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

By

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Acknowledgments

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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

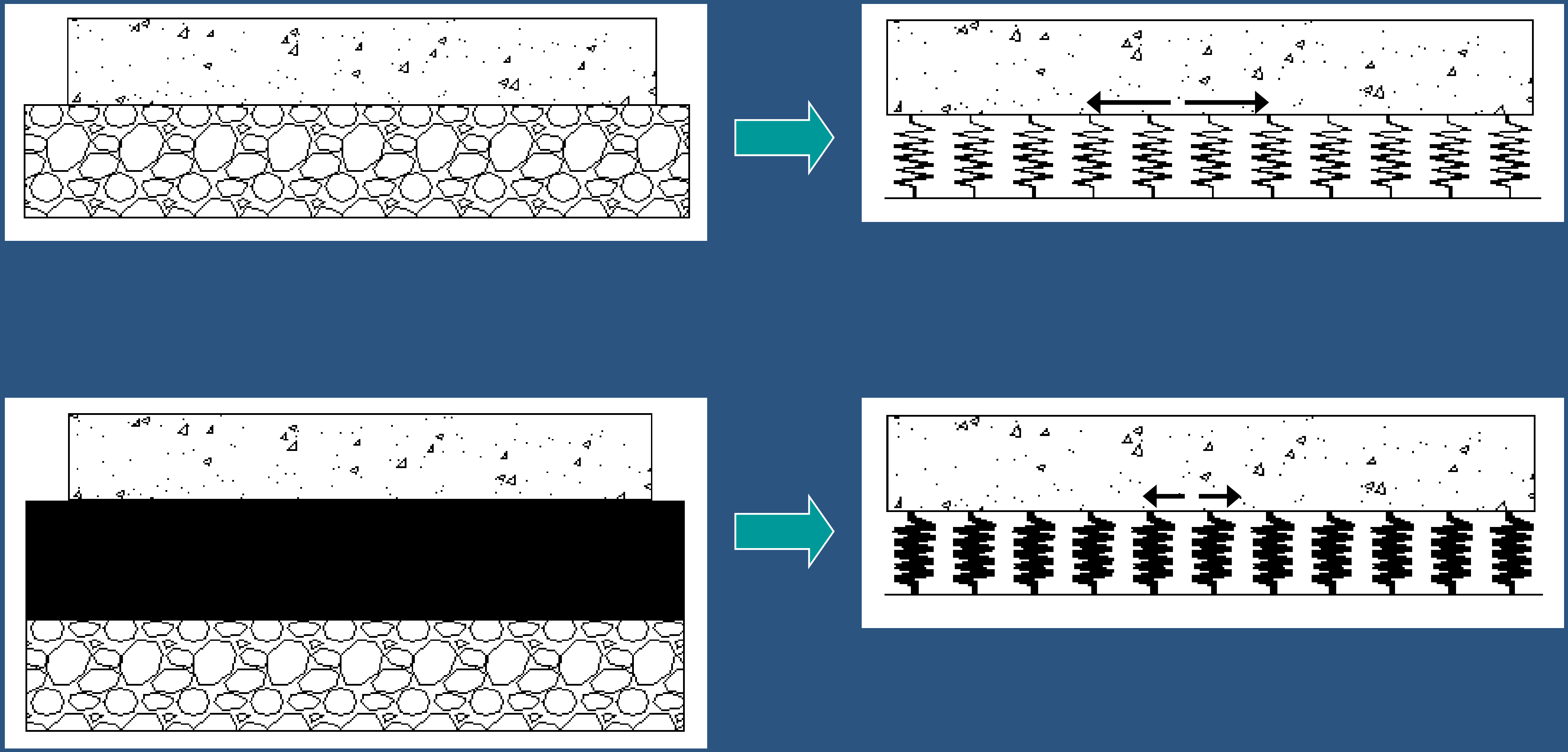
Types of Whitetopping

- Conventional White-topping (CWT)

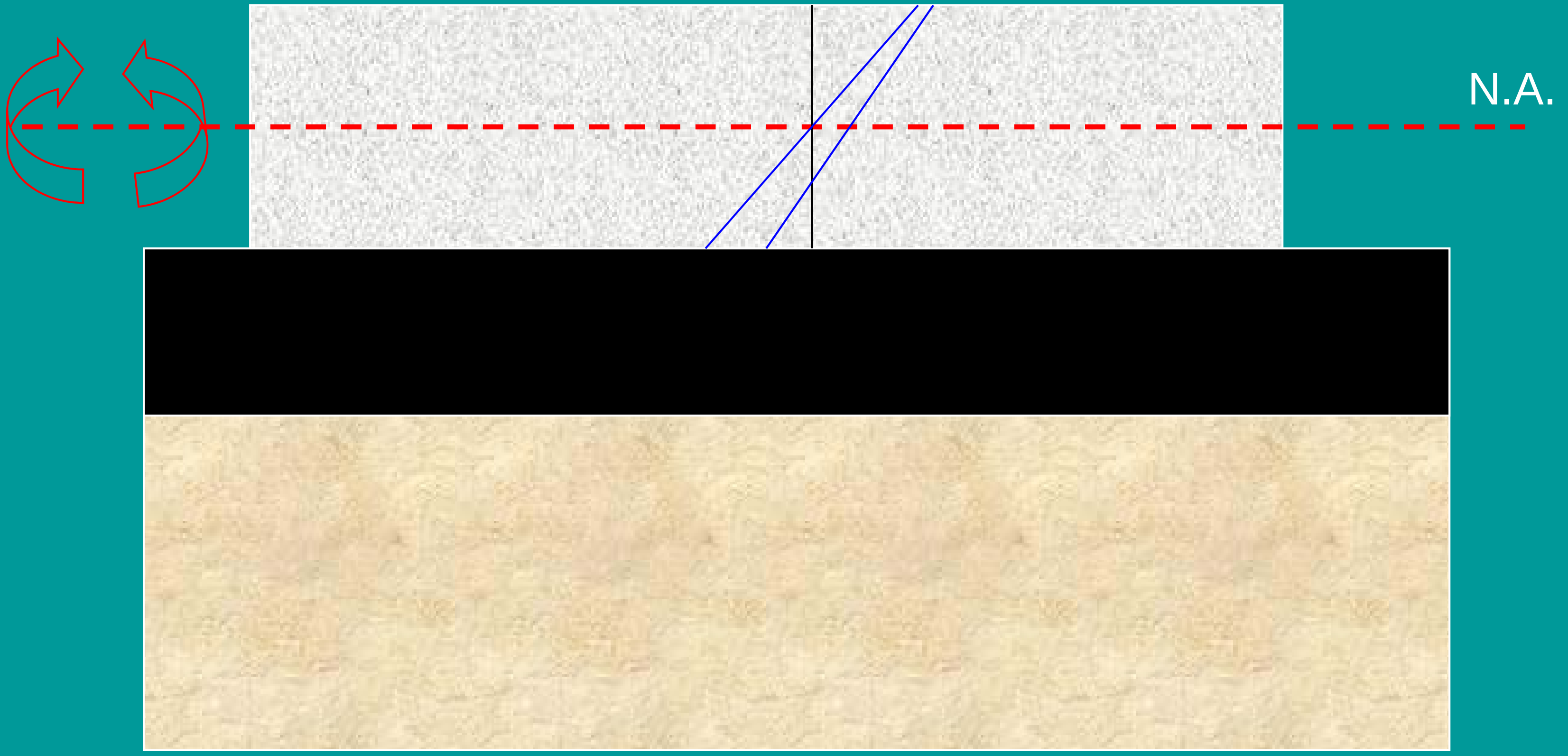
- Thin White-topping (TWT)

- Ultra-thin White-topping (UTW)

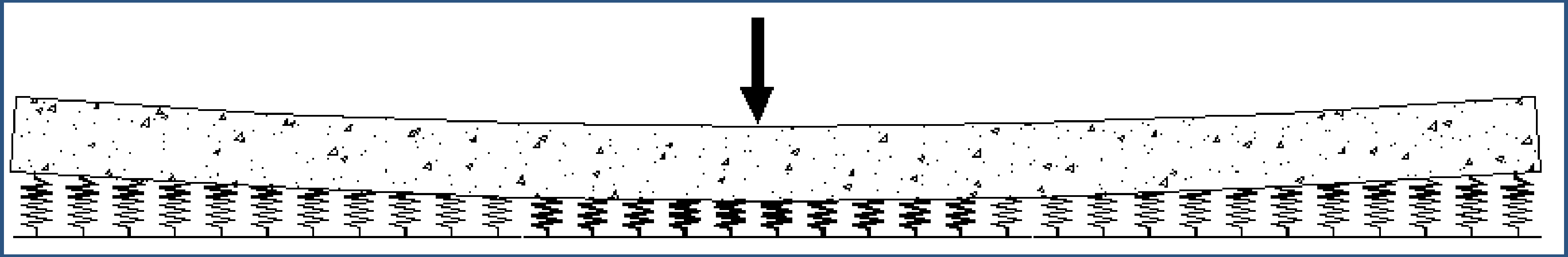
How does un-bonded Whitetopping work?

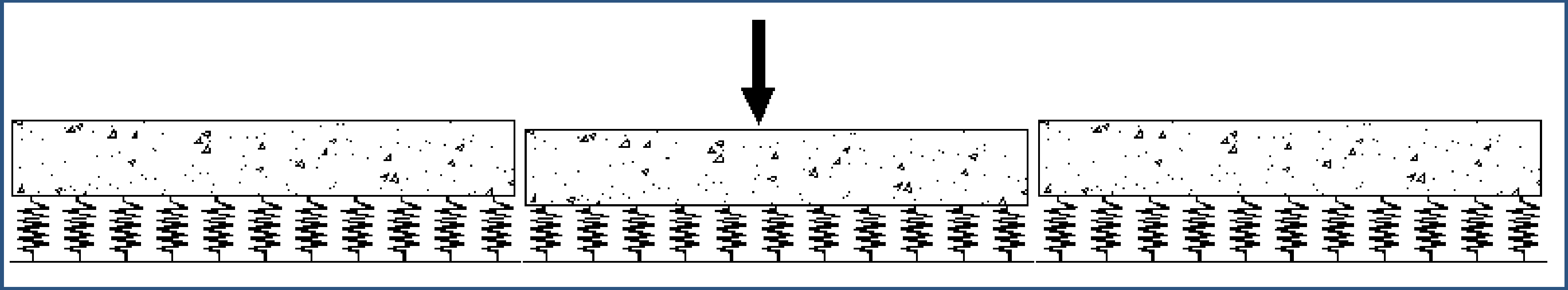


How does bonded Whitetopping work?

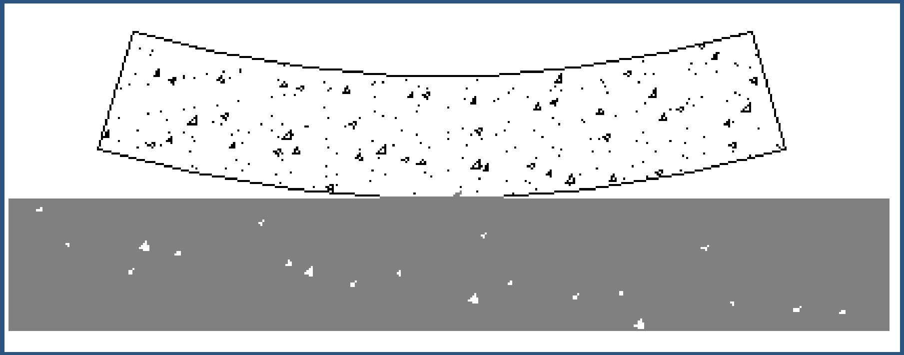


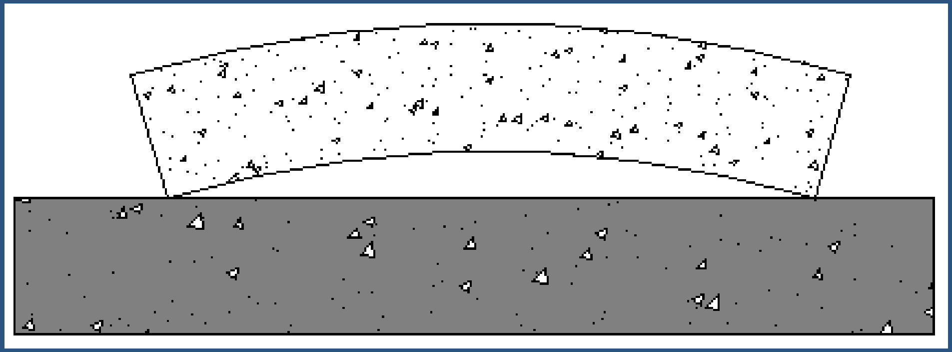
Effects of joint spacing





Effects of temperature differential in the concrete slab





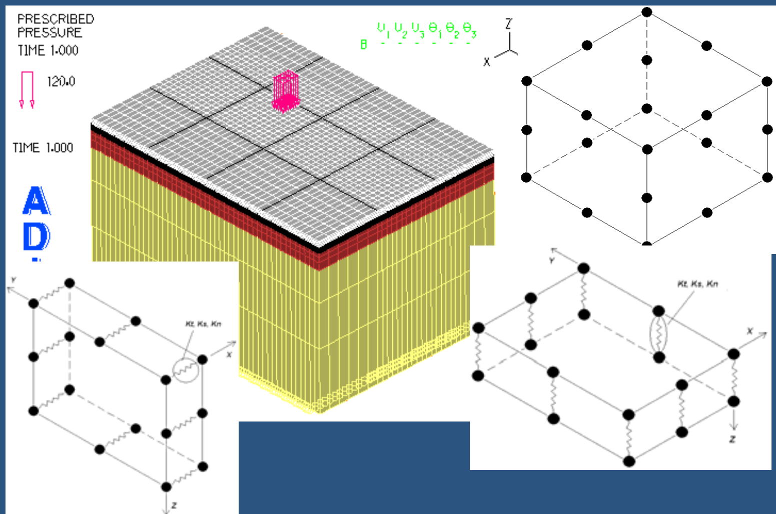
Objectives

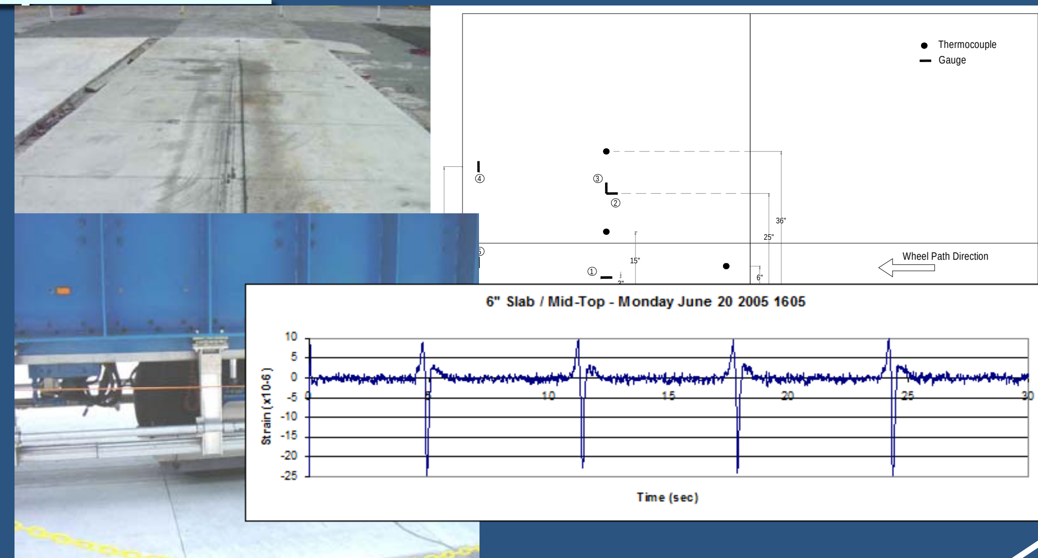
- To develop analytical models for analysis of the behavior of UTW, TWT and CWT pavements. These models are to be verified and fine-tuned by experimental results.
- To evaluate the potential performance of the WT pavement test sections for use under Florida conditions.
- To assess the applicability of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

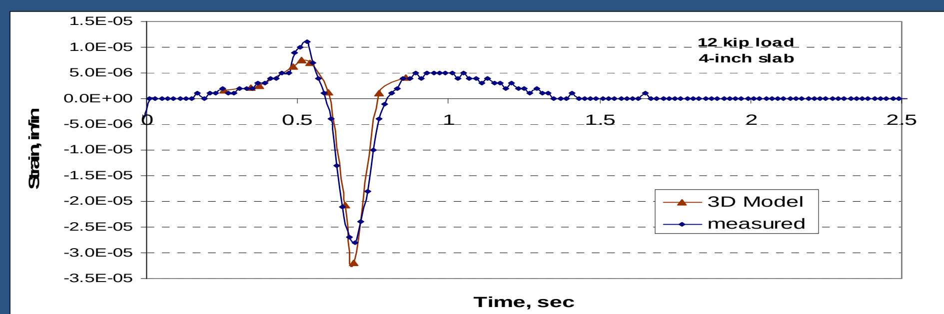
Approach

- 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





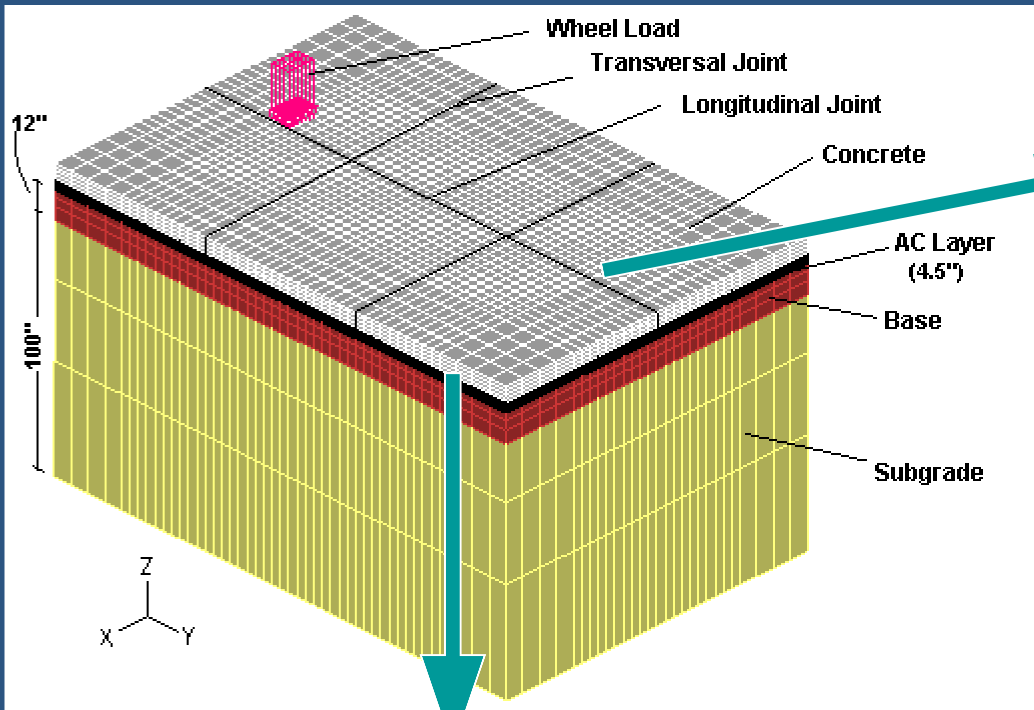


Model Calibration

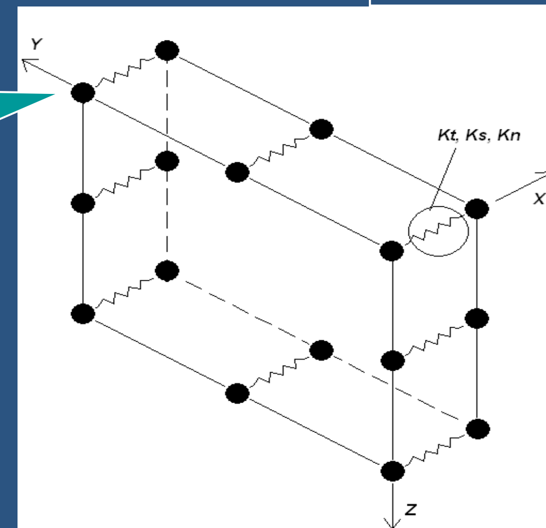
Analytical Tool to predict the behavior of WT pavements

Design recommendations

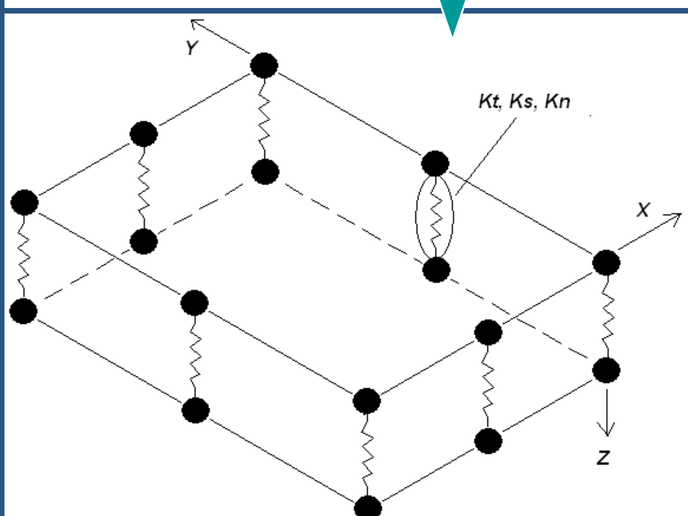
Analytical Model



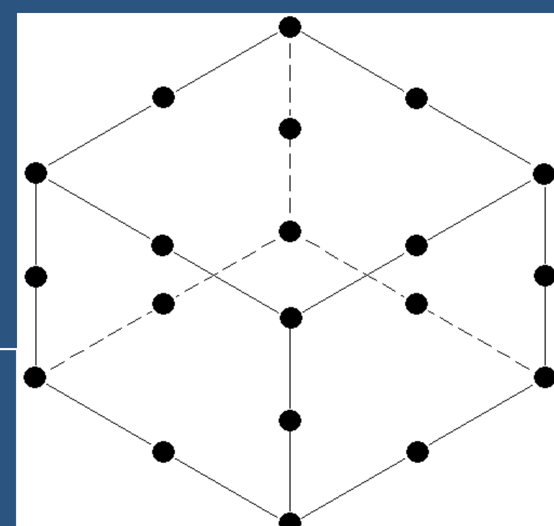
Joints



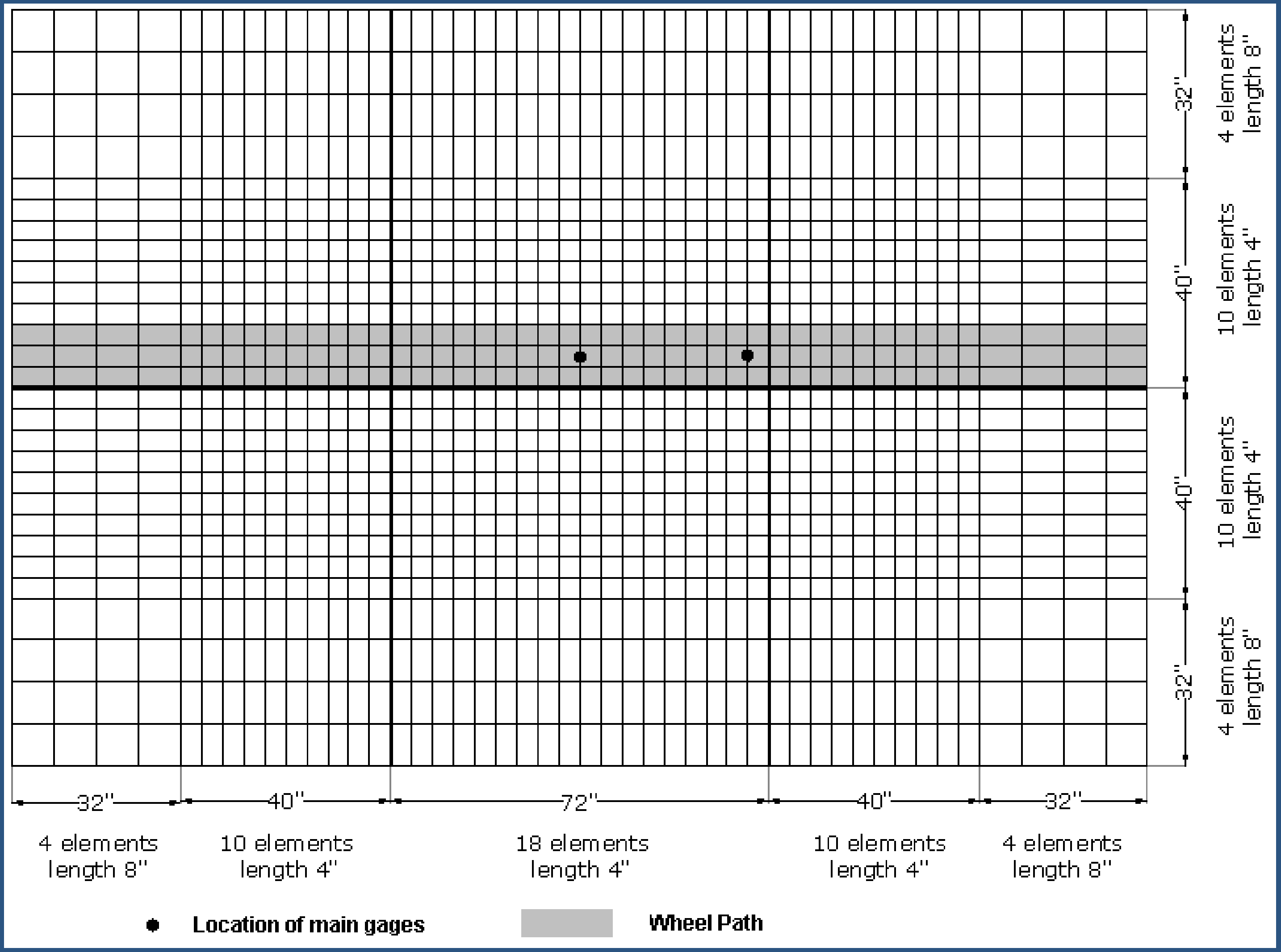
Interface



3D Solid Element

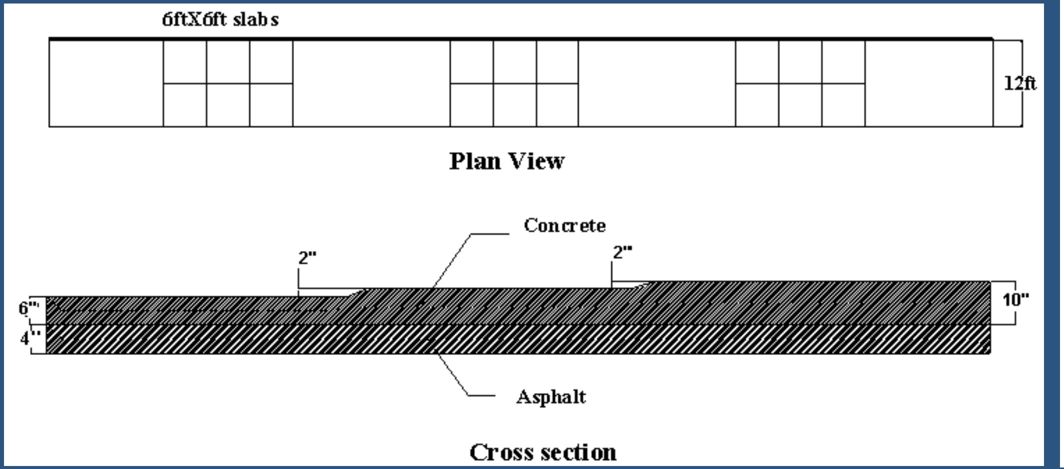


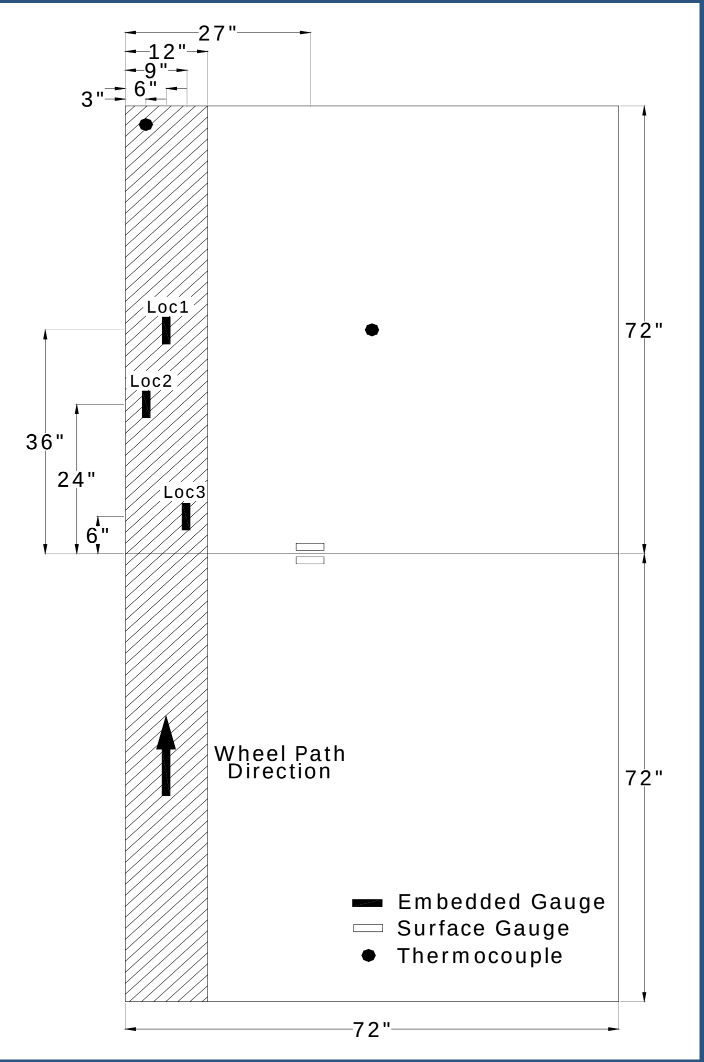
Analytical Model



Test Sections

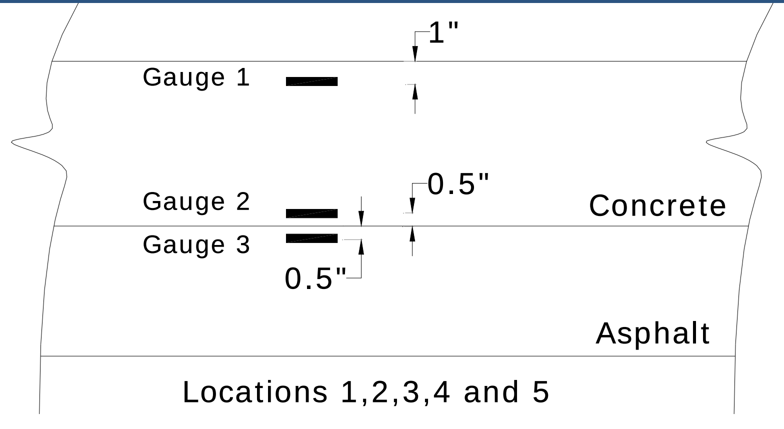
- Phase I: bonded
  - Phase I-a: 6’ x 6’ Slabs
  - Phase I-b: 4’ x 4’ Slabs
  - 4, 5 and 6 inch slabs
- Phase II: Un-bonded
  - 6’ x 6’ Slabs
  - 6, 8 and 10 inch slabs

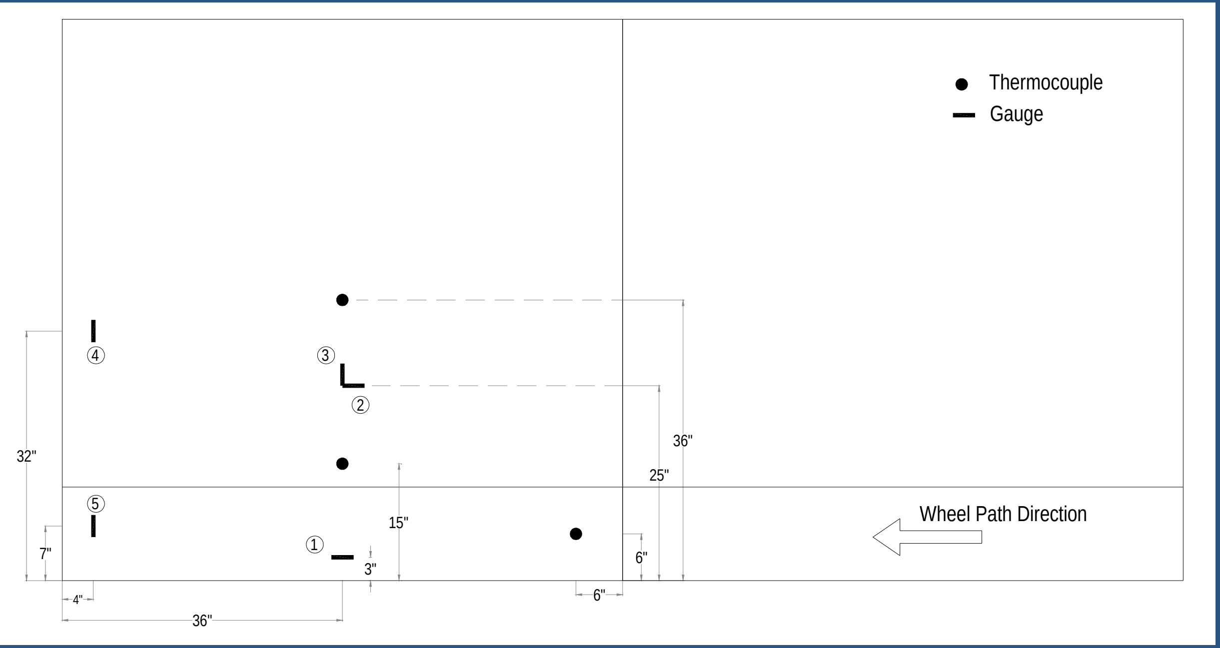




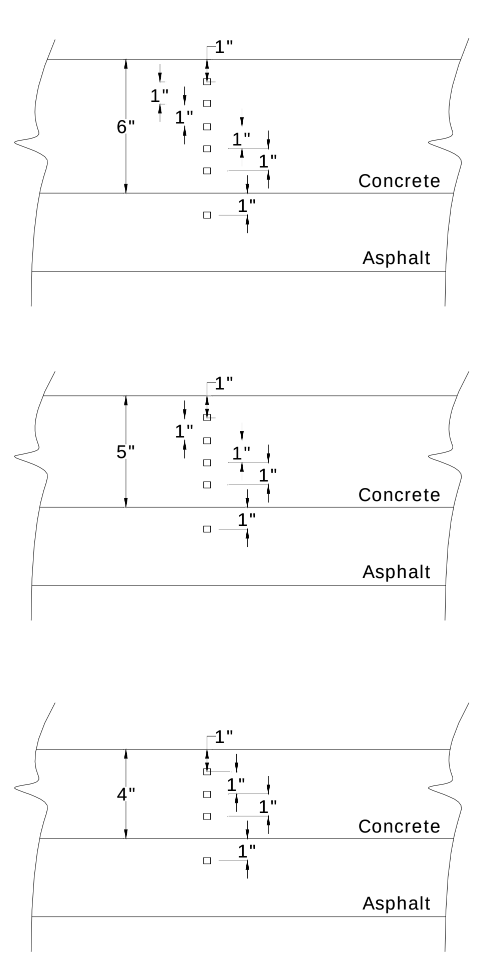
Instrumentation

Gages locations





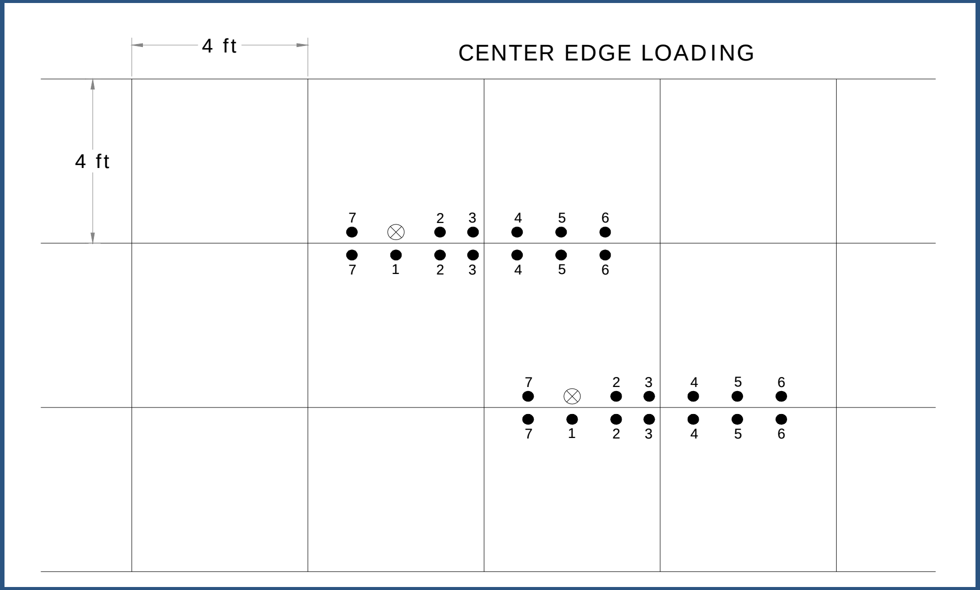
Thermocouples



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

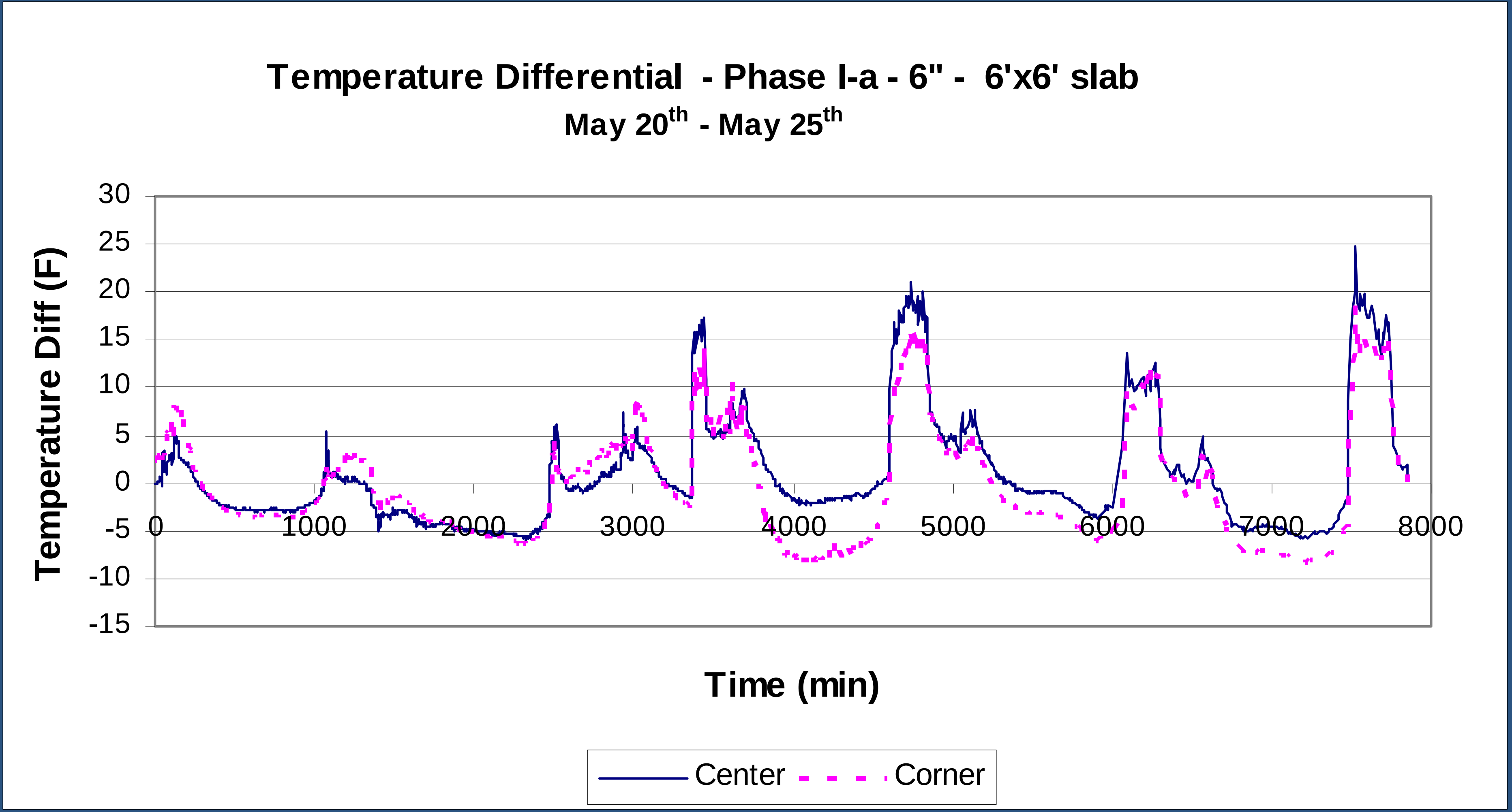
Curing Time, days	Compressive Strength, psi	Elastic Modulus, ksi	Flexural Strength, psi
1	1,933	-	-
3	3,608	-	-
7	4,651	3,307	-
14	-	3,875	808
28	6,083	4,004	855
56	6,612	4,272	-

Asphalt

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

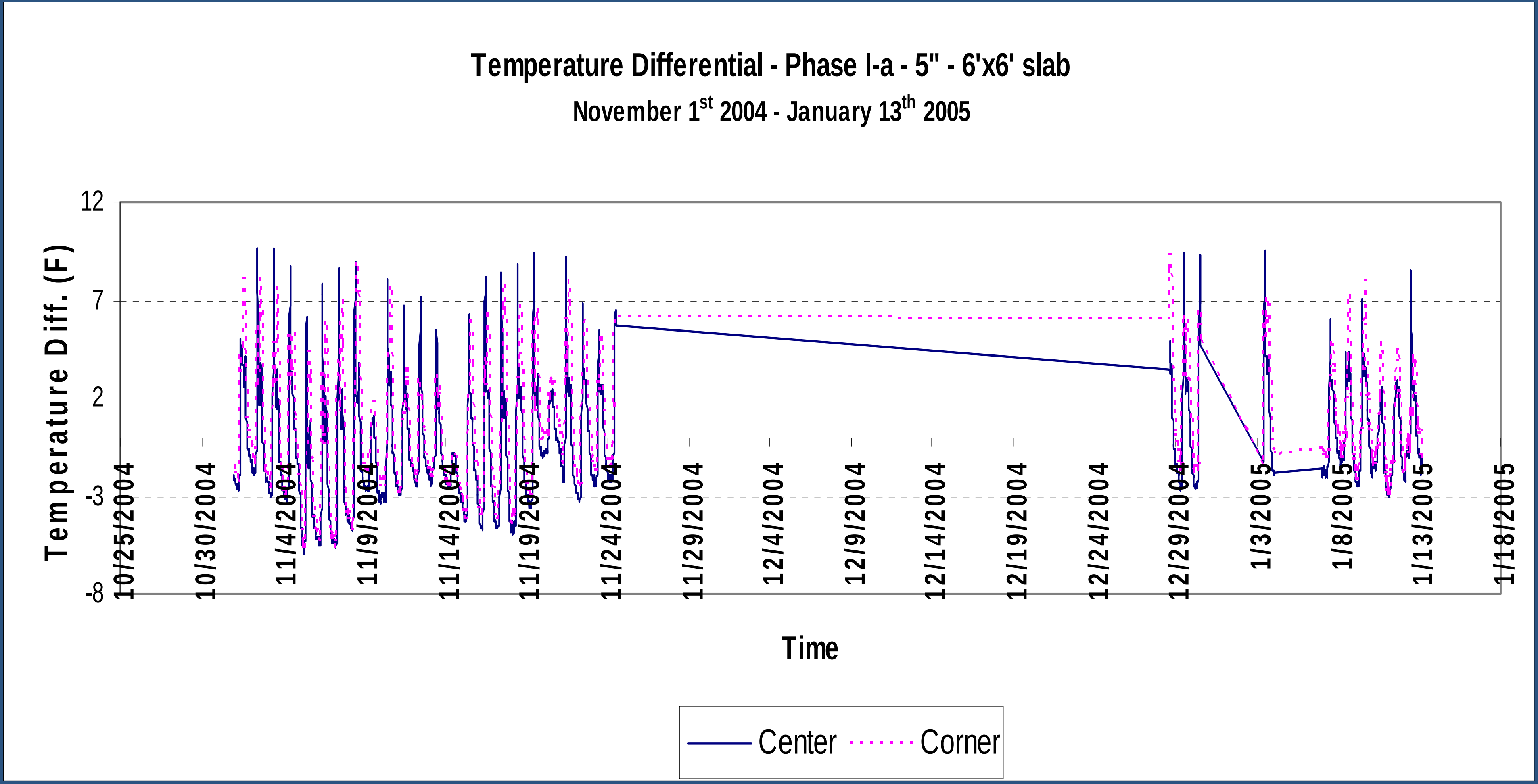
Temperature Differential in Concrete

Spring



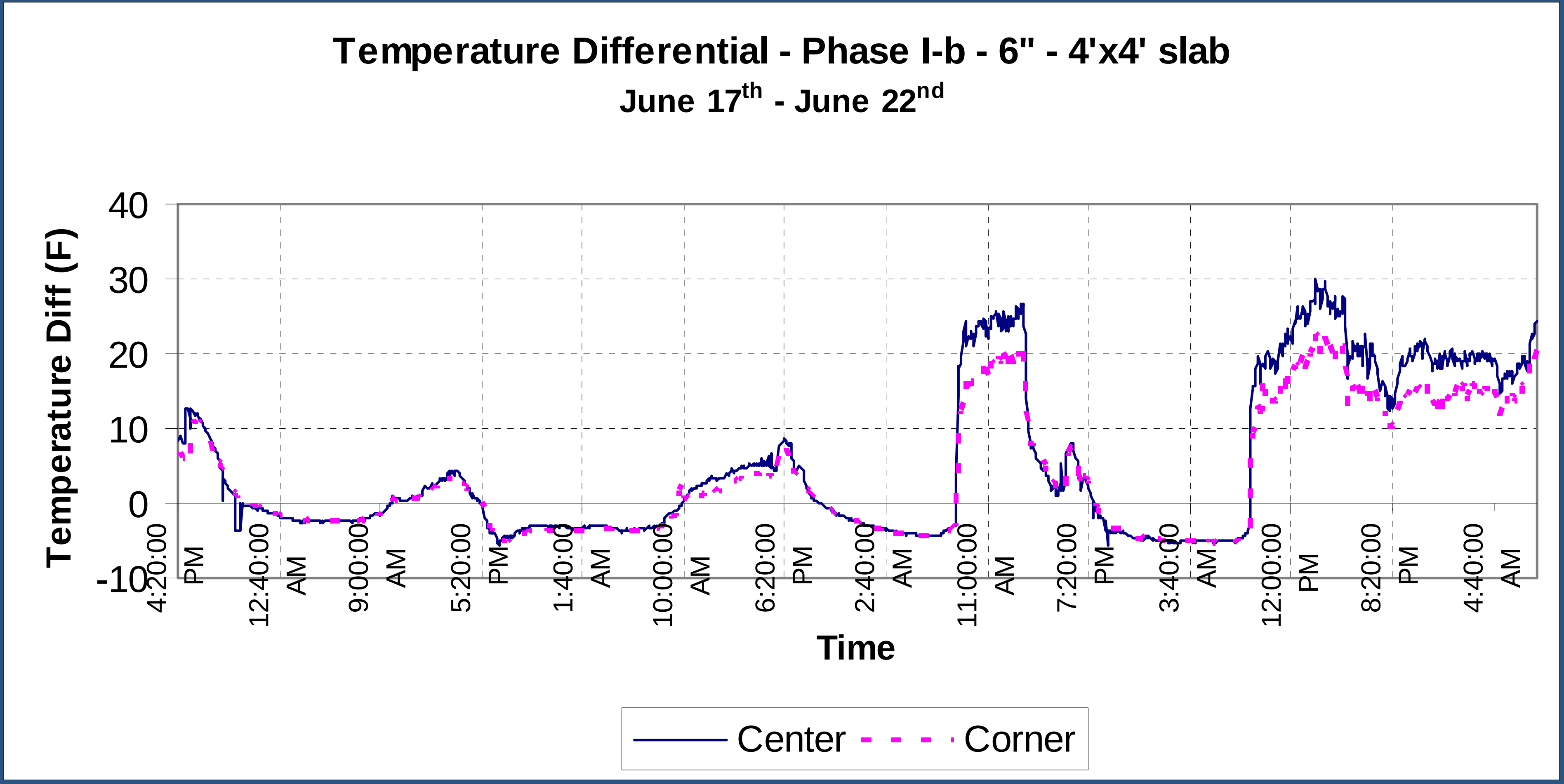
Temperature Differential in Concrete

Fall – Winter



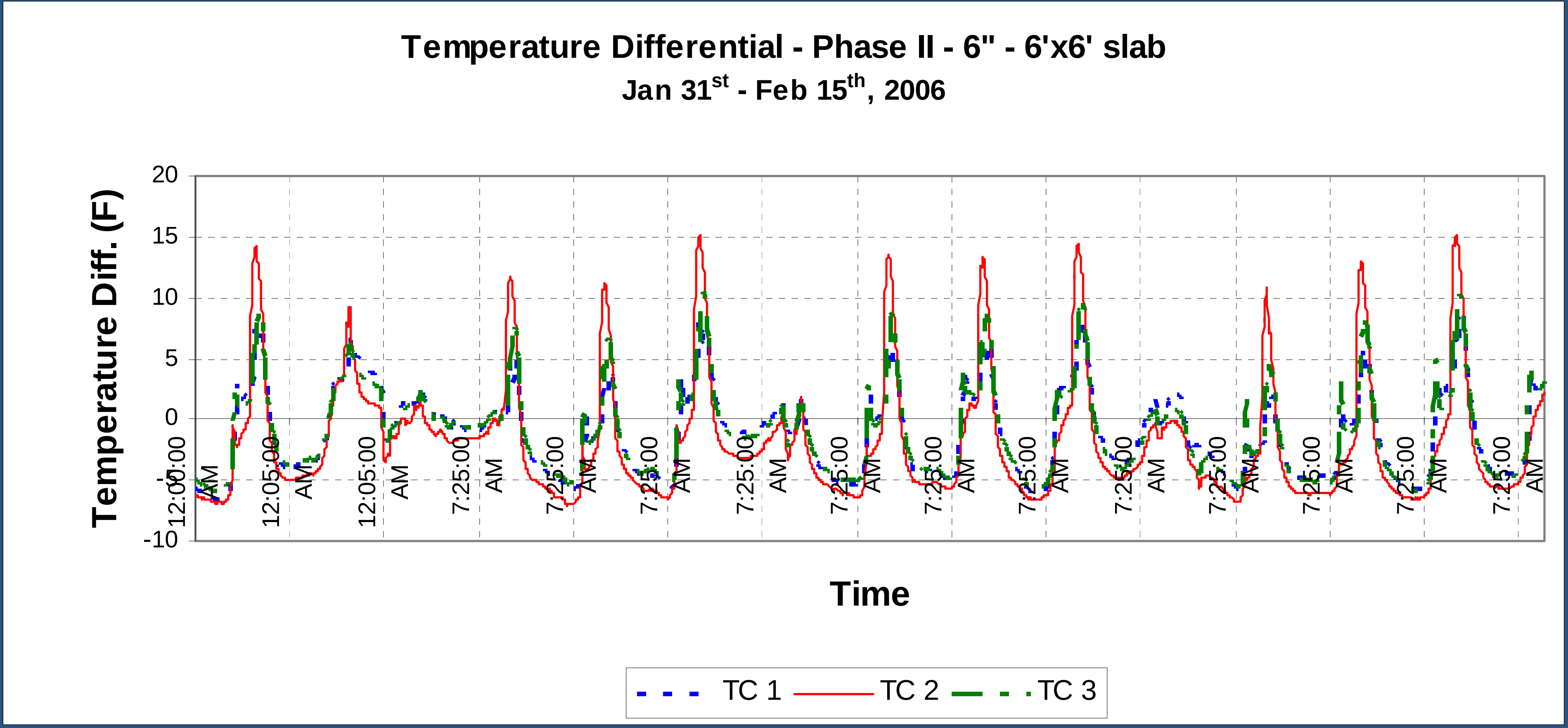
Temperature Differential in Concrete

Summer



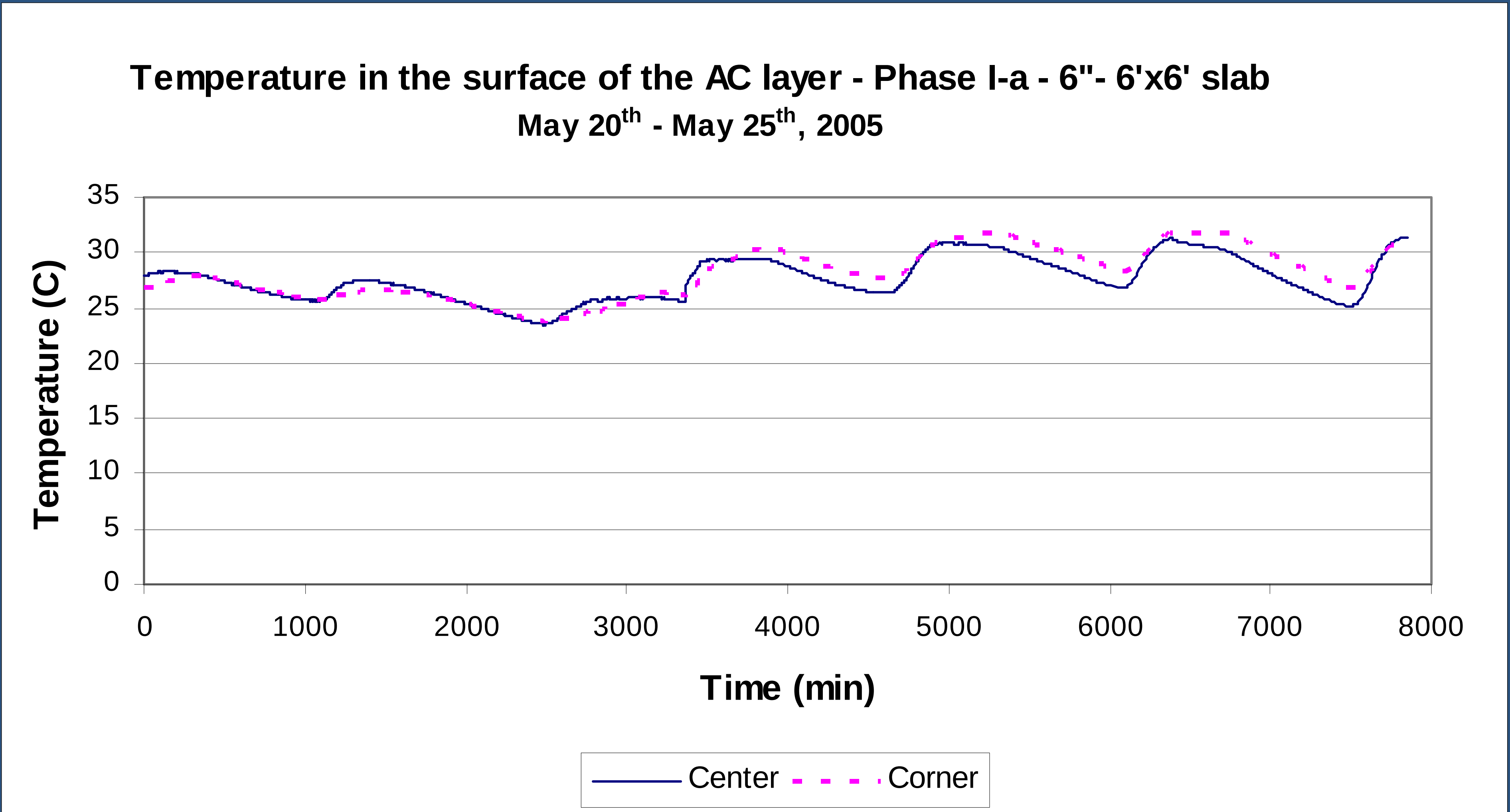
Temperature Differential in Concrete

Winter



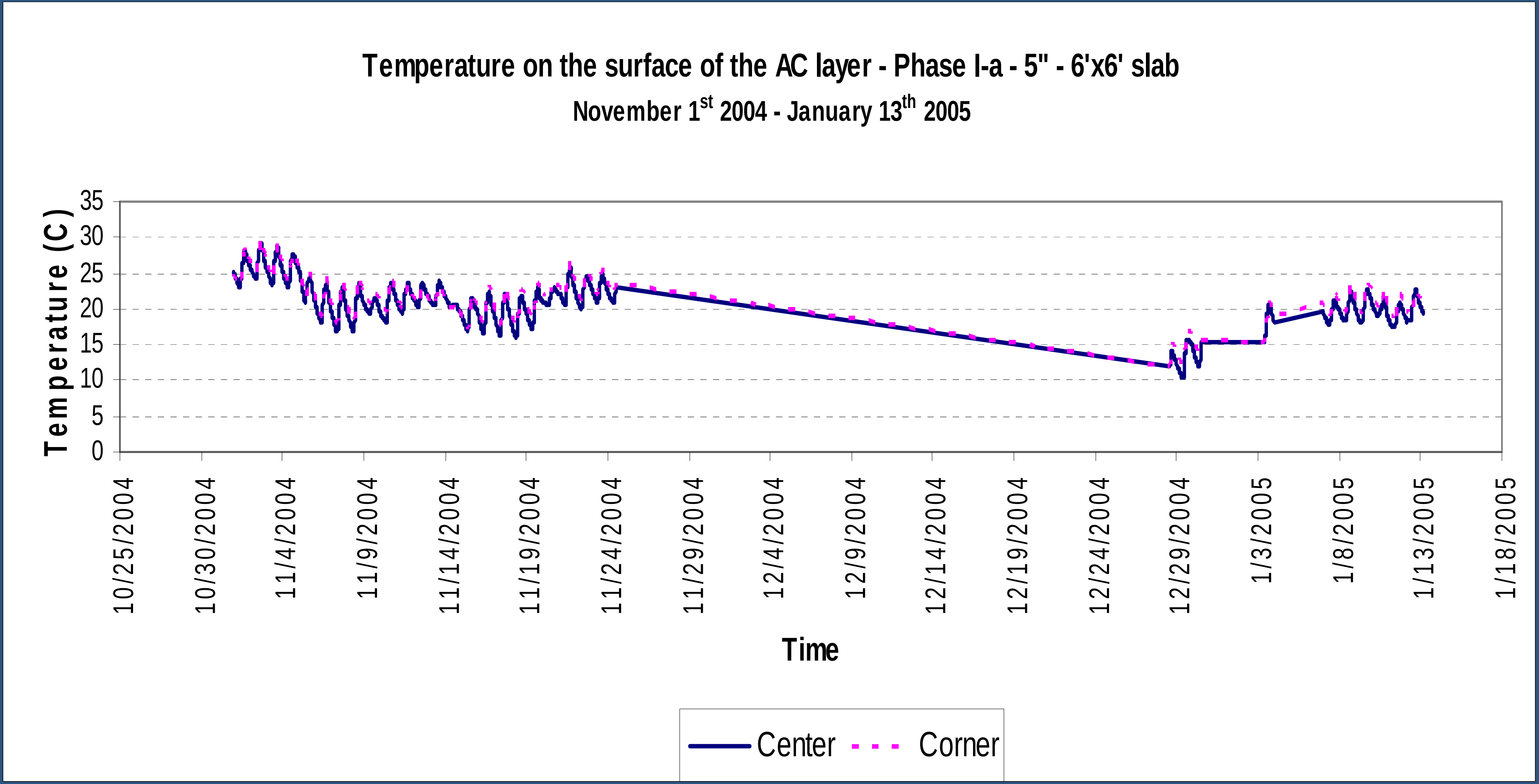
Temperature in AC Layer

Spring



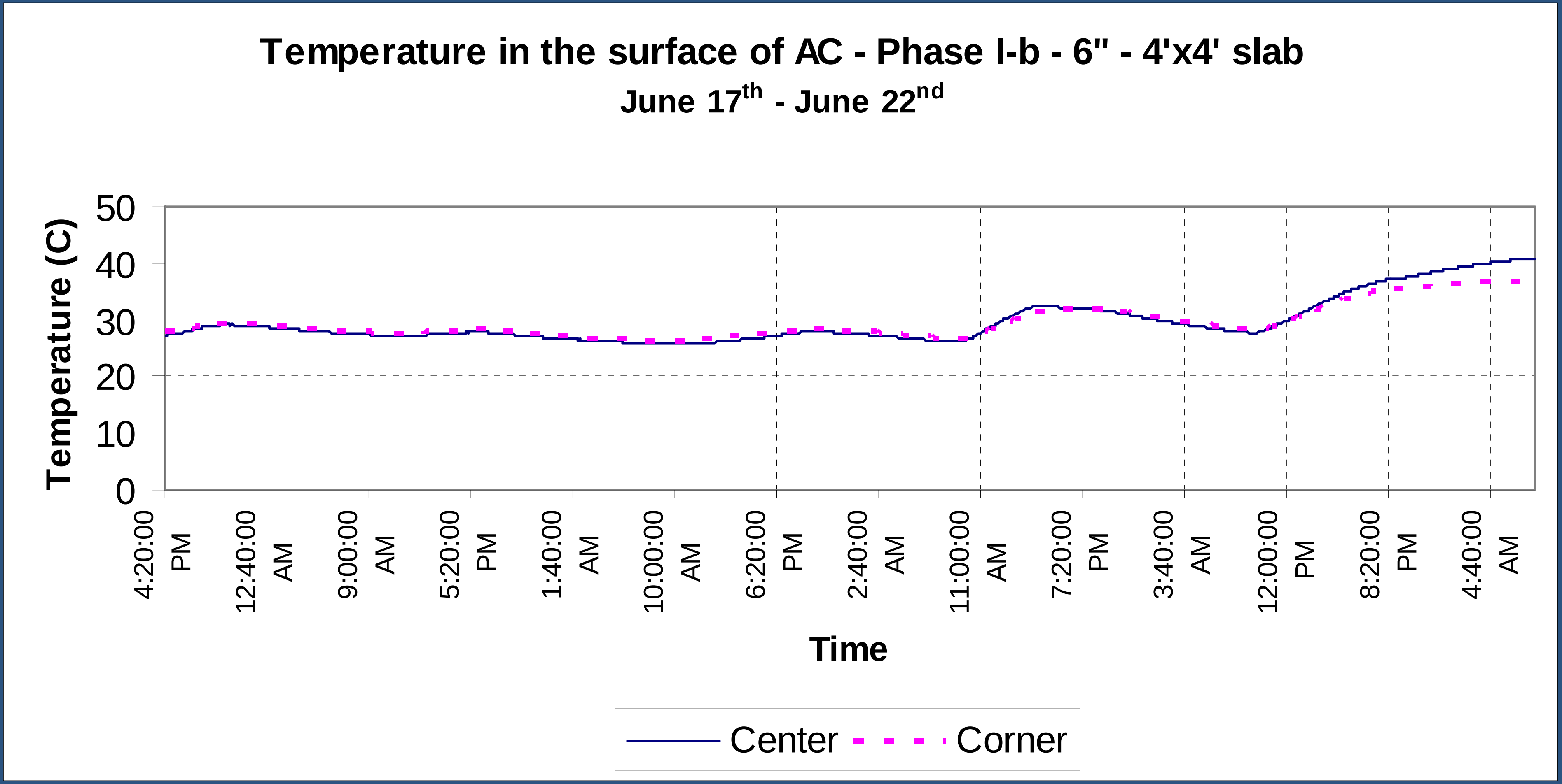
Temperature in AC Layer

Fall – Winter



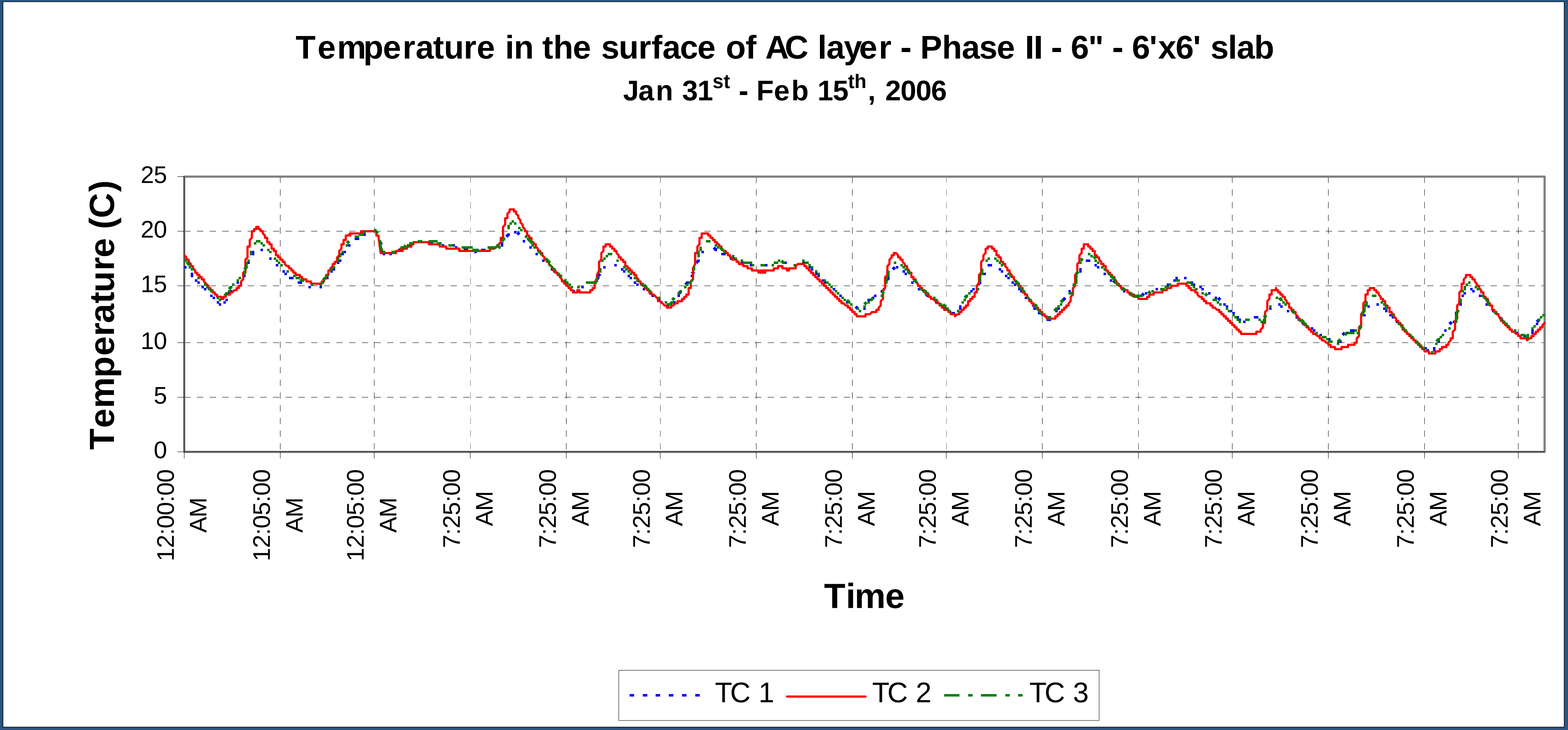
Temperature in AC Layer

Summer

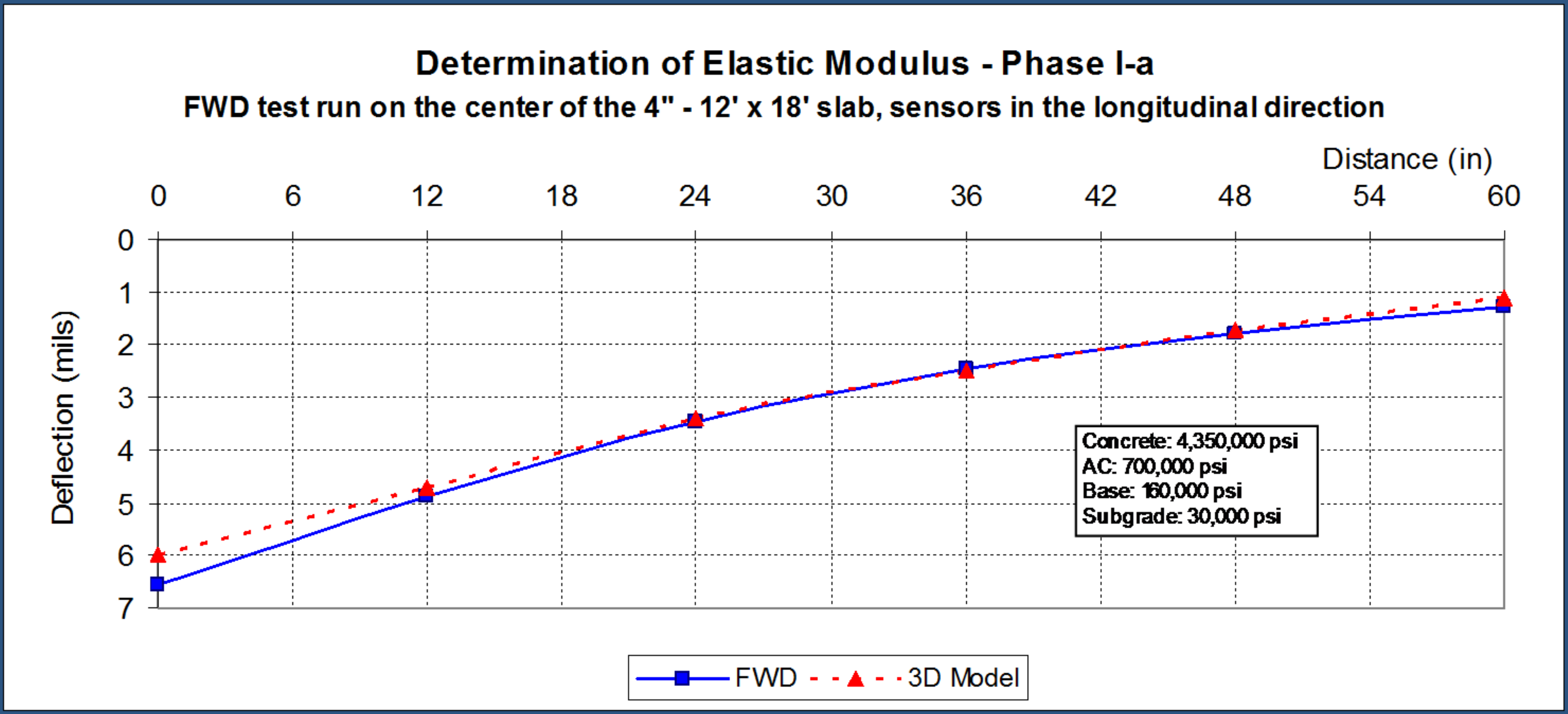


Temperature in AC Layer

Winter



Deflection-based calibration



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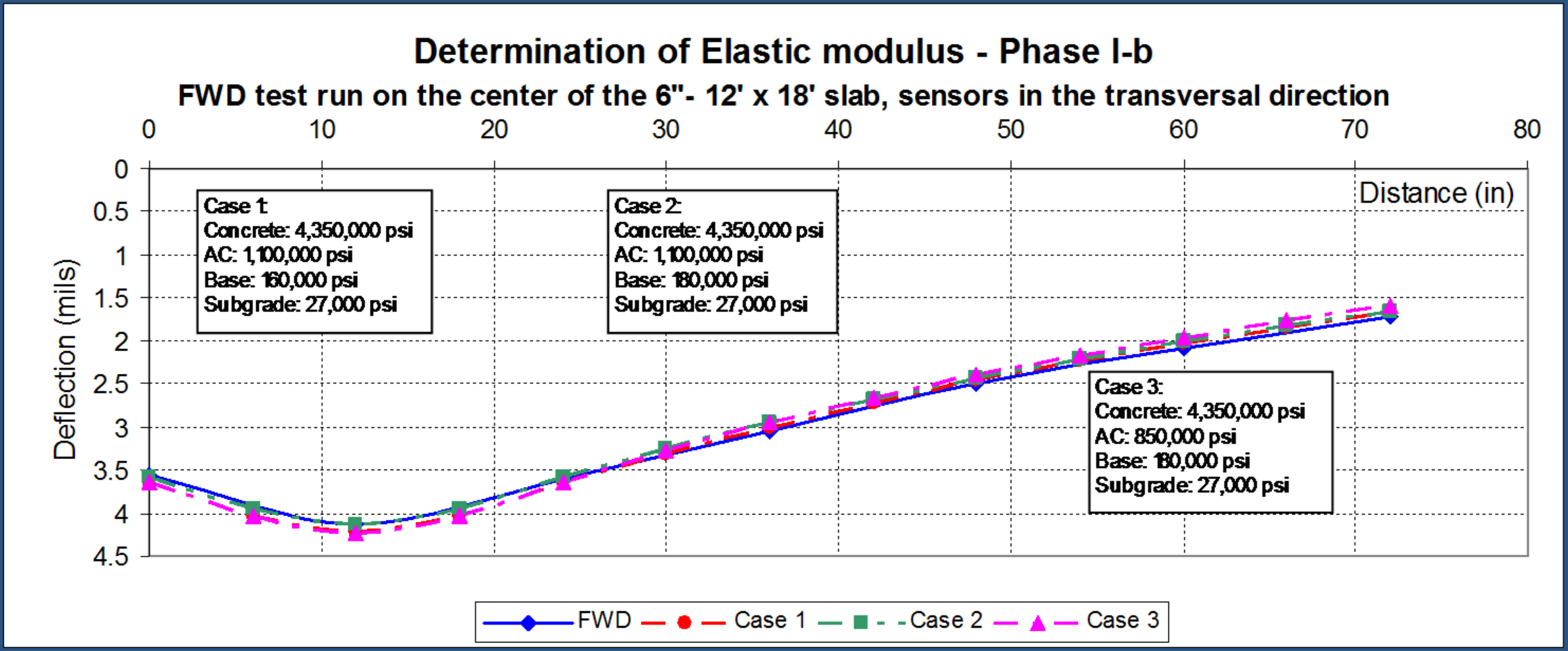

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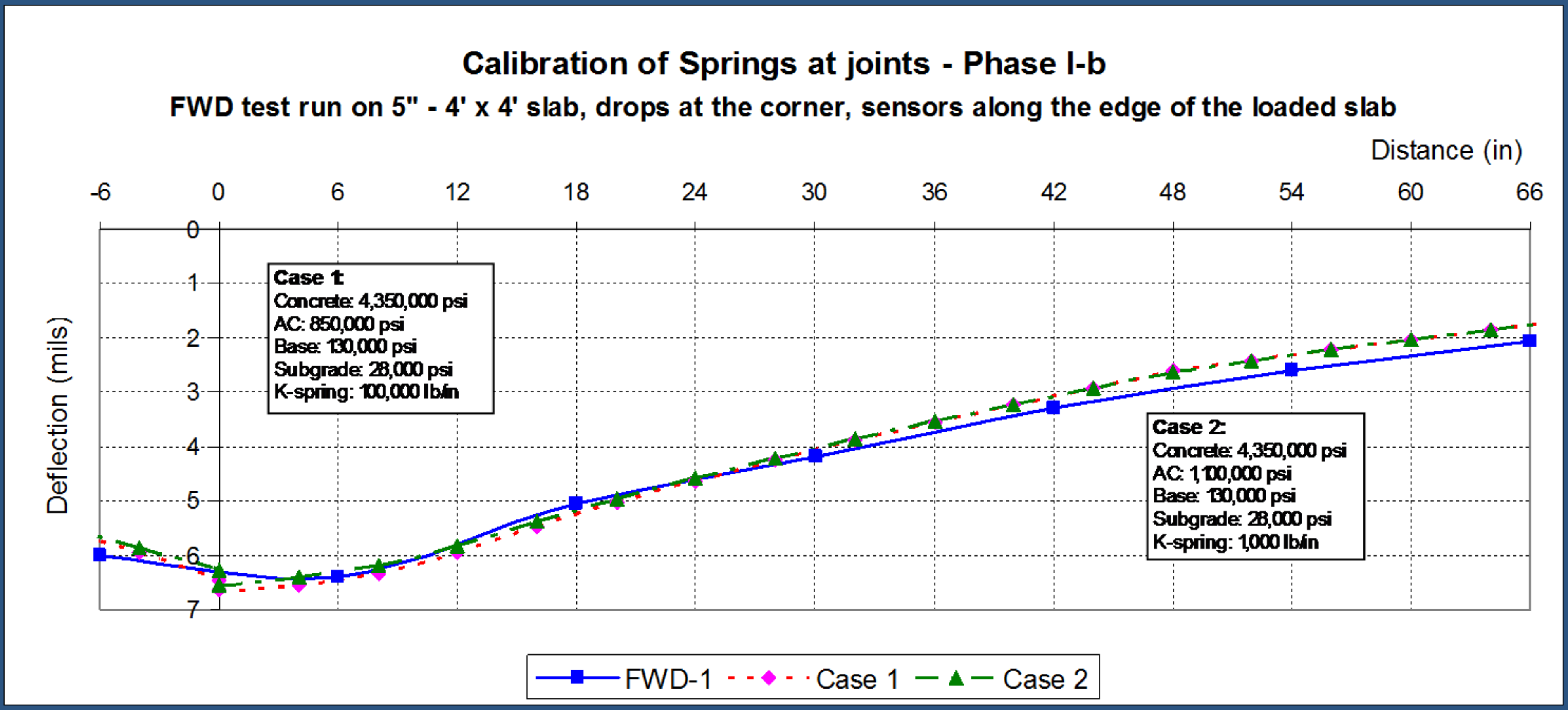

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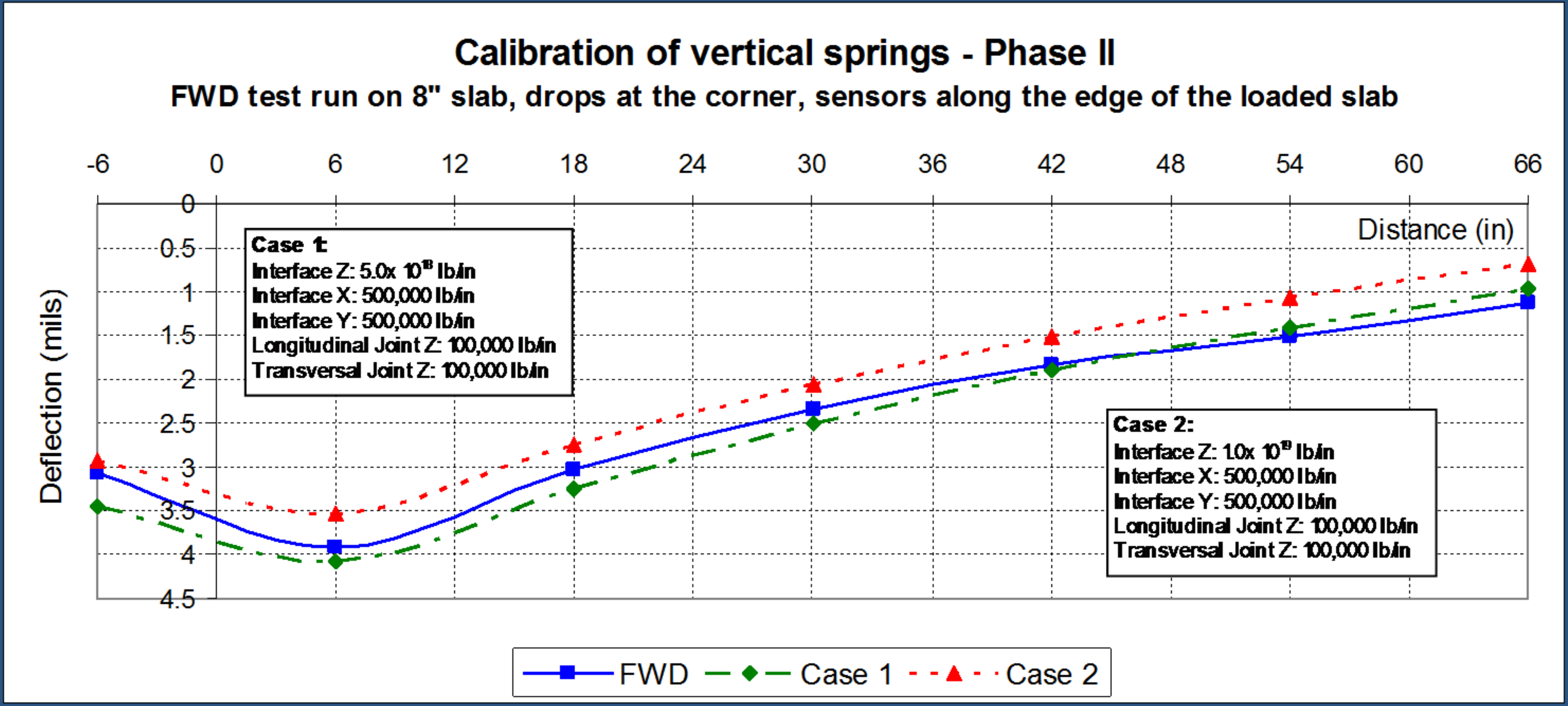
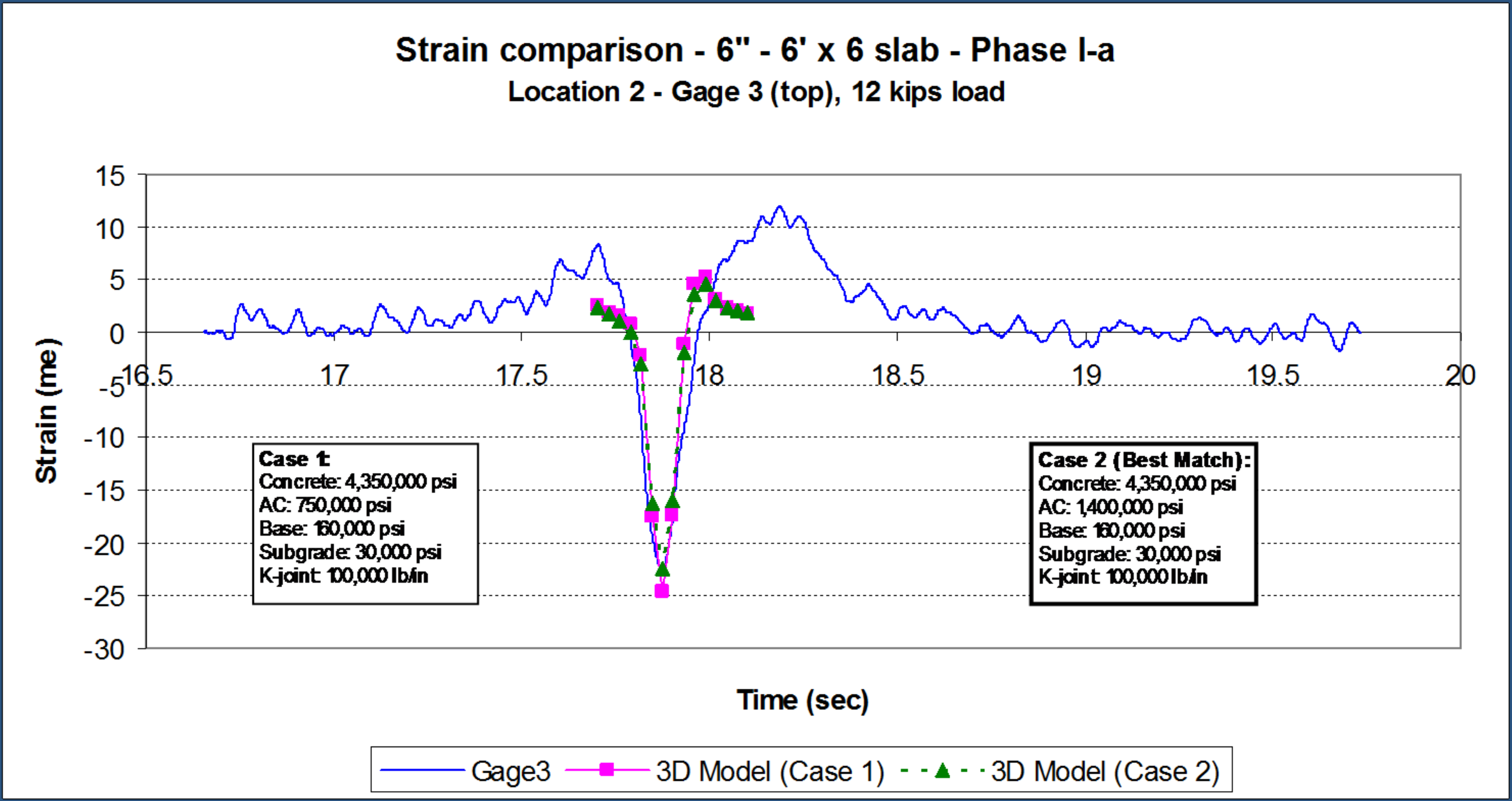
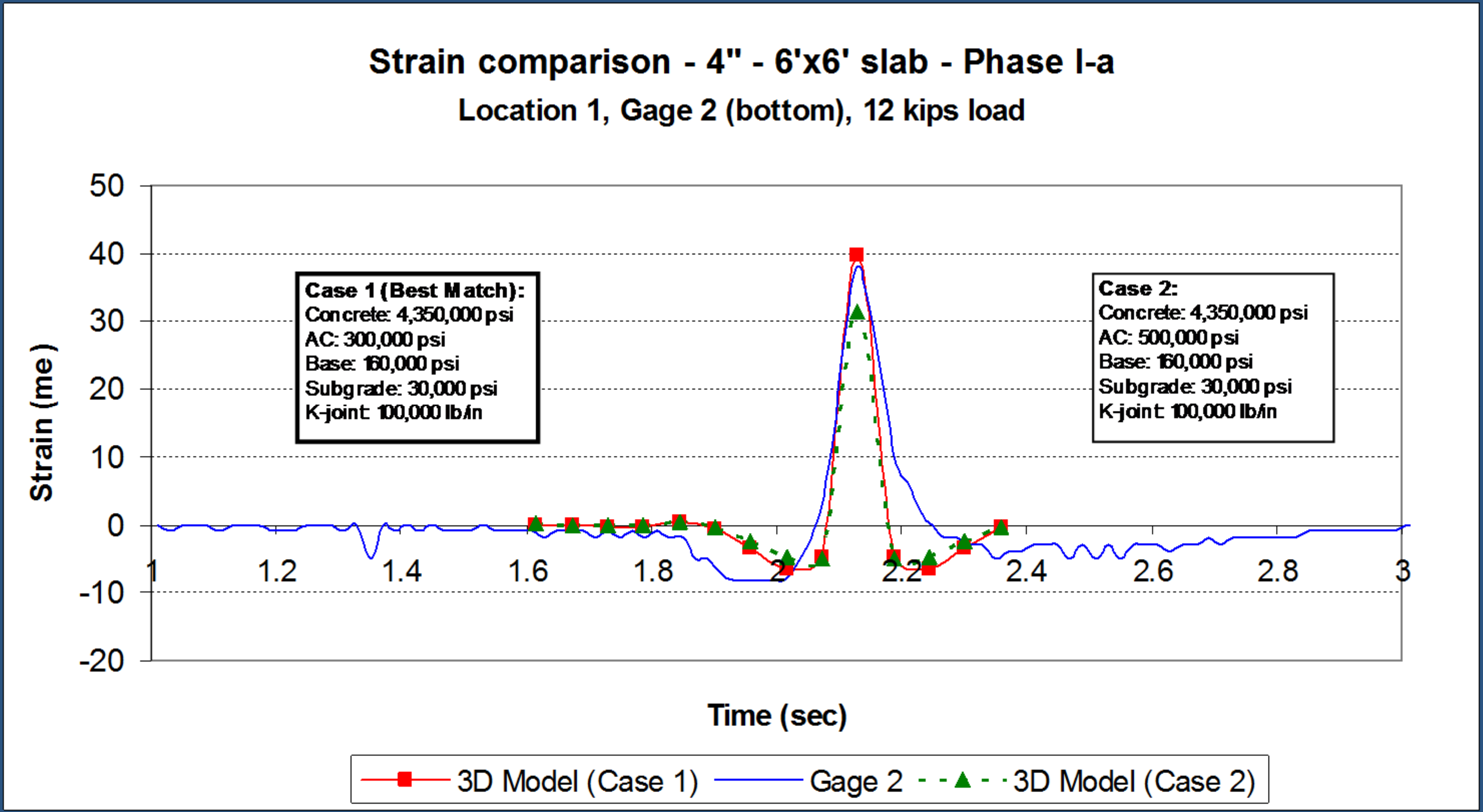


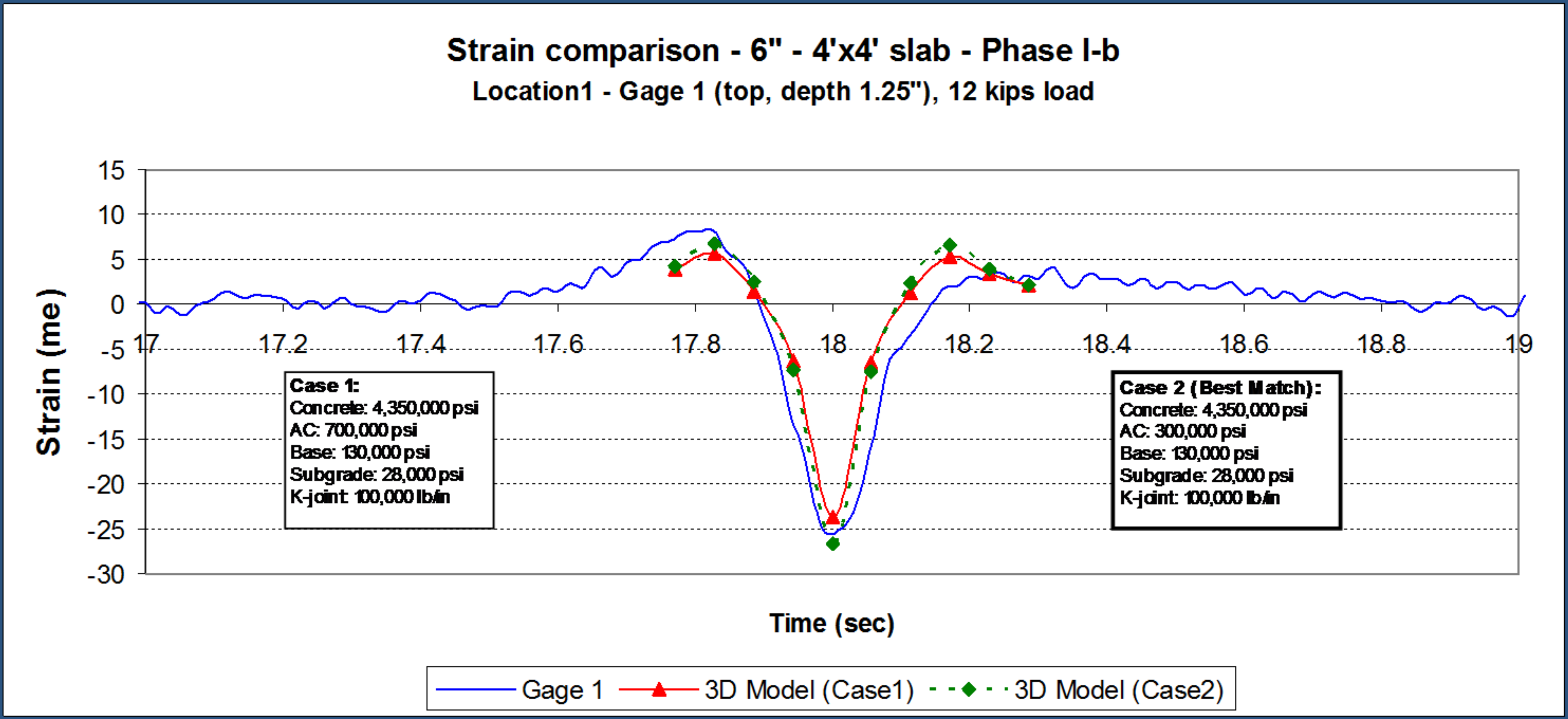
Strain-based Calibration



Strain-based Calibration



Strain-based Calibration



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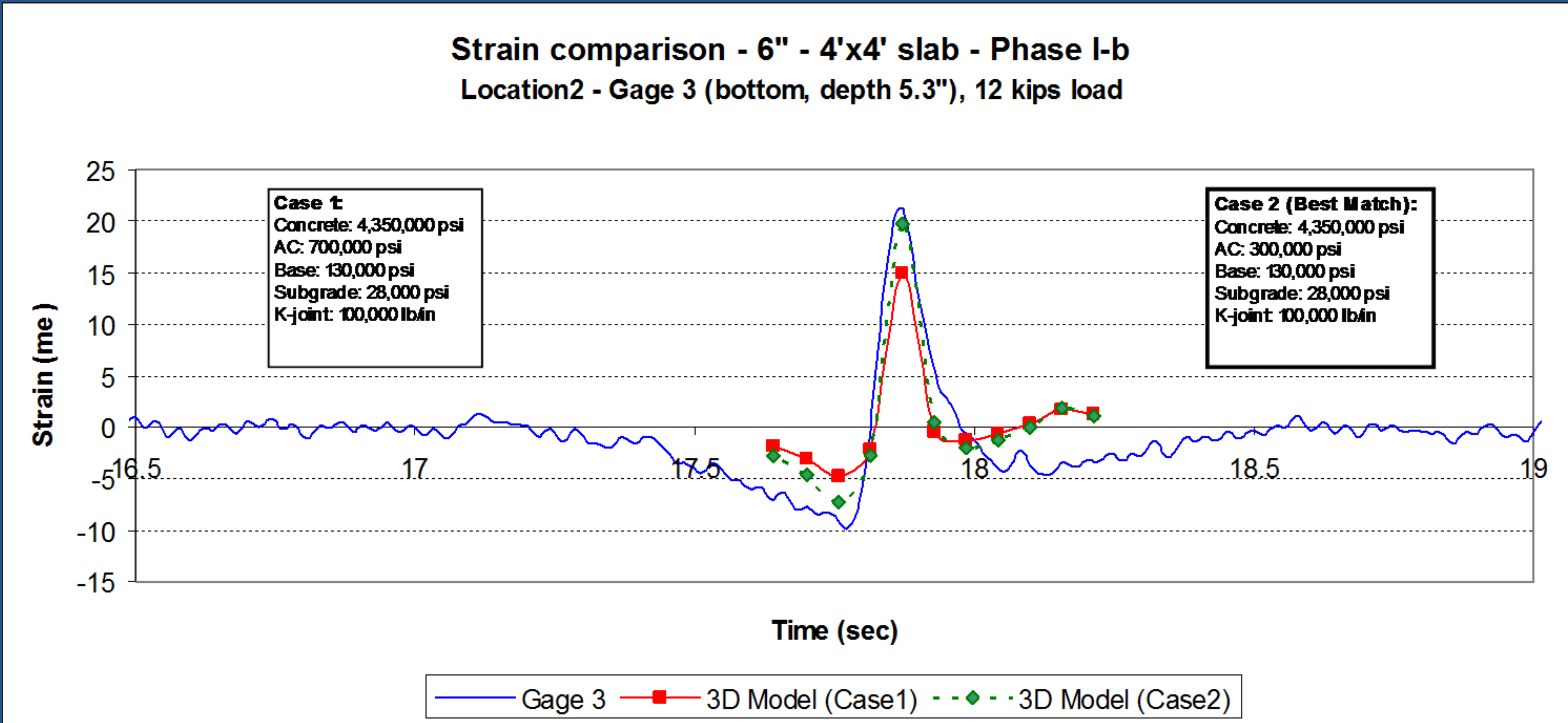

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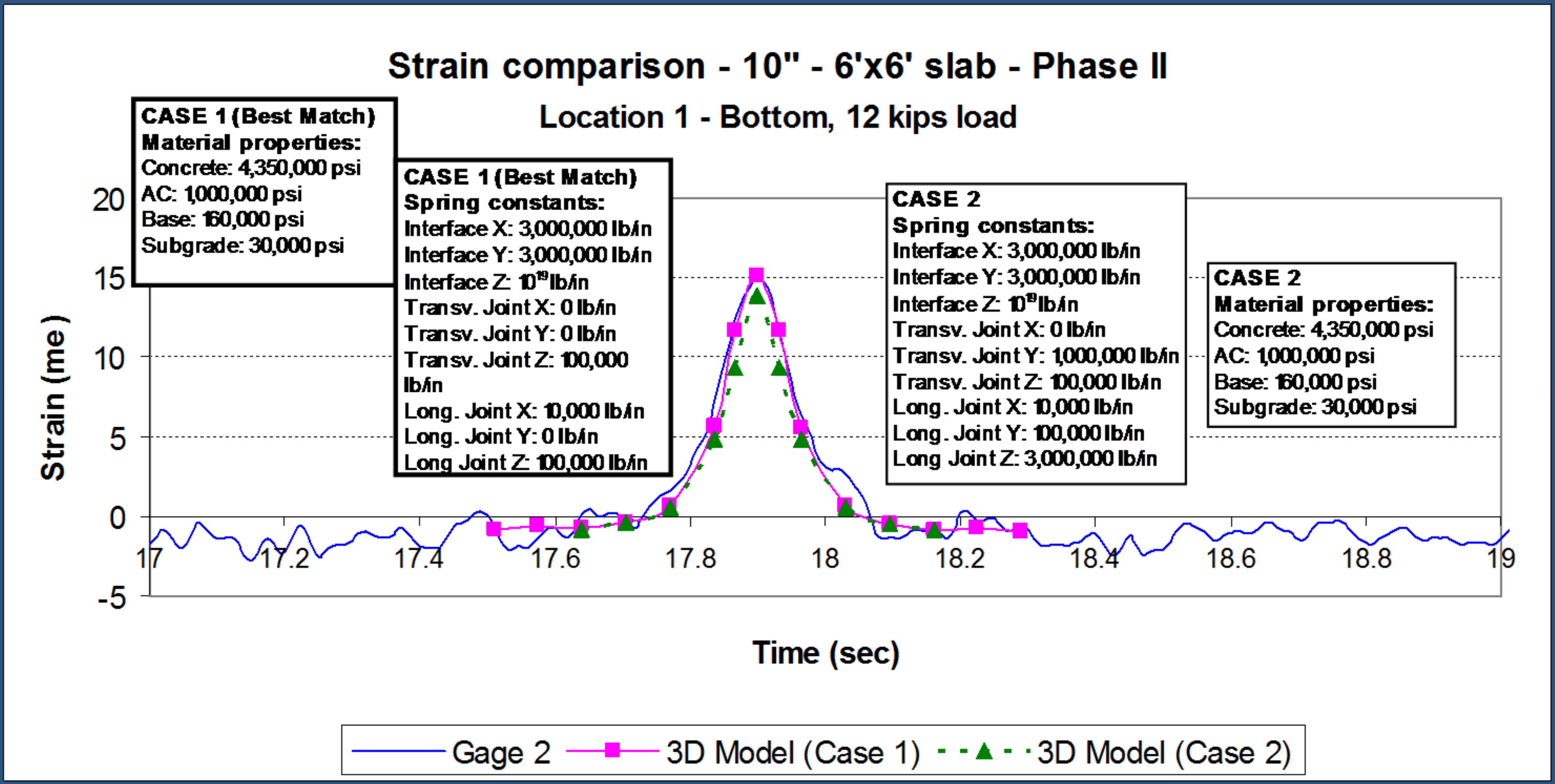

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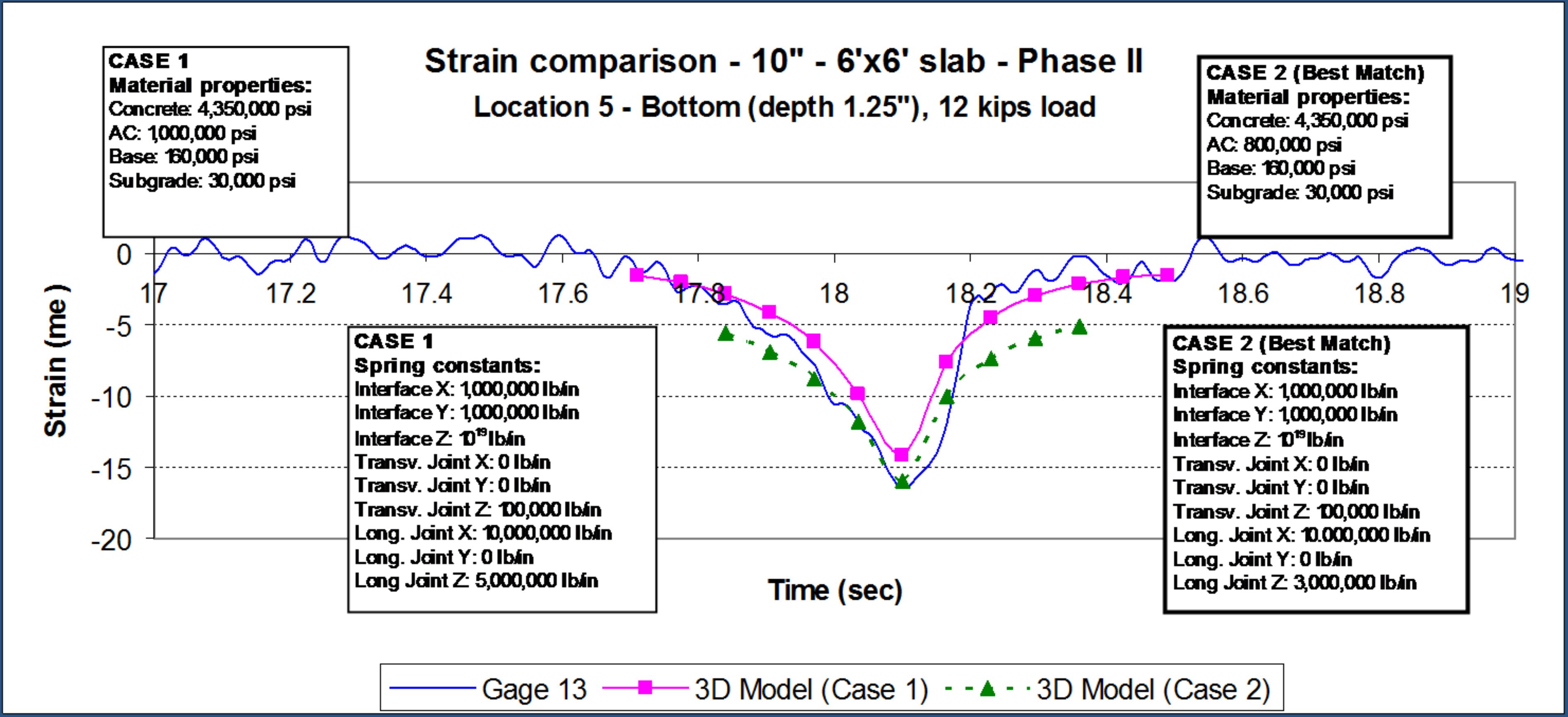

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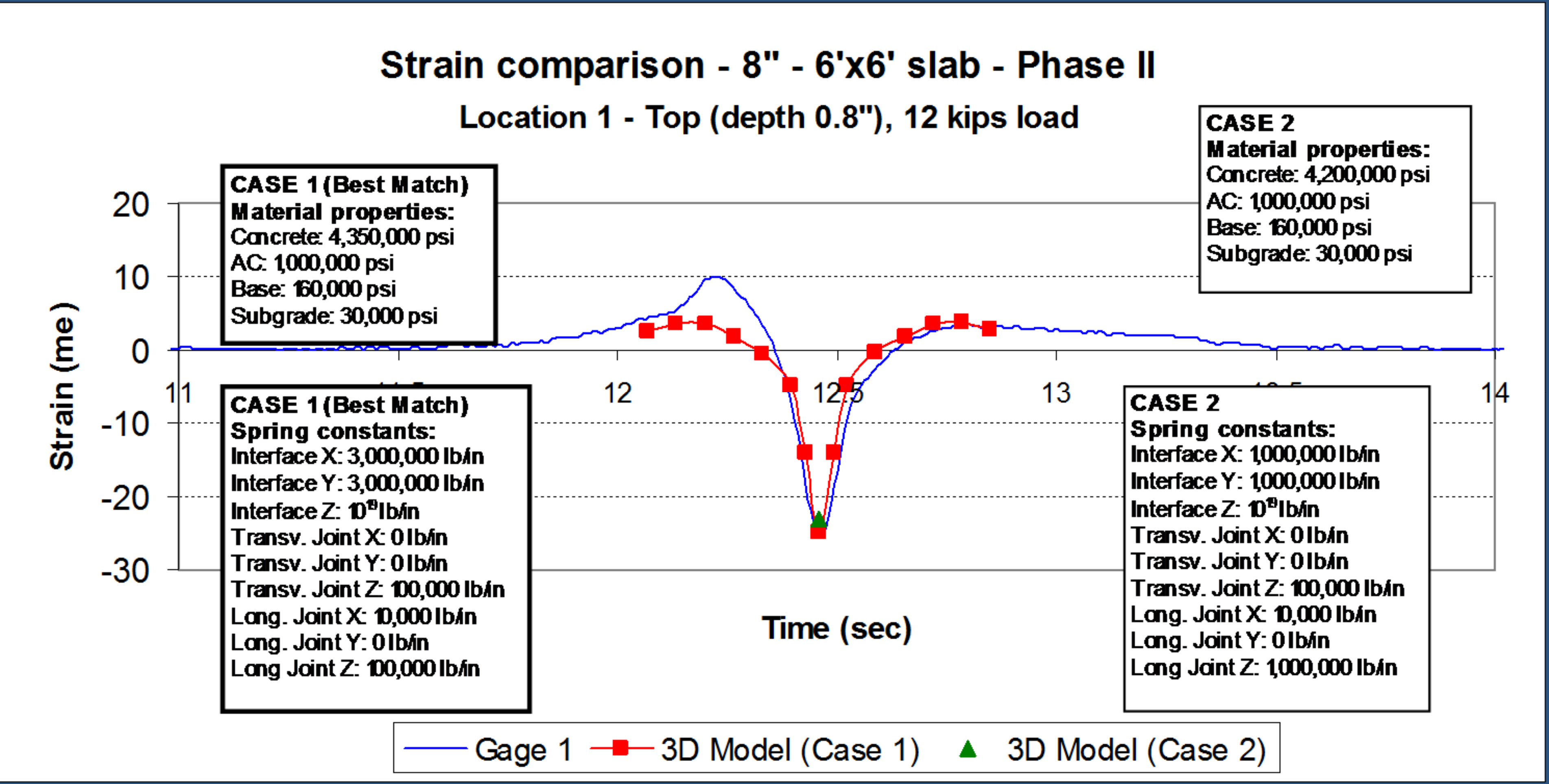

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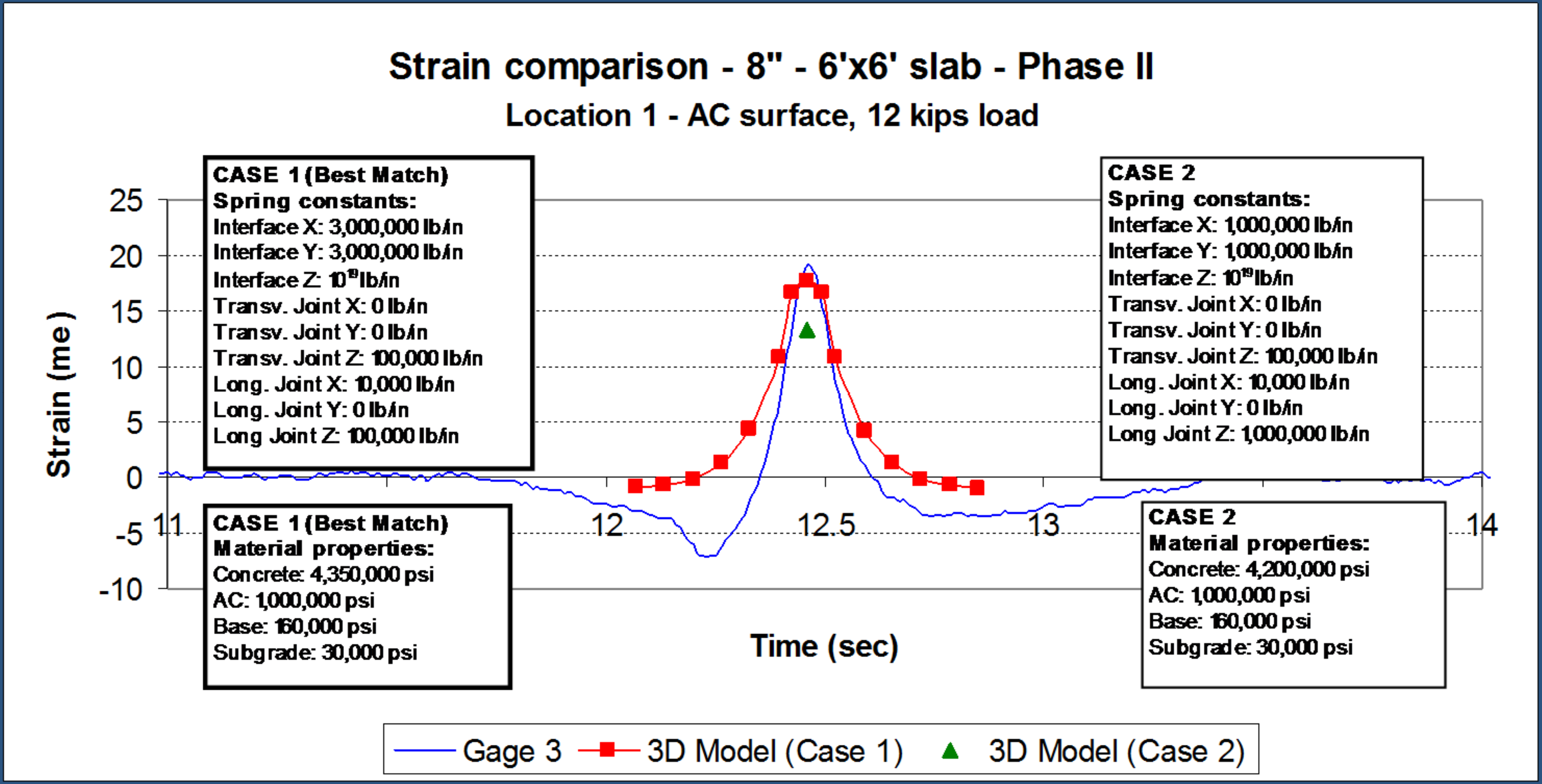
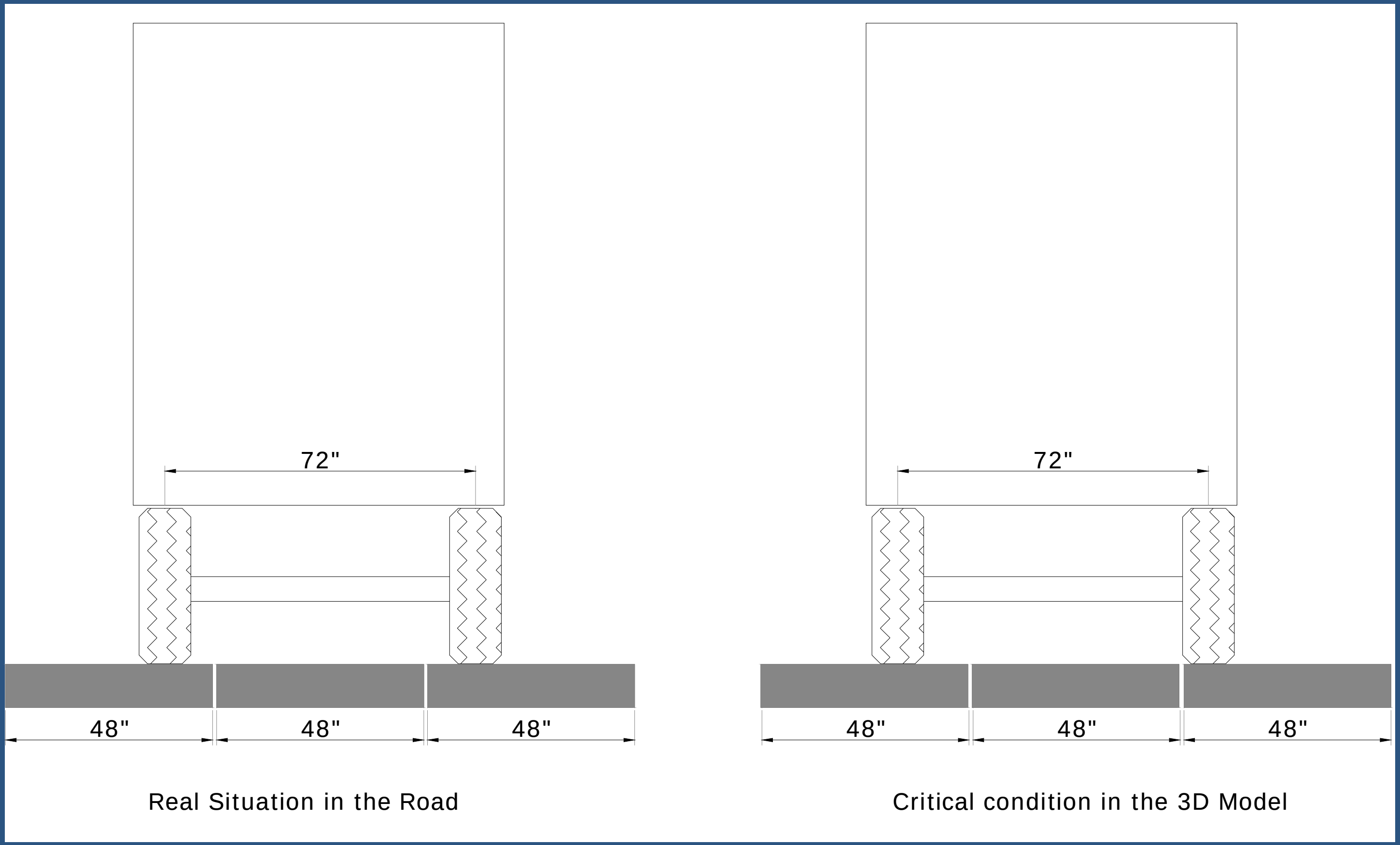


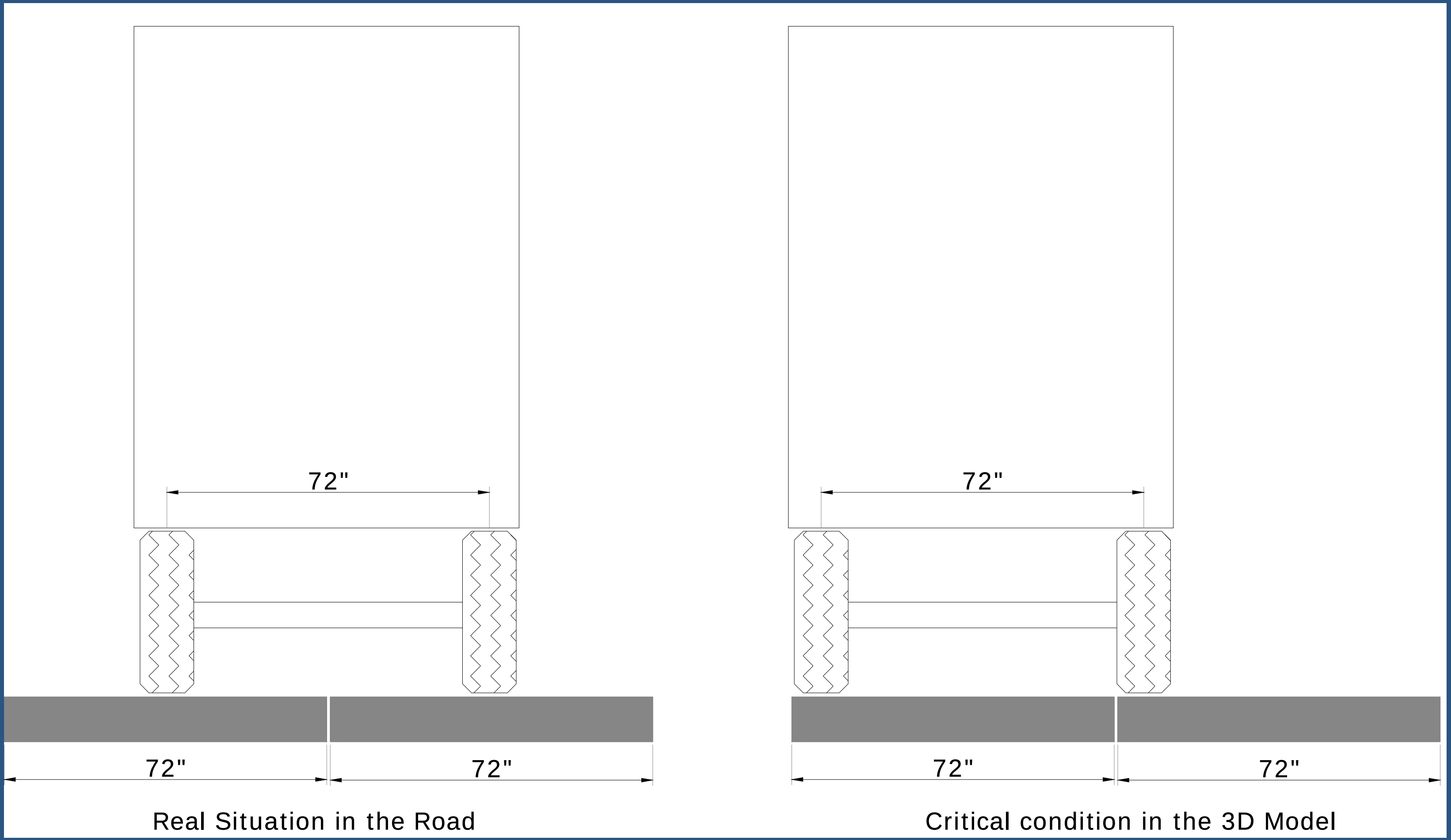
Critical Stress Analysis :

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



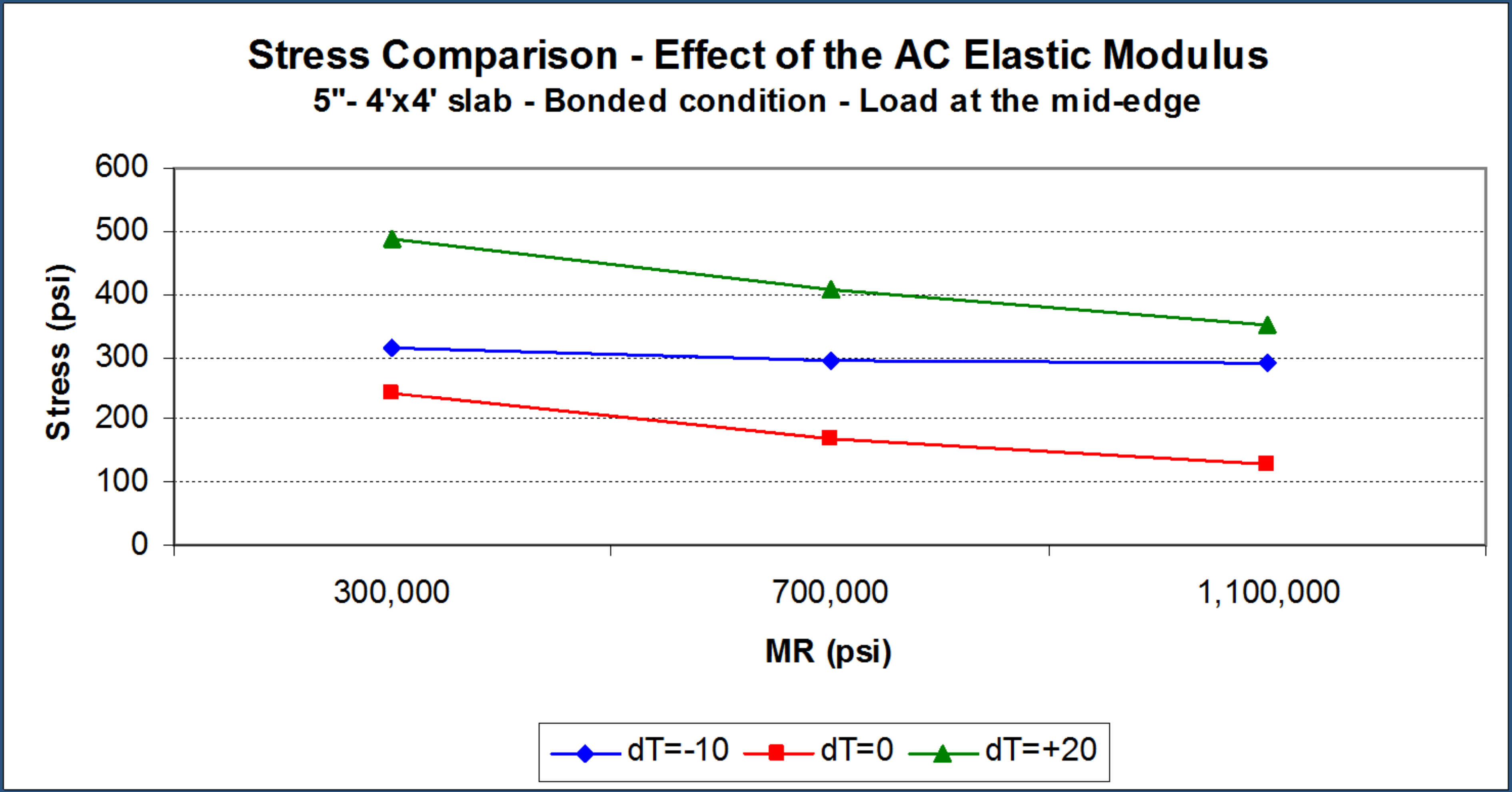
Axle Load Positioned on Slabs with 4-ft Joint Spacing

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

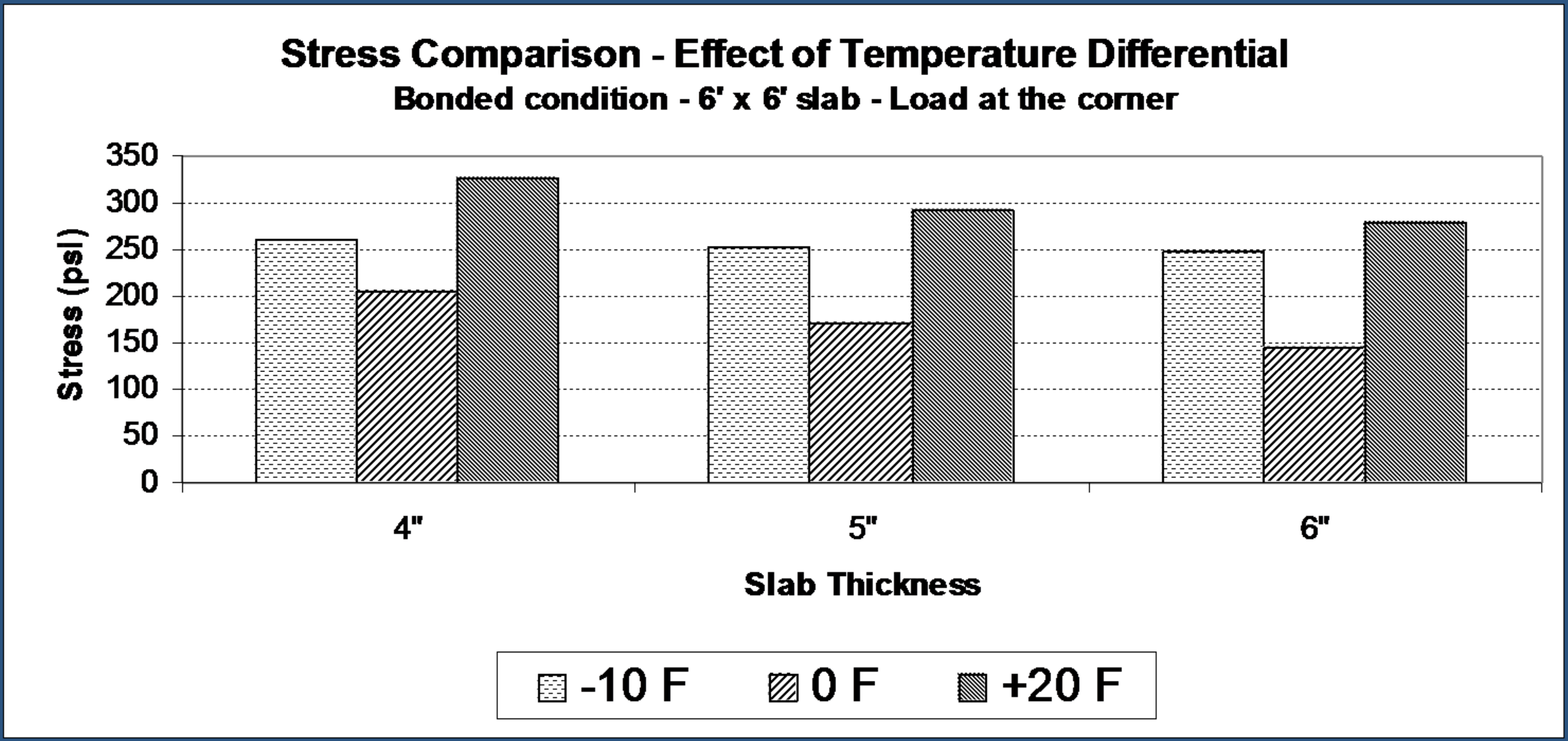


Axle Load Positioned on Slabs with 6-ft Joint Spacing

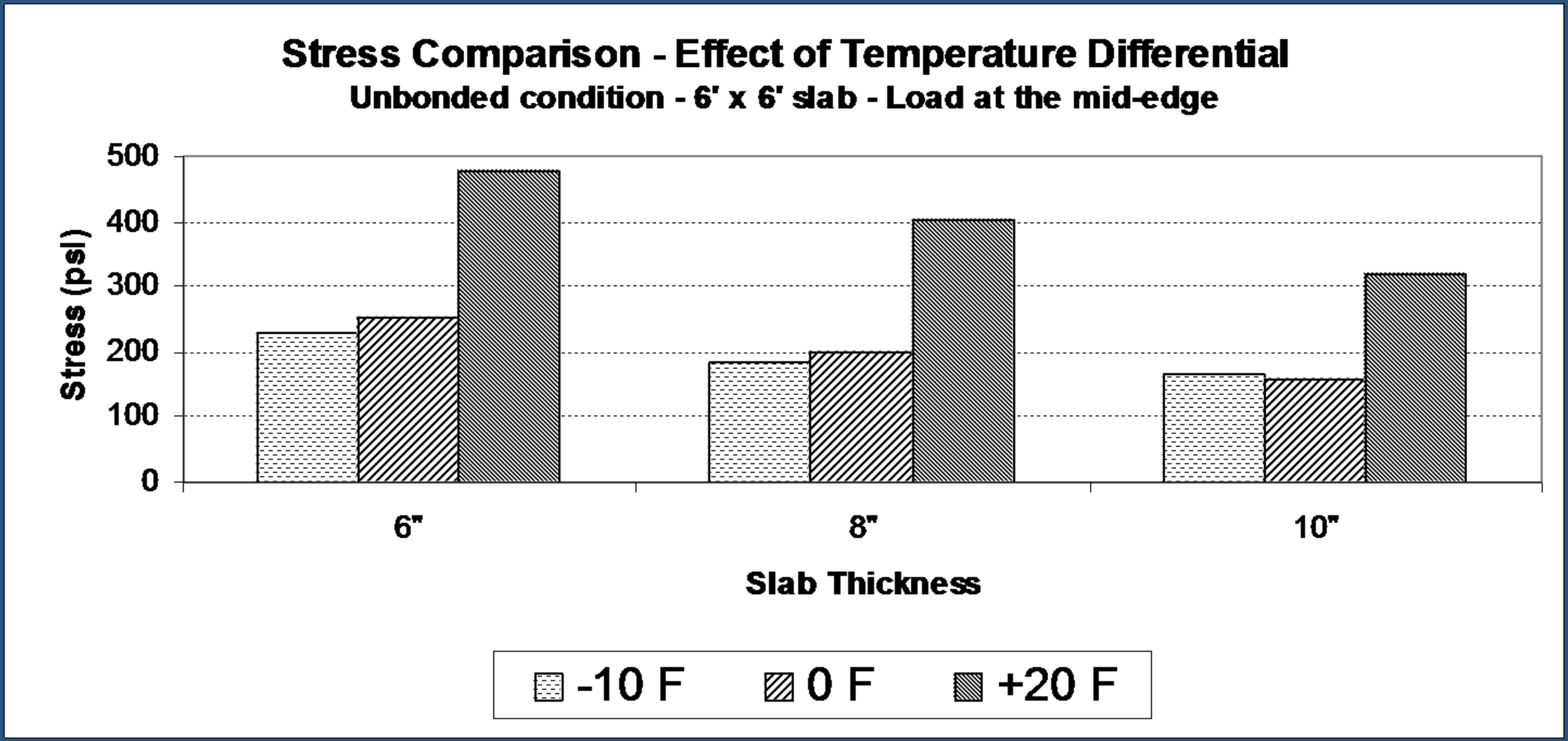
Effect of AC Elastic Modulus



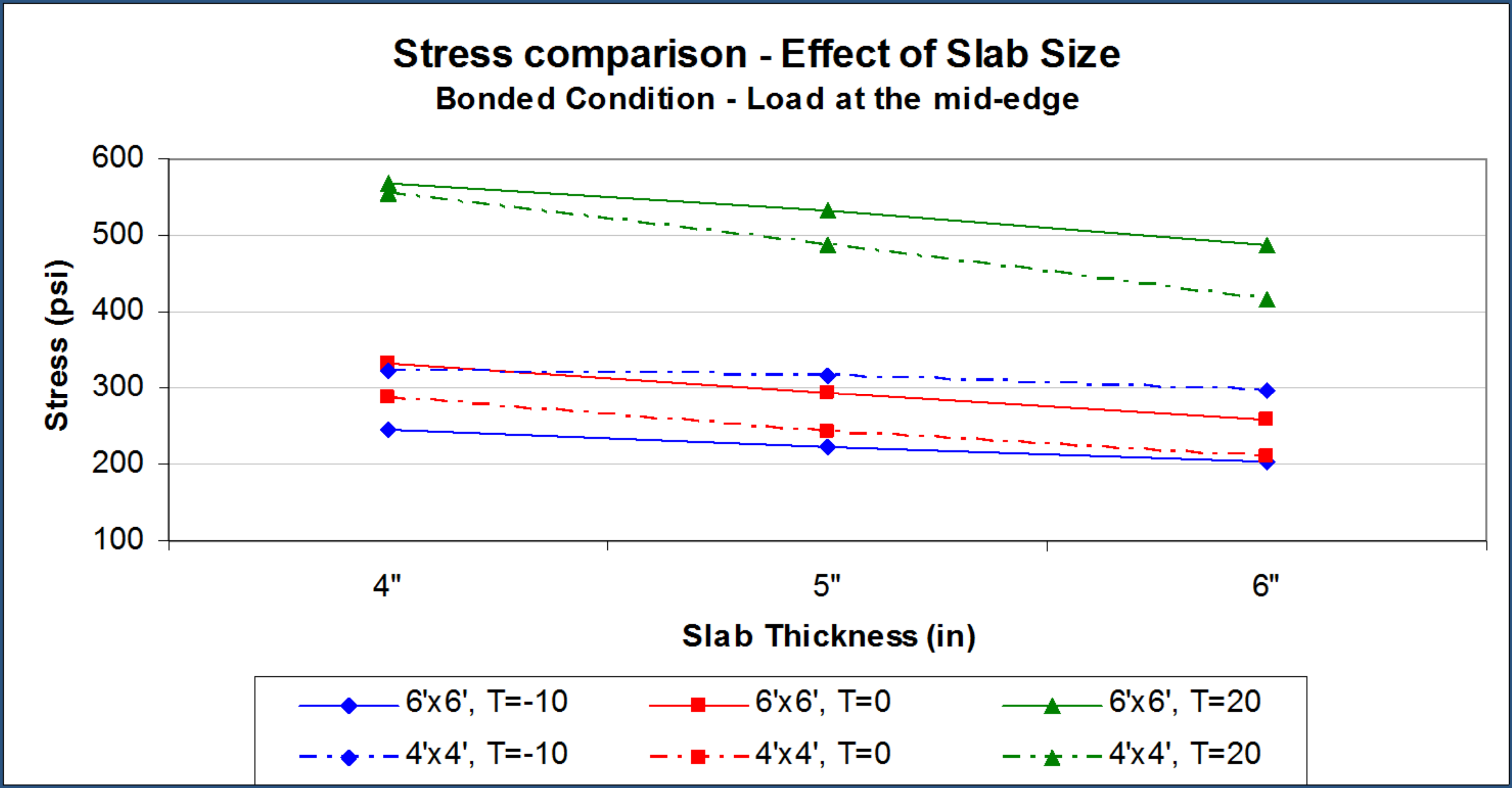
Effect of Temperature Differential



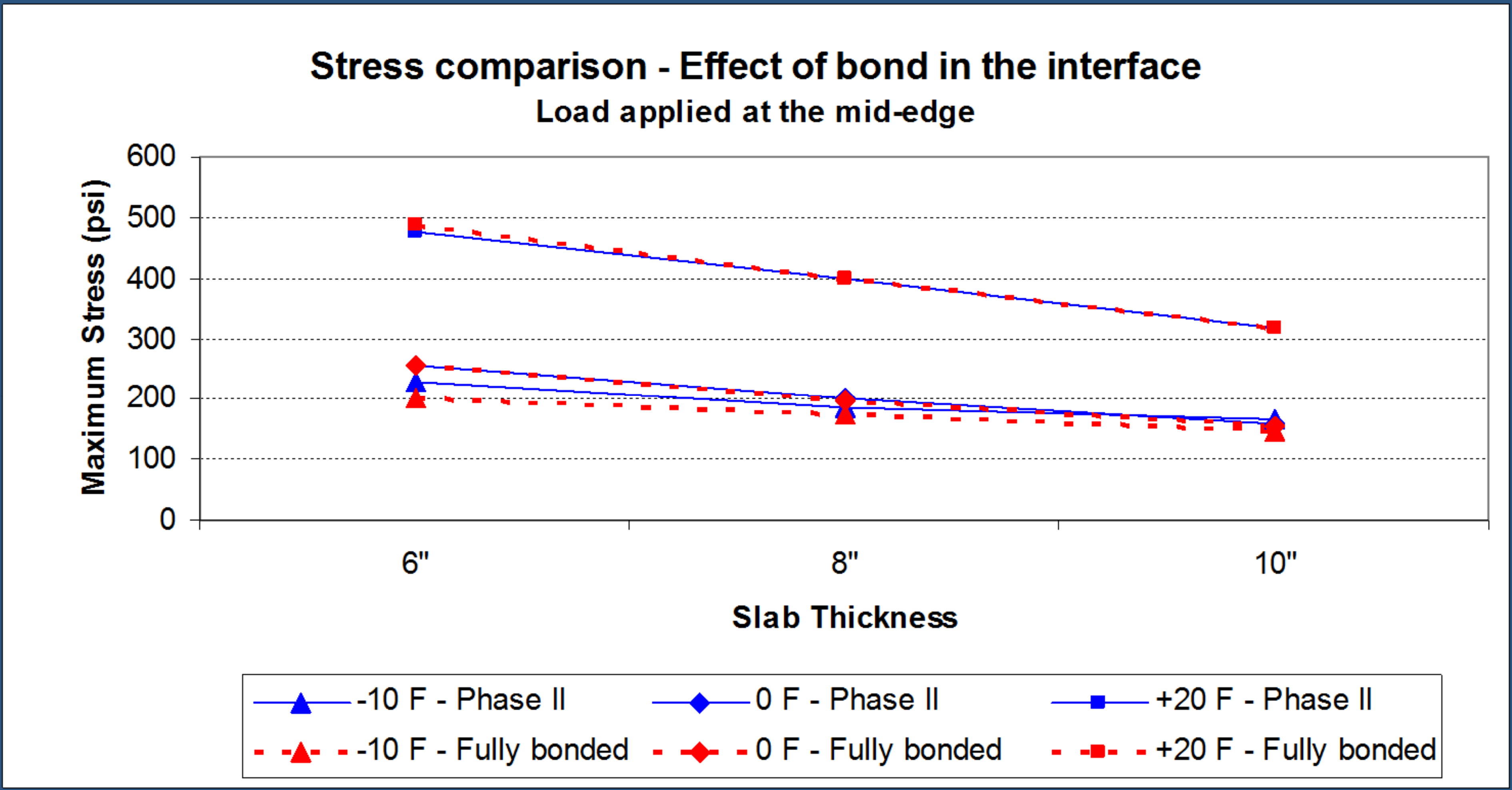
Effect of Temperature Differential



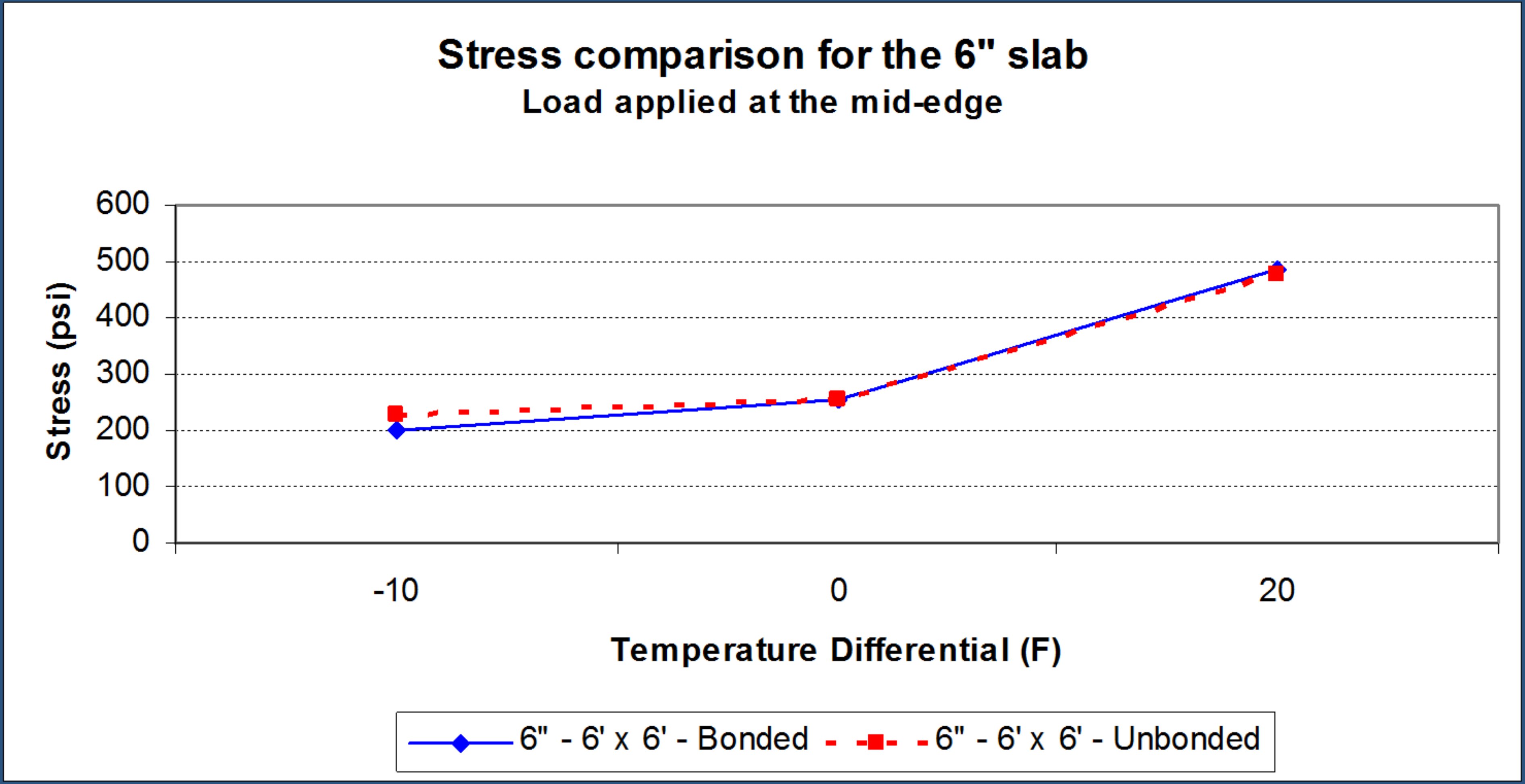
Effect of the Slab Size



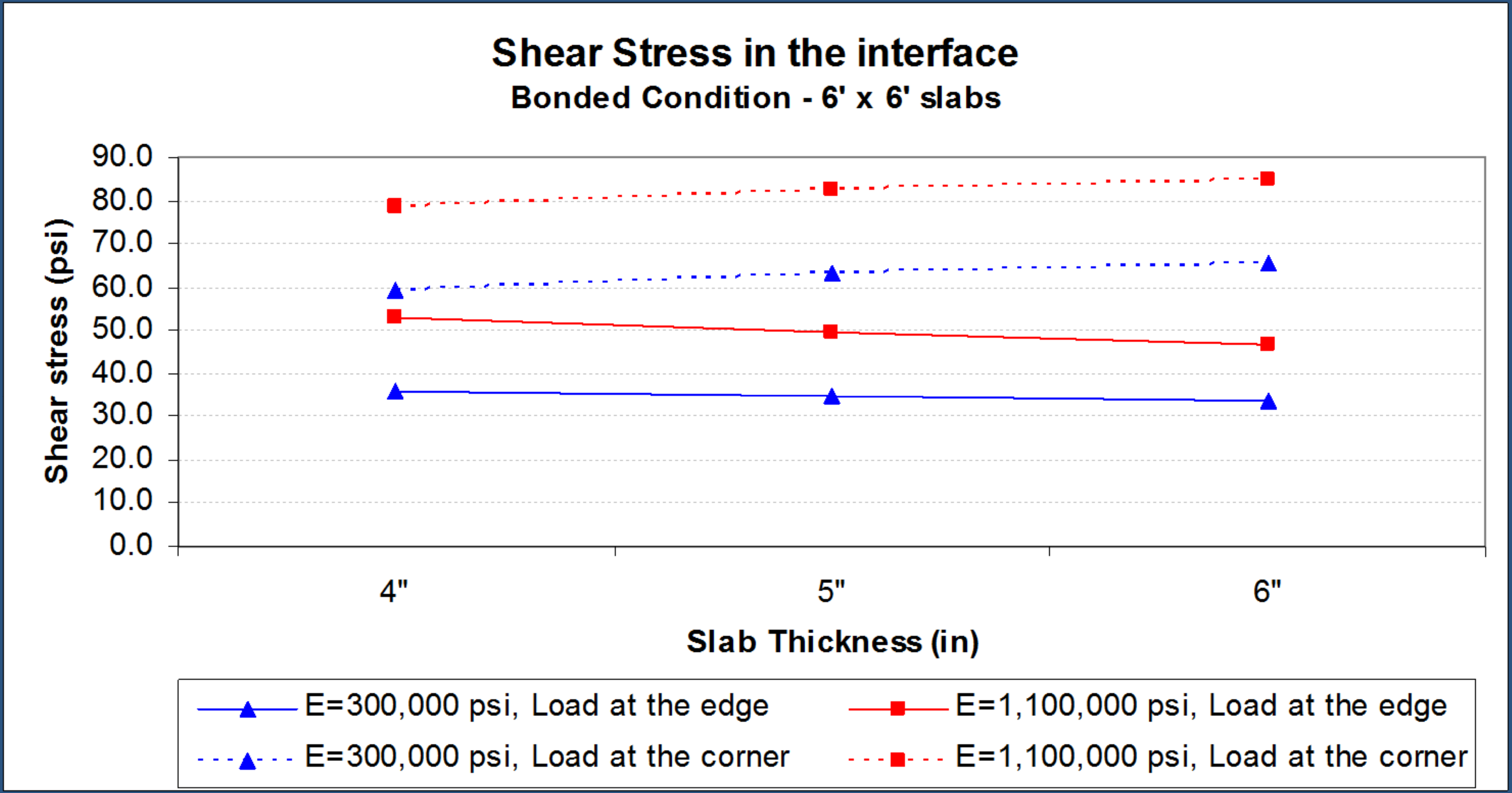
Effect of the bond in the interface



Effect of the bond in the interface



Shear stress in the interface



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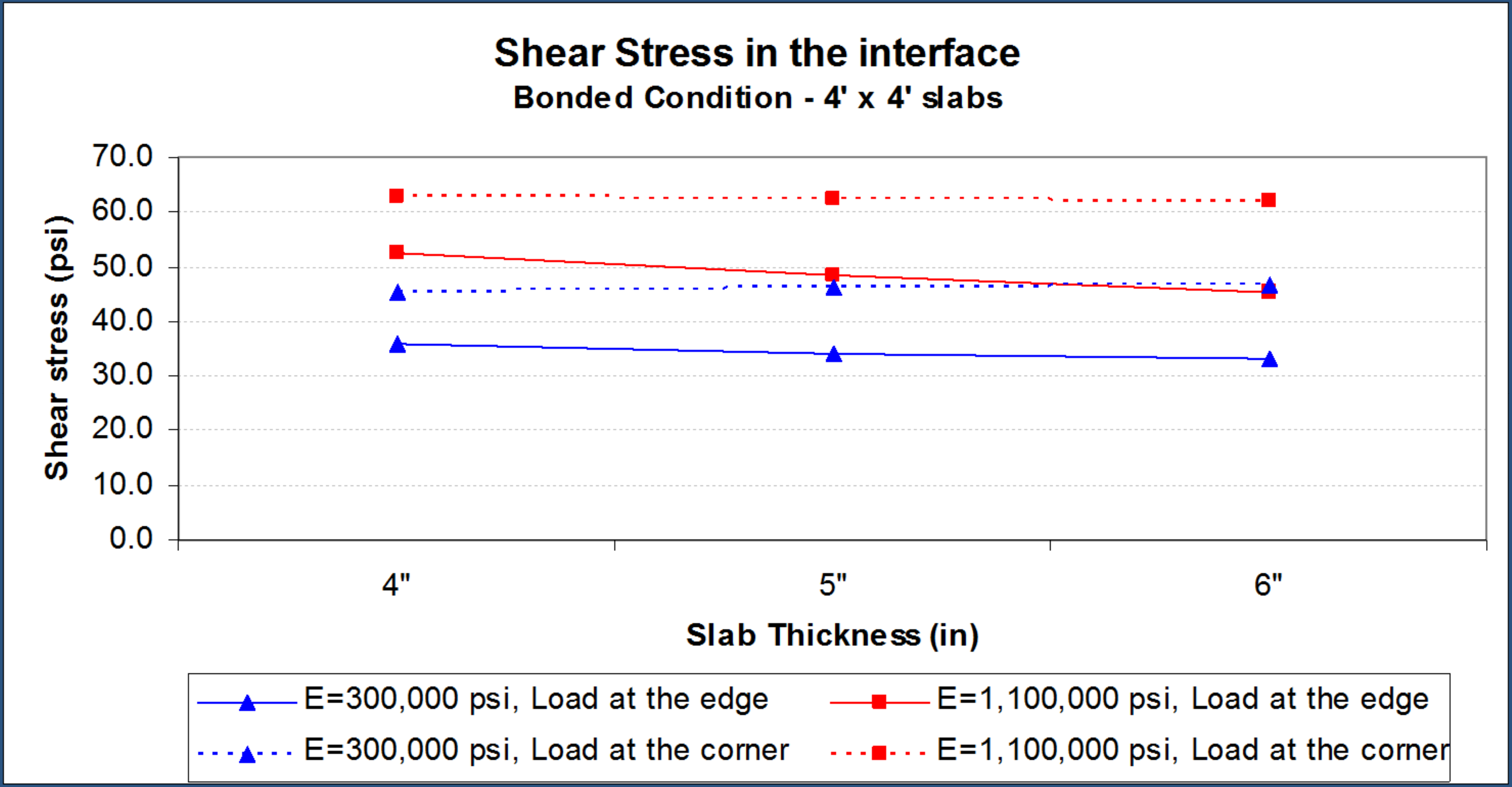
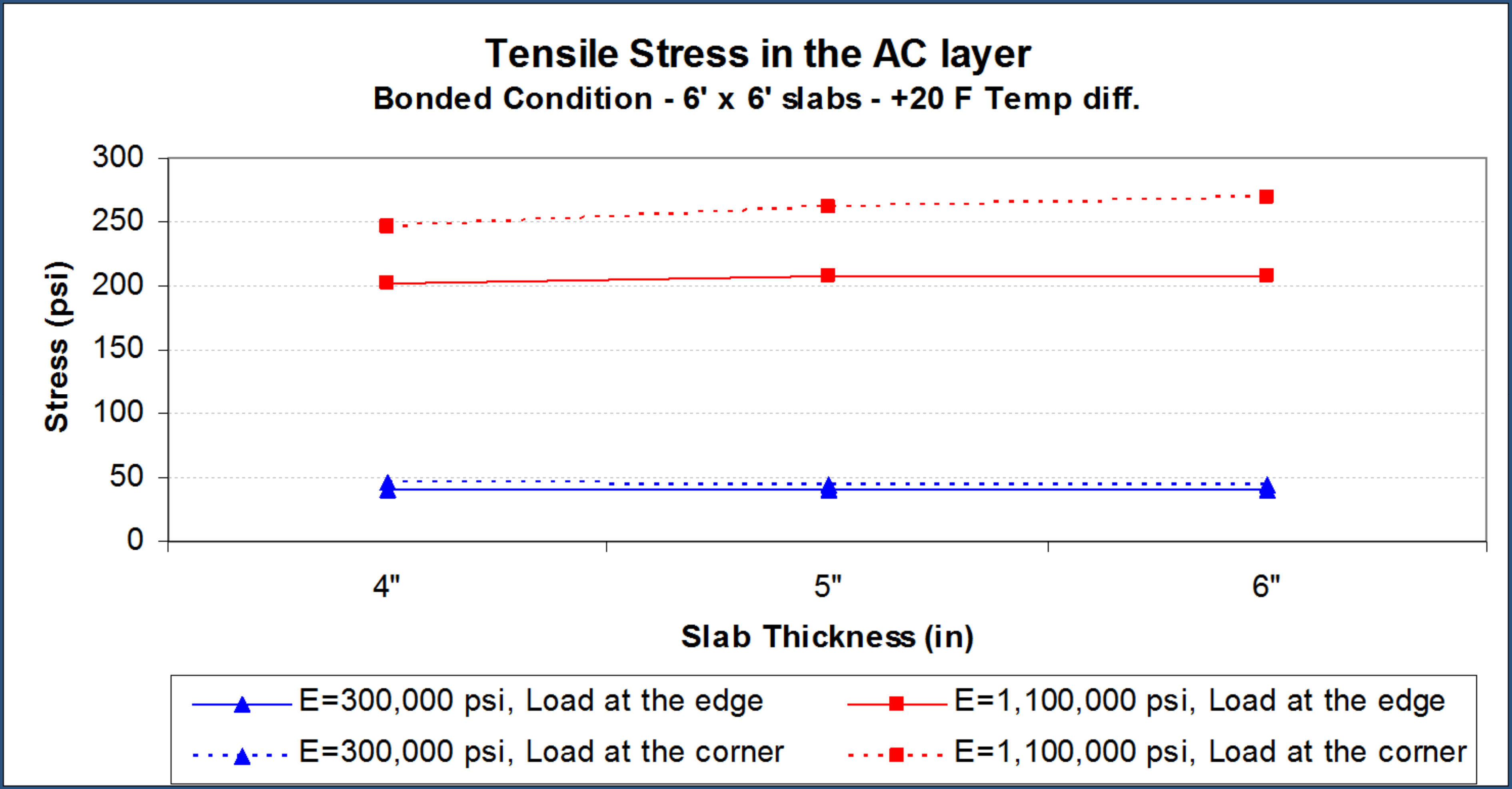
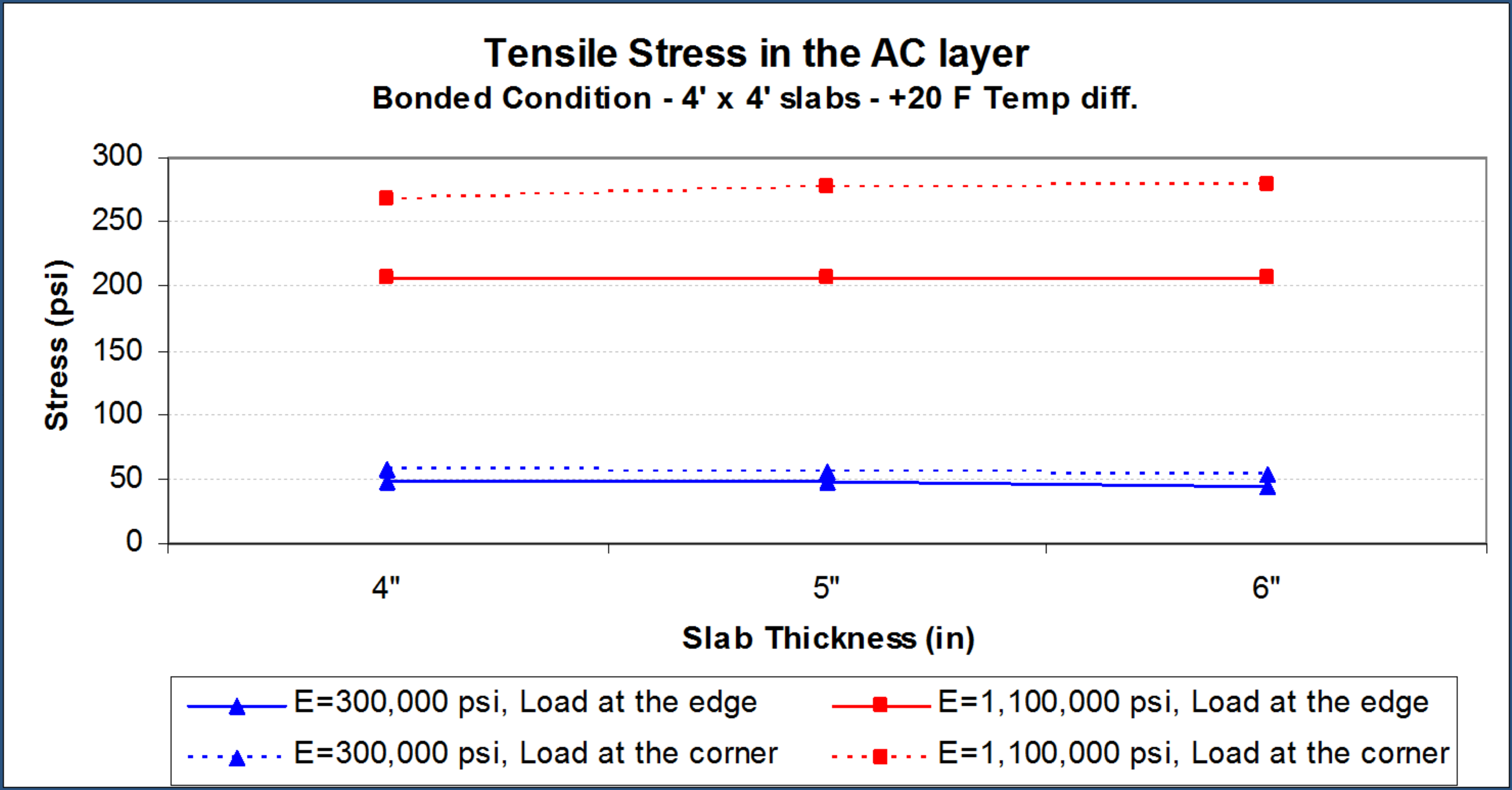


Tensile Stress in the AC layer



Tensile Stress in the AC layer



Findings- Potential Performance

Phase	Slab Thickness	Stress (psi)	Stress-strength Ratio	# of Repetitions of 24-kip Axle Loads to Failure
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?