

# Evaluation of Feasibility of Using Composite Pavements in Florida By Means of HVS Testing



By

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# Acknowledgments

Project Manager: Dr. Bouzid Choubane

Key FDOT Personnel (alphabetical order): Mike Bergin, Tom Byron, Richard Delorenzo, Lance Denmark, Shawn English, Joseph Fitzgerald, Vidal Francis, Charles Ishee, Abdenour Nazef, Aaron Philpott, Steve Ross, Greg Sholar, Kyle Younger, and others

# Research Need

**Increasing truck loads and tire pressure**

**Rutting and surface-initiated cracking in asphalt pavements**

**Increasing price of asphalt**

**Possible Solution:  
Whitetopping (WT)**

## **Advantages of WT**

- Resistant to rutting and surface-initiated cracking**
- Better long-term performance**



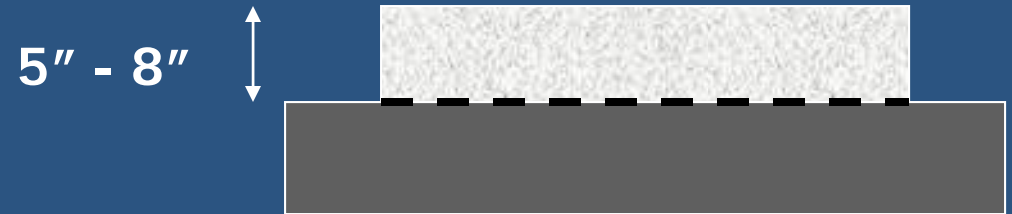
**There is a need to effectively evaluate the feasibility and proper application of WT pavements in Florida**

# Types of Whitetopping

- Conventional White-topping (CWT)



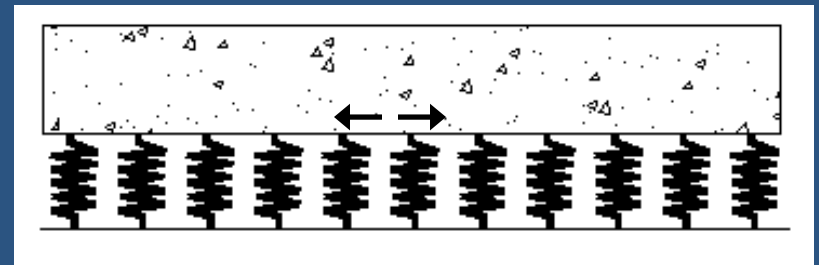
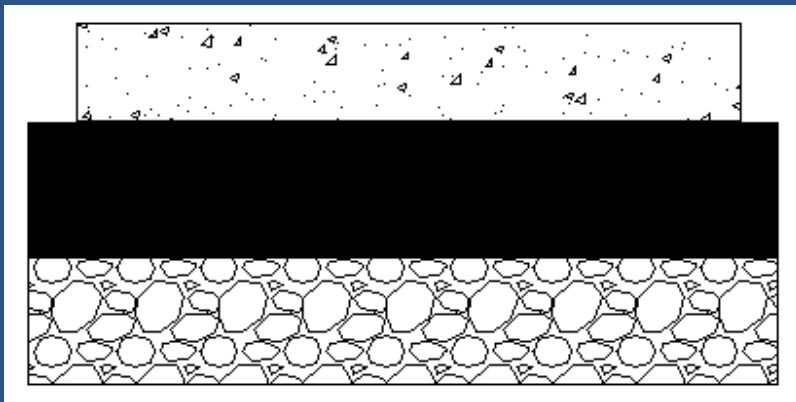
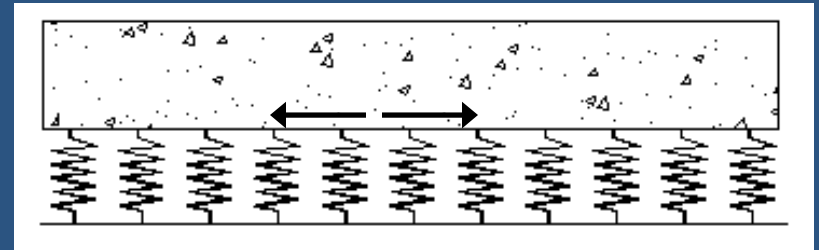
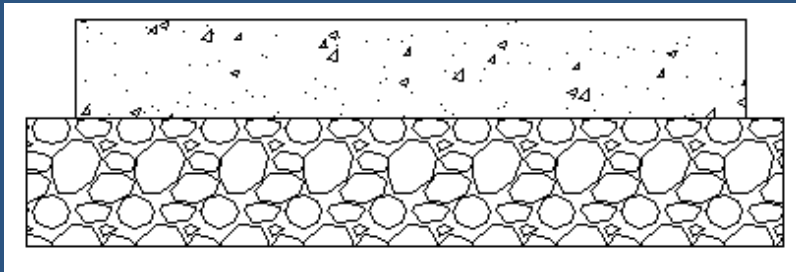
- Thin White-topping (TWT)



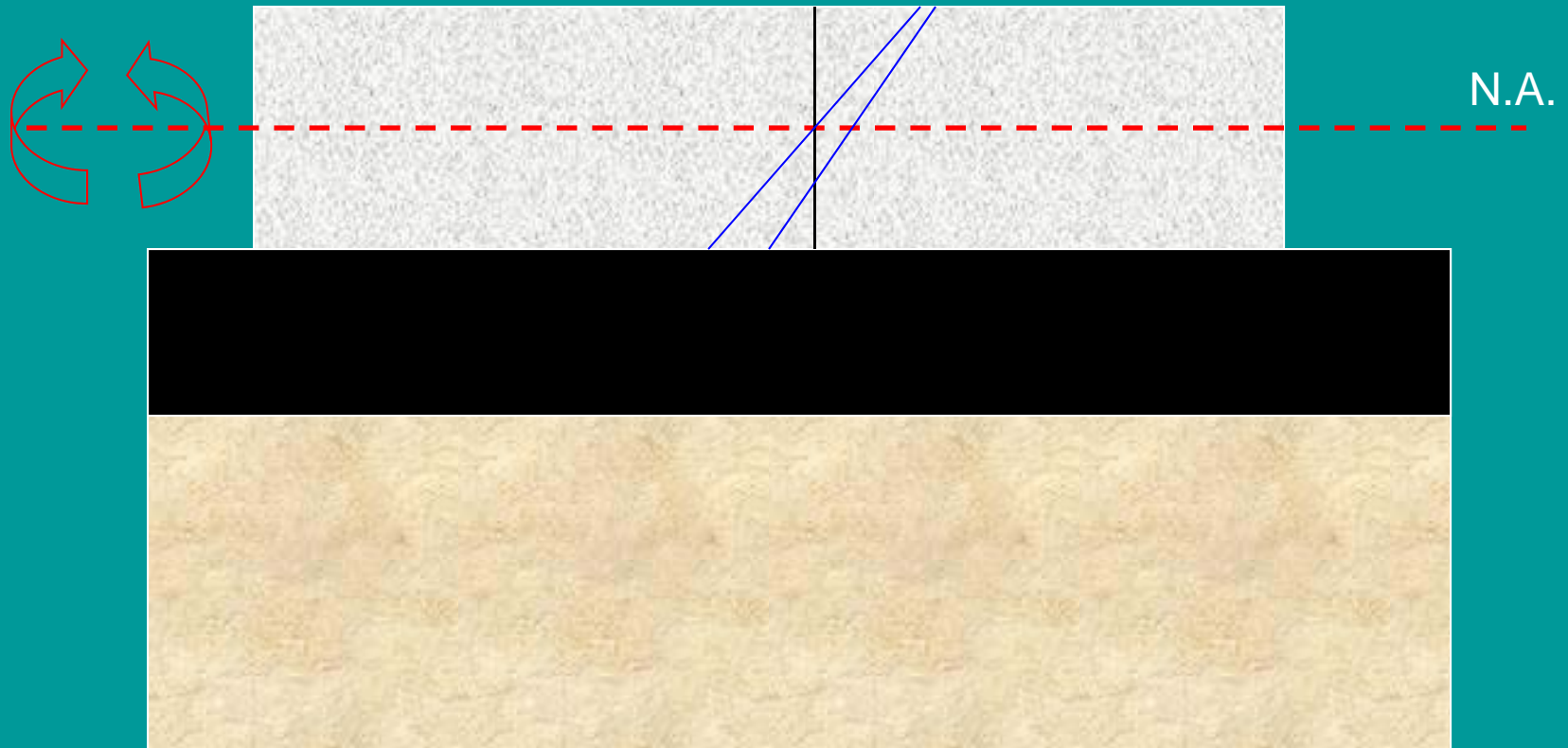
- Ultra-thin White-topping (UTW)



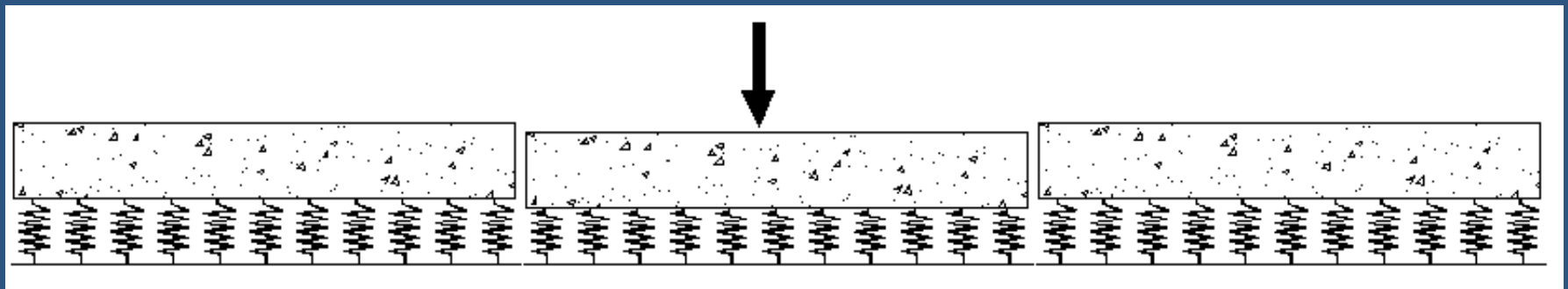
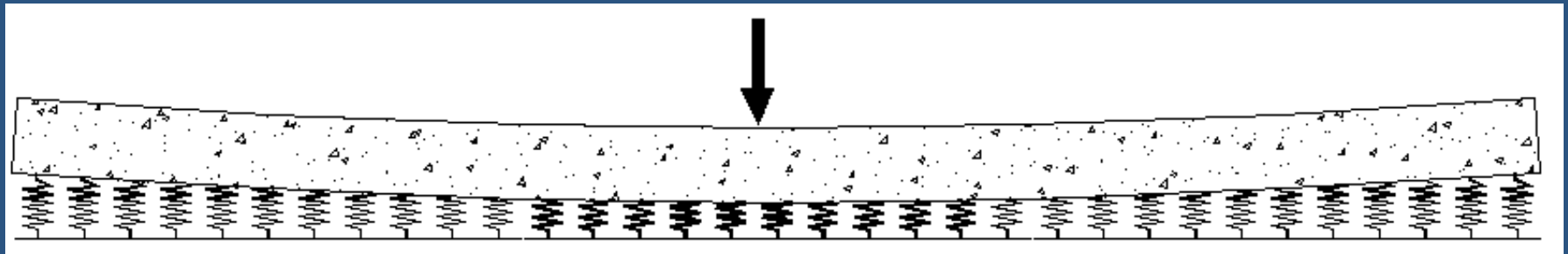
# How does un-bonded Whitetopping work?



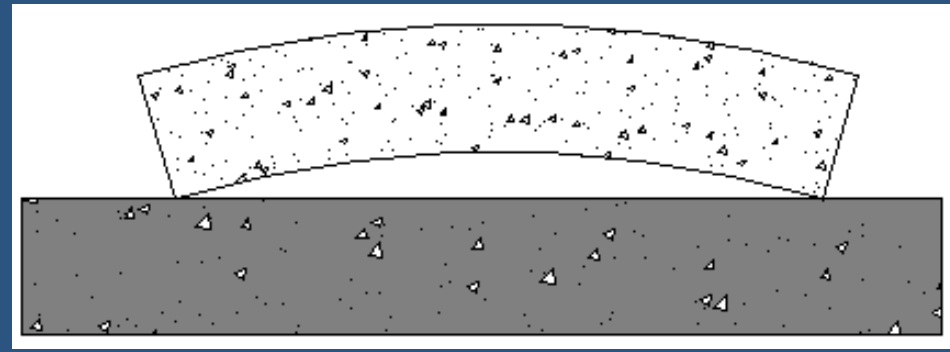
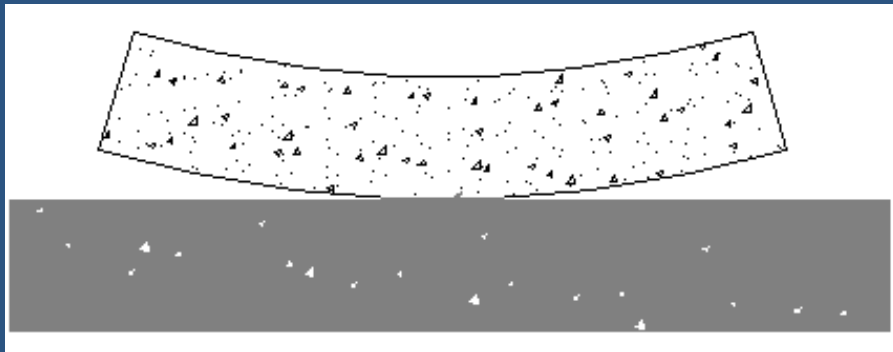
# How does bonded Whitetopping work?



# Effects of joint spacing



# Effects of temperature differential in the concrete slab





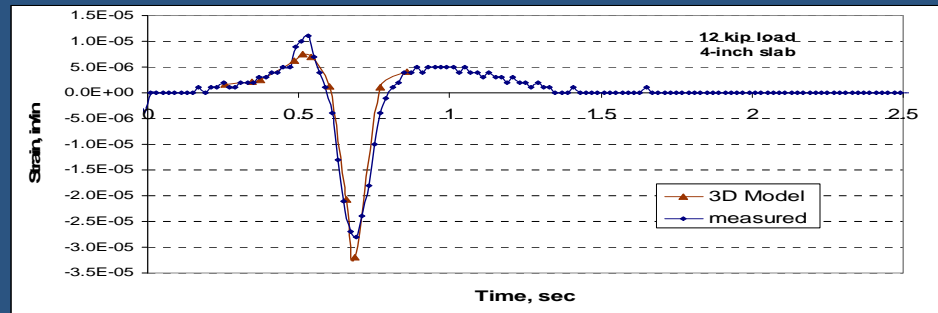
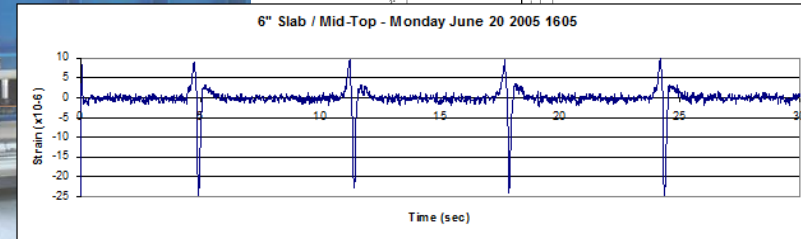
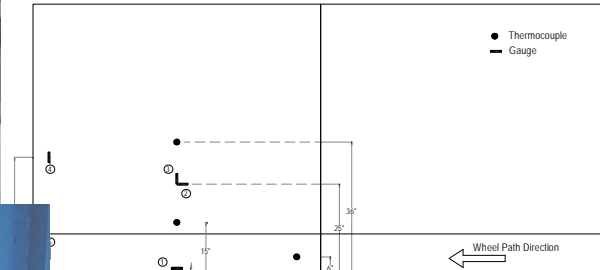
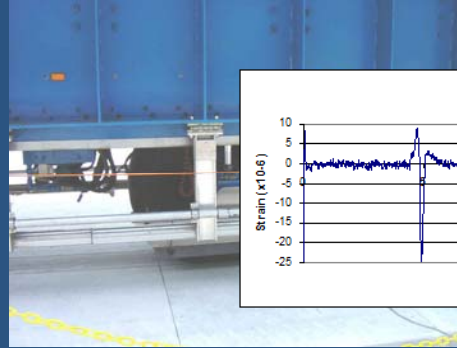
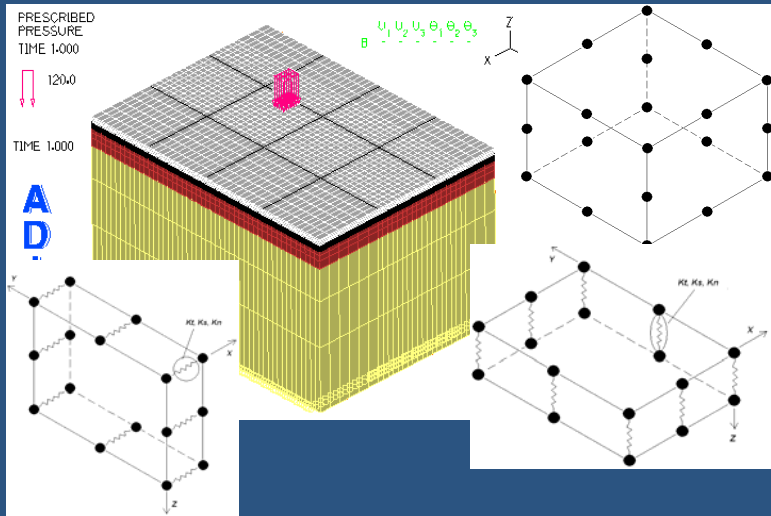
# Objectives

- To develop analytical models for analysis of the behavior of UTW, TWT and CWT pavements. These models are to be verified and fine-tuned by experimental results.
- To evaluate the potential performance of the WT pavement test sections for use under Florida conditions.
- To assess the applicability of UTW, TWT and CWT techniques for rehabilitation of asphalt pavements in Florida.

# Approach

- Run full scale experiments with proper instrumentation
- Develop a reliable model and methodology to analyze the behavior of WT pavements under the effects of load and temperature
  - calibrate and verify the analytical model
  - observe relationships between performance (distresses) and measured strains and calculated stresses

# Approach

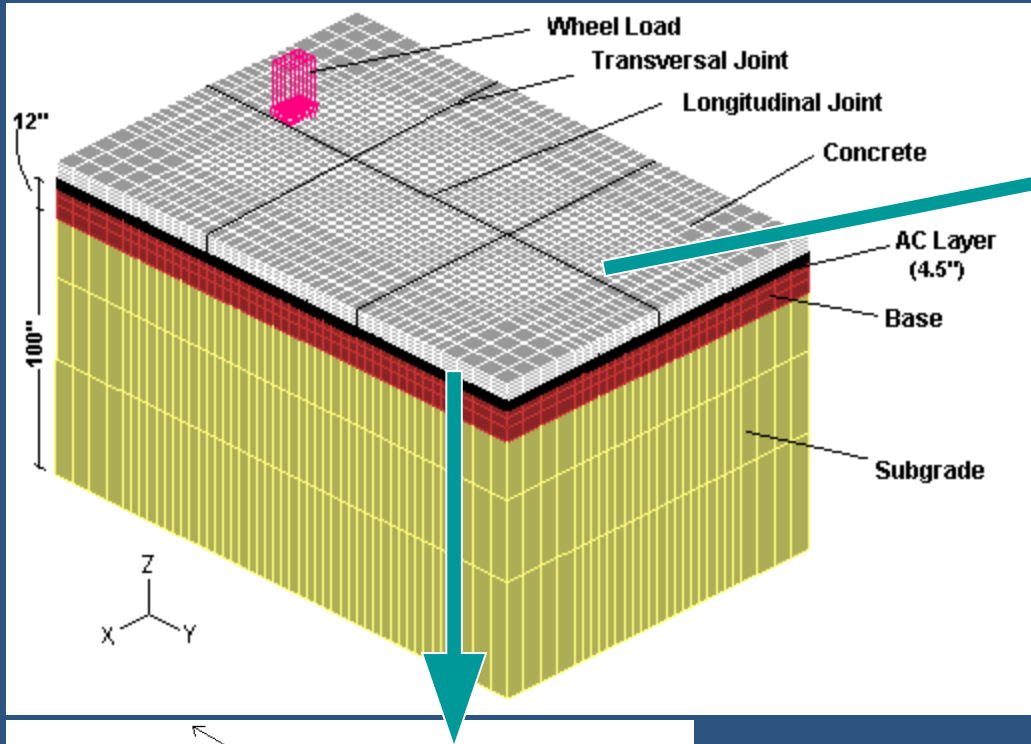


Model  
Calibration

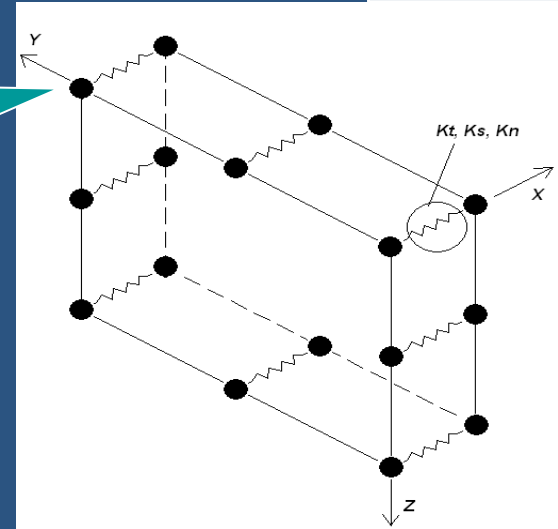
Analytical Tool to predict the behavior of WT pavements

Design recommendations

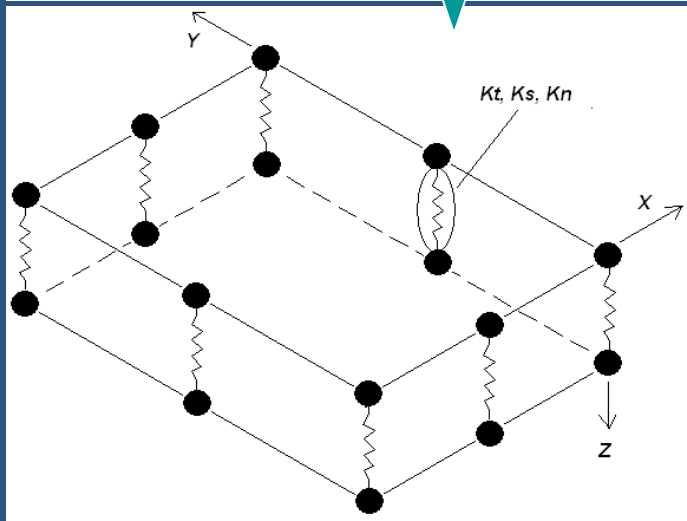
# Analytical Model



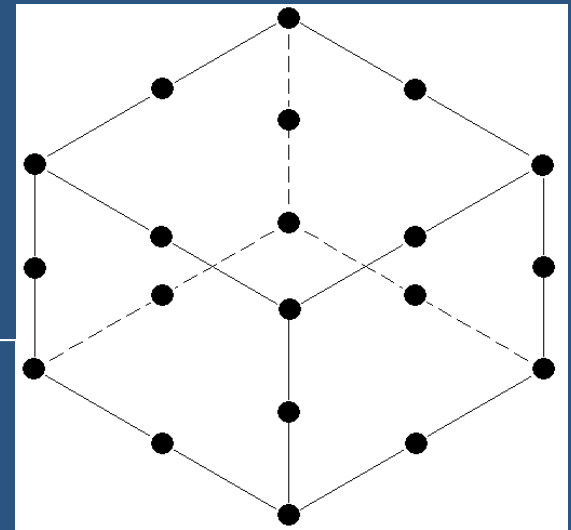
## Joints



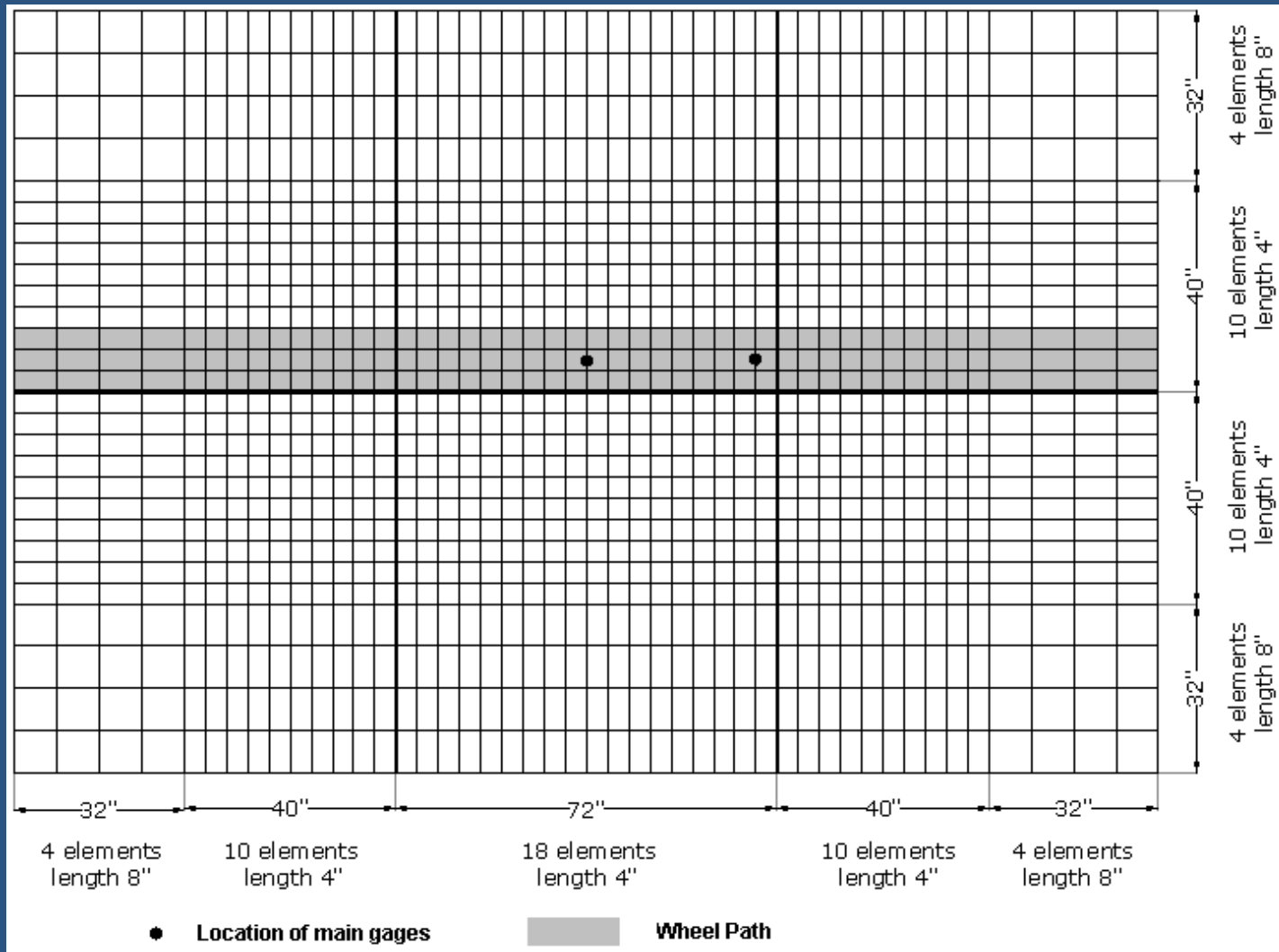
## Interface



## 3D Solid Element



# Analytical Model



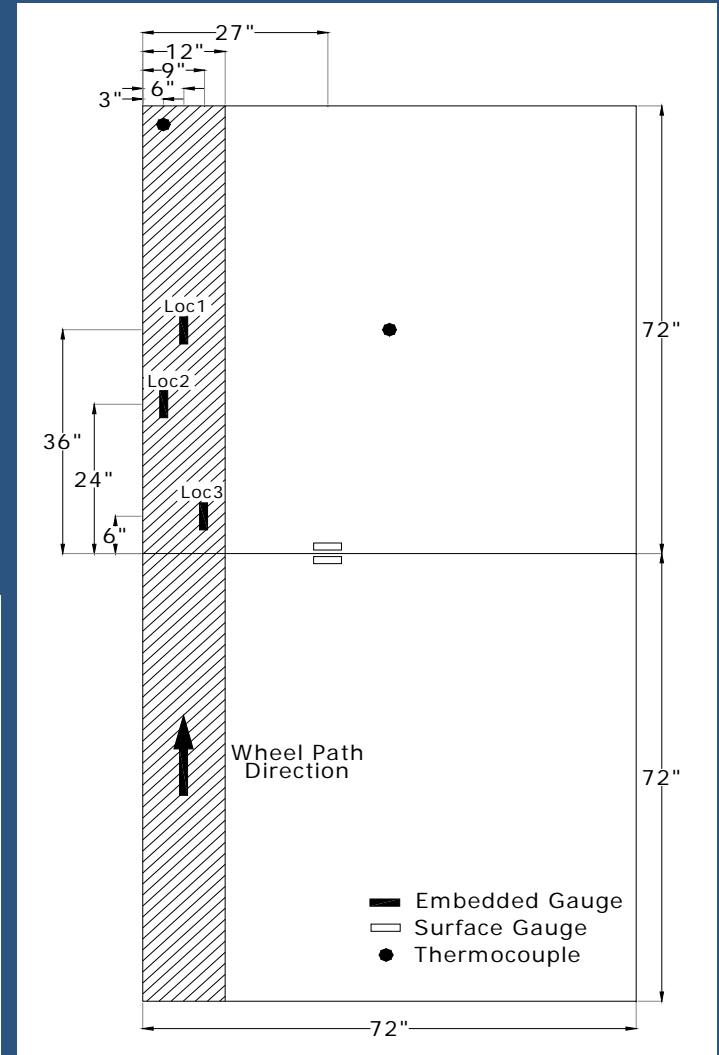
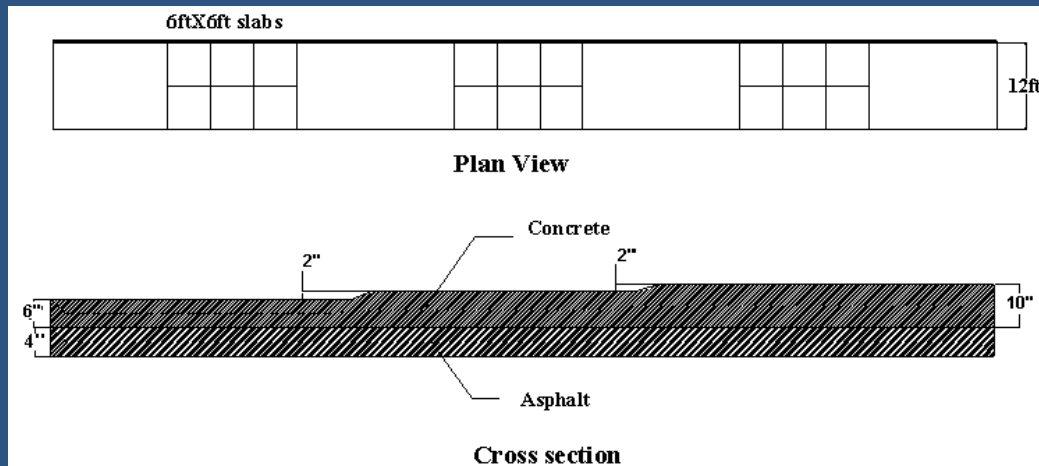
# Test Sections

## ■ Phase I: bonded

- Phase I-a: 6' x 6' Slabs
- Phase I-b: 4' x 4' Slabs
- 4, 5 and 6 inch slabs

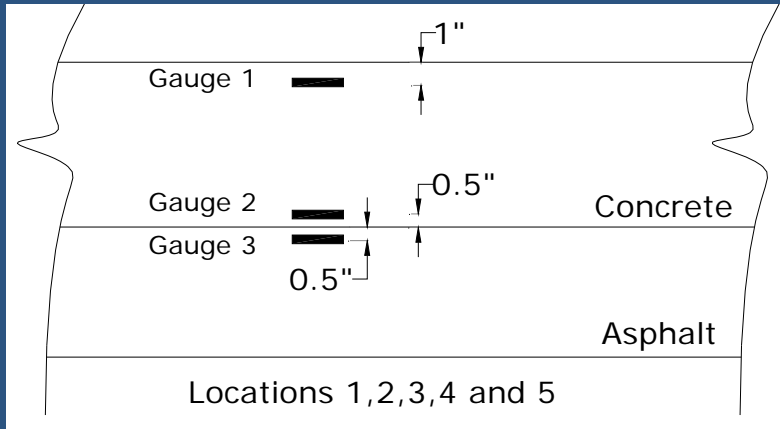
## ■ Phase II: Un-bonded

- 6' x 6' Slabs
- 6, 8 and 10 inch slabs

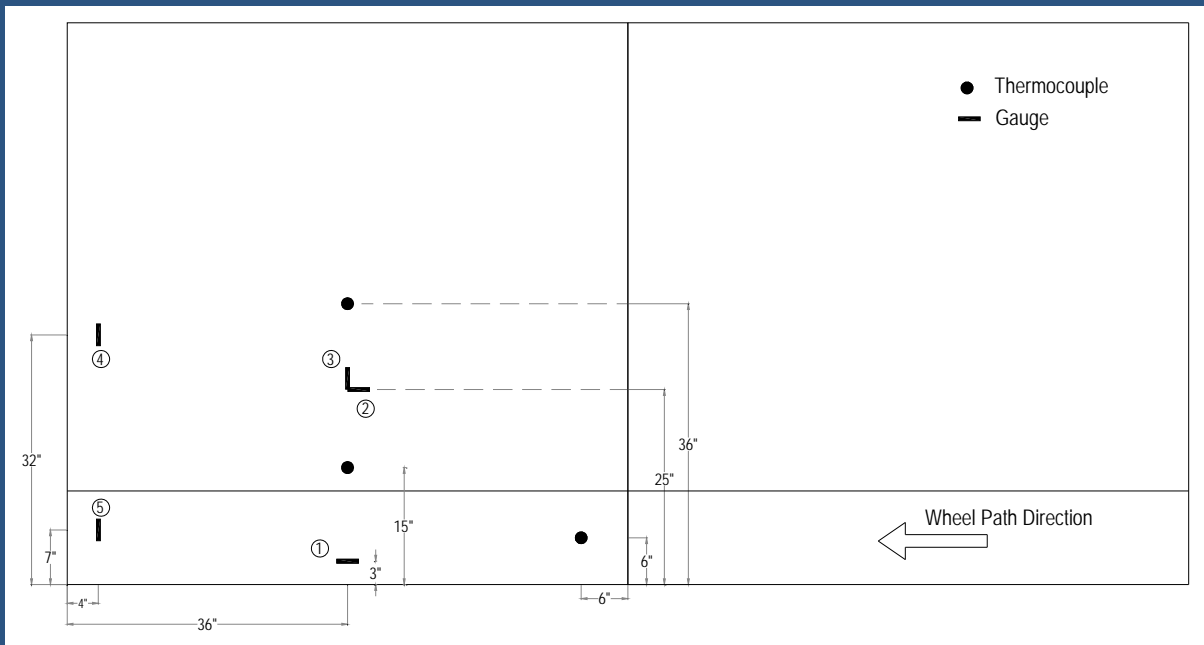
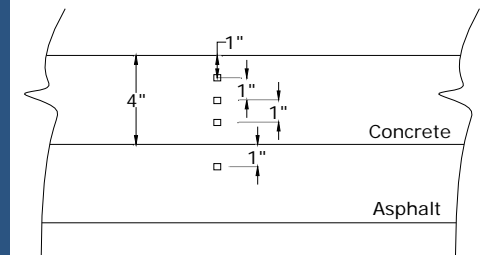
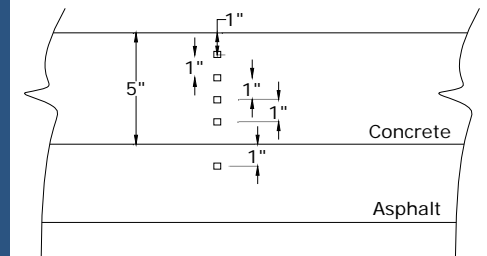
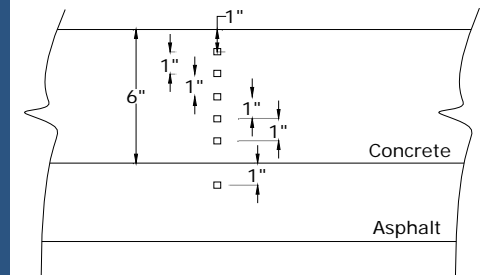


# Instrumentation

## Gages locations



## Thermocouples



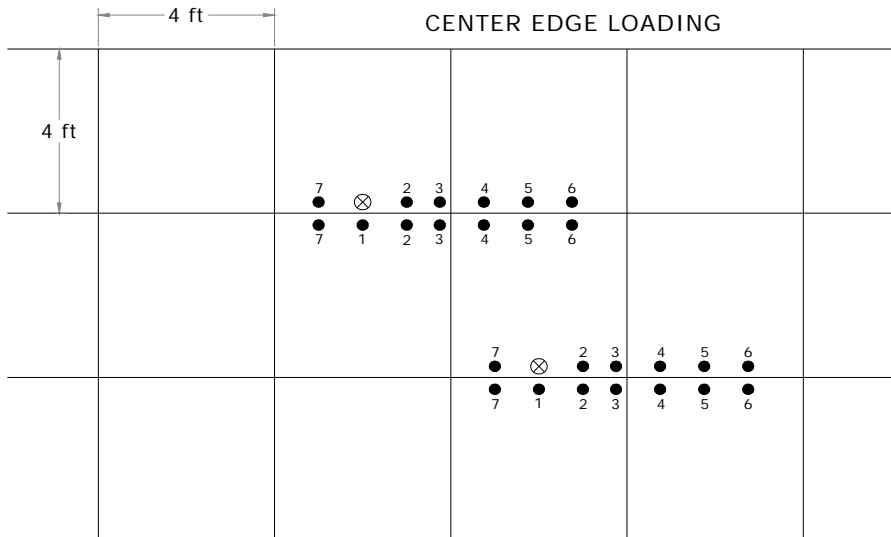
# Construction & Testing of Test Sections





# Material Characterization

- Characterization of the test sections by both laboratory and FWD testing, to obtain pavement parameters of the test sections



# Material Characterization

## Interface

Intended Bond Condition	Slab Size	Shear Strength Before Loading (psi)	Shear Strength After Loading (psi)
Bonded (Phase I-a)	6' x 6'	207.5	220
Bonded (Phase I-b)	4' x 4'	-	194.5
Un-bonded (Phase II)	6' x 6'	118.6	134.4

## Concrete

### Phase I

Curing Time, days	Compressive Strength, psi	Elastic Modulus, ksi	Flexural Strength, psi
1	1,690	-	-
3	2,940	-	-
7	3,930	3,440	-
14	4,750	3,737	732
28	5,980	3,940	772
56	6,750	4,380	847

### Phase II

Curing Time, days	Compressive Strength, psi	Elastic Modulus, ksi	Flexural Strength, psi
1	1,933	-	-
3	3,608	-	-
7	4,651	3,307	-
14	-	3,875	808
28	6,083	4,004	855
56	6,612	4,272	-

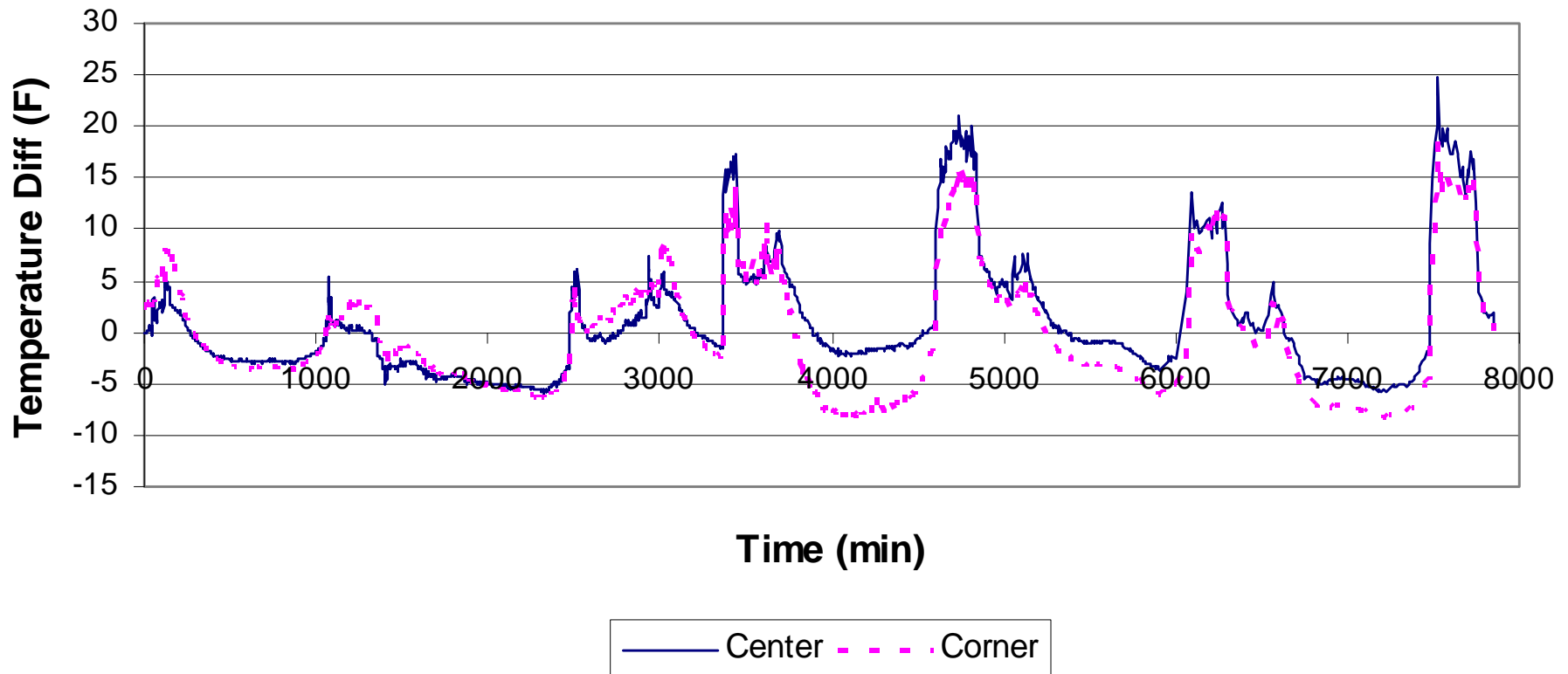
## Asphalt

AC Properties	Temperature		
	5 °C	15 °C	25 °C
Resilient Modulus (ksi)	1,787	1,193	750
Indirect Tensile Strength (psi)		272	

# Temperature Differential in Concrete

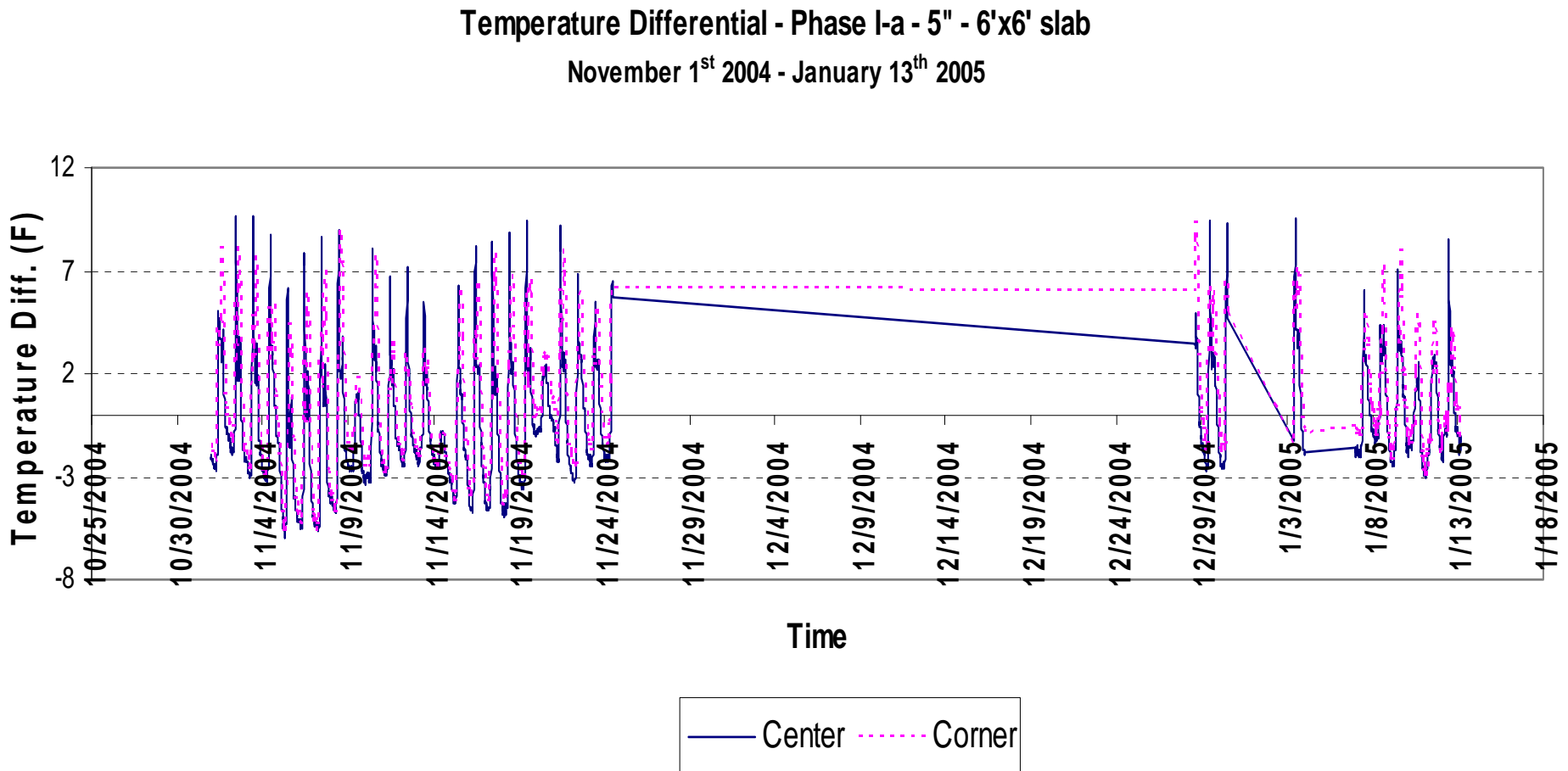
Spring

Temperature Differential - Phase I-a - 6" - 6'x6' slab  
May 20<sup>th</sup> - May 25<sup>th</sup>



# Temperature Differential in Concrete

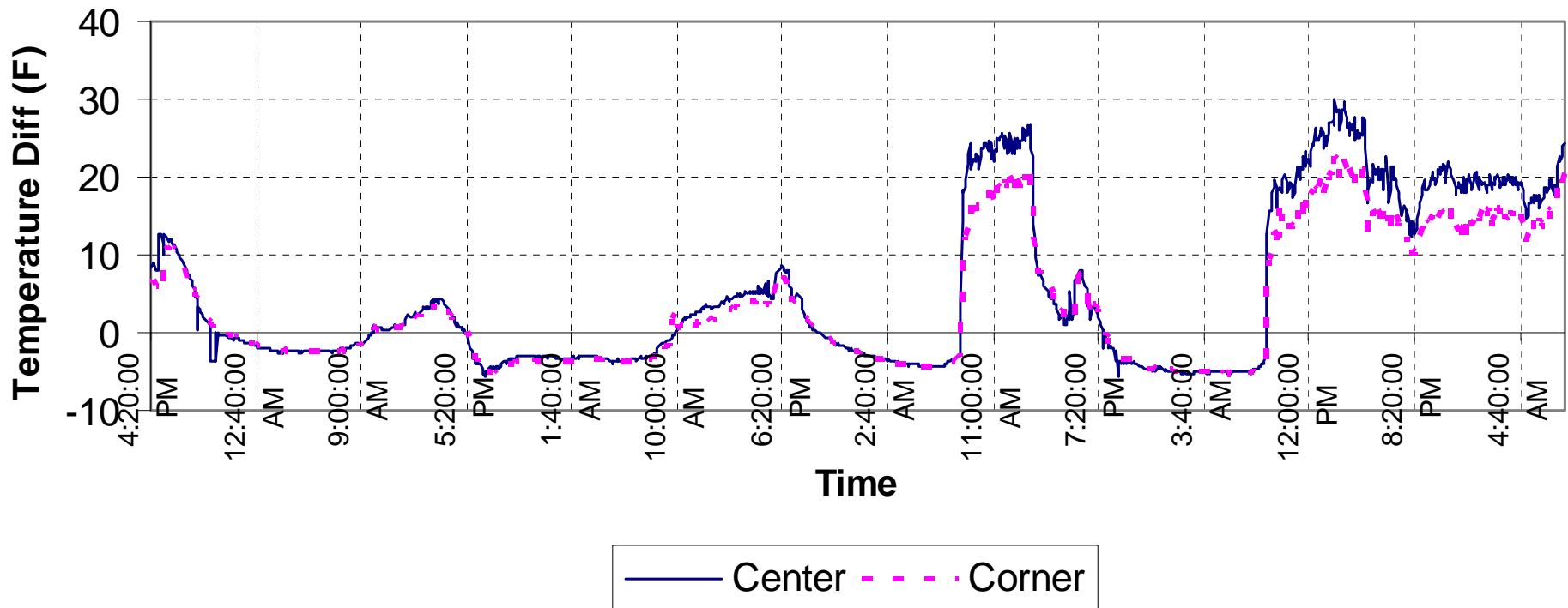
Fall – Winter



# Temperature Differential in Concrete

Summer

Temperature Differential - Phase I-b - 6" - 4'x4' slab  
June 17<sup>th</sup> - June 22<sup>nd</sup>

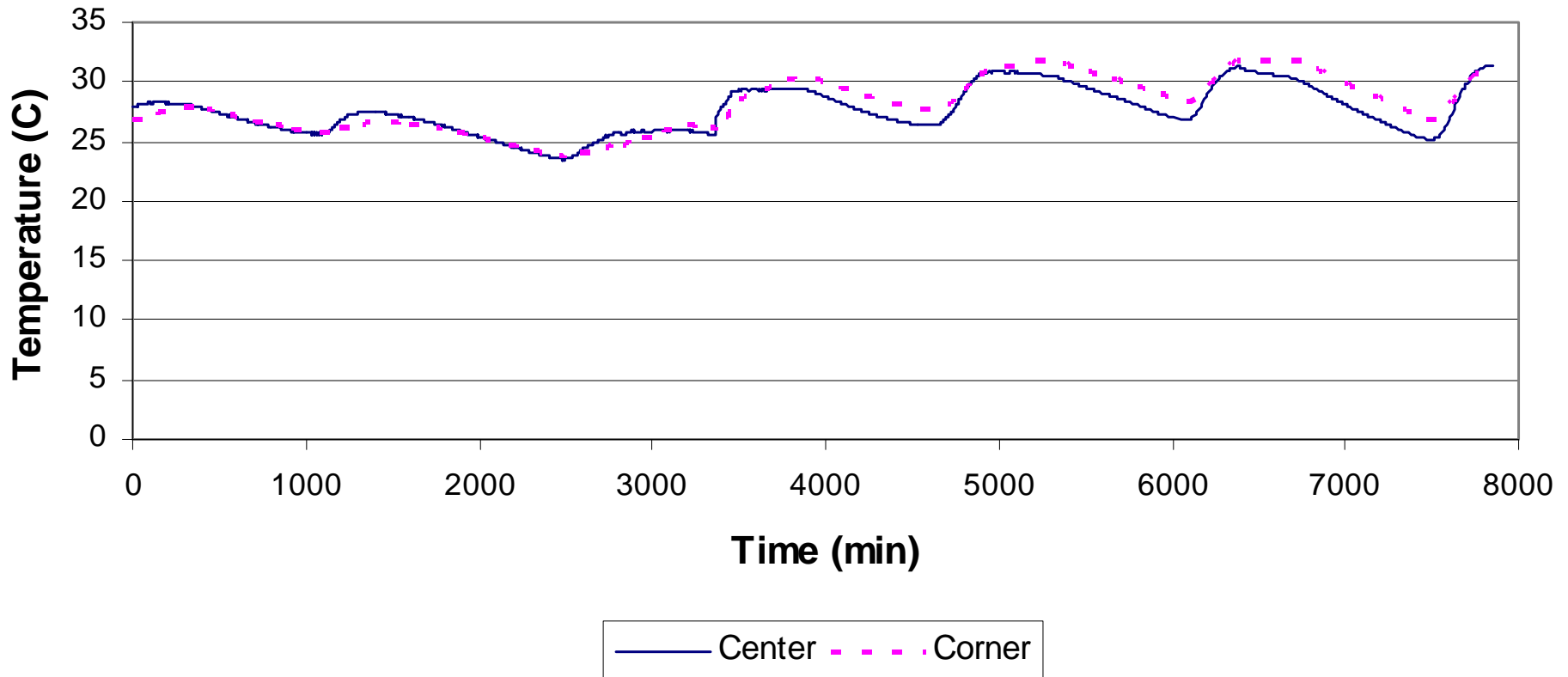




# Temperature in AC Layer

Spring

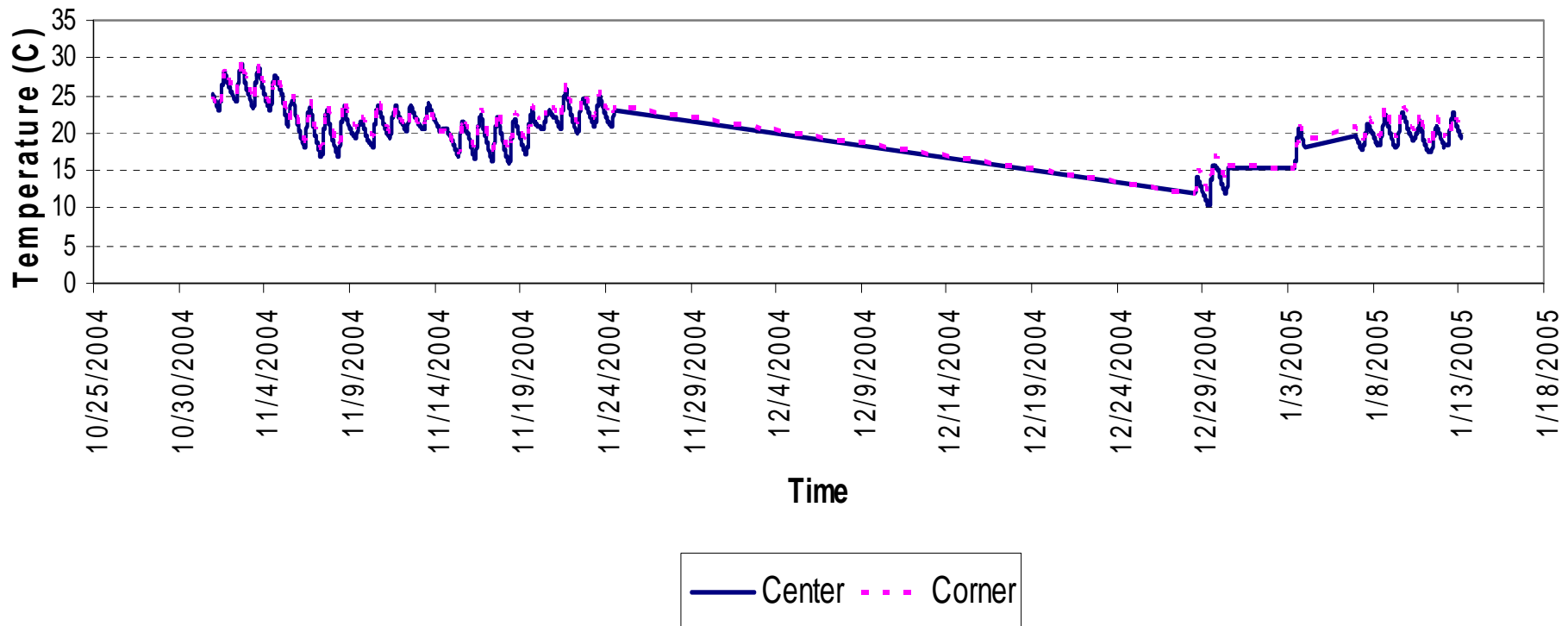
Temperature in the surface of the AC layer - Phase I-a - 6"- 6'x6' slab  
May 20<sup>th</sup> - May 25<sup>th</sup>, 2005



# Temperature in AC Layer

Fall – Winter

Temperature on the surface of the AC layer - Phase I-a - 5" - 6'x6' slab  
November 1<sup>st</sup> 2004 - January 13<sup>th</sup> 2005

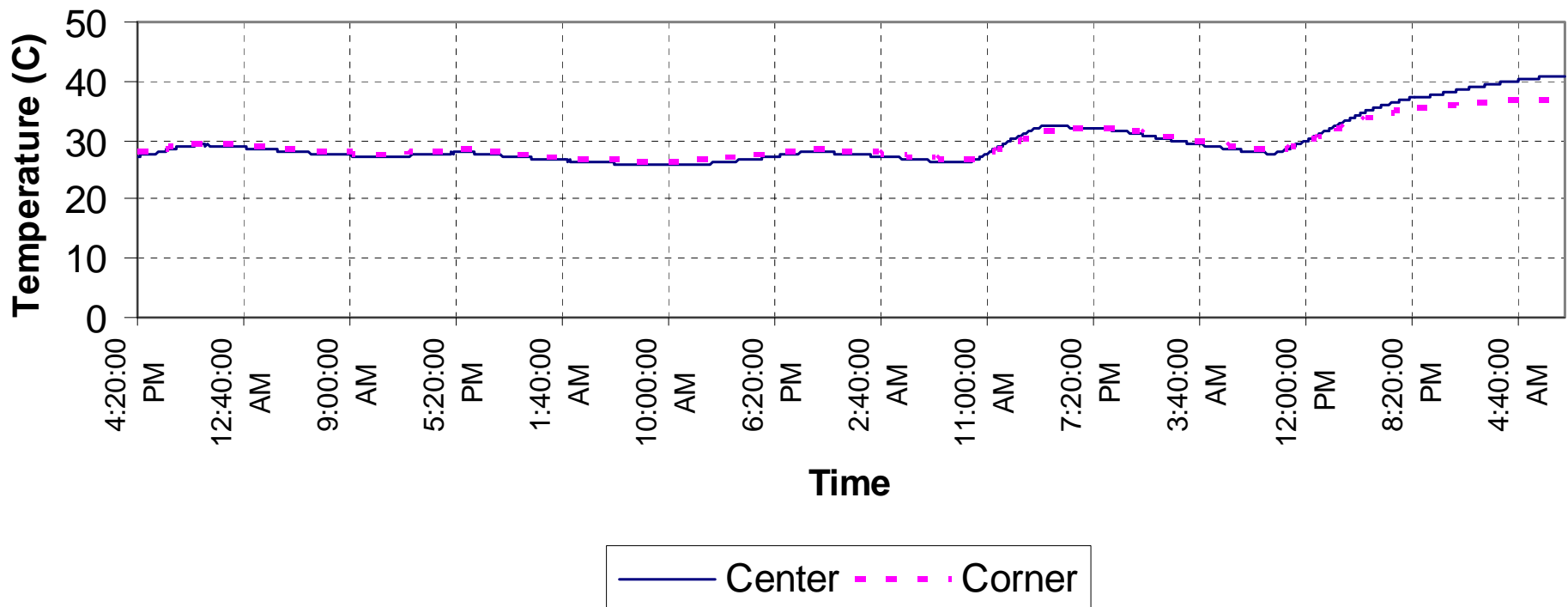




# Temperature in AC Layer

Summer

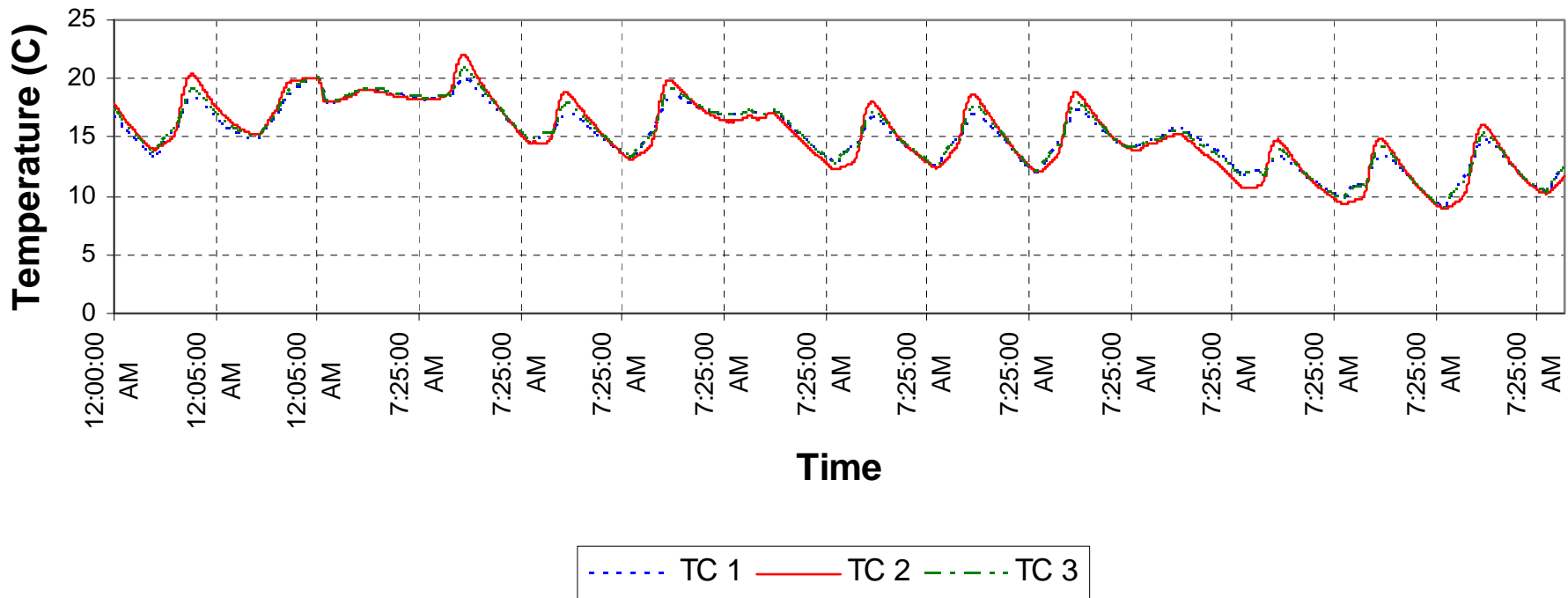
Temperature in the surface of AC - Phase I-b - 6" - 4'x4' slab  
June 17<sup>th</sup> - June 22<sup>nd</sup>



# Temperature in AC Layer

Winter

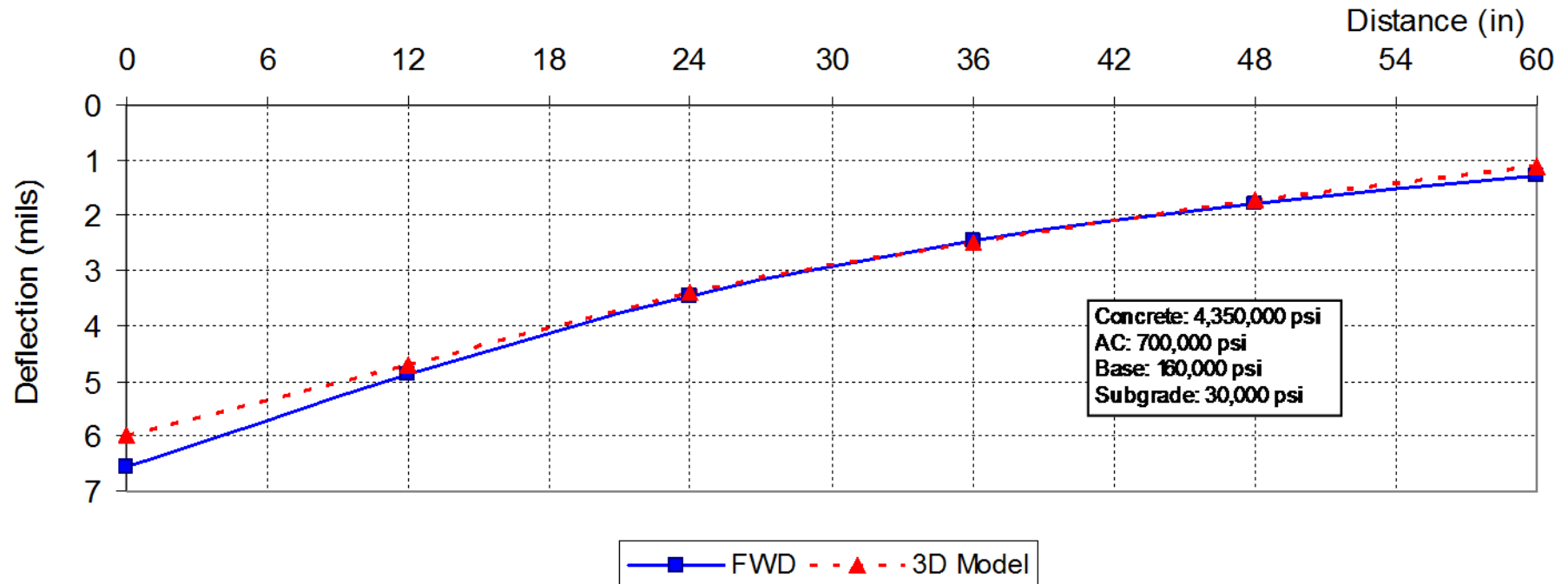
Temperature in the surface of AC layer - Phase II - 6" - 6'x6' slab  
Jan 31<sup>st</sup> - Feb 15<sup>th</sup>, 2006



# Deflection-based calibration

## Determination of Elastic Modulus - Phase I-a

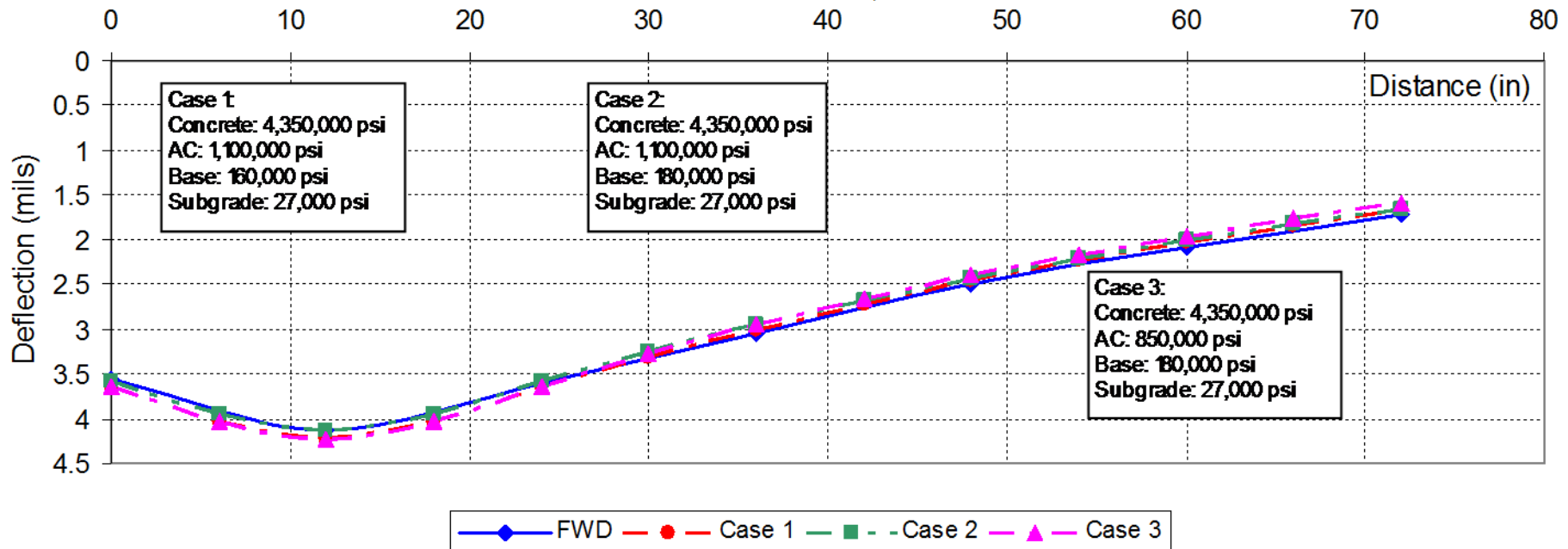
FWD test run on the center of the 4" - 12' x 18' slab, sensors in the longitudinal direction



# Deflection-based calibration

## Determination of Elastic modulus - Phase I-b

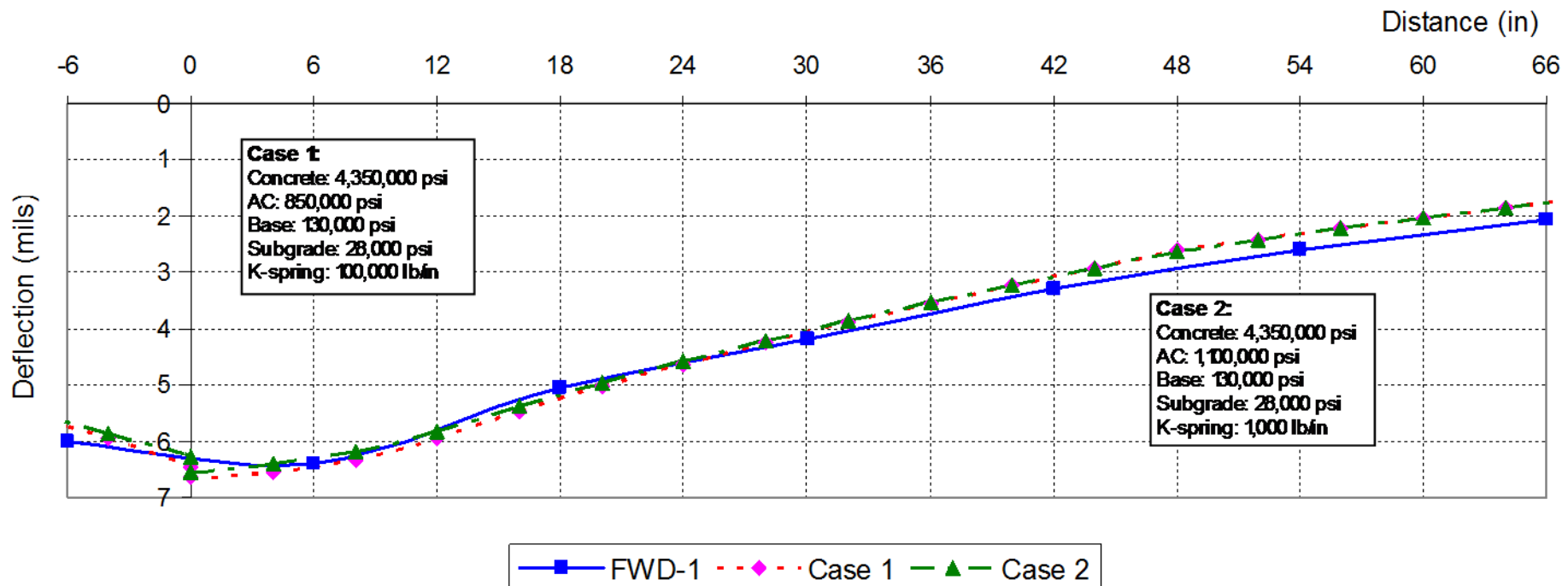
FWD test run on the center of the 6"- 12' x 18' slab, sensors in the transversal direction



# Deflection-based calibration

## Calibration of Springs at joints - Phase I-b

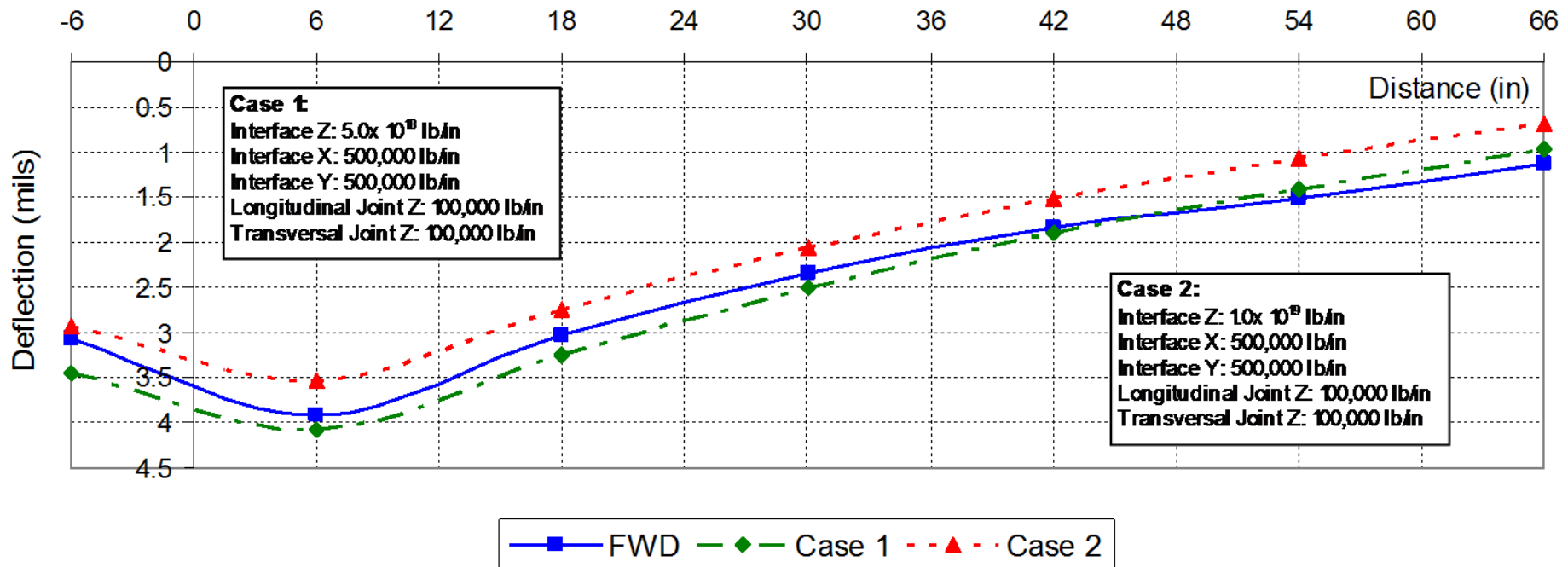
FWD test run on 5" - 4' x 4' slab, drops at the corner, sensors along the edge of the loaded slab



# Deflection-based calibration

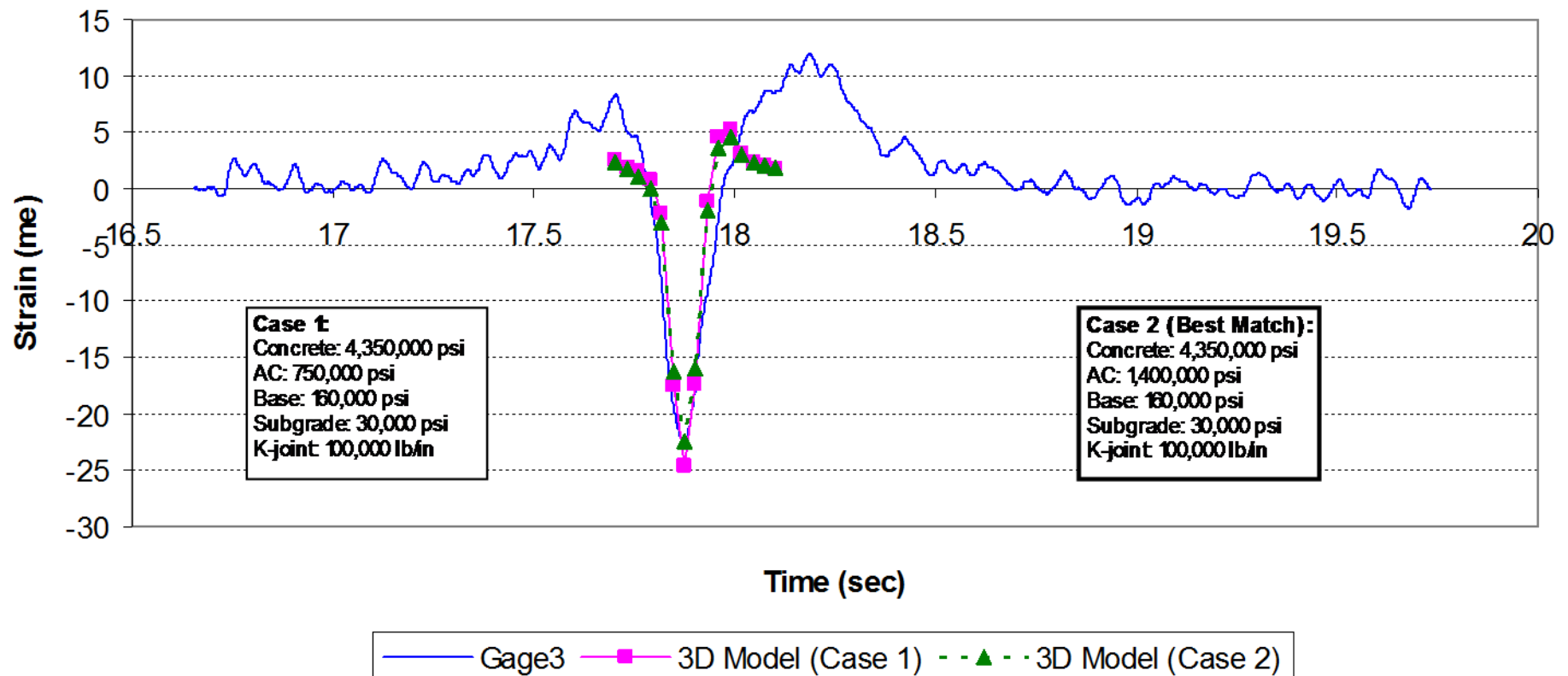
## Calibration of vertical springs - Phase II

FWD test run on 8" slab, drops at the corner, sensors along the edge of the loaded slab



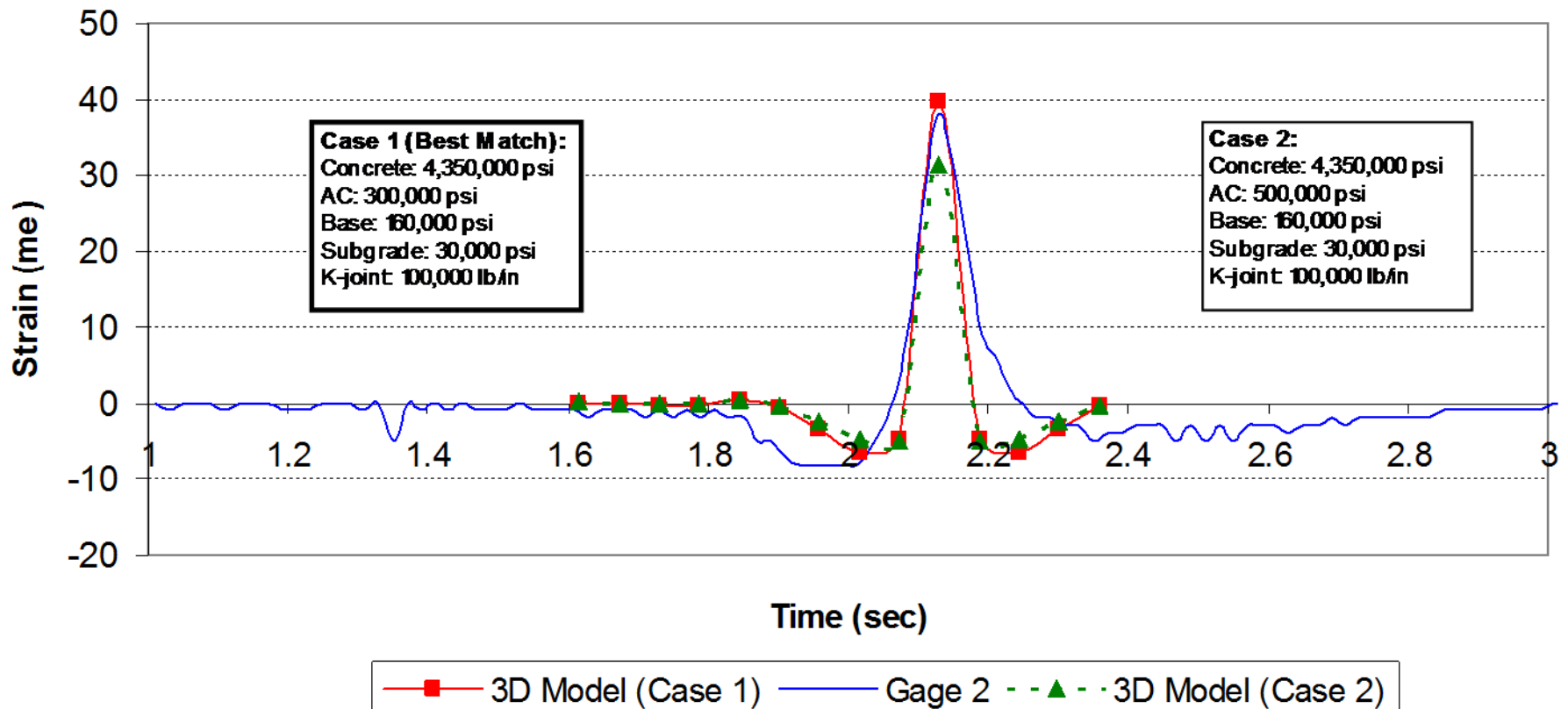
# Strain-based Calibration

Strain comparison - 6" - 6' x 6 slab - Phase I-a  
Location 2 - Gage 3 (top), 12 kips load



# Strain-based Calibration

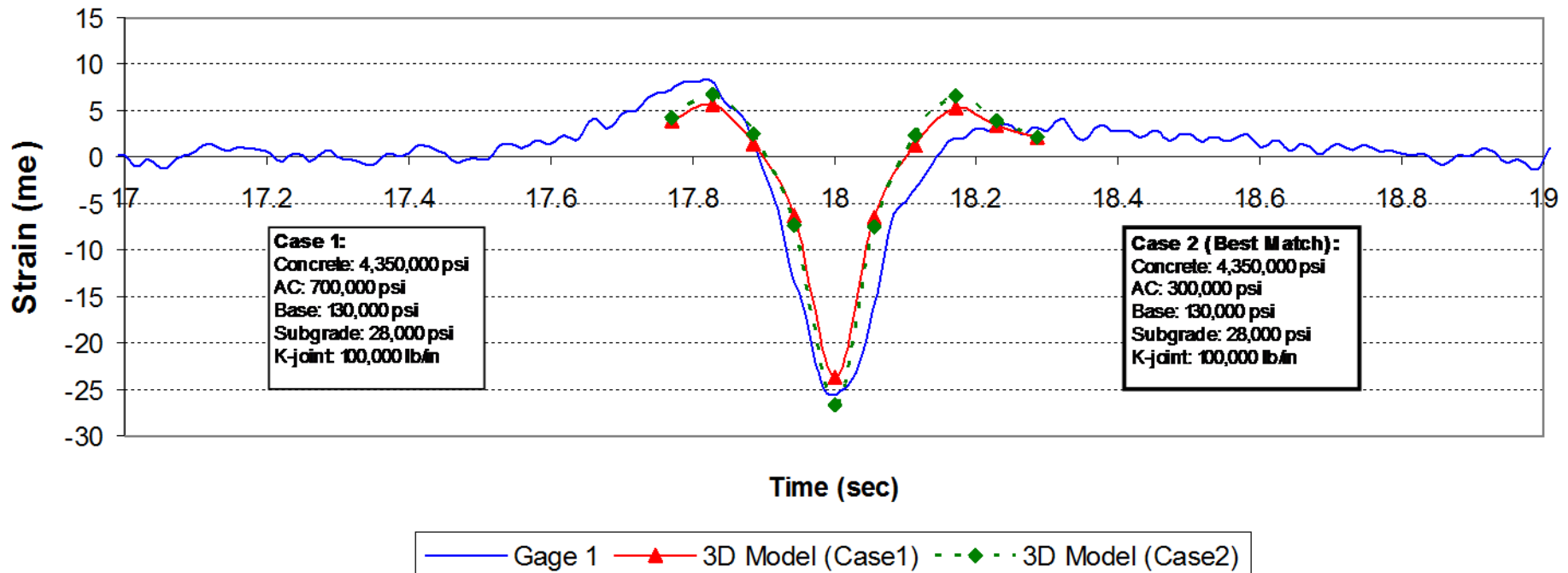
Strain comparison - 4" - 6'x6' slab - Phase I-a  
Location 1, Gage 2 (bottom), 12 kips load





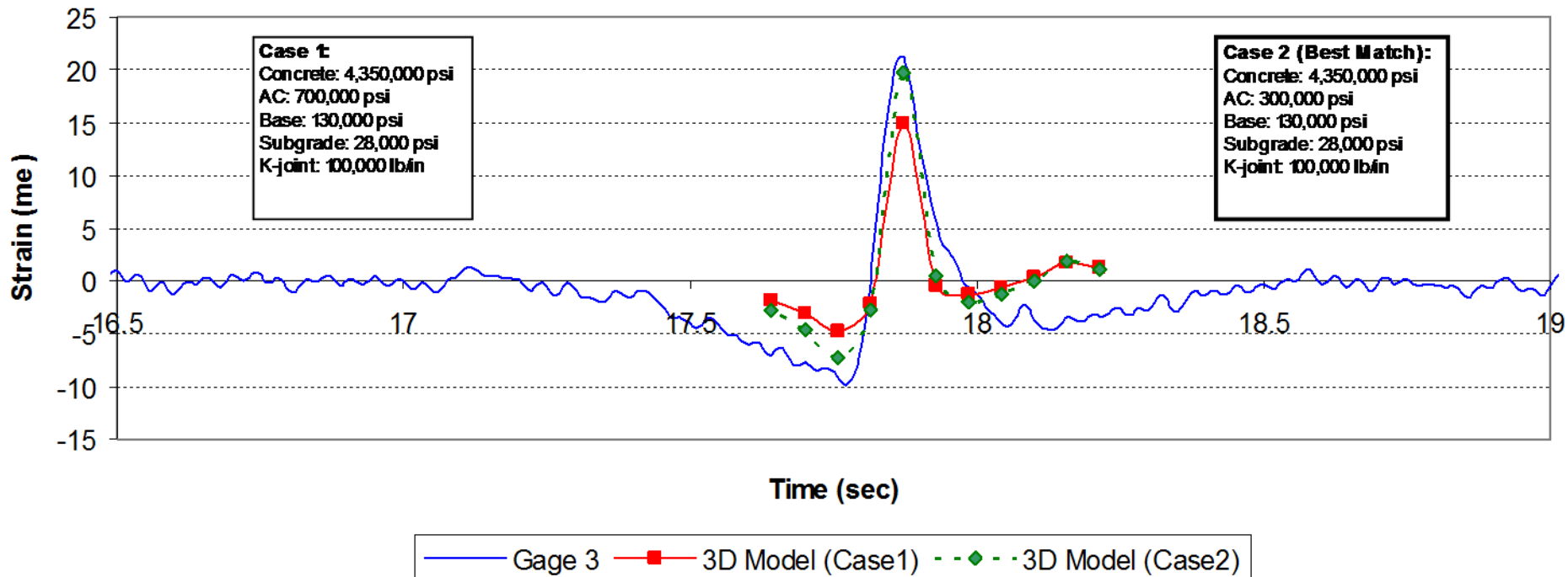
# Strain-based Calibration

Strain comparison - 6" - 4'x4' slab - Phase I-b  
Location1 - Gage 1 (top, depth 1.25"), 12 kips load



# Strain-based Calibration

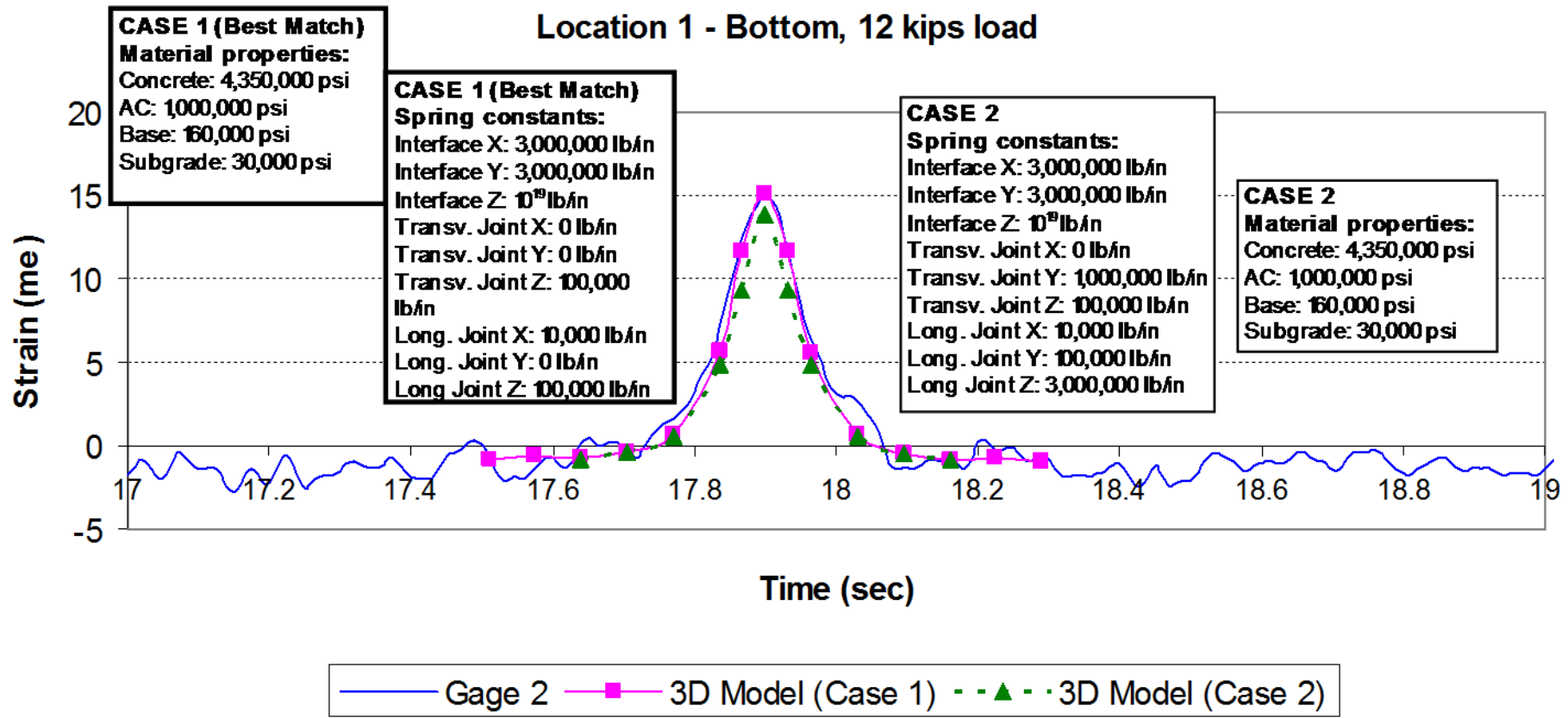
Strain comparison - 6" - 4'x4' slab - Phase I-b  
Location2 - Gage 3 (bottom, depth 5.3"), 12 kips load



# Strain-based Calibration

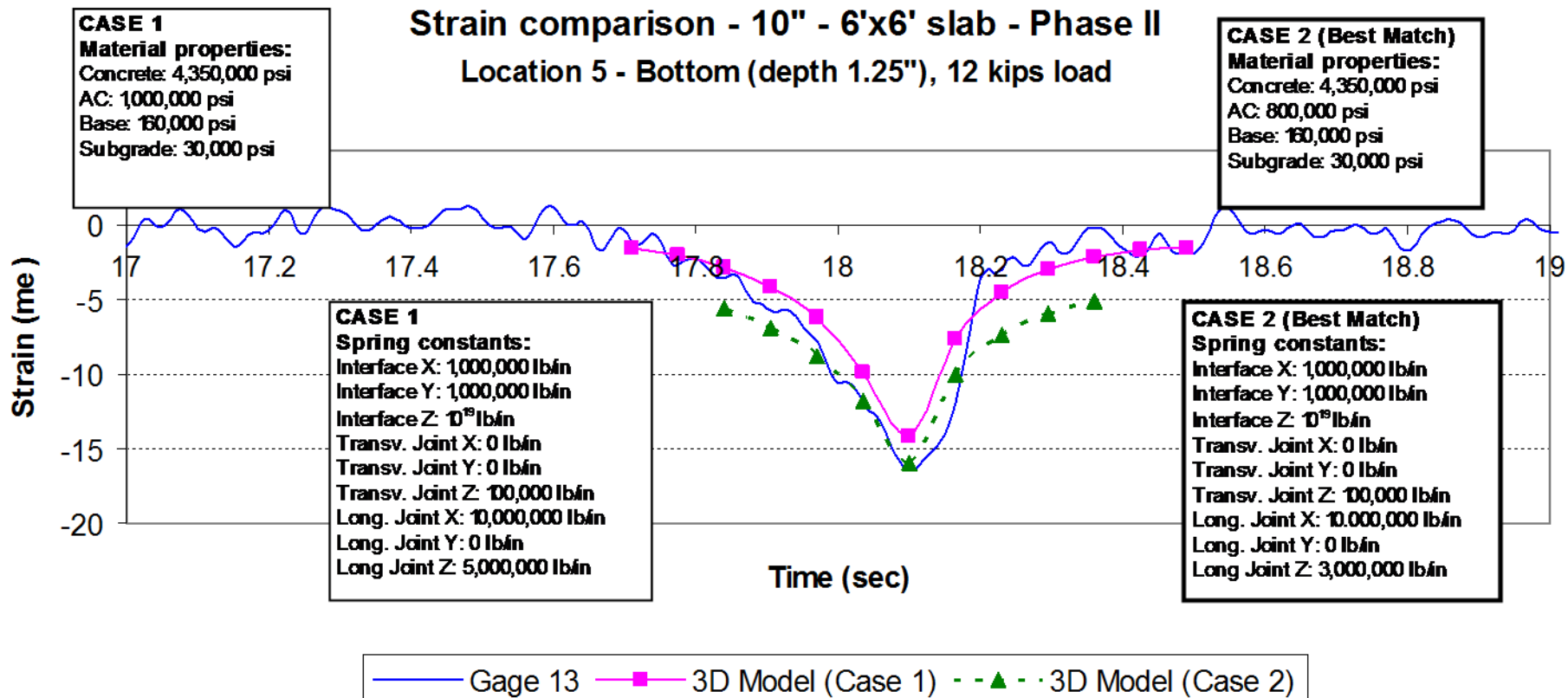
## Strain comparison - 10" - 6'x6' slab - Phase II

Location 1 - Bottom, 12 kips load



# Strain-based Calibration

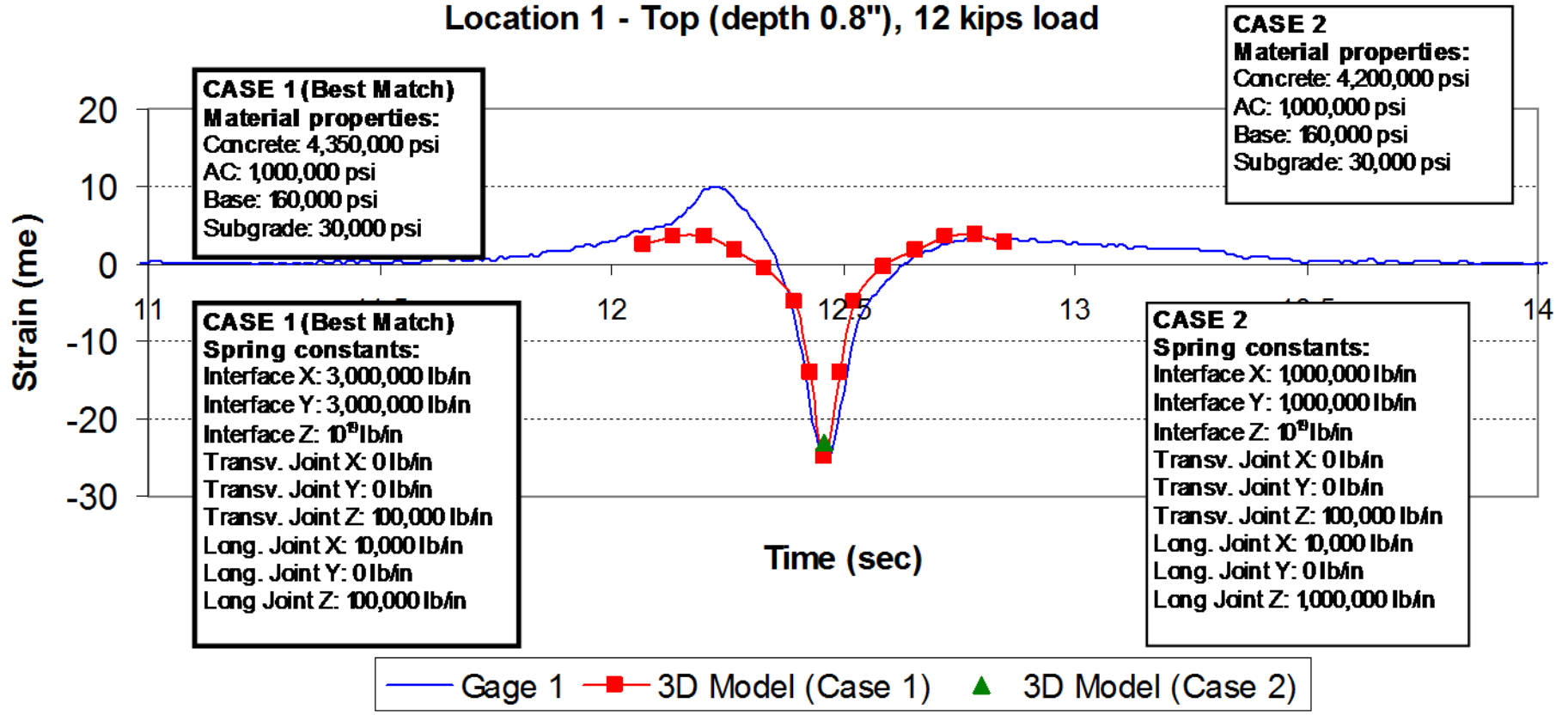
**Strain comparison - 10" - 6'x6' slab - Phase II**  
**Location 5 - Bottom (depth 1.25"), 12 kips load**



# Strain-based Calibration

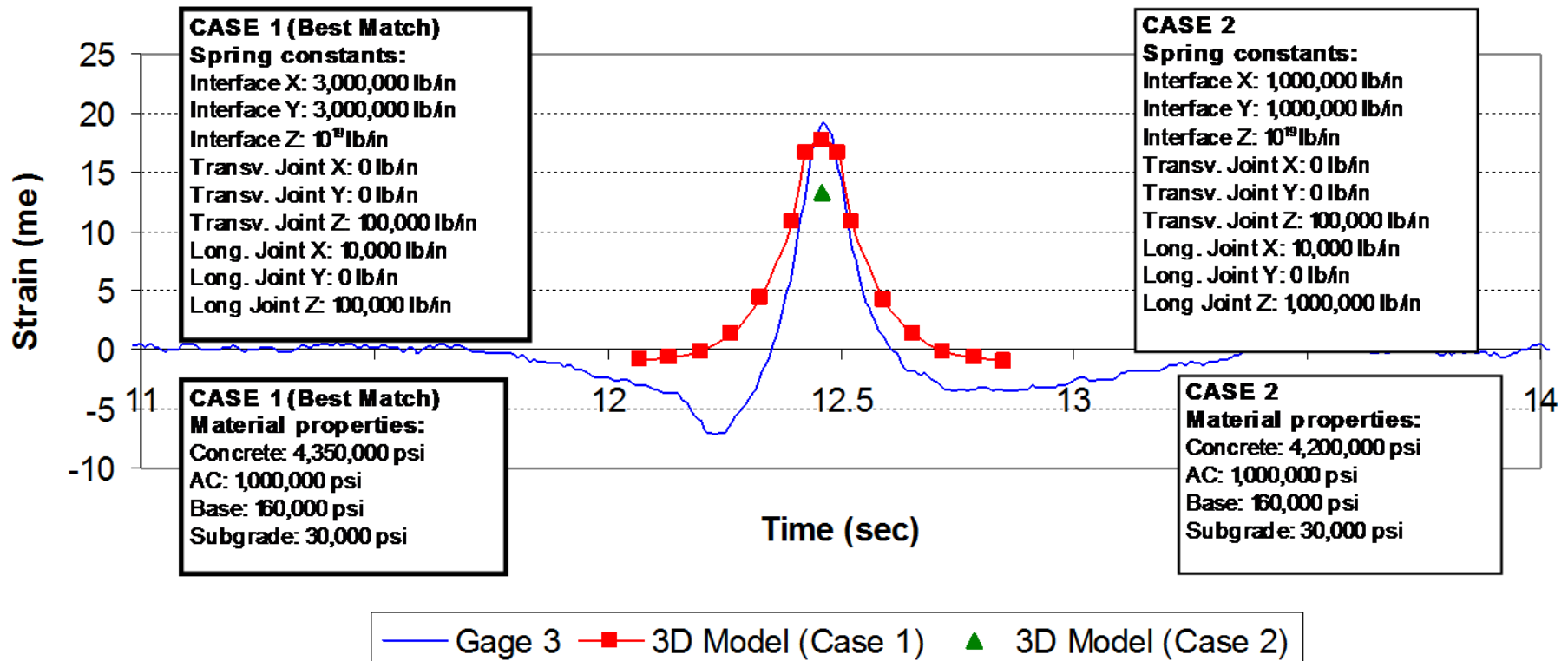
## Strain comparison - 8" - 6'x6' slab - Phase II

Location 1 - Top (depth 0.8"), 12 kips load



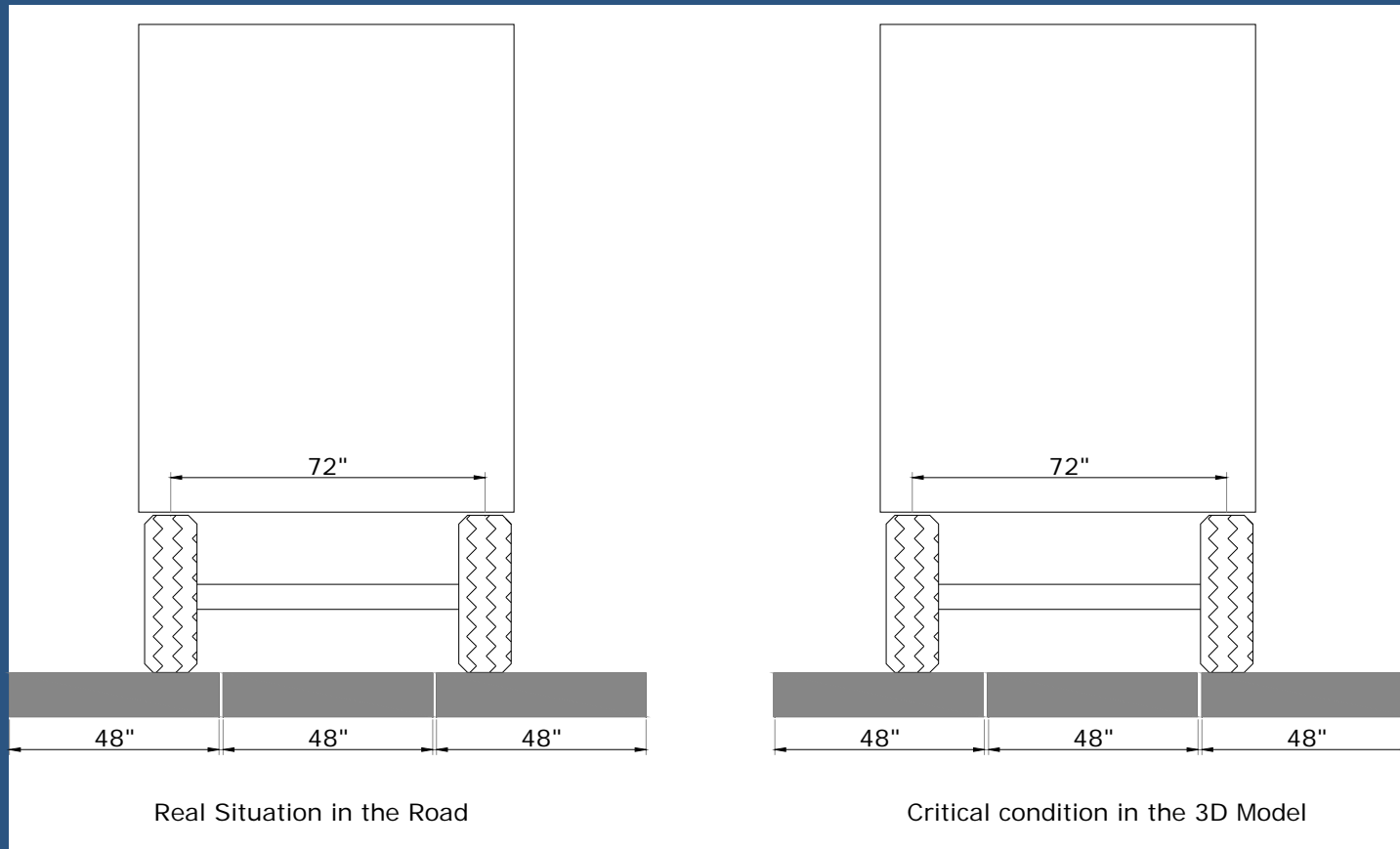
# Strain-based Calibration

Strain comparison - 8" - 6'x6' slab - Phase II  
Location 1 - AC surface, 12 kips load



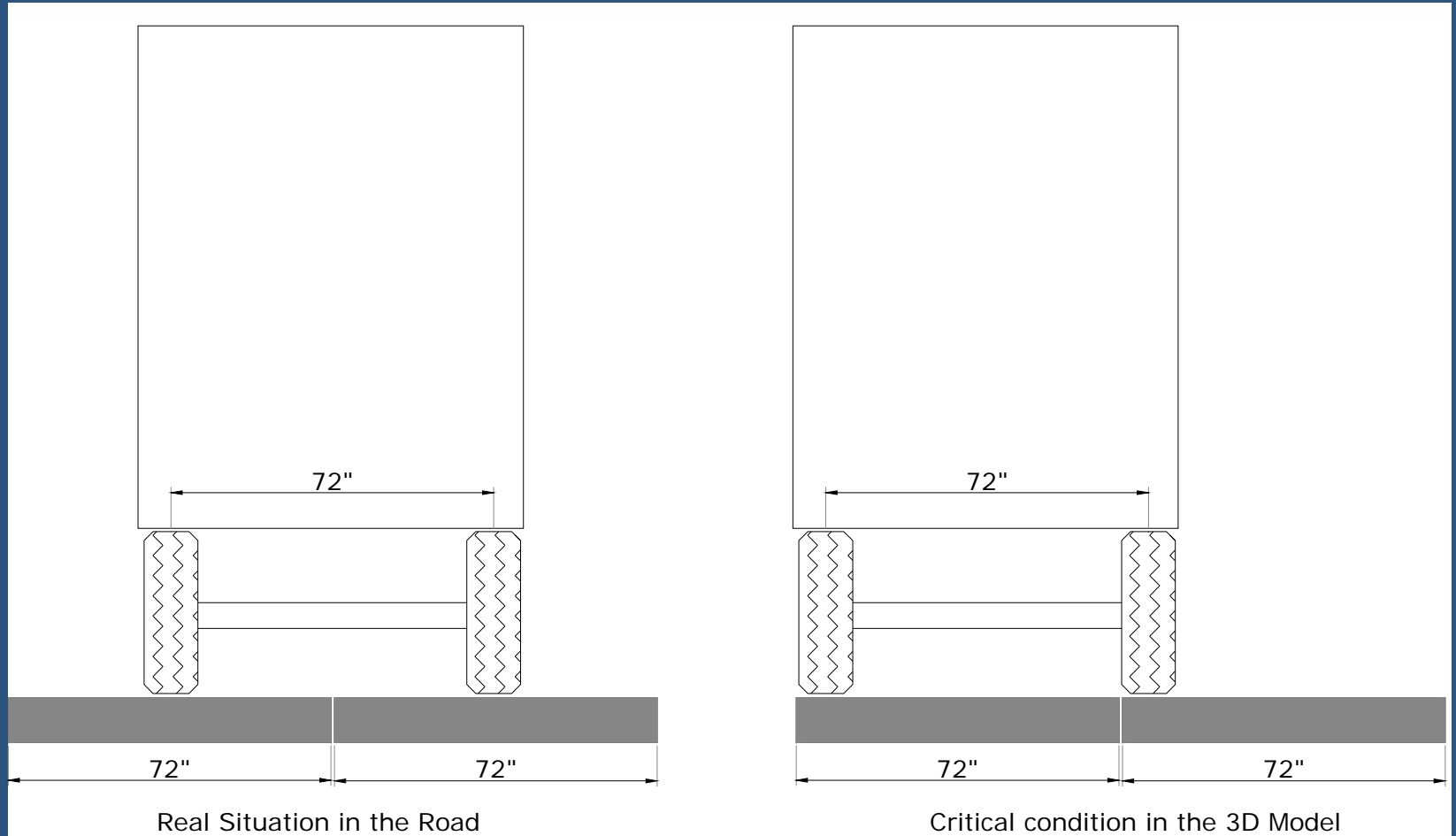
# Critical Stress Analysis :

24-kip single axle load placed at mid edge and at slab corner



**Axle Load Positioned on Slabs with 4-ft Joint Spacing**

# 24-kip single axle load placed at mid edge and at slab corner

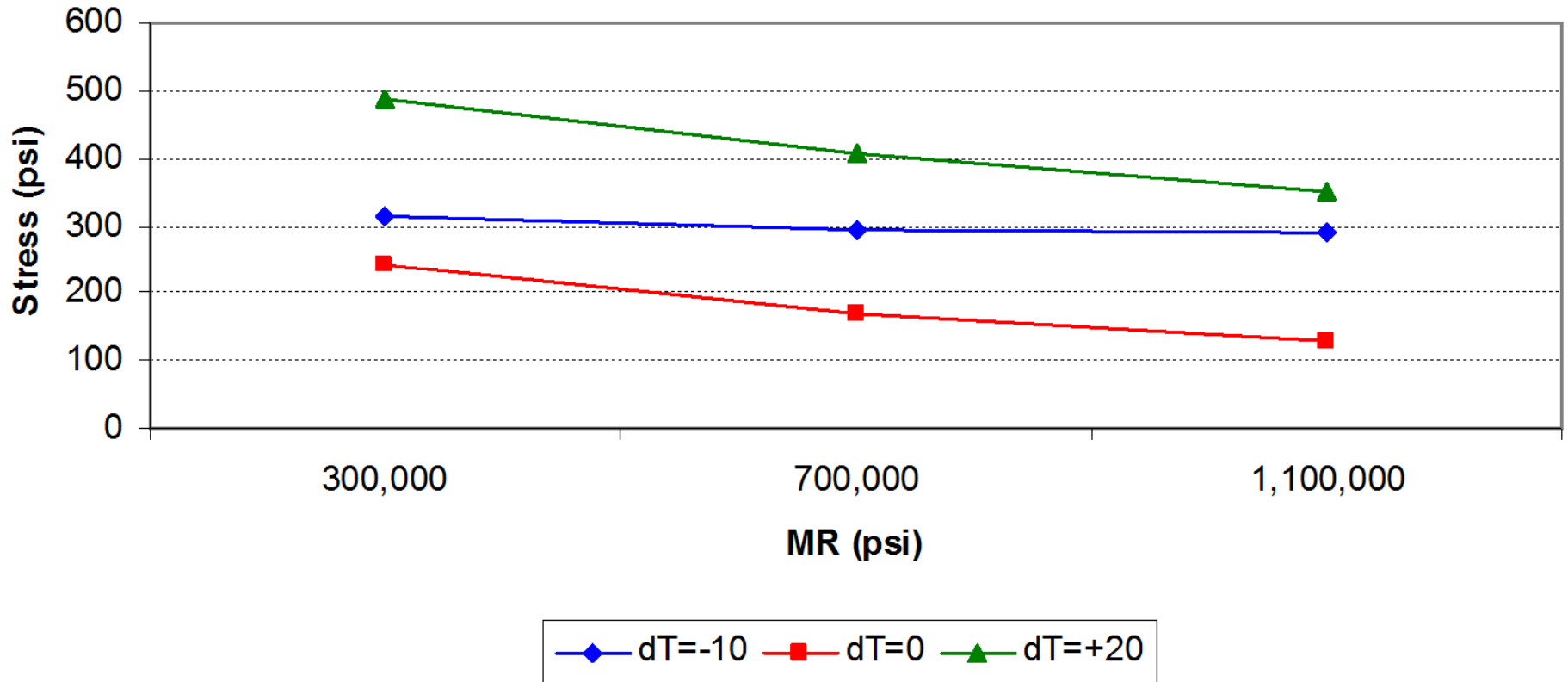


**Axle Load Positioned on Slabs with 6-ft Joint Spacing**



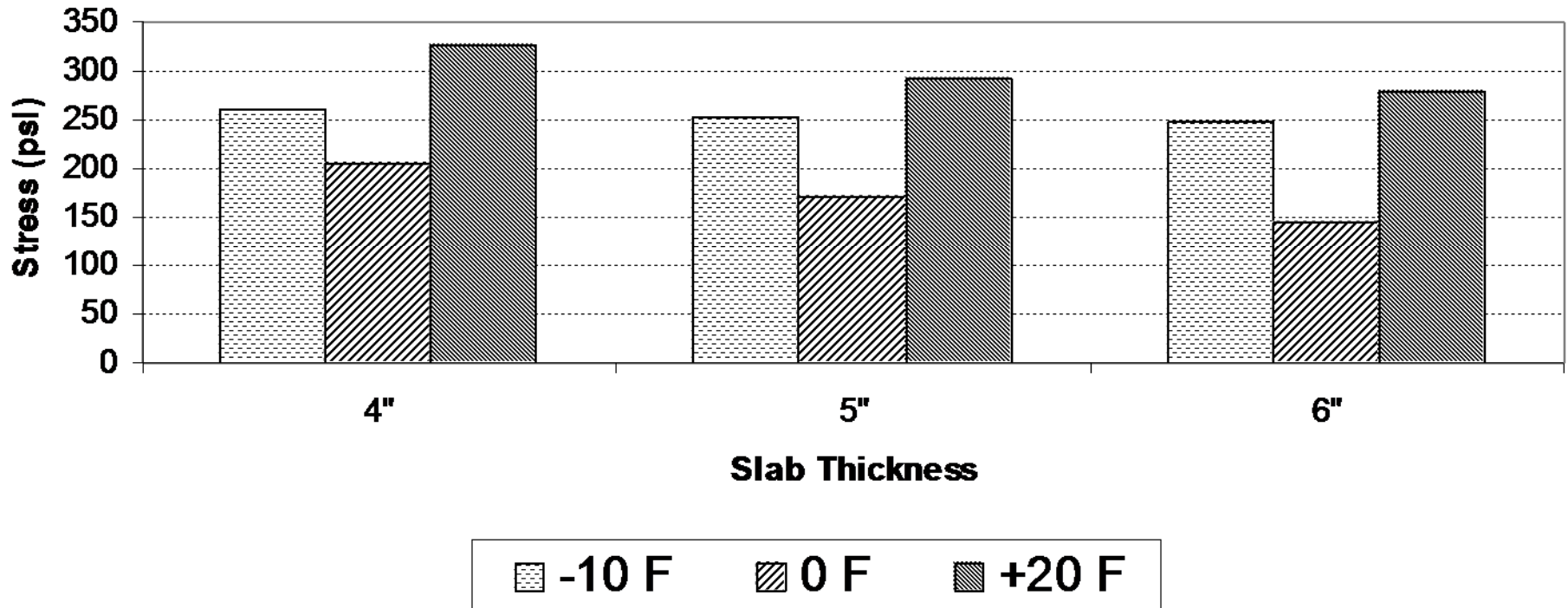
# Effect of AC Elastic Modulus

**Stress Comparison - Effect of the AC Elastic Modulus**  
5" - 4'x4' slab - Bonded condition - Load at the mid-edge



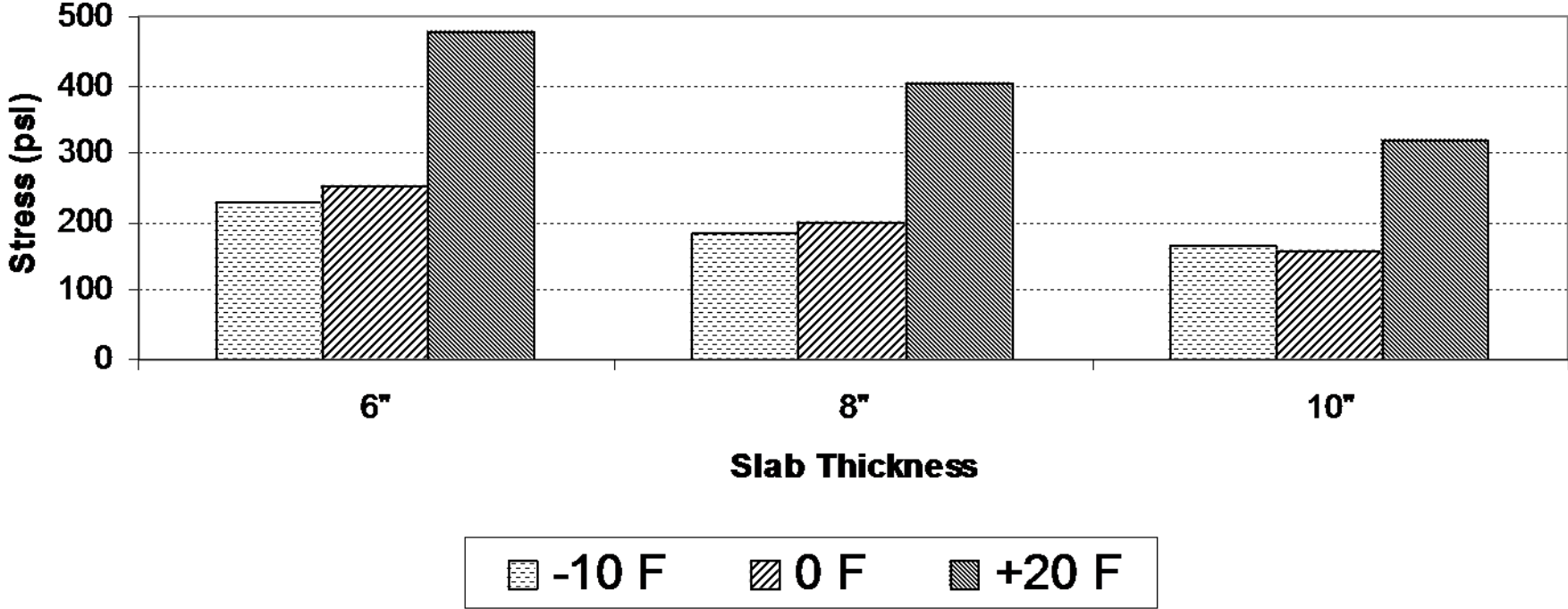
# Effect of Temperature Differential

**Stress Comparison - Effect of Temperature Differential**  
Bonded condition - 6' x 6' slab - Load at the corner



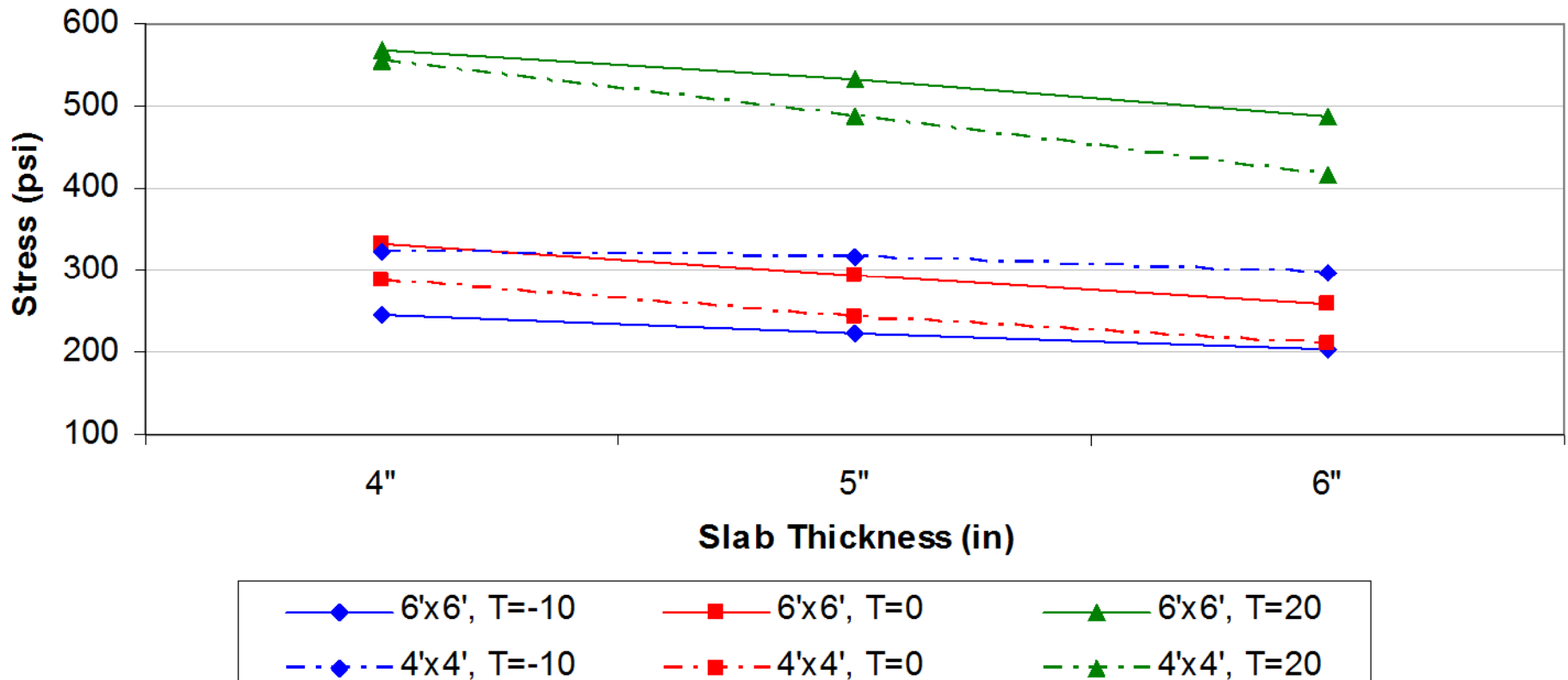
# Effect of Temperature Differential

**Stress Comparison - Effect of Temperature Differential**  
Unbonded condition - 6' x 6' slab - Load at the mid-edge



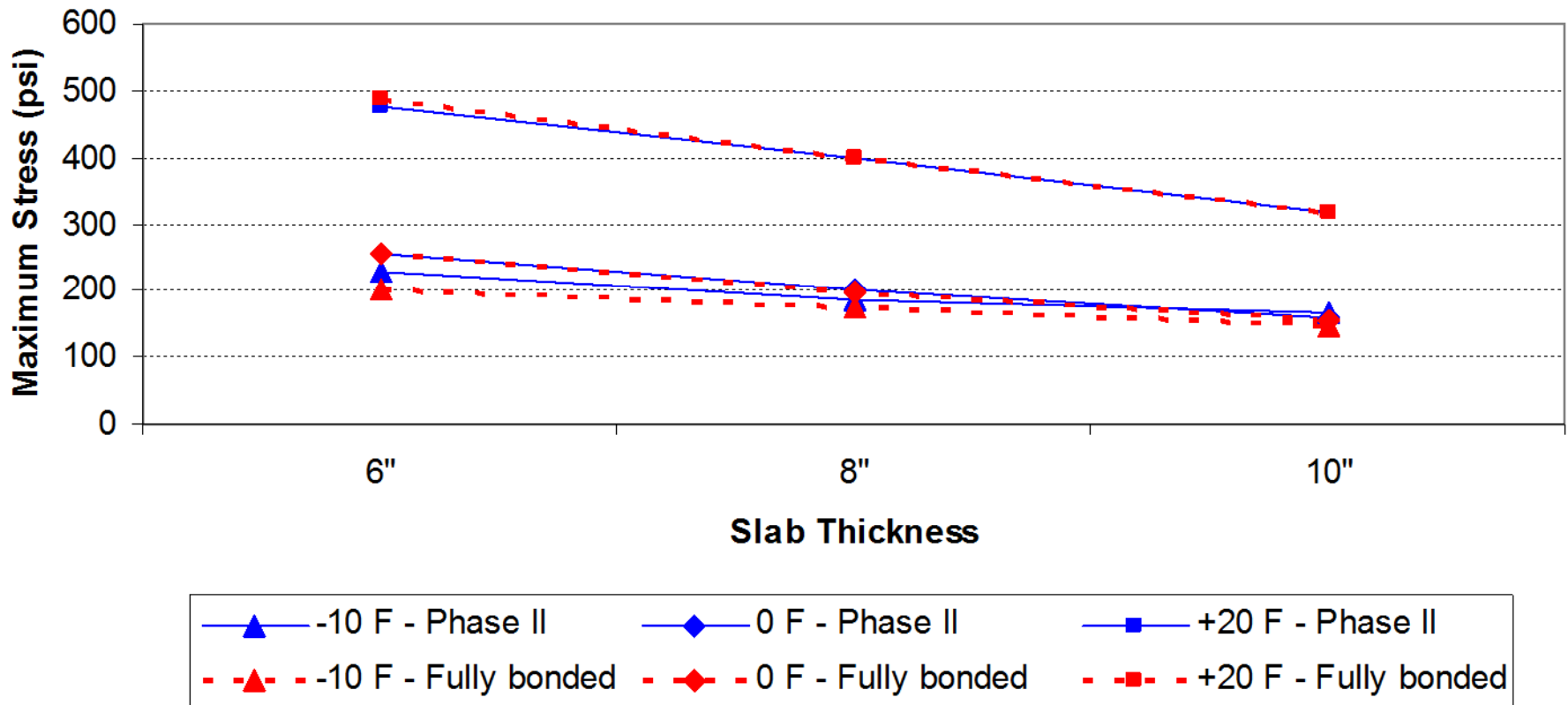
# Effect of the Slab Size

**Stress comparison - Effect of Slab Size**  
**Bonded Condition - Load at the mid-edge**



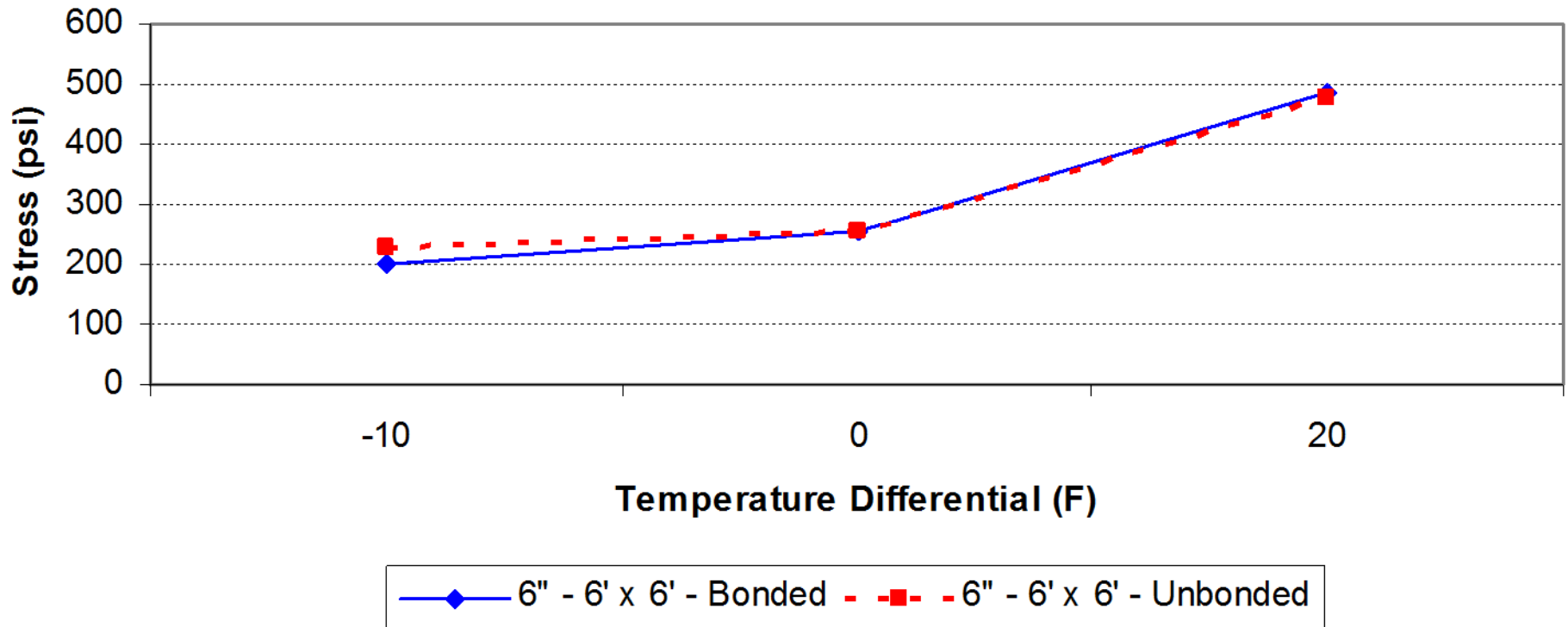
# Effect of the bond in the interface

Stress comparison - Effect of bond in the interface  
Load applied at the mid-edge



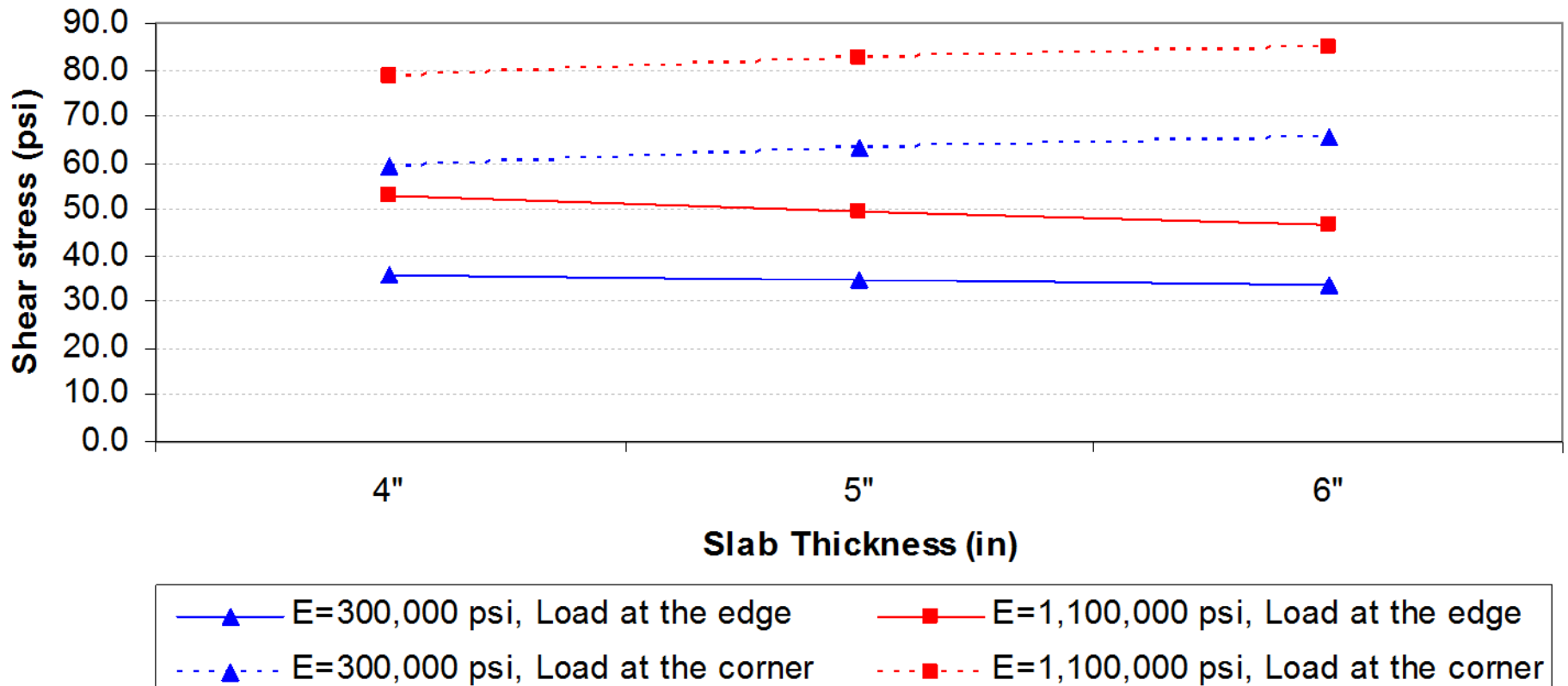
# Effect of the bond in the interface

**Stress comparison for the 6" slab**  
Load applied at the mid-edge



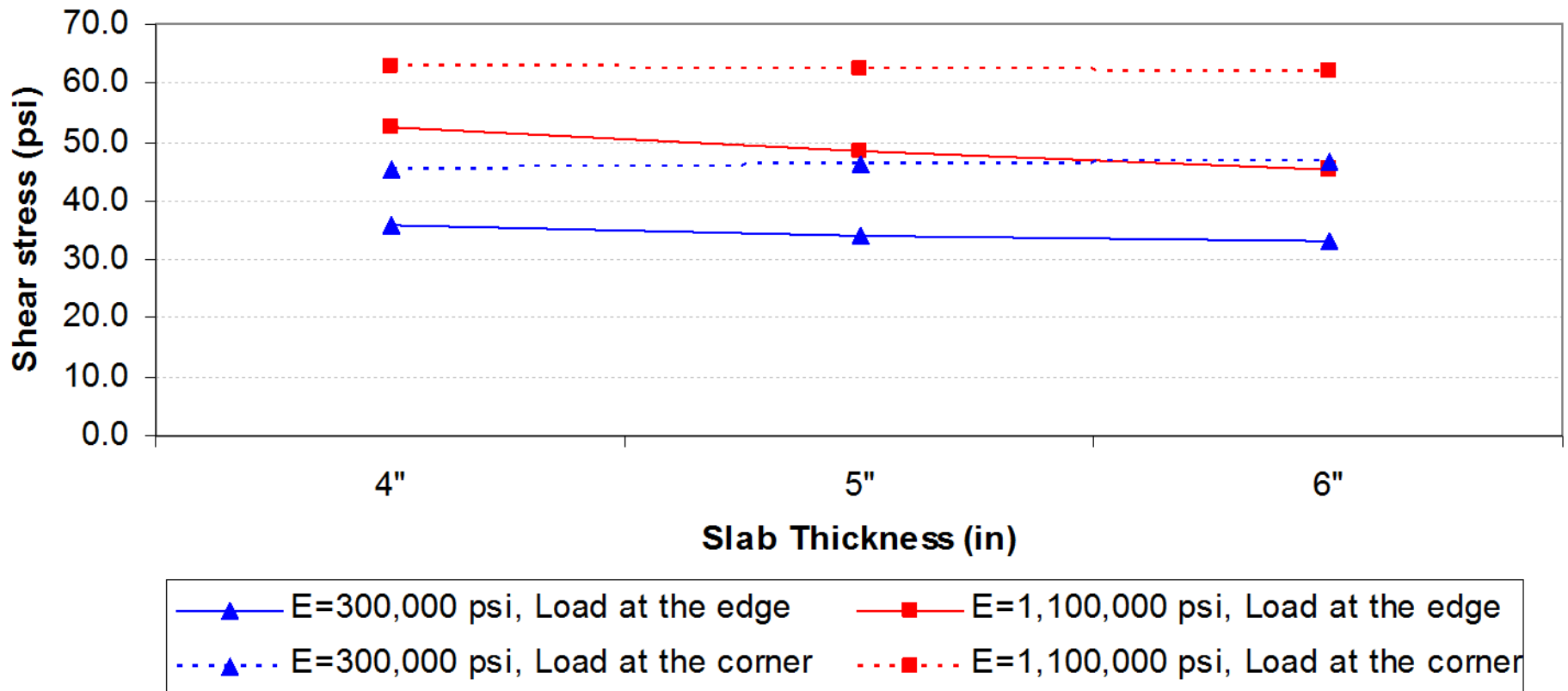
# Shear stress in the interface

**Shear Stress in the interface**  
**Bonded Condition - 6' x 6' slabs**



# Shear stress in the interface

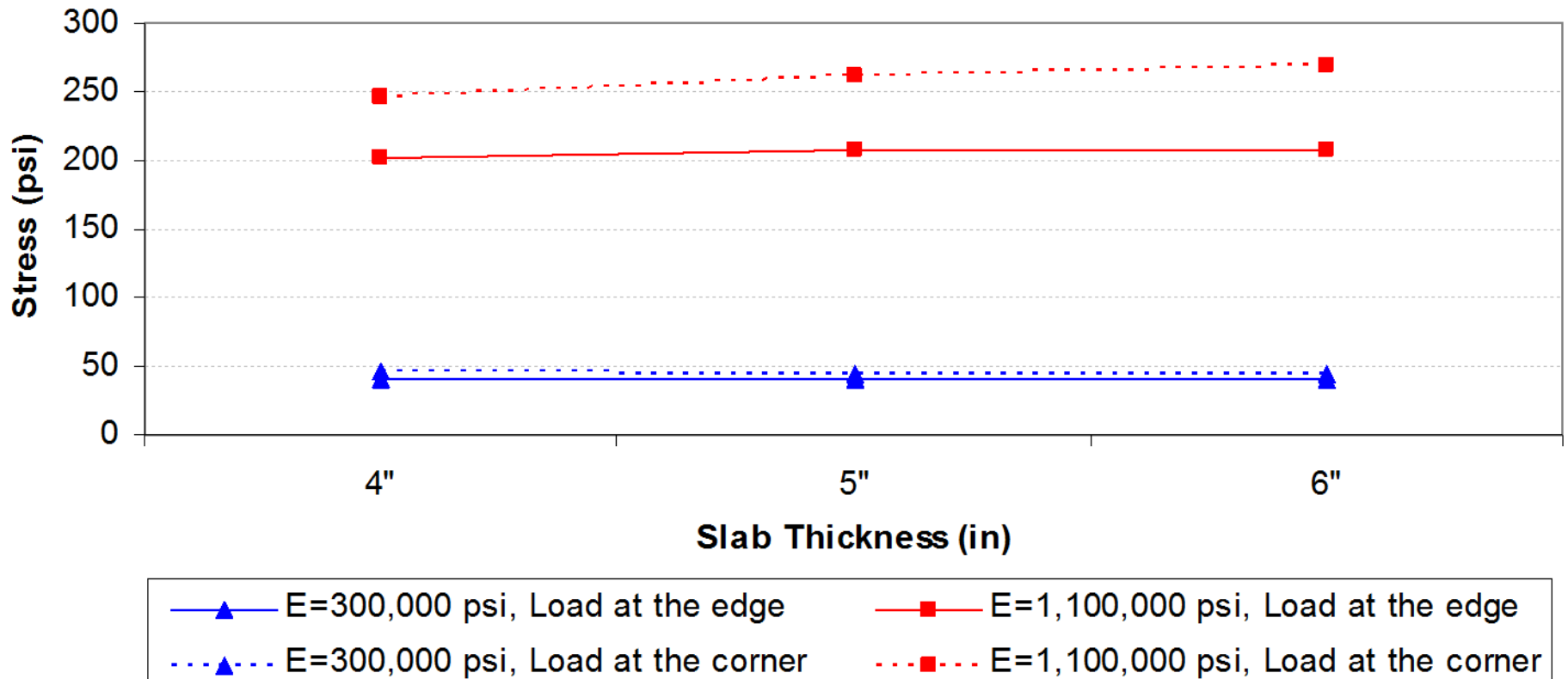
**Shear Stress in the interface**  
**Bonded Condition - 4' x 4' slabs**





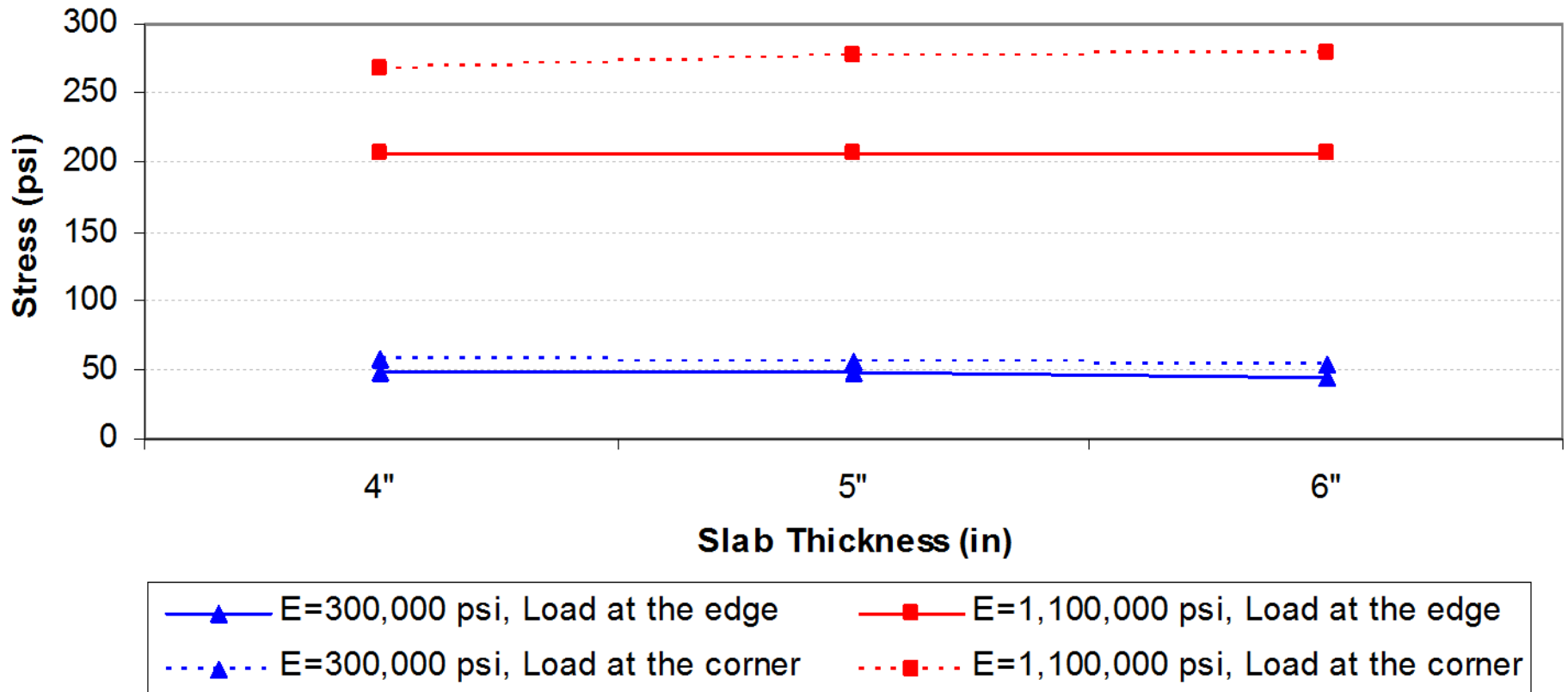
# Tensile Stress in the AC layer

**Tensile Stress in the AC layer**  
Bonded Condition - 6' x 6' slabs - +20 F Temp diff.



# Tensile Stress in the AC layer

**Tensile Stress in the AC layer**  
Bonded Condition - 4' x 4' slabs - +20 F Temp diff.



# Findings- Potential Performance

<b>Phase</b>	<b>Slab Thickness</b>	<b>Stress (psi)</b>	<b>Stress-strength Ratio</b>	<b># of Repetitions of 24- kip Axle Loads to Failure</b>
I-a	4"	568.3	0.675	3,810
	5"	531.43	0.631	13,231
	6"	488.6	0.580	56,178
I-b	4"	555.06	0.659	5,958
	5"	486.94	0.578	59,416
	6"	416.15	0.494	no limit
II	6"	476	0.565	85,963
	8"	400.42	0.476	no limit
	10"	318.4	0.378	no limit

# Summary of Findings

- The method of milling and cleaning the asphalt surface and spraying it with water before the placement of concrete was found to produce excellent bonding at the interface, with a shear strength of 195 to 220 psi.
- When a white-pigmented curing compound was sprayed on the surface of the asphalt before the placement of concrete to intend to produce an unbonded interface, partial bonding was found to exist, with an average shear strength of 119 psi before the HVS loading and 135 psi after the HVS loading.

## Summary of Findings (continued)

- With a relatively thin AC layer of 4.5 inches as typical for Florida conditions, a WT pavement with a 4-inch concrete layer can be used for low volume roads with heavy (24-kip single axle) loads.
- The allowable traffic volume increases as the concrete slab thickness increases.
- In order to be able to withstand the critical load without fear of fatigue failure (for an infinite number of critical load repetitions), a minimum slab thickness of 6 inches would be needed for a joint spacing of 4 ft, and a minimum slab thickness of 8 inches would be needed for a joint spacing of 6 ft.

# Recommendations

- The developed 3-D finite element model is recommended for use for analysis of WT pavements subjected to load and temperature effects.
- It is recommended that experimental WT pavement test sections of various designs be constructed on actual roadways in Florida to evaluate their behavior and performance under actual environmental and traffic conditions. The experimental pavement sections will be instrumented for monitoring of temperature and strains on a long-term basis. This will enable the monitoring of the behavior of the WT pavements under critical load and temperature conditions.

**Thank you!**

**Any Questions?**