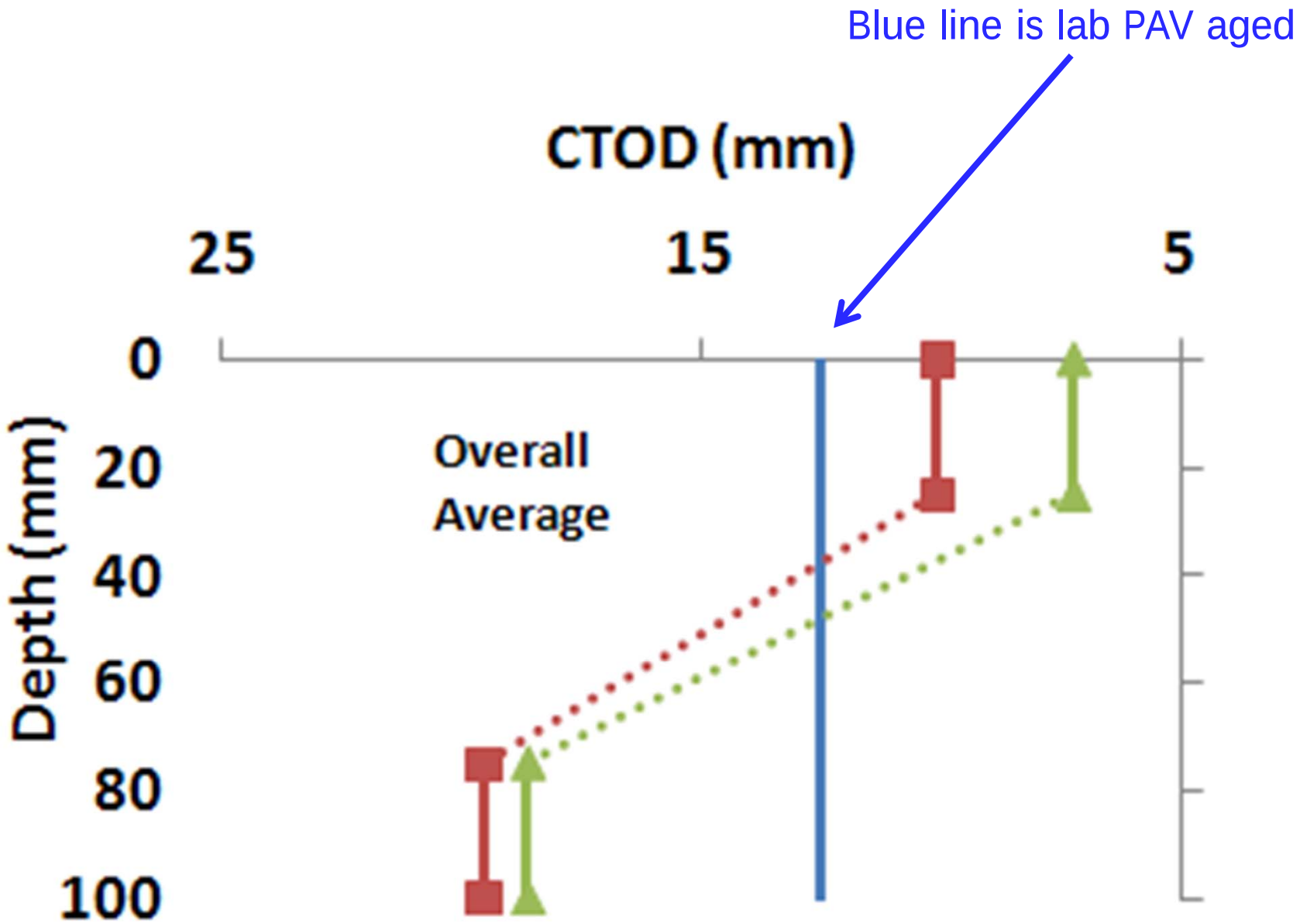
Solvent Extraction and Recovery



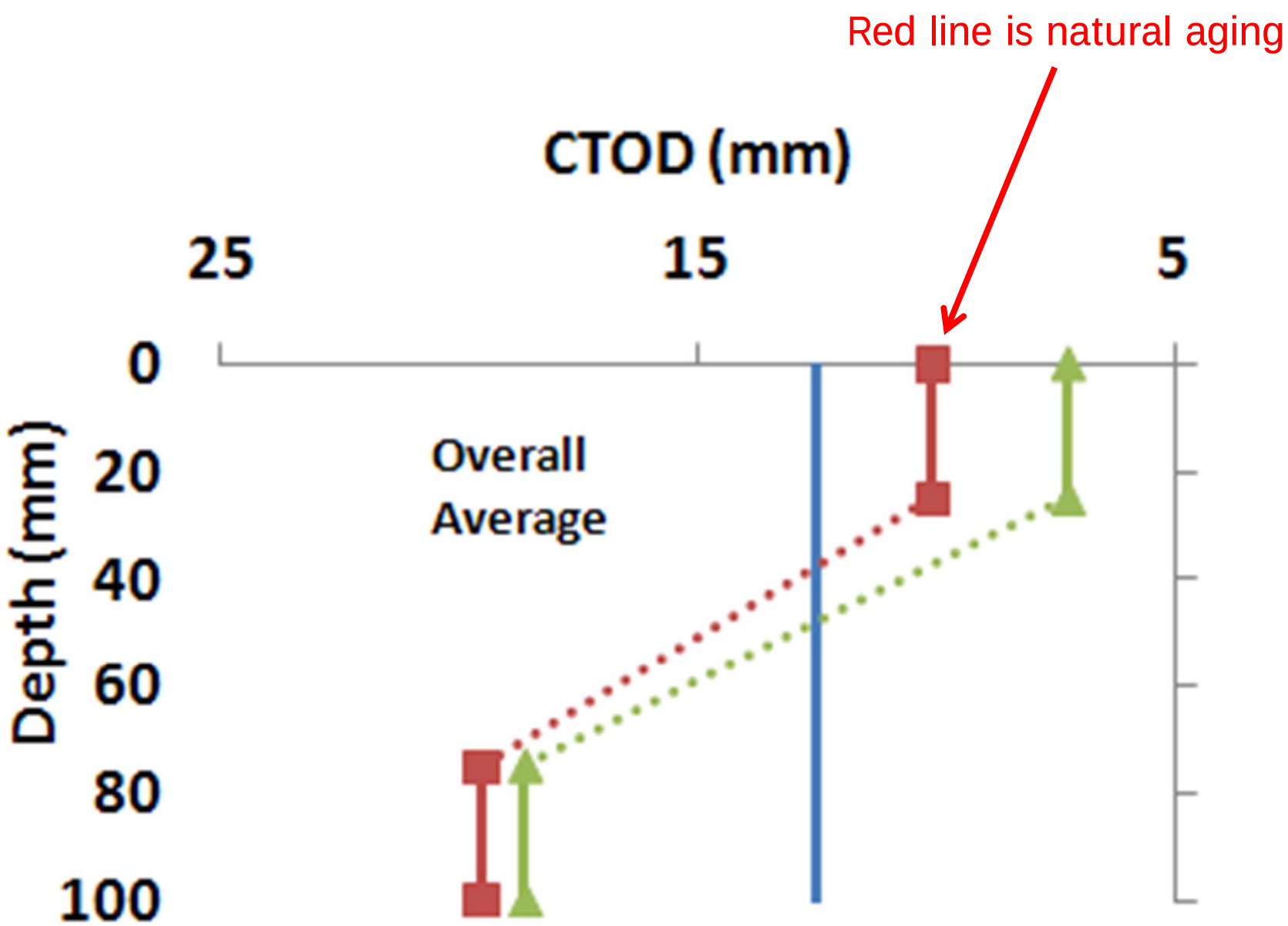
Solvent Extraction and Recovery



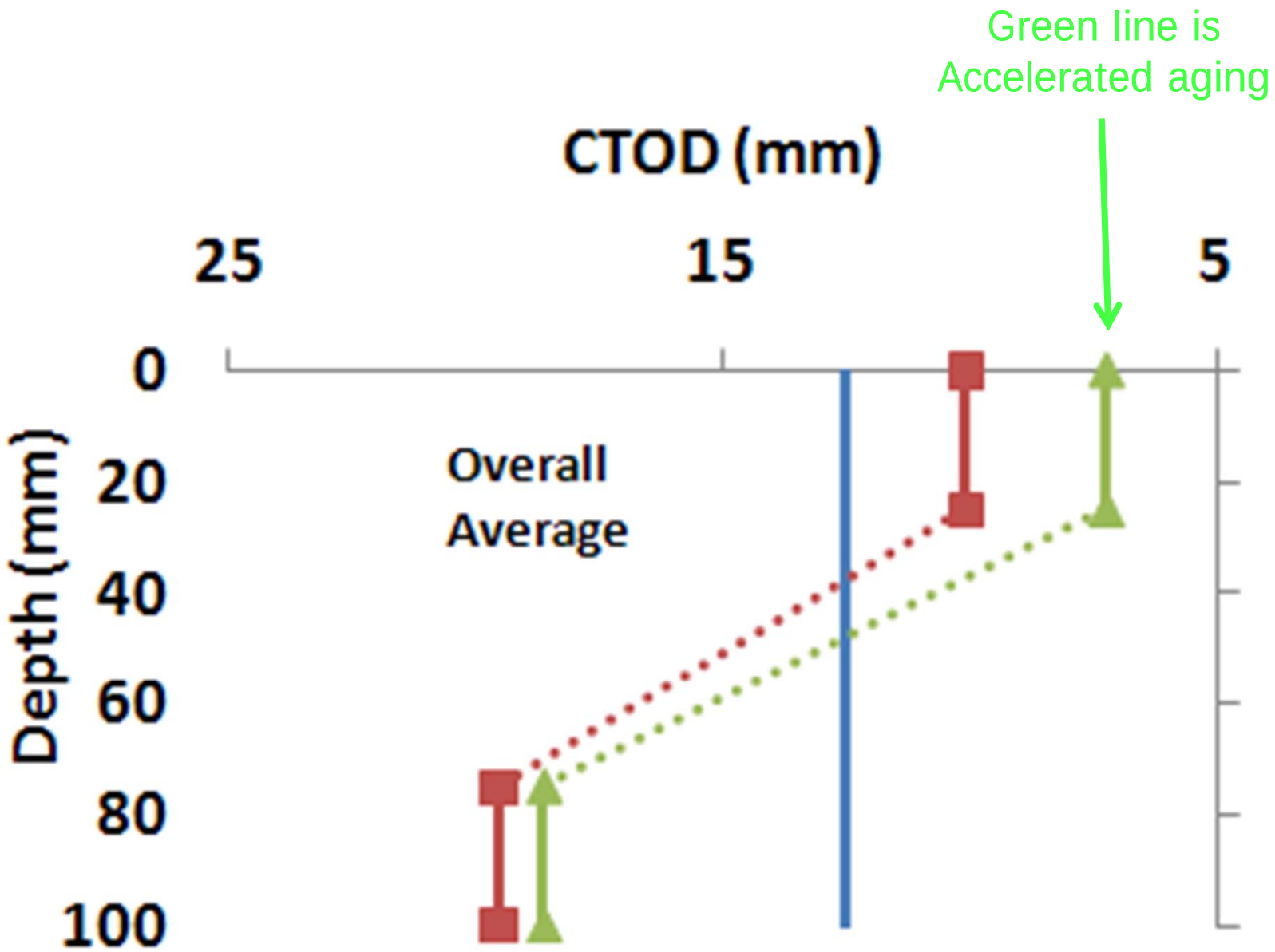
Solvent Extraction and Recovery



Solvent Extraction and Recovery



Solvent Extraction and Recovery

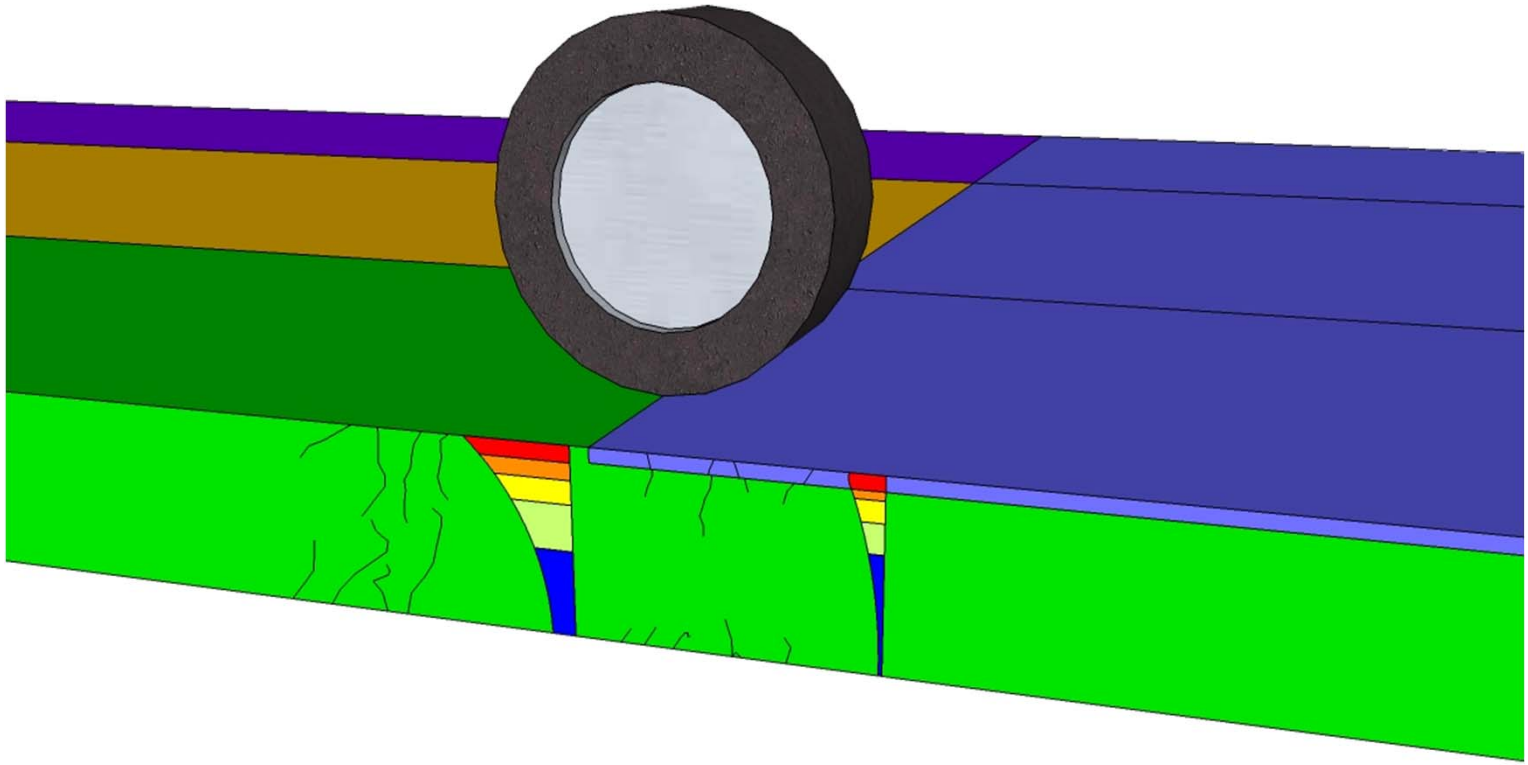


Top-Down / Bottom-Up Cracking Accelerated Aged Sections

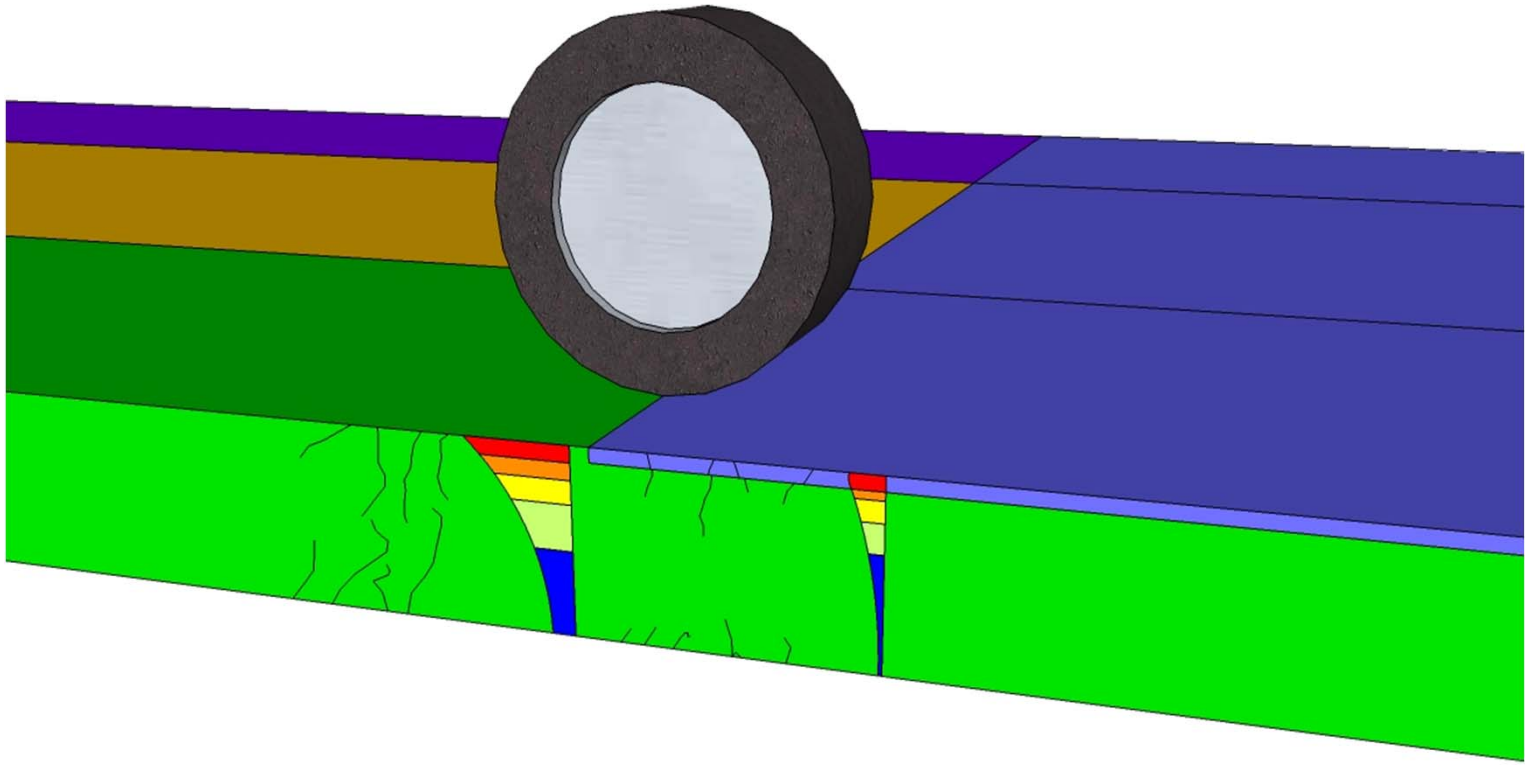
	Total Counts	Bottom-up Cracks		Top-Down Cracks		Full-Depth Cracks	
		Counts	Percentage	Counts	Percentage	Counts	Percentage
Lane 1 CR-AZ/Control	15	3	20%	11	73%	1	7%
Lane 2 Control	6	0	-	5	83%	1	17%
Lane 3 Air Blown	5	1	20%	0	-	4	80%
Lane 5 CR-TB	18	10	56%	5	28%	3	17%
Lane 6 Reacted Terpolymer	13	5	38%	8	62%	0	-

Motivation for the Thin Overlay Study

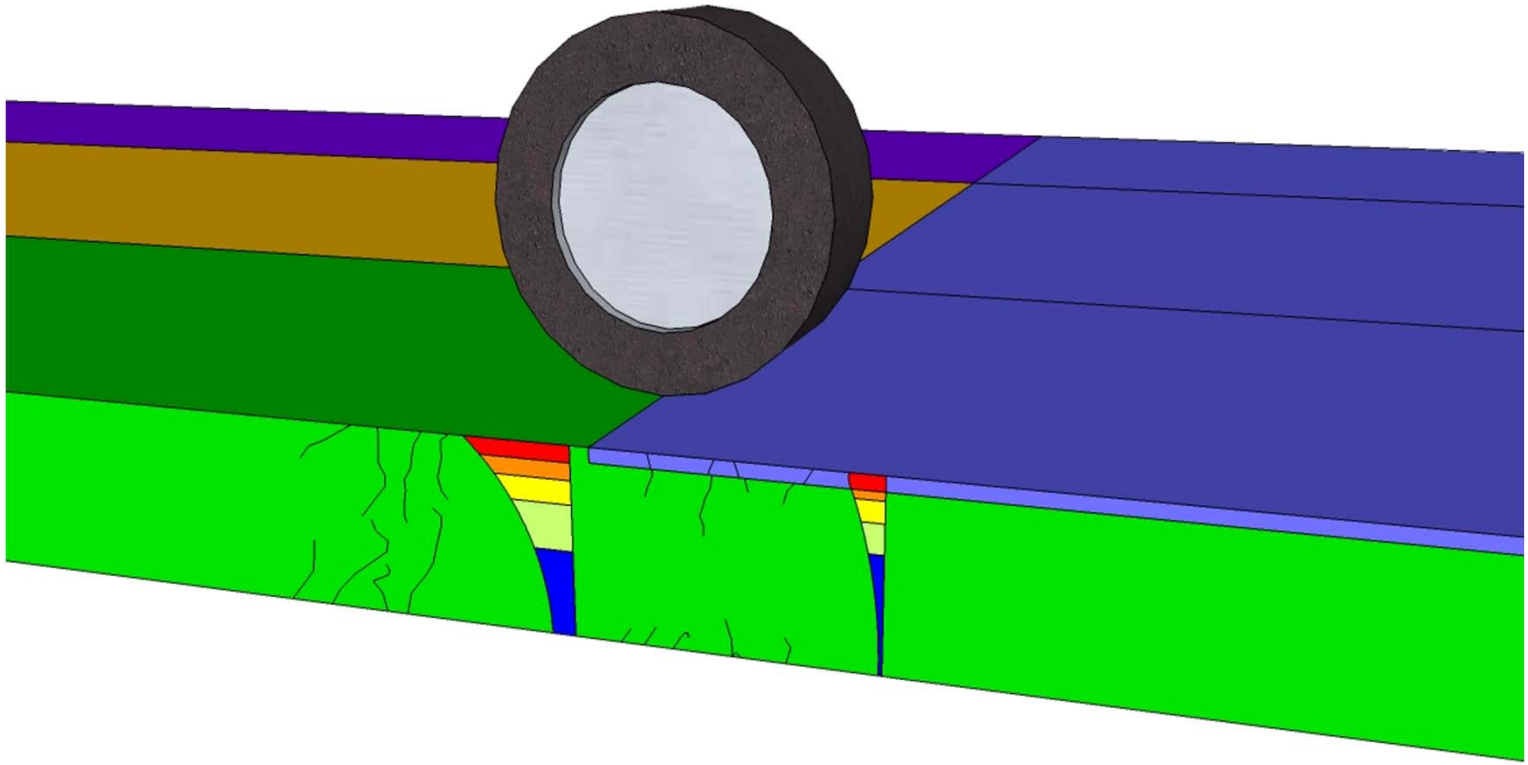
Although the aging experiment was intended to help with the statistics of the original experiment...



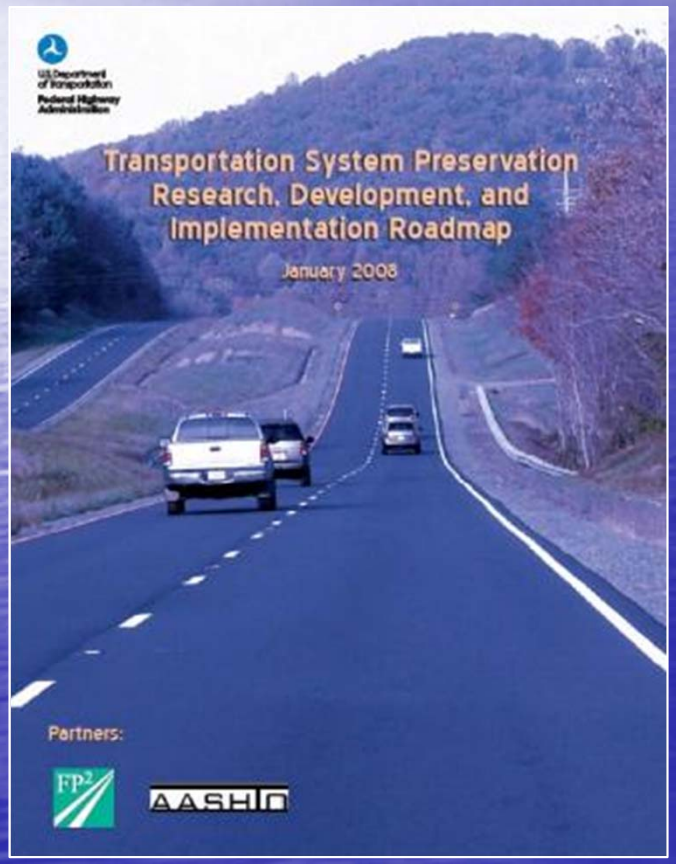
Although the aging experiment was intended to help with the statistics of the original experiment ... the concentration of aging at the surface and top-down fatigue cracking performance naturally led the research team to the scenario of pavement preservation



Although the aging experiment was intended to help with the statistics of the original experiment ... the concentration of aging at the surface and top-down fatigue cracking performance naturally led the research team to the scenario of pavement preservation....in other words, to what degree could the performance of the aged sections be extended they were renewed with a treatment?



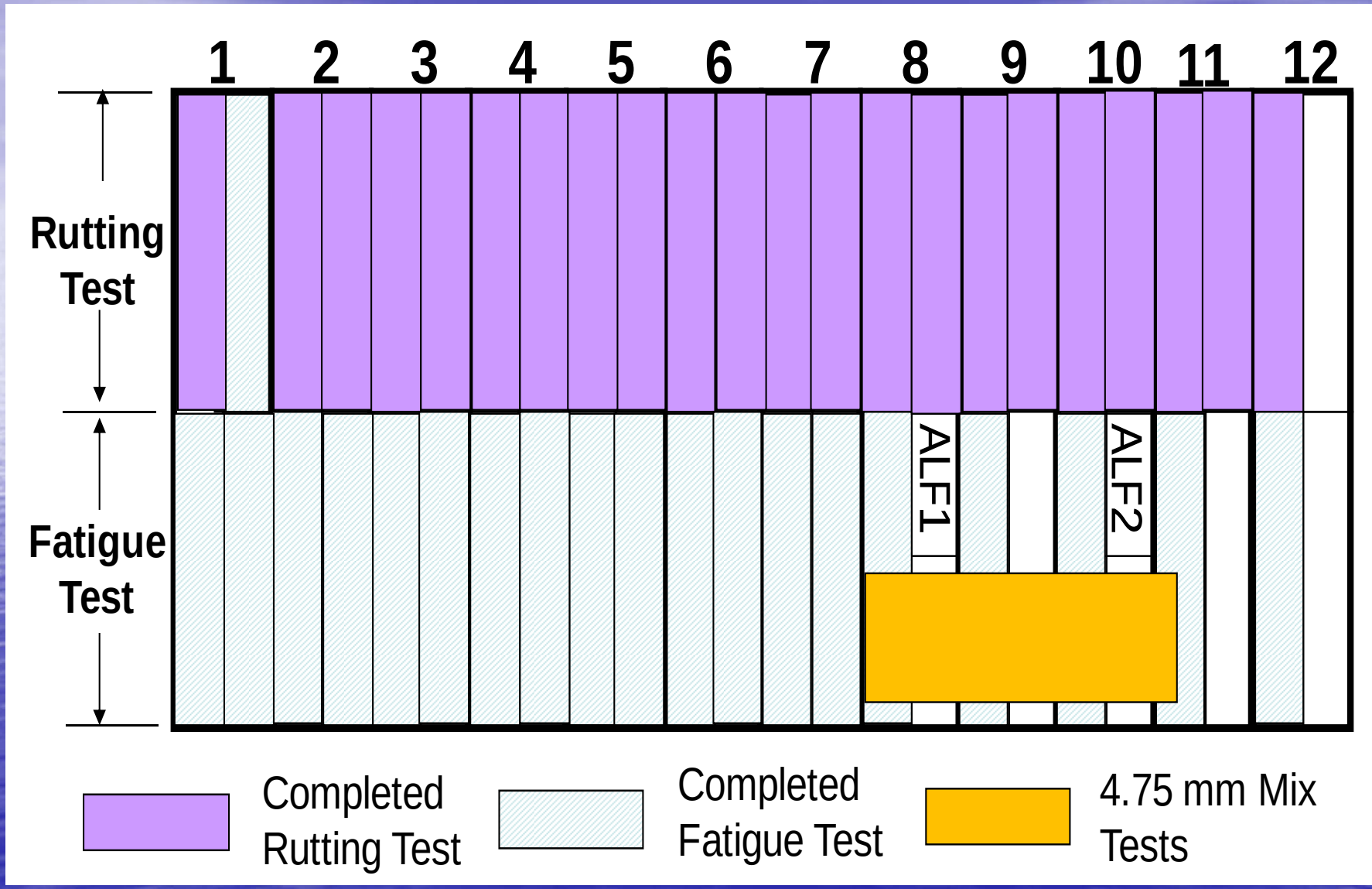
AASHTO – FHWA – FP2. Transportation System Preservation Research, Development, and Implementation Roadmap

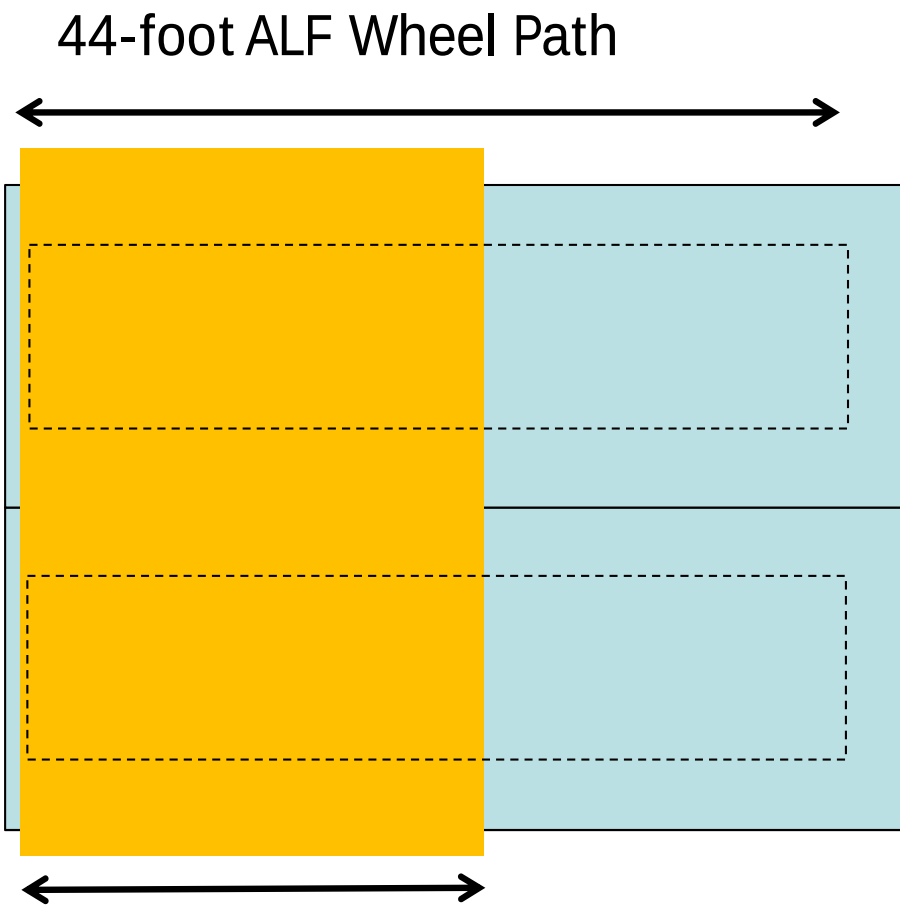


- **<u>Performance #03</u> - Quantify Performance and Benefits of Various Pavement Preservation Treatments and Develop Pavement Preservation Treatment Performance Models.**
- **<u>Performance # 04</u> - Quantifying the Benefits of Pavement Preservation Treatments**
- **<u>Design #02</u> – Determining Pavement Preservation Treatment Lives and Related Pavement Life Extension**
- **<u>Design #06</u> – Integrating Pavement Preservation into the Design Process**
- **<u>Materials #01</u> – Mechanical Binder Properties to Predict Surface Treatment Performance**

Superpave 4.75mm NMAS

- Explored the concept of placing a chip seal, or slurry seal or other approach
- Collaborated with Virginia DOT as they are the closest neighbor to FHWA-TFHRC
- Recommended the experiment use a thin overlay of a trial 4.75mm NMAS Superpave mix that was being considered for preventive maintenance application
- Other benefits:
  - Use of excess fine aggregates
  - Inclusion of RAP


1
2
3
4
5
6
7
8
9
10
11
12
Rutting Test
Fatigue Test
ALF1
ALF2
Completed Rutting Test
Completed Fatigue Test
4.75 mm Mix Tests


44-foot ALF Wheel Path
22- foot 4.75mm Mix
Inlay Placed over Half
of ALF Loaded Area

Gradation of the mix design; job mix formula and production

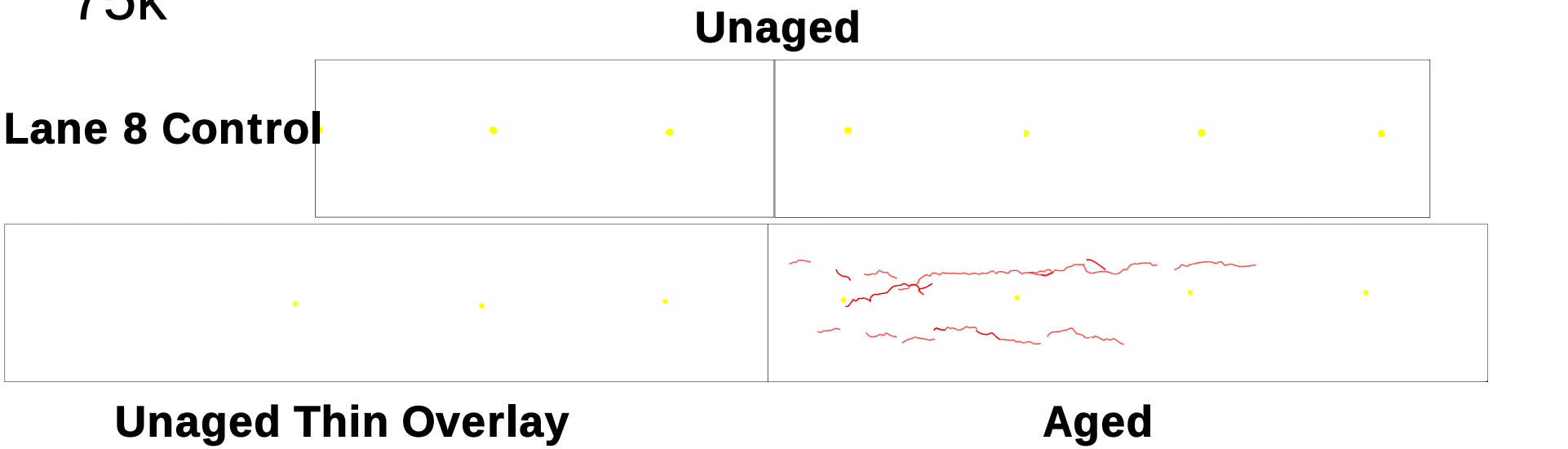
Sieves #	Bealton sand	#10	RAP	Nat. Sand	Bag House	Mix Design	Gradation Check
¾”(19mm)	100	100	100	100	100	100	100
½”(12.5mm)	100	100	99.8	100	100	100	99.7
3/8”(9.5mm)	100	100	95	100	100	99.1	97.0
#4 (4.75mm)	96	96	67	98	100	92.3	87.6
#8 (2.36mm)	62	66	50	86	100	68.7	60.1
#16(1.18mm)	38	45	39	66	100	45.7	43.1
#30(0.60mm)	26	33	29	36	100	31.9	31.0
#50(0.30mm)	17	24	21	12	100	21.6	21.4
#100(0.15mm)	10	18	14	5	98	14.7	15.1
#200(.075mm)	5.2	12.4	9.3	2.5	95	10.3	10.4
Blend %	26	44	20	10	1	-	-

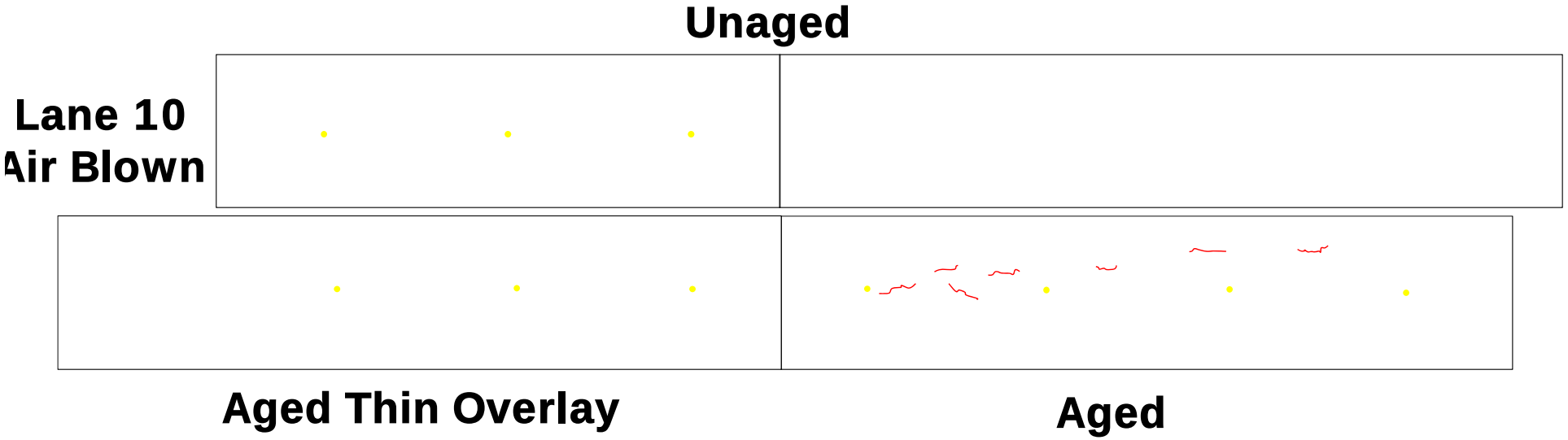
Volumetric properties of the mix design; job mix formula and production

Specification Criteria Ndesign = 50 gyrations			**Job Mix Formula**	**Produced FHWA Gmm = 2.595 Contractor's Gmm = 2.584**	
Volumetrics		Virginia DOT		FHWA extracted aggregate G_{SB} = 2.813	Contractor's aggregate G_{SB} = 2.789
VTM	Design	5%	4.4%	-	
	Pro-duction	3% - 6%	-	4.21% - 3.98%	
VFA	Design	70% - 75%	74%	-	
	Pro-duction	70% - 80%	-	75.1% - 76.2%	74.0% -75.2%
VMA		16.5% min.	16.9%	16.9% - 16.7%	16.2 %– 16.0%
V_{be}		-	-	14.96%	14.86%
Dust to Binder based on effective asphalt		1 – 2	1.98	1.99	2.11

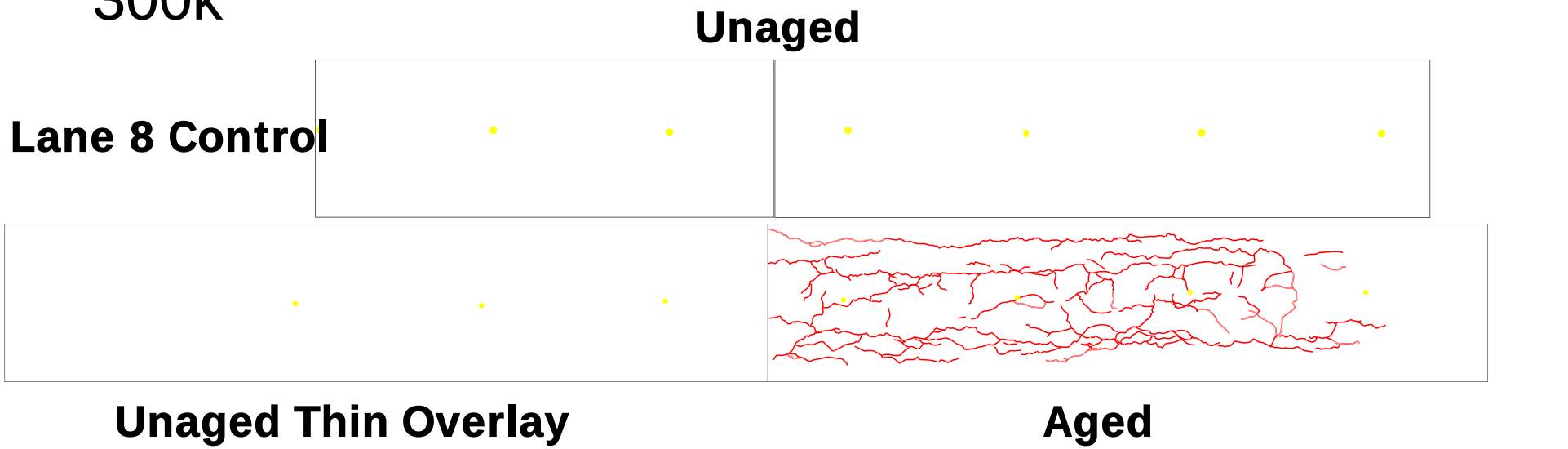
...Switch to animation of crack maps...

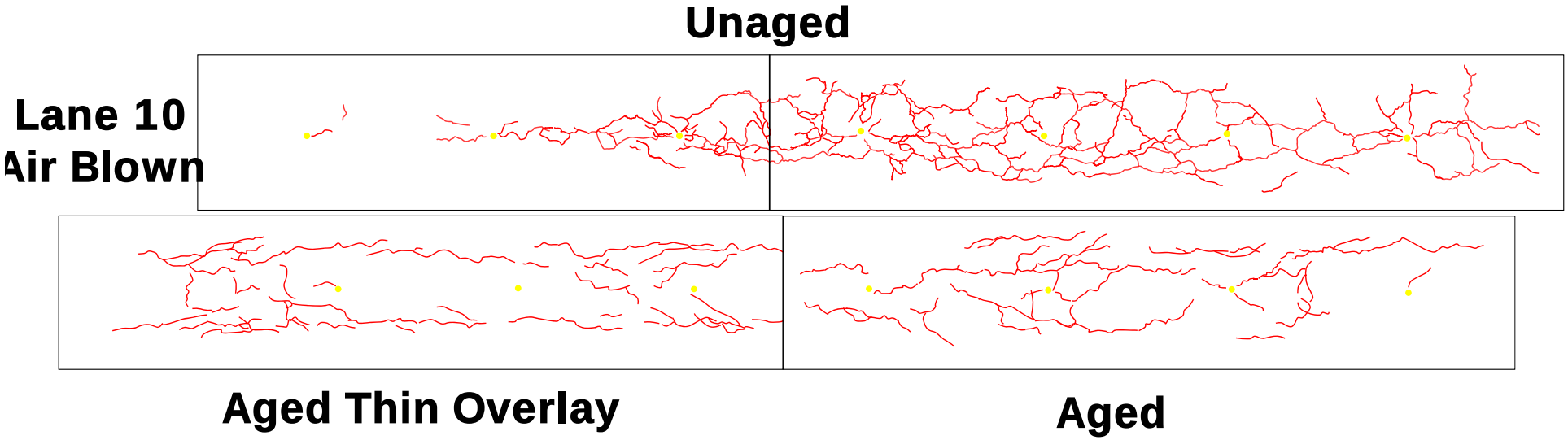
75k


Unaged
Lane 8 Control
Unaged Thin Overlay
Aged

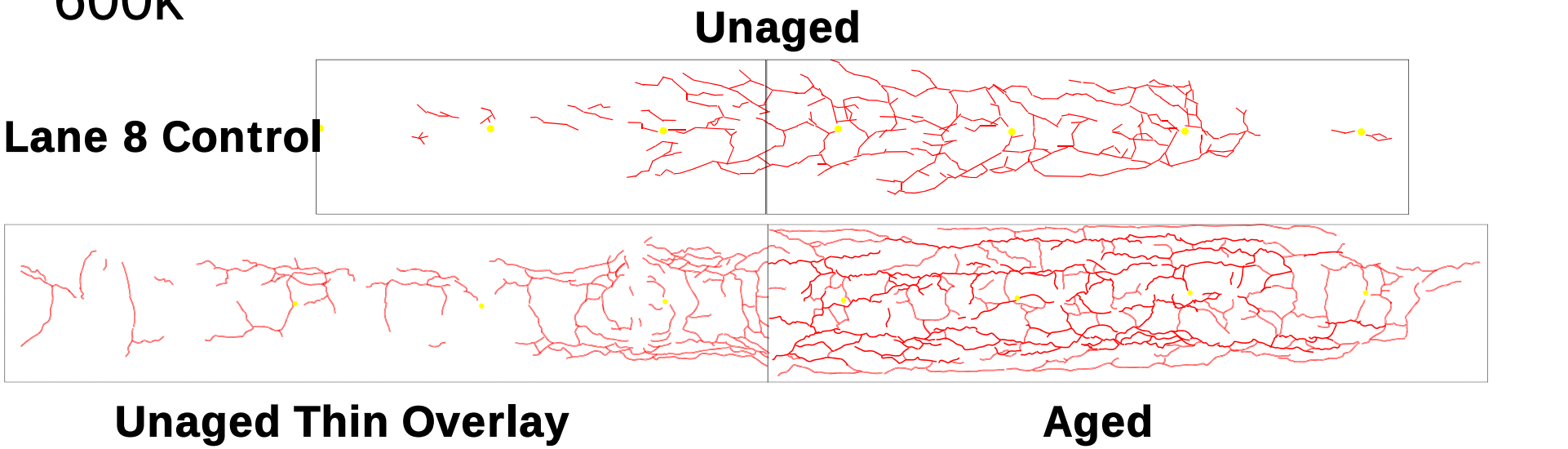

Unaged
Lane 10
Air Blown
Aged Thin Overlay
Aged

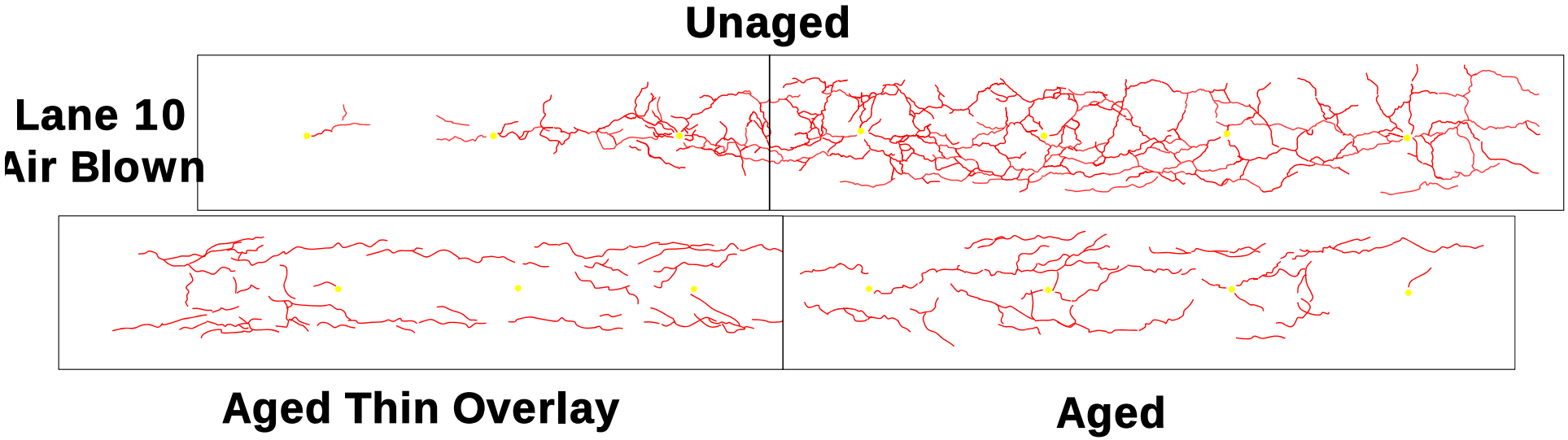
300k


Unaged
Lane 8 Control
Unaged Thin Overlay
Aged


Unaged
Lane 10
Air Blown
Aged Thin Overlay
Aged

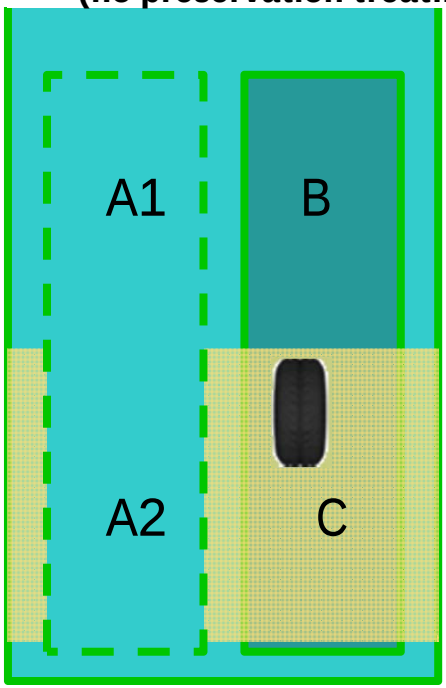
600k


Unaged
Lane 8 Control
Unaged Thin Overlay
Aged


Unaged
Lane 10
Air Blown
Aged Thin Overlay
Aged

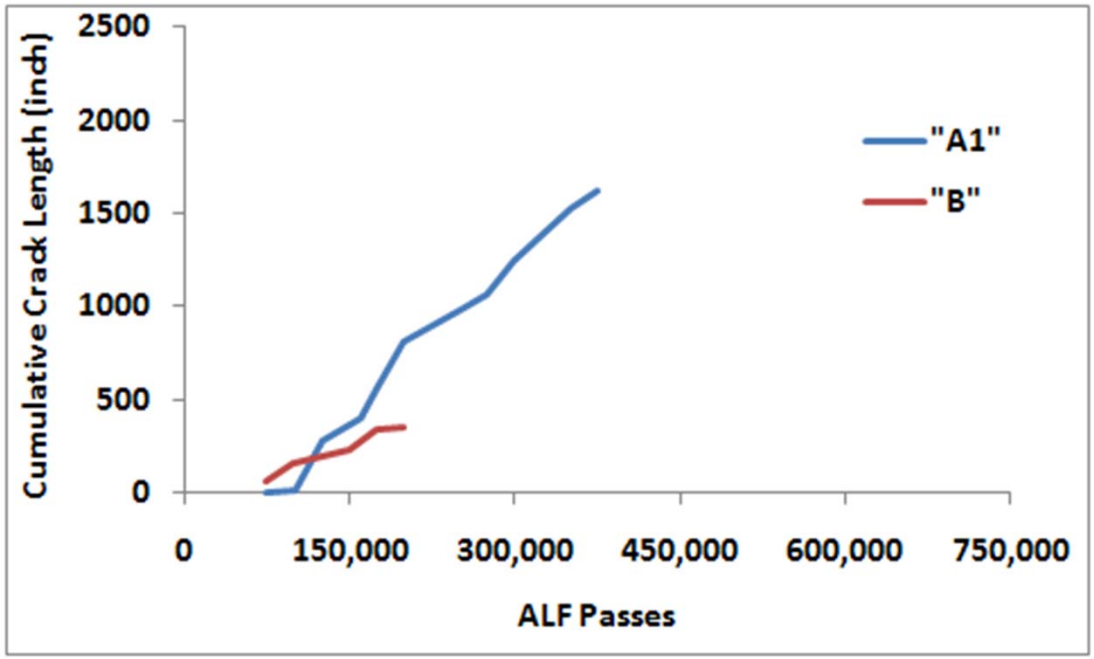
Lane 10
Air Blown

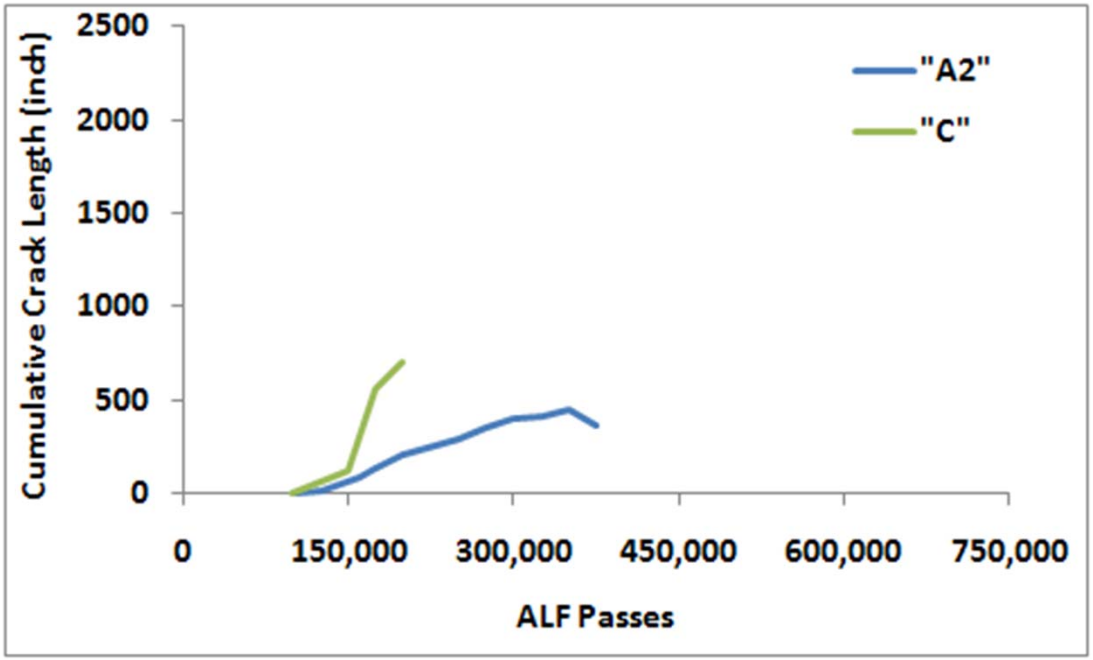
A1:B = Effect of Aging on Conventional HMA
(no preservation treatment)



Site 3 ***Site 4***

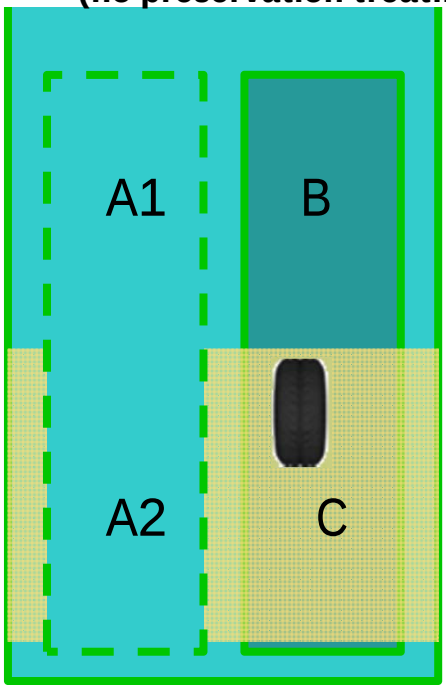
A2:C = Effect of "Old" Aged 4.75mm on Aged Pavement





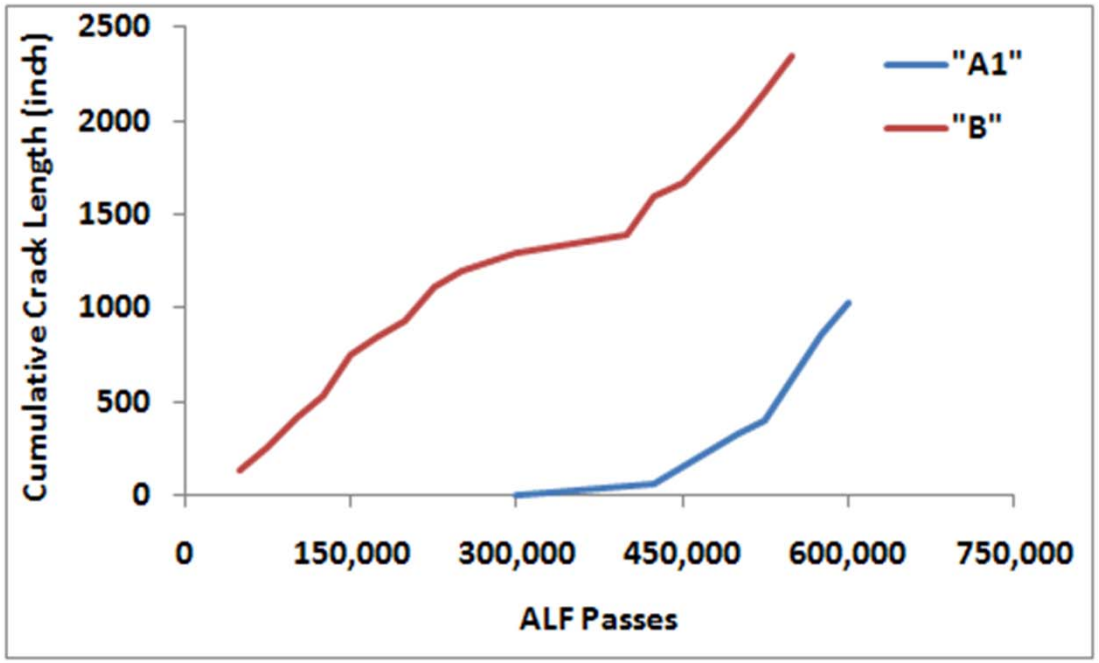
Lane 8
Control 70-22

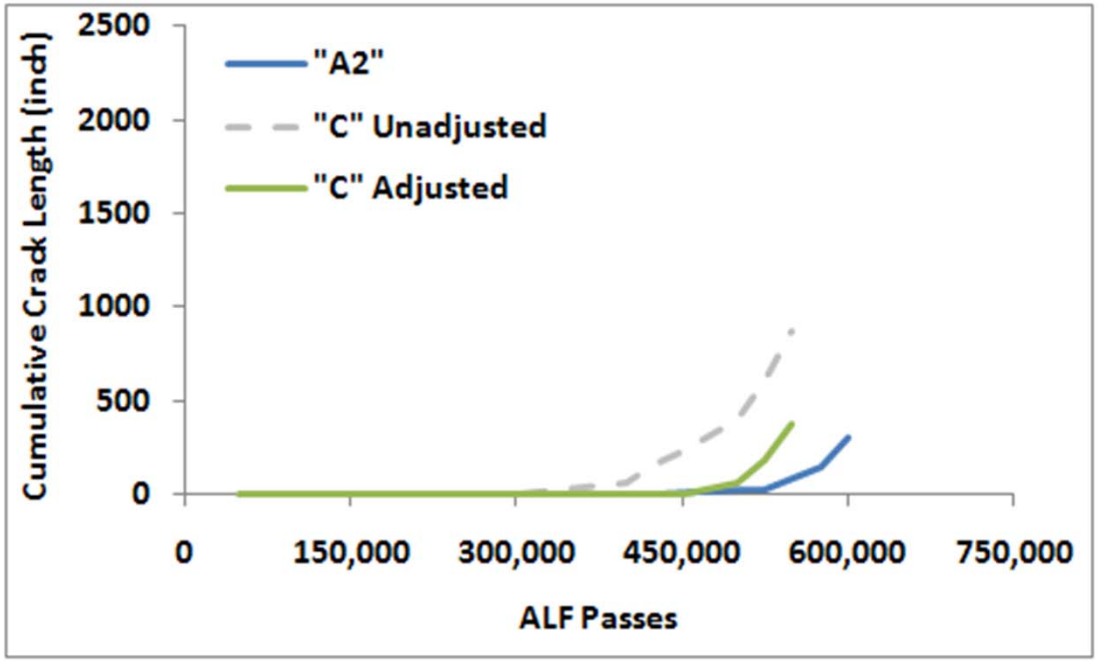
A1:B = Effect of Aging on Conventional HMA
(no preservation treatment)



Site 3 ***Site 4***

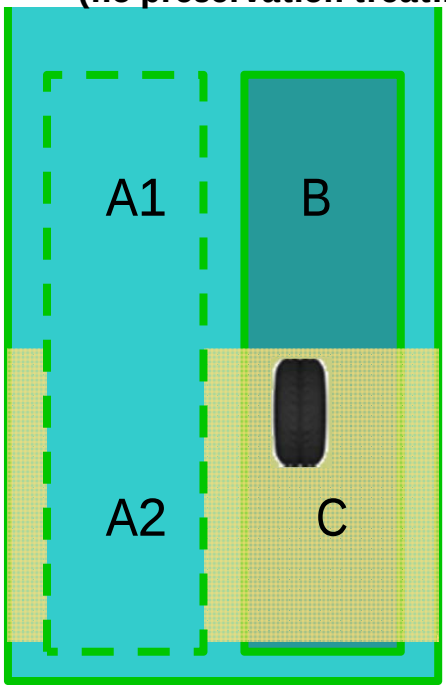
A2:C = Effect of "New" unaged 4.75mm on Aged Pavement





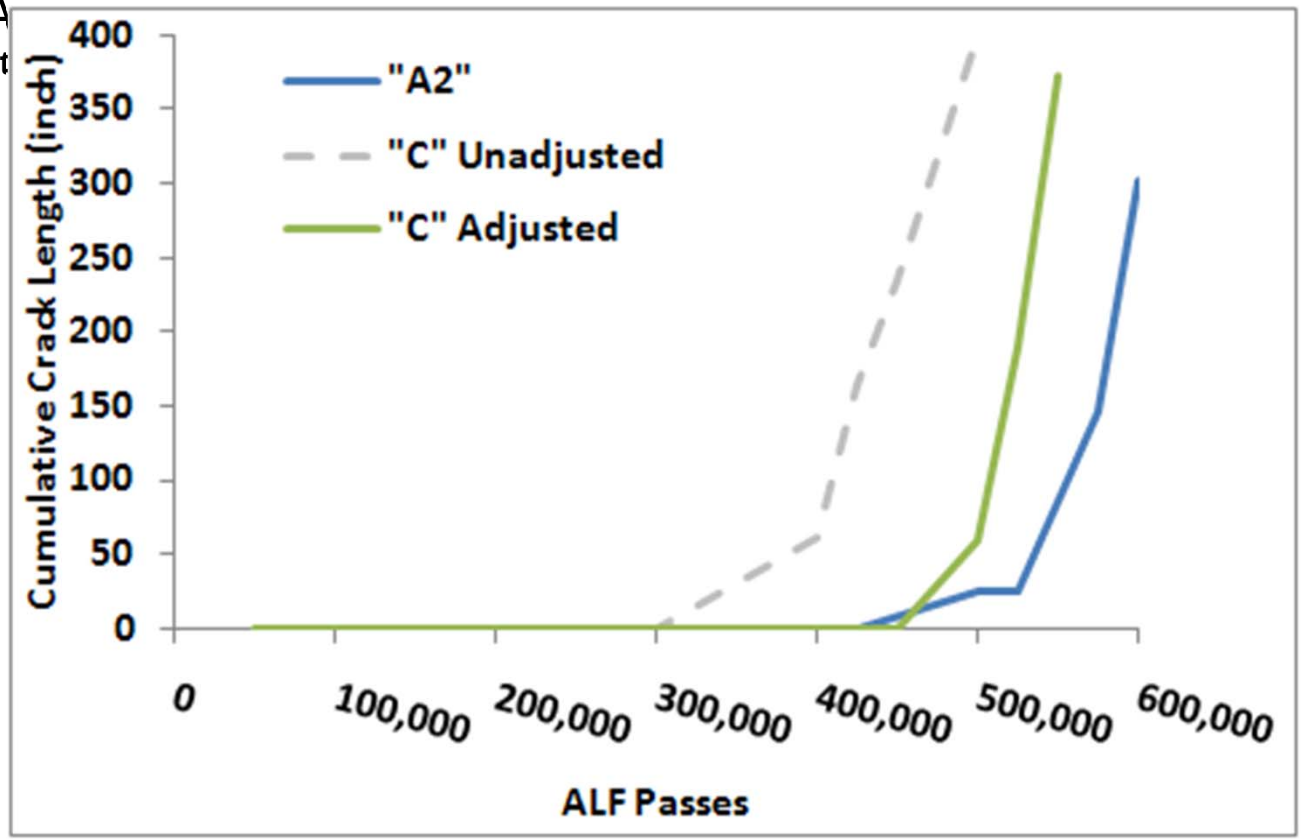
Lane 8
Control 70-22

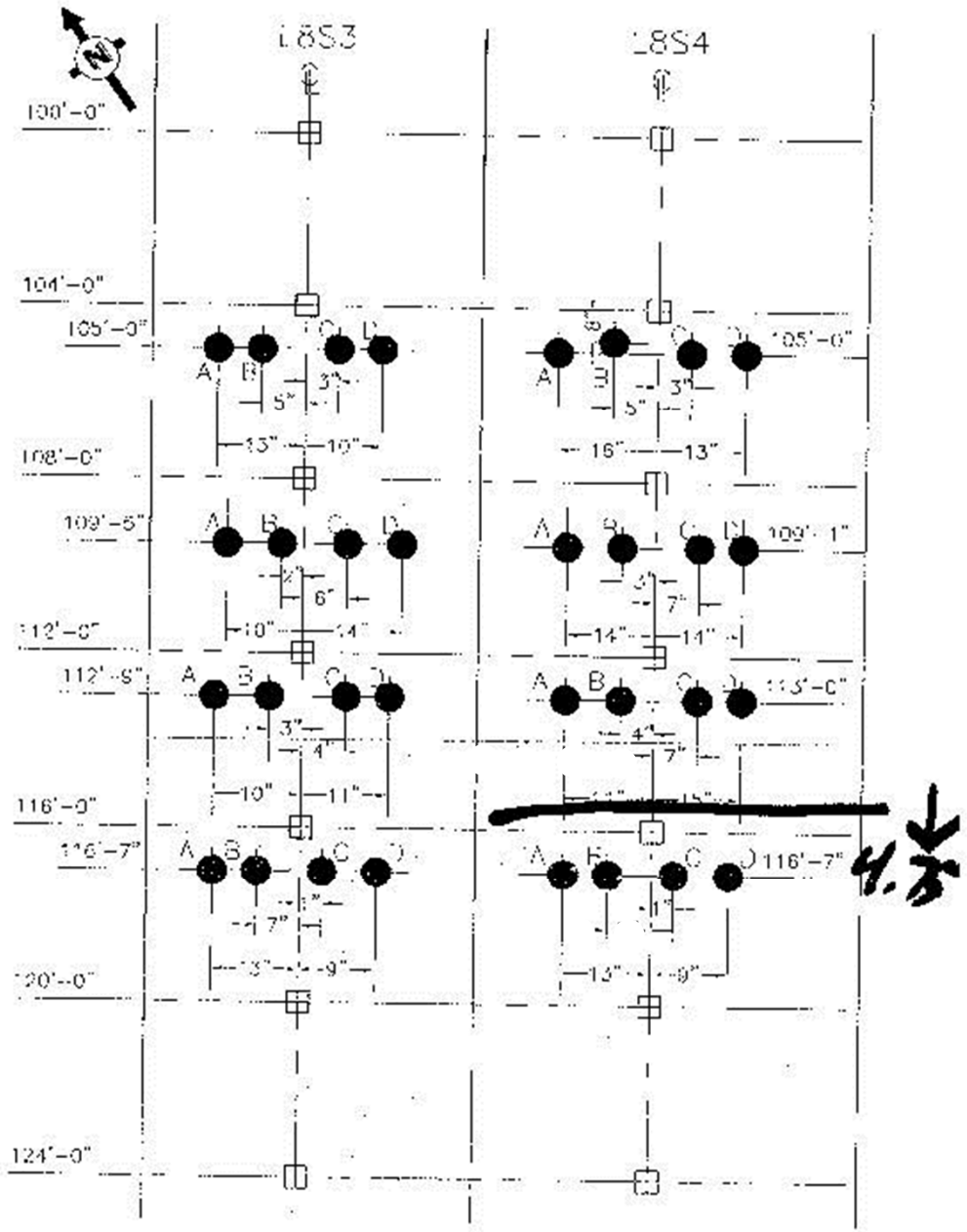
A1:B = Effect of Aging on Conventional HMA
(no preservation treatment



Site 3 ***Site 4***

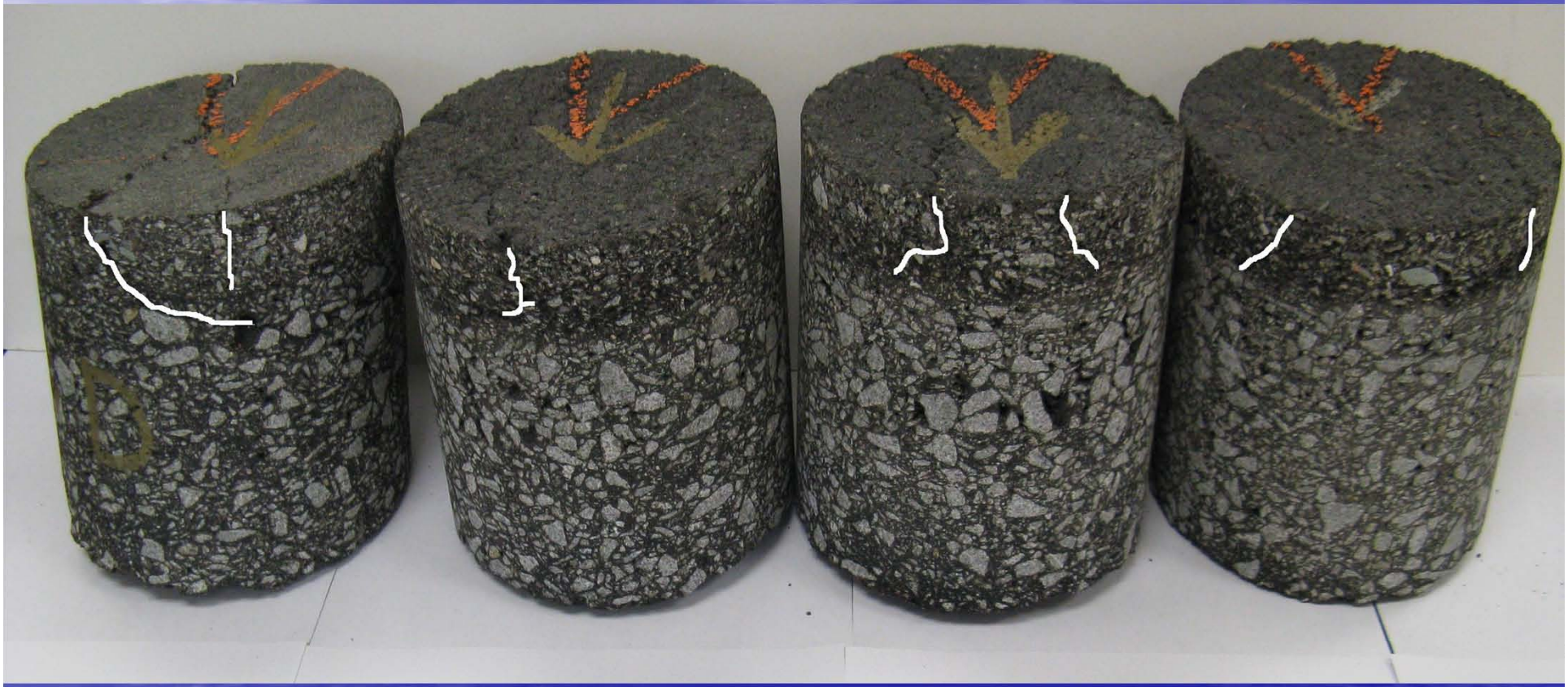
A2:C = Effect of "New" unaged 4.75mm on Aged Pavement

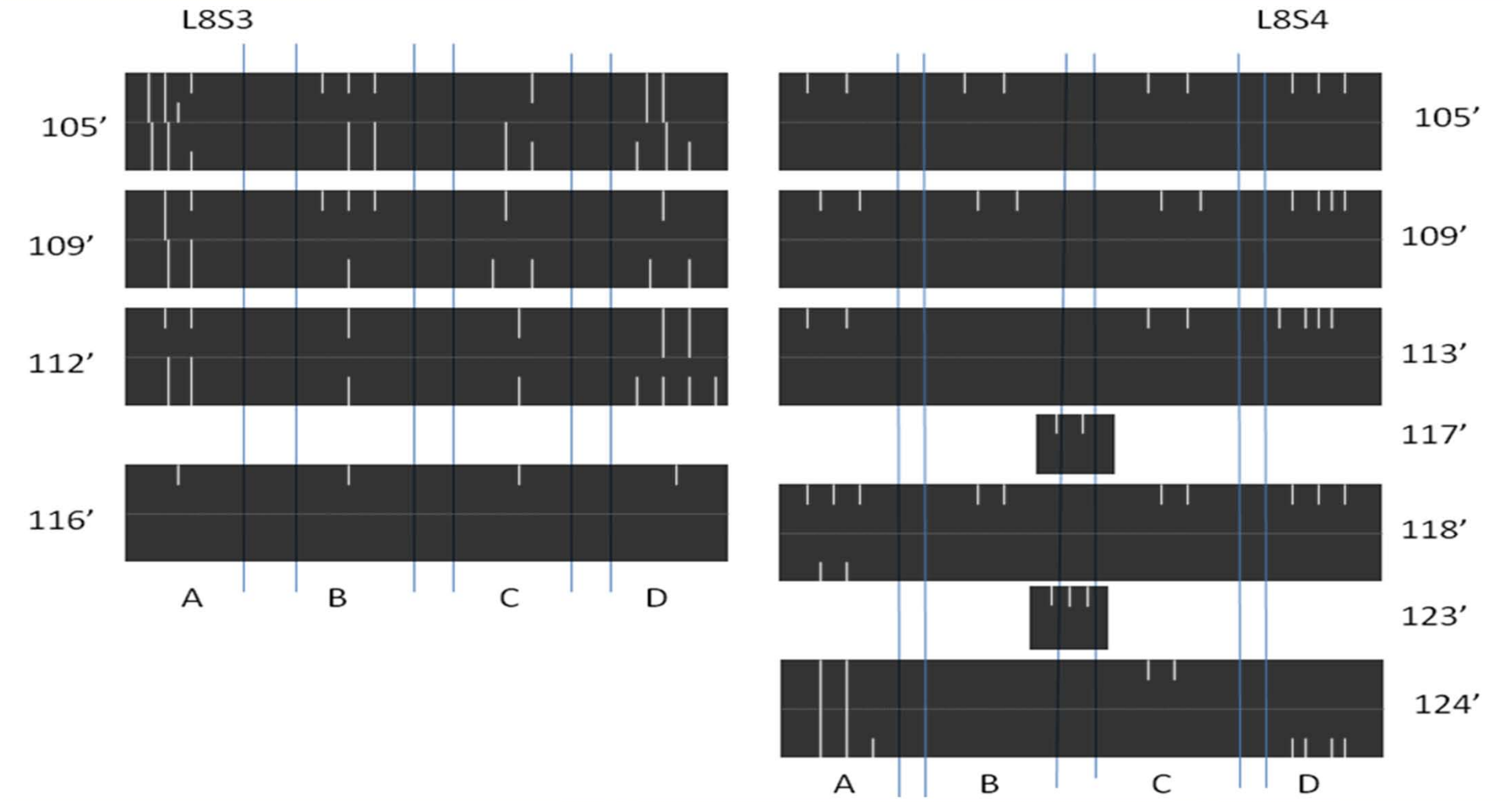


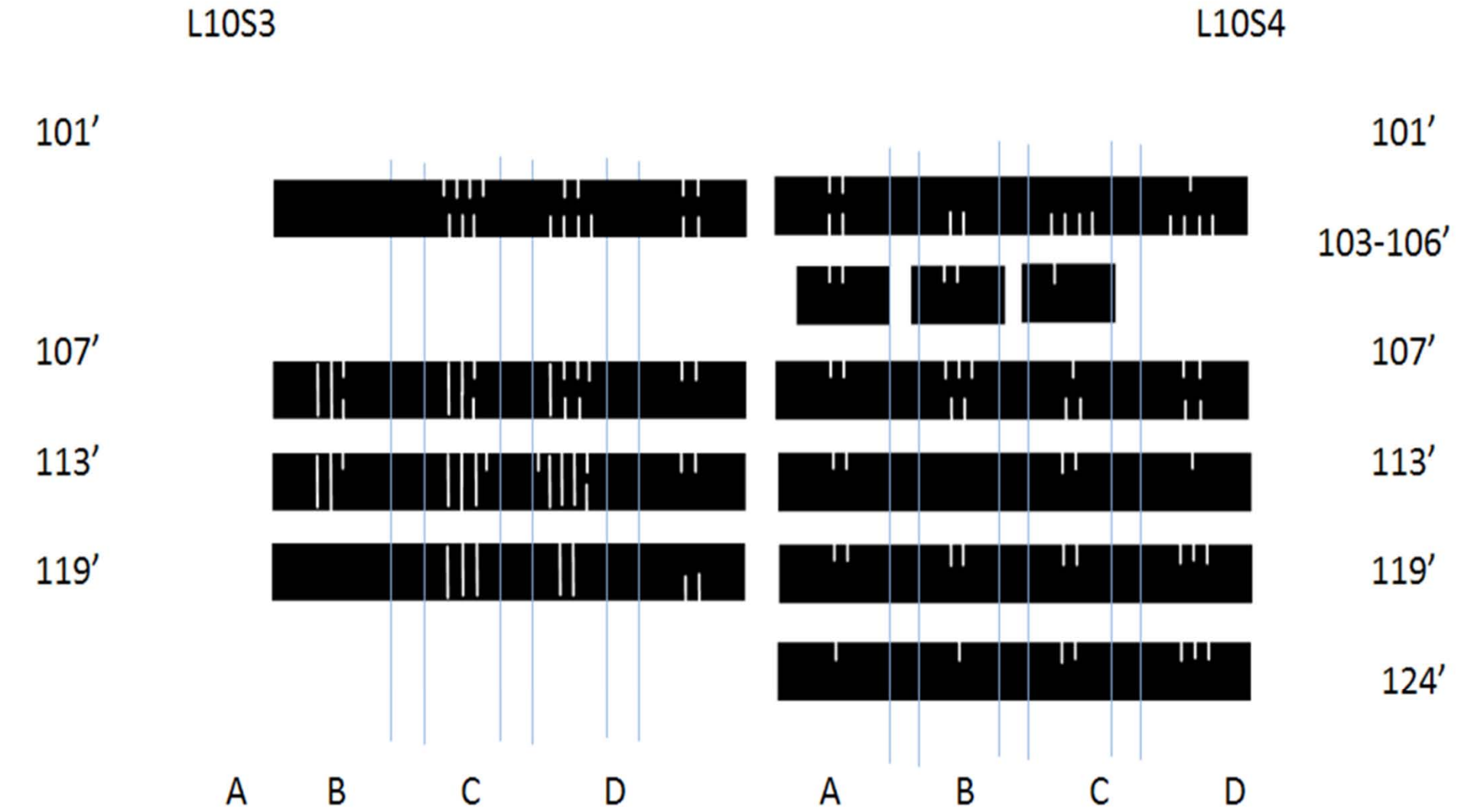


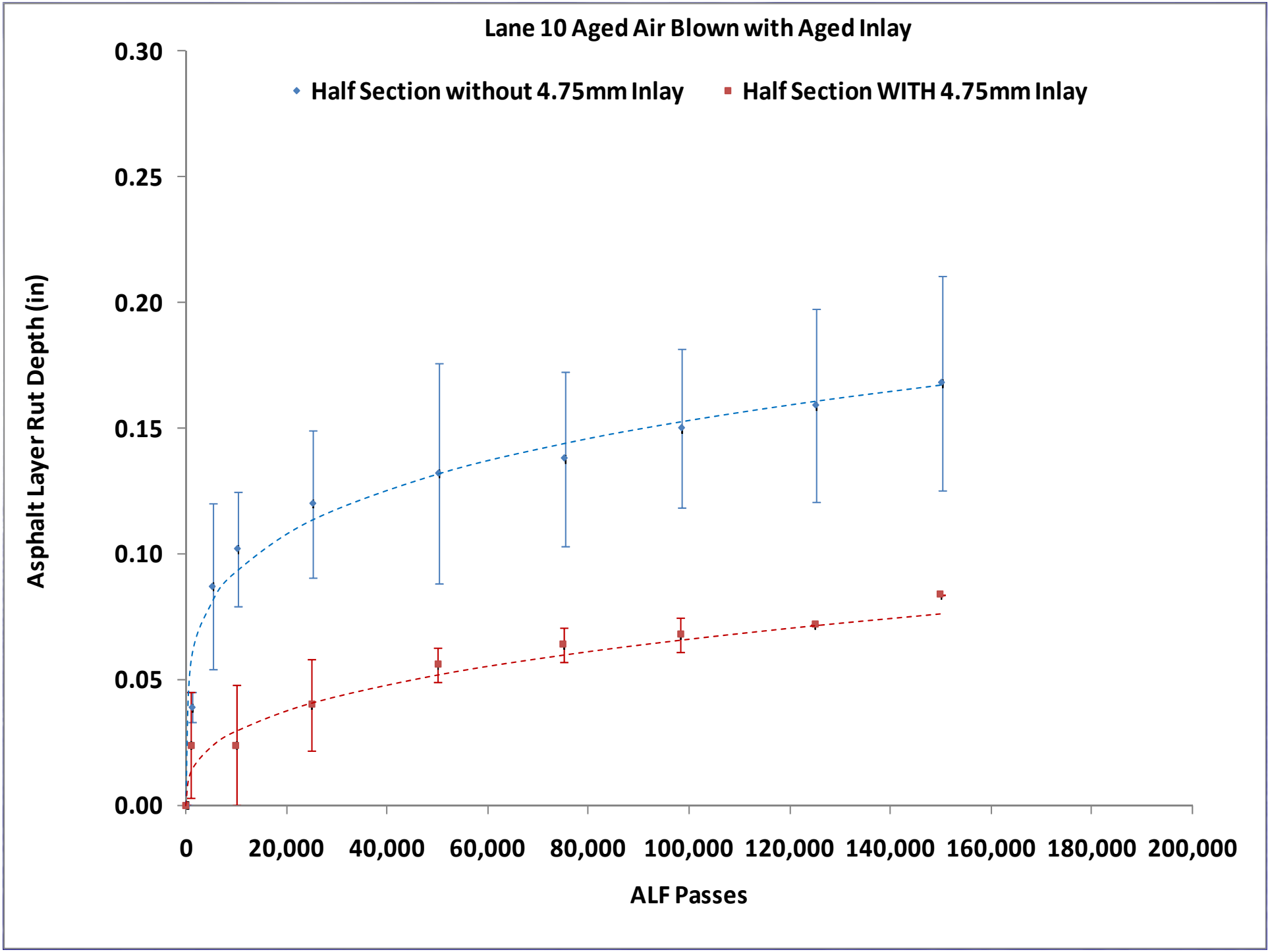
CORE LOCATIONS—LANE 8 (6"ø)

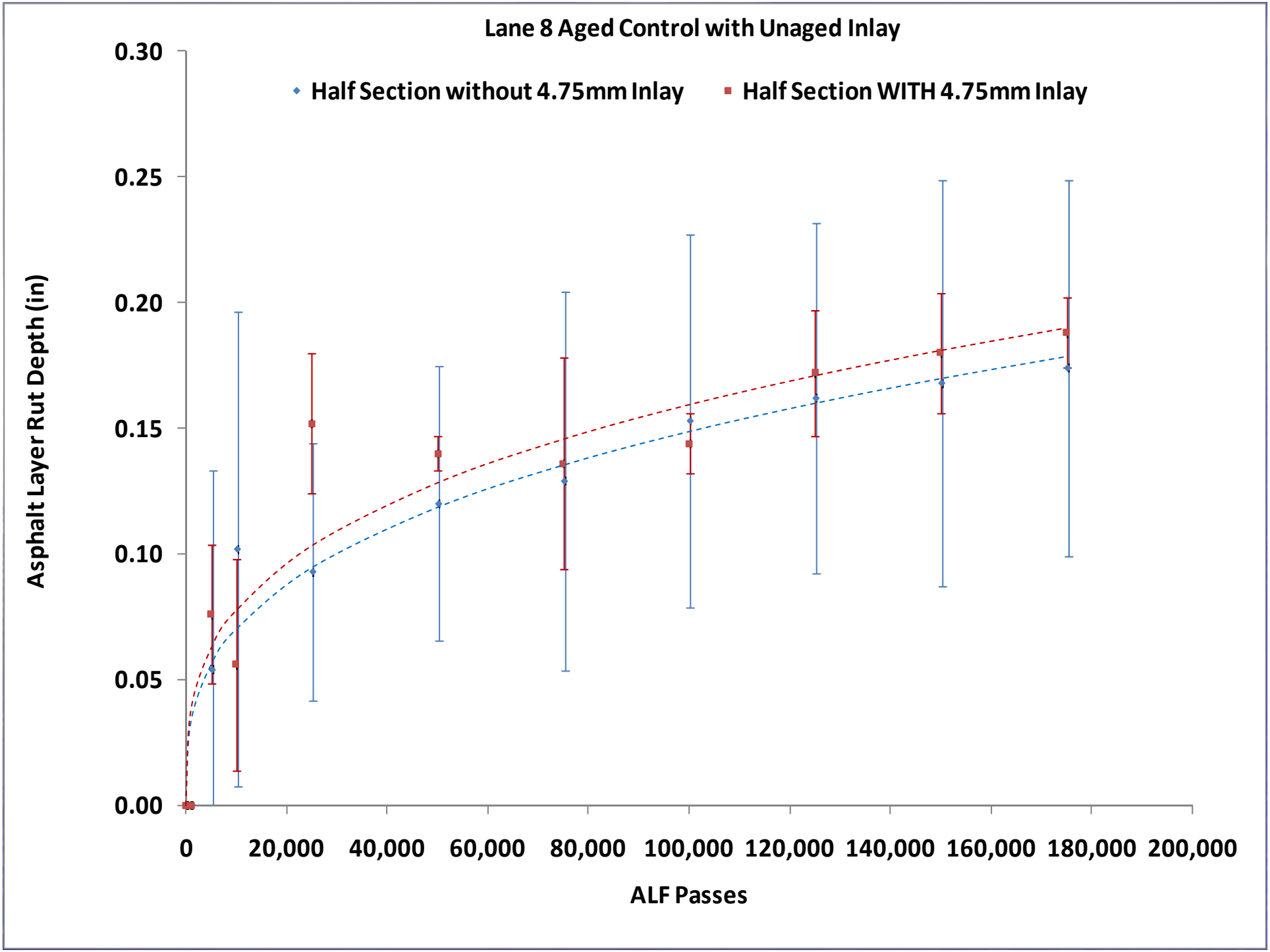
Cores cut from thin overlay section




L8S3
105’
109’
112’
116’
A
B
C
D
L8S4
105’
109’
113’
117’
118’
123’
124’
A
B
C
D


L10S3
L10S4
101′
107′
113′
119′
101′
103-106′
107′
113′
119′
124′
A
B
C
D
A
B
C
D


Lane 10 Aged Air Blown with Aged Inlay
Half Section without 4.75mm Inlay
Half Section WITH 4.75mm Inlay
Asphalt Layer Rut Depth (in)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
20,000
40,000
60,000
80,000
100,000
120,000
140,000
160,000
180,000
200,000
ALF Passes


Lane 8 Aged Control with Unaged Inlay
Half Section without 4.75mm Inlay
Half Section WITH 4.75mm Inlay
Asphalt Layer Rut Depth (in)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
20,000
40,000
60,000
80,000
100,000
120,000
140,000
160,000
180,000
200,000
ALF Passes

Summary and Conclusions

- A trial 4.75 mm NMAS mix from VDOT placed as a thin treatment over existing APT sections.
- Full scale accelerated aging and loading used to compare the fatigue cracking performance for four combinations of with and without 4.75 mm NMAS treatment plus with and without aging.
- The unaged 4.75 mm NMAS overlay performed much better in fatigue cracking resistance than the untreated existing pavement in Lane 8.

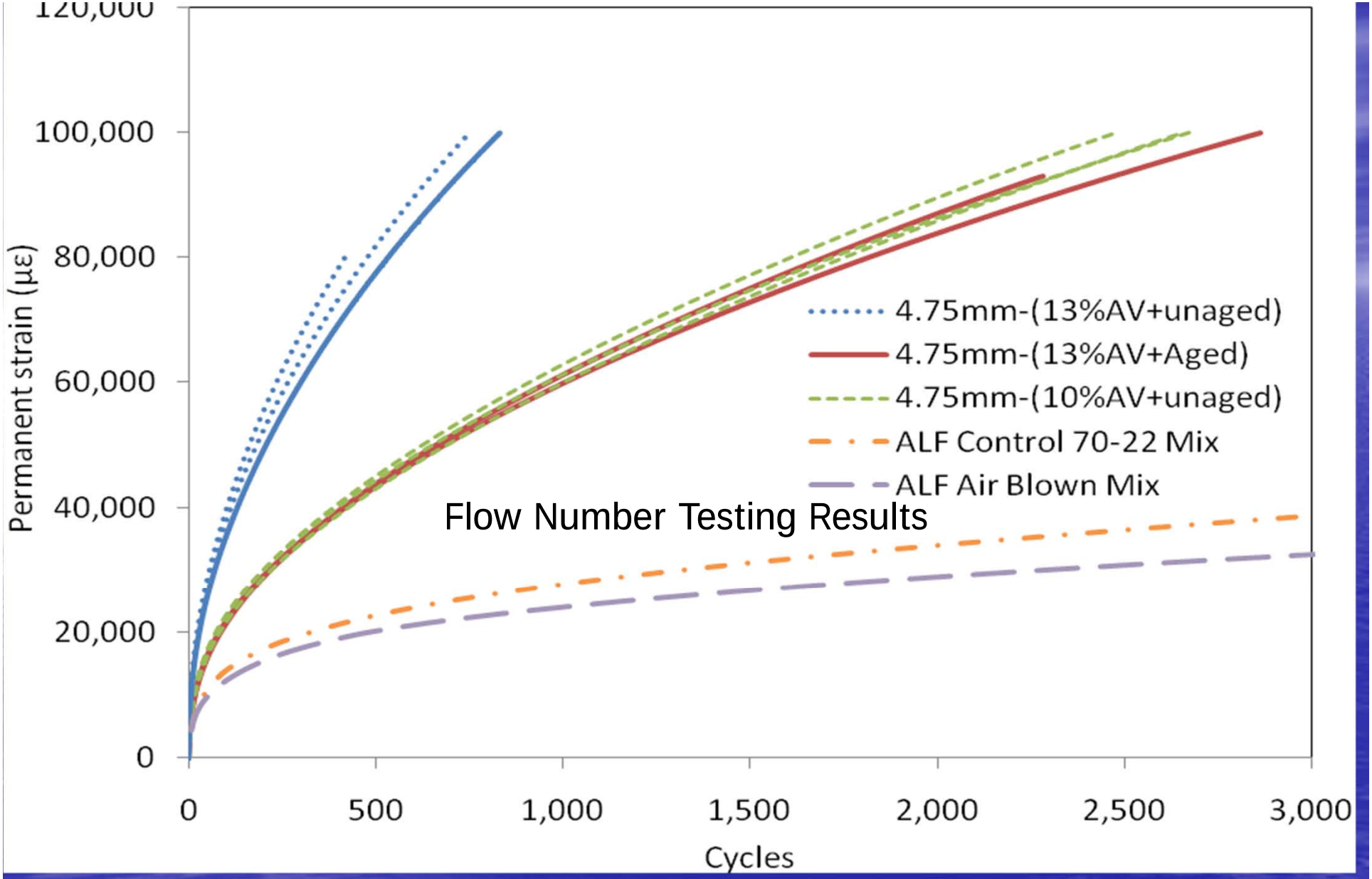
Summary and Conclusions (Continued)

- The aged 4.75mm NMAS overlay performed almost the same as the untreated existing pavement in Lane 10.
- Therefore, thin 4.75 mm NMAS overlays used as a preservation treatment have the ability to significantly delay the aging related top down cracking, but once such thin layers becomes brittle with age that benefit is lost.

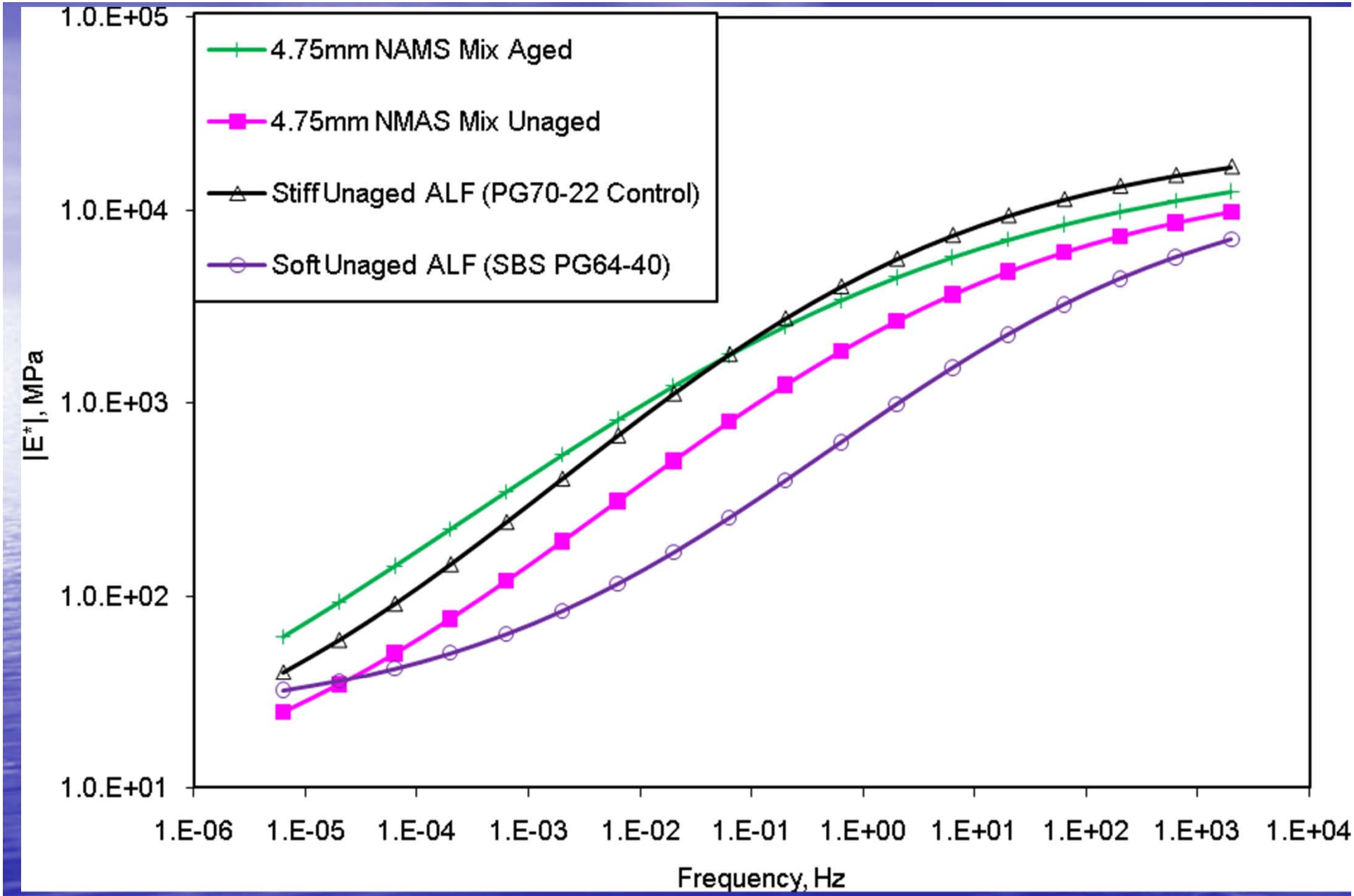
Summary and Conclusions (Continued)

- Pavement cores indicate the top-down cracks become the predominant cracks for the aged sections. Therefore, the accelerated aging has made the pavement more prone to crack in a top-down cracking pattern.
- During the 19°C full-scale fatigue testing, the measured total rut depth of the AC section with the underlying structural mix and thin inlay is less than or equal to the rutting of the section without the treatment.

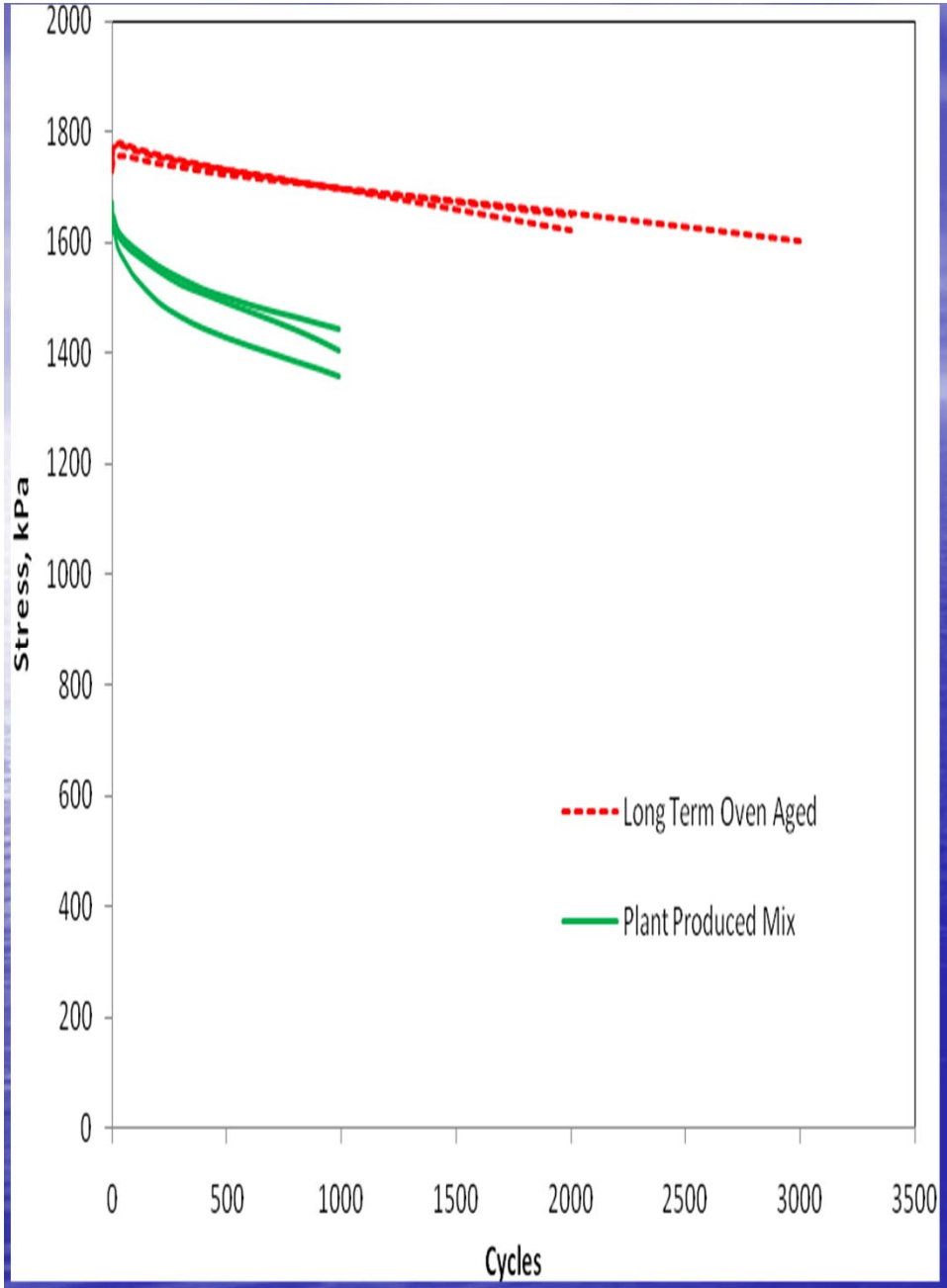
Discussion
&
Questions

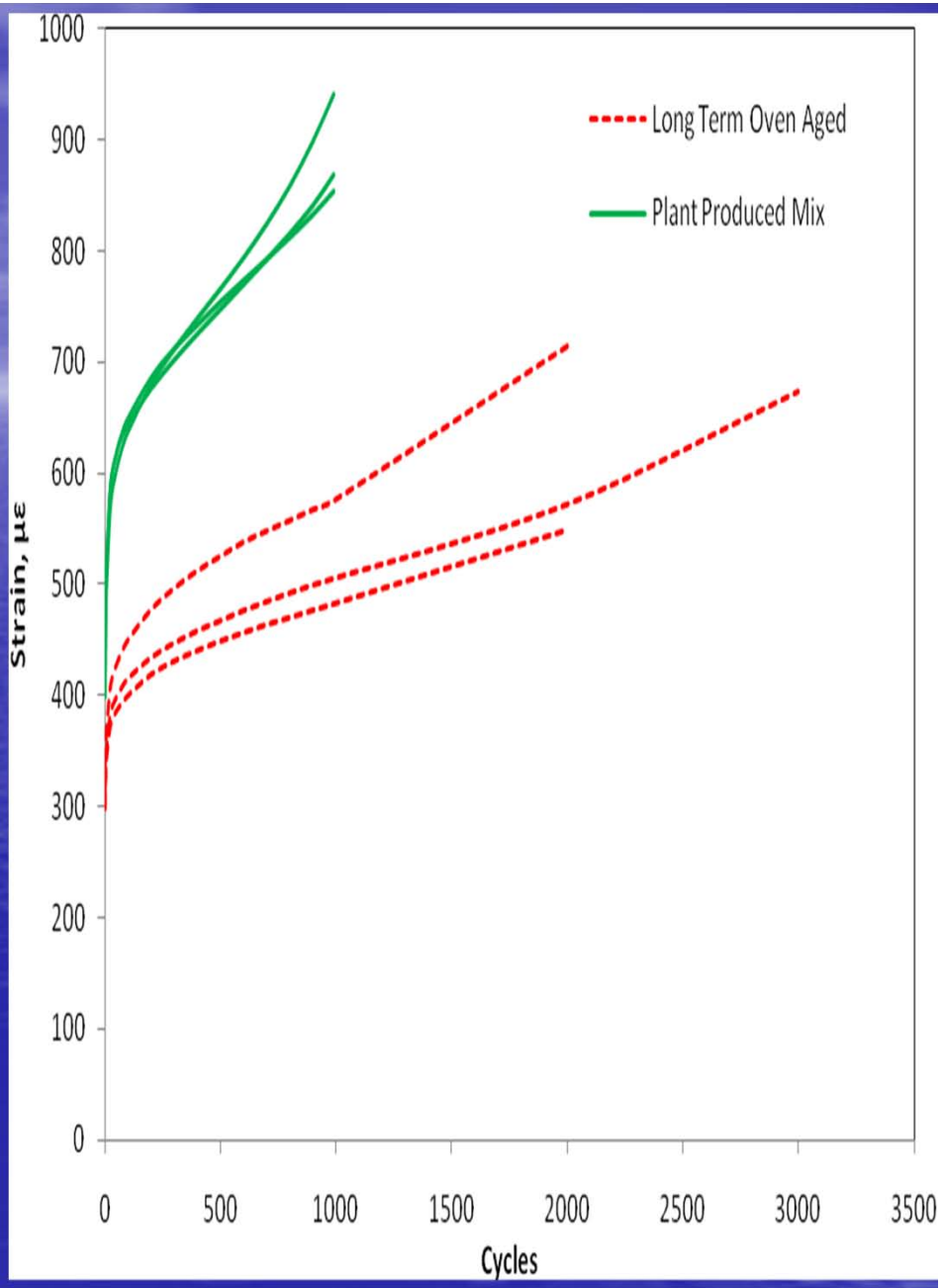


Flow Number Testing Results

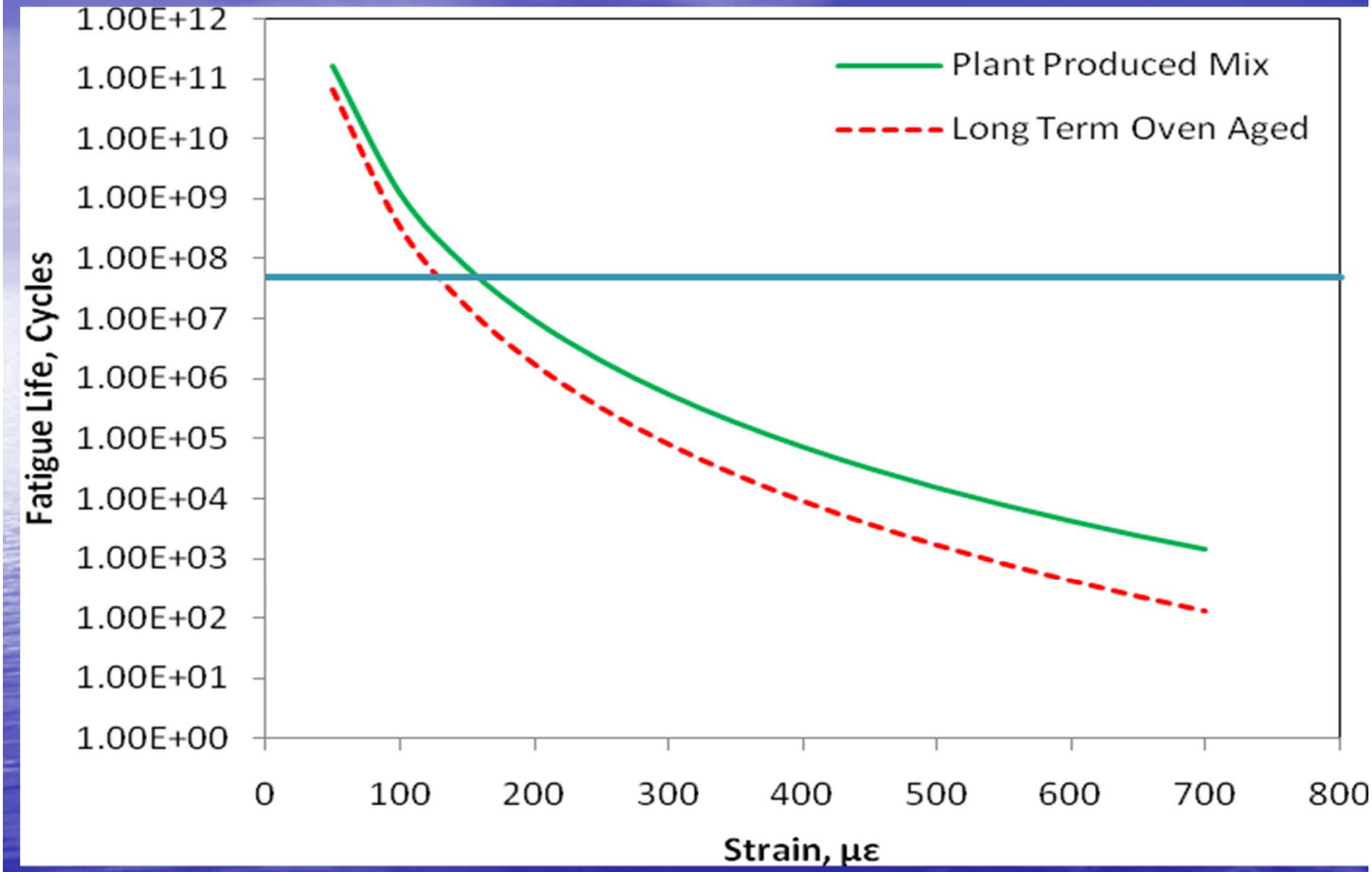


Dynamic Modulus Master Curves





Measured Stress and Strain in the Fatigue Test



Predicted Fatigue Life for Various Strains