RUSS COLLEGE
of Engineering and Technology

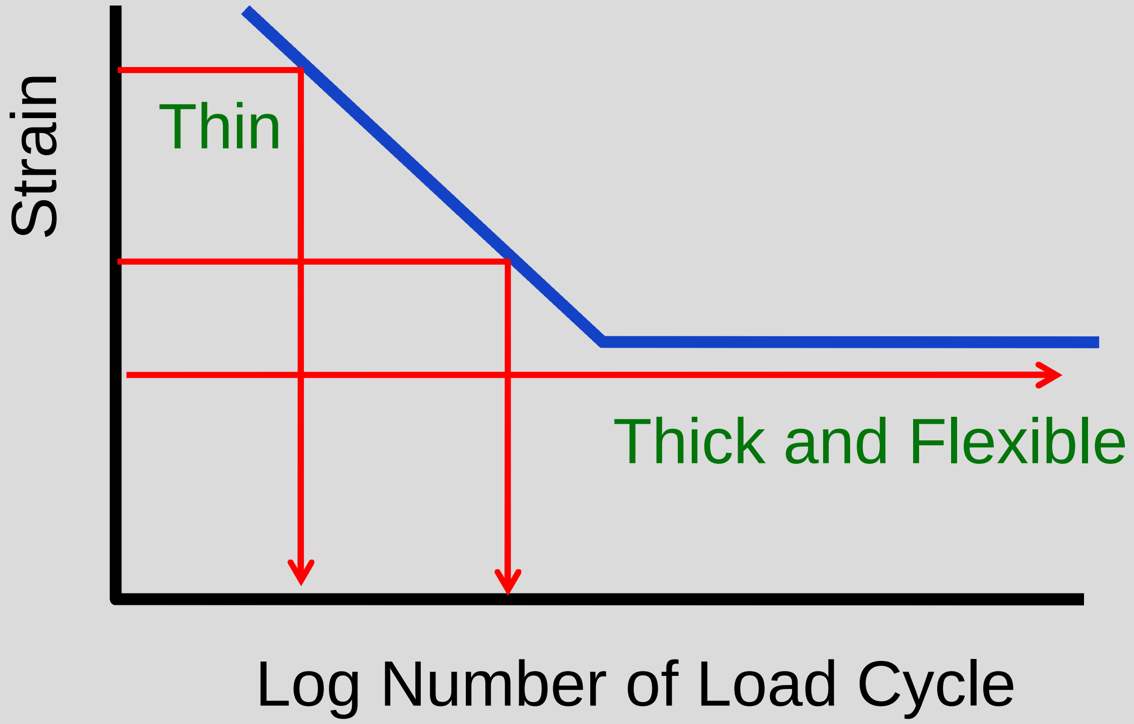
Perpetual Pavement

Ohio Asphalt Paving Conference
February 2, 2011

Shad Sargand
Russ Professor
Department of Civil Engineering

OHIO
UNIVERSITY

Fatigue Behavior (S-N Diagram)



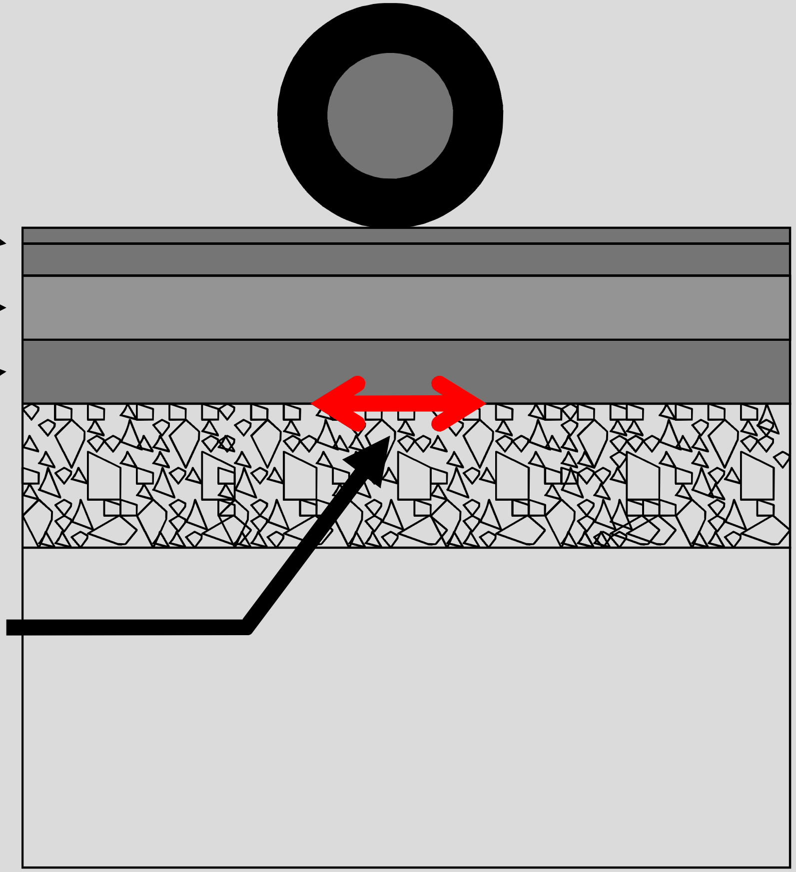
Perpetual Pavement

- No (Fatigue) Cracking → **Structural Design**

- No Rutting
- No Thermal Cracking
- No Stripping

} → **Mix Design**

Perpetual Design Criteria



Surface: High Performance

Base: Economical & Durable

Fatigue Resistant Layer

Maximum Tensile Strain for
Fatigue Control

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 Concr, 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

Project Information

- Project 44(2004)
- Project Length: 7.97 miles
- Letting Date: 2/20/2004
- Contractor: Beaver Excavating Company
- Total Cost: $47.2 million
- Work Started: 3/15/2004
- Opened to Traffic: 12/19/2005

Test Section at Geyer’s Chapel

Test Section at McQuaid Road

Instrumentation Plan

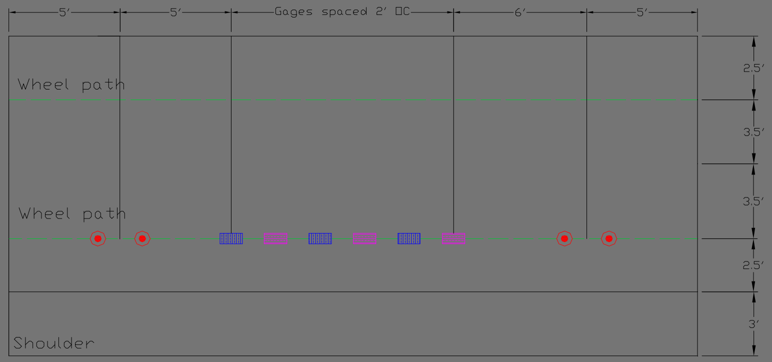
- ORITE’s instrumentation designed to monitor environmental and response parameters in each pavement type.
- Instruments purchased and calibrated, then installed during the construction process
- Environmental parameters monitored in one section.
- Dynamic load responses collected in duplicate sections

WAY-30 Work Plan

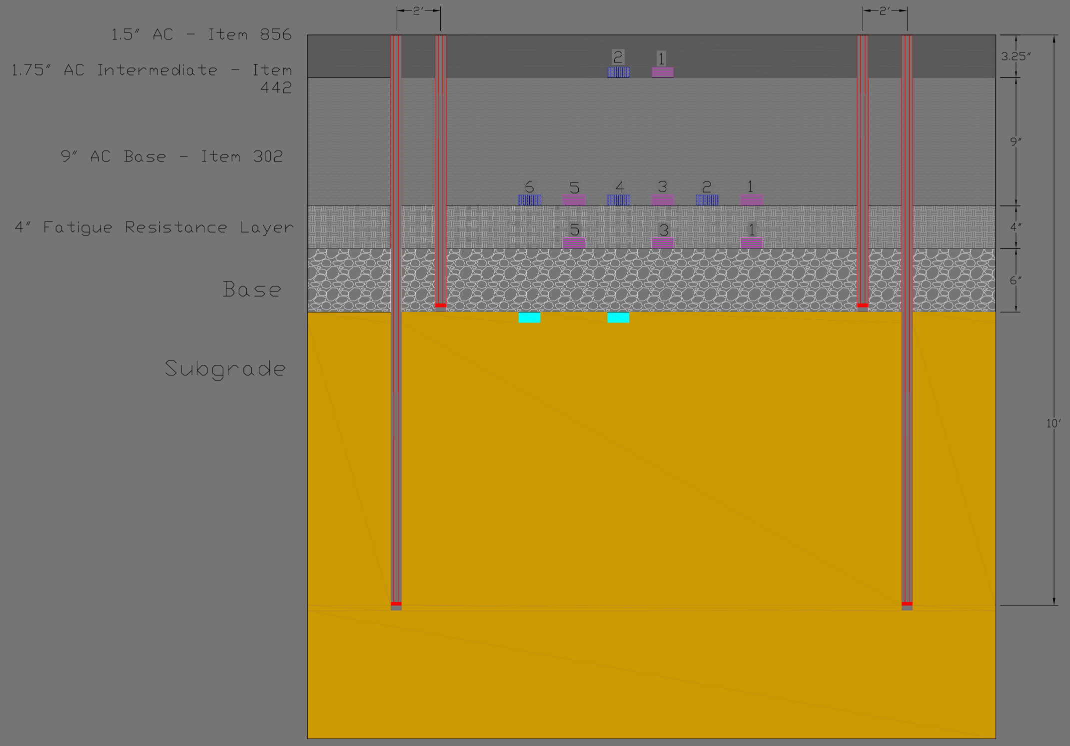
- ODOT measured/assessed
  - Costs & User Delay
  - Safety
  - Ride and Condition
- OU ORITE measured/assessed
  - Dynamic Pavement Load Response
  - Mechanical Properties of Materials
  - Verify Design Procedure

AC SECTION

AC Section A



Plan View

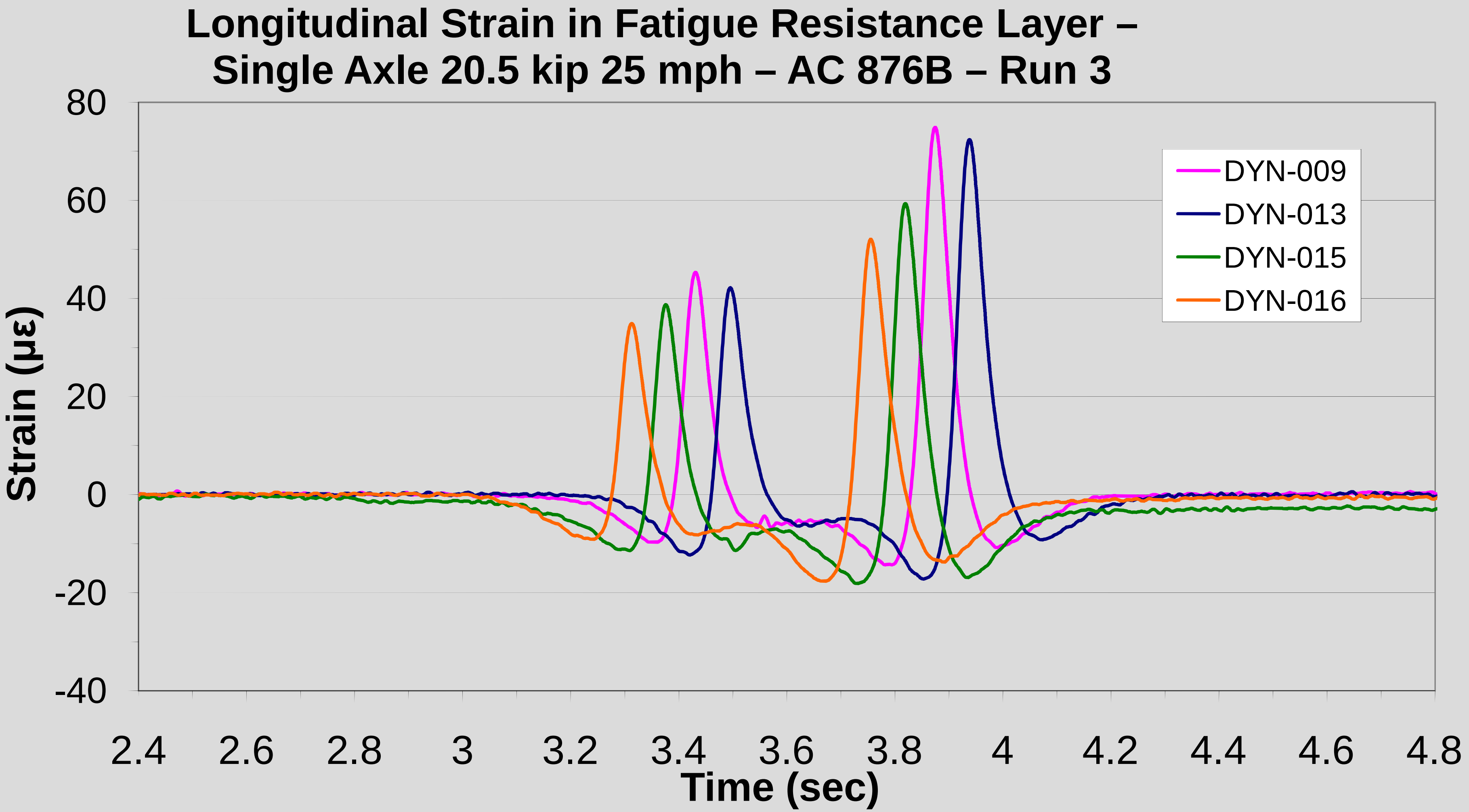


PROFILE VIEW (NTS)

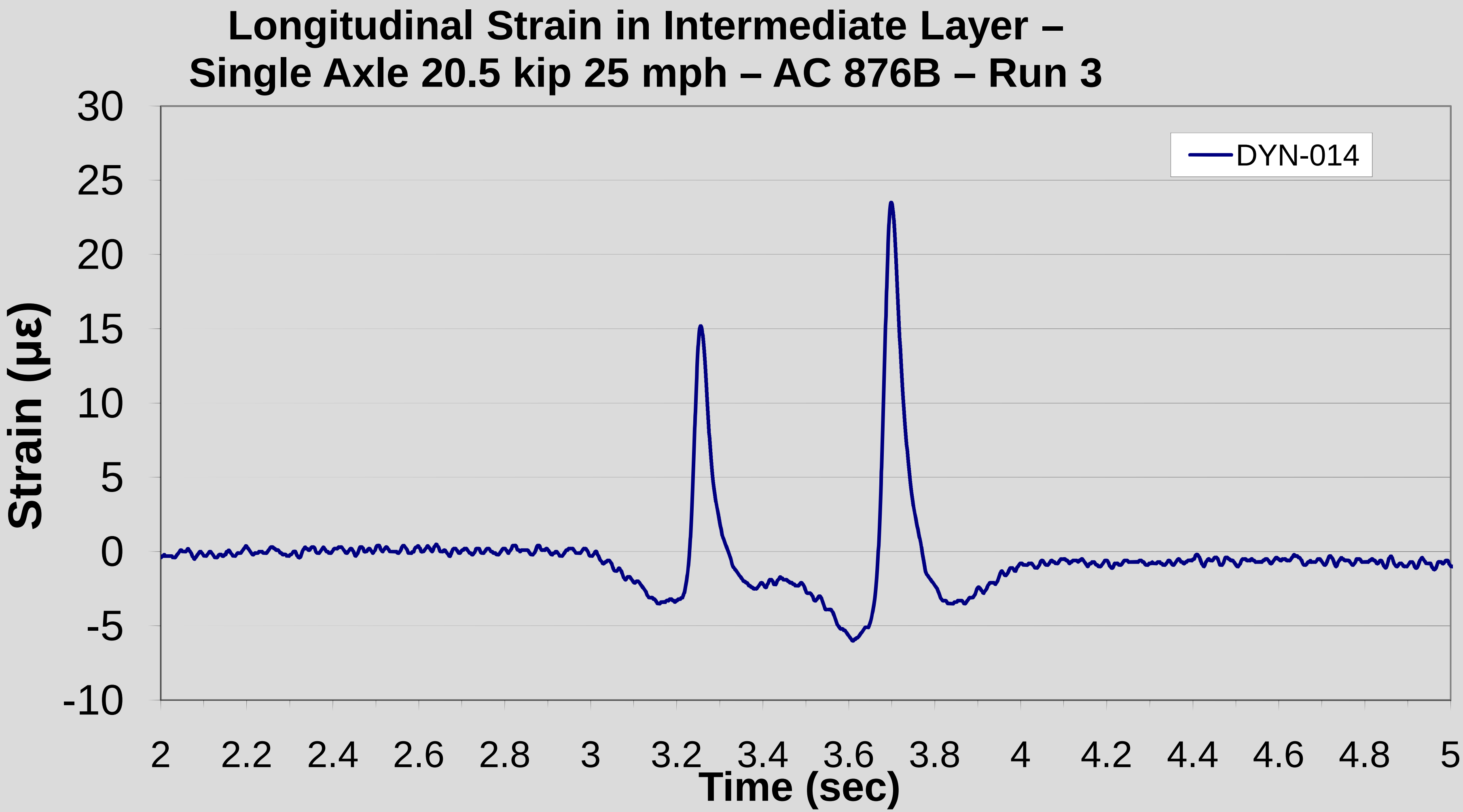
AC STN 876 SECTION A LABELING

● Single Layer Deflectometer
▤ Longitudinal Gage
▥ Transverse Gage
🟦 Pressure Cell

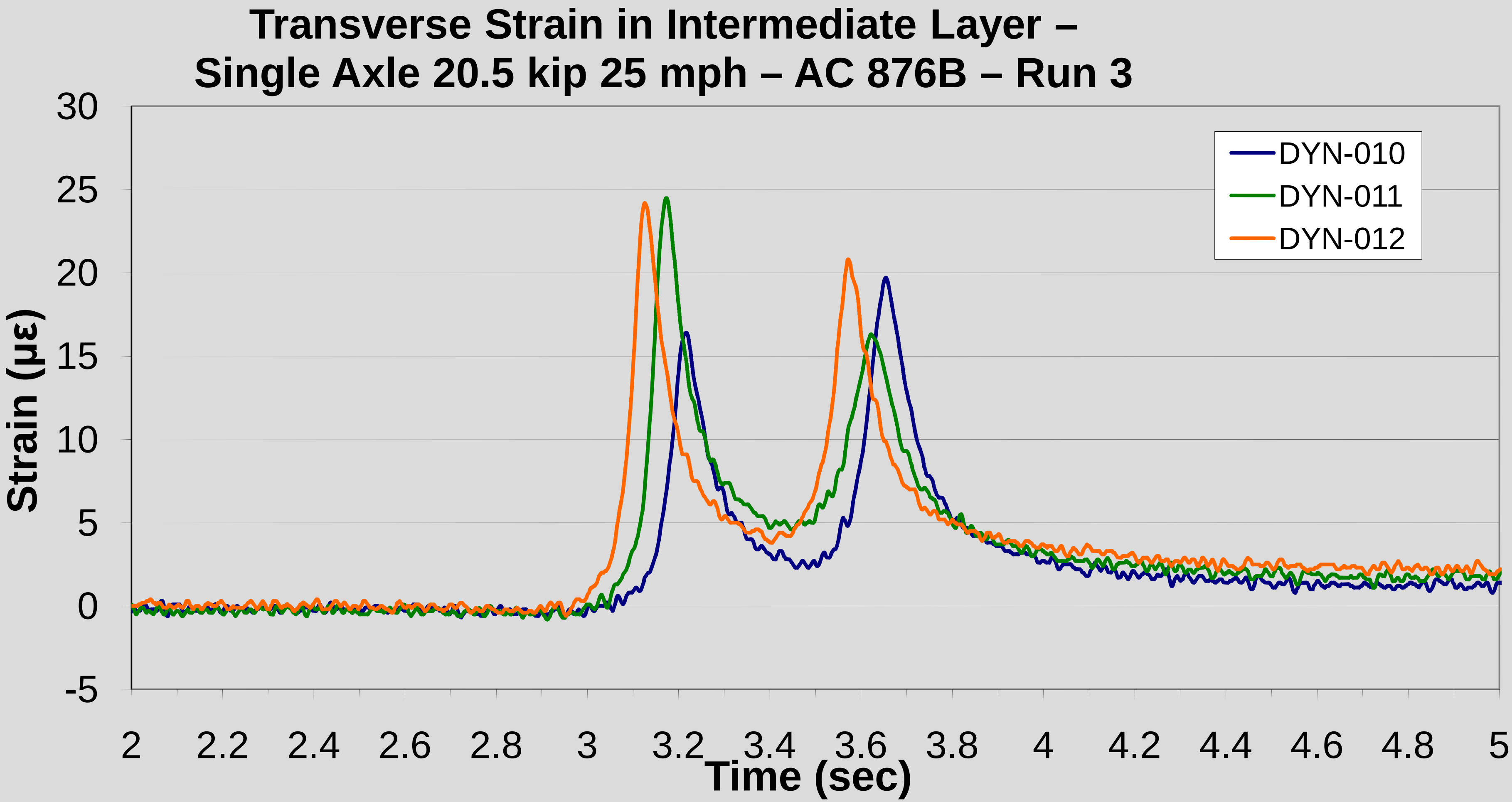
Controlled Vehicle Load Test



Controlled Vehicle Load Test

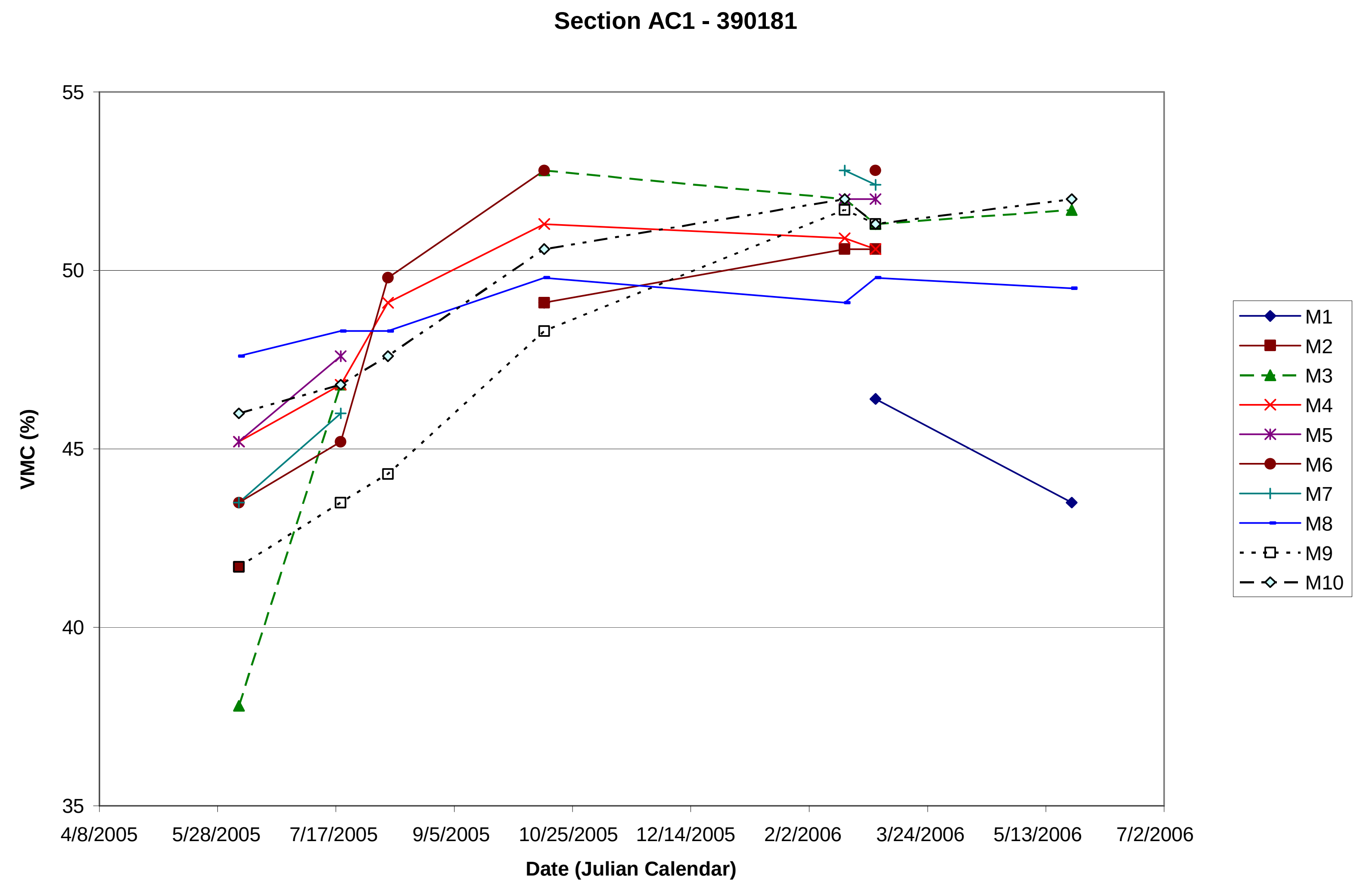


Controlled Vehicle Load Test

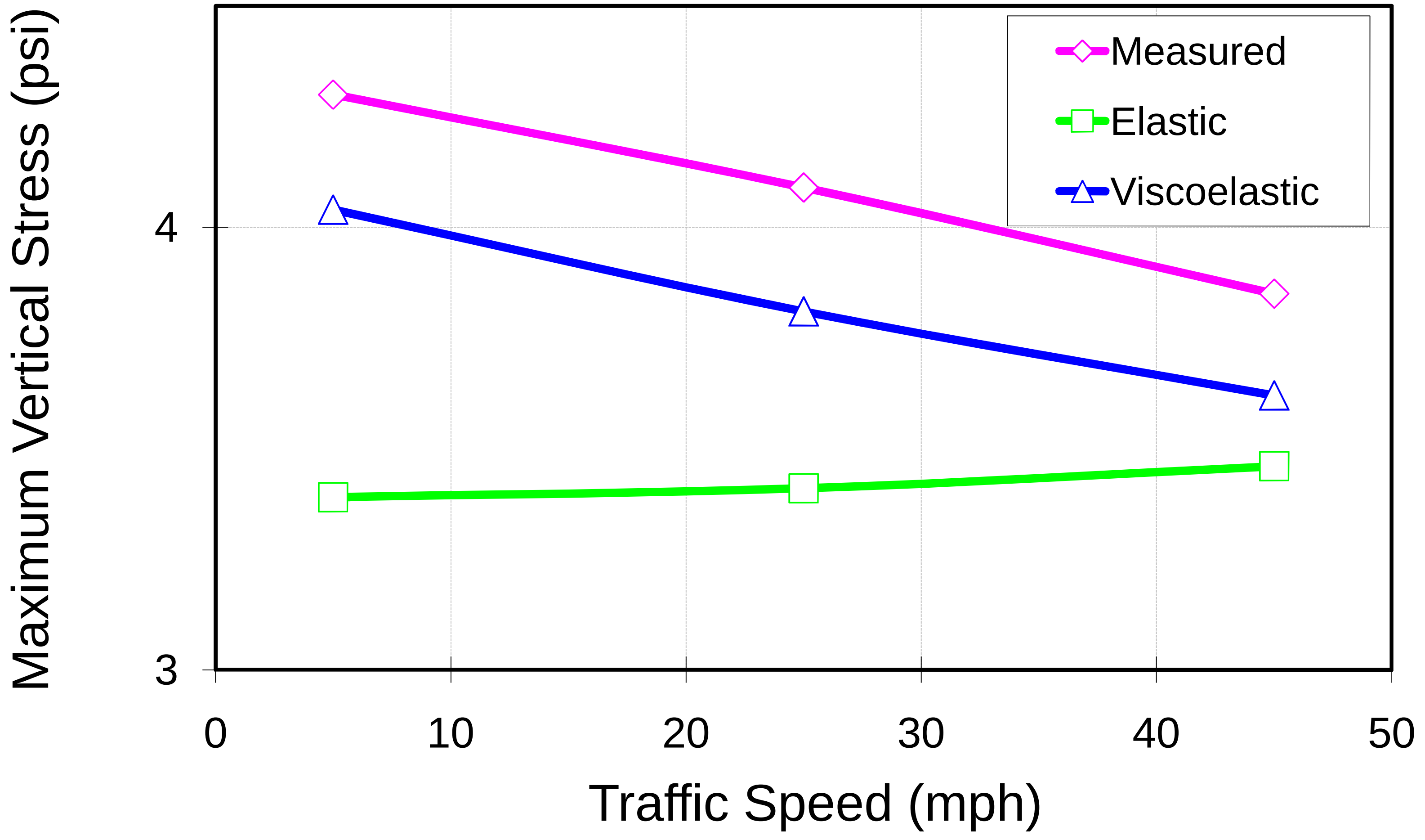


Subgrade Volumetric Moisture Content Variation Section 876 (AC1 – 390181)

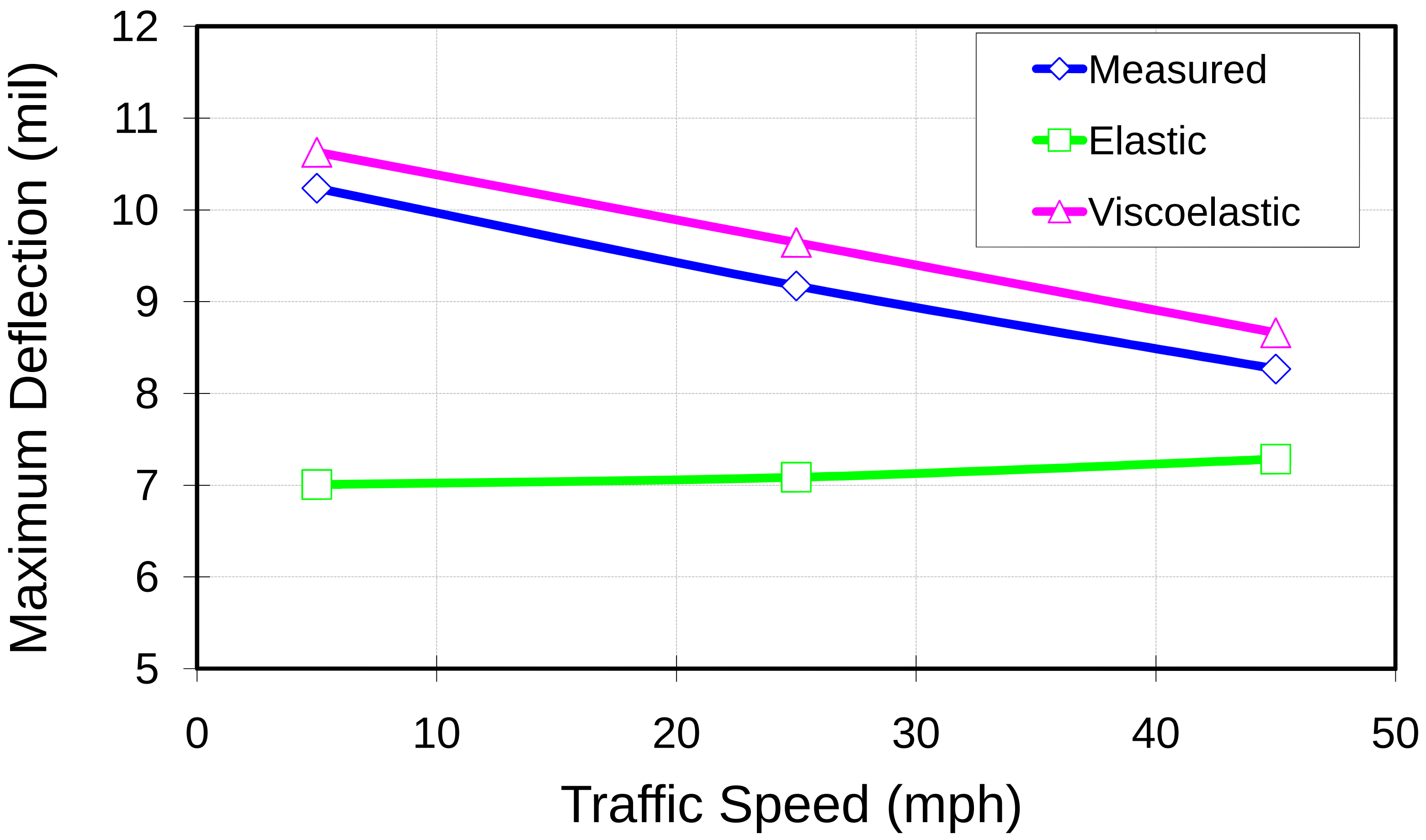
10 TDR Sensors

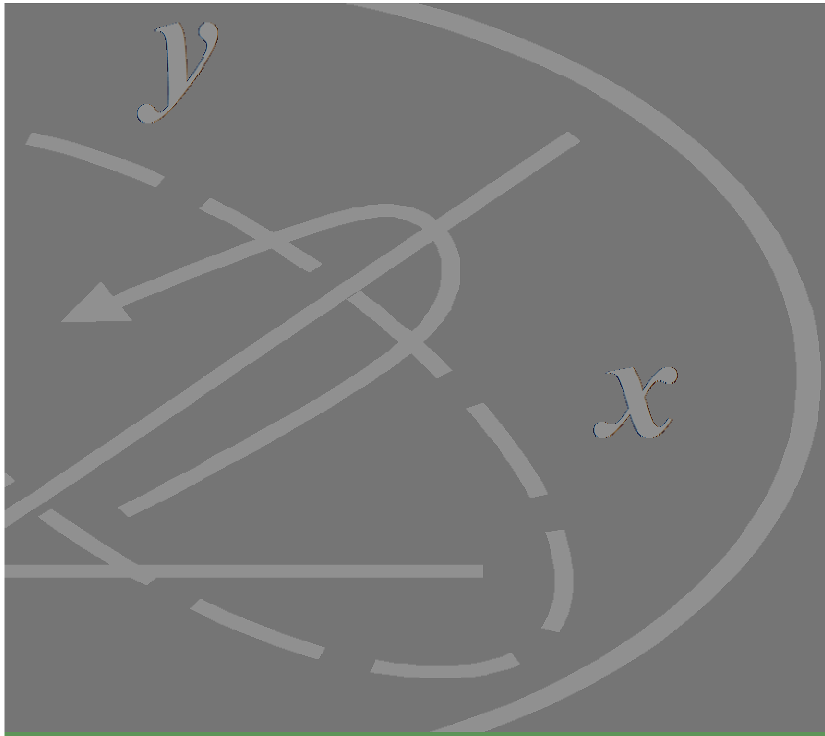


Elastic FE Model vs. Viscoelastic FE Model



Elastic FE Model vs. Viscoelastic FE Model





Warm Mix Asphalt
Perpetual Pavement

Four kinds of Warm Mix Asphalt (WMA) exist

- Aspha-min
  - Addition of sodium aluminum silicate or zeolite in a machine.
- Evotherm
  - Includes additives in the form of an emulsion to improve the coating and workability of WMA mixes.
- Sasobit
  - Uses foam in the form of a paraffin-wax compound extracted from coal gasification.
- WAM-Foam
  - Uses a soft binder and a hard foamed binder added at different times during the mixing process.
- In ORITE research project, only the first three were investigated
  - WAM-Foam dropped from project in consultation with Ohio Department of Transportation (ODOT) engineers and Flexible Pavements of Ohio

Accelerated Pavement Load Facility (APLF)

- Complete, full-scale two-lane pavement, base, and subgrade construction.
- Testing of Asphaltic Materials and PCC.
- 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.

- A rolling tire load of 9000 lb (40 kN) to 30,000 lb (133 kN) can be applied to simulate a passing truck with standard single or dual tires or wide single tires, up to 500 times per hour

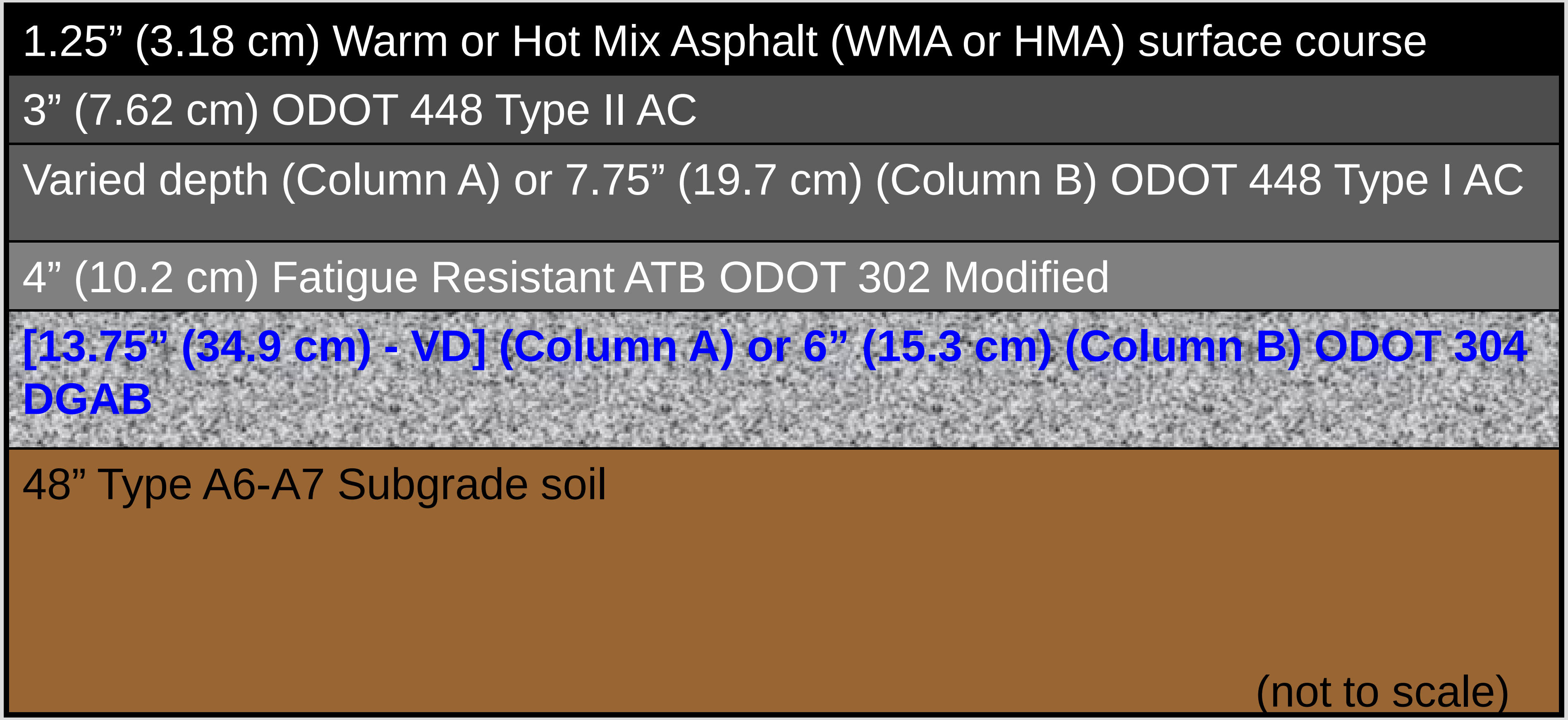
APLF Monitoring

- 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

Pavements constructed in APLF

Surface	Direction of wheel →		Lane width
Evotherm WMA	1.25” (3.18 cm) Evotherm WMA 3” (7.62 cm) ODOT 448 Type II AC 4.75” (12.1 cm) ODOT 448 Type I AC 4” (10.2 cm) Fatigue Resistant Layer 9” (22.9 cm) ODOT 304 DGAB 48” (120 cm) A6-A7 Subgrade	1.25” (3.18 cm) Evotherm WMA 3” (7.62 cm) ODOT 448 Type II AC 7.75” (19.7 cm) ODOT 448 Type I AC 4” (10.2 cm) Fatigue Resistant Layer 6” (15.3 cm) ODOT 304 DGAB 48” (120 cm) A6-A7 Subgrade	8 ft (2.44 m)
Sasobit WMA	1.25” (3.18 cm) Sasobit WMA 3” (7.62 cm) ODOT 448 Type II AC 5.75” (14.6 cm) ODOT 448 Type I AC 4” (10.2 cm) Fatigue Resistant Layer 8” (20.3 cm) ODOT 304 DGAB 48” (120 cm) A6-A7 Subgrade	1.25” (3.18 cm) Sasobit WMA 3” (7.62 cm) ODOT 448 Type II AC 7.75” (19.7 cm) ODOT 448 Type I AC 4” (10.2 cm) Fatigue Resistant Layer 6” (15.3 cm) ODOT 304 DGAB 48” (120 cm) A6-A7 Subgrade	8 ft (2.44 m)
Aspha-min WMA	1.25” (3.18 cm) Aspha-min WMA 3” (7.62 cm) ODOT 448 Type II AC 6.75” (17.1 cm) ODOT 448 Type I AC 4” (10.2 cm) Fatigue Resistant Layer 7” (17.8 cm) ODOT 304 DGAB 48” (120 cm) A6-A7 Subgrade	1.25” (3.18 cm) Aspha-min WMA 3” (7.62 cm) ODOT 448 Type II AC 7.75” (19.7 cm) ODOT 448 Type I AC 4” (10.2 cm) Fatigue Resistant Layer 6” (15.3 cm) ODOT 304 DGAB 48” (120 cm) A6-A7 Subgrade	8 ft (2.44 m)
Conventional HMA	1.25” (3.18 cm) Conventional HMA 3” (7.62 cm) ODOT 448 Type II AC 7.75” (19.7 cm) ODOT 448 Type I AC 4” (10.2 cm) Fatigue Resistant Layer 6” (15.3 cm) ODOT 304 DGAB 48” (120 cm) A6-A7 Subgrade	1.25” (3.18 cm) Conventional HMA 3” (7.62 cm) ODOT 448 Type II AC 7.75” (19.7 cm) ODOT 448 Type I AC 4” (10.2 cm) Fatigue Resistant Layer 6” (15.3 cm) ODOT 304 DGAB 48” (120 cm) A6-A7 Subgrade	8 ft (2.44 m)
	← 22.5 ft (6.9 m) →	← 22.5 ft (6.9 m) →	

Layers of WMA pavements constructed in APLF profile view



1.25” (3.18 cm) Warm or Hot Mix Asphalt (WMA or HMA) 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

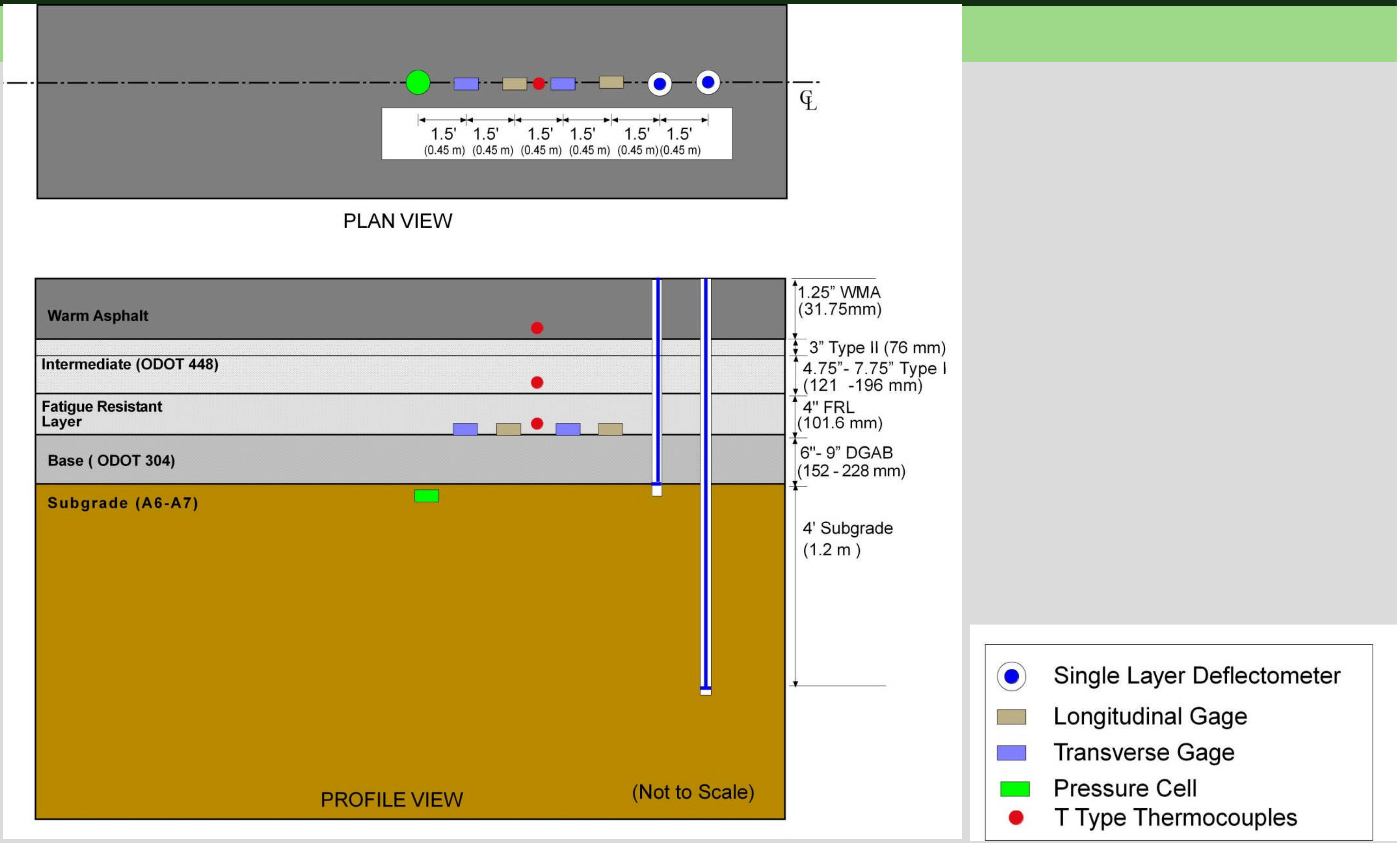
[13.75” (34.9 cm) - VD] (Column A) or 6” (15.3 cm) (Column B) ODOT 304 DGAB

48” Type A6-A7 Subgrade soil

(not to scale)

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

Instrumentation in APLF

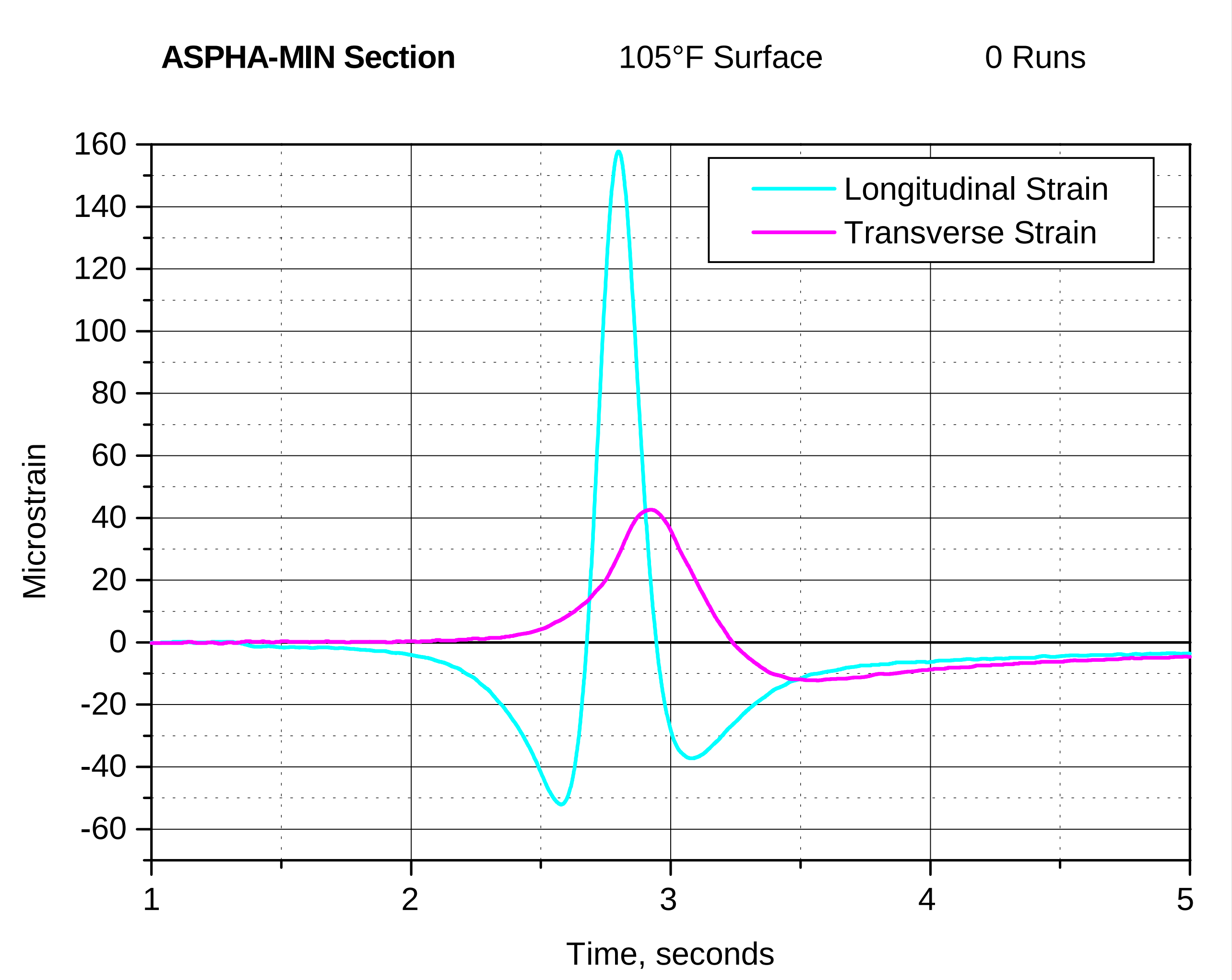


APLF Test Method

- 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

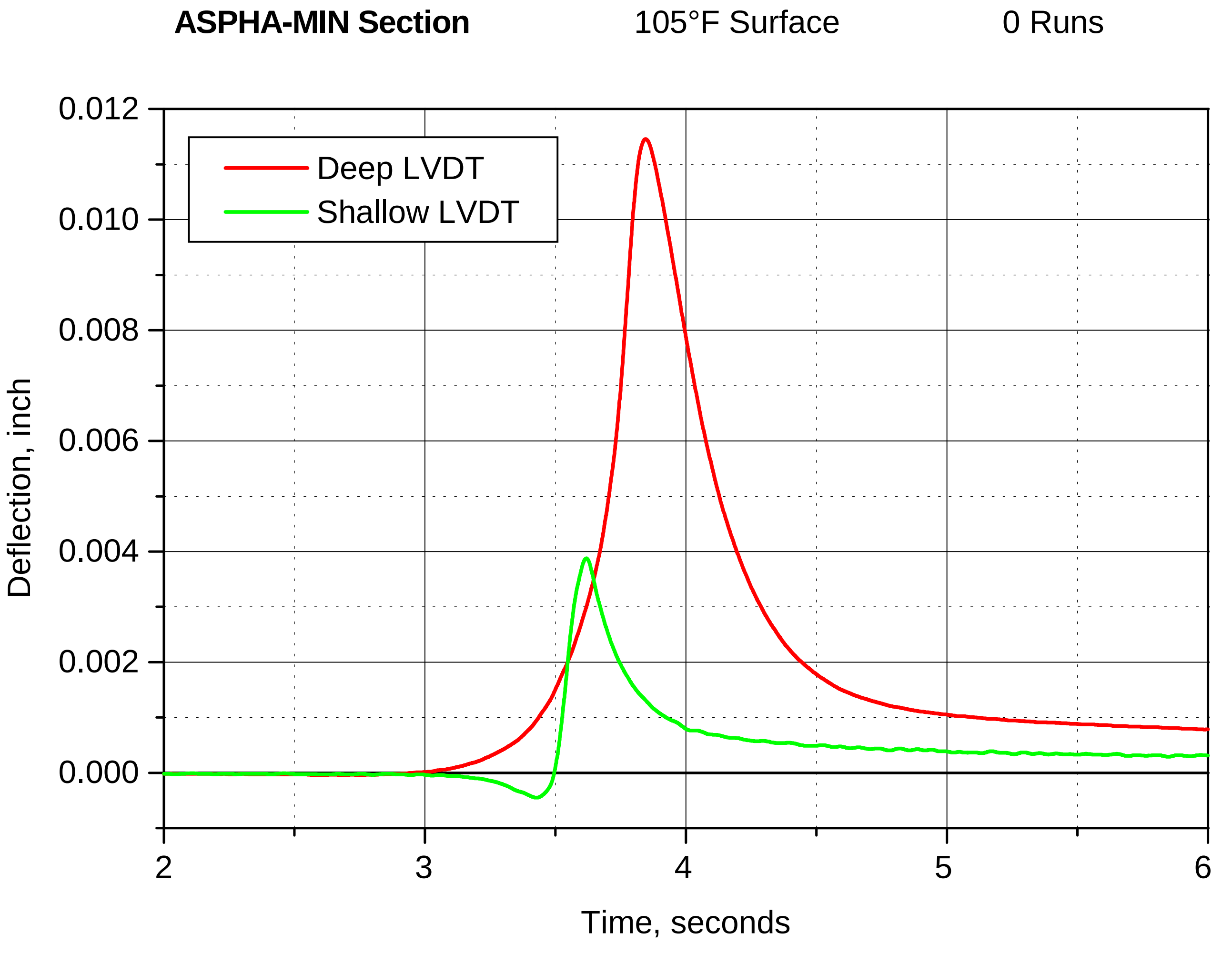
Asapha-min VD Section Results from APLF

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



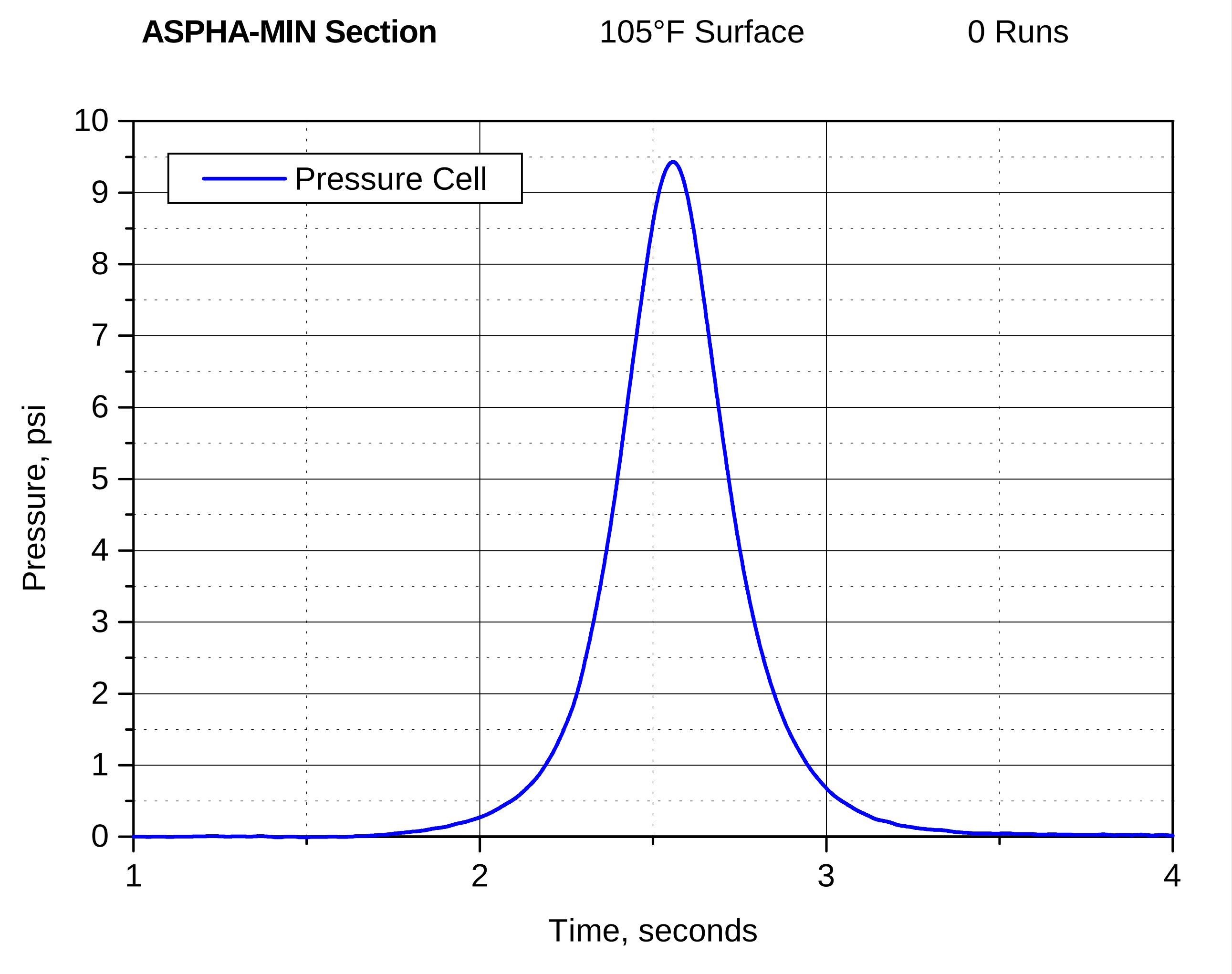
Asapha-min VD Section Results from APLF

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



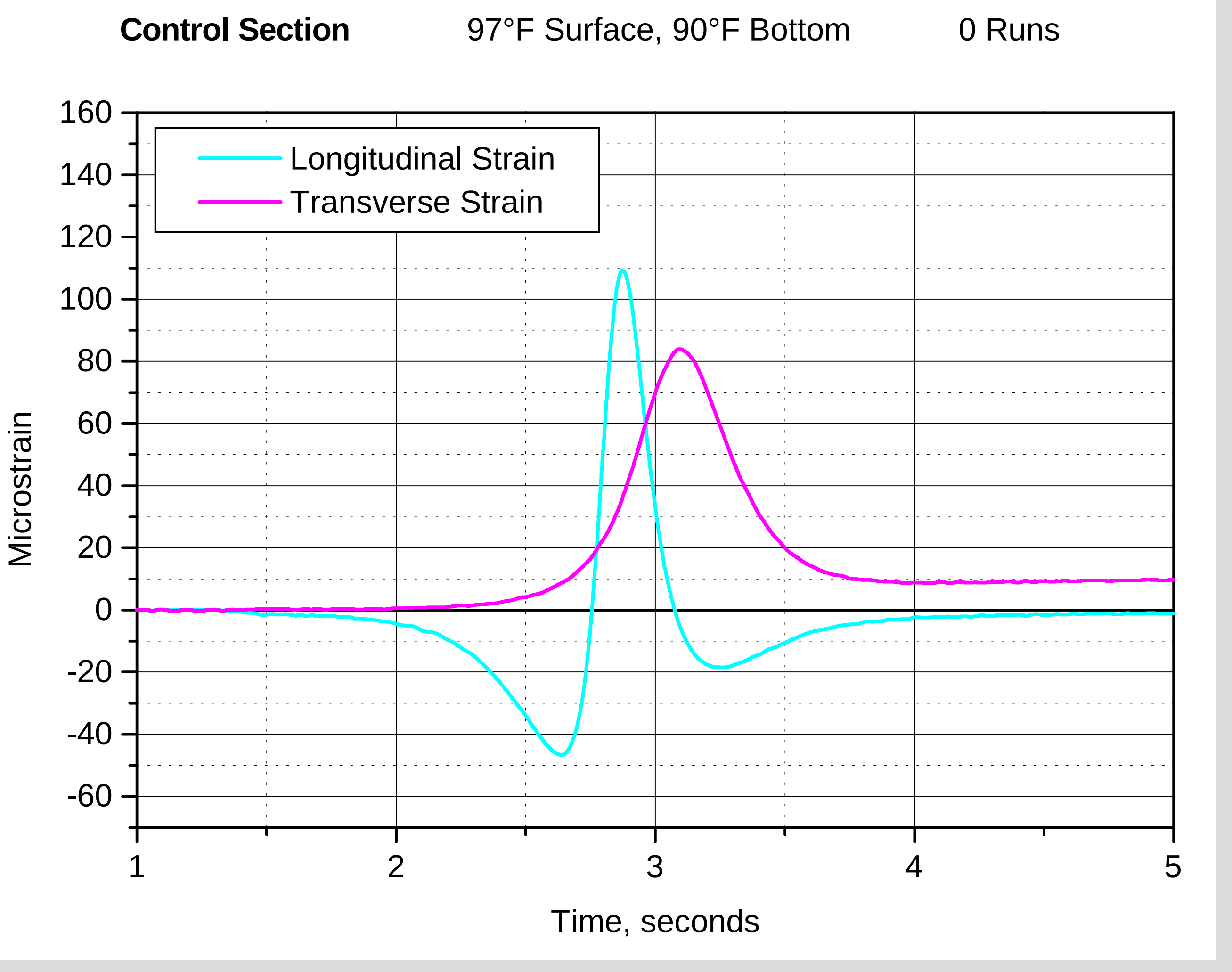
Asapha-min VD Section Results from APLF

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



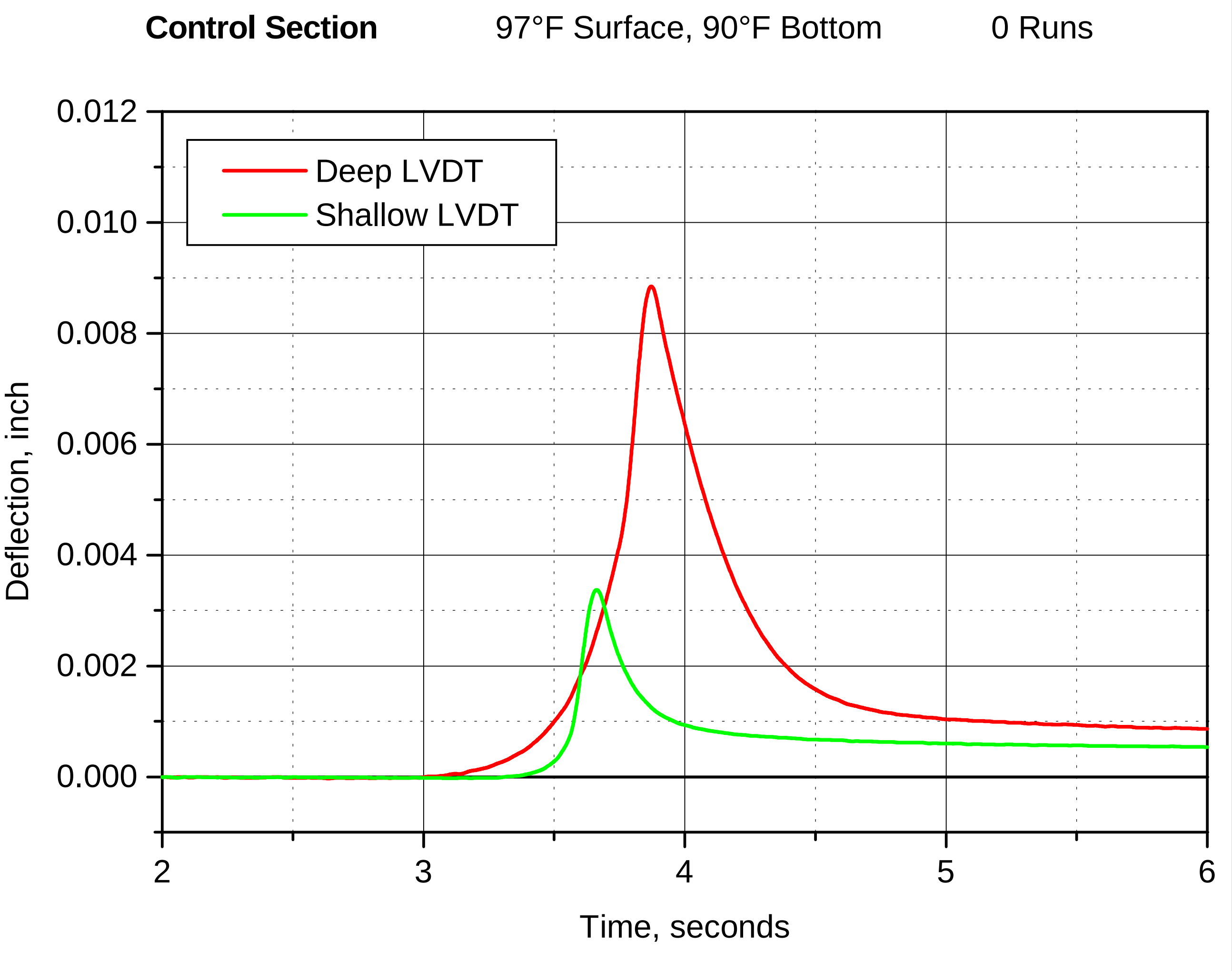
Control (HMA) Section Results from APLF

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



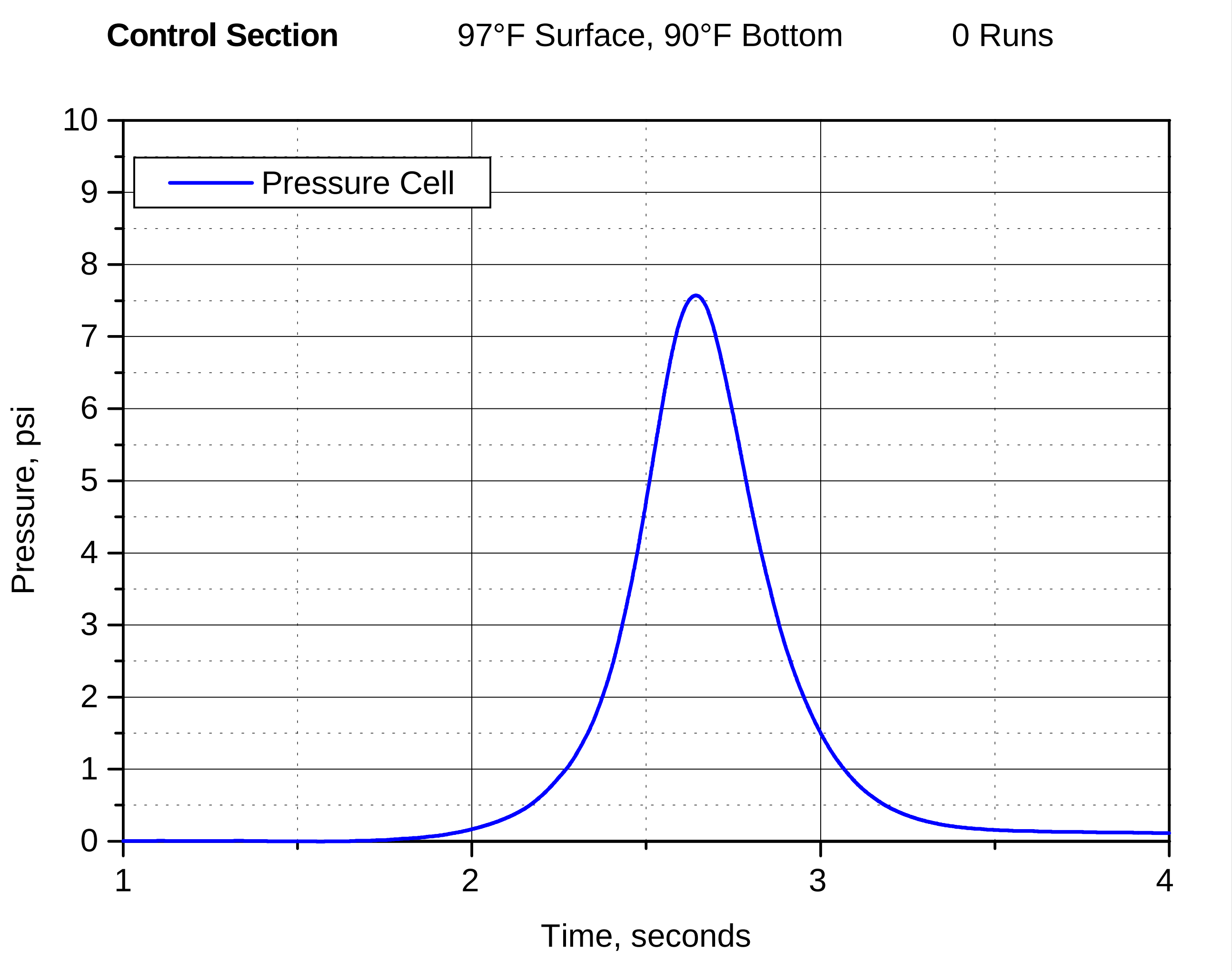
Control (HMA) Section Results from APLF

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



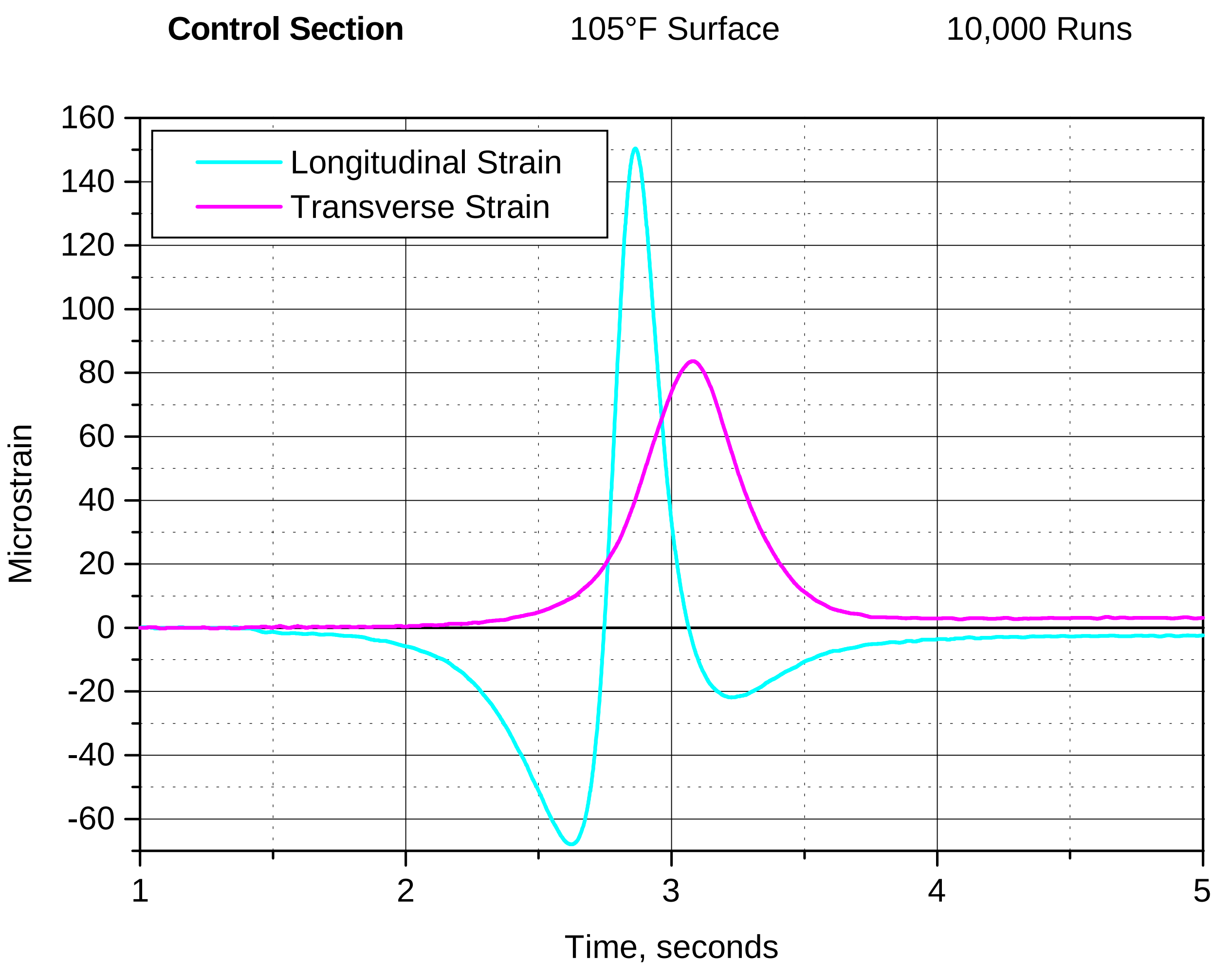
Control (HMA) Section Results from APLF

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



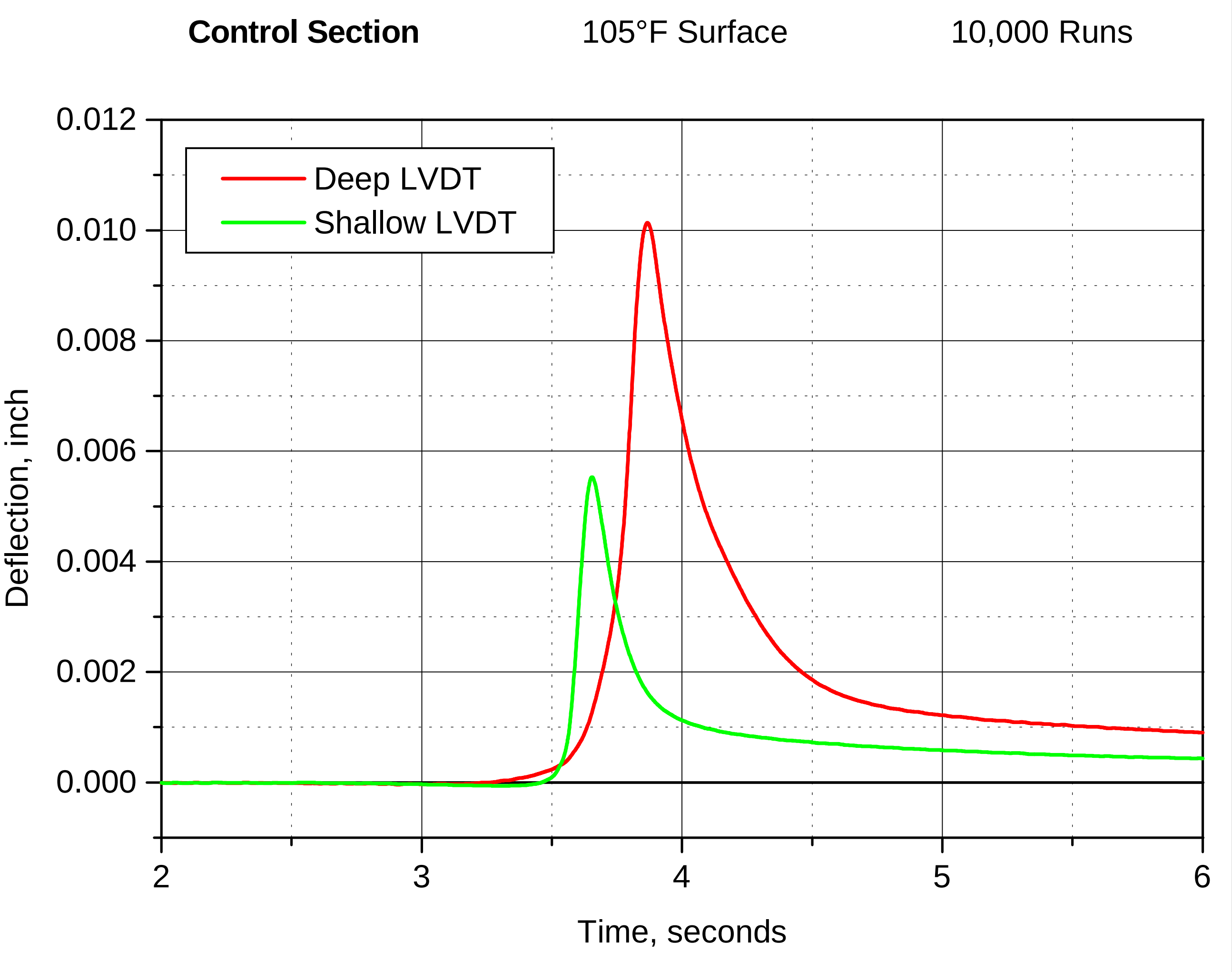
Control (HMA) Section Results from APLF

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



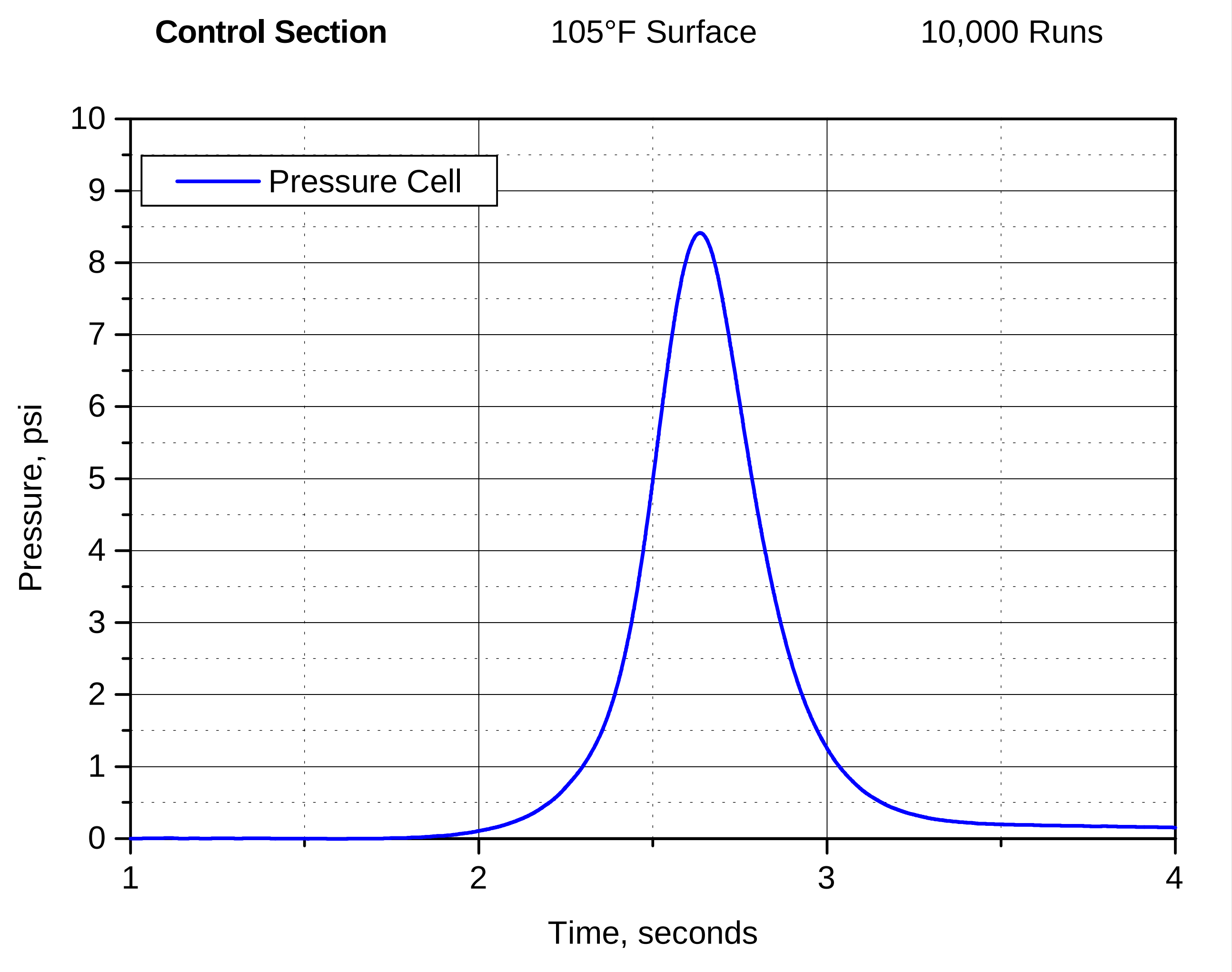
Control (HMA) Section Results from APLF

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



Control (HMA) Section Results from APLF

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



Conclusions

- The perpetual pavement concept works
- Perpetual pavement has the potential to eliminate road reconstruction costs
- Success of any construction project depends crucially on close cooperation between the DOT and the contractor
- 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 με design limit

WAY-30 Conclusions

Fatigue Resistance Layer

- During December CVL tests, longitudinal strain on FRL remained ≤35με, 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 Conclusions

Intermediate Layer and Subgrade

- Strains at bottom of intermediate layer are lower than at bottom of FRL, as expected.
- Maximum subgrade observed pressure during CVL tests was 6.5 psi (45 kPa) at 45 mph (72 km/h) under 40 kip (178 kN) tandem axle load.
- As shown from the TDR data collected, subgrade moisture fluctuates slightly with the seasons, but does not change significantly

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 and long-lived 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.
- The detailed data collected on the WAY-30 project, including data from the weather station data and on material properties make the pavement a good candidate for inclusion in the MEPDG calibration effort for Ohio.
- The data collected from these projects could be used for the validation of the load response computations of the MEPDG software for Ohio. This is in addition to calibration of the software's performance computations.

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
- Warm Mix Asphalt Perpetual Pavement title – *Performance Assessment of Warm Mix Asphalt (WMA) Pavements*: State Job No. 134312, Report No. FHWA/OH-2009/8

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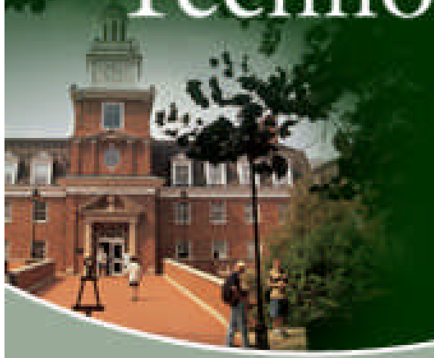

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