Impact of Thin Overlay on Top-Down Crack Resistance of Aged Pavement

Wednesday, August 29, 2012

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Trenton Clark
Virginia Asphalt Pavement Association

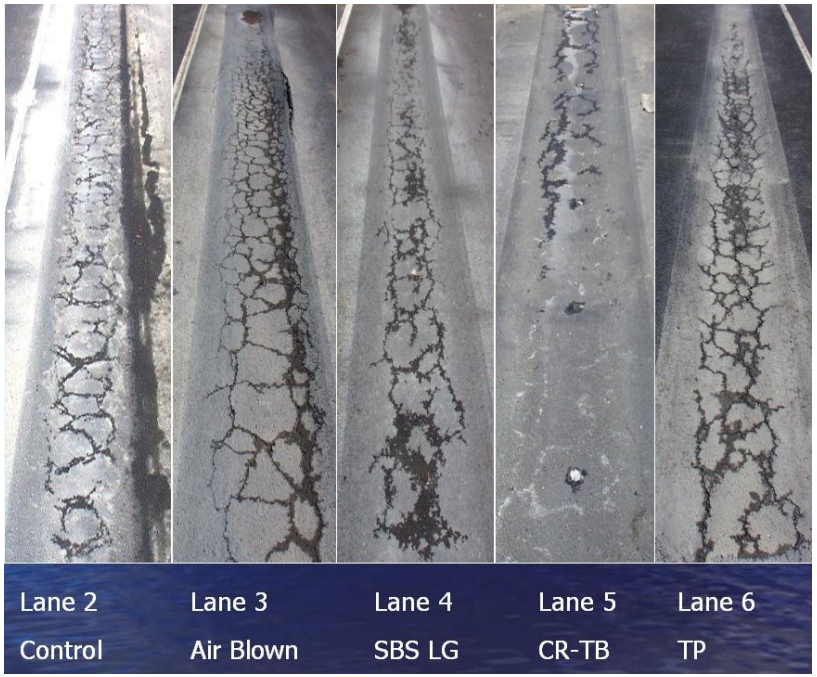
Kevin McGhee
Virginia Department of Transportation

Outline

- Background & Motivation
- Mix Design
- Construction
- Performance
- Findings

Background and Motivation

- Previous ALF research inspired the study
- The “Absence of Preservation” Scenario



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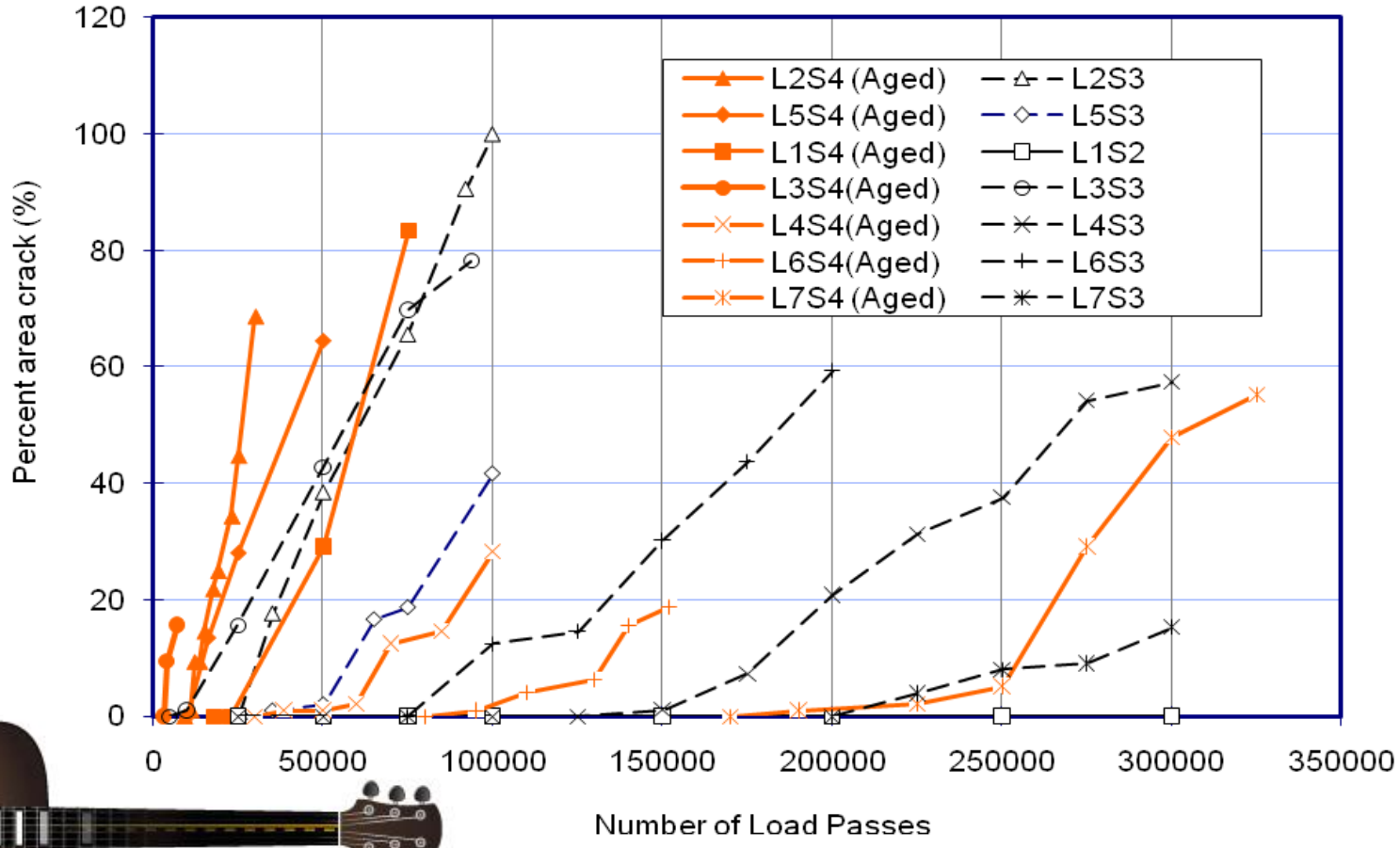
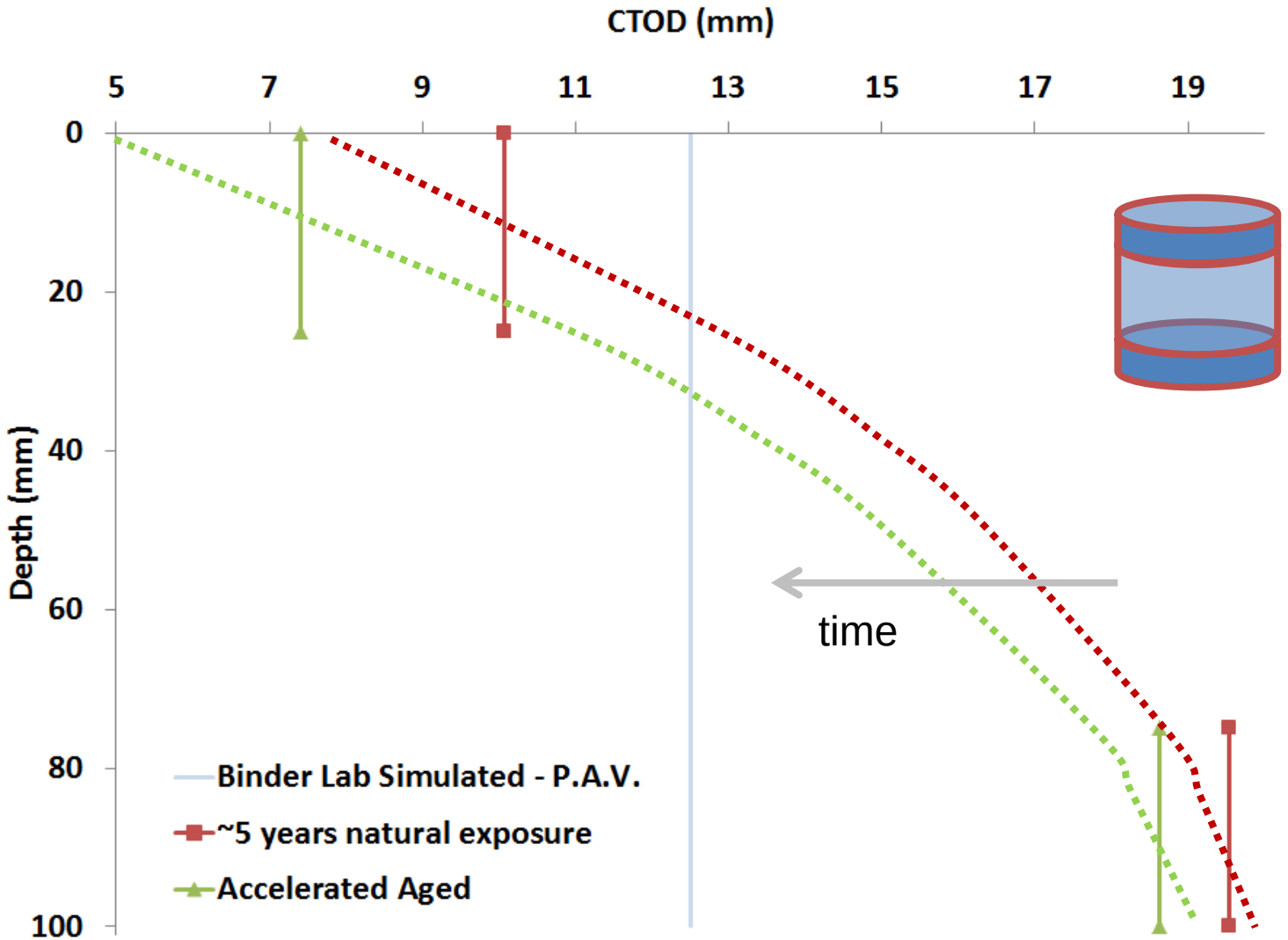


- Embrittlement of In-Situ Asphalt Binder



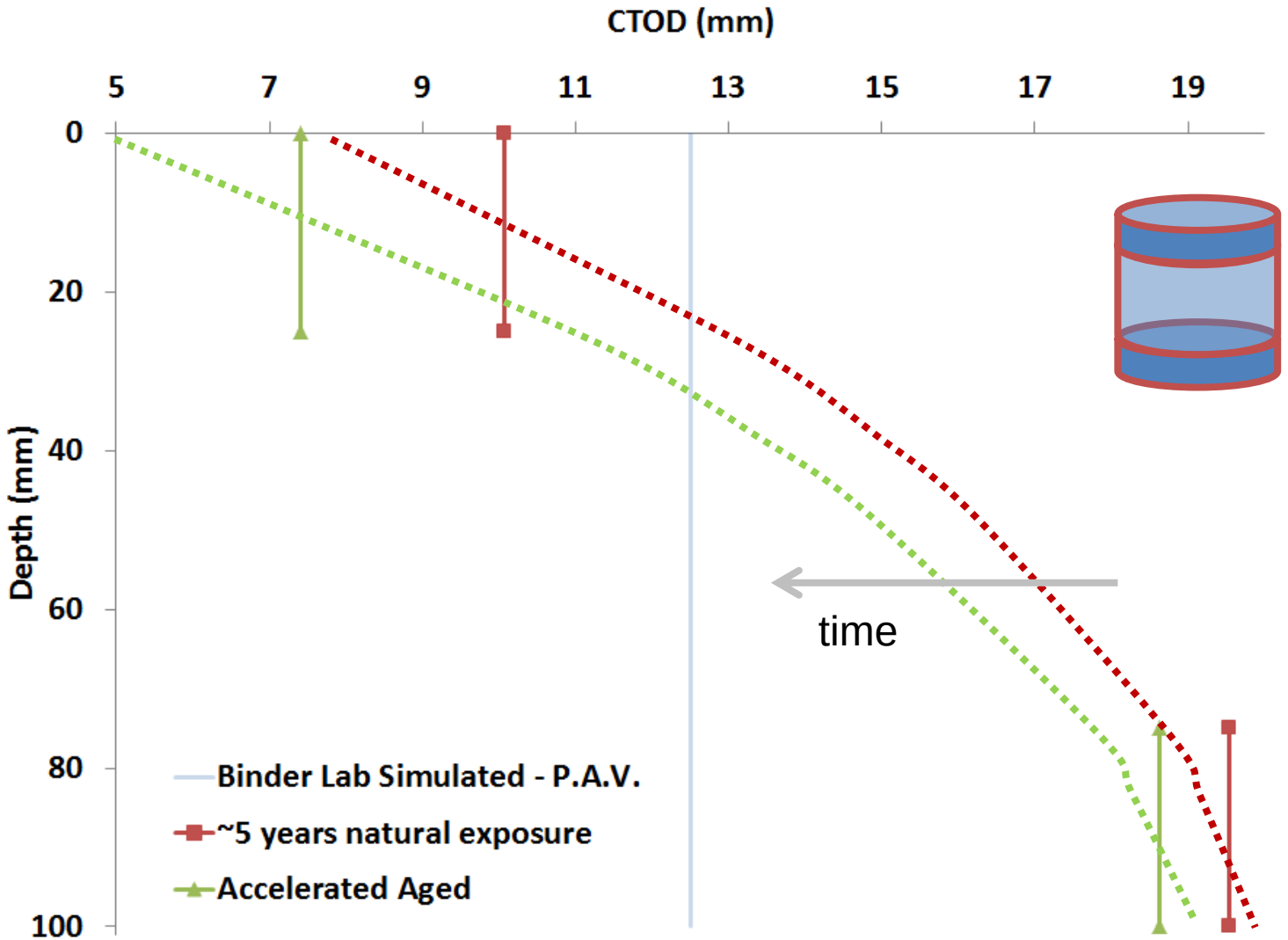
Background and Motivation

- TSP RD&I Roadmap
  - Design #02 – Determining Pavement Preservation Treatment Lives and Related Pavement Life Extension.
  - Design #06 – Integrating Pavement Preservation into the Design Process.
  - Materials #01 – Mechanical Binder Properties to Predict Surface Treatment Performance.

Background and Motivation

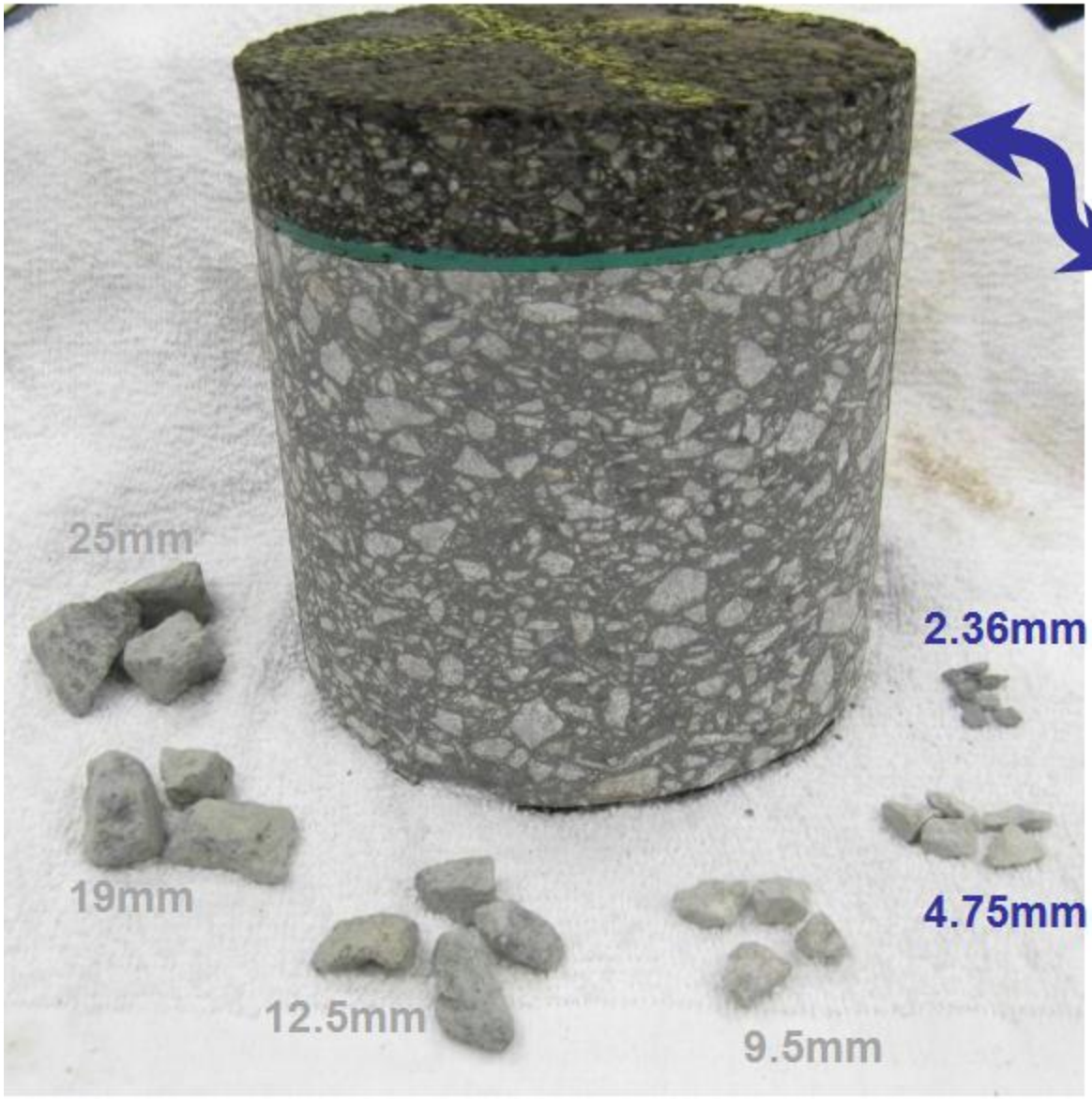
- TSP RD&I Roadmap
  - Performance #03 - Quantify Performance and Benefits of Various Pavement Preservation Treatments and Develop Pavement Preservation Treatment Performance Models.
  - Performance # 04 - Quantifying the Benefits of Pavement Preservation Treatments.

- Embrittlement of In-Situ Asphalt Binder



Preservation Treatment Options?

- Chip Seal?
- Microsurfacing?
- Fog Seal?
- Thin Overlay?



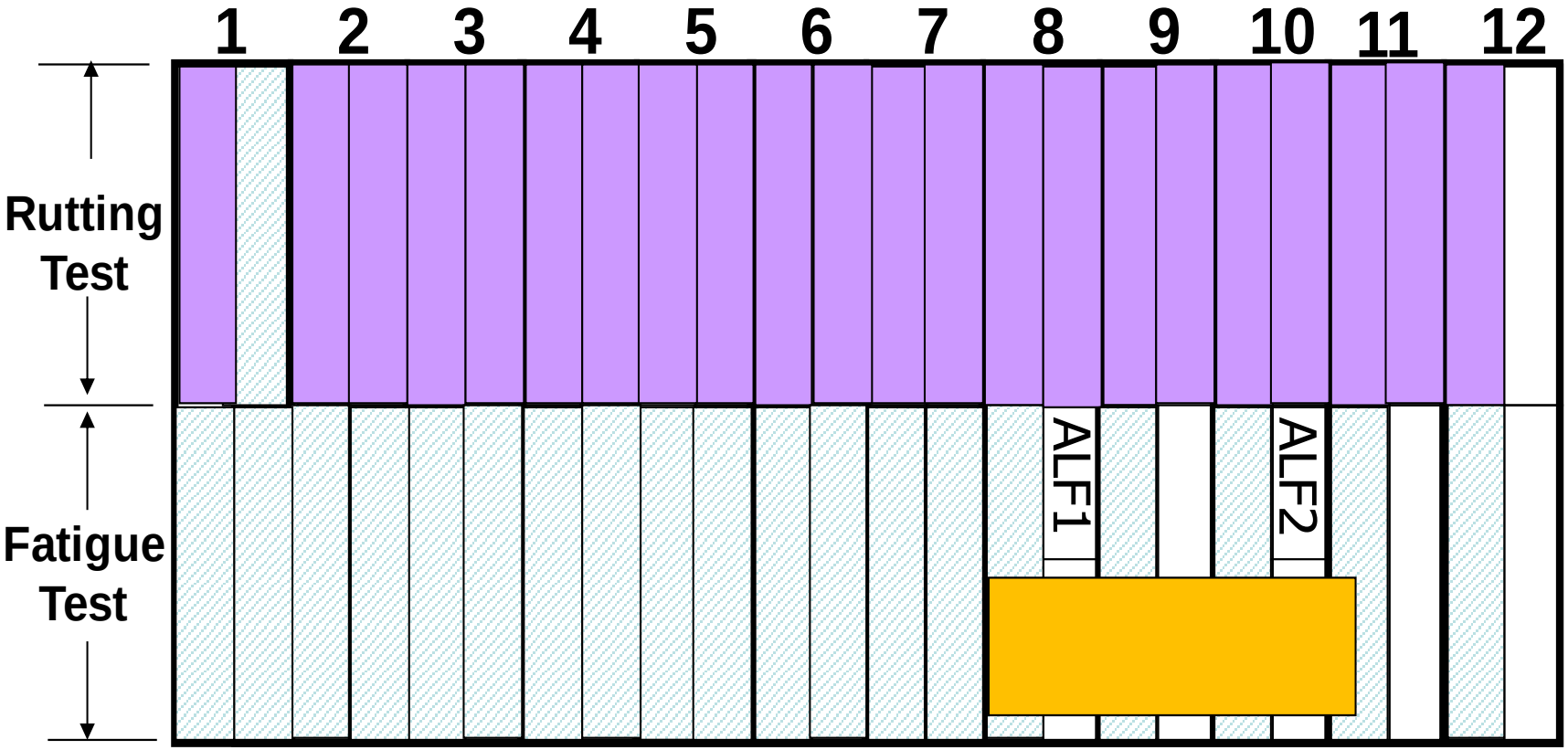
4.75mm HMA Contents

- 44% Fine Agg. Screenings (#10)
- 26% Sand (Manufactured)
- 20% RAP (Fine)
- 10% Sand (Natural)

- ✓ Virgin Asphalt Binder
  PG 76-22
- ✓ Extracted Binder
  PG 82-22

Construction

Construction



Completed Rutting Test

Completed Fatigue Test

4.75 mm Mix Tests

Construction

Construction

Construction

Construction

Construction

Construction

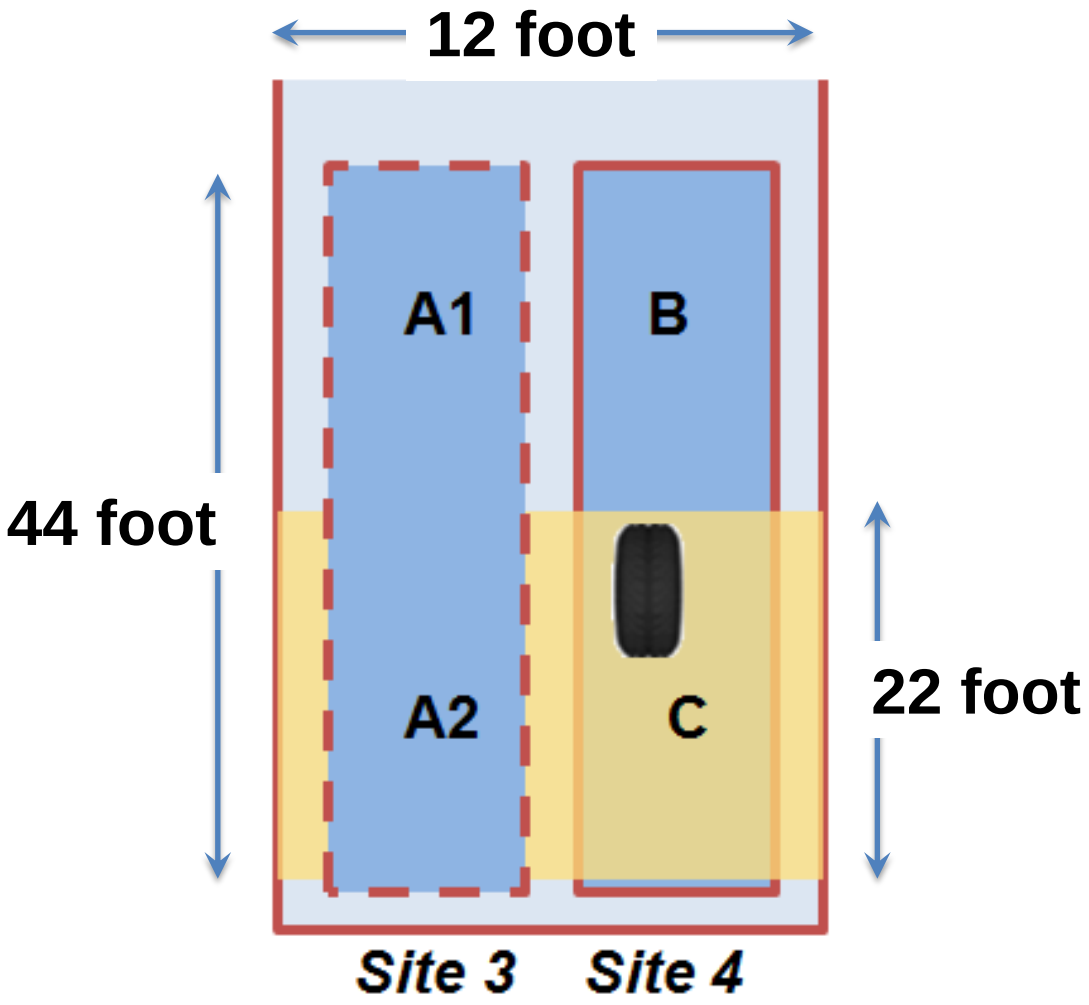
Construction

- 28 **mm** +/- 4 **mm** Thickness achieved
- Tack coat of CRS-1 @ 0.07 gallons/s.y.
- Warm Mix Asphalt Mix
  - 45 mile haul distance in congested area
  - Delivered about 255^{o}F (124^{o}C)
  - Mix was foamed (water)
  - Workable, with no clumps and easy hand-work

Construction

- Rolling and Achieving Density
  - Initial rolling was 2 vibratory and 1 static
  - 15,000 lb roller (DD 70-HF) as breakdown
  - 8,000 lb (DD 34-HF) as finish
  - 13% air voids rather than 10% air void target
  - VaDOT & contractor identified 27,000 lb roller is ideal

Construction



Historical Sequences

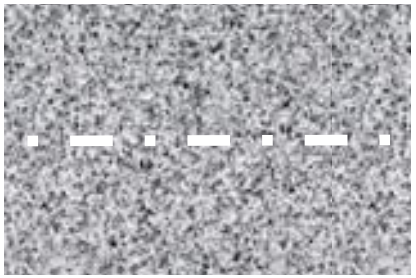
1. Lane 8 with Unaged Overlay
2. Lane 10 with Aged Overlay

Historical Sequence – Unaged Overlay

Historical Sequence – Unaged Overlay

3-inch lift

3-inch lift



Structure Built in 2002

Site 3 Fatigue loading
Dec 2005 – May 2006 +
Feb-March 2008

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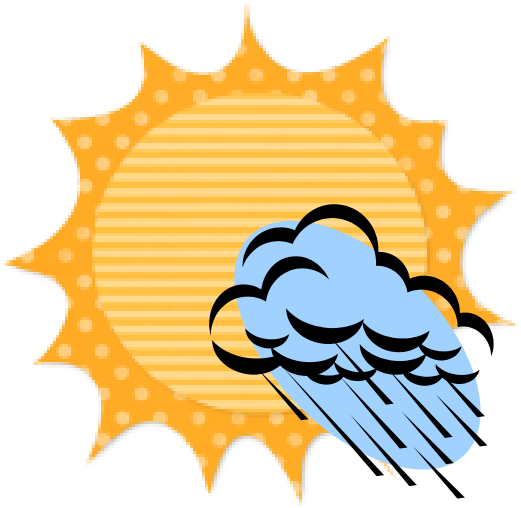

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Natural aging and weathering from 2002 construction up to June 2010

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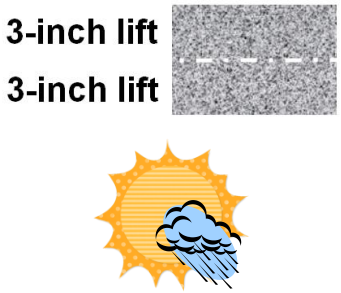

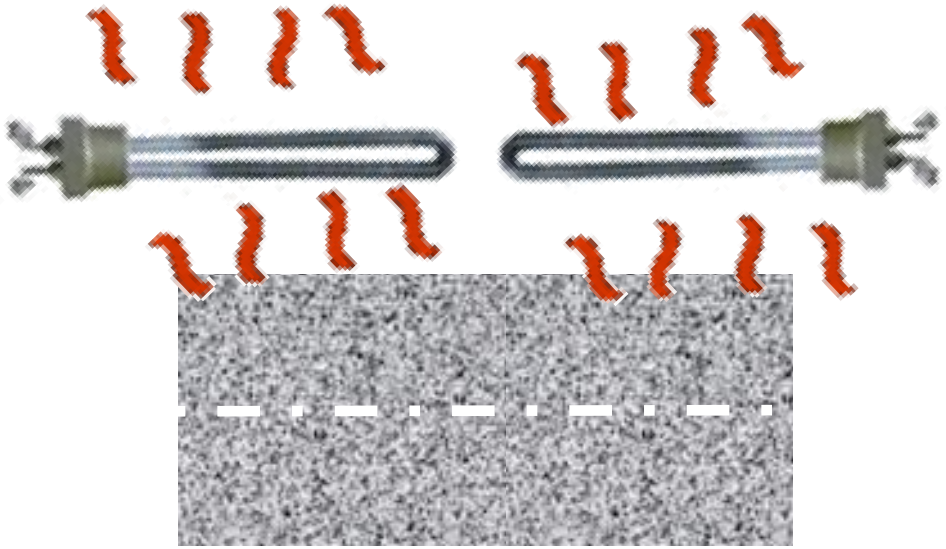

4 weeks of accelerated aging
via radiant heaters
April -May 2010

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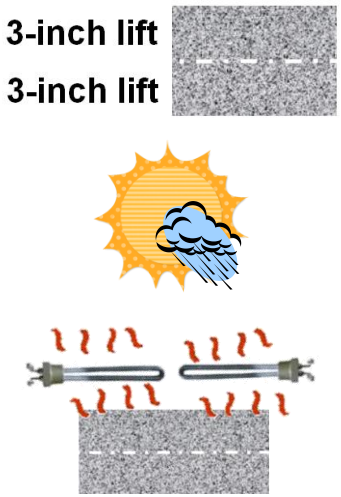

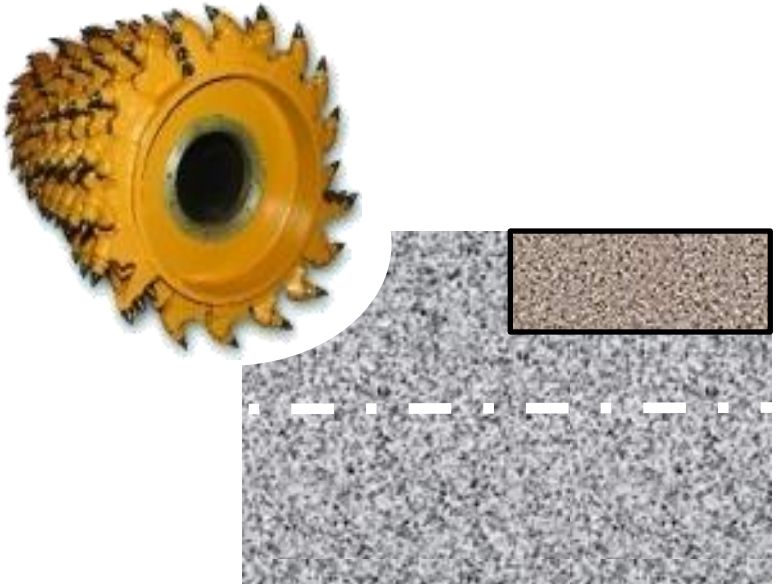

Milling
1-inch 4.75mm NMAS inlay
Installed June 2010

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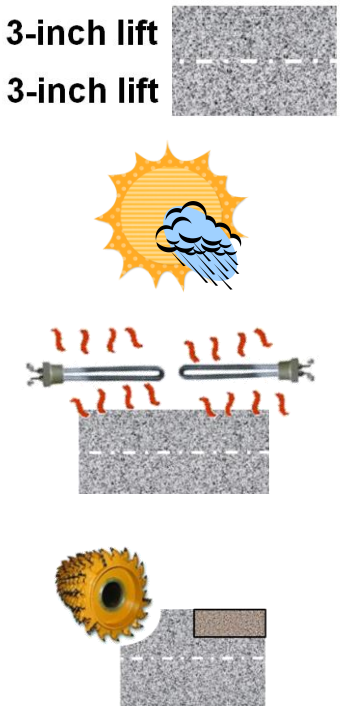

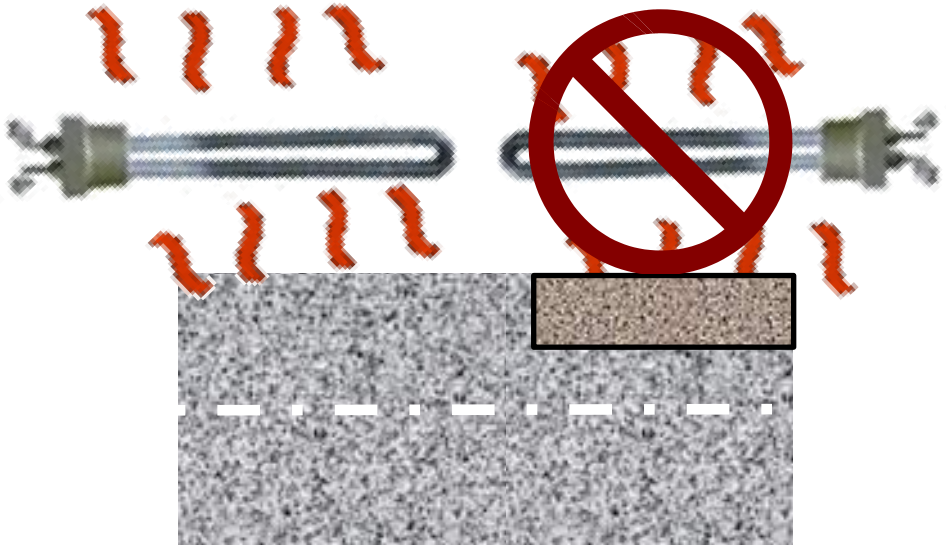

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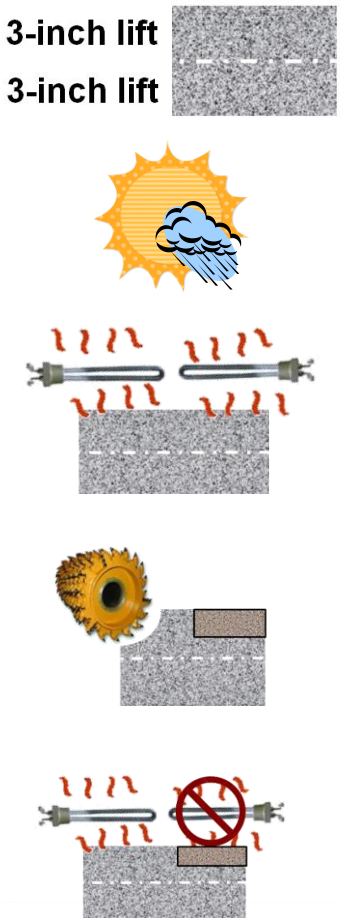
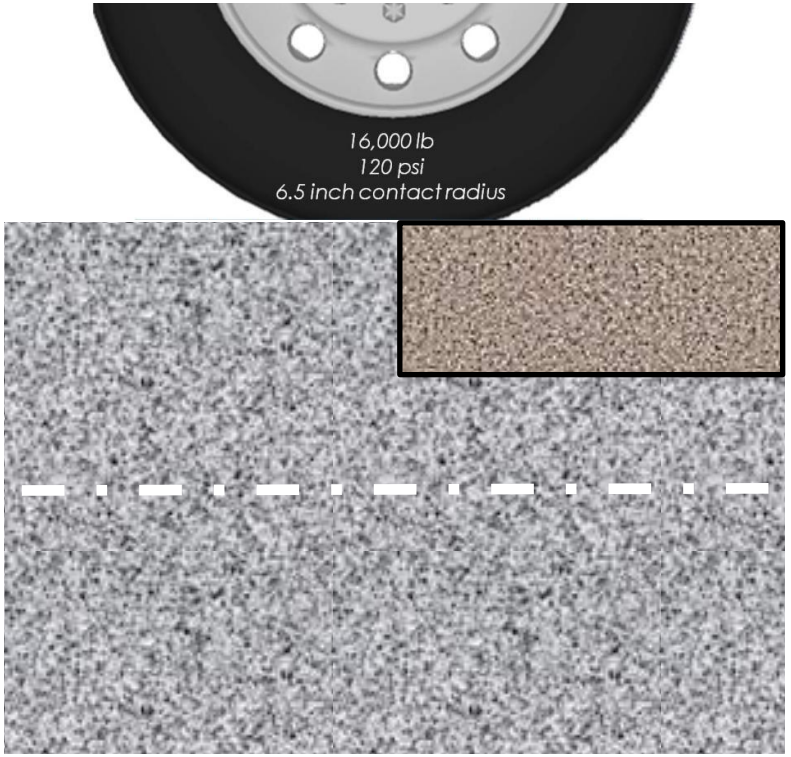
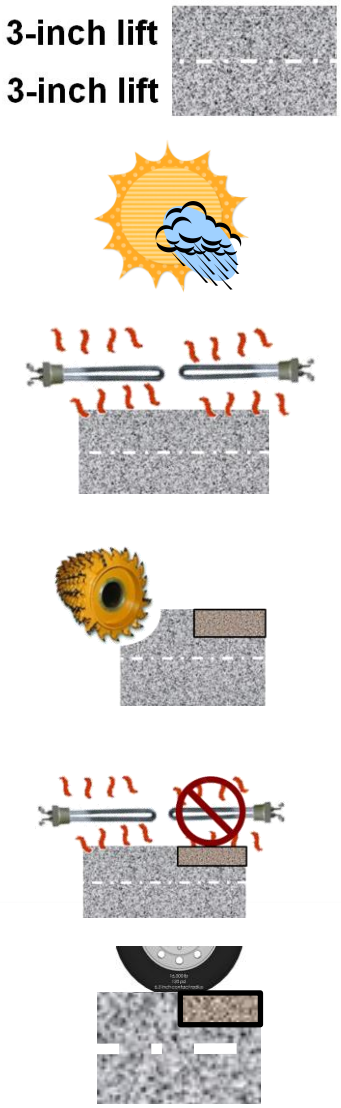




Reserved site 4 is loaded
September 2010 to April 2011

Historical Sequence – AGED Overlay



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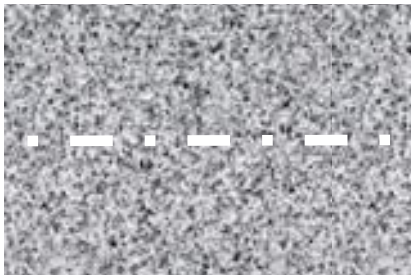

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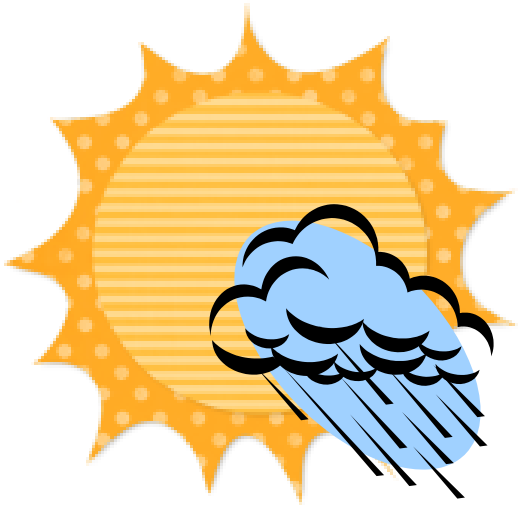

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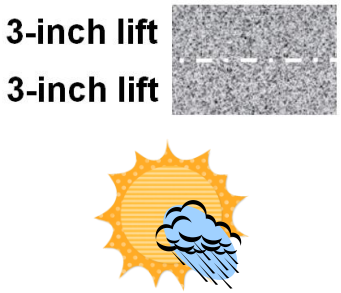

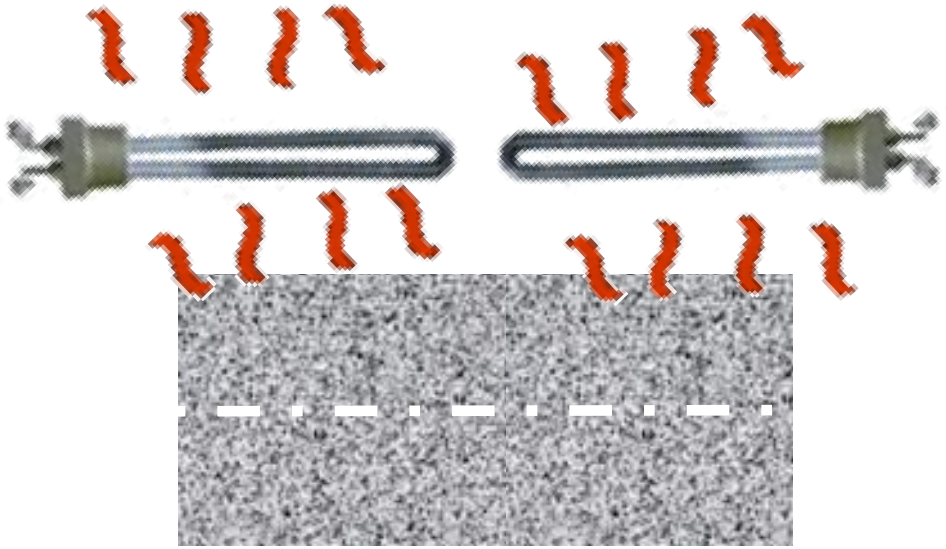

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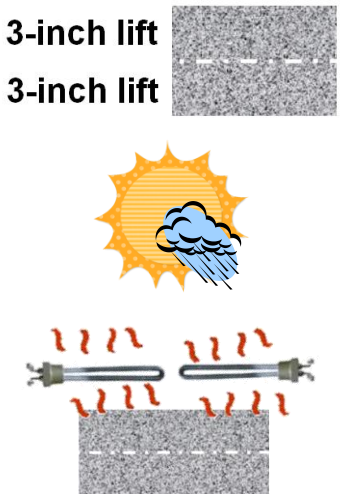

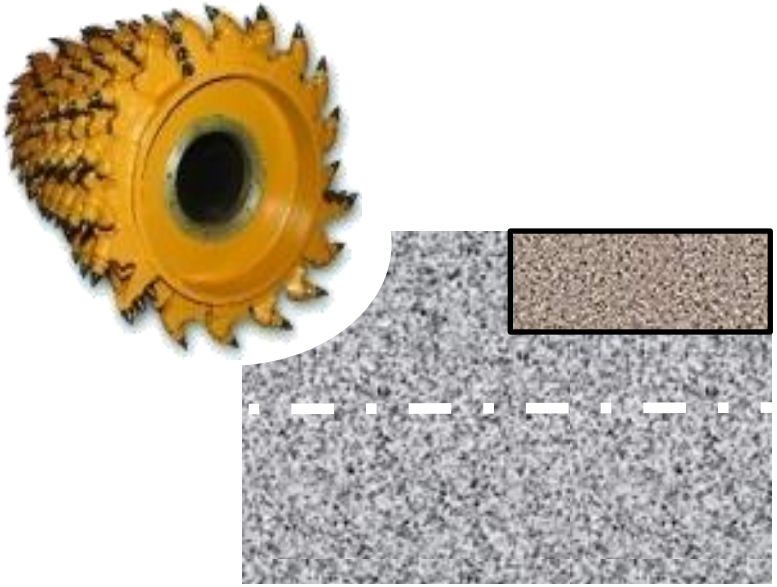

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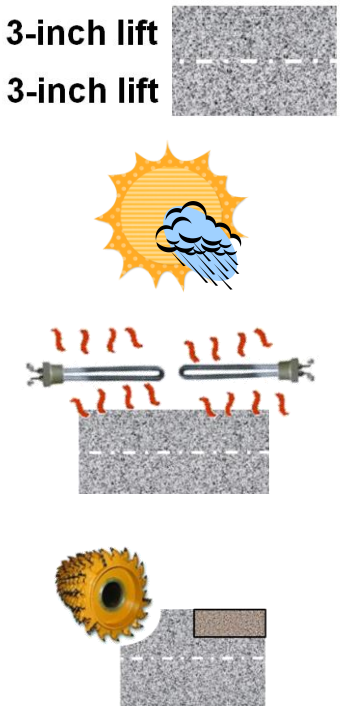

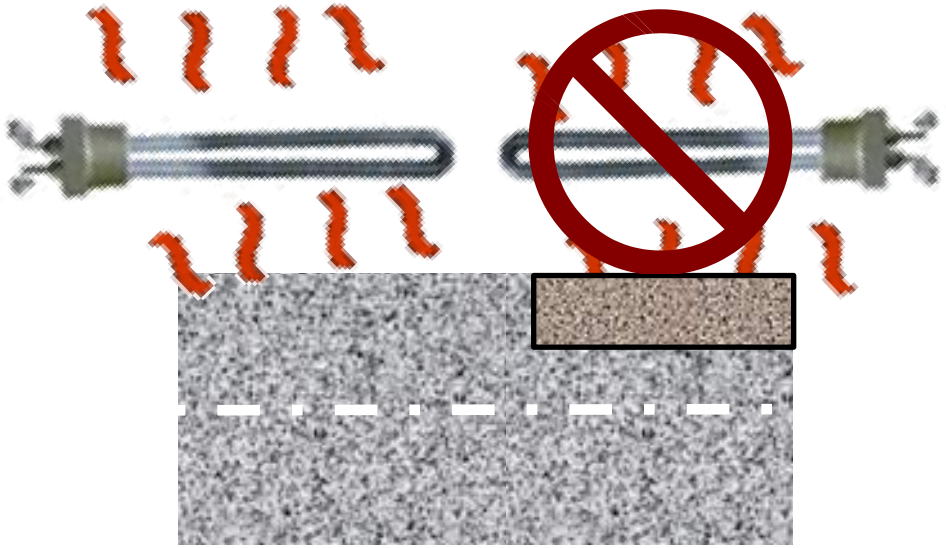

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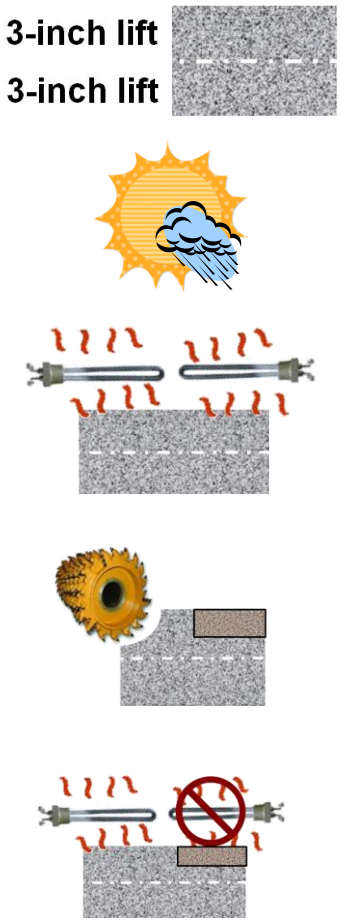

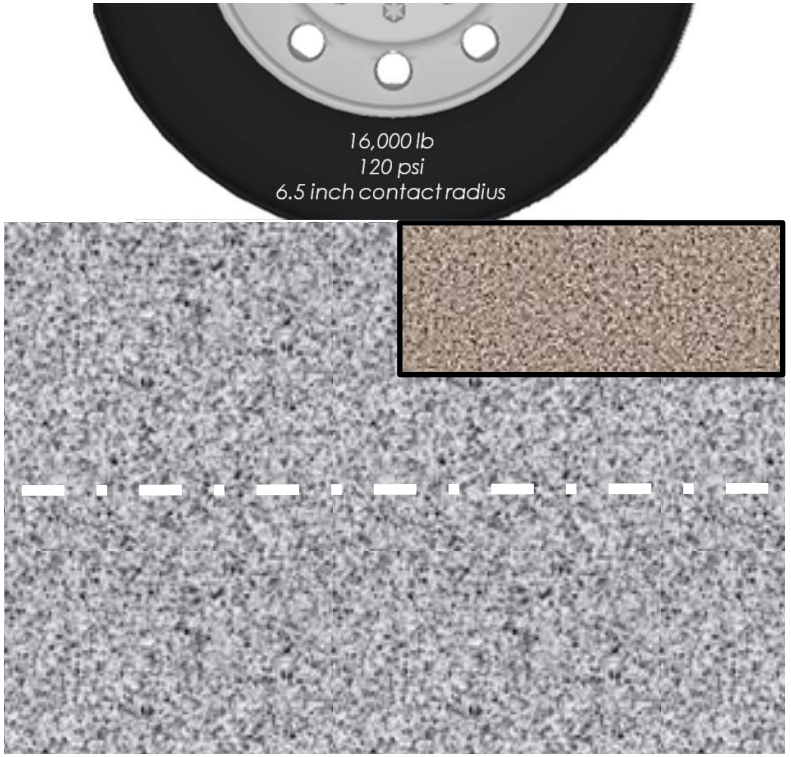

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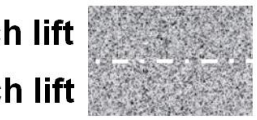

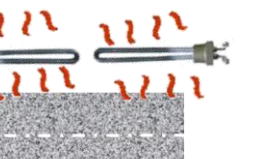

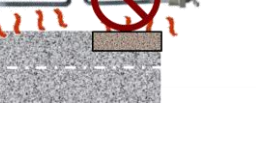

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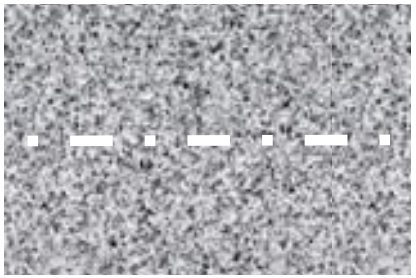

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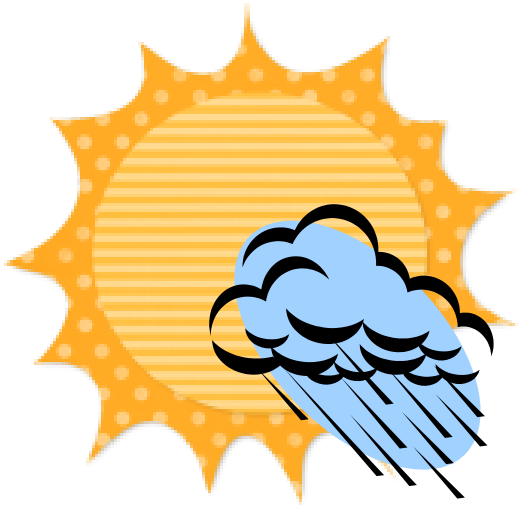

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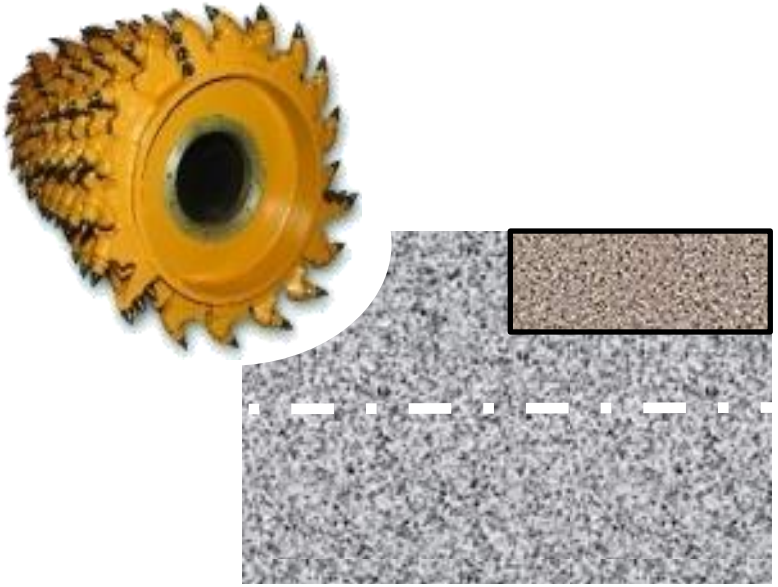

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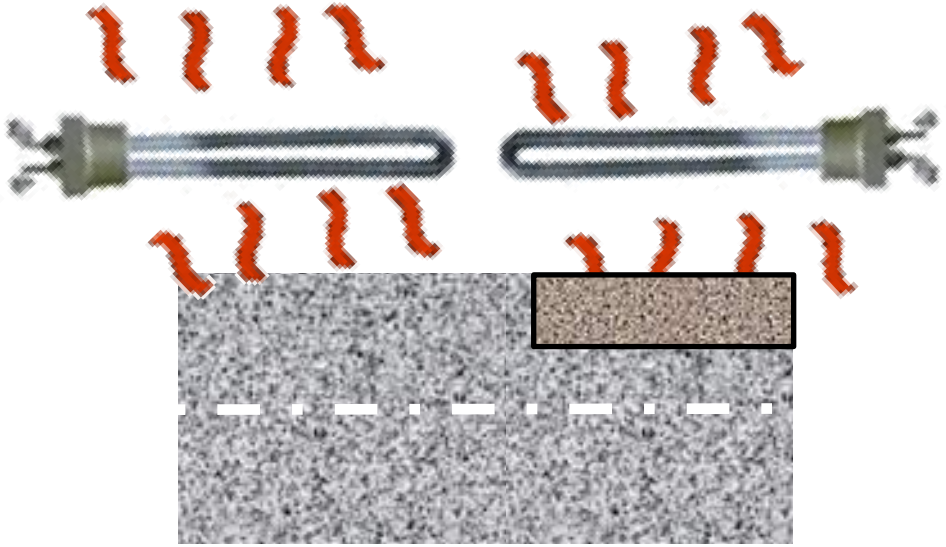

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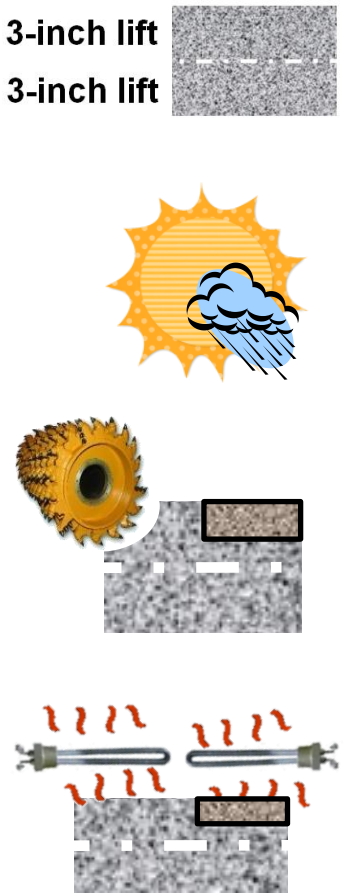

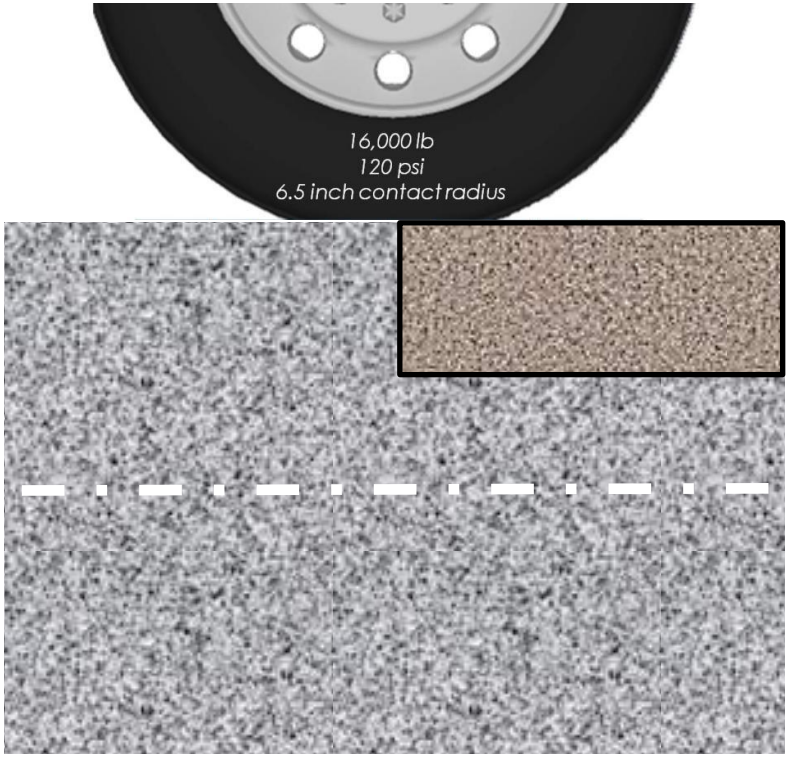

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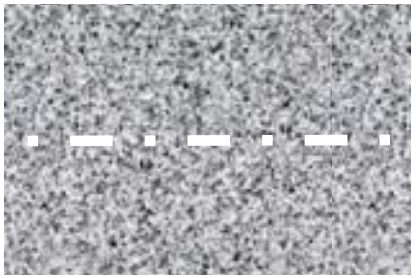

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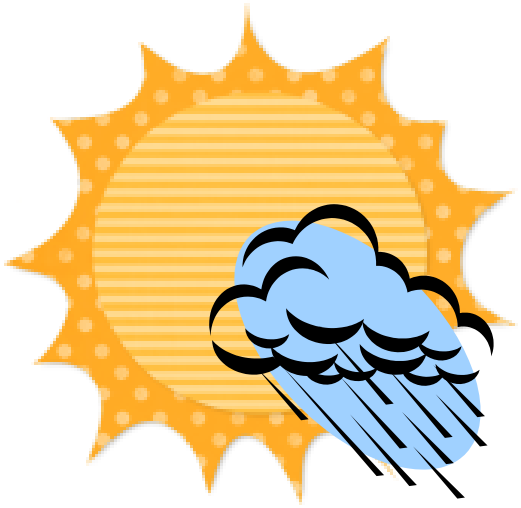

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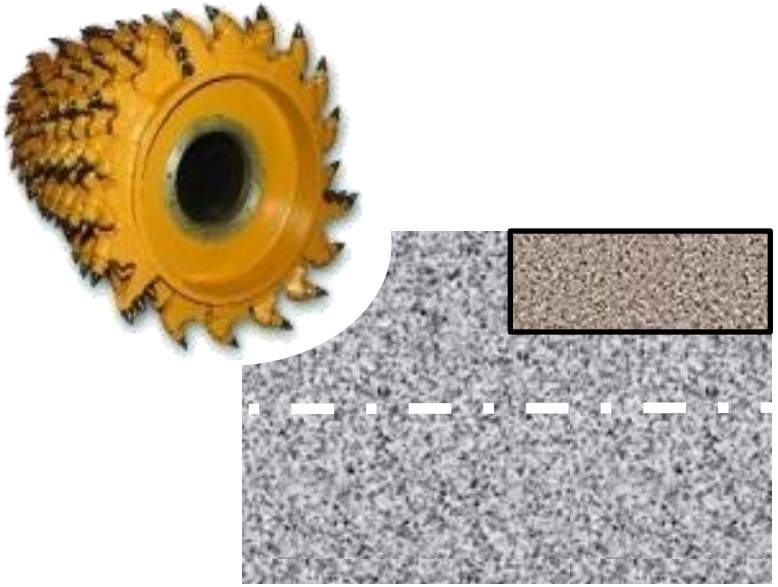

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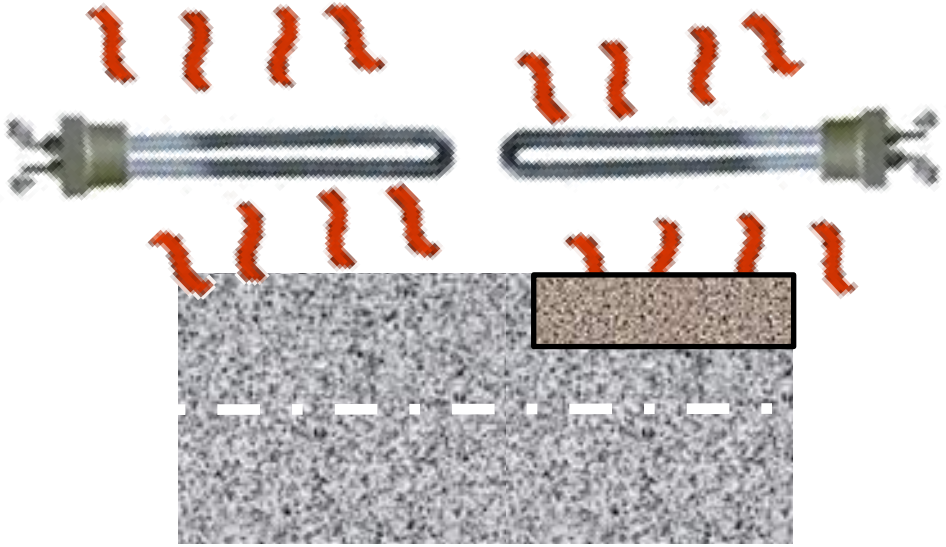

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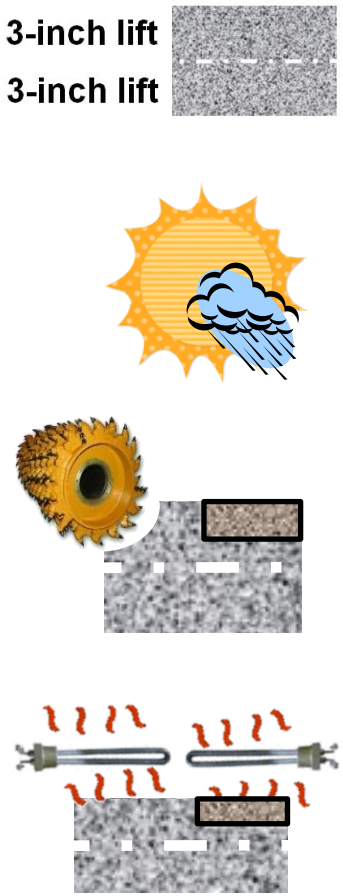

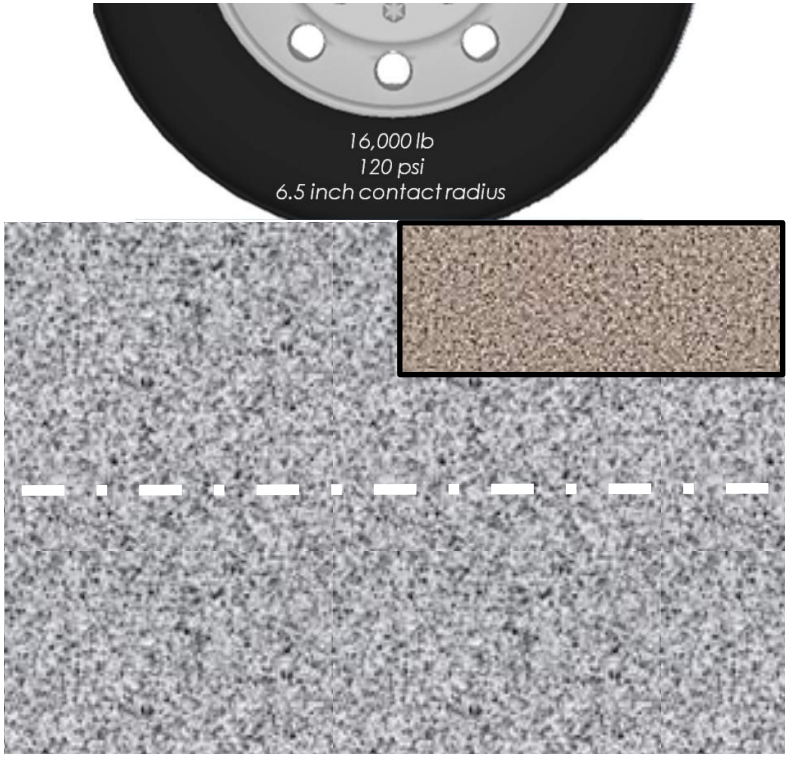

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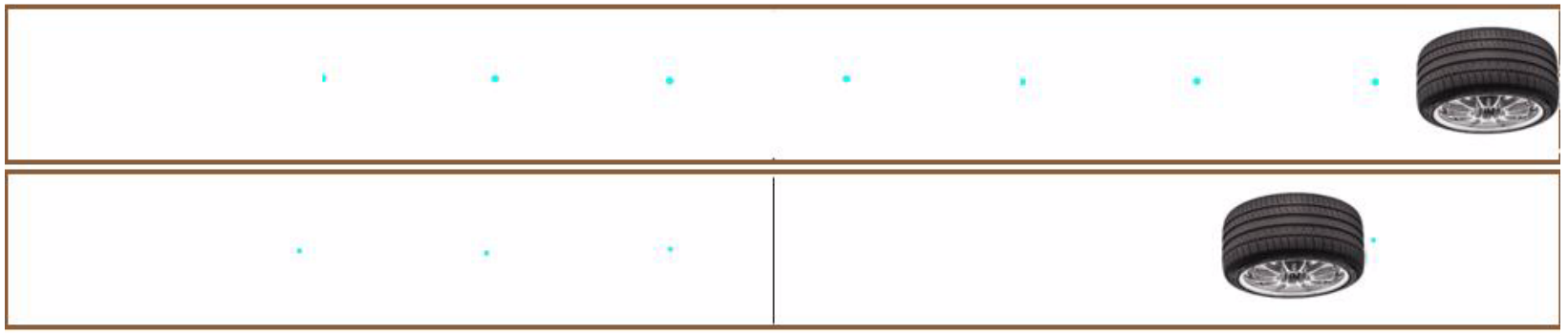
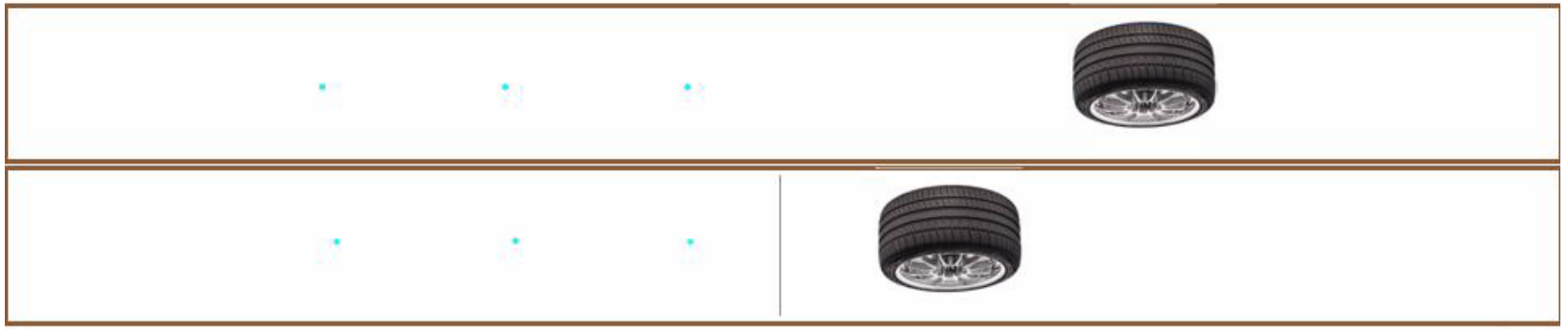
Development of Fatigue Cracks under APT Loading

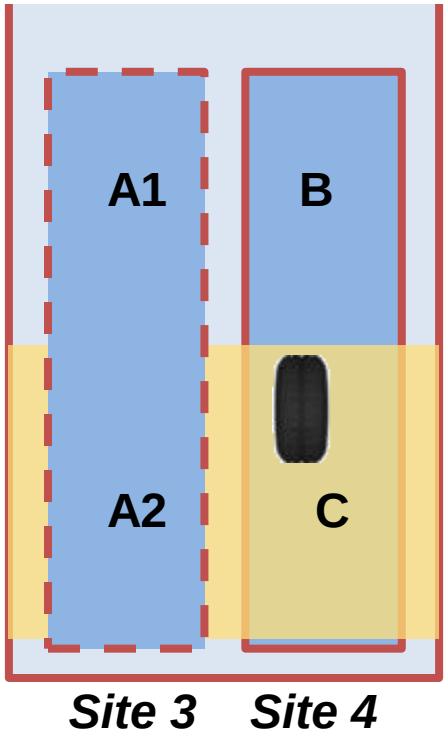


The development of fatigue cracks within loaded wheel paths are illustrated

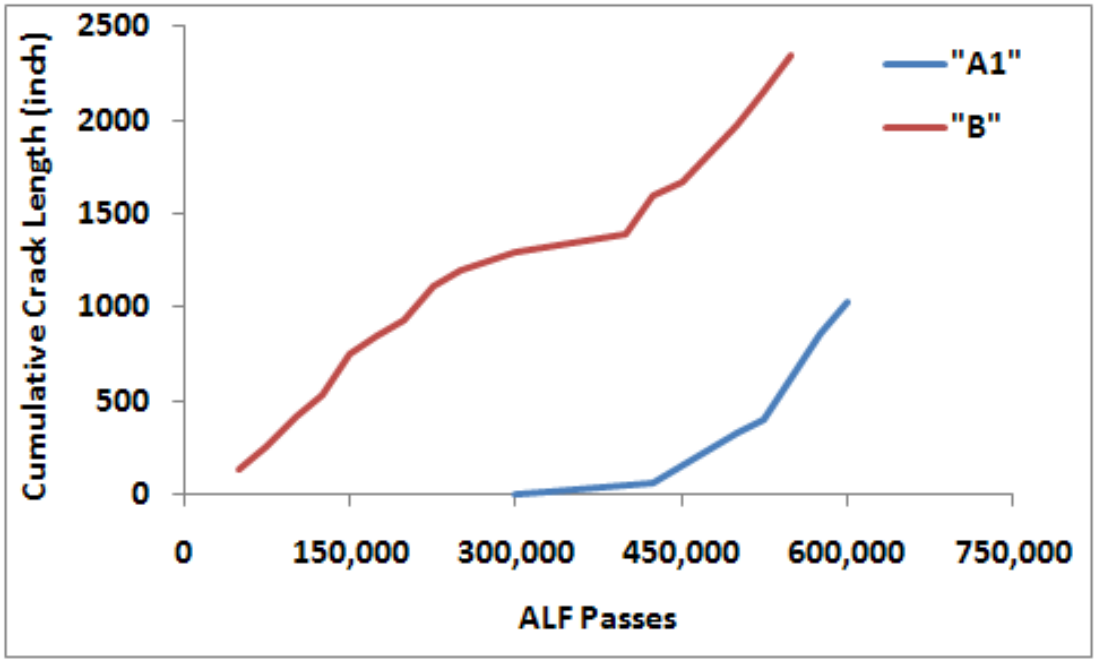


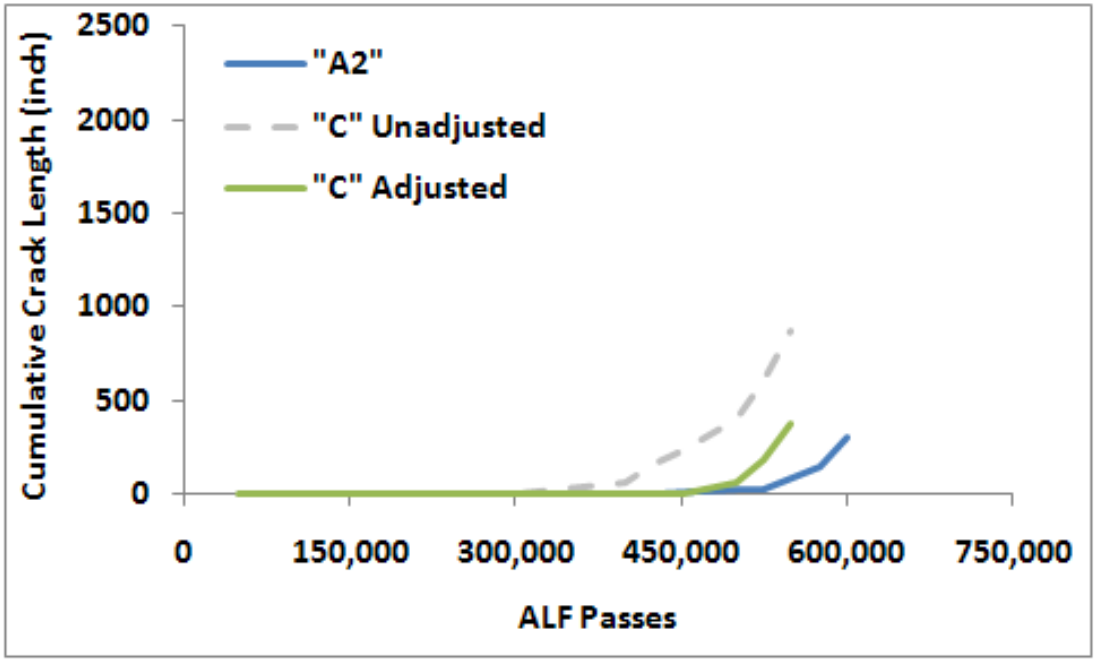
Lane 8
Control 70-22

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



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





Lane 10
Air Blown

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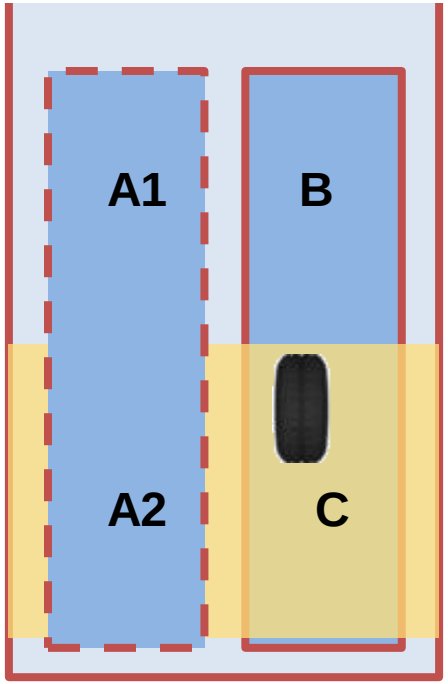
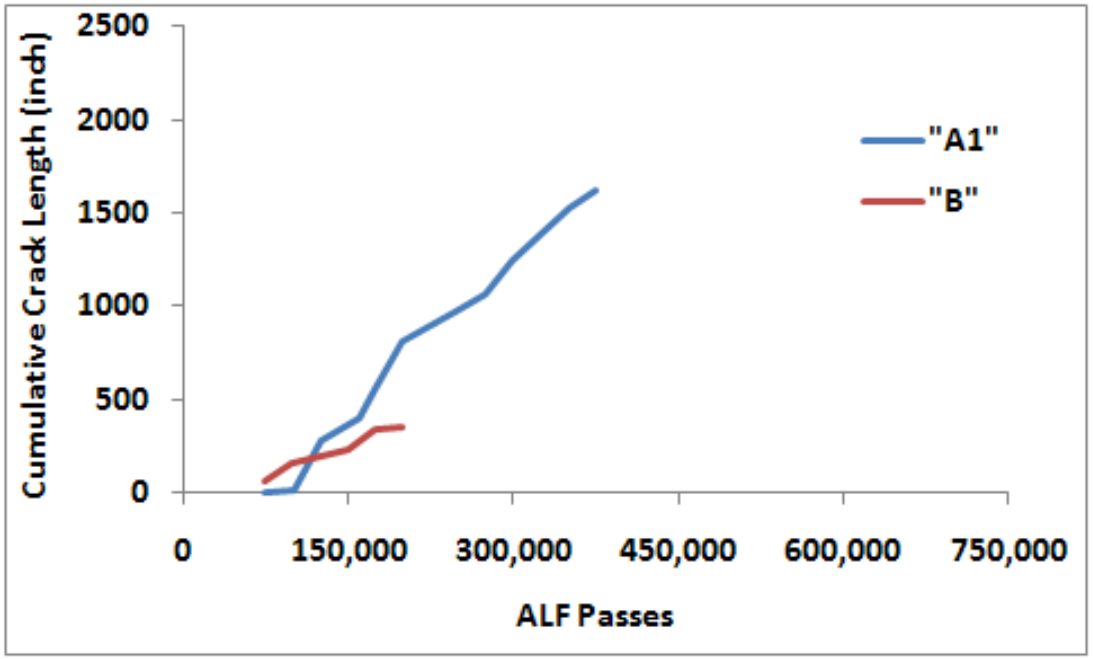
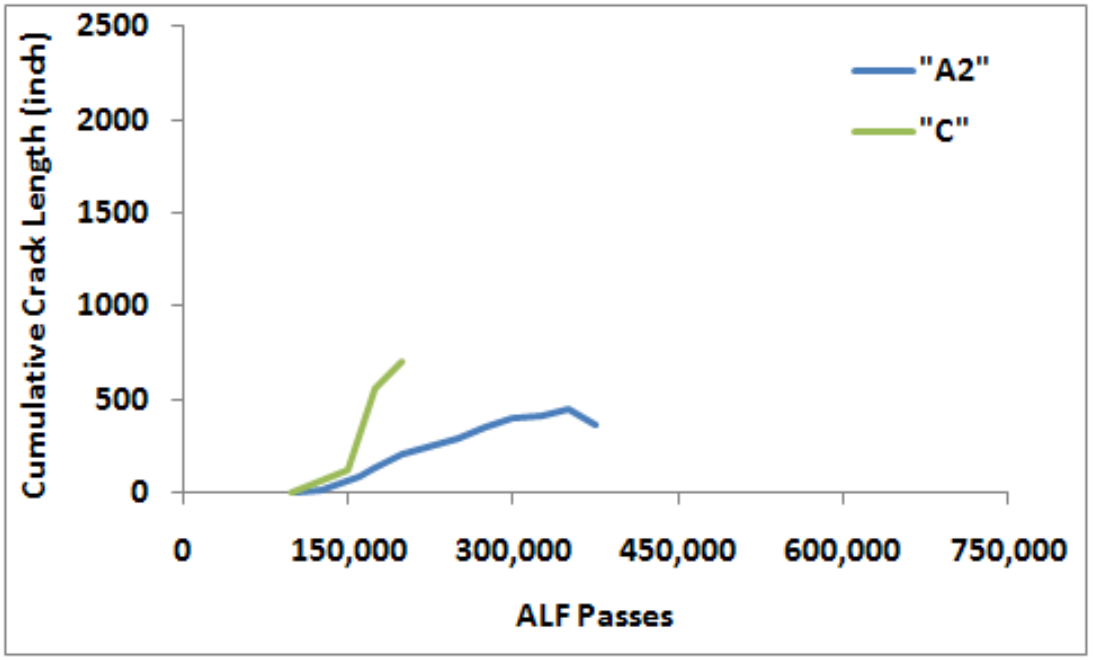


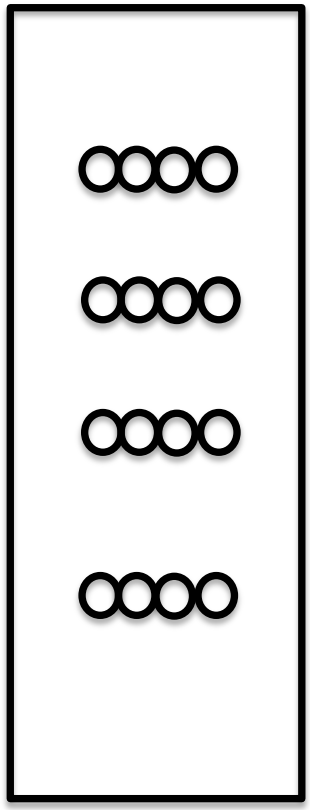
A2:C = Effect of "Old" Aged 4.75mm on Aged Pavement



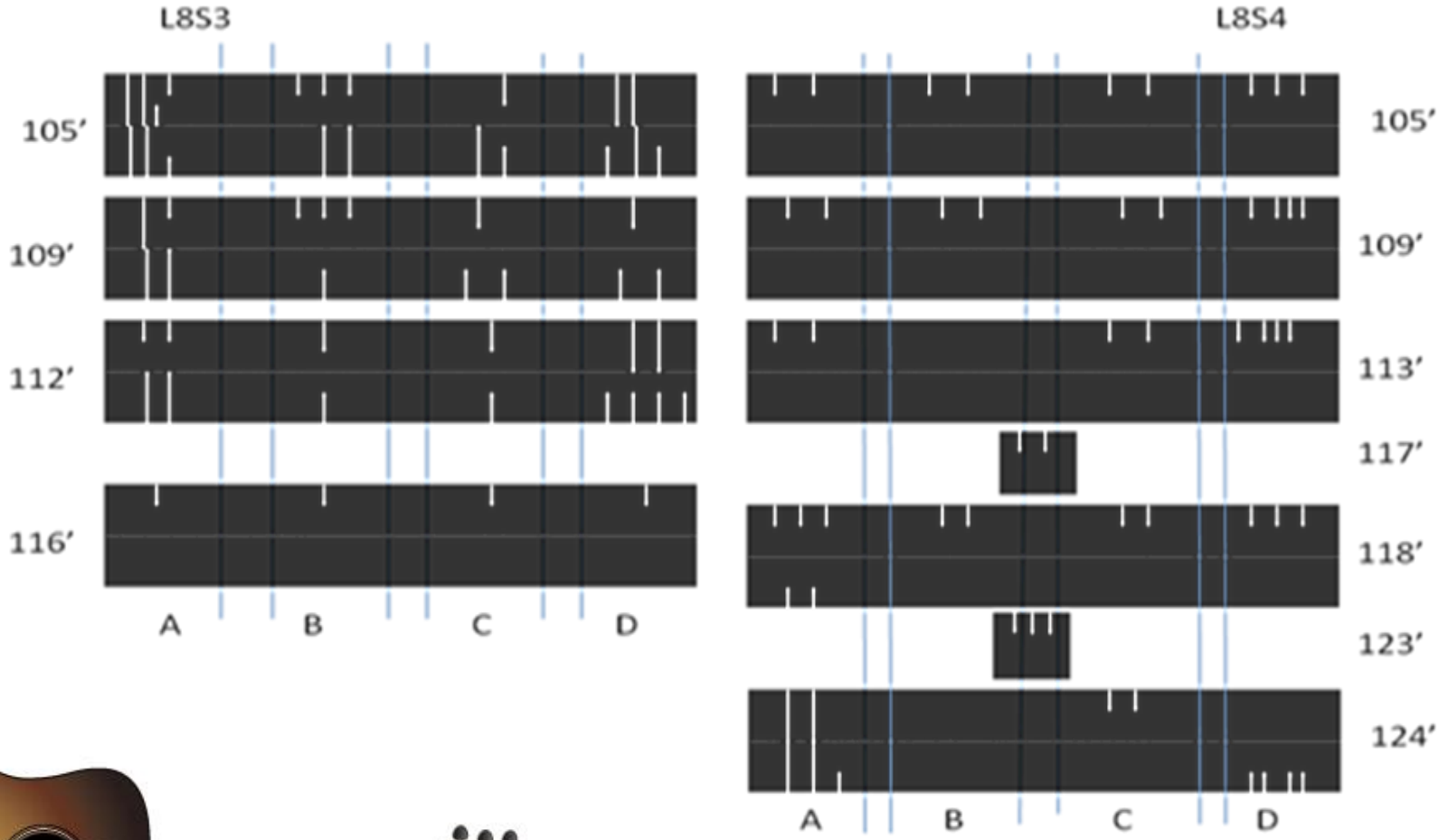


Vertical Crack Profiles

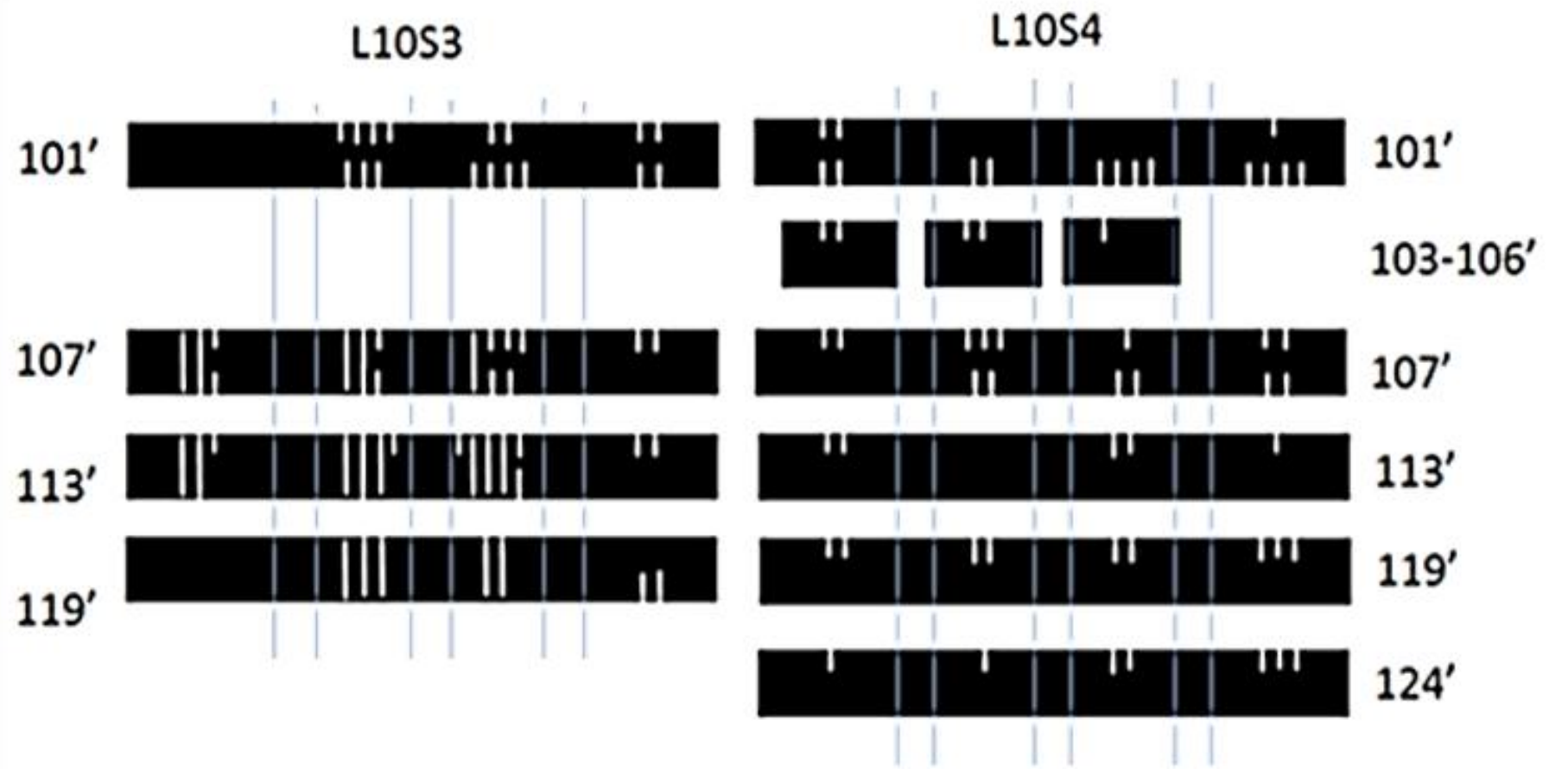
- Cores taken across the width of the wheel path



Vertical Crack Profiles



Vertical Crack Profiles



Findings

- Superpave 4.75mm NMAS mixture designed with 20% RAP content and WMA production
- Large rollers recommended to achieve density even though fine mix and higher binder content
- Aged pavements developed top-down cracking rather than bottom-up

Findings

- Thin overlay allows 8-year-old-***PLUS*** structure to perform like a 3-year-old structure
  - 425,000 - 500,000 passes to first crack
- While without milling-and-overlay the structure performed significantly less
  - 50,000 passes to first crack
- When the overlay was aged, the overlay provides little benefit

Thank You.
Questions?
Comments?

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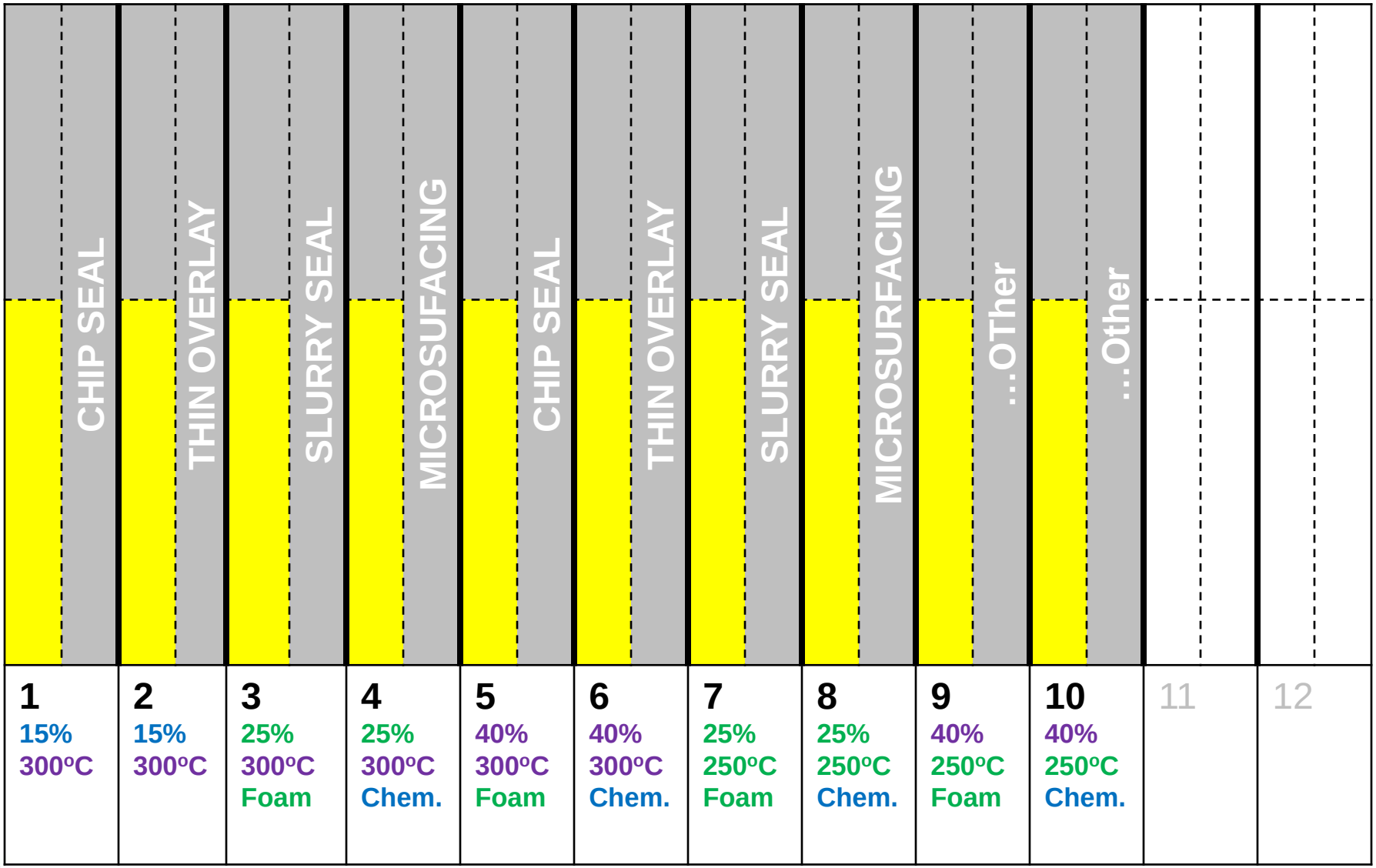
Characteristics of Accelerated Loading

- 16,000 lb single wheel load
- 425 super single tire
- 120 psi inflation
- 19^{o}C temperature control
- Lateral wheel wander (normal distribution)

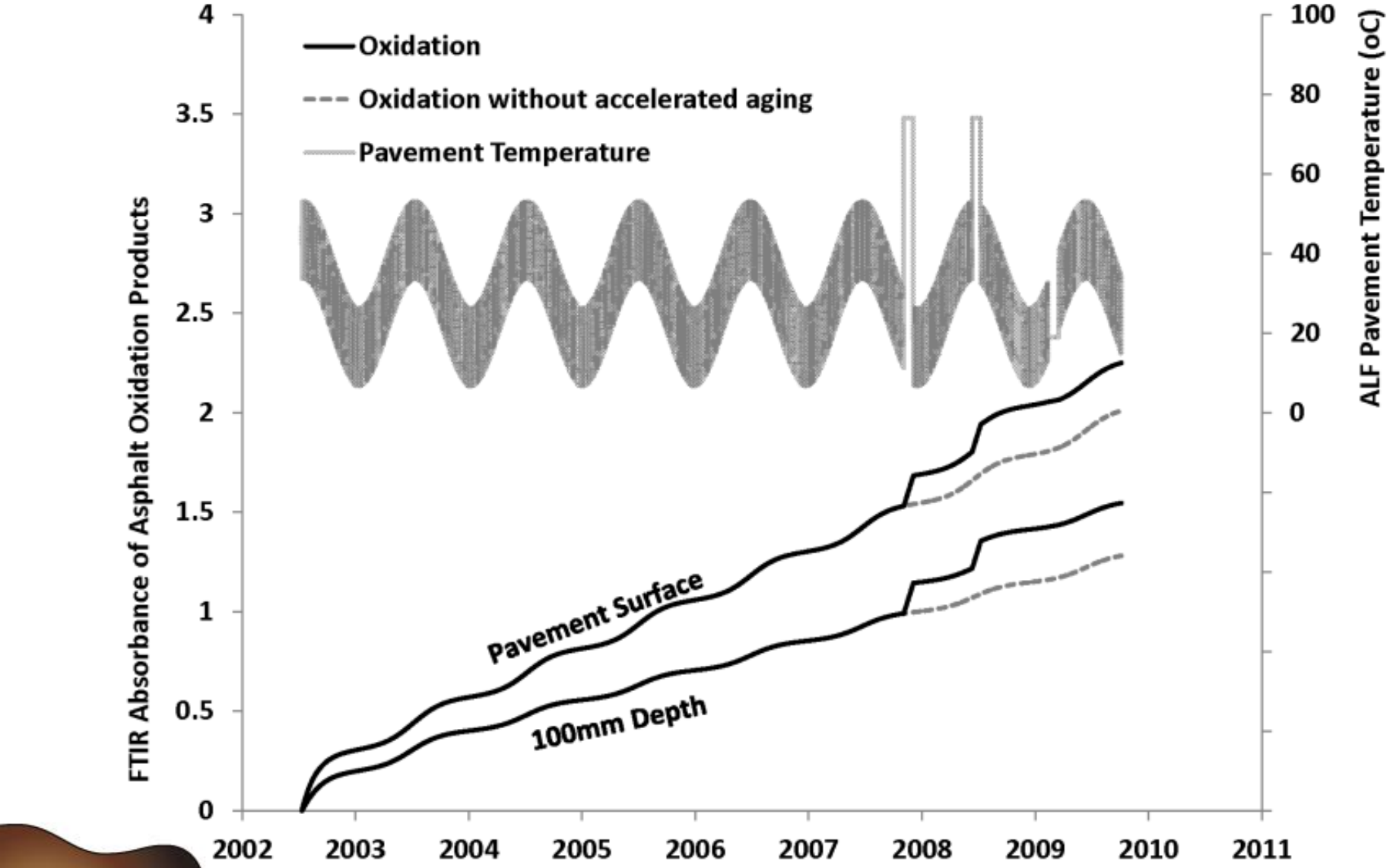

CHIP SEAL
THIN OVERLAY
SLURRY SEAL
MICROSUFACING
CHIP SEAL
THIN OVERLAY
SLURRY SEAL
MICROSURFACING
...OTher
...Other
1
15%
300ºC
2
15%
300ºC
3
25%
300ºC
Foam
4
25%
300ºC
Chem.
5
40%
300ºC
Foam
6
40%
300ºC
Chem.
7
25%
250ºC
Foam
8
25%
250ºC
Chem.
9
40%
250ºC
Foam
10
40%
250ºC
Chem.
11
12

Virginia DOT Mix Design

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	-	-

Virginia DOT Mix Design

Specification Criteria Ndesign = 50 gyrations			**Job Mix Formula**	**Produced Mix G_{mm} From FHWA: 2.595 From Contractor: 2.584**	
Volumetrics		Virginia DOT		FHWA extracted aggregate G_{SB} = 2.813	Contractor's aggregate G_{SB} = 2.789
VTM	Design	5%	4.4%	-	
	Production	3% - 6%	-	4.21% - 3.98%	
VFA	Design	70% - 75%	74%	-	
	Production	70% - 80%	-	75.1% - 76.2%	74.0% -75.2%
VMA		16.5% minimum	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


Oxidation
Oxidation without accelerated aging
Pavement Temperature
FTIR Absorbance of Asphalt Oxidation Products
ALF Pavement Temperature (oC)
Pavement Surface
100mm Depth
0
0.5
1
1.5
2
2.5
3
3.5
4
0
20
40
60
80
100
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011

Background and Motivation

- Embrittlement of In-Situ Asphalt Binder