



Perpetual Pavement

Ohio Asphalt Paving Conference
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Outline

- The Perpetual Pavement Concept
- Interstate 77, Canton, Ohio
- US Route 30, Wooster, Ohio
- Interstate 86, Angelica, New York
- Indoor test, Accelerated Pavement Load Facility, Lancaster, Ohio
- Interstate 270, Columbus, Ohio
- Summary and Conclusions
- New Project

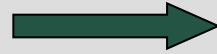


The Perpetual Pavement Concept

“an asphalt pavement designed and built to last longer than 50 years without requiring major structural rehabilitation or reconstruction, and needing only periodic surface renewal in response to distresses confined to the top of the pavement” (APA, 2002)

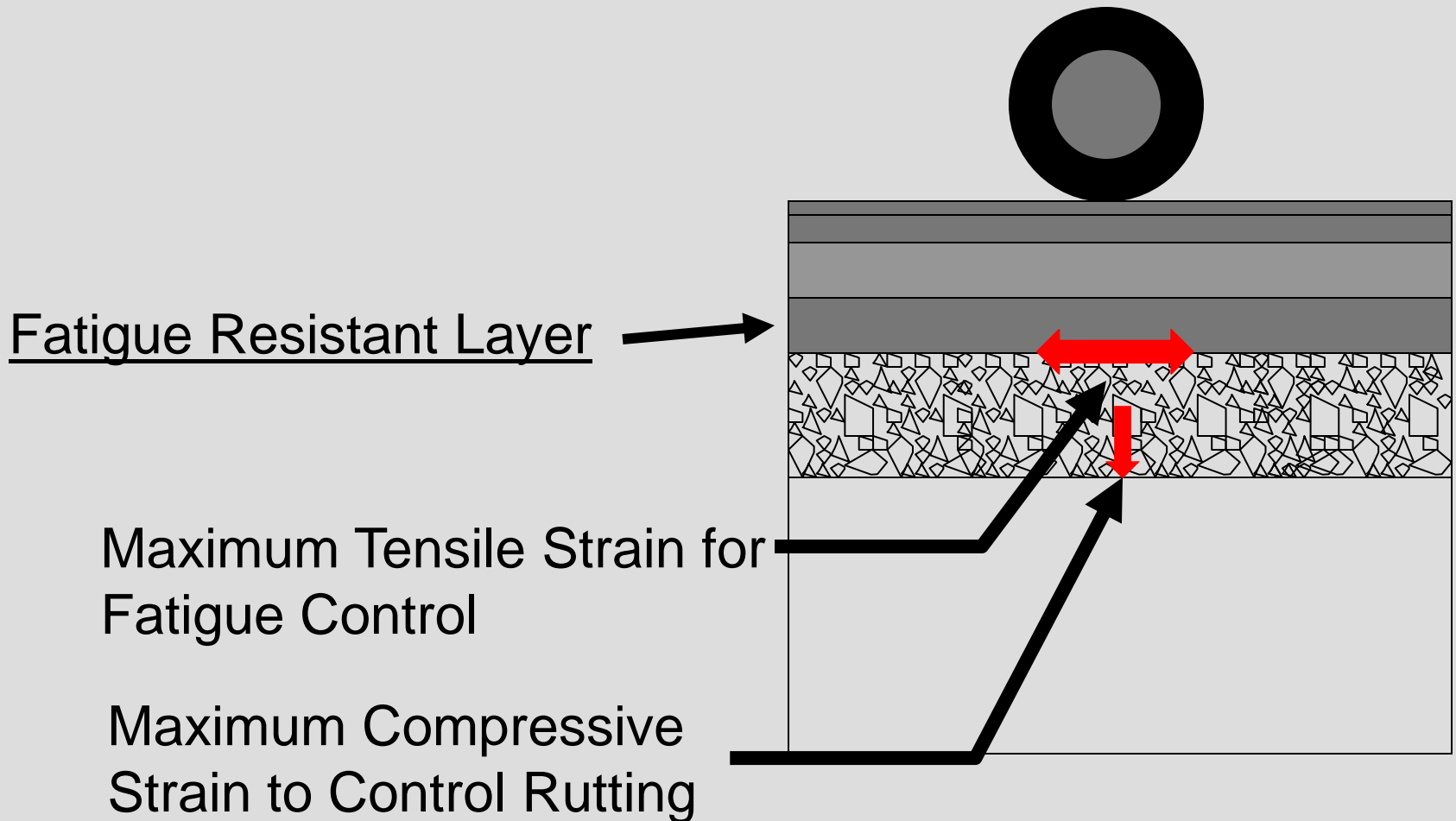
Perpetual Pavement

- No Fatigue Cracking or Subgrade Rutting



Structural Design

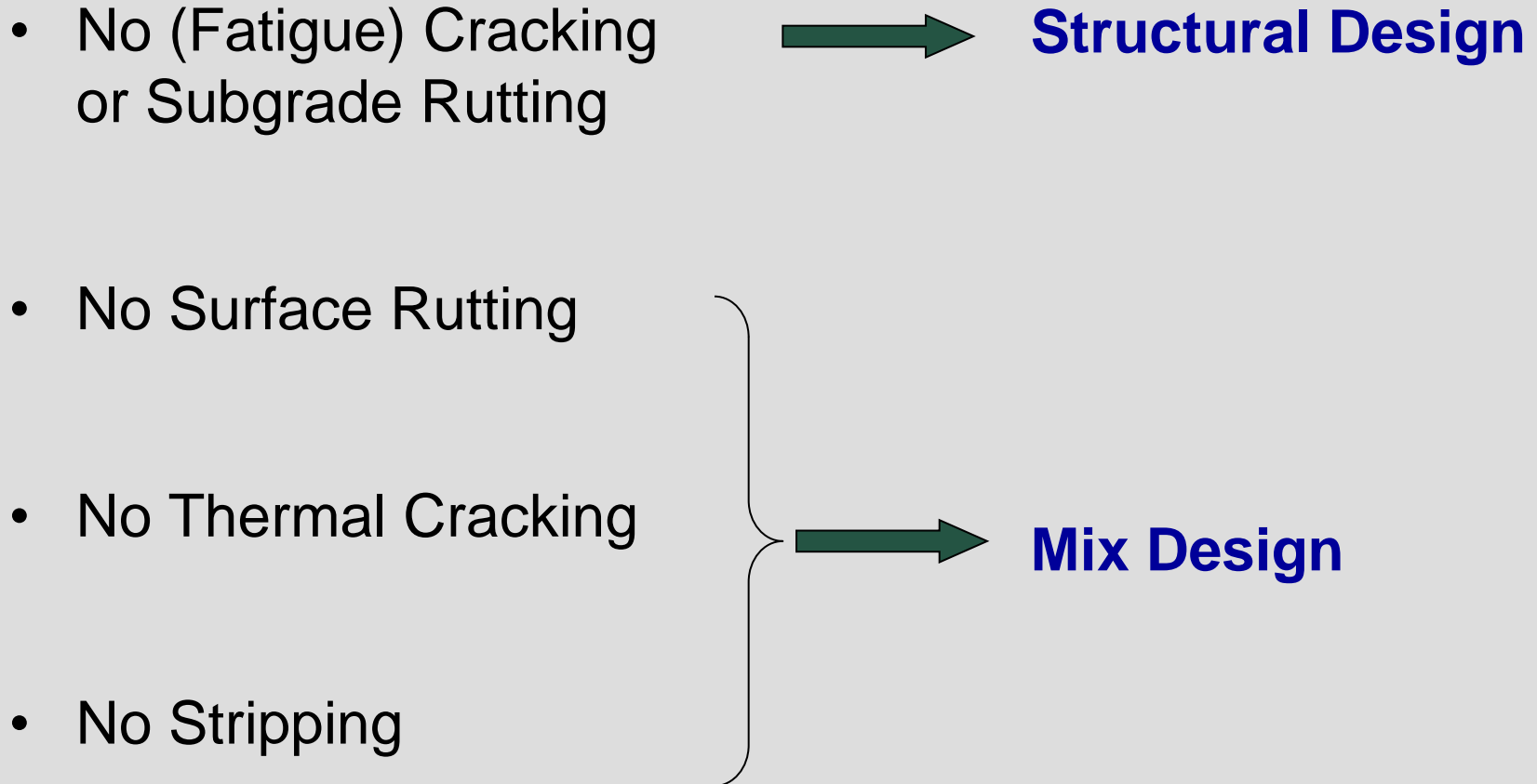
Perpetual Design Criteria



Perpetual Design Criteria

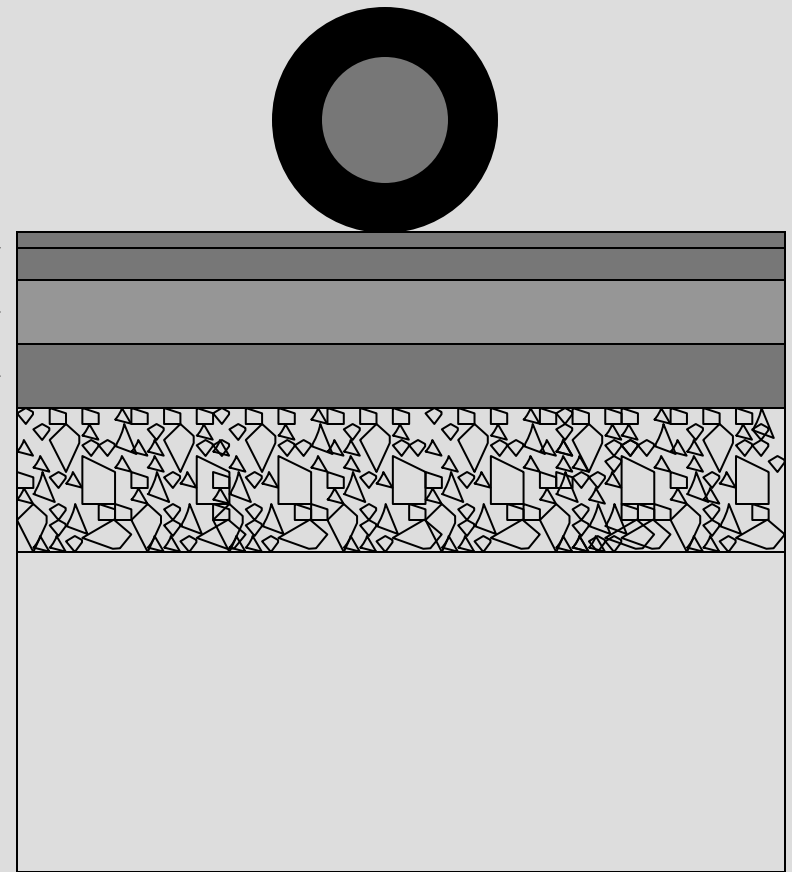
- Maximum subgrade compressive strain $< 200 \mu\epsilon$
- Maximum AC tensile strain $< 70 \mu\epsilon$
- Current research - endurance limit a function of
 - Temperature
 - Loading rate
 - Mix composition
 - Aging

Perpetual Pavement



Perpetual Design Criteria

Surface: High Performance →
Base: Economical & Durable →
Fatigue Resistant Layer →





Interstate 77, Canton (STA-77)

Project Information

- Project 454(2001)
- Project Length: 2.33 miles
- Contractor: Ruhlin Company
- Opened to Traffic: 11/7/2003
- Change order – replace 4" ATFDB with a fatigue resistant layer

STA 77 Asphalt Pavement Materials

Thickness (inches)	Material (ODOT item no. in parentheses)	Design Air Voids (%)	PG Binder	Properties
1.50	(856) Stone Matrix Asphalt Concrete, 12.5mm		76-22M	Durable Rut Resistant
1.75	(442) Asphalt Concrete Inter. Course, 19mm Type A		76-22M	Durable Rut Resistant
9	(302) Asphalt Concrete Base		64-22	Economical Stable
4	(302) Special Fatigue Resistant Base Layer	3.0	64-22	Fatigue Resistant
6	(304) Aggregate Base			Stable

STA-77 instrumentation

- The following instrumentation was installed in the NB right-hand driving lane near Station 234+00:
 - 6 Dynatest strain gauges 1 inch (2.5 cm) from the bottom of the 302 mix
 - 2 Pressure cells at the top of the subgrade
 - 2 Thermocouples near and at the same depth as the strain gauges
- Controlled vehicle tests were conducted on the late evening of December 15, 2003, due to high traffic.
- No further monitoring has been done at this site because of the high volume of traffic.



OHIO
UNIVERSITY

2011 Distress Survey





US Route 30, Wooster

(WAY-30)

Project Information

- Project 44(2004)
- Project Length: 7.97 miles
- Contractor: Beaver Excavating Company
- Asphalt Paving Subcontractor: Shelly and Sands
- Total Cost: \$47.2 million
- Opened to Traffic: 12/19/2005

US 30 Asphalt Pavement Materials

Thickness (inches)	Material (ODOT item no. in parentheses)	Design Air Voids (%)	PG Binder	Properties
1.25	(856) Stone Matrix Asphalt Concrete, 12.5mm	3.5	76-22M	Durable Rut Resistant
1.75	(442) Asphalt Concrete Inter. Course, 19mm Type A	4.0	76-22M	Durable Rut Resistant
9	(302) Asphalt Concrete Base	4.5	64-22	Economical Stable
4	(302) Special Fatigue Resistant Base Layer	3.0	64-22	Fatigue Resistant
6	(304) Aggregate Base			Stable

Test Section at Geyer's Chapel



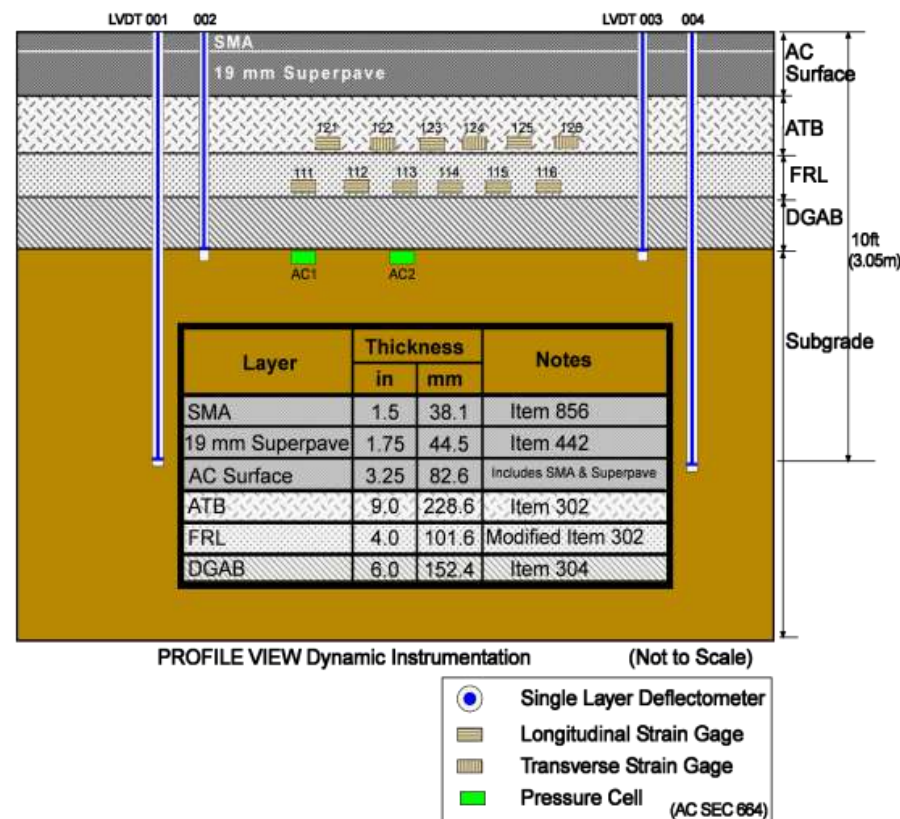
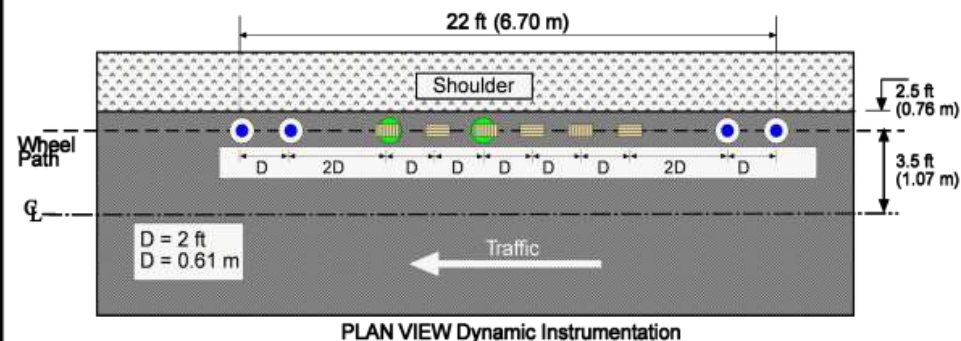
Test Section at McQuaid Road



US30 Instrumentation Layout

AC sections

- **ATB Layer:** 3 longitudinal & 3 transverse sensors that monitor cracking resulting from the use of the flexible material in the FRL.
- **FRL:** 6 longitudinal sensors that monitor resistance to fatigue.
- **Pressure Cells** above the subgrade measure vertical stress and monitor rutting.
- **LVDTs** measure vertical pavement deflections.



Strain Gauge Installation



Large aggregate is removed by sieve, then asphalt is placed over gages prior to paving.

WAY-30 Project

Test Procedures (CVL)

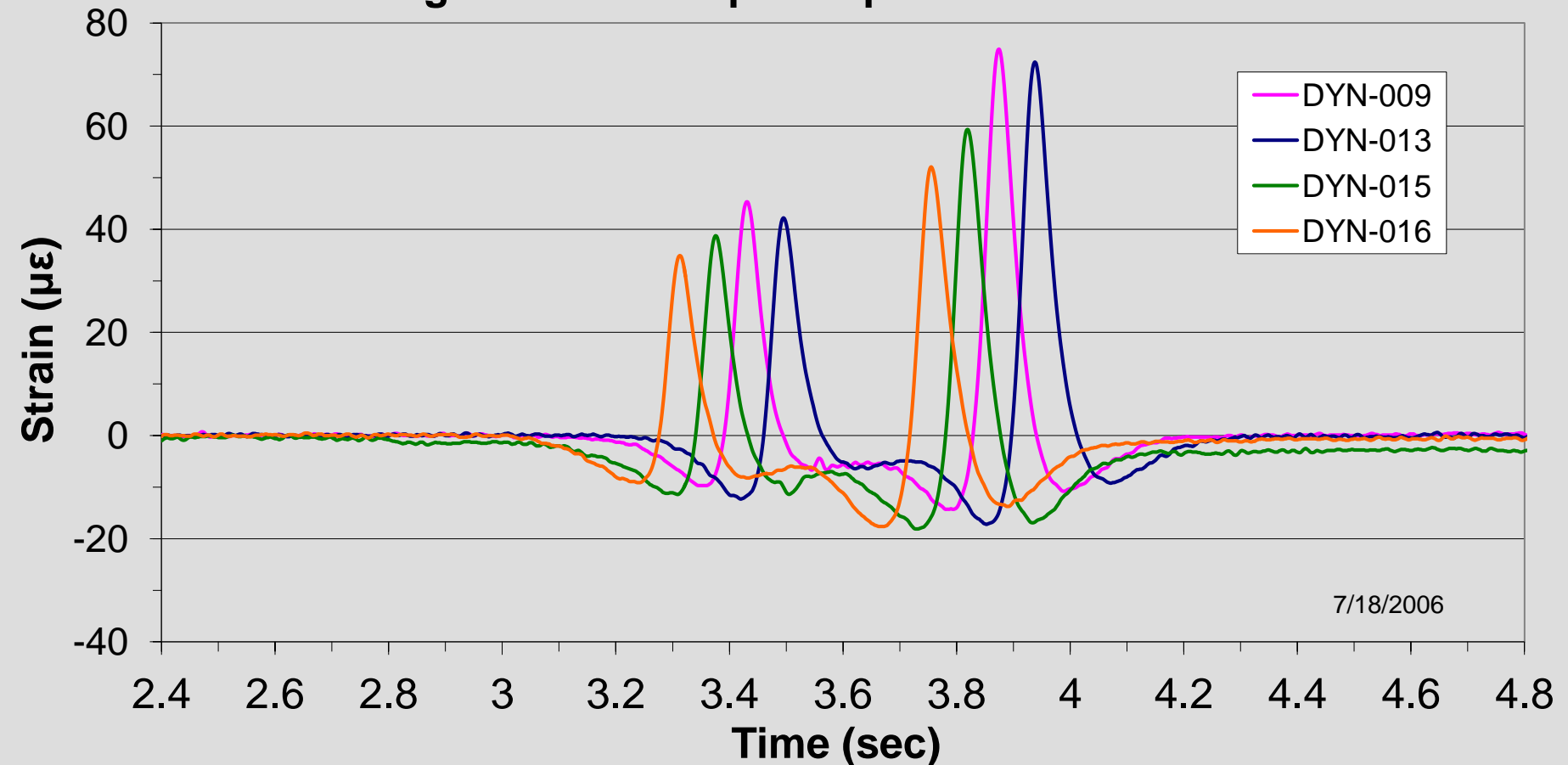


Section construction- WAY-30 Project

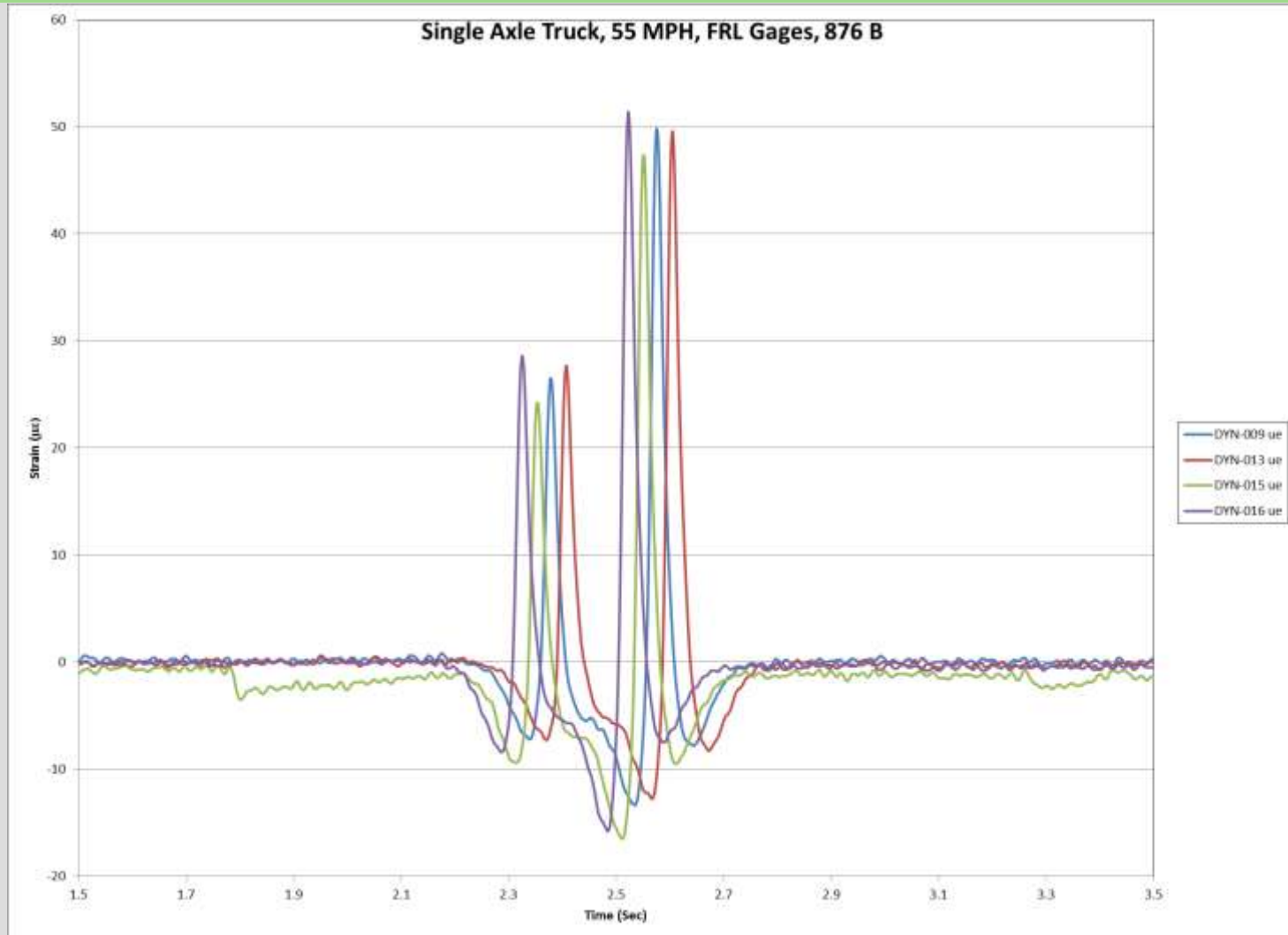
- The Controlled Vehicle Load (CVL) testing was used to record the dynamic load response of the pavement under traffic conditions.
- Tests were performed at speeds of 5, 25 or 30, 45, and 55 mph using 3 test runs per speed per truck.
- Three trials of the CVL test have been performed; December 2005, July 2006, and May 2008.

Controlled Vehicle Load Test

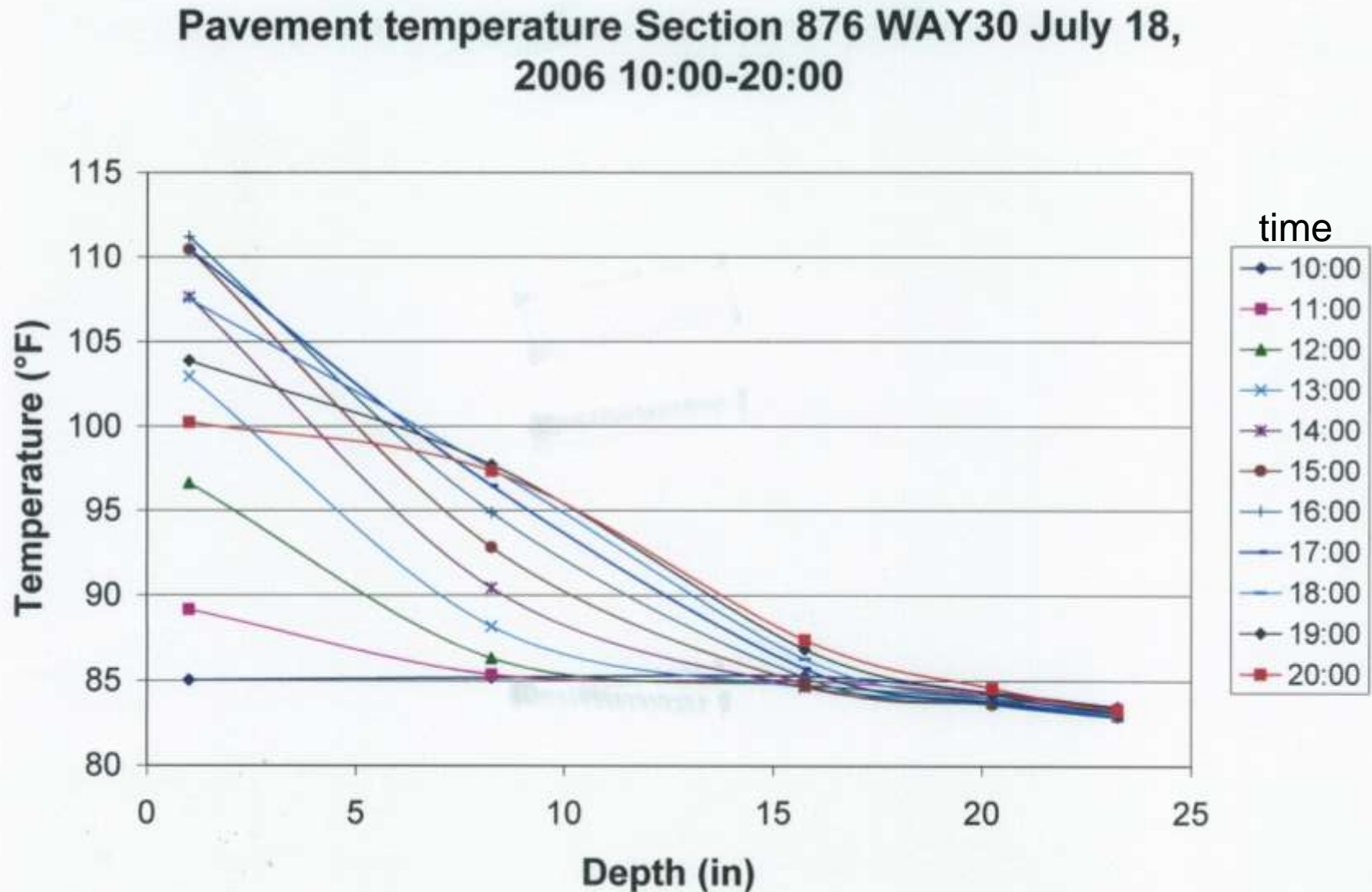
Longitudinal Strain in Fatigue Resistance Layer –
Single Axle 20.5 kip 25 mph – AC 876B – Run 3



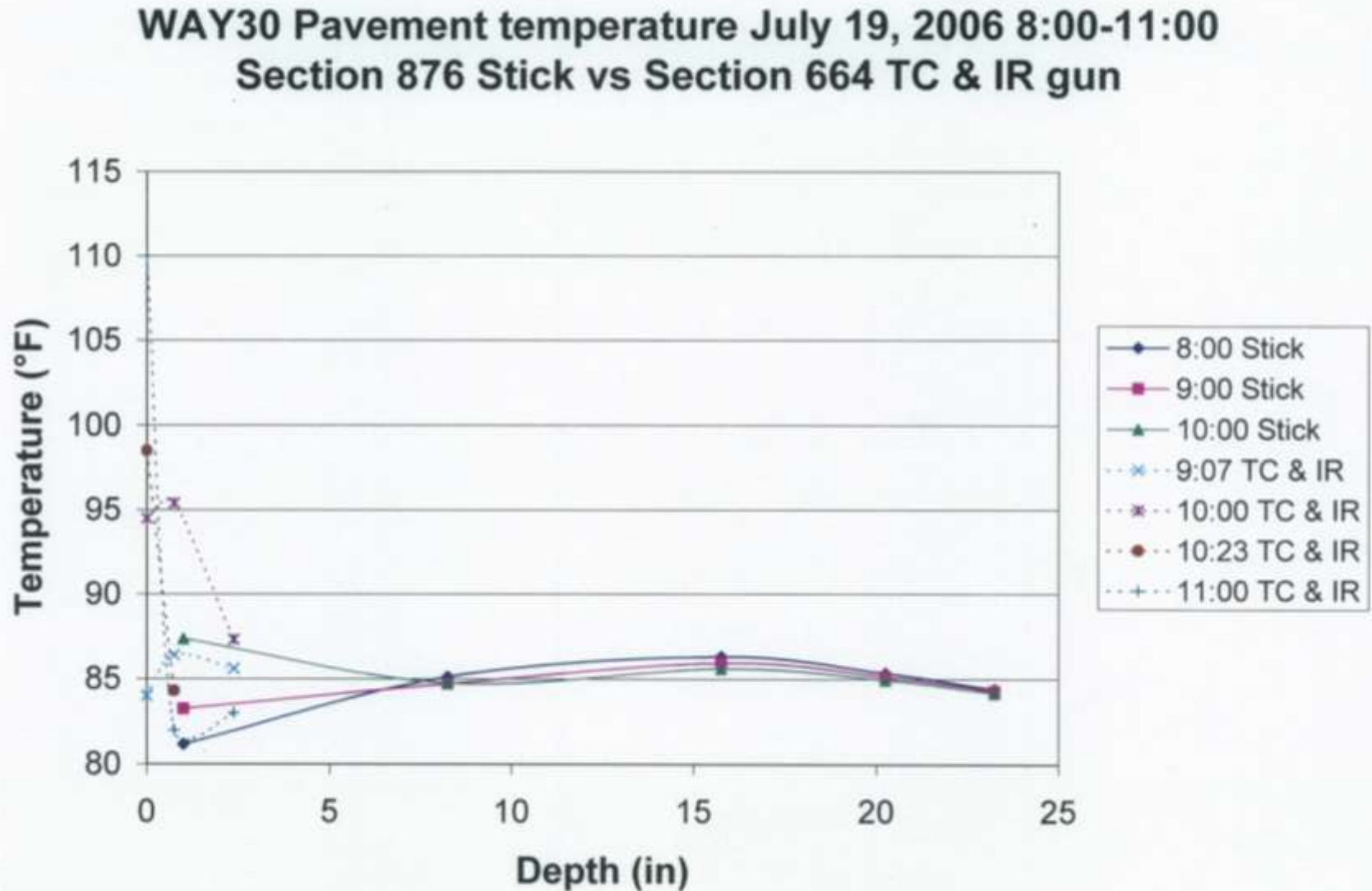
Controlled Vehicle Load Test



WAY-30 pavement temperature as a function of depth



WAY-30 pavement temperature as a function of depth



WAY-30 Observations

Fatigue Resistance Layer

- During December truck load tests, longitudinal strain on FRL remained $\leq 35\mu\epsilon$, even at slowest speed
- During July tests at highway speeds of 45 mph (72 km/h) and 55 mph (89 km/h), the strain in the FRL remained close to the design value under even the heaviest loads
 - In everyday use, such high-load strains will be rare
 - High-load strains at slower speeds will be even more rare (during traffic stoppage or slowdowns), though these did exceed design strain

WAY-30 Observations

Intermediate Layer and Subgrade

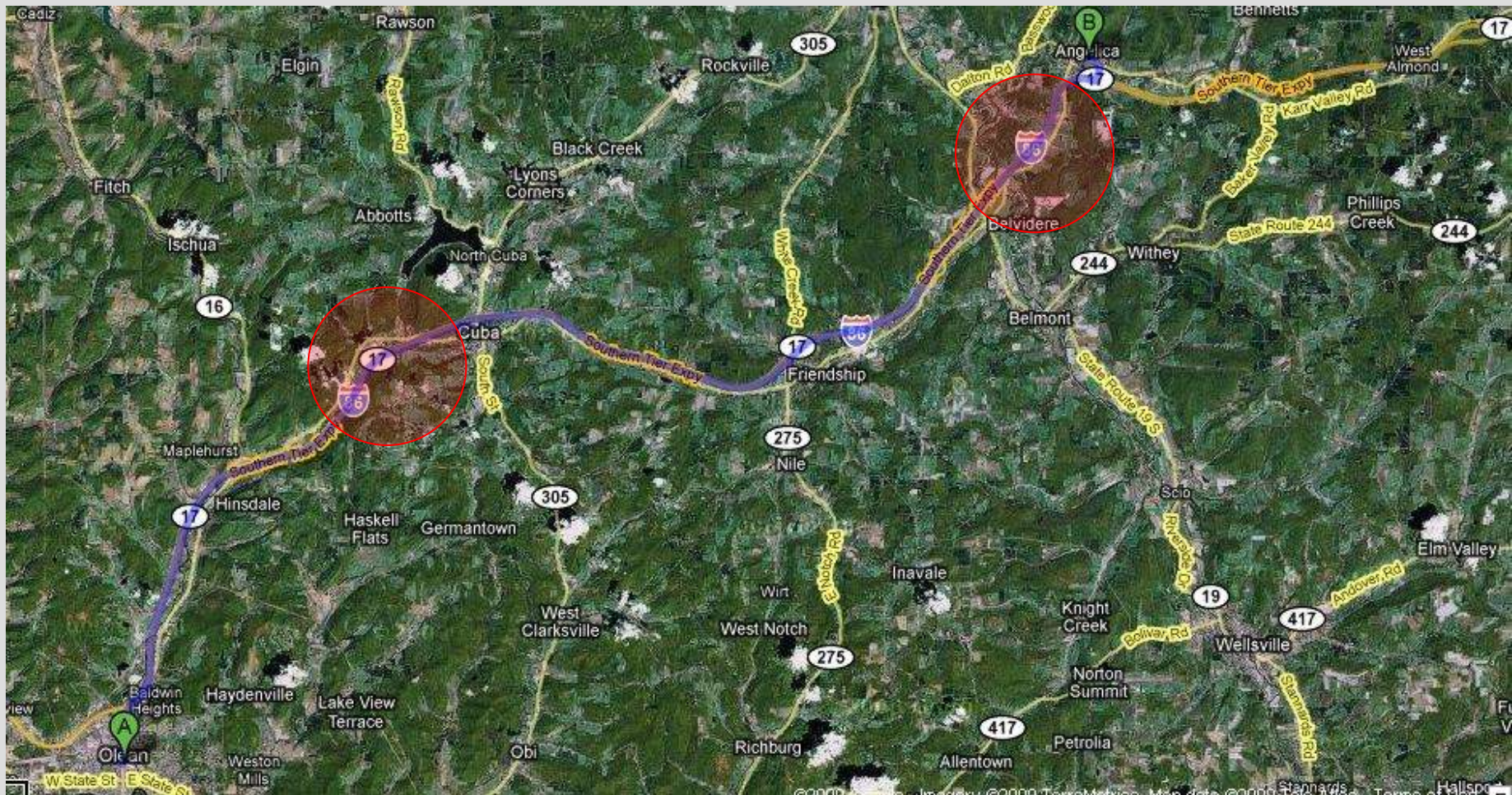
- Strains at bottom of intermediate layer are lower than at bottom of FRL, as expected.
- Maximum subgrade observed pressure during truck load tests were 6.5 psi (45 kPa) at 45 mph (72 km/h) under 40 kip (178 kN) tandem axle load.



Interstate 86, Angelica, NY

NY-I86 Sections Locations

AC Sections - Cuba & Angelica, NY



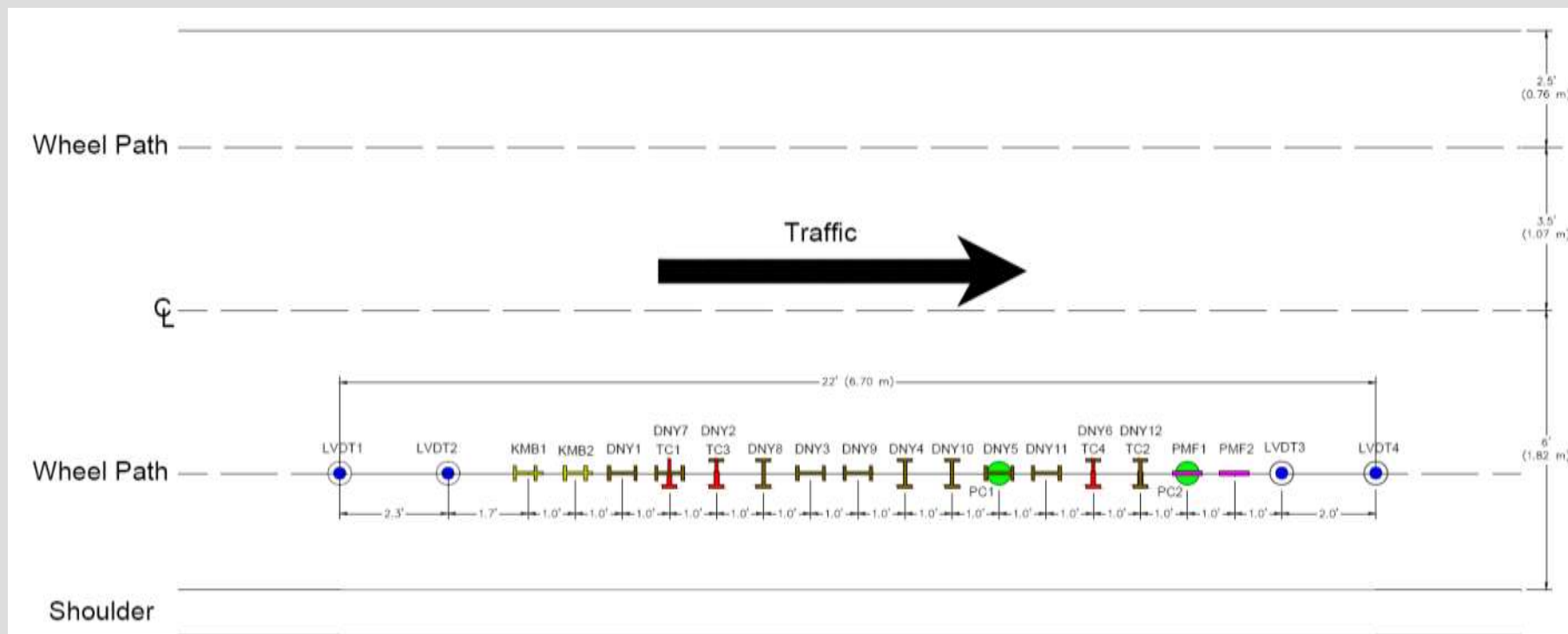
From Google Maps

NY-I86 AC Perpetual Pavement Build-up

Thickness (in (mm))	Material
1.57 (40)	Superpave HMA 9.5 mm F9 50 Series
3.94 (100)	Superpave HMA 19 mm F9 50 Series (two lifts)
3.55 (90)	Superpave HMA 25 mm F9 50 Series
9 (229)	Rubbilized concrete pavement (JRCP)
-	Subgrade soil

NY-I86 Instrumentation Plan

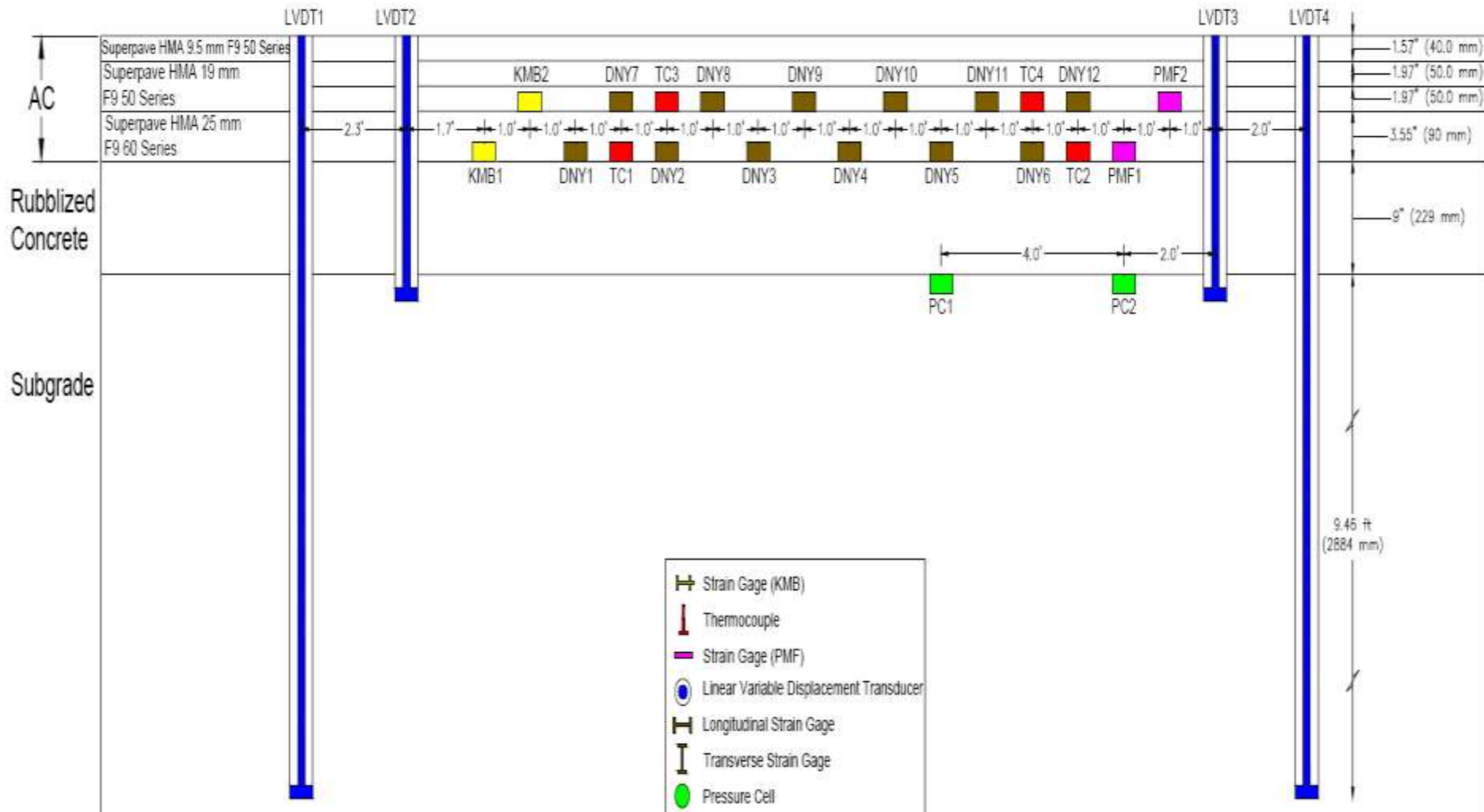
AC Perpetual Section – Angelica, NY



230mm (9.0in) AC Perpetual Pavement on Rubblized Concrete

NY-I86 Instrumentation Plan (Cont')

AC Perpetual Section - Angelica, NY



NY-I86 Instrumentation Summary

<u>MEASUREMENT</u>	<u>PARAMETERS</u>	<u>MANUFACTURER</u>	<u>SENSOR</u>
Displacement	Load Response	Honeywell /RDP	Submersible LVDTs
Pressure	Load Response	Geokon Inc.	Geokon 3500 Pressure Cell
Strain	Longitudinal and Transverse Strain	Dynatest	Dynatest PAST II Strain Transducer
Temperature	Pavement, Base and Subgrade	Various	T Type Thermocouple

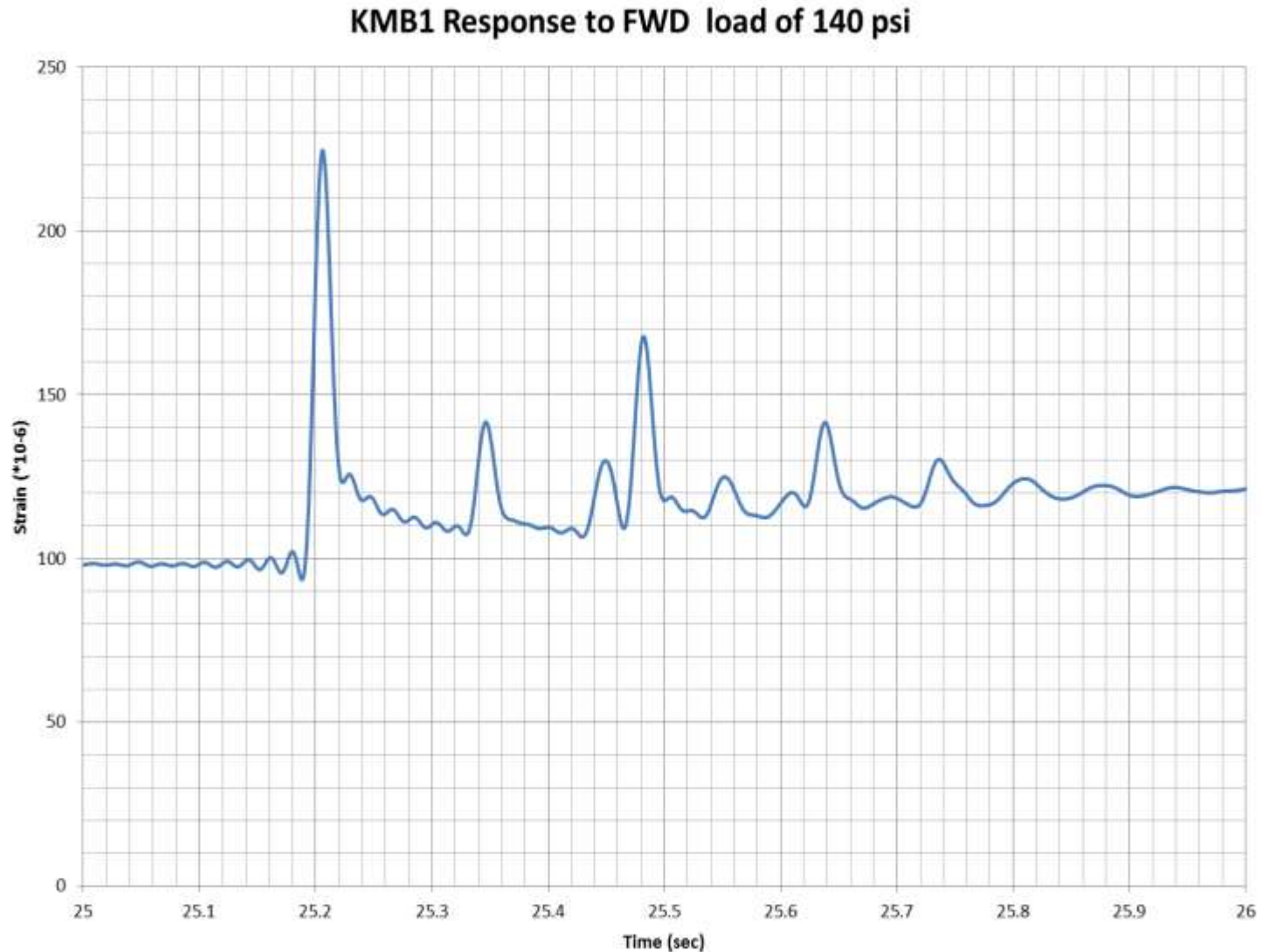
NY-I86 Construction & Installation



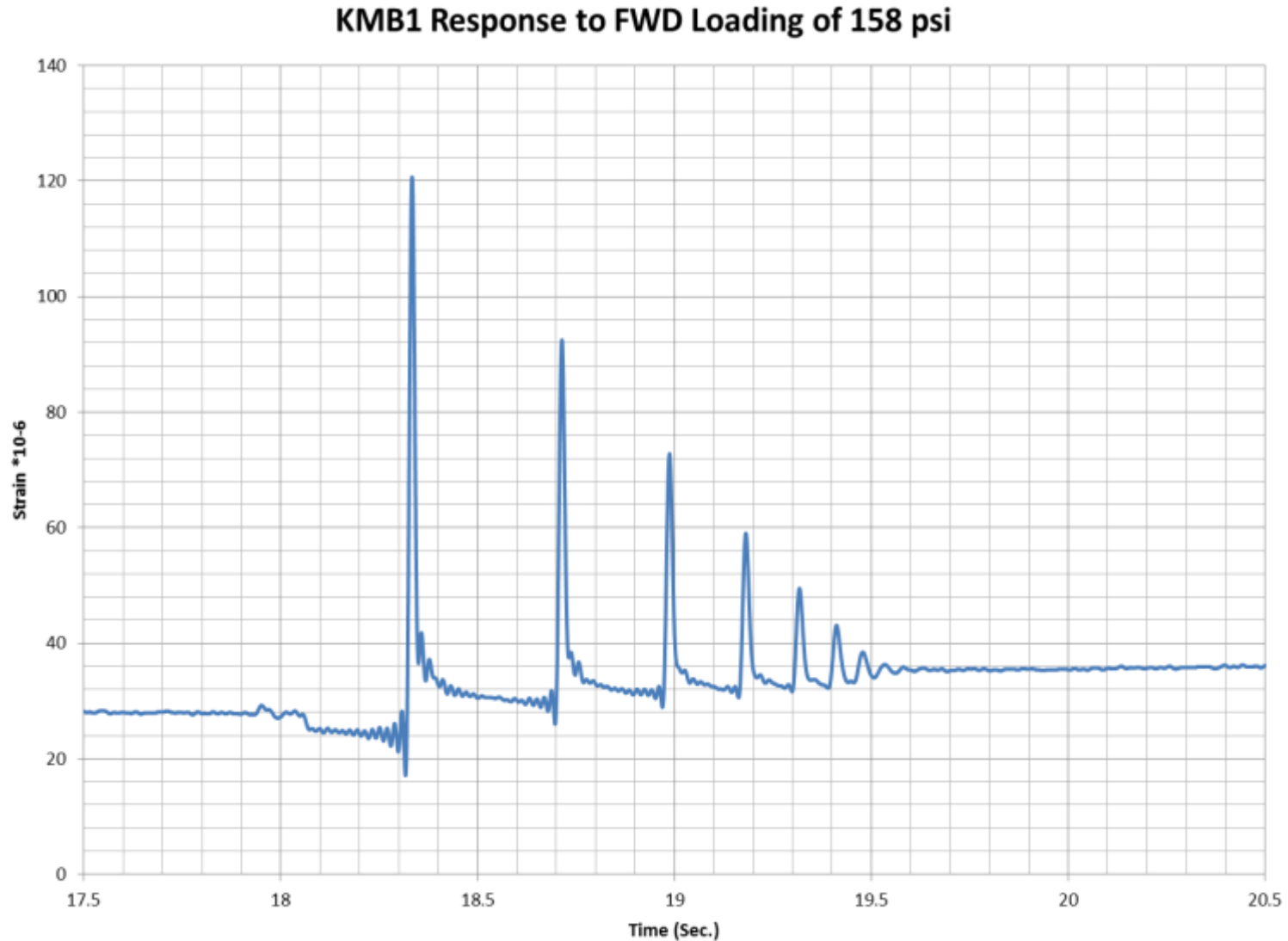
NY-I86 Construction & Installation (Cont')



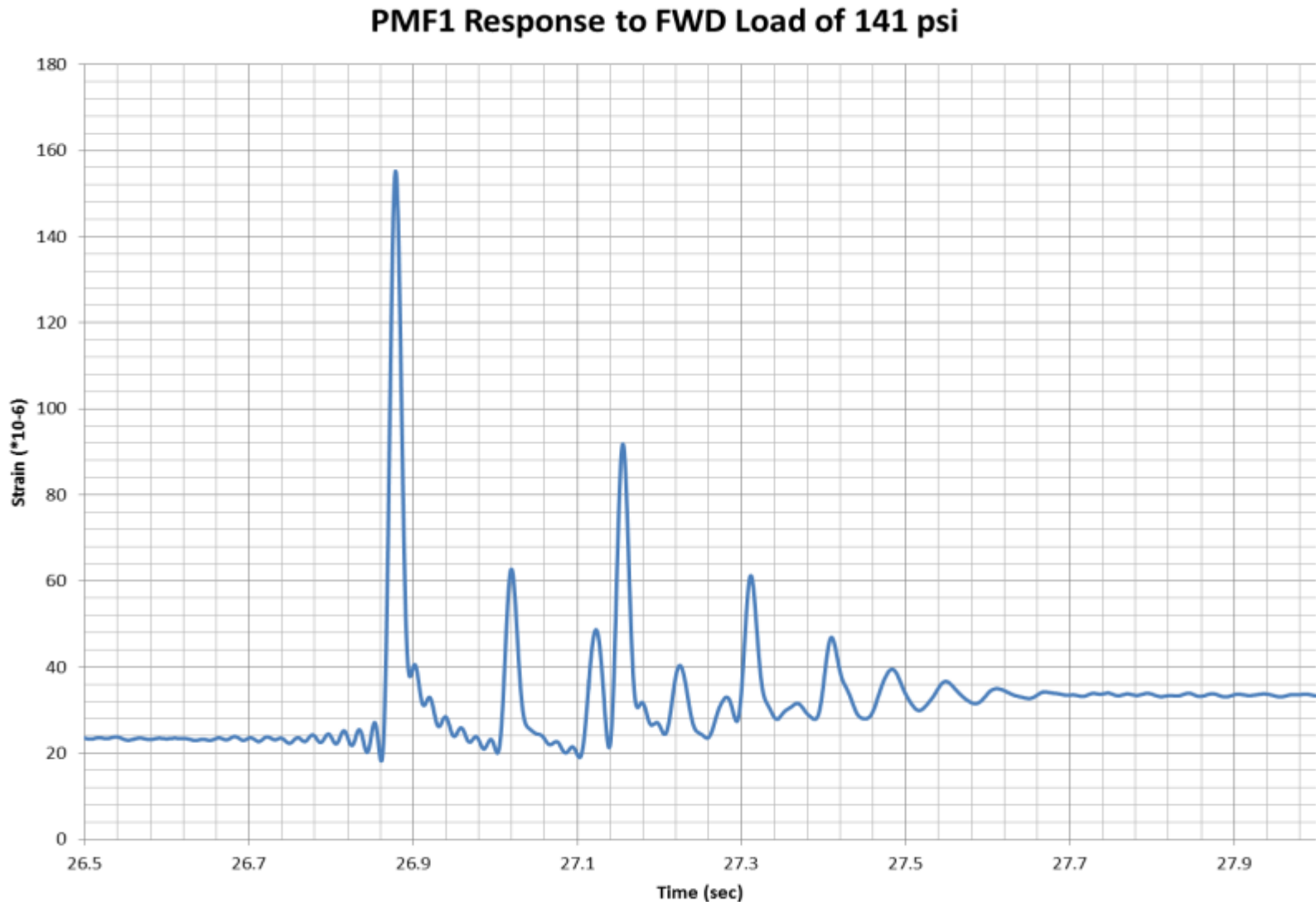
Response to 140 psi FWD load, Oct. 2008



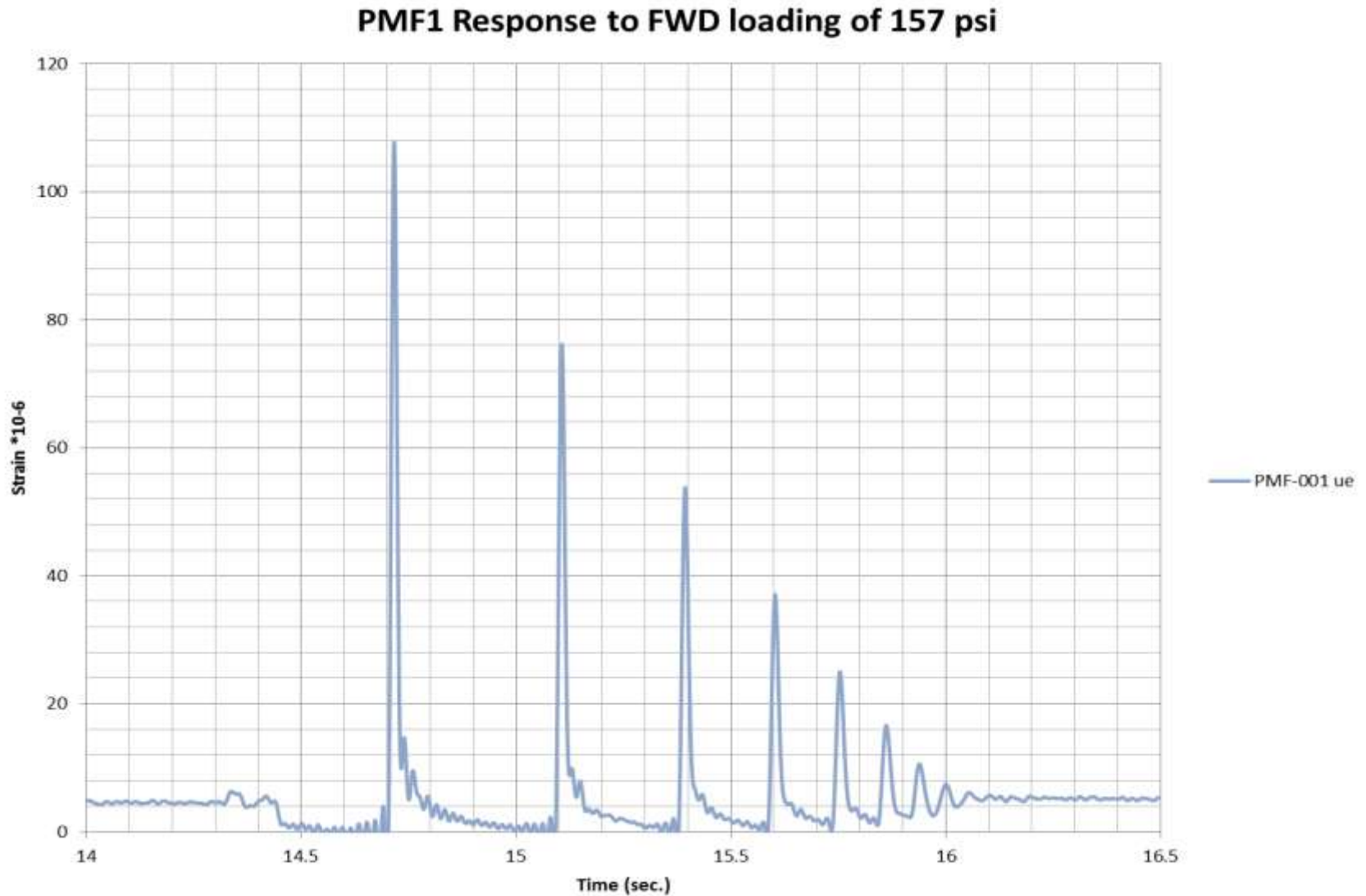
Response to 158 psi FWD load, Aug. 2011



Response to 141 psi FWD load, Oct. 2008




Response to 157 psi FWD load, Aug. 2011





Evaluating Thickness of Perpetual Pavement in Accelerated Pavement Load Facility (APLF)

Accelerated Pavement Load Facility (APLF)

- Complete, full-scale two-lane pavement, base, and subgrade construction.
 - Testing of flexible and rigid pavements possible.
 - Full environmental control to regulate humidity and temperature from 10°F (-12°C) to 130°F (54°C).
 - Multiple test paths across the 32-ft (9.75 m) wide pavement.
- 
- The photograph shows the interior of a large industrial facility. A long, straight test track is visible, flanked by green safety barriers. A vehicle is positioned in the distance on the track. The facility has a high ceiling with industrial lighting and a yellow overhead crane.
- A rolling tire load of 9000 lb (40 kN) to 30,000 lb (133 kN) can be applied to simulate a slowly passing truck (≤ 5 mph (≤ 8 km/h)) with standard single or dual tires or wide single tires, up to 500 times per hour

Installation at the APLF



← Paving in the APLF

Sensor placement →



APLF Monitoring

- Environmental parameters
 - pavement layer temperature
 - Base temperature and moisture
 - Subgrade temperature, moisture, and groundwater table
- Load parameters
 - Displacement
 - Strain
 - Pressure
- Also seasonal response in terms of displacement and pressure

Layers of Perpetual Pavements constructed in APLF profile view

1.25" (3.18 cm) surface course

3" (7.62 cm) ODOT 448 Type II AC

Varied depth (Column A) or 7.75" (19.7 cm) (Column B) ODOT 448 Type I AC

4" (10.2 cm) Fatigue Resistant ATB ODOT 302 Modified

[13.75" (34.9 cm) - VD] (Column A) or 6" (15.3 cm) (Column B) ODOT 304 DGAB

48" Type A6-A7 Subgrade soil

(not to scale)

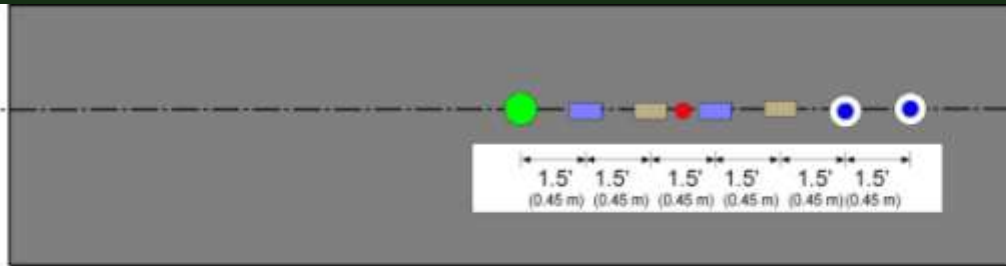
Surface courses and VD ("varied depth") of Type I AC displayed on next slide

Layout of Perpetual Pavements constructed in APLF plan view

A Load wheel direction B		
VD=4.75" (12.1 cm)	Standard depth	8 ft (2.44 m)
VD=5.75" (14.6 cm)	Standard depth	8 ft (2.44 m)
VD=6.75" (17.1 cm)	Standard depth	8 ft (2.44 m)
VD=7.75" (19.7 cm)	Standard depth	8 ft (2.44 m)
← 22.5 ft (6.9 m) →	← 22.5 ft (6.9 m) →	

Notes: Surface layer is 1.25" (3.18 cm);
 VD=varied depth of ODOT 448 Type I AC; Standard Depth is 7.75" (19.7 cm);
 DGAB layer is 13.75" (34.9 cm)-VD (Standard DGAB layer is 6" (15.3 cm));

Instrumentation in APLF








PLAN VIEW

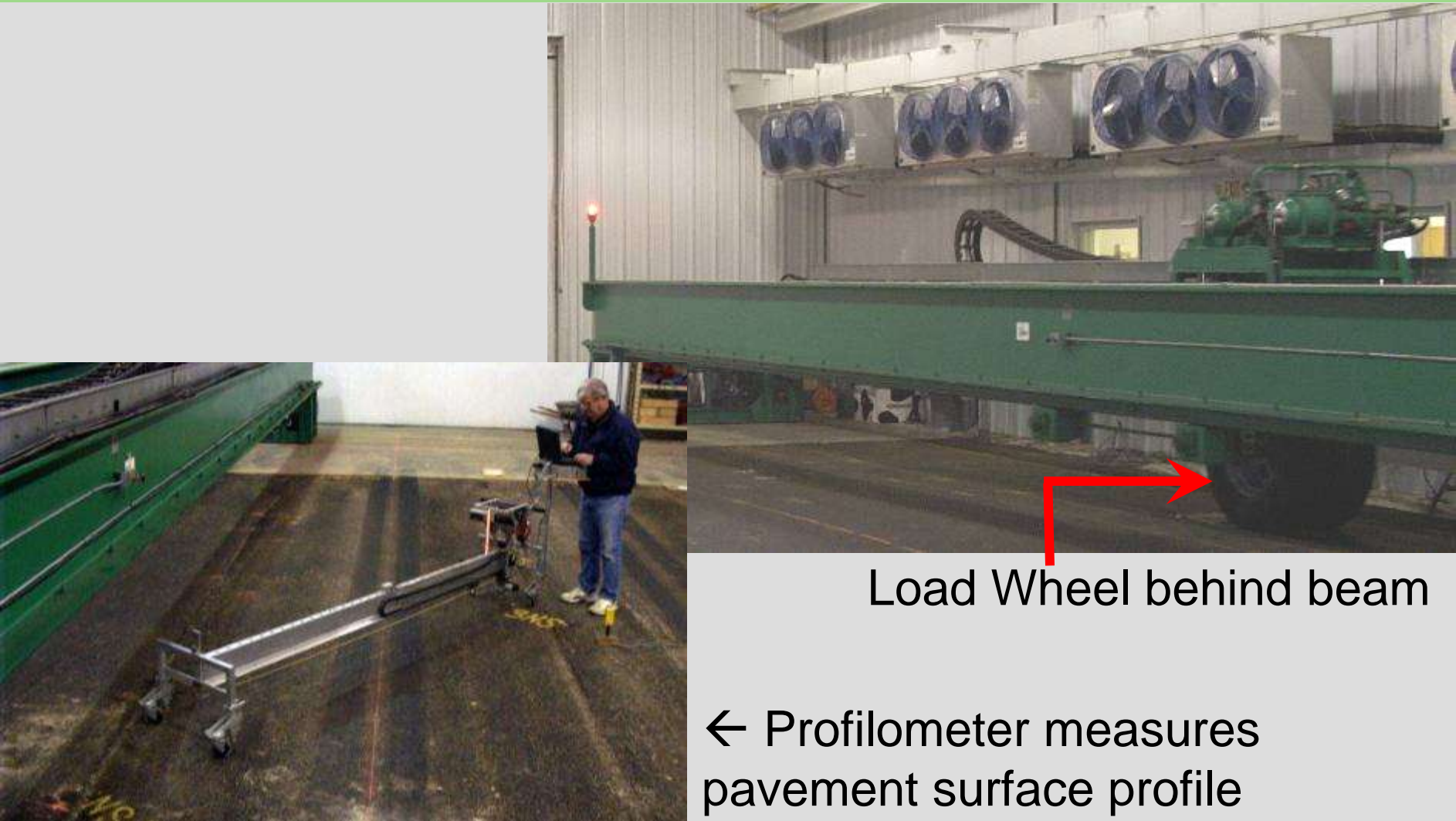


PROFILE VIEW

(Not to Scale)

-  Single Layer Deflectometer
-  Longitudinal Gage
-  Transverse Gage
-  Pressure Cell
-  T Type Thermocouples

APLF Equipment



Load Wheel behind beam

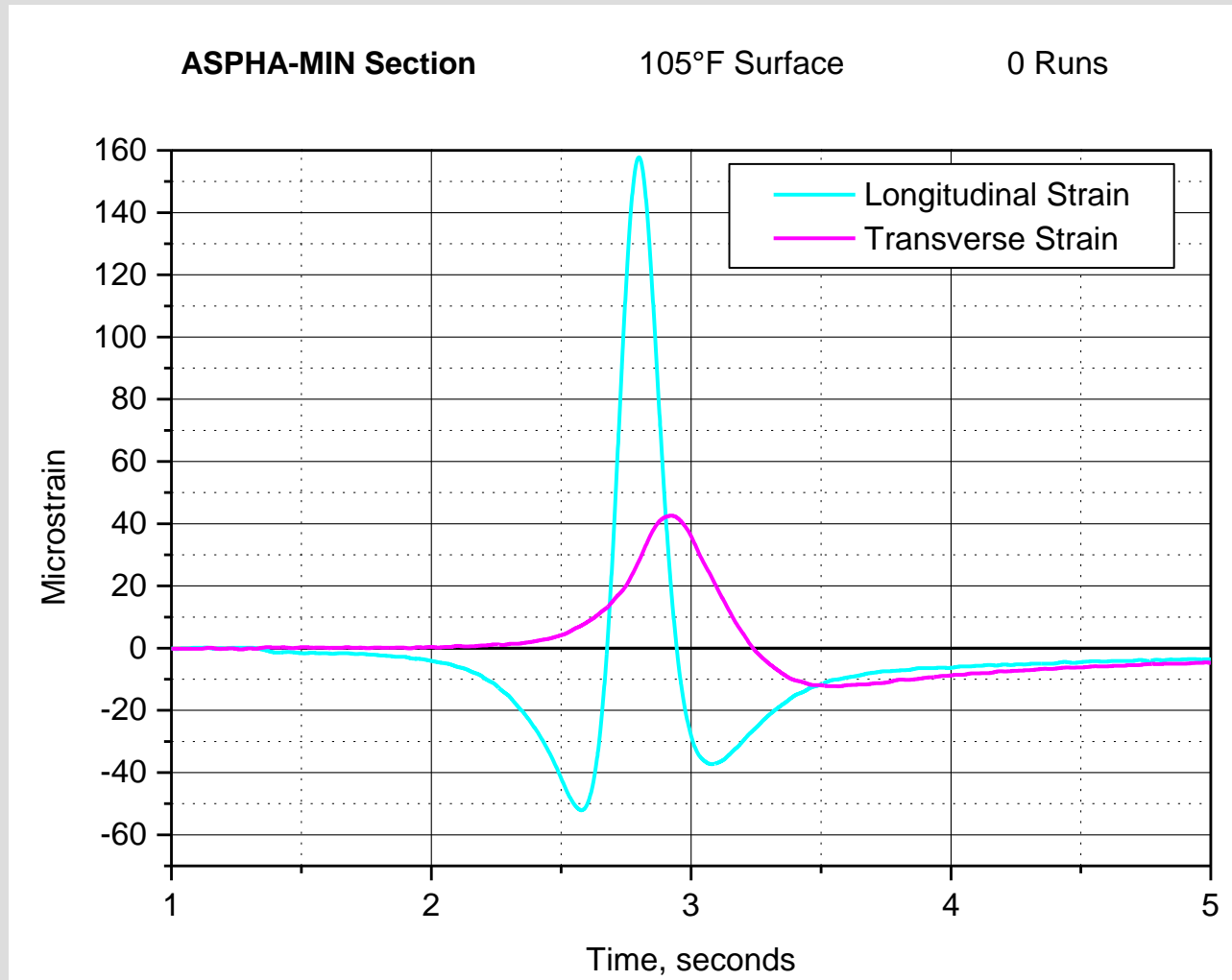
← Profilometer measures
pavement surface profile

APLF Test Method

- Tests conducted in this order:
 - Low temperature (40°F (4.4°C))
 - Medium temperature (70°F (21.1°C))
 - High temperature (105°F (40.6°C))
- At each temperature and for each pavement:
 - Collect data from instruments at beginning with tire loads of 6 kip (27 kN), 9 kip (40 kN), and 12 kip (53 kN)
 - 10,000 passes of 9 kip (40 kN) tire load at 5 mph (8 km/h)
 - Collect data from instruments at end with same loads as at beginning
 - Each type of pavement is tested in sequence
 - Measure profile with profilometer to check for rutting

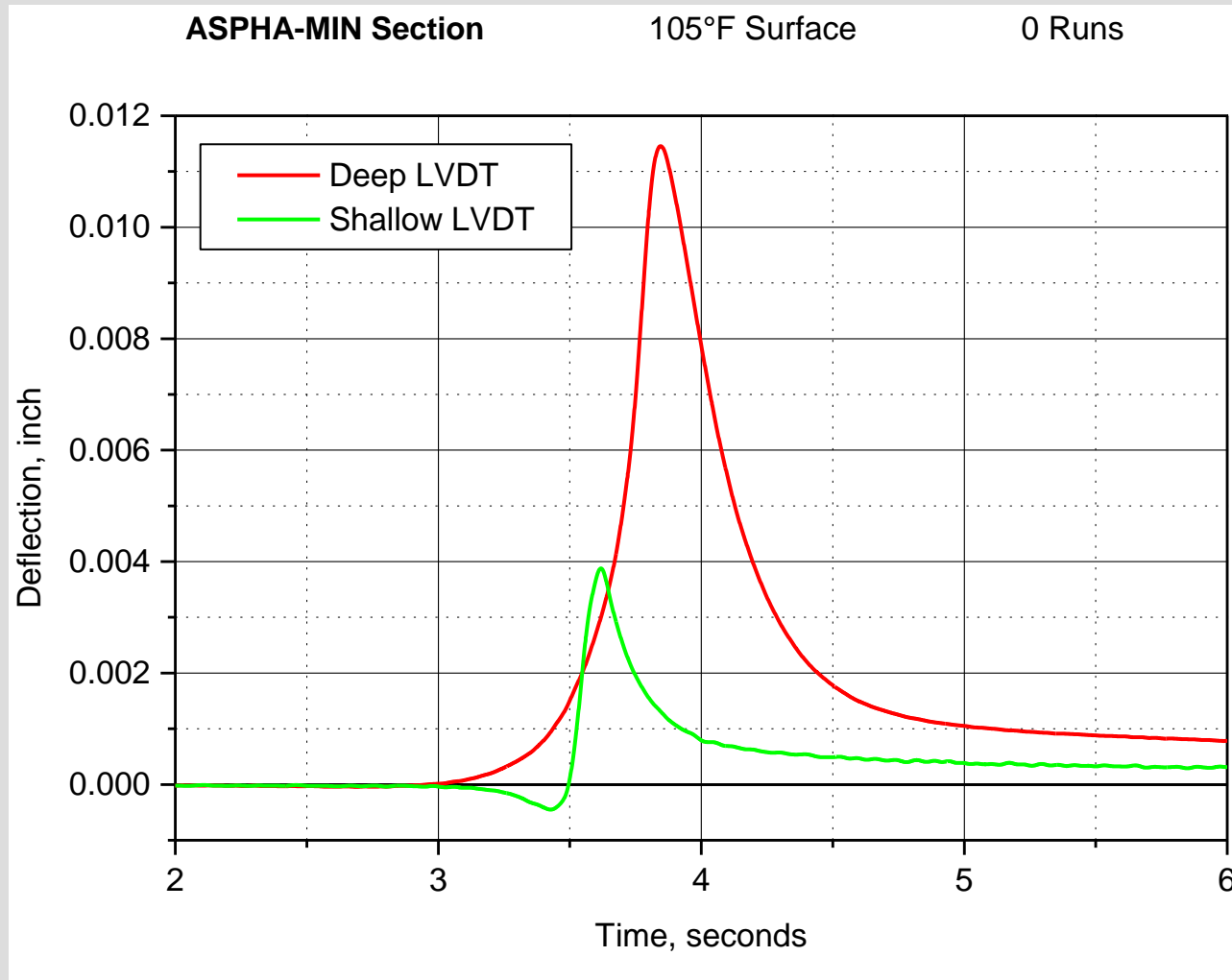
15 inch Section Results from APLF

Before any 9-kip passes at high temperature. Test Load = 12 kip.



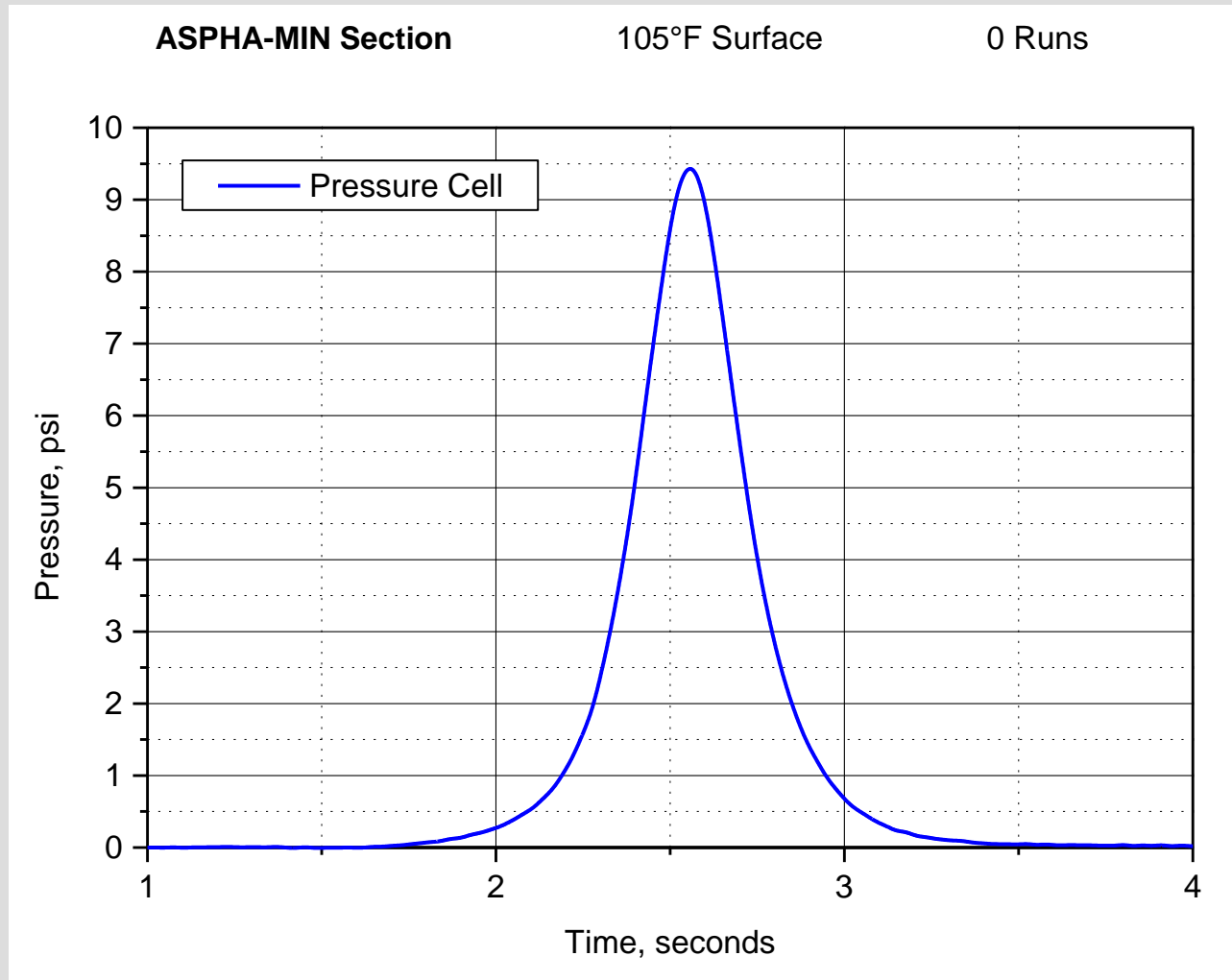
15 inch Section Results from APLF

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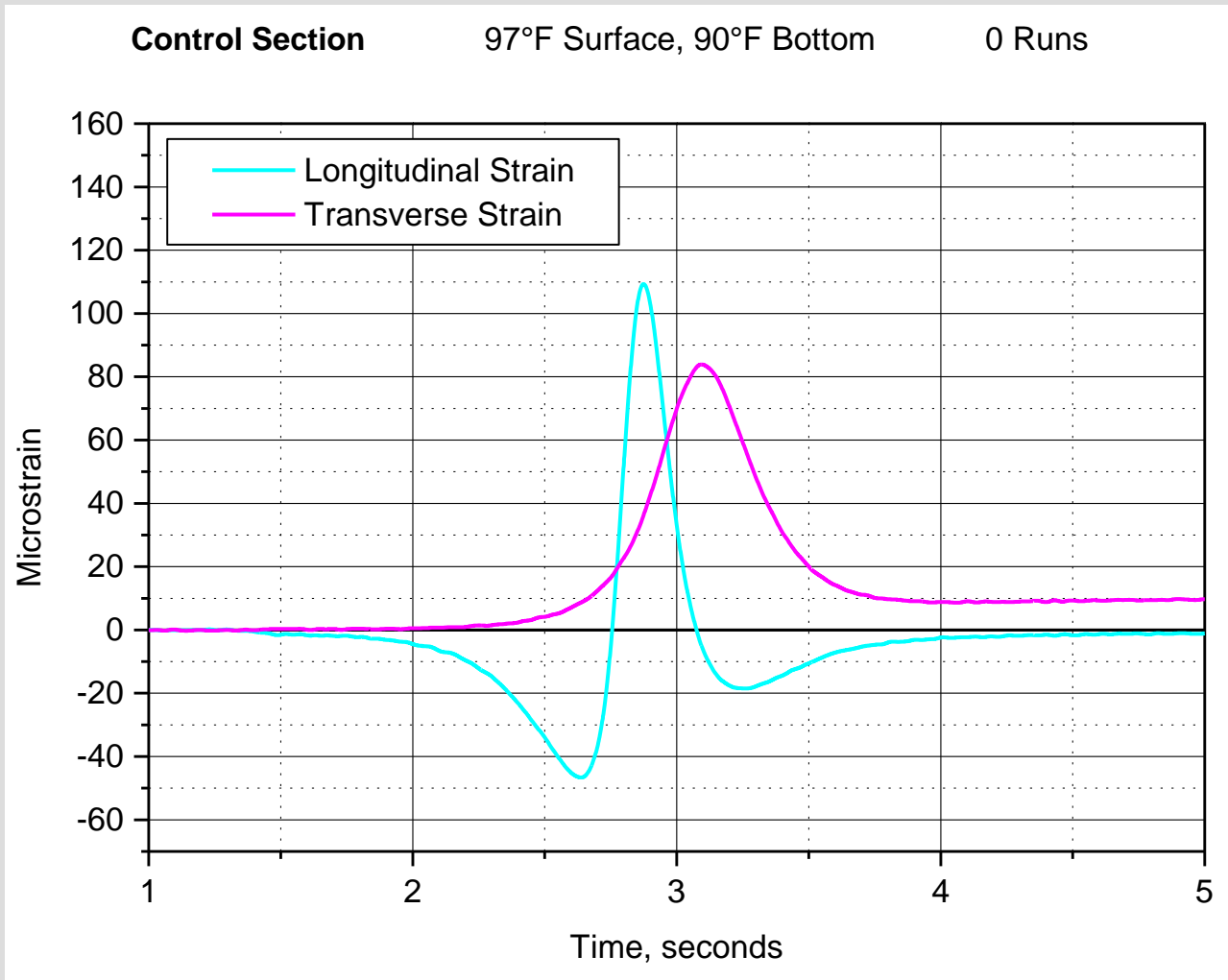
15 inch Section Results from APLF

Before any 9-kip passes at high temperature. Test Load = 12 kip.



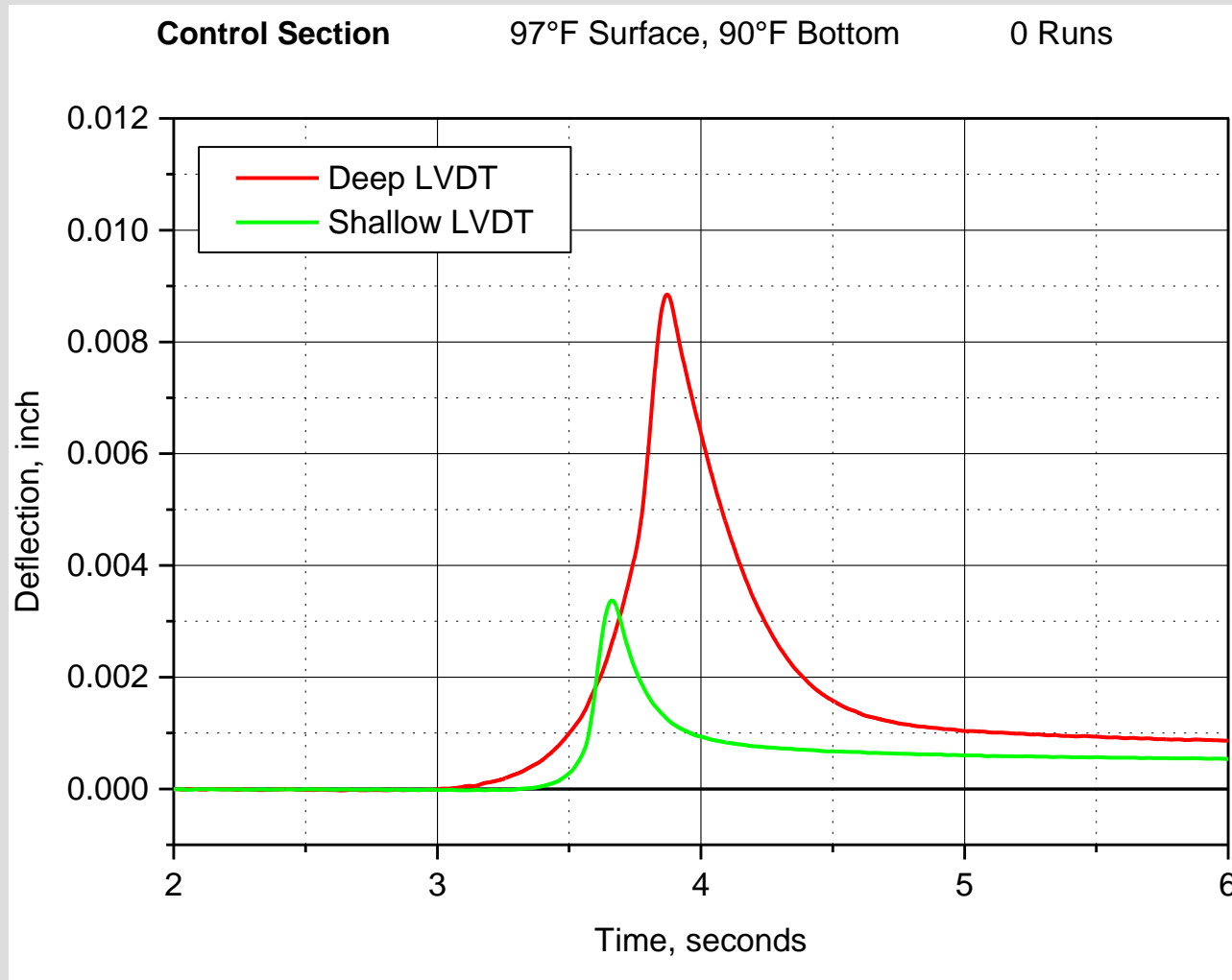
16 inch Section Results from APLF

Before any 9-kip passes at high temperature. Test Load = 12 kip.



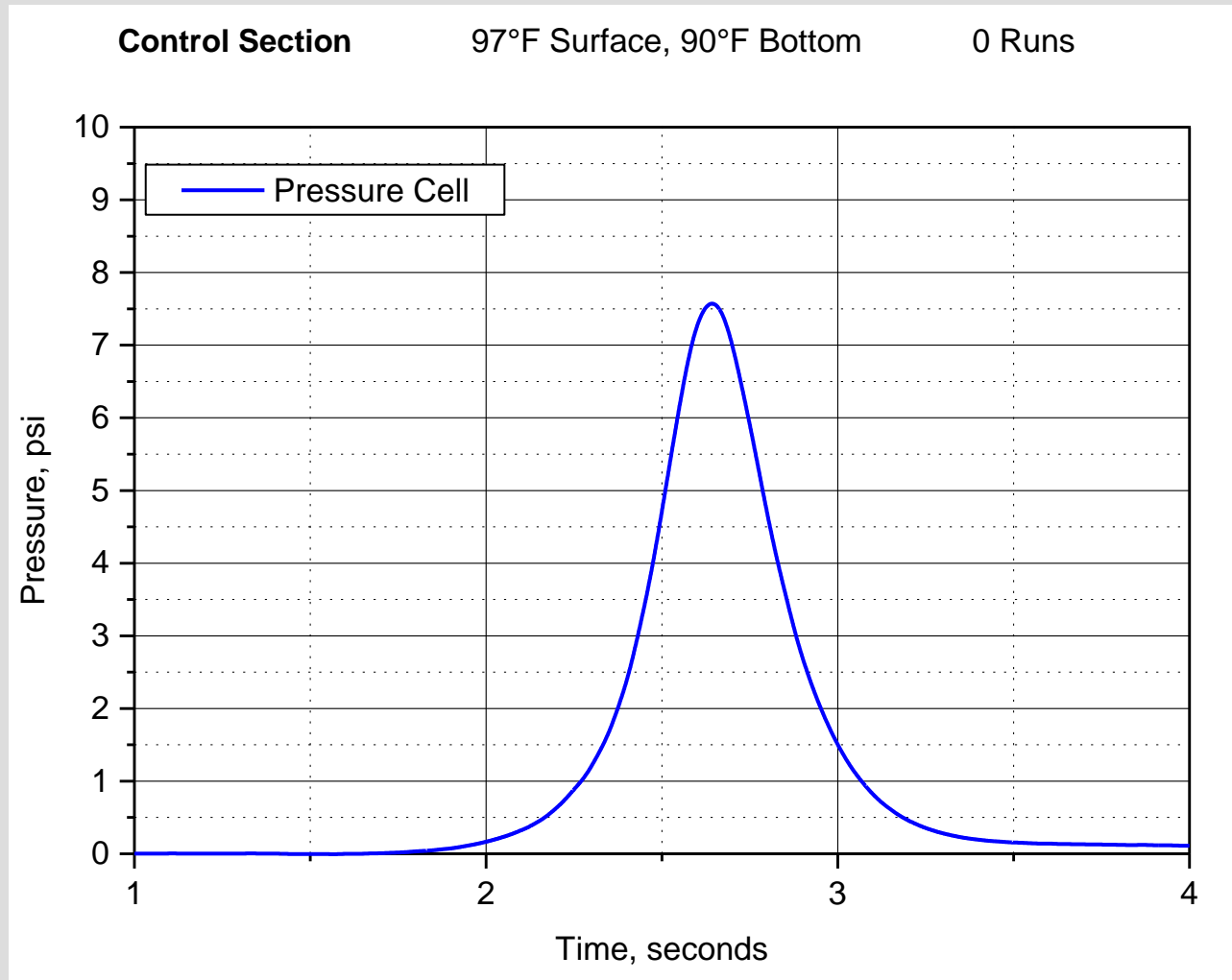
16 inch Section Results from APLF

Before any 9-kip passes at high temperature. Test Load = 12 kip.



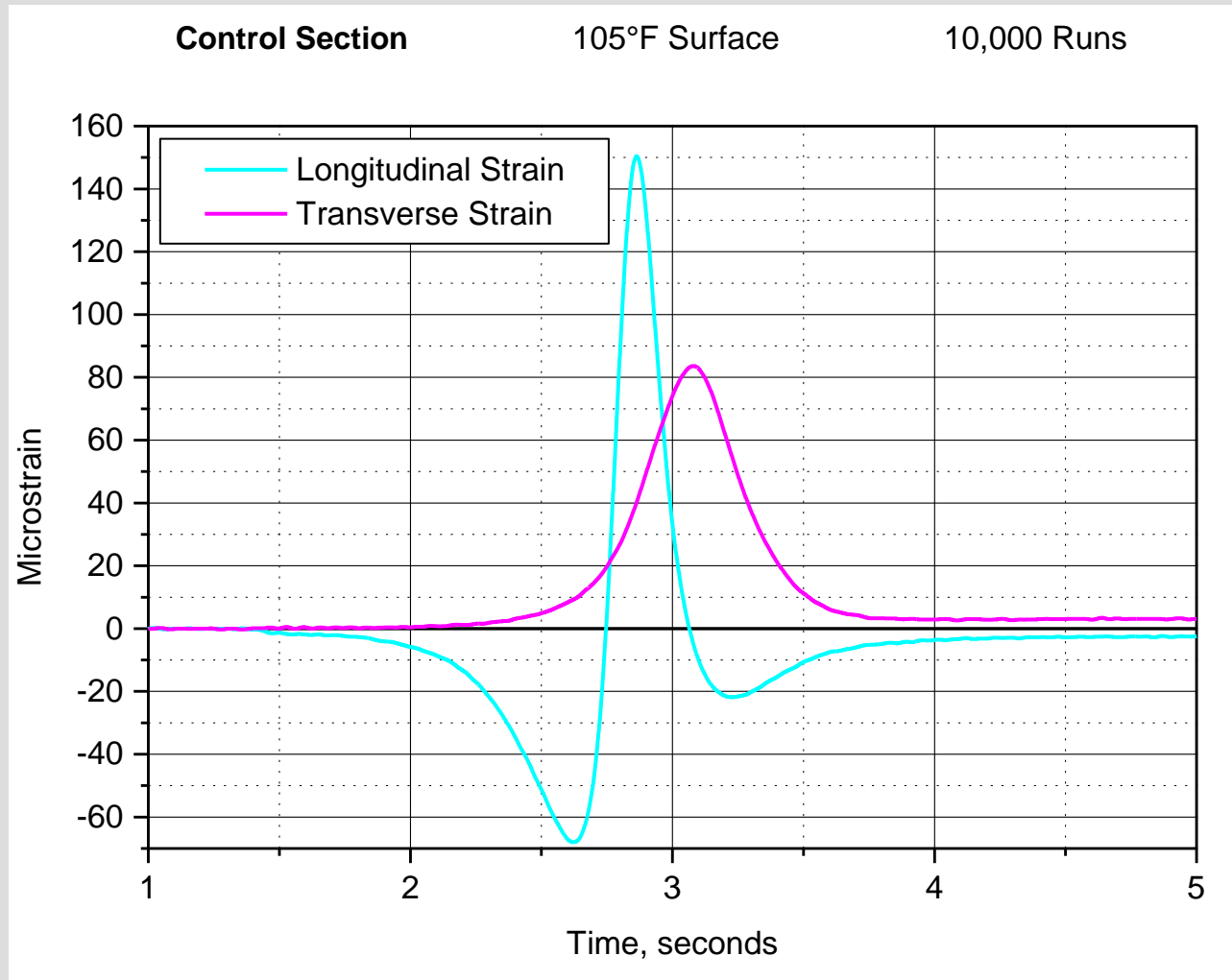
16 inch Section Results from APLF

Before any 9-kip passes at high temperature. Test Load = 12 kip.



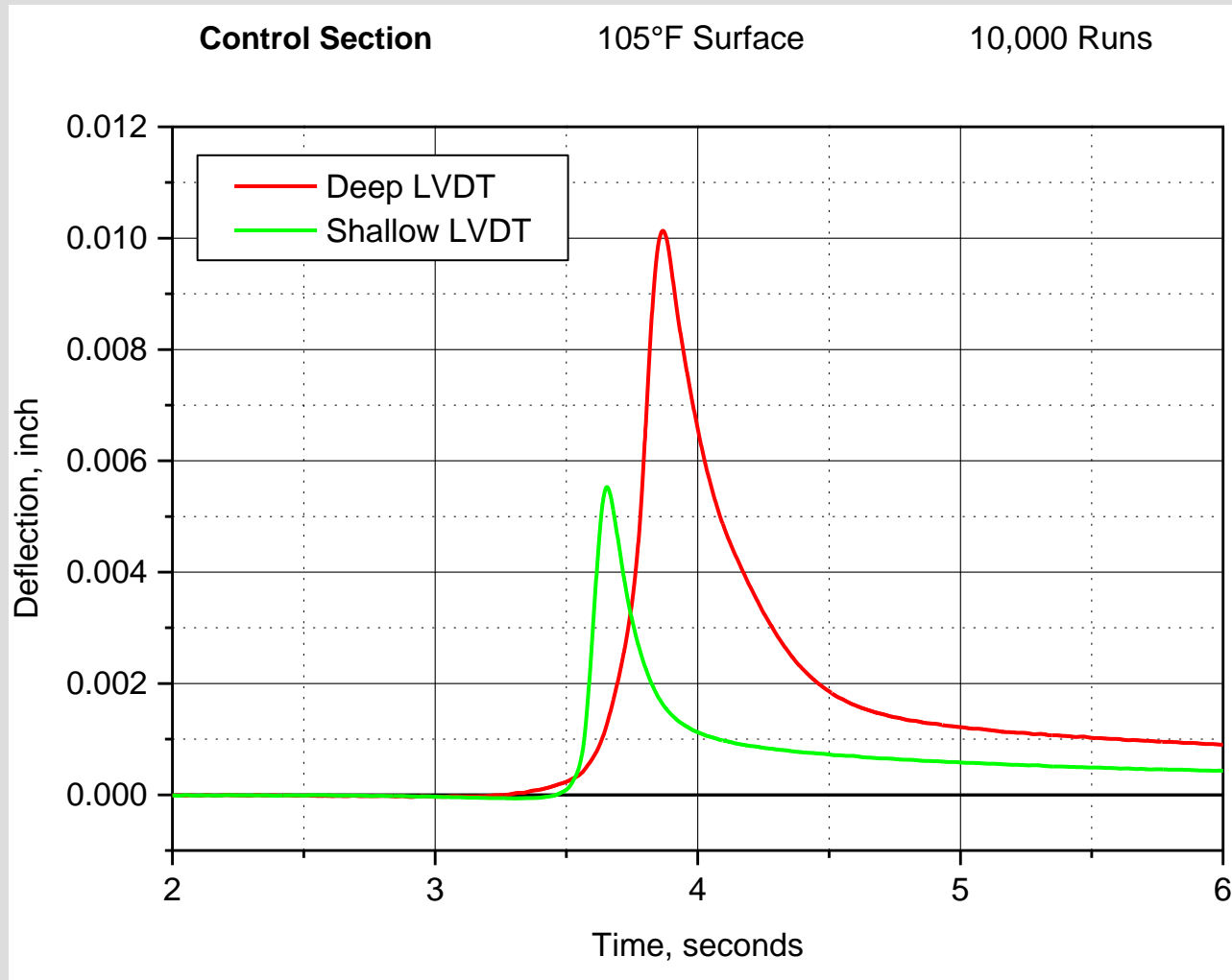
16 inch Section Results from APLF

After 10,000 9-kip passes at high temperature. Test Load = 12 kip



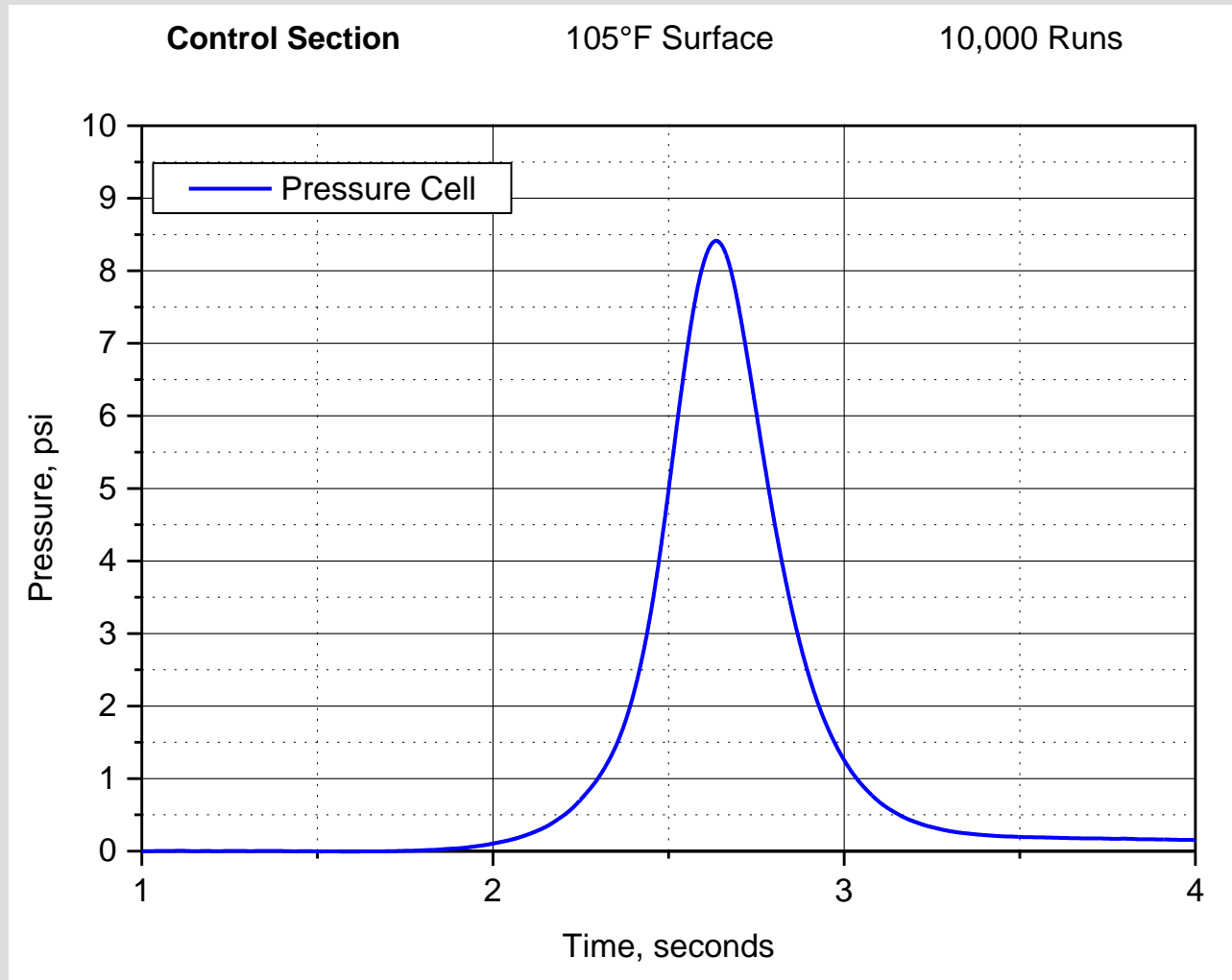
16 inch Section Results from APLF

After 10,000 9-kip passes at high temperature. Test Load = 12 kip



16 inch Section Results from APLF

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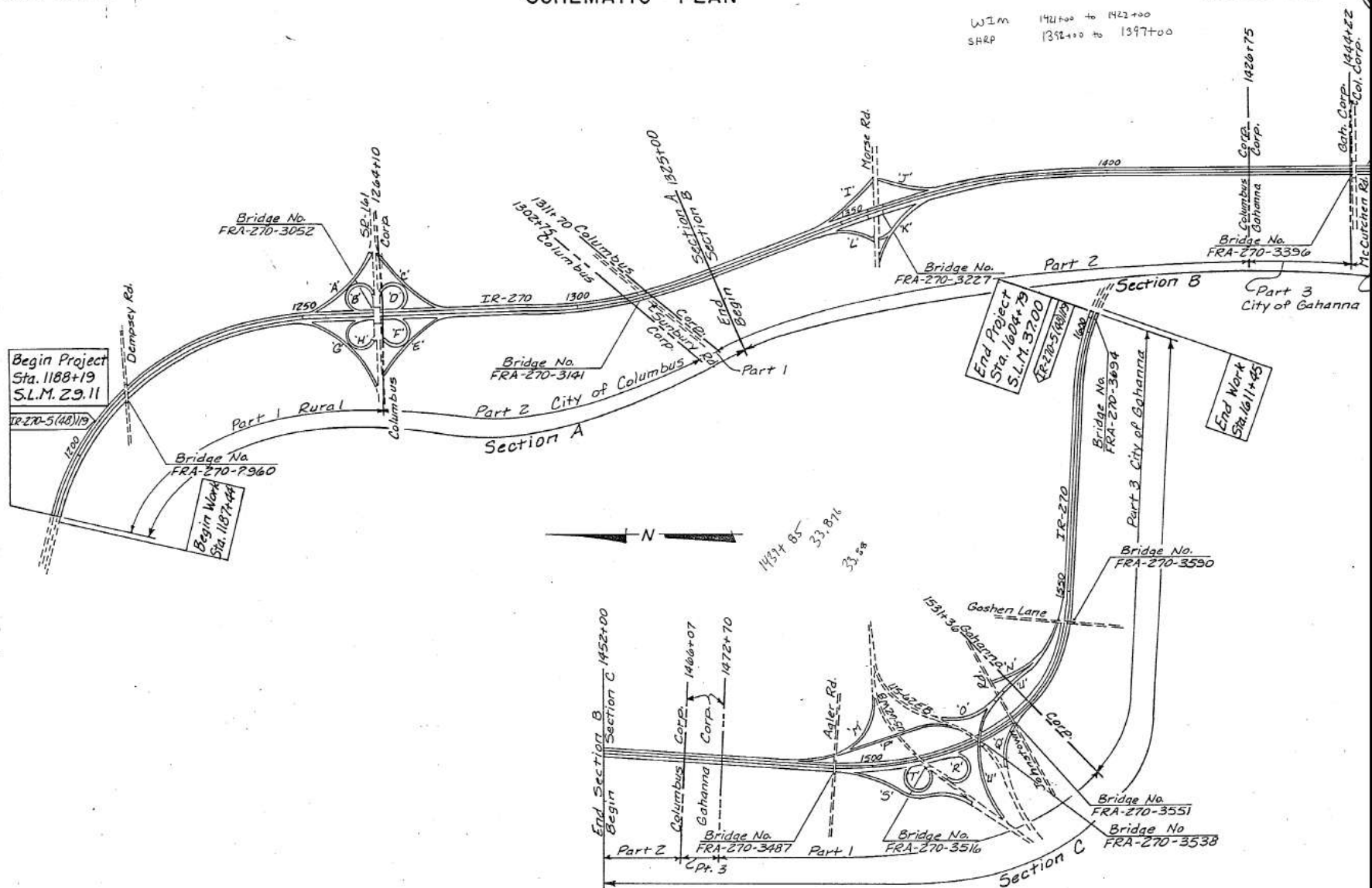
Interstate 270, Columbus

(FRA-270)

DEPARTMENT OF TRANSPORTATION
M&R 712 REV. 9-1-83

FRA-270-29.11

WIM 142100 to 142200
SHRP 139200 to 139700



Plan Profile, as built in 1987

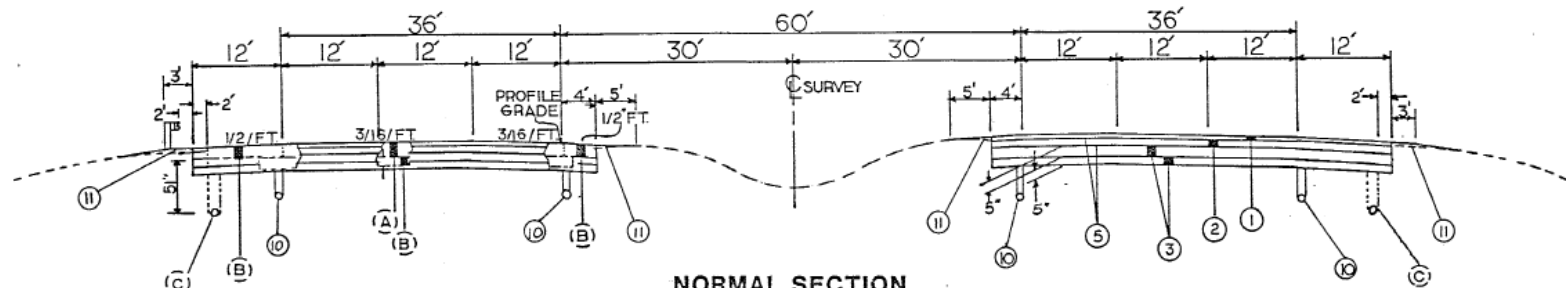
DEPARTMENT OF TRANSPORTATION
M & R 712 REV. 9-1-83

FRA-270-29.11

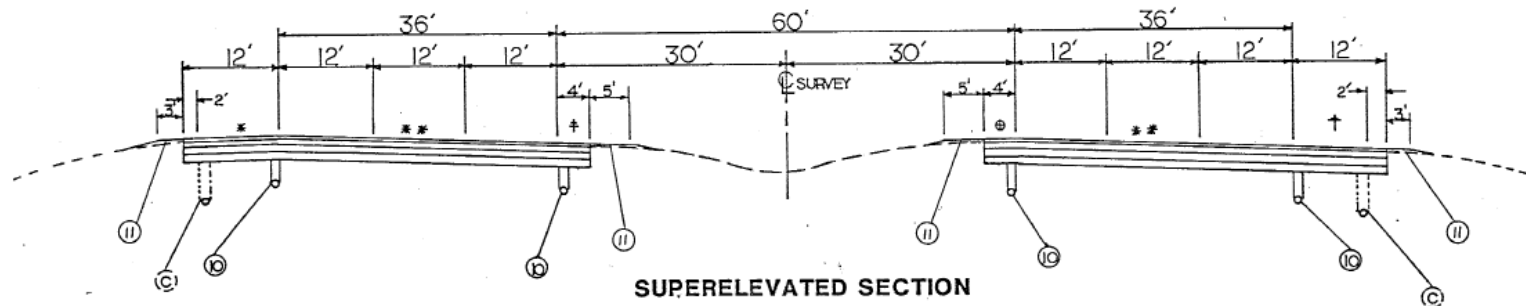
TYPICAL SECTIONS

TYPE 846 ON 301

SECTION C



STA. 1439+85 to 1490+00



STA. 1490+00 to 1546+28

LEGEND - EXISTING PAVEMENT

- (A) ITEM 453 - 8" CONTINUOUSLY REINFORCED CONCRETE PAVEMENT
- (B) ITEM 301 - BITUMINOUS AGGREGATE BASE
- (C) ITEM 605 - 6" PIPE UNDERDRAIN

- * 3/8"/FT. STA. 1490+00 - 1524+00
- 1/8"/FT. STA. 1524+00 - 1546+28
- ** .032 FT./FT. MAX. STA. 1490+00 - 1519+75
- .064 FT./FT. MAX. STA. 1519+75 - 1524+00
- .0645 FT./FT. MAX. STA. 1524+00 - 1546+28
- † 1/2"/FT. OR SAME AS PAV'T. STA. 1490+00 - 1546+28
- ⊕ NO SLOPE - STA. 1490+00 - 1524+00
- 1/8"/FT. STA. 1524+00 - 1546+28

LEGEND - PROPOSED PAVEMENT

- ① ITEM 846 - 1 1/4" ASPHALT CONCRETE, SURFACE COURSE, TYPE 1 AC-20, AS PER PLAN
- ② ITEM 846 - 1 3/4" ASPHALT CONCRETE, INTERMEDIATE COURSE, TYPE 2 AC-20
- ③ ITEM 301 - BITUMINOUS AGGREGATE BASE: AC-20
- ⑤ ITEM 407 - TACK COAT @ .10 GAL./S.Y. - COVER AGGREGATE @ 7 lbs./S.Y.
- Ⓜ ITEM 203 - EMBANKMENT
- ⑩ ITEM 605 - SHALLOW PIPE UNDERDRAIN

Plan Profile, as built in 1987

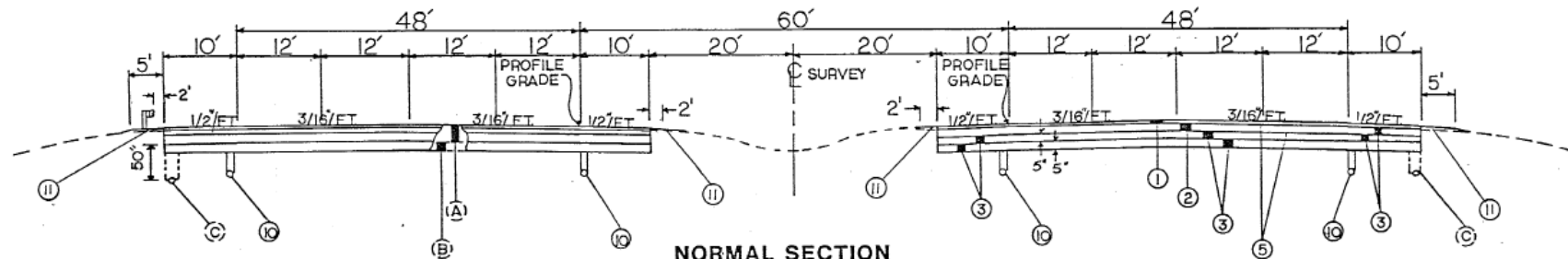
DEPARTMENT OF TRANSPORTATION
M.S. R 712 REV. 9-1-83

FRA-270-29.11

TYPICAL SECTIONS

TYPE 846 ON 301

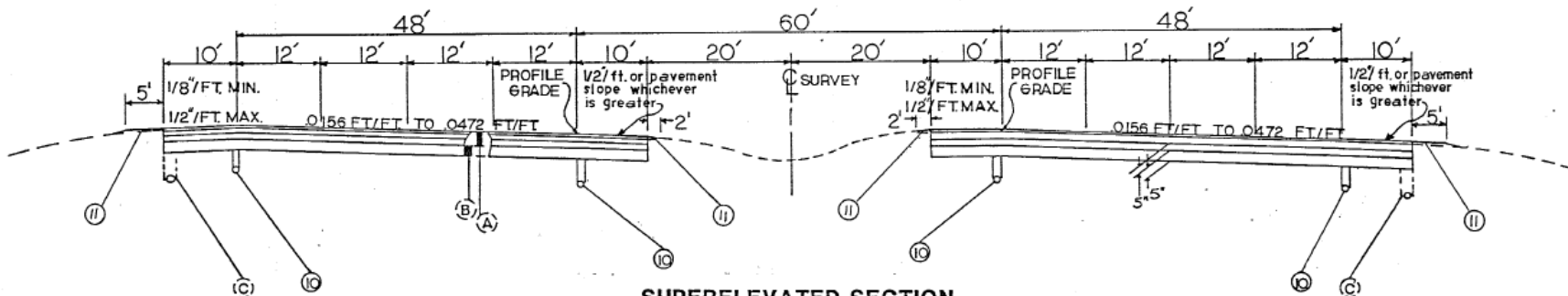
SECTION C



NORMAL SECTION

STA. 1546+28 to 1588+26

STA. 1600+22 to 1601+61



SUPERELEVATED SECTION

STA. 1588+26 to 1600+22

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I270 pavement core collection



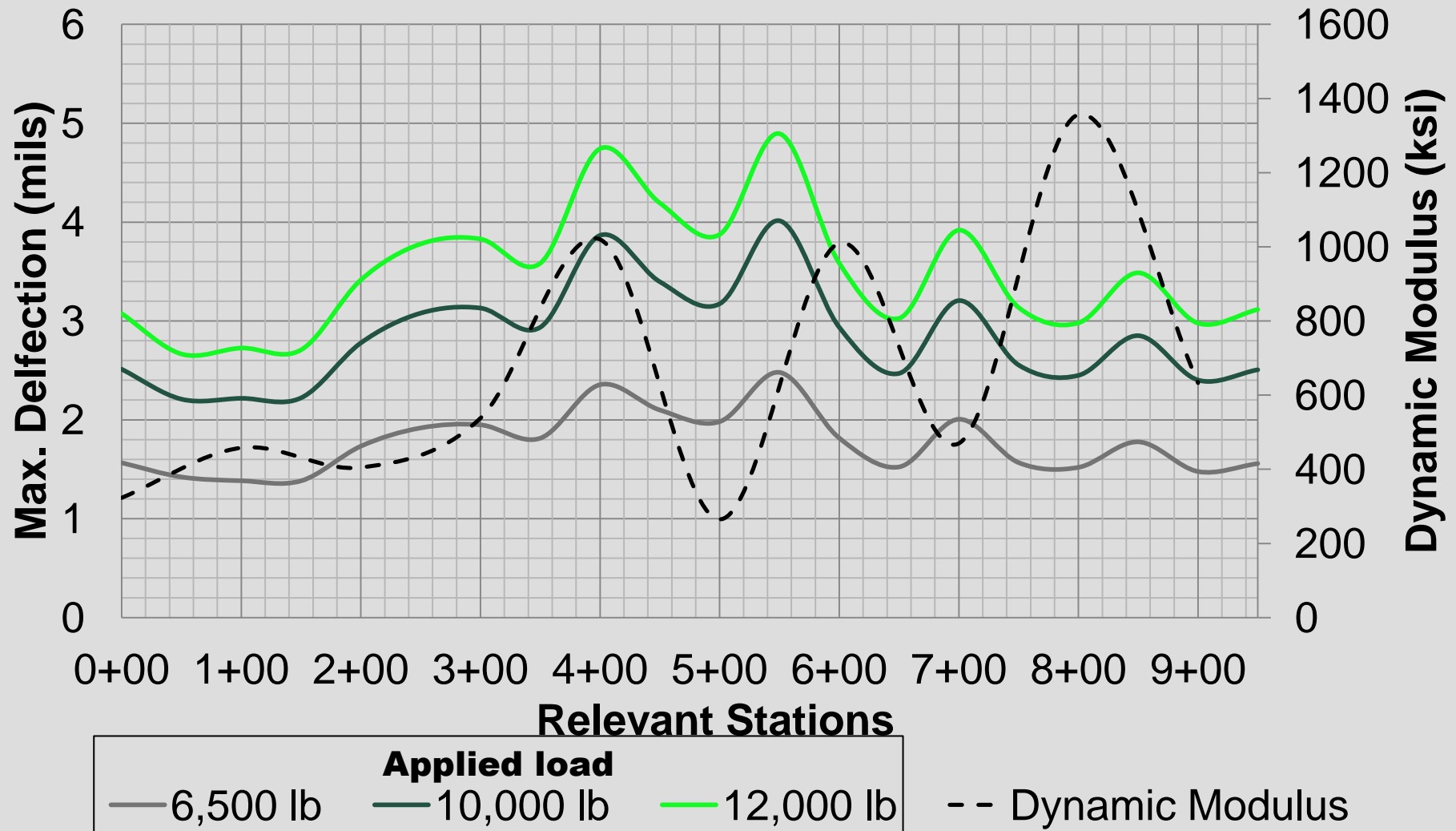
I270 cores



Falling Weight Deflectometer (behind truck) and Portable Seismic Properties Analyzer (at front)



I270 S Falling Weight Deflectometer Results





Summary and Conclusions

Conclusions

- The perpetual pavement concept works
- Perpetual pavement has the potential to eliminate road reconstruction costs
- The Perpetual Pavement design was based on the strain at bottom of FRL. The measured strain in the FRL on WAY30 was generally below the $70 \mu\epsilon$ design limit

APLF Perpetual Pavement Conclusions

- The strains measured in the Fatigue Resistant Layer (FRL) did not show significant differences between the different sections in the APLF. It thus appears that the reduction of a perpetual pavement thickness from 16 in (40 cm) to 13 in (33 cm) accompanied by a corresponding increase in the thickness of the base structure will respond about equally well to loads.
- At the highest APLF temperature of 104°F (40°C), the highest longitudinal strains exceeded the FRL design strain. However, the uniformly distributed high temperature in the APLF pavement structure led to the high strains and represented an extremely harsh condition. Under real world conditions, a temperature gradient would exist between the hot surface and the cooler subgrade, which would be expected to reduce the strain at the bottom.

Implementation – Where do we go from here?

- Perpetual pavements can be built as needed. The design elements and specifications used in these pavements could be adapted to create new specifications, standard drawings, and other documents needed to establish perpetual AC pavements as specific bid items that could be required for particular projects.
- In addition, existing AC pavements can be studied to determine those that which may already qualify for perpetual pavement status, and those which may qualify with some relatively small and easy modifications.

Project reports available on ODOT website

- <http://www.dot.state.oh.us/Divisions/TransSysDev/Research/reportsandplans/Pages/PavementReports.aspx>
- WAY-30 Perpetual Pavement report titles:
 - *Monitoring and Modeling of Pavement Response and Performance*: State Job No. 134287, Report No. FHWA/OH-2010/3A,
 - *Instrumentation of the WAY-30 Test Pavements*: State Job No. 14815, Report No. FHWA/OH-2008/7
- Variable Depth Perpetual Pavement title – *Performance Assessment of Warm Mix Asphalt (WMA) Pavements*: State Job No. 134312, Report No. FHWA/OH-2009/8



New Project:

**Implementation and Thickness
Optimization of Perpetual
Pavements in Ohio**

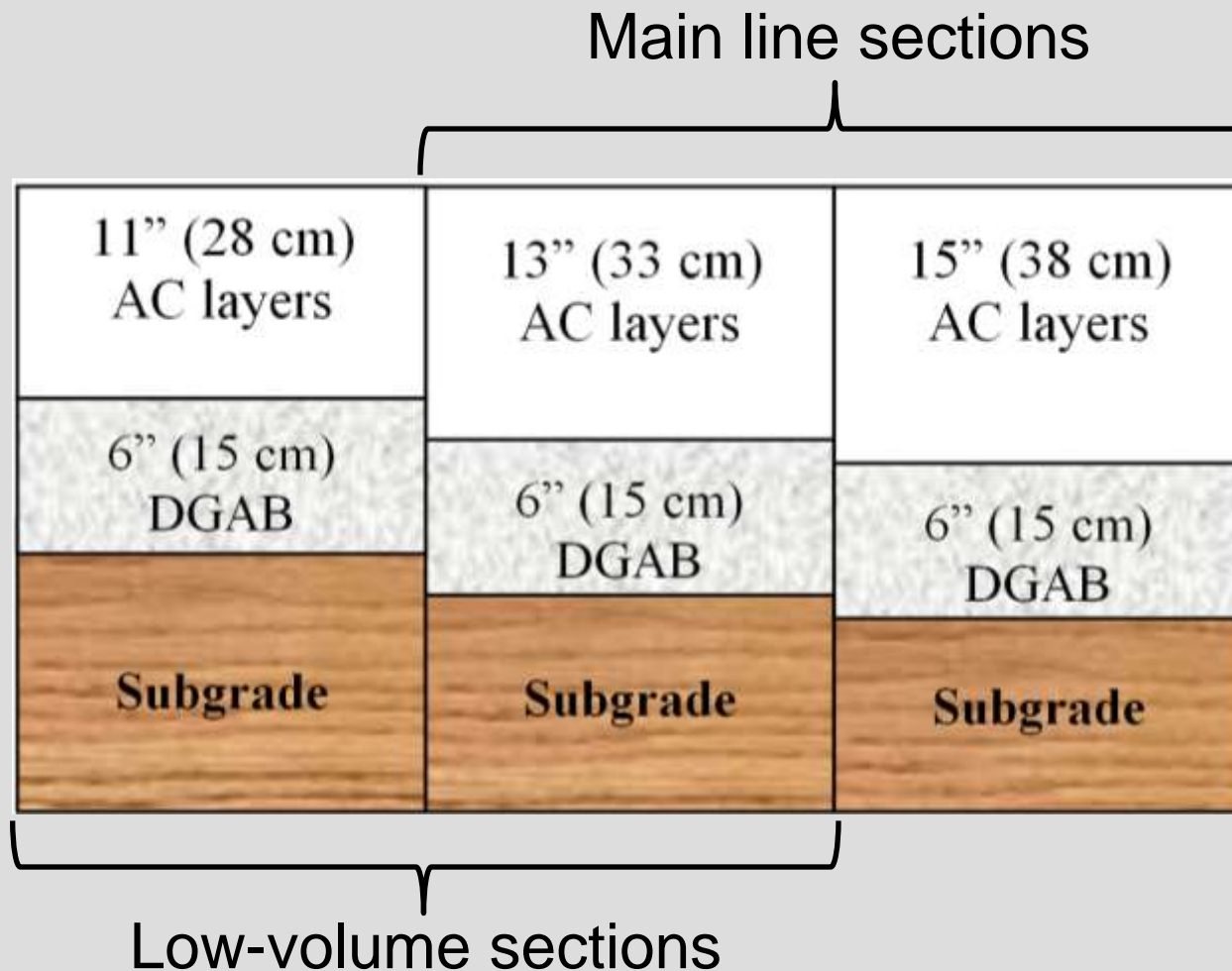
Objectives

- Develop a procedure for the selection of the optimal design for perpetual pavements in Ohio
- Investigate various perpetual pavement structure alternatives through varying the thickness and material properties of pavement layers in field test sections.
- Use data collected at the field test sections to verify the analysis results.
- Evaluate typical conventional asphalt pavement designs currently used in Ohio and develop an approach to retrofit existing conventional asphalt pavements in good conditions to meet the perpetual pavement requirements.

New field sections on DEL-23

- Built on SHRP test road on US Route 23 in Delaware County (DEL-23).
 - Two sections on main line
 - Two sections on low volume access roads
- Fully instrumented to monitor environmental and load response.
 - Laboratory testing of materials
 - Controlled load tests
 - FWD, PSPA, DCP tests
 - MEPDG calibration

Perpetual pavement structure on DEL-23





<http://www.ohio.edu/orite/>

www.ohio.edu/engineering

