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NCAT Experience with Perpetual Pavements and High Polymer Mixtures

IDAHO ASPHALT CONFERENCE
OCTOBER 23-24, 2013
MOSCOW, IDAHO

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Regional Engineer
Asphalt Institute

Training, so necessary.

Texas Perpetual Pavements

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Waco	Cotulla	McAllen
1.5” PFC	3.0” SMA	1.5” PFC
2.0” SMA	3.0” 19 mm SP	2.0” SMA
3.0” 19 mm SP	8.0” 25 mm SP	10.0”, 19 mm or 25 mm SP
10.0” 25 mm SP	2.0” 12.5 mm 2% air voids	3.0” 12.5 mm 2% air voids
4.0” 19 mm 2% air voids		8.0” lime-treated salvaged aggregate
6.0” crushed stone		

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20.5” Total HMA	**16” Total HMA**	**16.5” Total HMA**

How thick is too thick?

Cost of 5 Miles of Pavement

Assume 80’ width, $50 per ton *

Save 1” in over-design: $650,000

Save 2” in over-design: $1,300,000

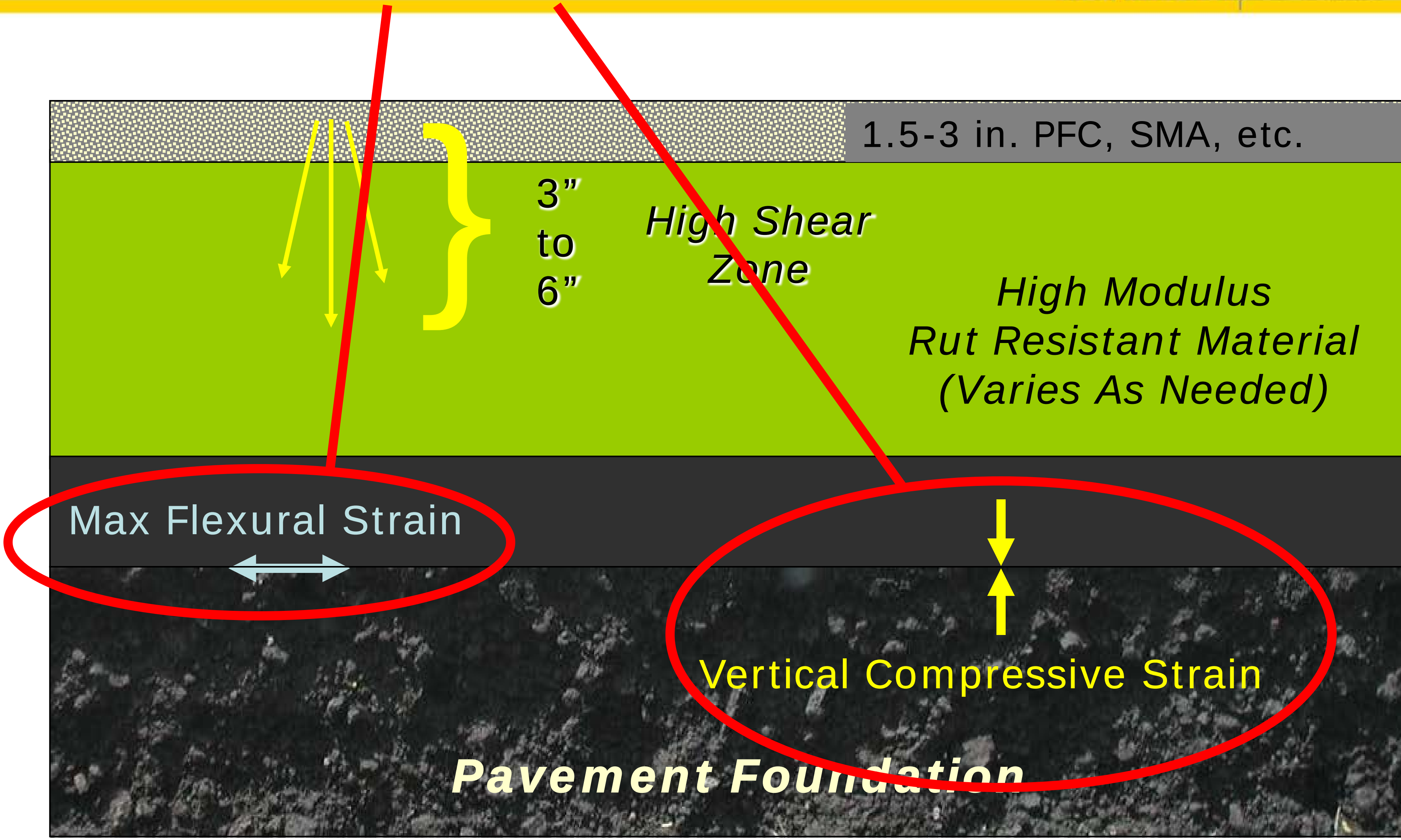
Save 4” in over-design: $2,600,000

* Original estimate used in 2005

How thin is too thin?

If the perpetual pavement structure is designed too thin, the risk of bottom-up cracking increases dramatically, defeating the purpose of the design and resulting in an expensive rebuild.

To design against potential bottom-up cracking, certain strain thresholds cannot be exceeded.



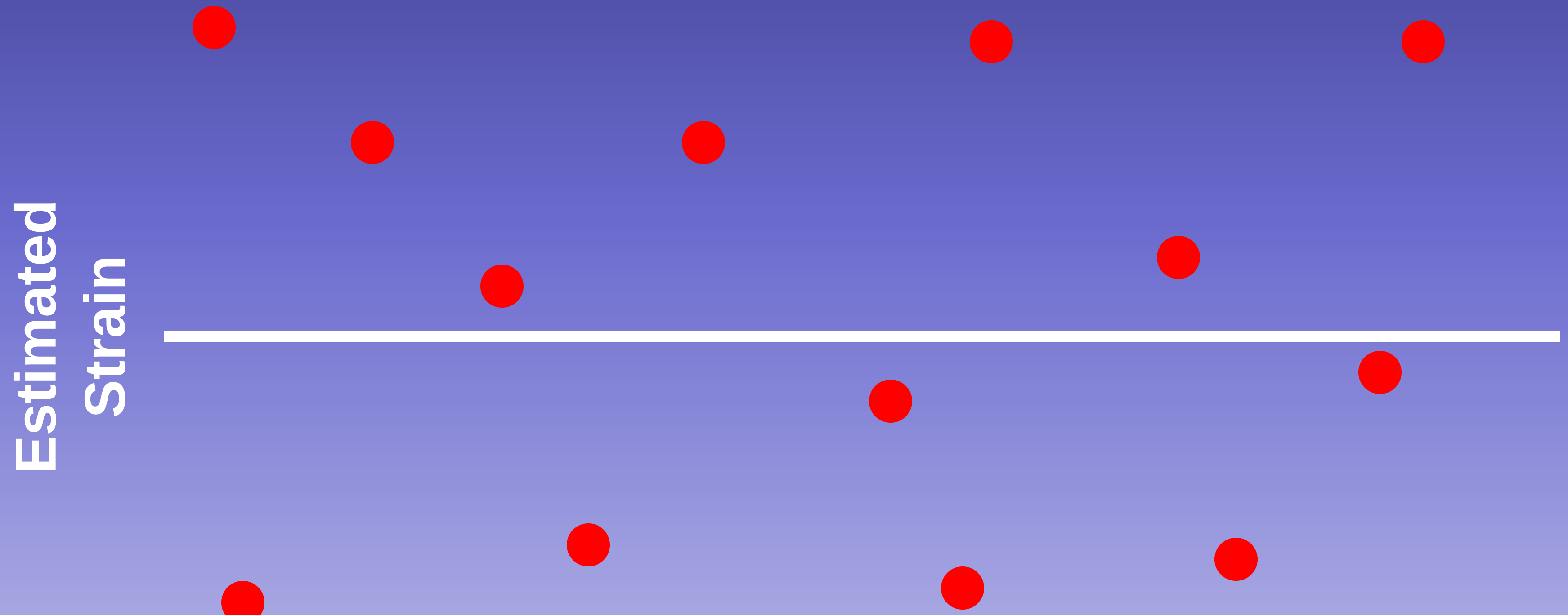
Limiting Strain / Endurance Limit Theory

- Based on laboratory beam fatigue data
- "Small" strains will never induce cracking
- Limiting strain (lab) at 75 to 125 microstrain *(later found out that higher limiting strains have been encountered in the field with no problems)*
- No bottom-up cracking below this level

These strains can be estimated based on total pavement thickness and material properties.

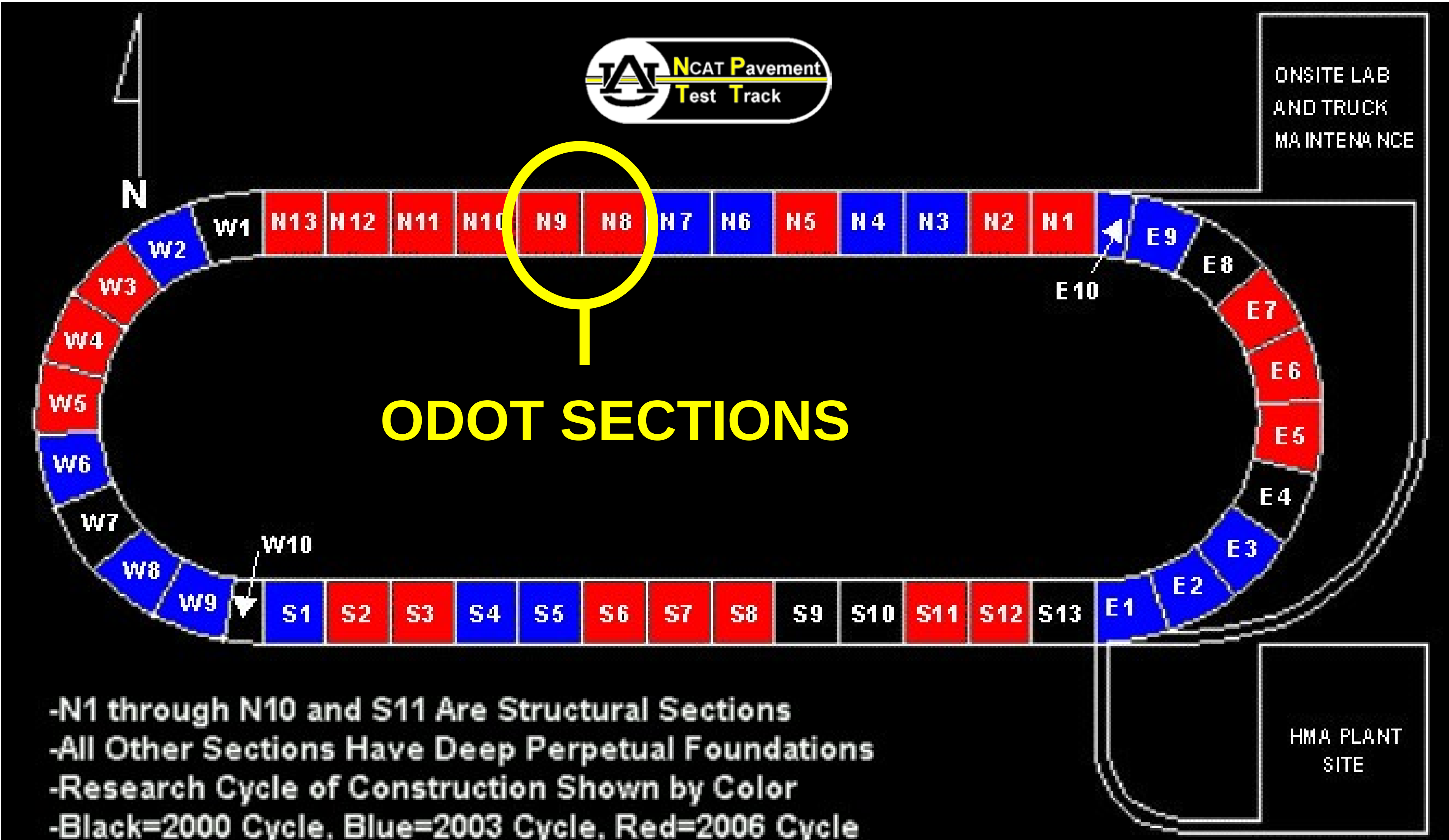
However, the estimations would be based on assumptions made from previously collected data.

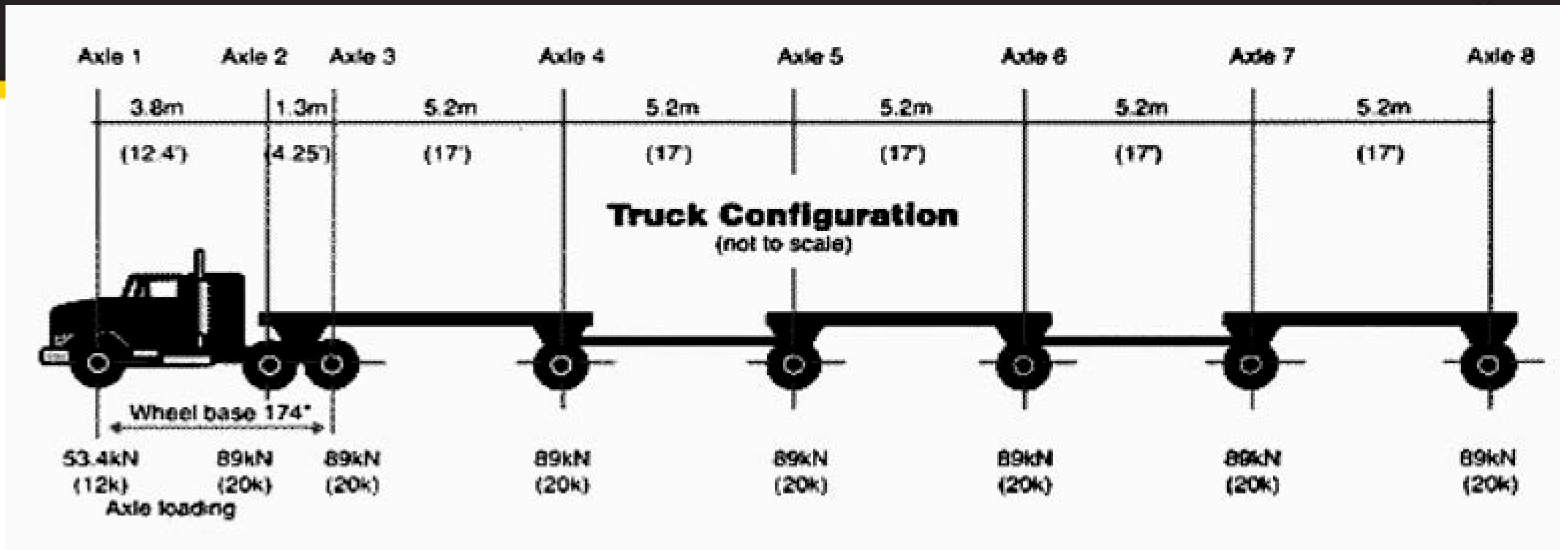
There are large deviations in the types of environment around the country, the types of materials used and the types of pavement specified. These deviations decrease the reliability of the assumptions made to calculate strains.



If the strains could be measured directly, using Oklahoma materials and mix designs, the data would be much more reliable.

National Center for Asphalt Technology (NCAT) Test Track – 1.7 Miles



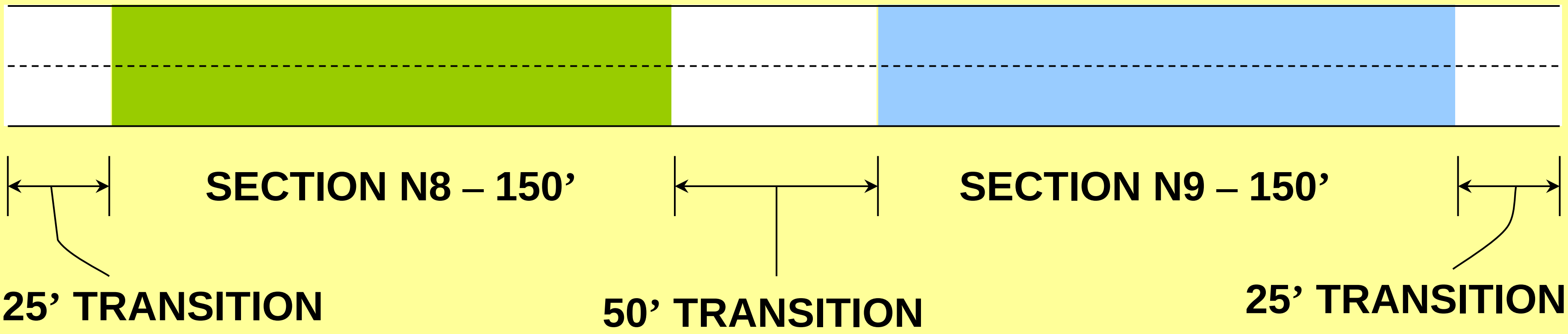


Specially-configured trucks drive around the track to apply a specific number of Equivalent Single Axle Loads (ESALs)

10 Million/2-year cycle

ODOT'S PERPETUAL PAVEMENT STRUCTURAL SECTIONS AT NCAT TEST TRACK

PLAN VIEW



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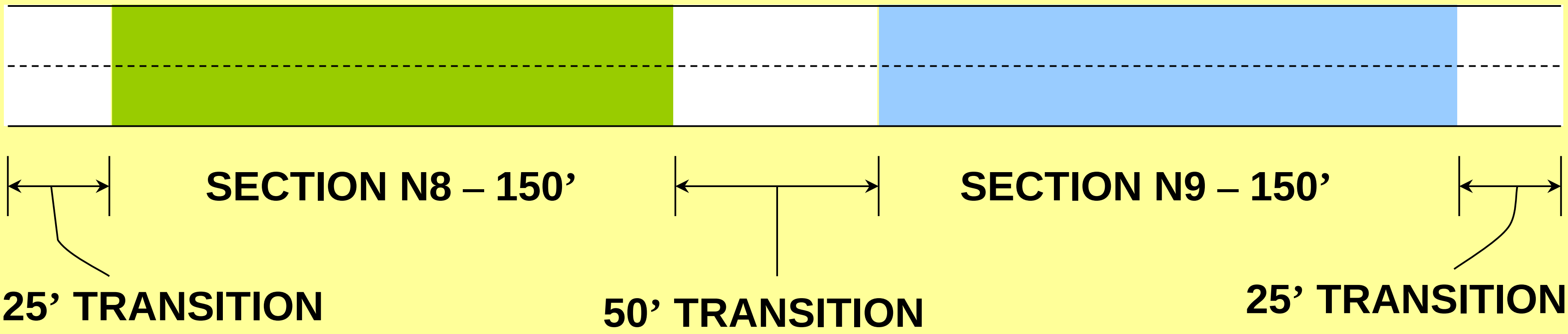
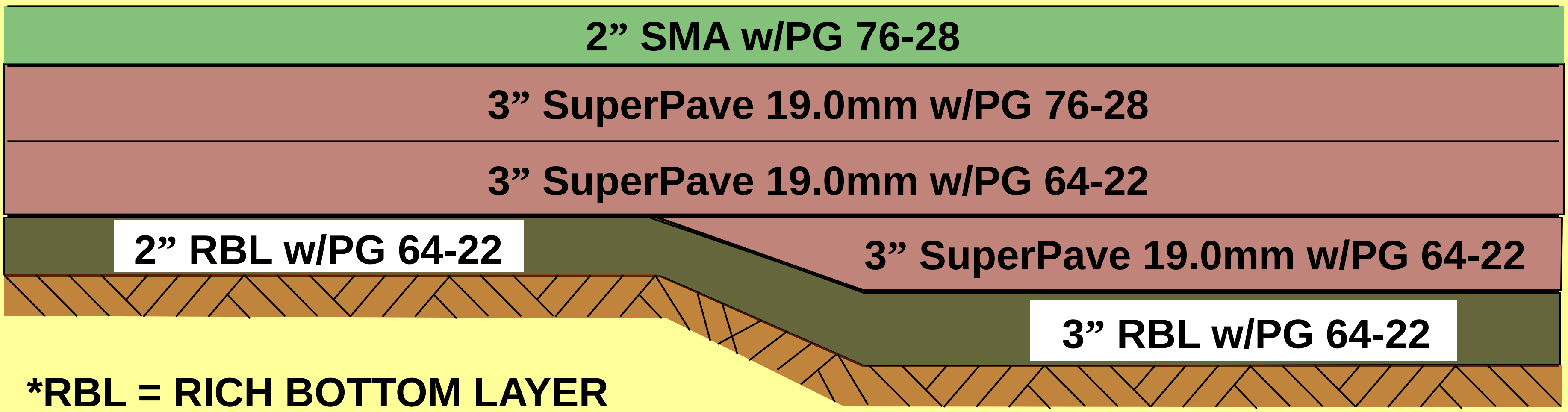
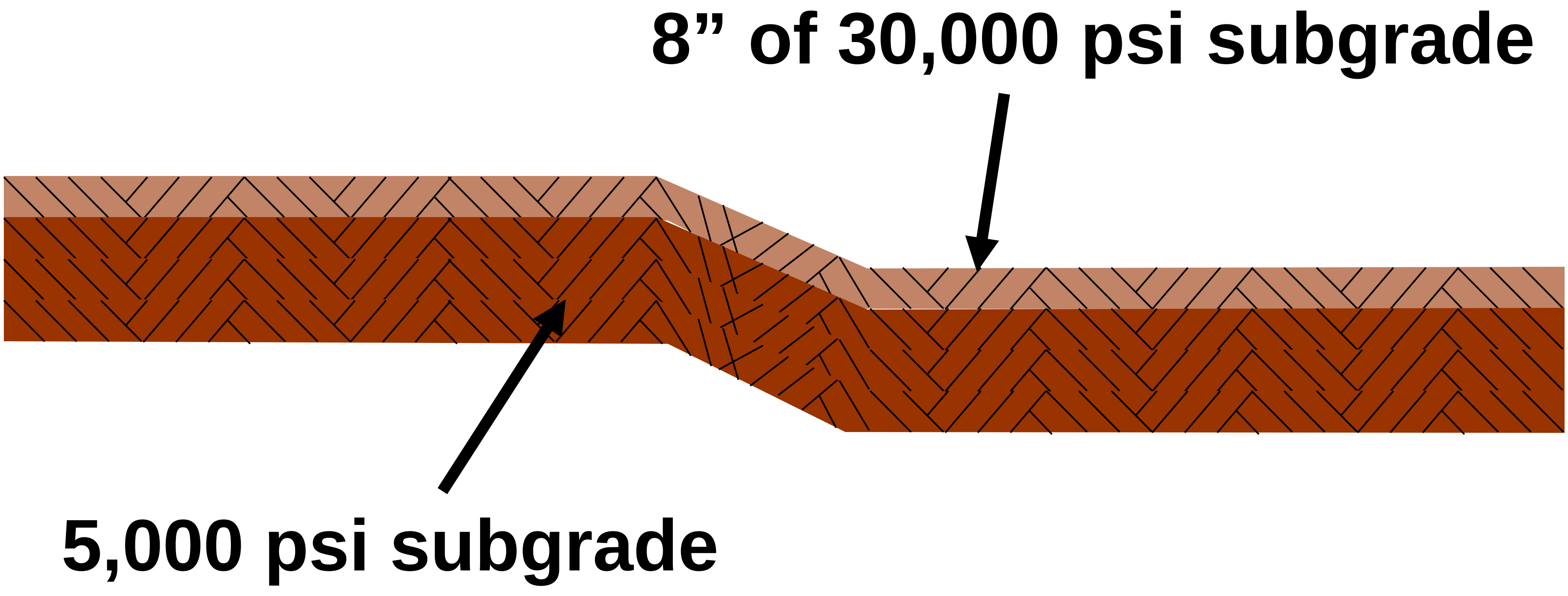


PROFILE VIEW

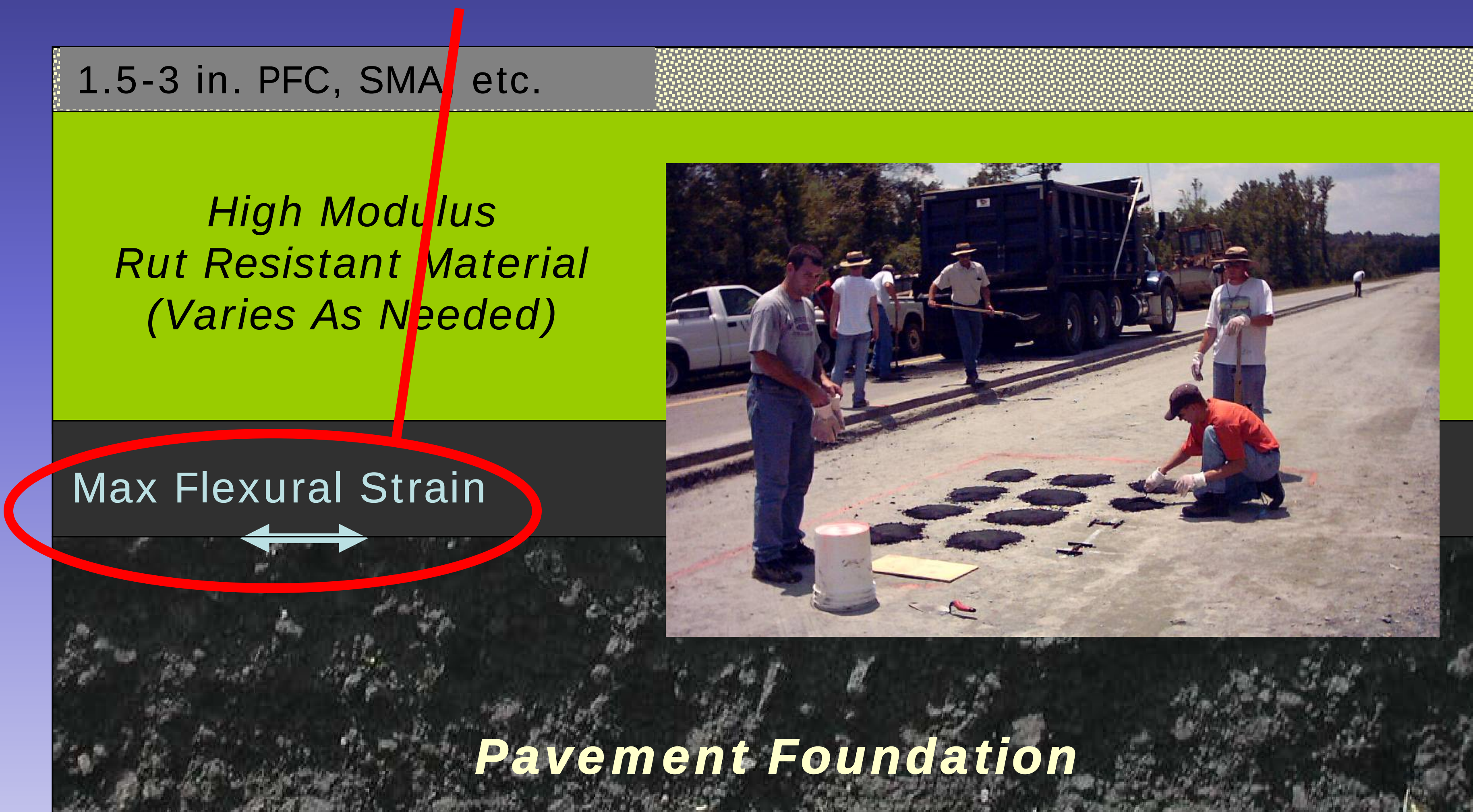


*RBL = RICH BOTTOM LAYER

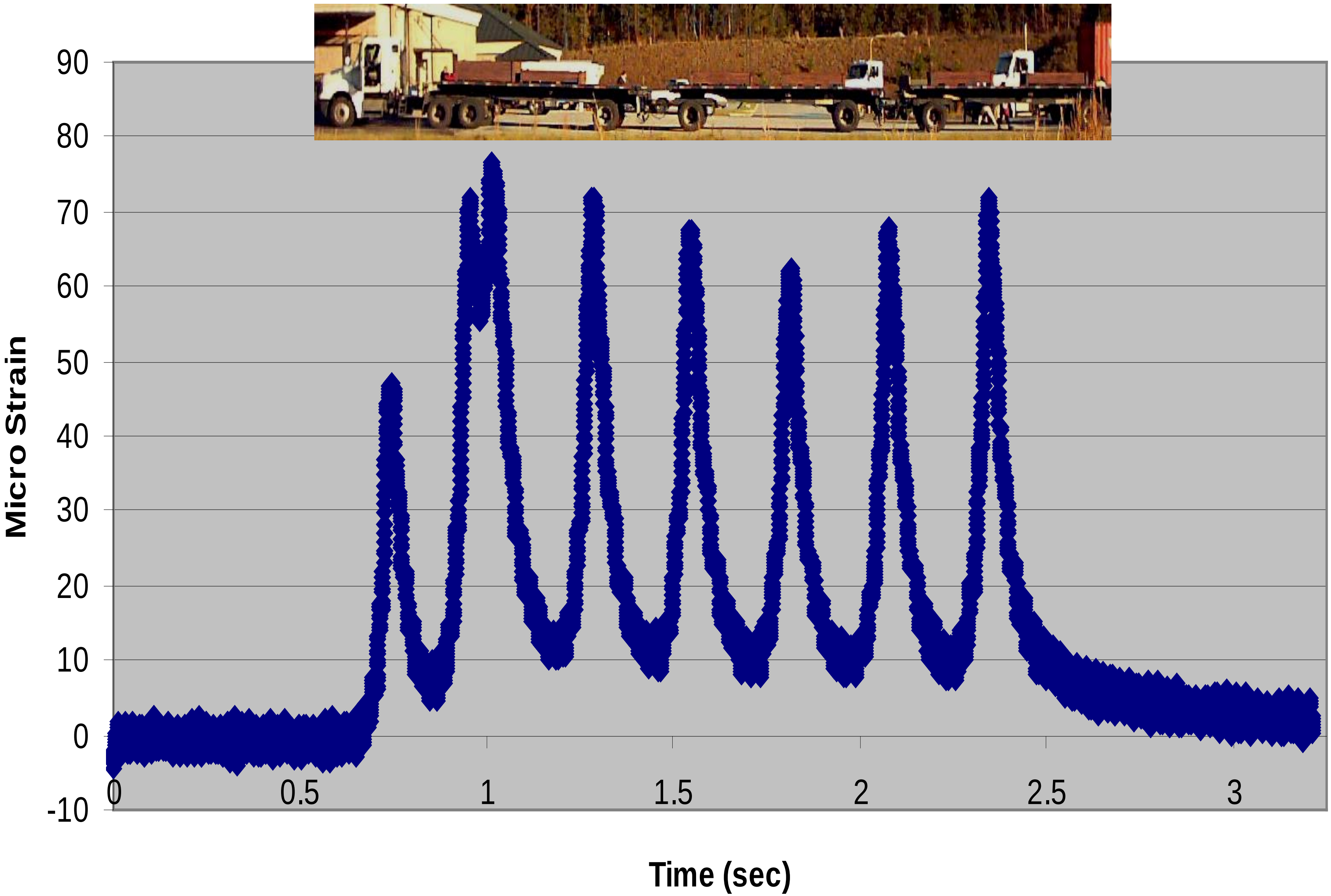
Simulating lime-treated subgrade



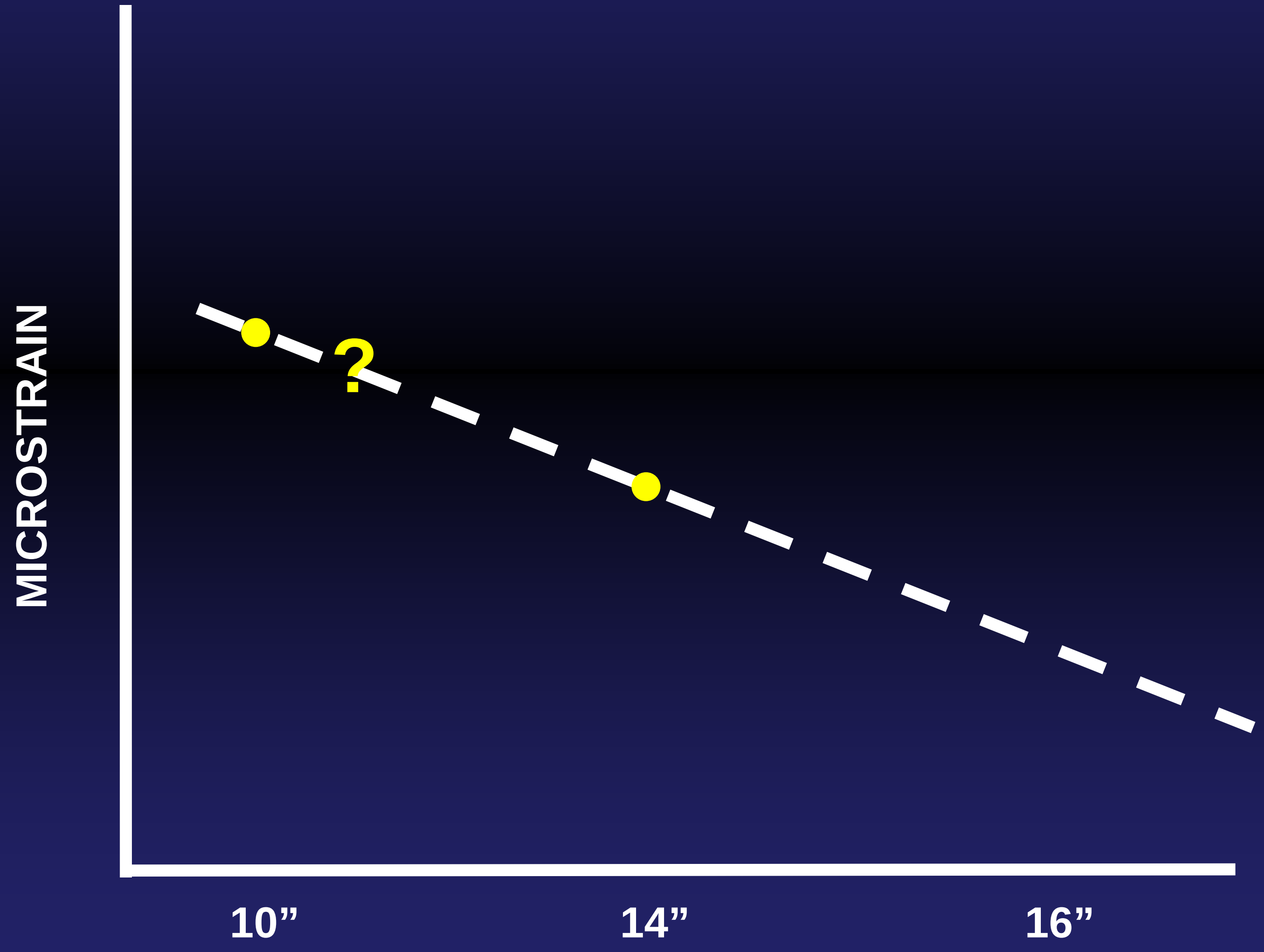
The maximum flexural strain was directly measured using a series of strain gauges installed at the bottom of the asphalt section.



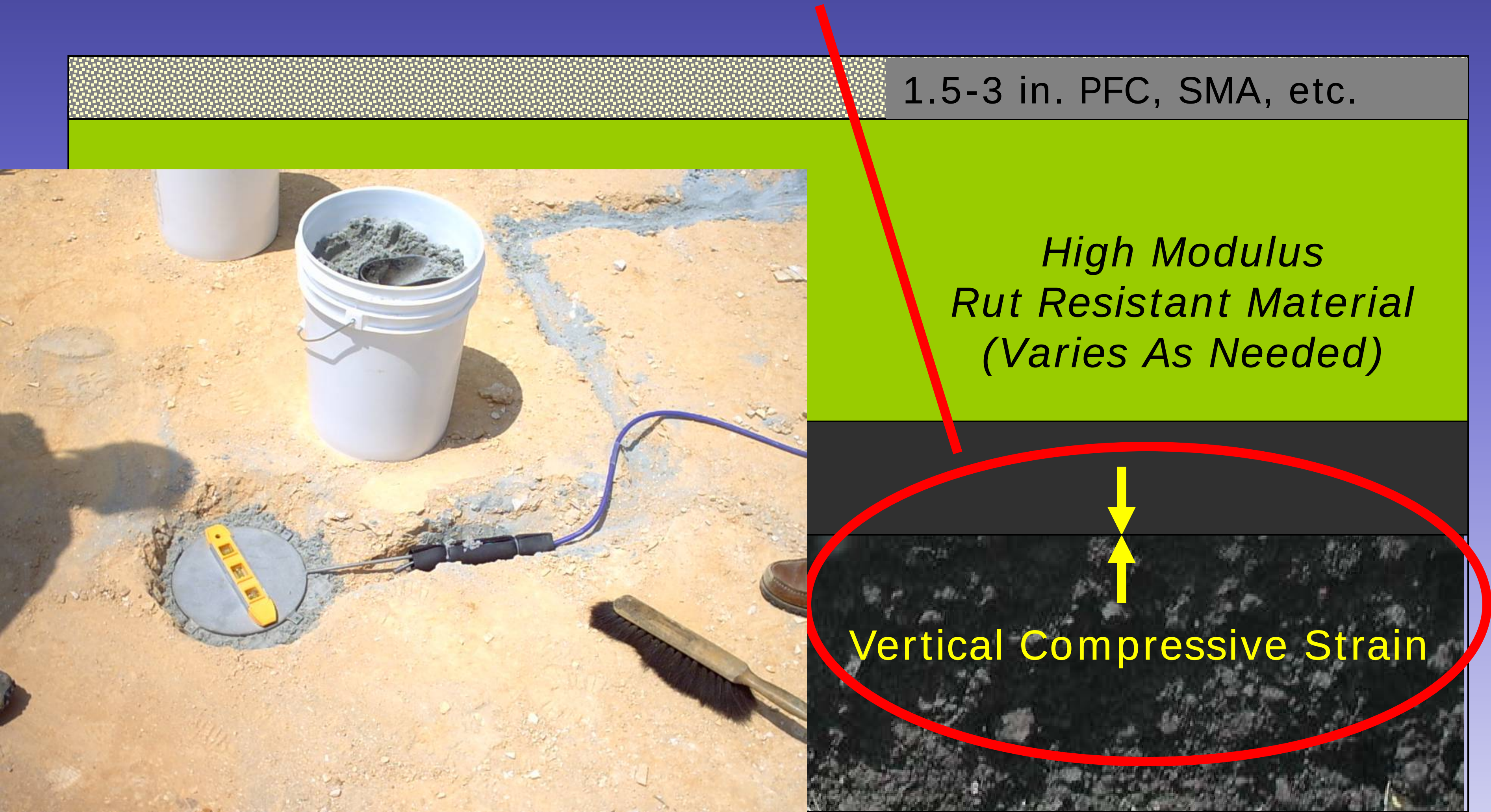
Transverse Strain



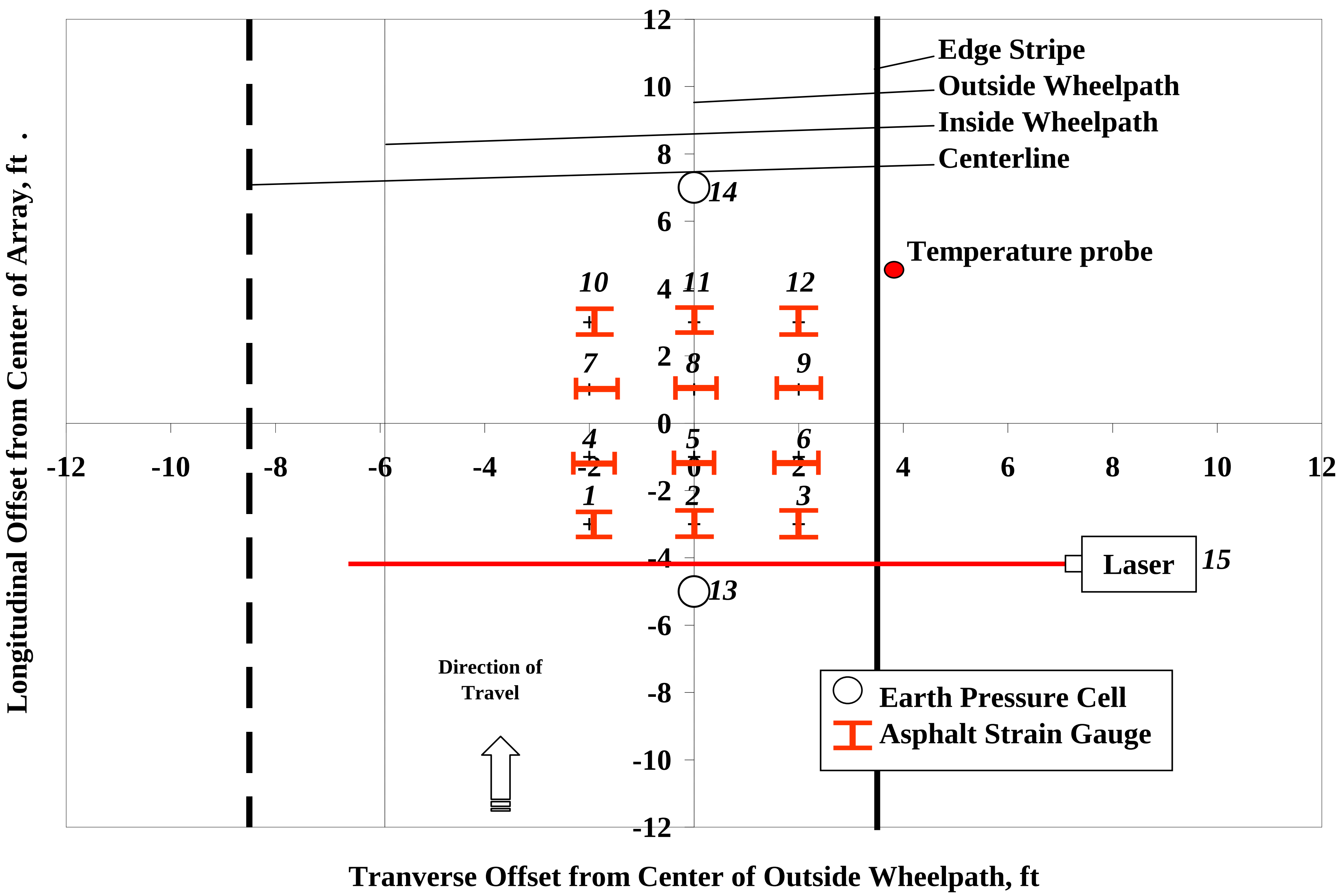
If we have determined the strain for a 10” and 14” thick pavement, the thickness at the critical strain level an be interpolated / extrapolated



The vertical compressive strain was directly measured using pressure plates installed at the top of the subgrade.

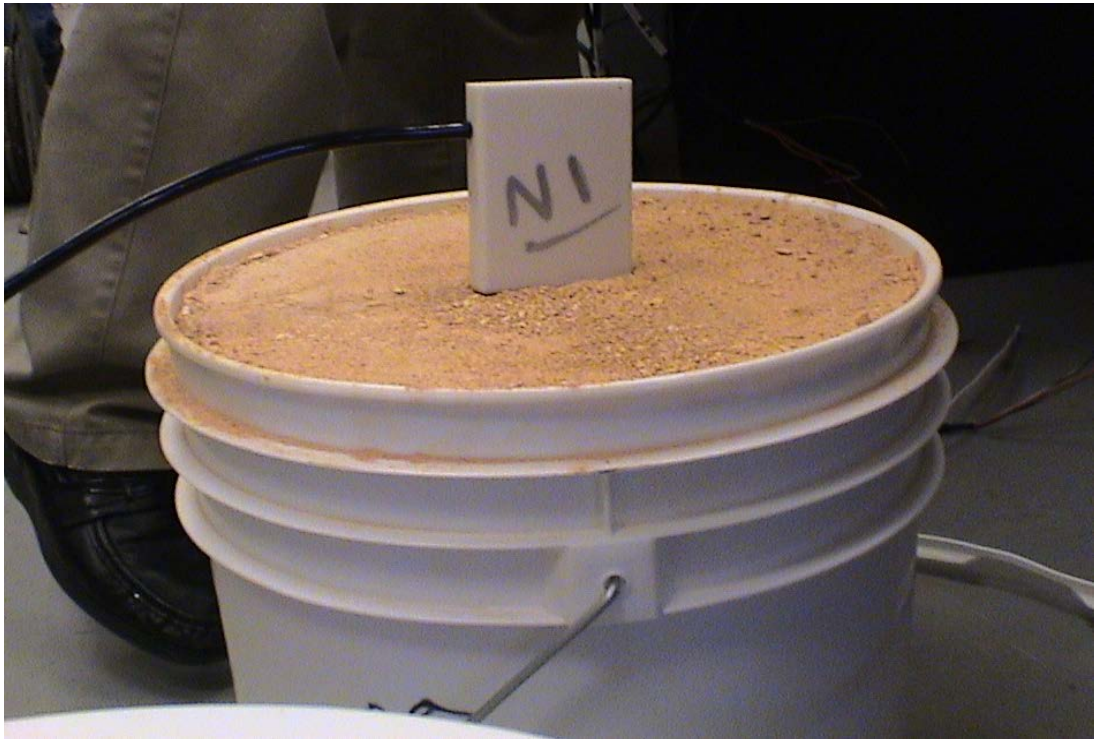


Instrumentation



Temperature probes are placed in the pavement to continuously monitor temperature at various depths

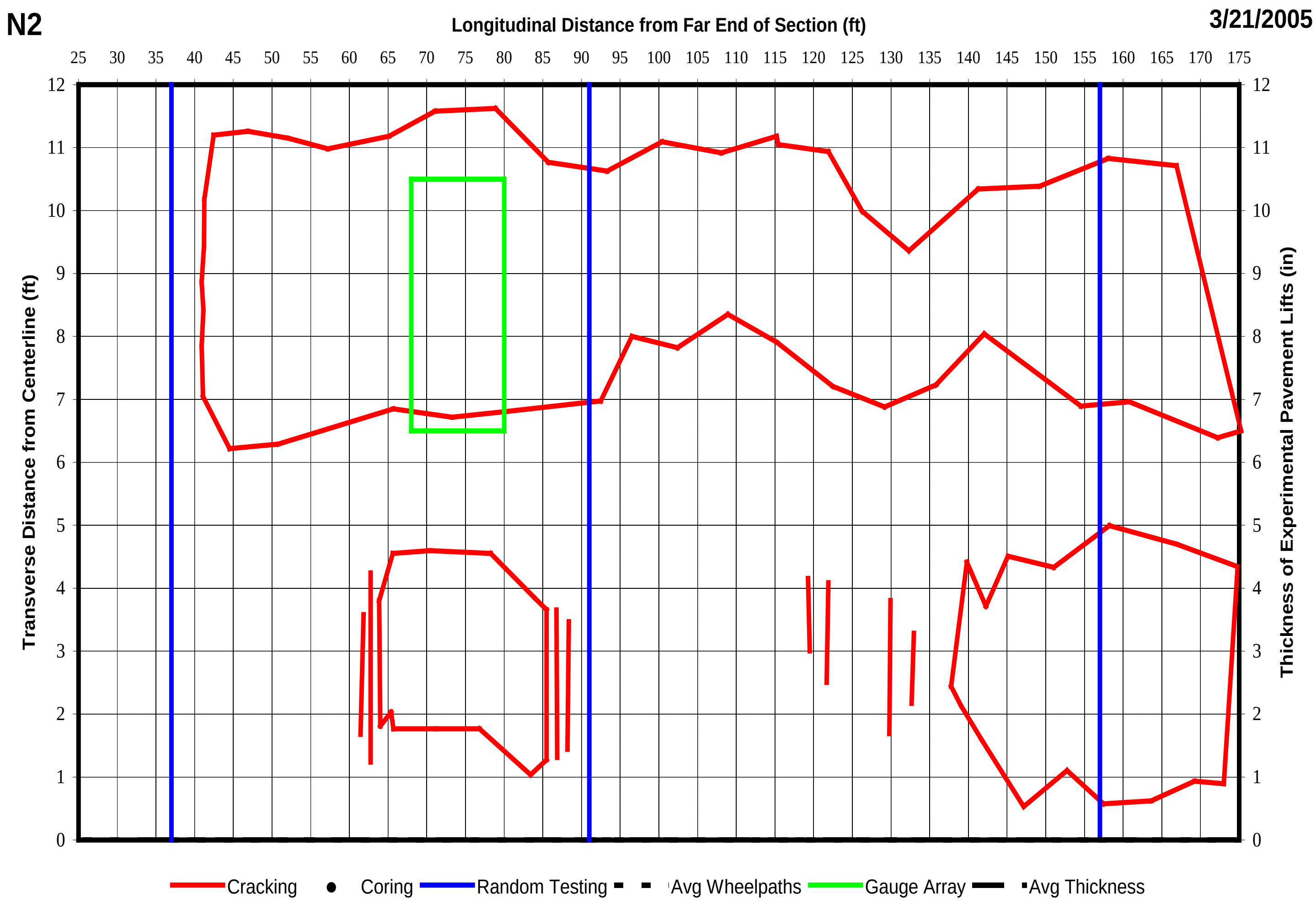
Moisture sensors were also placed in the subgrade to continuously monitor soil conditions



A datalogger was used to collect information from the different pavement sensors.

In addition to the normal “slow speed” mode that continuously gathers data, a “high speed” mode can be used to collect 40,000 data points per second.

Additional Testing – Surface Map Cracking



FWD Testing

Rut Testing

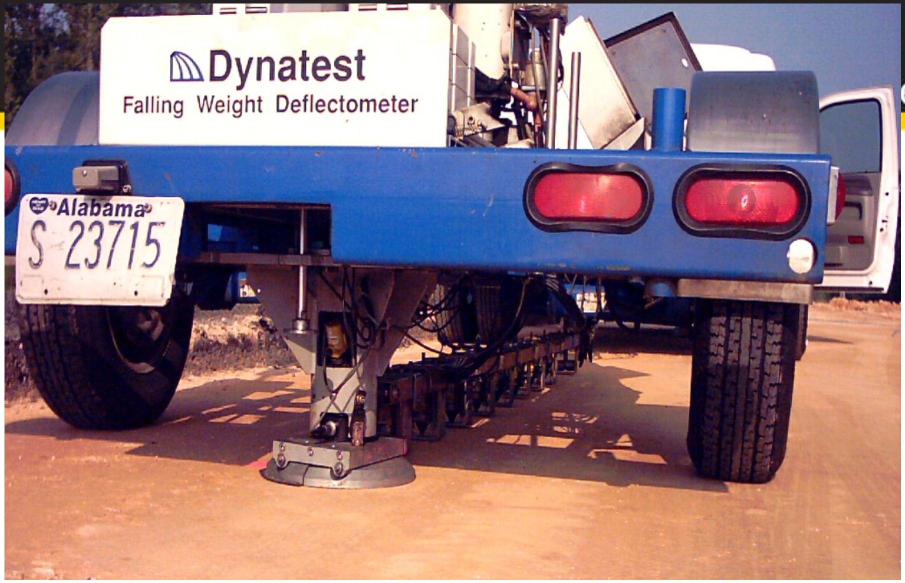
Skid Testing

Inertial Profiler –

Rutting

Smoothness

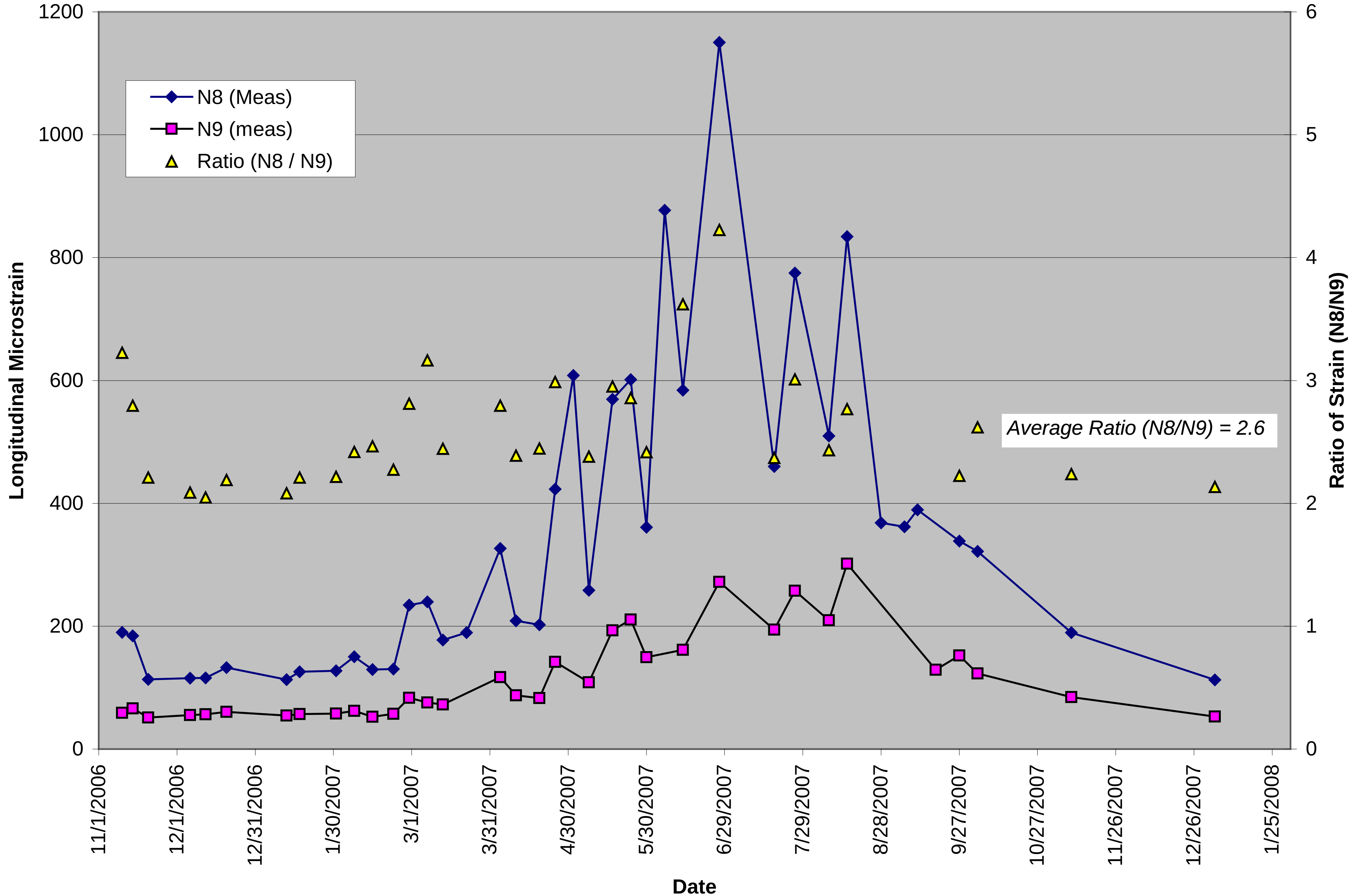
Surface Texture



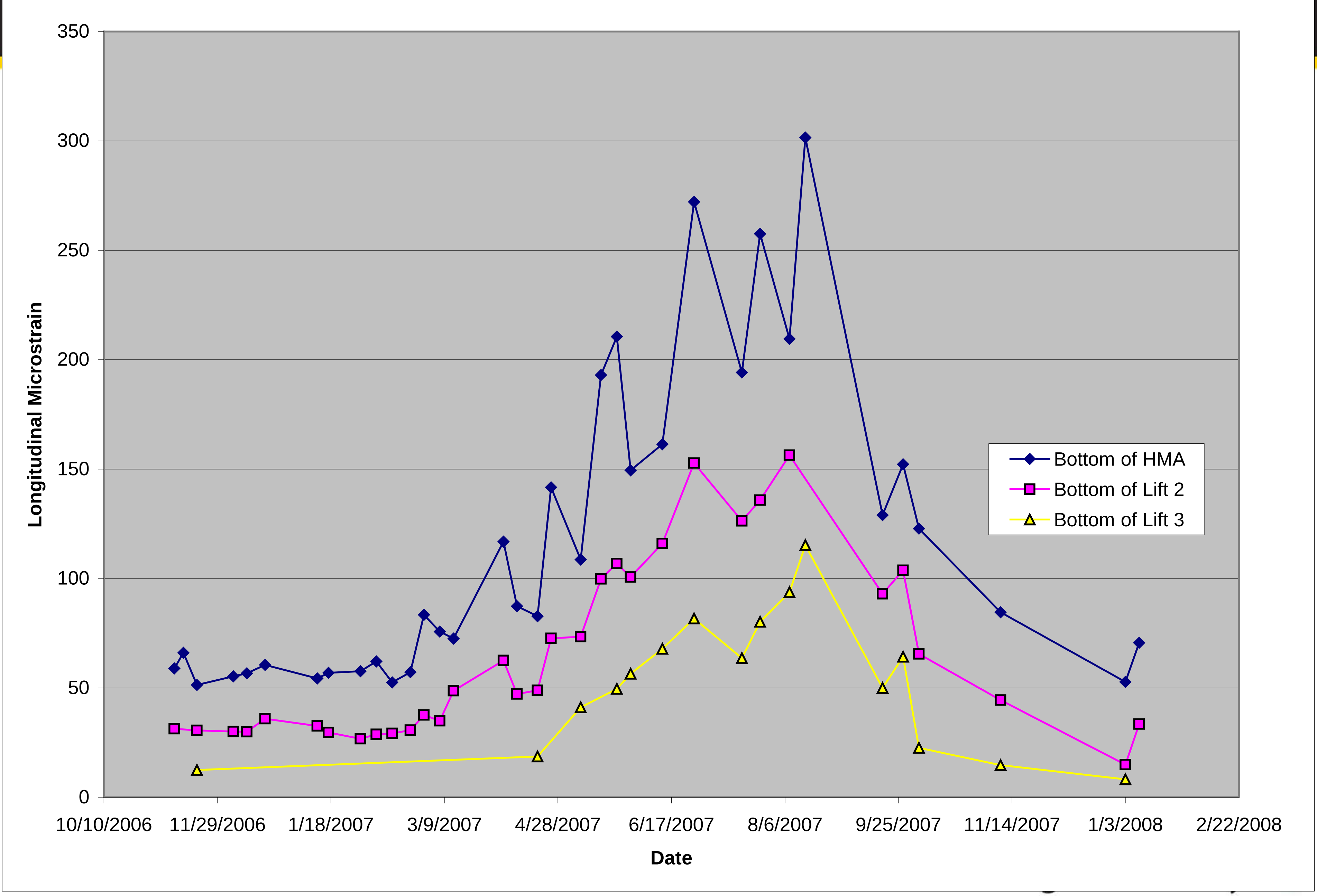

ROADTEC
SB-2500C


ROADTEC
ROADTEC
CARLSON

N8 and N9 – Strain vs. Date



Effect of Depth (N9)



Temperature Normalized Response

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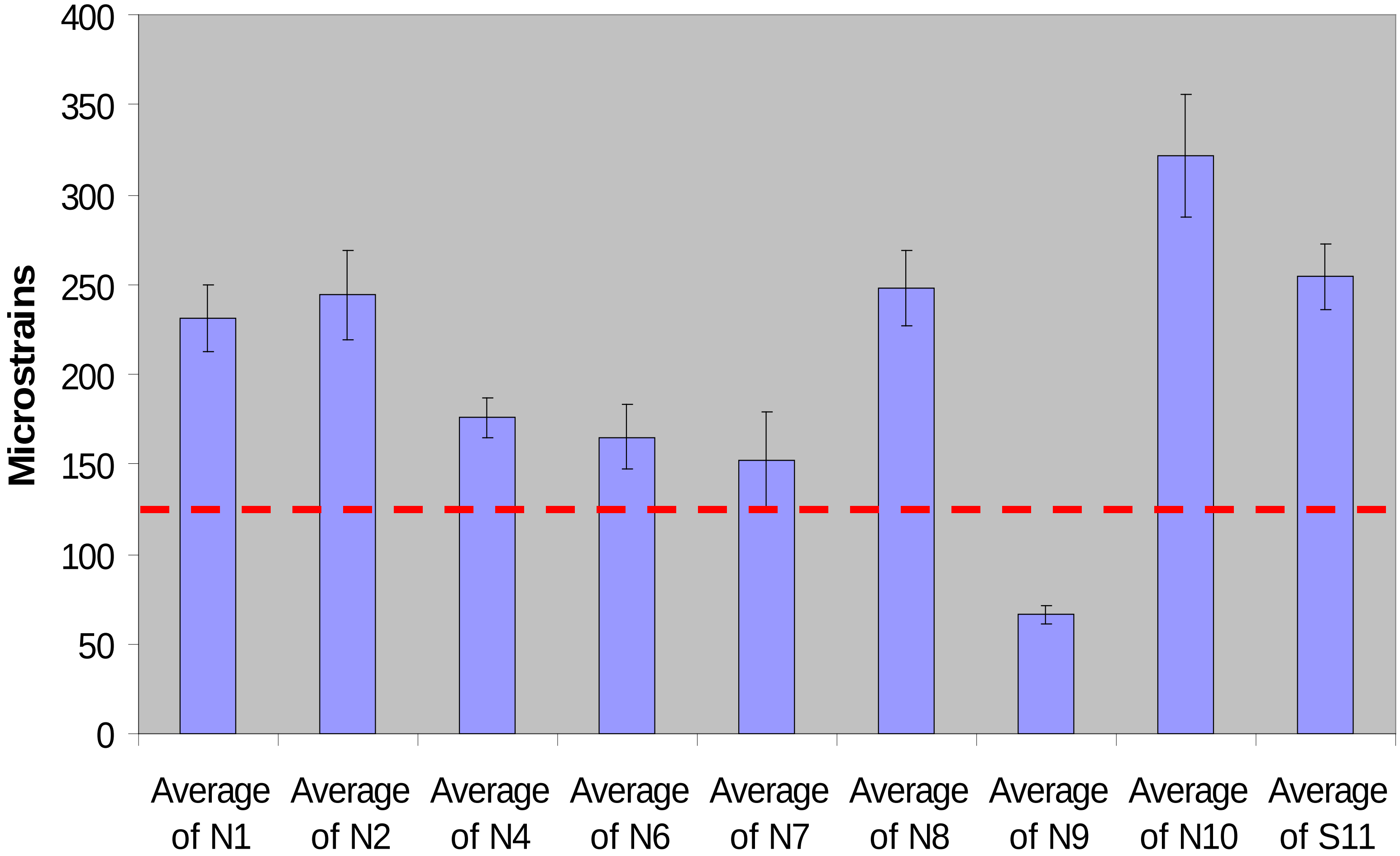
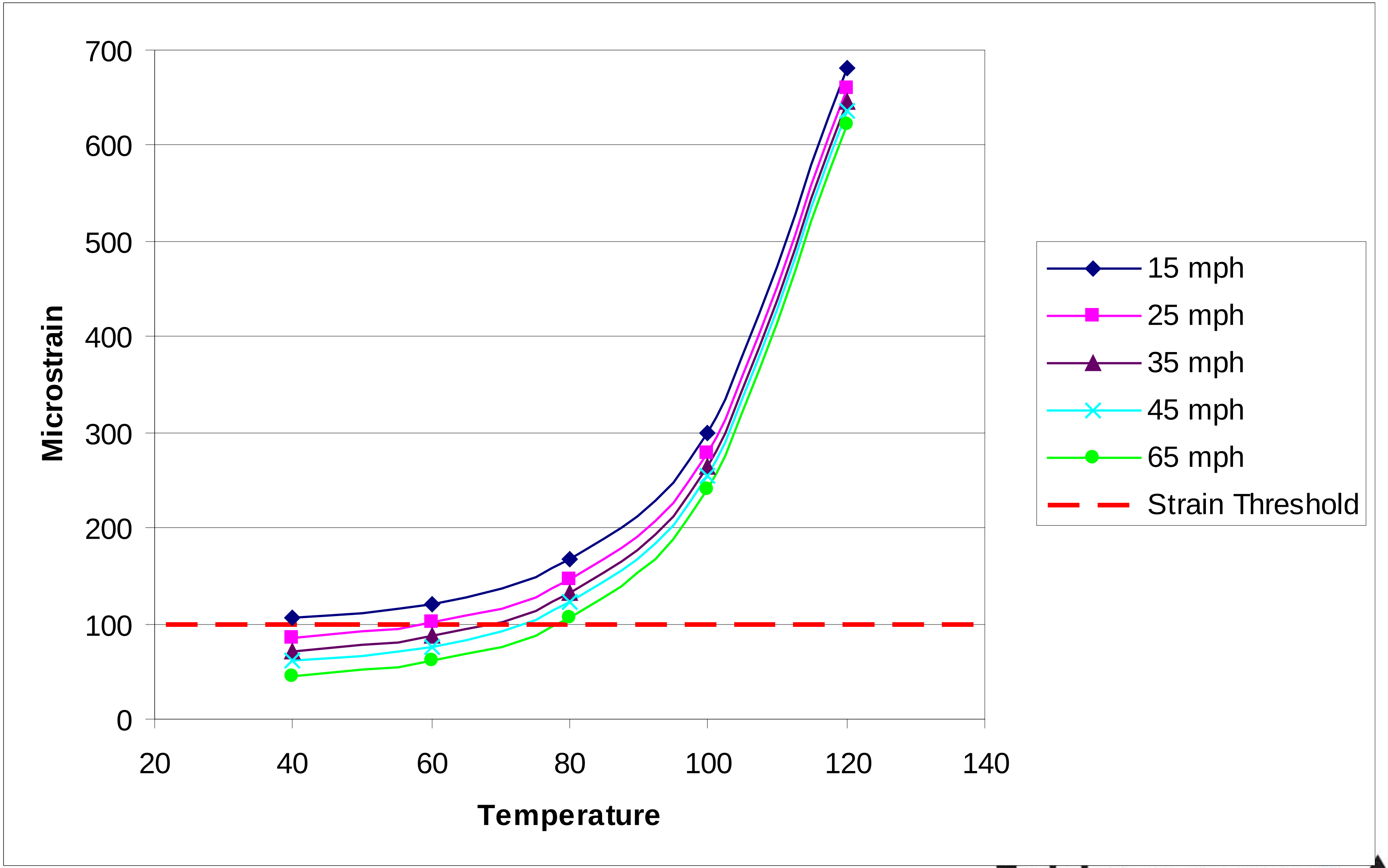
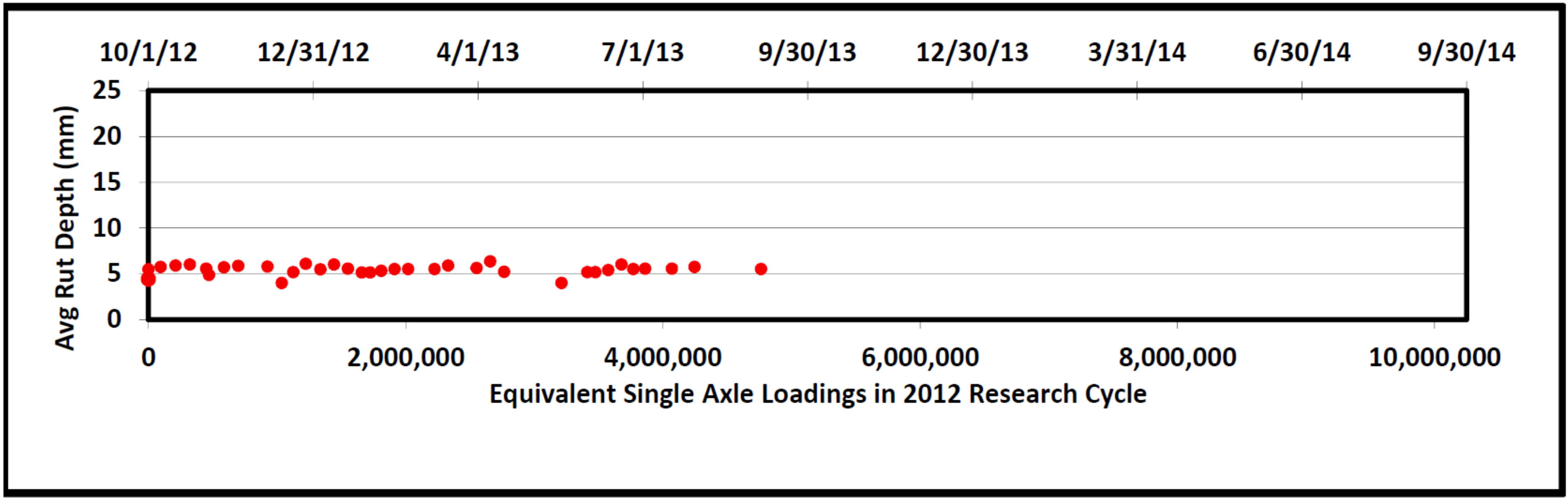


Strain Threshold



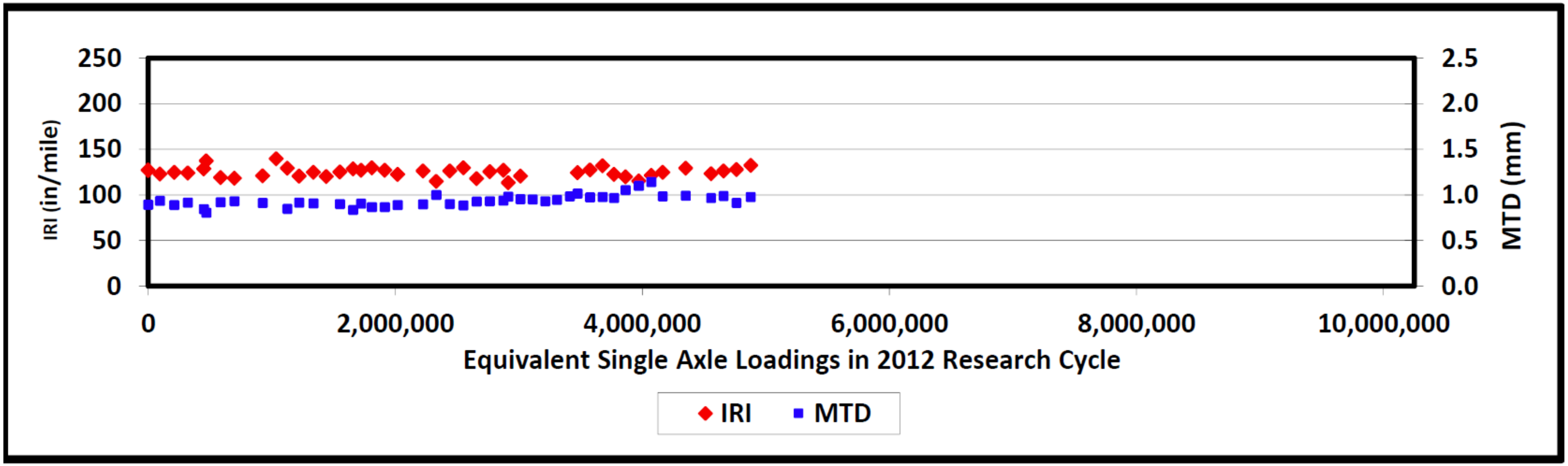
14" Section as of October 2013

Rut depth holding steady at about 5 mm



14” Section as of October 2013

Roughness holding steady



14” Section as of October 2013

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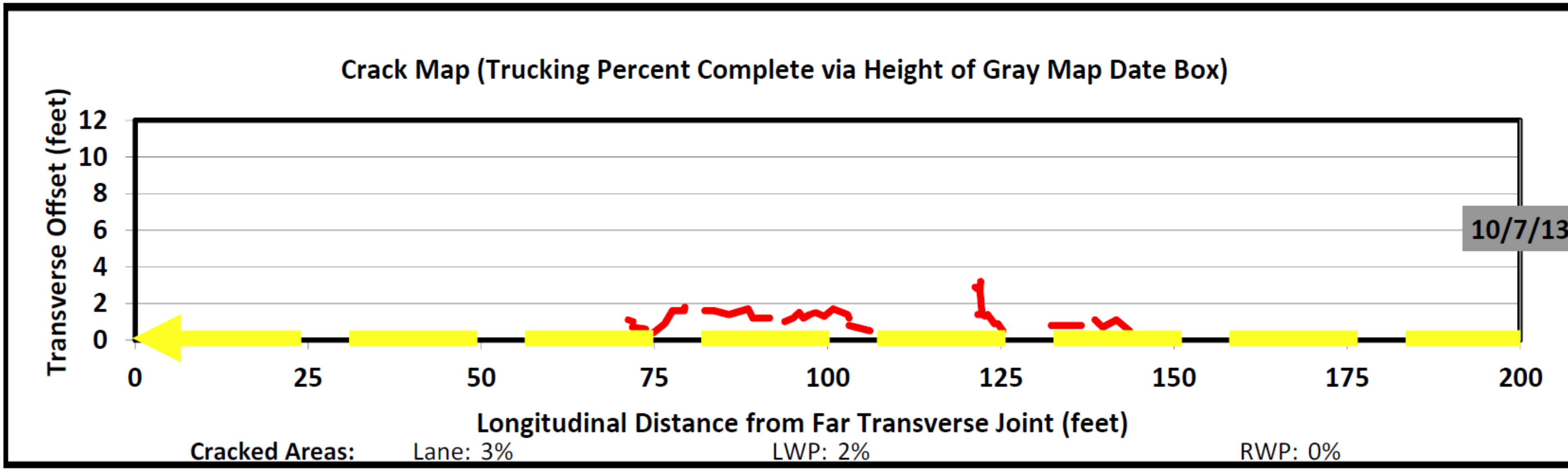

Top lift beginning to crack next to joint after 20 M ESALs

10" Failed after 10 Million ESALs

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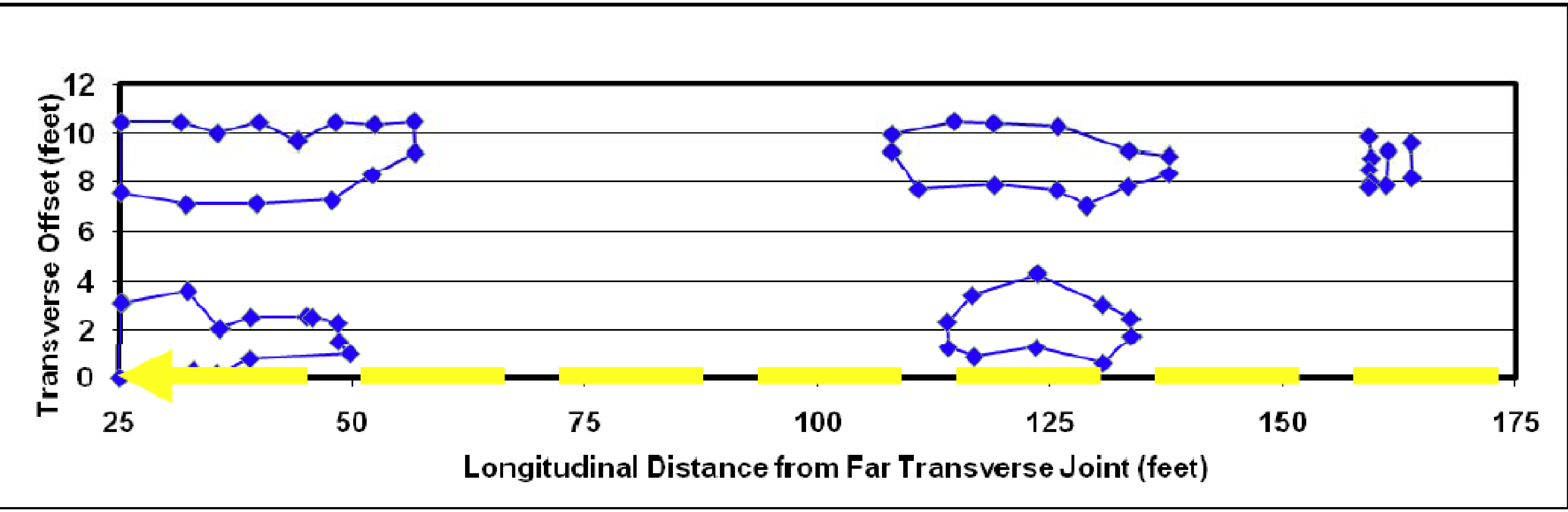
- **Top lift began to crack after 8 M ESALs**



Section N8 – June 29, 2010 – 4.0 M ESALs

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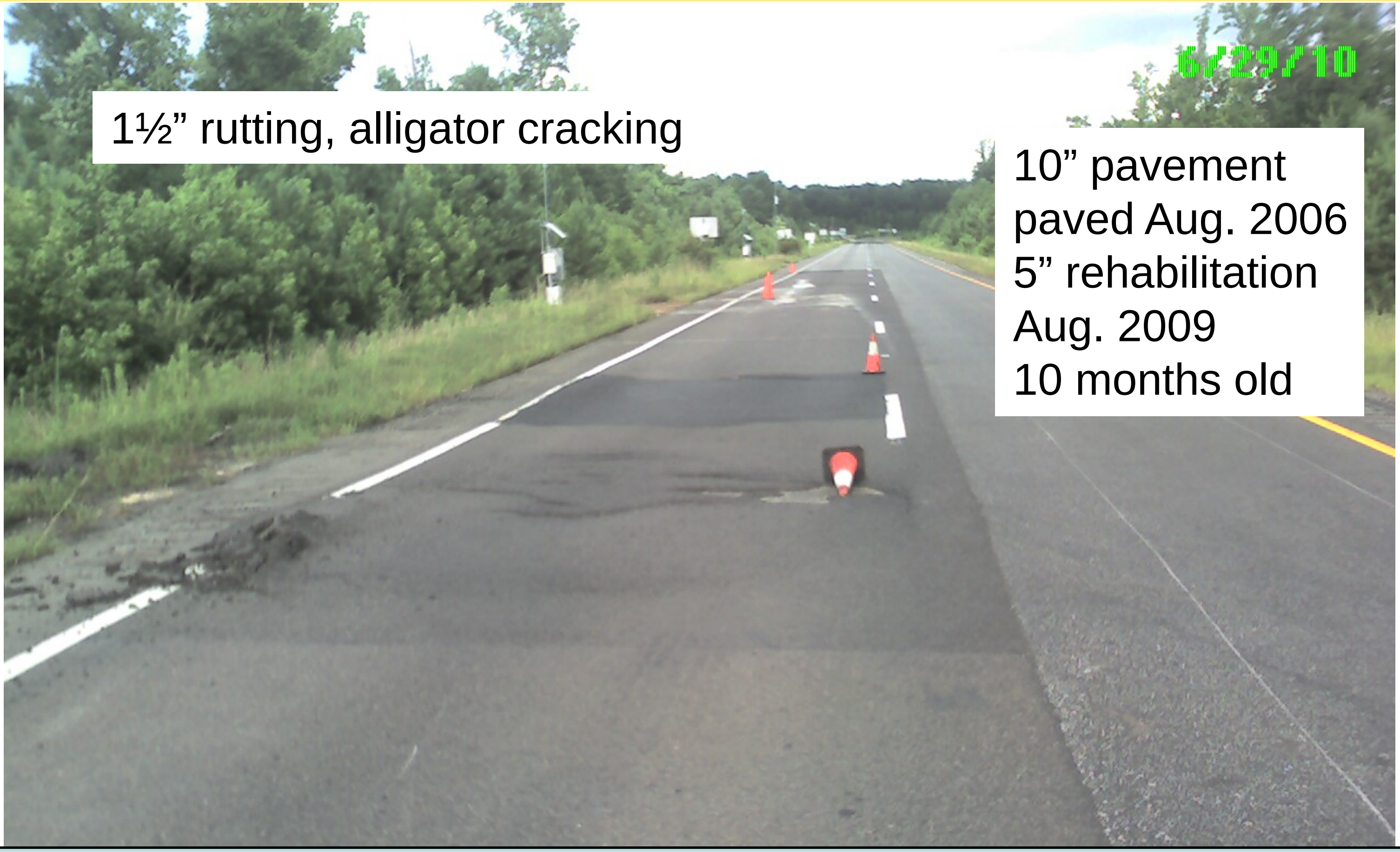


1½" rutting, alligator cracking

10" pavement
paved Aug. 2006
5" rehabilitation
Aug. 2009
10 months old

- 10" Section was milled and inlaid with two different fabric interlayers in August 2009
- Failure bad enough to reroute trucks after 10 months

Tested new rehabilitation strategy after seeing High Polymer Section in NCAT Group Experiment

Control (7" HMA)

1 ¼" (PG 76-22; 9.5mm NMAS; 80 Gyrations)

2 ¾" (PG 76-22; 19mm NMAS; 80 Gyrations)

3" (PG 67-22; 19mm NMAS; 80 Gyrations)

Experimental (5 ¾" HMA)

1 ¼" (Kraton Modified, 9.5 mm NMAS)

2 ¼" (7½% polymer;19mm NMAS; 80 Gyrations)

2 ¼" (7½% polymer;19mm NMAS; 80 Gyrations)

Dense Graded Crushed Aggregate Base
M_r = 12,500 psi
n = 0.40

Lift thicknesses limited by 3:1 thickness:NMAS requirement

6"

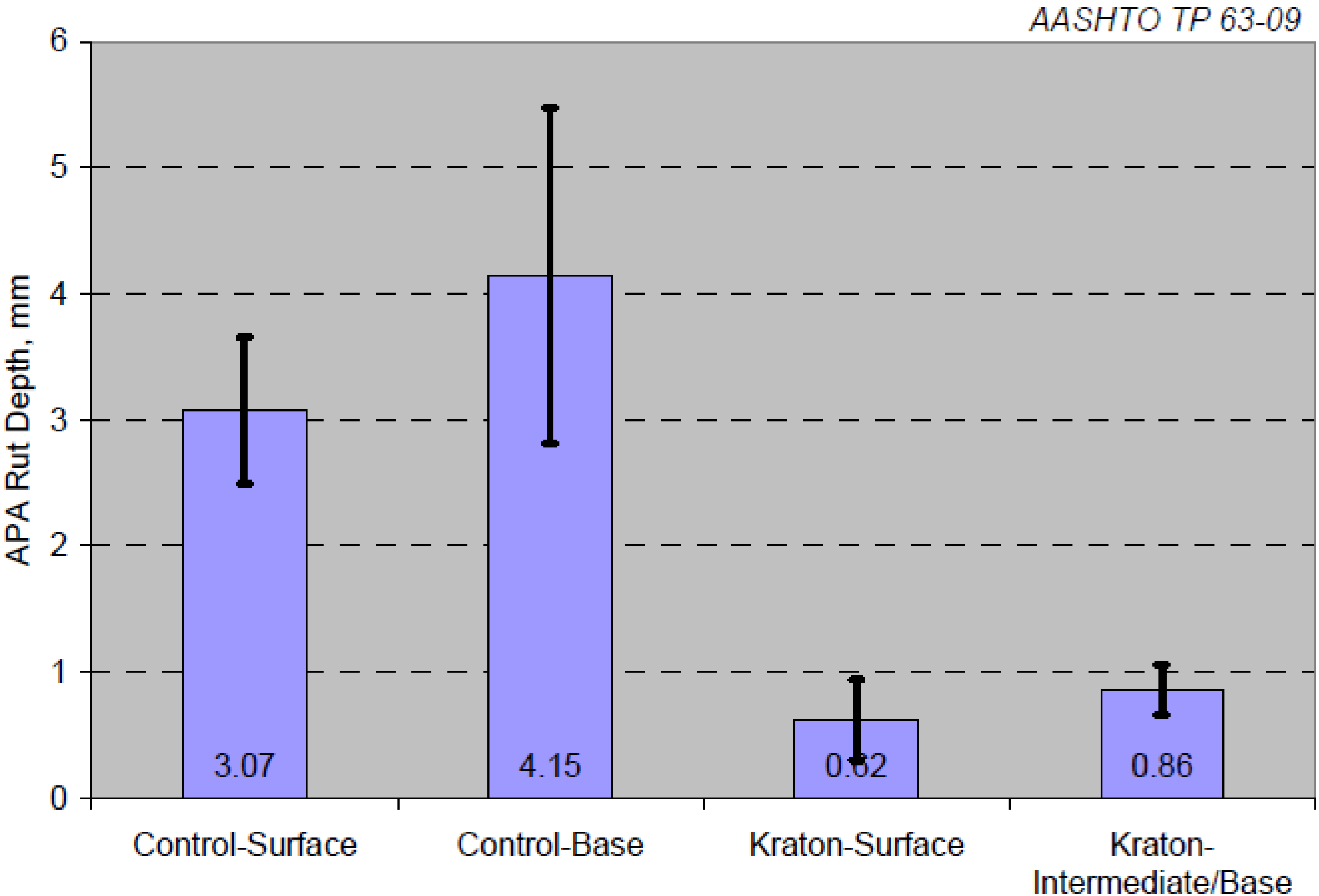
Test Track Soil
M_r = 28,900 psi
n = 0.45

Courtesy Prof. David Timm, Auburn U.

Simplified Viscoelastic Continuum Damage (S-VECD) Fatigue Testing

- Predicted fatigue life estimated 17x greater than control mixtures with PG 76-22
- Finding in agreement with previous beam fatigue testing

APA Rutting


AASHTO TP 63-09
APA Rut Depth, mm
0
1
2
3
4
5
6
3.07
4.15
0.62
0.86
Control-Surface
Control-Base
Kraton-Surface
Kraton-Intermediate/Base

Crack Mapping Control vs. Hi Poly

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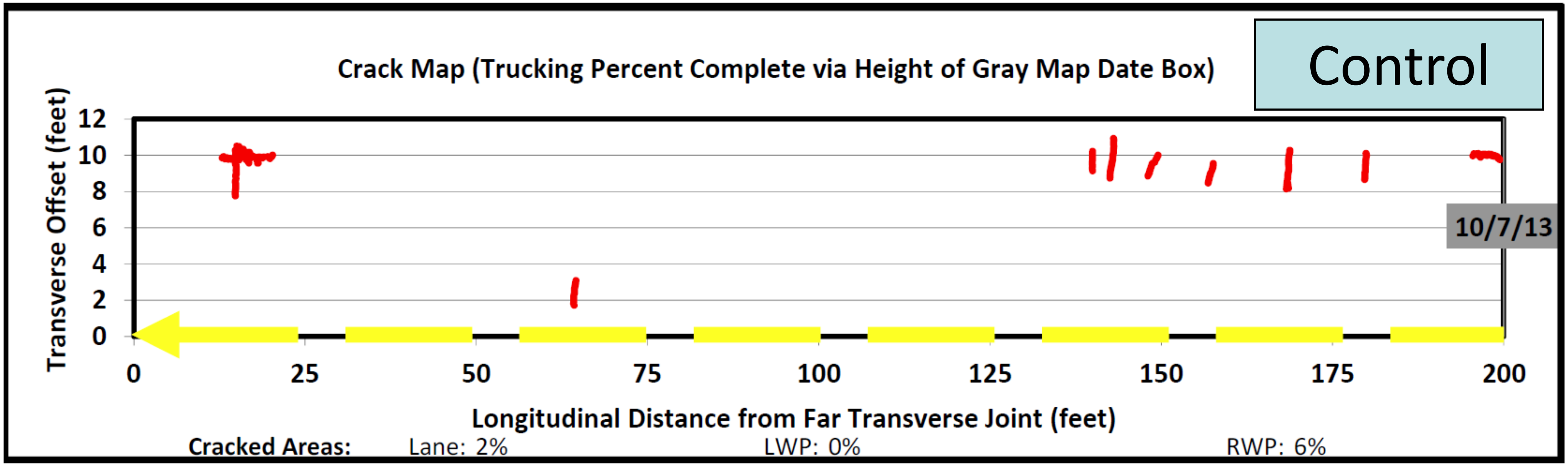
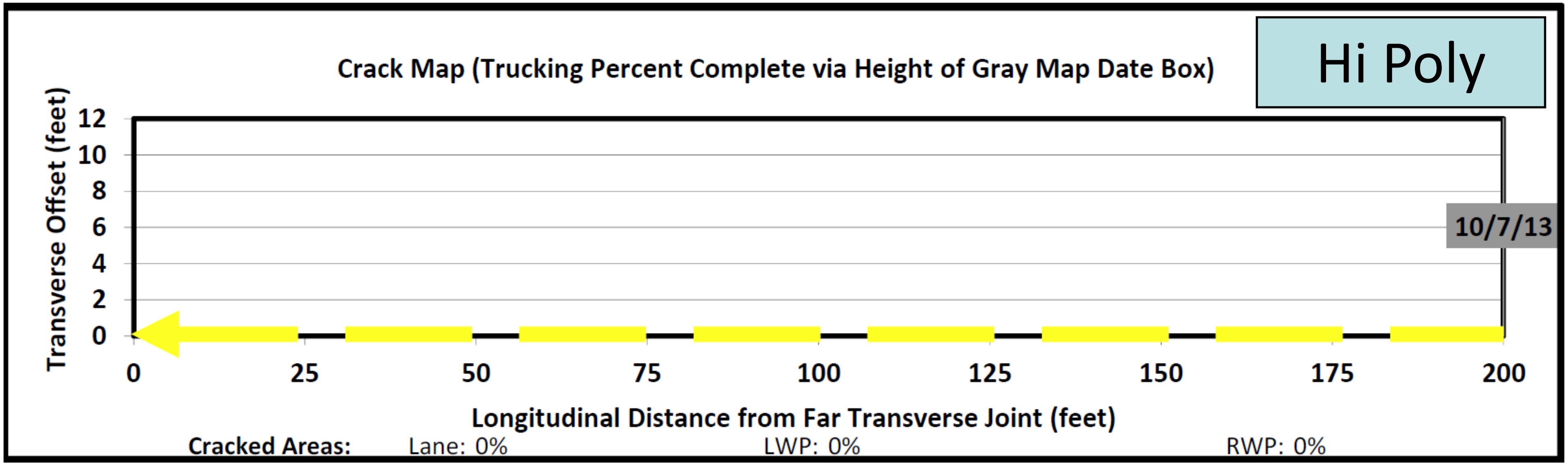
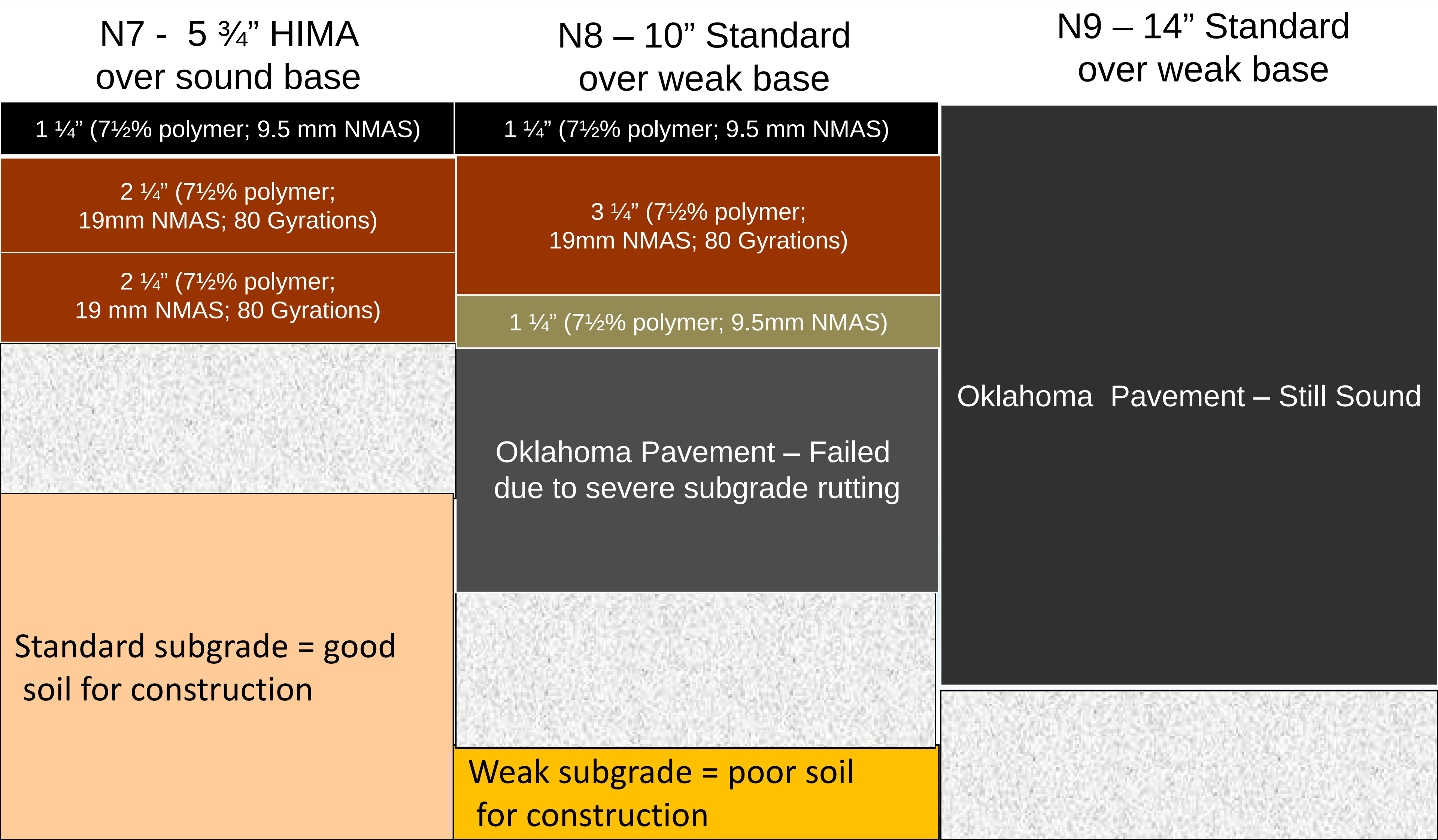




2009 NCAT Construction Cycle – August 2010

Kraton

Oklahoma proposed design modification



Change in performance

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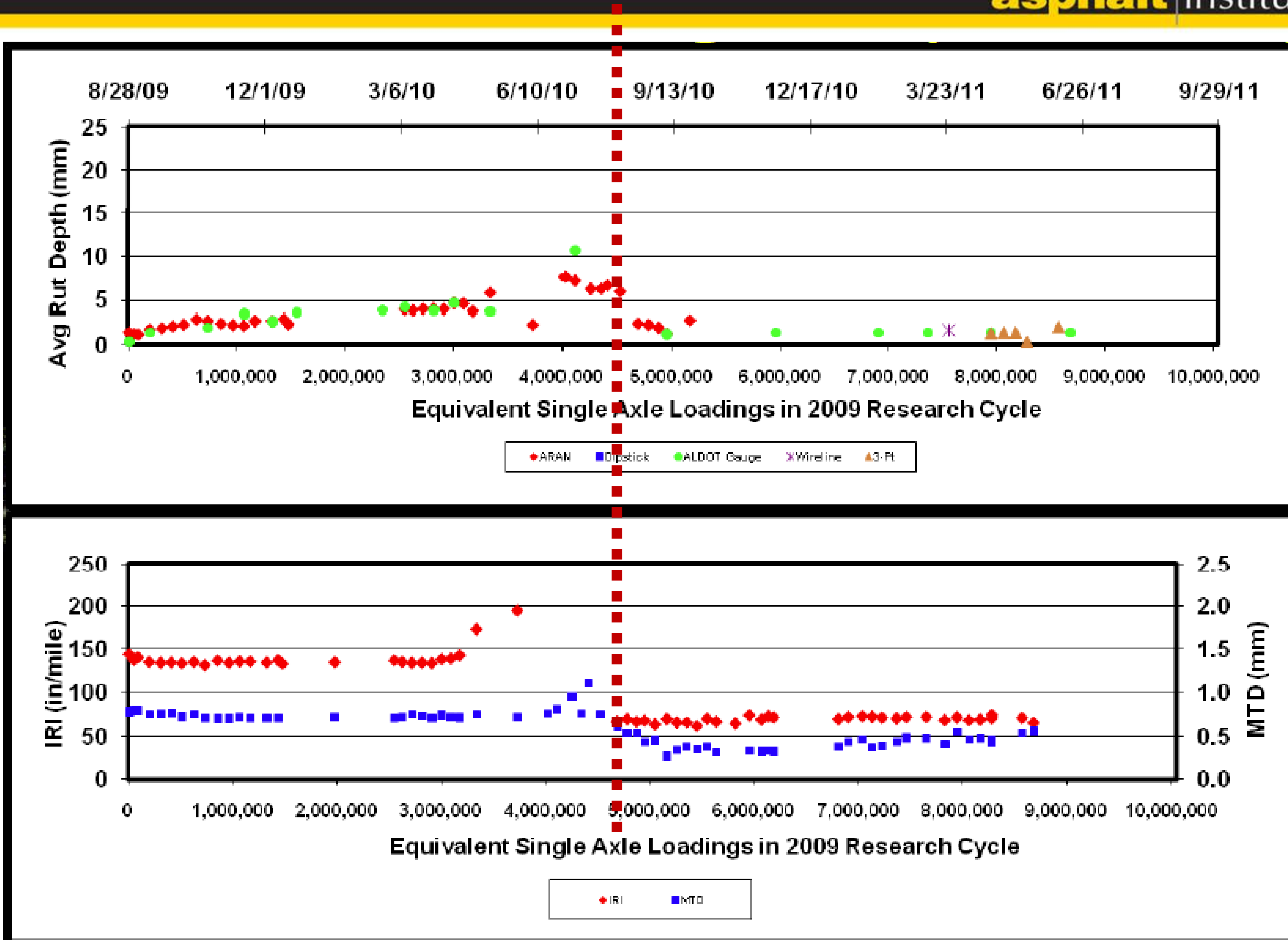

Training, so necessary.

Section N8 – Sept. 12, 2011 – 5.27 MM ESALs as of 5/31/13 – 9.1 MM ESALs

Similar crack appeared in first overlay at 2.7 MM ESALs
Oklahoma is sponsoring this section through the 2012 cycle to monitor further deterioration and evaluate preservation strategies.

QUESTIONS?

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