MONITORING AND MODELING OF PAVEMENT RESPONSE AND PERFORMANCE
TASK B: NEW YORK
Pooled Fund Project TPF-5 (121)
Volume 1: I490, RT9A, and I86 AC Pavement

by
Shad M. Sargand, Issam S. Khoury,
and Jill Morrison

for the
Ohio Department of Transportation
Research Section
the
New York State Department of Transportation
and the
United States Department of Transportation
Federal Highway Administration

State Job Number 134287

May 2012

Ohio Research Institute for
Transportation and the Environment

1. Report No. FHWA/OH-2012/08A	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle MONITORING AND MODELING OF PAVEMENT RESPONSE AND PERFORMANCE TASK B: NEW YORK Volume 1: I490, RT9A, and I86 AC Pavement		5. Report Date May 2012 6. Performing Organization Code
7. Author(s) Shad Sargand, Issam Khoury, and Jill Morrison		8. Performing Organization Report No.
9. Performing Organization Name and Address Ohio Research Institute for Transportation and the Environment (ORITE) 141 Stocker Center Ohio University Athens OH 45701-2979		10. Work Unit No. (TRAIS) 11. Contract or Grant No. Pooled Fund Project TPF-5(121) State Job No. 134287 Agreement No. 21182
12. Sponsoring Agency Name and Address Ohio Department of Transportation Innovation, Research, and Implementation Section 1980 West Broad St. Columbus OH 43223		13. Type of Report and Period Covered Technical Report 14. Sponsoring Agency Code

15. Supplementary Notes

Prepared in cooperation with the Ohio Department of Transportation (ODOT), the New York State Department of Transportation (NYSDOT) and the U.S. Department of Transportation, Federal Highway Administration

16. Abstract

This volume reports on experiments at three pavement sites in New York, I490 in Rochester, RT9A in New York City, and I86 near Angelica. I490 included JPCP sections instrumented to monitor loss of support from curling and warping during curing and early use, plus an experiment on different dowel bar and tie bar configurations. Instrumentation included linear variable displacement transducers (LVDTs) measuring displacement and vibrating wire strain gauges (VWSGs) measuring strain, stress, and temperature. Data were gathered by applying falling weight deflectometer (FWD) and with a Dipstick® and a profilometer. Environmental and response data from the embedded instrumentation were collected from construction in June 2002 through 2004, and FWD responses were measured during 2006-2011. In conclusion, evidence for loss of support resulting from both warping and built-in curling was found. Among the three dowel bar configurations, E2, which had the narrowest spacing and the smallest bar cross-sections, had test sections with the least curling and the best FWD load transfer efficiency (LTE) under negative temperature gradient (morning). All sections performed well under positive temperature gradient (afternoon), with LTE>93%.

Instrumentation of a PCC section on RT9A adjacent to the Freedom Tower site in Manhattan, New York City, was installed in June 2008 to monitor the heavy construction related traffic. Instrumentation included LVDTs, VWSG, other strain gauges, and thermocouples. FWD data were collected after two months, but further data could not be collected due to restrictions accessing the site.

On I86 near Angelica, a JRCP pavement was rubblized and covered with a 20 cm (8 in) asphalt pavement. A special test section substituted a perpetual pavement structure for the standard design, and included four layers ranging from 100 mm (4 in) to 40 mm (1.57 in) in thickness. The test pavement was instrumented with LVDTs, thermocouples, strain gauges, and pressure cells. FWD testing was conducted November 2006 through August 2011. After nearly five years of service, very slight distress could be observed in the standard AC pavement, and no distress was observed in the perpetual pavement section.

17. Key Words	18. Distribution Statement No Restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 154	22. Price

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: Volumes greater than 1000 L shall be shown in m^3.				
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(°F-32)/9 or (°F-32)/1.8	Celsius temperature	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2 or psi	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celsius temperature	1.8°C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2 or psi

* SI is the symbol for the International Symbol of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

MONITORING AND MODELING OF PAVEMENT RESPONSE AND PERFORMANCE TASK B: NEW YORK Volume 1: I490, RT9A, and I86 AC Pavement

Draft Final Report

Prepared in Cooperation with the
Ohio Department of Transportation,
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The New York State Department of Transportation,
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Prepared by

Shad M. Sargand
Issam Khoury
Jill Morrison

Ohio Research Institute for Transportation and the Environment
Russ College of Engineering and Technology
Ohio University
Athens, Ohio 45701-2979

May 2012

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ACKNOWLEDGEMENTS

On large field-oriented projects such as this, many tasks are involved and many people contribute to the successful completion of those tasks. On this project, NYSDOT personnel were needed to collect certain types of data and to secure the field sites for testing. Juliàn Bendaña and Wes Yang from the central office, who coordinated all activities, and the various FWD operators, who performed the FWD testing. From the Region Offices were several people who supported the research by allowing the researchers access to the road, by providing, loading, and driving dump trucks for controlled vehicle testing, and by providing traffic control.

Several people at ORITE were also necessary to complete this work, including Sam Khoury who coordinated all of the instrumentation, scheduled and trained students for the field activities and maintained contact with NYSDOT to keep everything going smoothly. Mike Krumlauf assisted with the instrumentation, and with designing and fabricating various devices used in the lab and field. Assistant Professor Deborah McAvoy contributed the analysis of variance study of the dowel bar configurations on I490. Many students worked on the project team, and some wrote theses on topics associated with the project.

1 Introduction and Objectives

This report documents work by the Ohio Research Institute for Transportation and the Environment (ORITE) at Ohio University on specific tasks to be performed in New York under pooled fund study, TPF-5(121), "Monitoring and Modeling of Pavement Response and Performance," funded by the New York Department of Transportation (NYSDOT) and the Federal Highway Administration (FHWA). Some additional tasks funded by and performed for the Ohio Department of Transportation were documented in a previous report [Sargand and Figueroa, 2010]. The overall objectives for the study were presented as follows in the proposal.

Perpetual asphalt concrete pavements are relatively new to the pavement community. These newer pavements require the use of innovative Mechanistic-Empirical (ME) design procedures, advanced climatic models, updated specifications, test methods providing detailed material properties, and construction techniques not been entirely adopted into standard practice. Standard practice for rehabilitating distressed highway pavements generally involves the application of AC overlays. When AC overlays are placed on distressed PCC pavements, slab movements cause stress concentrations to develop at joints and cracks, which often results in premature cracks reflecting up through to the surface at these locations. By breaking PCC slabs into smaller pieces prior to overlaying or repaving, stresses reduced by distributing the load over a wider area. Instrumentation installed in these pavement sections will provide data regarding measured responses under known environmental and loading conditions.

The primary objectives of the research were to: (1) monitor new perpetual AC and long-lasting PCC pavements constructed on US-30 in Ohio, rehabilitated PCC pavements on I-86 in New York, and other existing instrumented pavements in both states, (2) verify ME design procedures for all pavements in the study by comparing theoretical calculations with measured responses and performance, (3) calibrate ME procedures presented in the NCHRP 1-37A AASHTO Pavement Guide for Ohio and New York using data collected in this and other previous studies, (4) conduct controlled testing of perpetual pavement systems to determine their relative performance and to recommend the most promising layer configurations, and (5) document all research findings in a final report. Within each of these primary objectives were various secondary objectives related to the primary goals.

The tasks in the original proposal were separated into three groups. Group A tasks were conducted in Ohio and were sponsored by ODOT, and are reported on previously [Sargand and Figueroa, 2010]. Group B tasks included projects located in New York and were funded by NYSDOT. The results from the Group B tasks are the topic of this report. Group C tasks, which mostly involved additional modeling work, were not funded.

1.1 Description of the New York Task (Task B)

The efforts in New York included instrumentation and monitoring of several pavements not listed in the original proposal. In the interest of clarity, each is listed here with a brief discussion of its main purpose.

Interstate 490, Victor, near Rochester, New York. This is a JPCP pavement where different spacings and diameters of dowel bars and spacings of tie bars were installed. The objective consisted of determining the effect of the different dowel and tie bar configurations on response and performance due to environmental factors and to applied loads.

State Route 9, Manhattan, New York City. This was a pavement at the former World Trade Center site, instrumented to monitor the effect on pavement performance of the large number of heavy loaded trucks that were anticipated to haul away debris from the destroyed towers and construction materials for the Freedom Tower to be erected in its place. Unfortunately, the inability to obtain traffic control at this busy location severely limited the amount of measurements that could be made at this site.

Interstate 86, Angelica and Cuba. This was a JRCP pavement which was rehabilitated by rubblizing and topping with an asphalt concrete (AC) pavement. The Angelica section used a perpetual pavement design intended to last 40 years or more with only minor resurfacing; the Cuba section is a NYSDOT standard AC design. The objective was to monitor the response and performance of the pavement.

Interstate 86, Hinsdale, near Olean, in Cattaraugus County, New York. This was a jointed reinforced concrete pavement (JRCP) that was rehabilitated in 2007 by constructing an unbonded jointed plain concrete pavement (JPCP) on top of the existing pavement. In the test section, three treatments were selected to apply to the existing JRCP before applying the JPCP: rubblization, break and seat, or no treatment. The objective of the test was to compare the response and performance of the completed pavement with JPCP as a function of the treatment applied to the original JRCP.

Interstate 90, Weedsport, near Syracuse. This pavement consisted of JPCP constructed on different bases, namely the standard New York configuration of a cement treated permeable base (CTPB) built on a dense graded aggregate base (DGAB) versus the alternate of a full-depth DGAB. The objective was to determine if there was an effect on the response and performance of the pavement depending on the type of base.

Because of the extensive amount of effort in this project, this report is divided into three volumes as follows: Volume 1: I490, State Route 9A (RT9A), and I86 AC Pavement, Volume 2: I86 PCC, and Volume 3: I90 PCC.

2 I490 Project Description and Methods

2.1 General Problem Statement

Environmental factors have a major impact on the initial and long term performance of Portland Cement Concrete (PCC) pavements. Past research has shown the significant influence environmental factors have on the longevity of PCC pavement. However, additional research is needed in order to make environmental factors a part of the PCC design process.

Additionally, the load transfer capability from slab to slab by the use of dowel bars is critical for maintaining the quality of PCC pavement. The importance of these dynamic effects has long been recognized, but additional research is needed to determine the most effective dowel bar configuration.

The New York Department of Transportation constructed test sections in Interstate 490 near Rochester, New York with the objective of evaluating the effects of environmental factors and dynamic loading on PCC pavements and the effect of varying tie bar and dowel bar spacing on the performance of concrete pavement. This report updates information about this project first published by Shad Sargand and Jill Morrison [2007] as part of the project entitled *Truck/Pavement/Economic Modeling and In-Situ Field Test Data Analysis Applications – Volume 4: Effects of Slab Shape and Load Transfer Mechanism on Portland Cement Concrete Pavement*.

2.2 Detailed Objectives

In order to increase the research based knowledge on the dynamic and environmental effects on PCC pavement, dowel bar diameter and spacing, and longitudinal tie bar effectiveness, the objectives for this research were:

- Present descriptions of pavement instrumentation and data acquisition systems for measuring environmental and dynamic effects on PCC pavement sections.
- Evaluate the loss of support for PCC during the curing process and service using strain gauges, thermistors, LVDT's, FWD, Dipstick® surveys, and pavement profiles. Initial data was presented by Wise [2004]. Additional data were reported by Sargand and Morrison [2007], and further results are reported here.
- Investigate the effect of three variations of dowel bar diameter and spacing on LTEs and pavement performance.
- Examine the effect of five variations of tie bar spacing in longitudinal joints on pavement performance.
- Recommend layout design for dowel bars in transverse joints and additional research in this area.
- Determine the environmental and dynamic effects on pavement and recommend additional research in this area.

To this end the original report by Sargand and Morrison [2007] addressed these objectives. This report describes the continued data collection effort on this site for this project and updates the conclusions.

2.3 Project Location and Background

This research was conducted on concrete pavement located on I-490, approximately 16 km (10 mi) south-east of Rochester, New York close to Victor NY, as part of a two year reconstruction project of both the east and west bound lanes of I-490. The pavement was placed two lanes at a time by a slip form paver. The jointed plain concrete pavement (JPCP) slab dimensions are 5 meters (16.4 feet) long, 4.27 meters (14 feet) wide, and 250 millimeters (9.84 inches) thick. The two driving lanes were constructed first, with the 3.6 meter (11.8 feet) passing lane and 3.0 meter (9.8 feet) concrete shoulders installed later. Typical dowel bar spacing is 305 mm (12 inches) on center, with a dowel bar diameter of 32 mm (1.25 inches). The typical tie bar spacing is 714 mm (28.1 inches) on center with a diameter of 19 mm (0.75 inches). The eastbound lanes were constructed in 1999. Five slabs were studied to determine the effects of varying tie bar spacing. Additionally, nine sections of ten slabs each were studied to investigate the effect of transverse dowel bar spacing and diameter.

The westbound lanes were constructed in 2002. Two slabs were instrumented in the driving lane to study the environmental effects on the pavement. Both the eastbound and westbound test sections were paved with NYDOT Class C mix as detailed in Table 1. The desired 28 day strength of this mix is 31.5 MPa (4.57 ksi). The concrete has a coefficient of thermal expansion of 12×10^{-6}/°C (6.7×10^{-6}/°F) and elastic modulus of 29,000 MPa (4200 ksi). The slabs are supported by a 100 mm (4 in) thick cement treated permeable base placed on a 150 mm (6in) thick dense graded aggregate base.

Table 1 PCC Mix Design

Material	kg/m^3	pcf
Water	158	9.87
Cement	287	17.9
Fly Ash	72	4.5
Fine Aggregates	634	39.6
Coarse Aggregates (#1 Stone, 40% Split)	454	28.3
Coarse Aggregates (#2 Stone)	682	42.6
Water-Cement Ratio	0.44	

2.3.1 Westbound Lanes

In the westbound driving lanes, two adjacent slabs were instrumented to monitor the environmental strain on the slabs as well the vertical deflection. The concrete strength, base type, base thickness, and drainage conditions were consistent for these two slabs. The slabs were monitored during construction so that the actual strains and deflections the slab experienced during the curing process could be recorded. Additional periods of monitoring occurred after the pavement cured.

2.3.2 Eastbound Lanes

The first five PCC slabs in the eastbound test section were constructed to study the effect of varying longitudinal tie bar spacing. The tie bar diameter and length were held constant at 19 mm (0.75 in) and 700 mm (27.6 in) respectively. Joint A, between Lane 1 and Lane 2, was constructed during the concrete placement and subsequently saw-cut. Lane 3 was later constructed; resulting in a cold construction joint, joint B, between Lane 2 and Lane 3. As illustrated in Figure 1, for joint A, the tie bar is centered between Lane 1 and Lane 2. For joint B the tie bar is installed with the epoxy joint method, and is slightly offset from center. The epoxy joint method allows for tie bar installation during shoulder placement and after the placement of the driving lane. The side of the previously poured driving lane is drilled at the desired tie bar locations. The tie bars are then inserted and secured with epoxy grout. The shoulder is then placed around the tie bars. The tie bar configuration for each slab is listed in Table 2 and depicted in Figure 2. The cross sectional area of the three dowel bar configurations for both the entire slab width as well as one-third of the slab surrounding the right wheel path is listed in Table 3.

Also installed in the eastbound test section of I-490 is a series of slabs with three variations in transverse dowel bar diameters and spacing. This pavement section includes nine sections consisting of ten slabs each as shown in Figure 3. The dowel bar length is 450 mm (17.7 inches) with the diameter and spacing as varying as shown in Table 4 and depicted in Figure 4. The total cross sectional area of steel from the three dowel bar arrangements is given in Table 5.

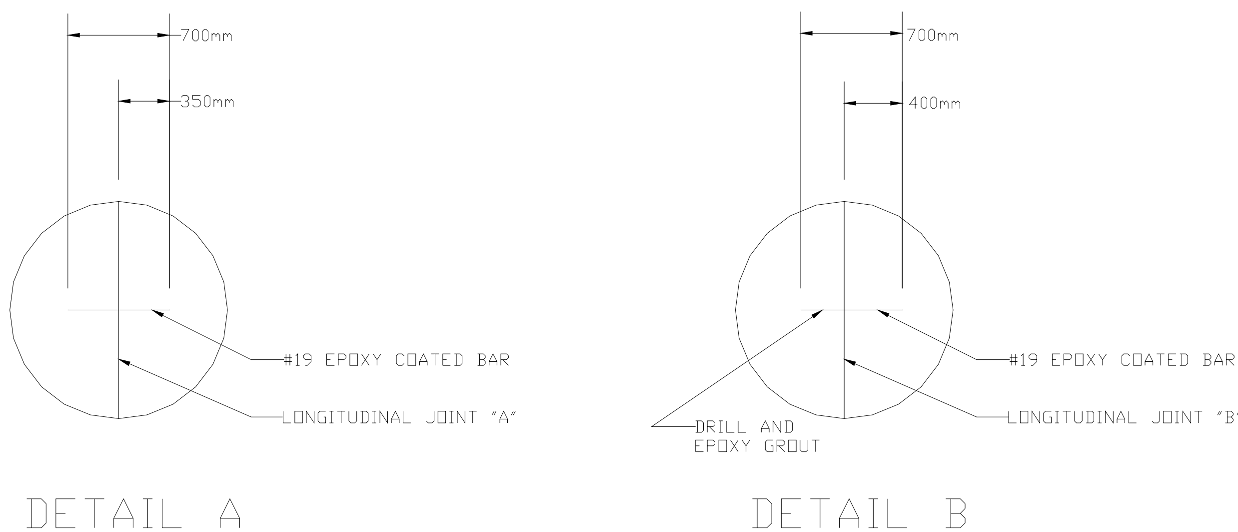

Figure 1 Tie Bar Detail (350 mm = 13.8 in, 400 mm = 15.7 in, 700 mm = 27.6 in)

Table 2 I-490 Eastbound Tie Bar Spacing

Slab Number	Number of Tie Bars	Tie Bar Spacing (mm)	Tie Bar Spacing (in)
1	5	1075	42.3
2	7	717	28.2
3	9	538	21.2
4	11	430	16.9
5	13	358	14.1

Table 3 I-490 East Cross-Sectional Area of Steel

Section	Slab		1/3 Slab	
	(mm^2)	(in^2)	(mm^2)	(in^2)
STD	11,259	17.45	4,021	6.23
E1	10,468	16.23	3,695	5.73
E2	10,800	16.74	3,436	5.33

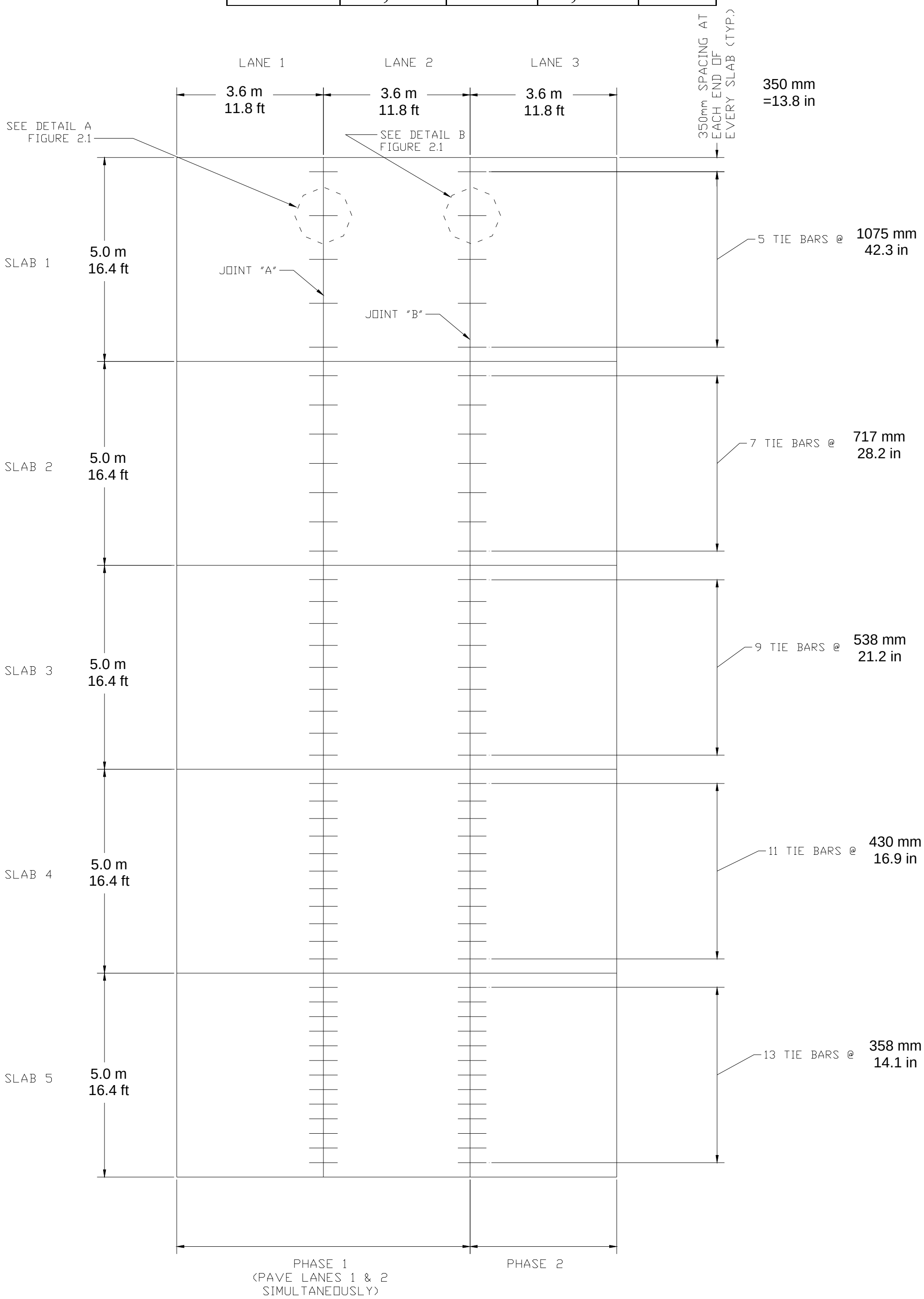

Figure 2 Tie Bar Configuration

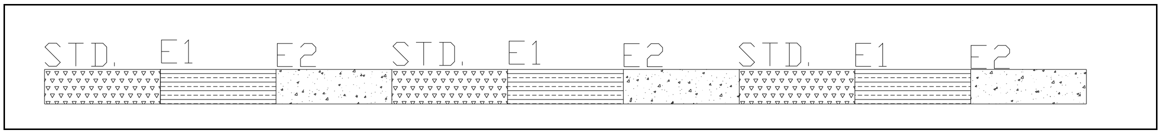

Figure 3 I-490 East Test Sections Overview

Table 4 I-490 East Dowel Bar Spacing

Type	Bar Diameter		Dowel Bar Spacing							
			A		B		C		D	
	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)
STD	32	1.26	150	5.9	300	11.8	150	5.9	300	11.8
E1	28	1.10	180	7.1	240	9.4	120	4.7	240	9.4
E2	25	0.98	105	4.1	190	7.5	90	3.5	190	7.5

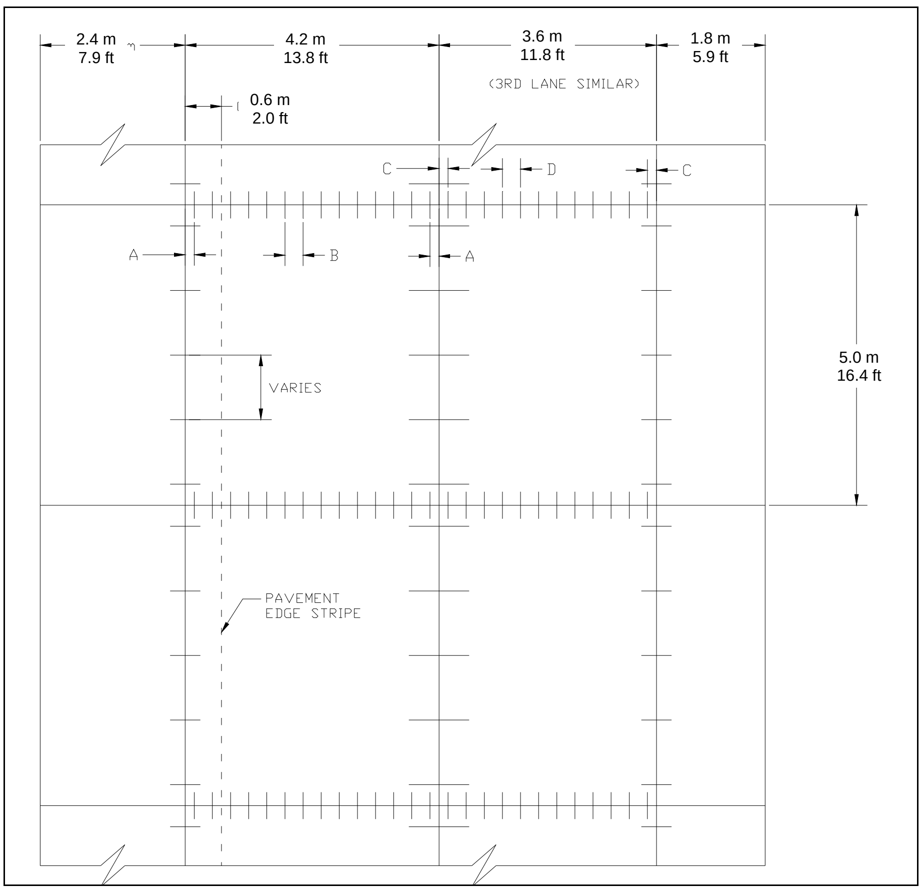

Figure 4 I-490 East Dowel Bar Detail

Table 5. Cross-sectional dowel bar areas for the three dowel bar arrangements on I490 East.

	Bar cross section		Number of dowel bars in lane		Total bar cross section			
					driving		passing	
Type	(mm^2)	(in^2)	driving	passing	(mm^2)	(in^2)	(mm^2)	(in^2)
STD	804.2	1.247	14	12	11259	17.46	9651	14.96
E1	615.8	0.950	17	15	10468	16.16	9236	14.25
E2	490.9	0.754	22	18	10799	16.59	8836	13.58

2.4 Instrumentation

Figure 5 shows the station numbering and location of the test sections for the project. Figure 6 shows the section layout and instrumentation of I490 West section. A complete description of the instrumentation configurations and sensors installed is given in Sargand and Morrison [2007].

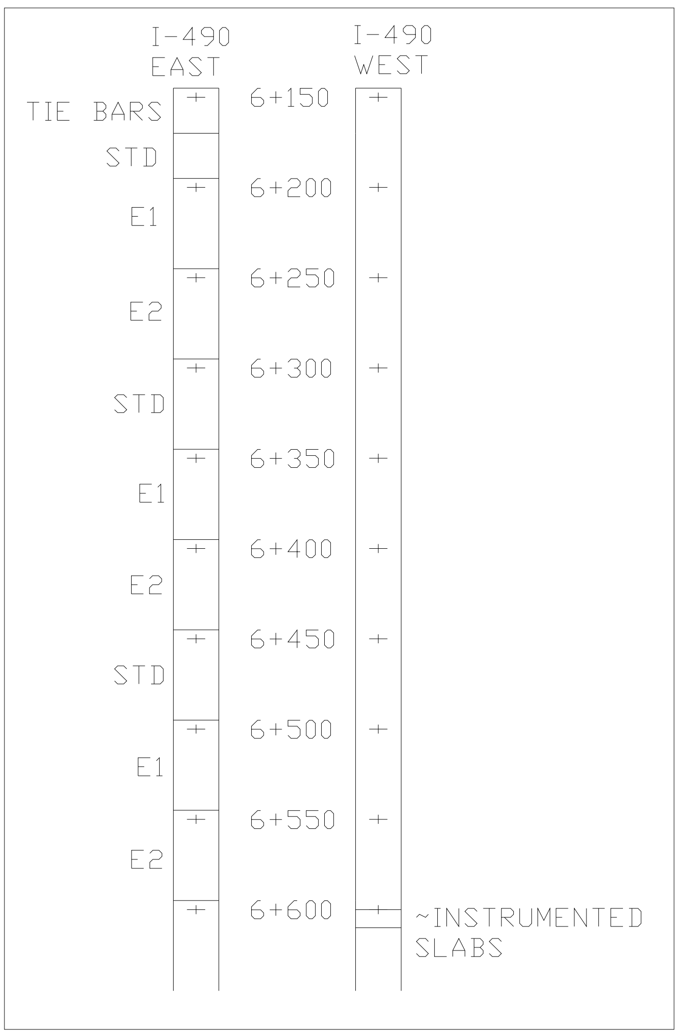

Figure 5 I-490 East and West test sections with section numbers

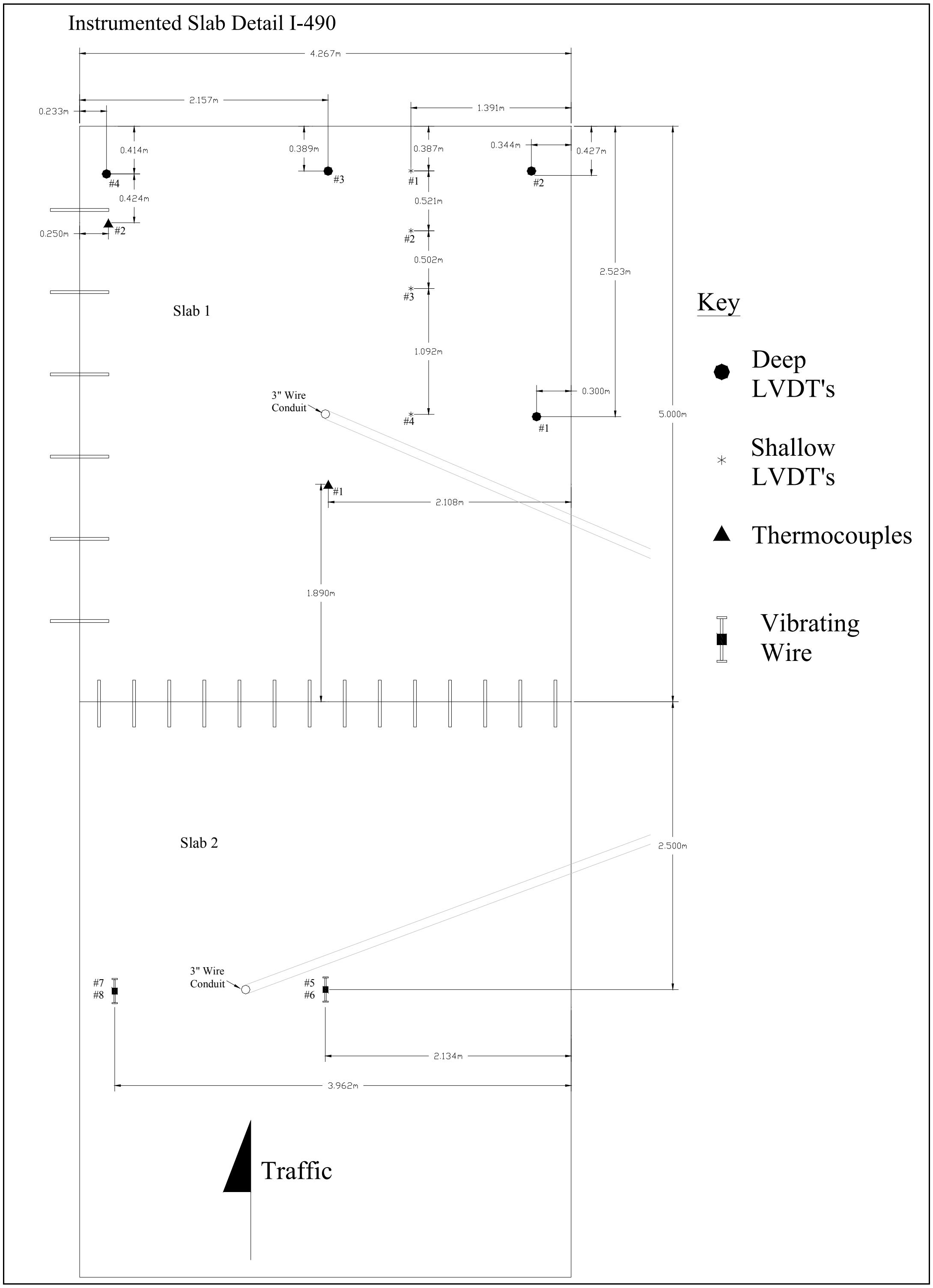

Figure 6 I-490 West Instrumentation (1 m = 3.28 ft)

2.5 Data Acquisition and Analysis

The data acquisition equipment and procedures used for this project have been described in previous reports, for brevity these processes will not be discussed in detail in this report. Equations and data reduction processes unique to this project will be presented in this section.

2.5.1 Data Acquisition Equipment

Originally data were collected for this project by directly reading instrumentation and by recording data from external devices. The Campbell Scientific CR7 and CR10 data acquisition systems were used to read and record data over extended periods of time from LVDT's, thermocouples, and vibrating wire strain gauges. The pavement warping and curling were measured using the Dipstick and the ORITE profiler. Pavement deflection and load transfer data were obtained with the use of a Falling Weight Deflectometer (FWD), shown in Figure 7.

Figure 7 New York Department of Transportation Falling Weight Deflectometer

2.5.1.1 Falling Weight Deflectometer

For the evaluation of support of the westbound slabs, FWD data was collected in a precise grid pattern shown in Figure 8. This collection pattern allows comparison between testing times of data from the exact same locations. At each point on this grid pattern a load of approximately 71 kN (16 kip) was dropped at times of both the positive and negative gradient. For the eastbound slabs, loads of approximately 37.4 kN (8.4 kip) and 50.3 kN (11.3 kip) were dropped at mid panel and at each transverse joint. The resulting deflections from all loadings were recorded for further processing. During later measurement sessions in 2006 through 2011, FWD loads were applied at midslab and at joints in approach and leave configurations using nominal loads of 44 kN (10 kip), 58 kN (13 kip), and 71 kN (16 kip) or 80 kN (18 kip).

When evaluating the load transfer efficiency of the eastbound slabs, the weight was dropped directly before and directly after each joint. The geophones were arranged such that the deflection on both the approach and leave slab was recorded.

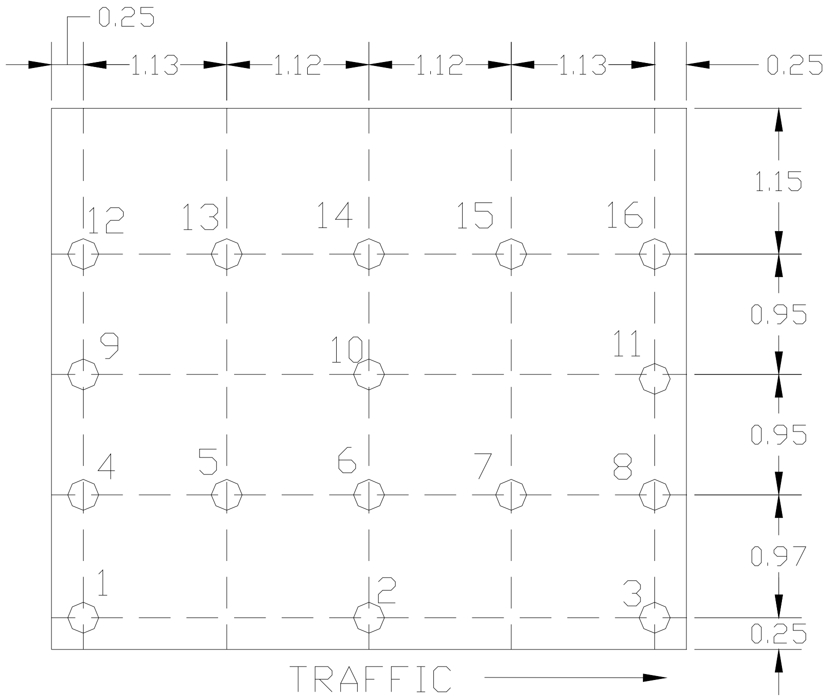

Figure 8 Grid for Westbound FWD Test Drop Locations. Dimensions along top and right are in meters (1 m =3.28 ft).

2.5.1.2 Profiler

The profiler was set up at the initial test location, as close to the edge of the pavement as possible. The collection sequence was then initiated and the 5.1 cm (2.0 in) diameter 14 mm (0.55 in) wide ball bearing follower measured the pavement elevation over the 284 cm (112 in) profiler test length. This bearing is attached to an arm which is connected to an incremental optical rotary encoder. Each increment records the change in elevation of the bearing to a precision of 0.13 mm (5.1 mil). Additionally, the angle of the profilometer guide rail is measured with respect to horizontal using a servo inclinometer reading with a precision of 0.001°. After the first run is recorded, the profiler is moved to the end of the first run, and the subsequent run is initiated.

2.6 Test Procedures

In June 2002, just after the concrete for the westbound slabs was placed, the instrumented slabs were monitored for a 24 hour period to observe shrinkage, curling, and warping. Subsequent testing took place in July 2002, June 2003, October 2003, and October 2004 for at least a period of 24 hours each time. The pavement was monitored and tested for strain, curling, warping, deformation, and load response. The eastbound slabs were tested in October 2004 to determine curling and warping as well as slab response to dynamic loading.

The next site visit to the I 490 project was in October of 2006, during that site visit it was discovered that mice had nested in the pull box and data acquisition box and had subsequently eating through the instrumentation wires. Data was collected from the LVDTs, and strain gauges, but analysis of the data showed that damage to the wires by mice had rendered the data unreliable and thus data collection from the embedded sensors was not continued after this date. Subsequent visits to the site included collecting FWD data on the east and west bound lanes and forensic surveys of the both sides. In addition during the last trip in 2011, faulting data were collected from the east bound lanes to determine if any faulting exists between the lanes.

2.6.1 **Falling Weight Deflectometer**

The FWD deflection data were used to plot the maximum deflections due to an approximate 71 kN (16 kip) load at each drop location throughout the slab. The eastbound FWD data were used to calculate the load transfer efficiency across the dowel transverse joints.

Using the arrangement of FWD seismometers shown in the top portion of Figure 9, the approach load transfer efficiency (LTE) is calculated by the following equation:

$$approach\,LTE = \frac{Df_2}{Df_0} \cdot 100 \qquad \text{Equation 1}$$

Where:
Df_2 = deflection 305 mm (12 in) in front of the plate
Df_0 = deflection at the load cell

Similarly referring to the bottom portion of Figure 9, the leave LTE is calculated by the following equation:

$$leave\,LTE = \frac{Df_1}{Df_0} \cdot 100 \qquad \text{Equation 2}$$

Where:
Df_1 = deflection 305 mm (12 in) behind the plate
Df_0 = deflection at the load cell

Additionally, the Joint Support Ratio (JSR) is calculated by dividing the deflection at the load cell after the joint by the deflection at the load cell before the joint.

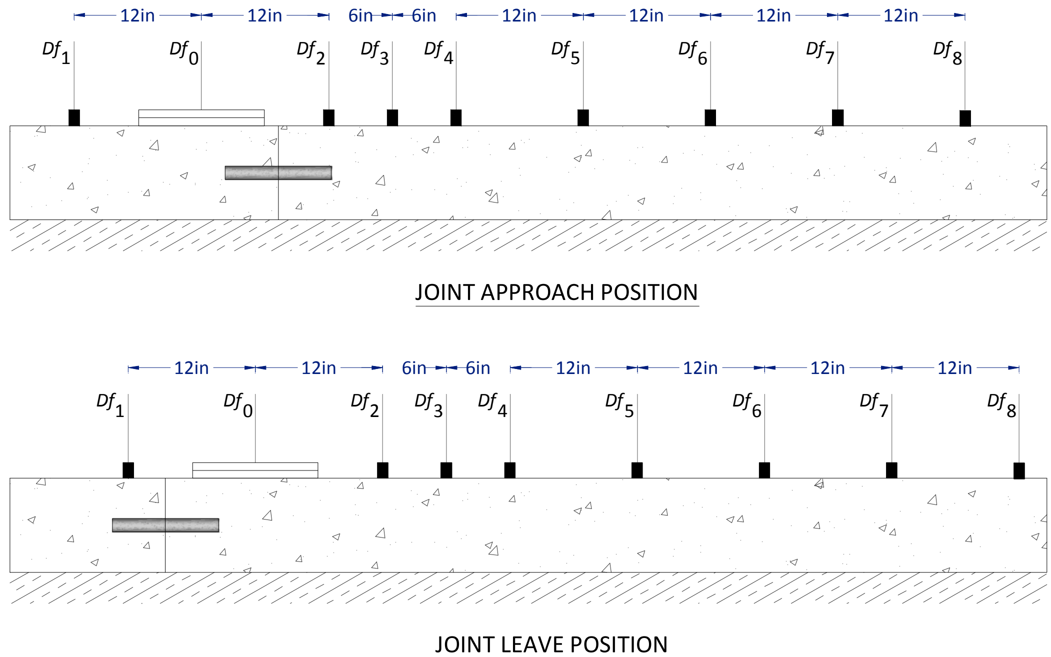

Figure 9 Seismometer arrangement in the FWD system and LTE positions (6 in = 15.2 cm, 12 in = 30.5 cm).

3 Data Presentation and Test Results

Data were collected from both the Westbound and Eastbound test sections during the project. The gauges installed in the westbound test section were performing properly after the construction of the two test slabs. Data were collected from the westbound test section in June 2002, July 2002, June 2003, October 2003, and October 2004. Data were also collected on the eastbound section in October 2004. These data were previously reported by Sargand and Morrison [2007] and some of those results are included here for convenience. Subsequent data collection trips to the site were conducted in October 2006 and in September 2007, September 2008, August 2009, and the last site visit was in June 2011. During the site visits from 2007 through 2011, FWD data were collected and visual inspections were conducted; by 2006 most of the strain gauges were no longer functioning.

For the data collection trips from 2002 through 2004, the temperature, strain, stress, and deflection readings, as applicable, are plotted versus time during each data collection visit in Appendix A through Appendix F, as indicated in Table 6. Additionally, 3D plots of the slab deflection from FWD testing and slab shape from Dipstick surveys are presented. The Eastbound test section was monitored in October 2004. Dipstick surveys are presented in Appendix F for the tie bar test sections. For the dowel bar test sections, FWD results of load transfer and joint support are presented as well as slab curling data from the profiles. Slab profiles are presented in Appendix E. Appendix G through Appendix J have the FWD data from the later site visits. For a detailed indication of what is included in each appendix, see Table 6.

Table 6. Grid indicating contents of appendices in this report.

			from vibrating wire gauges			3-D slab		
Appendix	direction	date	temp	strain	stress	profile	FWD deflection	Dipstick
A	WB	Jun-02	X	X	X	X		
B	WB	Jul-02	X	X	X			
C	WB	Jun-03	X			X		
D	WB	Oct-03	X	X	X		X	
E	WB	Oct-04				X		
F	EB	Oct-04						X
G	WB/EB	Oct-06					X	
H	WB/EB	Sep-08					X	
I	EB	Aug-09					X	
J	EB	Jun-11					X	

3.1 I-490 East October 2004 Tie Bar Testing

Dipstick® surveys were taken of the five slabs with the variable tie bar arrangements in 490 Eastbound. Because Dipstick® surveys had not been taken previously, the total deflection of each slab could not be plotted in 3 dimensions. Two-dimensional graphs of the slab shape relative to one another are presented in Appendix F. However, these graphs provide little information as to the best tie bar arrangement.

3.2 I-490 East October 2004 Dowel Bar Testing

In October 2004 the slab shapes of the sections in I490 East containing the varied dowel bar arrangements were measured using the profilometer. Additionally, FWD testing was conducted at each of the test joints.

3.2.1 Slab Profiles

The eighty-five slab profiles were recorded continuously beginning at 10:00 am and ending at 1:30 pm. Instrumentation to continuously monitor air temperature was not available. However, the initial pavement surface temperature at the beginning of testing was 13°C (55.4°F) in the sun and 10°C (50°F) in the shade. By the end of the testing period, the pavement surface temperature had risen to 20°C (68°F). The effect of this temperature change was evident in the slab profiles. While the profile for each slab was measured only once, the dowel bar arrangements were repeated at 10 slab intervals making it possible to compare the reaction of the same dowel bar arrangement throughout the testing period. At the beginning of the testing period the slabs all had significant amounts of curling ranging from an average of 3.1 mm (0.12 in) for the E2 slabs to 3.6 mm (0.14 in) for the STD slabs. As the day progressed and the temperature increased, the slabs generally flattened out with the slab curl in the afternoon averaging from 1.9 mm (0.075 in) to 2.1 mm (0.083 in) for all dowel bar arrangements. The elevation difference between the center of the slab and the slab corner ("estimated curl") is presented in Table 7.

When comparing sections containing different dowel bar arrangements that were tested close to the same time, it is noted that for the group from slab 1 to slab 25 as well as the group from slab 26 through slab 55, the STD slab sections had the highest average curl, followed by the E1 sections. The slab group from slab 56 to slab 85 had a nearly consistent curl for all dowel bar arrangements, with the E1 sections curling an average of 0.2 mm (0.008 in) more than the STD and E2 sections. This reduction in curl for all slabs corresponds to the rising temperature throughout the test period which is assumed to increase the temperature gradient throughout the depth of the slab.

Table 7. I-490 East Estimated Curl of Individual Slabs (1 mm = 0.039 in).

	Slab No.	**1**	**2**	**3**	**4**	**5**	--	--	--	--	--	**Avg**
STD	**Curl (mm)**	3.6	4.1	3.3	3.3	3.6	--	--	--	--	--	3.6
	Curl (in)	0.14	0.16	0.13	0.13	0.14	--	--	--	--	--	0.14
	Slab No.	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
E1	**Curl (mm)**	3	2.3	3.8	3.6	3.3	3.6	2.8	4.1	3.6	3.8	3.4
	Curl (in)	0.12	0.09	0.15	0.14	0.13	0.14	0.11	0.16	0.14	0.15	0.13
	Slab No.	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**Avg**
E2	**Curl (mm)**	4.3	2.3	3	2.8	4.3	2.5	2.5	3.3	3.6	2.3	3.1
	Curl (in)	0.17	0.09	0.12	0.11	0.17	0.10	0.10	0.13	0.14	0.09	0.12
	Slab No.	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**Avg**
STD	**Curl (mm)**	2.3	3.6	4.3	3.8	3.6	4.1	4.6	3.6	4.1	2.5	3.7
	Curl (in)	0.09	0.14	0.17	0.15	0.14	0.16	0.18	0.14	0.16	0.10	0.15
	Slab No.	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**Avg**
E1	**Curl (mm)**	2	1.8	2.3	3	3	2.8	2.5	2	3.3	4.3	2.7
	Curl (in)	0.08	0.07	0.09	0.12	0.12	0.11	0.10	0.08	0.13	0.17	0.11
	Slab No.	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**Avg**
E2	**Curl (mm)**	3.3	2.3	2	2.5	2.8	2.3	2.3	2.5	2.3	2.8	2.5
	Curl (in)	0.13	0.09	0.08	0.10	0.11	0.09	0.09	0.10	0.09	0.11	0.10
	Slab No.	**56**	**57**	**58**	**59**	**60**	**61**	**62**	**63**	**64**	**65**	**Avg**
STD	**Curl (mm)**	1.5	2	1.8	1.5	2.8	2.3	2	1.5	2	1.5	1.9
	Curl (in)	0.06	0.08	0.07	0.06	0.11	0.09	0.08	0.06	0.08	0.06	0.07
	Slab No.	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**Avg**
E1	**Curl (mm)**	4.1	2.3	2.8	2	1.5	1.5	2	1.8	2	1	2.1
	Curl (in)	0.16	0.09	0.11	0.08	0.06	0.06	0.08	0.07	0.08	0.04	0.08
	Slab No.	**76**	**77**	**78**	**79**	**80**	**81**	**82**	**83**	**84**	**85**	**Avg**
E2	**Curl (mm)**	1.3	2	2.3	2.5	2.3	1.8	1.5	1.3	2	1.5	1.9
	Curl (in)	0.05	0.08	0.09	0.10	0.09	0.07	0.06	0.05	0.08	0.06	0.07

3.2.2 Falling Weight Deflectometer Testing

FWD testing was conducted on the joints of 84 of the 85 slabs in the test section beginning at 10:30 am and continuing until 2:00 pm. Not all of the collected data is thought to be accurate because some of the calculated load transfer efficiencies (LTE) are significantly greater than the maximum possible LTE of 100%. These discrepancies most likely result from faulty FWD testing equipment. For analysis purposes, all LTE values greater than 105% are considered inaccurate and are eliminated from the calculations. The LTE, deflection in μm/kN and mils/kip, and Joint Support Ratio (JSR) of the different dowel bar test sections for both the 37.4 kN (8.4 kip) and the 50.3 kN (11.3 kip) test loads are compared in Table 8 through Table 13. These results indicate that as the test progressed the LTE generally increased, corresponding to the flattening of the slabs as the temperature increased. Additionally, the changes in LTE from sections with different dowel bar arrangements tested in a close timeframe are can be compared in Table 8 through Table 13.

The STD, E1 and E2 sections from Slab 1 to Slab 25 are tabulated in Table 8 and Table 9. The E2 sections deflected the least while the STD sections deflected the most in both the approach and leave positions for both test weights. This corresponds to the average slab curl, with the STD slabs curled 0.5 mm (0.02 in or 20 mil) more than the E2 sections. The JSR for these sections also follows this trend, with the E2 sections having the highest JSR, E1 sections in the middle and STD sections the lowest JSR. When the LTE data is examined for these sections, the previously established trend is not followed as closely.

For the 37.4 kN (8.4 kip) test weight, the E1 approach LTE is an average of 0.4% higher that the E2 approach LTE, with the STD section approach LTE over 10% less than either E1 or E2. However, in leave position, the LTE for the E2 section is about 4% less than either the STD or E1 LTE. For the 50.3 kN (11.3 kip) test weight the E2 section did perform better than either the STD or E1 sections, with both the approach and leave LTE over 2% higher than either the STD or E1 efficiencies.

Upon examining the data for the joints from Slab 26 to Slab 55 in Table 10 and Table 11, it can be seen that the E2 sections once again deflected the least. However, the E1 sections deflected slightly more that the STD sections in this group. The JSR results for the 50.3 kN (11.3 kip) test correspond to this data with the E2 and STD slabs having higher JSR's than the E1 slabs. The JSR results for the 37.4 kN (8.4 kip) loading was opposite of those expected based on the deflection data, with the E1 slabs having the highest JSR while the E2 slabs had the lowest JSR.

Table 8 I-490 East 37.4 kN (8.4 kip) FWD, Slabs 1-25, October 26, 2004, from Sargand and Morrison [2007]

Joint Number	Joint Approach			Joint Leave			JSR
	Deflection		LTE (%)	Deflection		LTE (%)	
	(μm/kN)	(mil/kip)		(μm/kN)	(mil/kip)		
STD Dowel Bar Arrangement							
1	0.623	0.109	83.8	0.470	0.082	96.1	0.75
2	0.530	0.093	64.6	0.548	0.096	83.6	1.03
3	0.507	0.089	97.9	0.502	0.088	89.7	0.99
4	0.484	0.085	83.6	0.432	0.076	88.3	0.89
5	0.434	0.076	107	0.440	0.077	95.1	1.01
μ	0.536	0.094	82.5	0.488	0.085	89.4	0.92
σ	0.061	0.011	13.7	0.049	0.009	5.2	0.12
E1 Dowel Bar Arrangement							
6	0.444	0.078	91.8	0.414	0.073	86.0	0.93
7	0.432	0.076	97.9	0.432	0.076	93.6	1.00
8	0.446	0.078	90.8	0.432	0.076	90.8	0.97
9	0.398	0.070	106.9	0.460	0.081	86.4	1.15
10	0.432	0.076	95.8	0.395	0.069	91.9	0.92
11	0.382	0.067	95.2	0.368	0.064	88.8	0.96
12	0.392	0.069	92.2	0.426	0.075	97.5	1.09
13	0.345	0.060	110.2	0.392	0.069	270.4	1.14
14	0.411	0.072	94.8	0.379	0.066	85.9	0.92
15	0.426	0.075	88.9	0.415	0.073	147.8	0.97
μ	0.421	0.074	93.4	0.413	0.072	90.1	0.97
σ	0.024	0.004	3.0	0.031	0.005	4.2	0.06
E2 Dowel Bar Arrangement							
16	0.357	0.063	97.9	0.380	0.067	147.4	1.06
17	0.369	0.065	95.5	0.437	0.077	72.7	1.18
18	0.374	0.065	95.5	0.359	0.063	90.2	0.96
19	0.275	0.048	115.6	0.333	0.058	230.7	1.21
20	0.366	0.064	92.1	0.374	0.065	79.6	1.02
21	0.333	0.058	89.0	0.350	0.061	86.0	1.05
22	0.316	0.055	91.8	0.270	0.047	106.8	0.86
23	0.278	0.049	115.9	0.369	0.065	85.5	1.33
24	0.350	0.061	91.3	0.301	0.053	97.5	0.86
25	0.337	0.059	91.0	0.330	0.058	93.1	0.98
μ	0.350	0.061	93.0	0.360	0.063	86.4	1.01
σ	0.020	0.004	3.0	0.042	0.007	8.3	0.11

LTE=Load Transfer Efficiency
JSR=Joint Support Ratio
Averages (μ) and standard deviations (σ) include only slabs with LTE less than 105%

Table 9 I-490 East 50.3 kN (11.3 kip) FWD, Slabs 1-25, October 26, 2004, from Sargand and Morrison [2007]

Joint Number	Joint Approach			Joint Leave			JSR
	Deflection		LTE	Deflection		LTE	
	(μm/kN)	(mil/kip)	(%)	(μm/kN)	(mil/kip)	(%)	
STD Dowel Bar Arrangement							
1	0.619	0.108	85.1	0.610	0.107	87.3	0.99
2	0.601	0.105	86.0	0.581	0.102	85.7	0.97
3	0.626	0.110	82.0	0.610	0.107	80.4	0.97
4	0.553	0.097	83.2	0.552	0.097	81.5	1.00
5	0.555	0.097	87.3	0.561	0.098	81.6	1.01
μ	0.591	0.103	84.7	0.583	0.102	83.3	0.99
σ	0.035	0.006	2.1	0.027	0.005	3.0	0.02
E1 Dowel Bar Arrangement							
6	0.505	0.088	86.3	0.482	0.084	81.6	0.96
7	0.498	0.087	89.3	0.528	0.092	83.0	1.06
8	0.504	0.088	81.8	0.509	0.089	81.0	1.01
9	0.502	0.088	88.2	0.504	0.088	84.5	1
10	0.512	0.090	88.0	0.505	0.088	80.2	0.99
11	0.472	0.083	79.6	0.478	0.084	78.4	1.01
12	0.518	0.091	74.6	0.480	0.084	198.8	0.93
13	0.481	0.084	85.8	0.495	0.087	181.9	1.03
14	0.515	0.090	81.7	0.492	0.086	139.0	0.95
15	0.506	0.089	82.1	0.489	0.086	105.8	0.97
μ	0.501	0.088	83.7	0.501	0.088	81.5	1
σ	0.014	0.002	4.6	0.018	0.003	2.1	0.03
E2 Dowel Bar Arrangement							
16	0.472	0.083	81.7	0.455	0.080	143.1	0.96
17	0.439	0.077	89.9	0.464	0.081	91.9	1.06
18	0.444	0.078	87.0	0.459	0.080	85.1	1.03
19	0.380	0.067	89.6	0.392	0.069	291.3	1.03
20	0.433	0.076	82.9	0.420	0.074	79.2	0.97
21	0.378	0.066	89.8	0.385	0.067	86.1	1.02
22	0.338	0.059	98.3	0.395	0.069	81.9	1.17
23	0.434	0.076	82.5	0.400	0.070	85.5	0.92
24	0.383	0.067	89.3	0.371	0.065	88.4	0.97
25	0.418	0.073	82.9	0.404	0.071	83.4	0.97
μ	0.412	0.072	87.4	0.412	0.072	85.2	1.01
σ	0.041	0.007	5.1	0.034	0.006	3.9	0.08

LTE=Load Transfer Efficiency

JSR=Joint Support Ratio

Averages (μ) and standard deviations (σ) include only slabs with LTE less than 105%

Table 10 I-490 East 37.4 kN (8.4 kip) FWD, Slabs 26-55, October 26, 2004, from Sargand and Morrison [2007]

Joint Number	Joint Approach			Joint Leave			JSR
	Deflection		LTE	Deflection		LTE	
	(μm/kN)	(mil/kip)	(%)	(μm/kN)	(mil/kip)	(%)	
STD Dowel Bar Arrangement							
26	0.331	0.058	98.6	0.345	0.060	89.8	1.04
27	0.308	0.054	100.0	0.336	0.059	85.5	1.09
28	0.414	0.073	70.8	0.339	0.059	81.1	0.82
29	0.339	0.059	97.3	0.334	0.058	100.5	0.99
30	0.334	0.058	94.5	0.316	0.055	92.8	0.95
31	0.313	0.055	86.8	0.307	0.054	85.6	0.98
32	0.322	0.056	88.2	0.269	0.047	106.3	0.83
33	0.325	0.057	83.1	0.284	0.050	87.1	0.87
34	0.278	0.049	84.1	0.232	0.041	100.0	0.84
35	0.243	0.043	101.9	0.302	0.053	78.8	1.25
μ	0.321	0.056	90.5	0.311	0.054	89.0	0.98
σ	0.044	0.008	9.7	0.036	0.006	7.6	0.13
E1 Dowel Bar Arrangement							
36	0.405	0.071	53.6	0.377	0.066	65.2	0.93
37	0.328	0.057	91.6	0.356	0.062	82.0	1.08
38	0.365	0.064	87.0	0.261	0.046	117.0	0.72
39	0.289	0.051	106.9	0.302	0.053	101.5	1.05
40	0.276	0.048	114.9	0.275	0.048	111.7	0.99
41	0.330	0.058	97.2	0.385	0.067	77.4	1.17
42	0.290	0.051	96.8	0.282	0.049	101.6	0.97
43	0.298	0.052	94.4	0.290	0.051	96.8	0.97
44	0.278	0.049	98.9	0.276	0.048	92.3	0.99
45	0.246	0.043	113.7	0.316	0.055	85.0	1.29
μ	0.328	0.057	88.5	0.323	0.057	87.7	1.02
σ	0.045	0.008	15.9	0.043	0.008	12.8	0.09
E2 Dowel Bar Arrangement							
46	0.286	0.050	91.4	0.275	0.048	98.3	0.96
47	0.263	0.046	107.6	0.247	0.043	119.8	0.94
48	0.273	0.048	117.3	0.301	0.053	102.0	1.10
49	0.256	0.045	116.1	0.240	0.042	117.2	0.93
50	0.249	0.044	122.1	0.261	0.046	113.5	1.05
51	0.270	0.047	119.8	0.292	0.051	107.9	1.08
52	0.255	0.045	122.2	0.324	0.057	99.5	1.27
53	0.289	0.051	107.4	0.340	0.060	88.8	1.18
54	0.235	0.041	133.8	0.205	0.036	147.0	0.87
55	0.331	0.058	94.0	0.299	0.052	108.2	0.90
μ	0.308	0.054	92.7	0.310	0.054	97.2	0.96
σ	0.032	0.006	1.8	0.029	0.005	5.8	-

LTE=Load Transfer Efficiency
JSR=Joint Support Ratio
Averages (μ) and standard deviations (σ) include only slabs with LTE less than 105%

Table 11 I-490 East 50.3 kN (11.3 kip) FWD, Slabs 26-55, October 26, 2004, from Sargand and Morrison [2007]

Joint Number	Joint Approach			Joint Leave			JSR
	Deflection		LTE	Deflection		LTE	
	(μm/kN)	(mil/kip)	(%)	(μm/kN)	(mil/kip)	(%)	
STD Dowel Bar Arrangement							
26	0.394	0.069	91.1	0.397	0.070	85.1	1.01
27	0.381	0.067	88.4	0.394	0.069	80.1	1.03
28	0.385	0.067	82.3	0.383	0.067	78.9	0.99
29	0.386	0.068	92.9	0.427	0.075	82.7	1.11
30	0.396	0.069	86.5	0.383	0.067	86.9	0.97
31	0.334	0.058	89.1	0.364	0.064	79.8	1.09
32	0.362	0.063	86.8	0.359	0.063	85.1	0.99
33	0.333	0.058	87.4	0.356	0.062	76.8	1.07
34	0.342	0.060	80.1	0.354	0.062	74.0	1.04
35	0.336	0.059	80.1	0.346	0.061	75.4	1.03
μ	0.365	0.064	86.5	0.376	0.066	80.5	1.03
σ	0.027	0.005	4.4	0.025	0.004	4.4	0.05
E1 Dowel Bar Arrangement							
36	0.463	0.081	52.9	0.435	0.076	60.3	0.94
37	0.386	0.068	85.3	0.371	0.065	84.7	0.96
38	0.401	0.070	85.8	0.426	0.075	78.1	1.06
39	0.396	0.069	86.5	0.415	0.073	80.3	1.05
40	0.381	0.067	90.8	0.395	0.069	83.6	1.04
41	0.384	0.067	87.3	0.400	0.070	83.5	1.04
42	0.370	0.065	82.5	0.373	0.065	82.1	1.01
43	0.367	0.064	86.7	0.360	0.063	83.9	0.98
44	0.337	0.059	87.2	0.341	0.060	84.0	1.01
45	0.336	0.059	90.2	0.342	0.060	87.0	1.02
μ	0.382	0.067	83.5	0.386	0.068	80.8	1.01
σ	0.036	0.006	11.0	0.034	0.006	7.6	0.04
E2 Dowel Bar Arrangement							
46	0.328	0.057	89.6	0.337	0.059	85.5	1.03
47	0.349	0.061	92.8	0.352	0.062	91.3	1.01
48	0.369	0.065	94.2	0.385	0.067	87.3	1.04
49	0.347	0.061	91.5	0.352	0.062	87.1	1.01
50	0.318	0.056	102.9	0.339	0.059	93.3	1.07
51	0.364	0.064	94.1	0.369	0.065	90.2	1.01
52	0.351	0.061	97.7	0.366	0.064	92.5	1.04
53	0.370	0.065	89.0	0.378	0.066	84.4	1.02
54	0.356	0.062	93.6	0.350	0.061	91.9	0.98
55	0.334	0.058	101.4	0.358	0.063	94.9	1.07
μ	0.349	0.061	94.7	0.359	0.063	89.8	1.03
σ	0.018	0.003	4.6	0.016	0.003	3.6	0.03

LTE=Load Transfer Efficiency

JSR=Joint Support Ratio

Averages (μ) and standard deviations (σ) include only slabs with LTE less than 105%

When comparing the LTE's for this group, the E2 slabs consistently had the highest efficiency. Upon comparison of the STD and E1 sections, the STD sections generally had a higher LTE. While this corresponds to the deflection data as well as the JSR results, it conflicts with the curling data gathered with the profilometer. The profiles show the STD slabs with an average curling 1 mm (0.04 in or 40 mil) greater than the E1 sections and 1.2 mm (0.047 in or 47 mil) greater than the E2 sections. To follow the trend established from Slabs 1 through 25, the STD slabs should experience more deflection and have lower LTE's and JSR's than the E1 slabs. This discrepancy may be due to the fact that there was a slight difference between the time the profile surveys were collected and the FWD testing was conducted. The FWD testing was conducted about 25 minutes after the profile was collected. These data collections took place between 11:00 am and 12:00 pm while the air temperature was rising. The rising air temperature may have caused the pavement gradient to rise significantly between the time of the profile and FWD, which would have resulted in the pavement flattening between the collections. Therefore, the results from the slab warp and the LTE may not correspond directly.

The deflection data from the joints between slabs 56 to 84 displayed in Table 12 and Table 13 consistently show the E1 slabs deflecting the least. During the 37.4 kN (8.4 kip) test weight the STD slabs deflected slightly less than the E2 sections while during the 50.3 kN (11.3 kip) test weight the E2 slabs deflected slightly less than the STD slabs. This is not what is expected from the slab shapes; the E1 section had an average warp of 2.1 mm (0.083 in or 83 mil) while both the STD and E2 sections had an average warp of 1.9 mm (0.075 in or 75 mil) so the E1 section would be expected to deflect the most.

However, when these curling measurements are compared with the original warping of the slabs of up to 3.6 mm (0.14 in or 140 mil), the difference of 0.2 mm (0.008 in or 8 mil) between all three slab types becomes negligible. Therefore since the slab curl is nearly the same for the three dowel bar arrangements, the differences in slab performance during this testing time is based primarily on the differences in dowel bar arrangement.

Upon comparing the LTE's for the 37.4 kN (8.4 kip) testing, the E1 sections were most efficient for both the approach and leave tests. The STD sections averaged slightly higher LTE's than the E2 sections. For the 50.3 kN (11.3 kip) testing, the E2 sections were most efficient followed closely by the STD sections then the E1 sections. Within both approach and leave efficiencies test categories for both test weights, the difference between the three dowel bar arrangements never exceeded 4.6%. In contrast, the LTE difference in some other test sections approached 11%. The relatively close efficiencies of the 56 to 84 slab sections reinforces that the relaxation of the slabs due to temperature gradient increase resulted in similar slab reactions.

Table 12 I-490 East 37.4 kN (8.4 kip) FWD, Slabs 56-84, October 26, 2004, from Sargand and Morrison [2007]

Joint Number	Joint Approach			Joint Leave			JSR
	Deflection		LTE	Deflection		LTE	
	(μm/kN)	(mil/kip)	(%)	(μm/kN)	(mil/kip)	(%)	
STD Dowel Bar Arrangement							
56	0.311	0.054	97.5	0.272	0.048	109.6	0.87
57	0.299	0.052	110.2	0.301	0.053	109.1	1.01
58	0.331	0.058	97.2	0.304	0.053	99.5	0.92
59	0.319	0.056	91.4	0.218	0.038	132.9	0.68
60	0.25	0.044	107.3	0.231	0.040	118.5	0.92
61	0.293	0.051	89.1	0.266	0.047	97.1	0.91
62	0.197	0.034	118.6	0.226	0.040	113.5	1.15
63	0.279	0.049	92.9	0.304	0.053	85.4	1.09
64	0.229	0.040	102.7	0.209	0.037	116.1	0.91
65	0.269	0.047	95.5	0.229	0.040	122.7	0.85
μ	0.290	0.051	95.2	0.291	0.051	94.0	0.97
σ	0.035	0.006	4.5	0.022	0.004	7.5	0.10
E1 Dowel Bar Arrangement							
66	0.269	0.047	105.7	0.249	0.044	102.5	0.93
67	0.224	0.039	109.5	0.217	0.038	110.6	0.97
68	0.261	0.046	99.4	0.273	0.048	90.5	1.05
69	0.253	0.044	92.8	0.231	0.040	101.3	0.91
70	0.235	0.041	98.7	0.218	0.038	103.5	0.93
71	0.221	0.039	116.6	0.246	0.043	87.6	1.11
72	0.208	0.036	101.5	0.202	0.035	105.3	0.97
73	0.189	0.033	122.6	0.226	0.040	89.2	1.19
74	0.223	0.039	104.8	0.214	0.037	112.9	0.96
75	0.235	0.041	96.8	0.234	0.041	98.0	0.99
μ	0.236	0.041	99.0	0.239	0.042	96.1	0.97
σ	0.020	0.004	4.1	0.018	0.003	6.8	0.06
E2 Dowel Bar Arrangement							
76	0.191	0.033	111.2	0.197	0.034	113.2	1.03
77	0.198	0.035	133.1	0.202	0.035	128.0	1.02
78	0.266	0.047	108.6	0.29	0.051	103.7	1.09
79	0.296	0.052	111.3	0.319	0.056	97.1	1.08
80	0.325	0.057	98.6	0.263	0.046	112.8	0.81
81	0.266	0.047	108.0	0.305	0.053	93.0	1.15
82	0.295	0.052	88.1	0.223	0.039	115.8	0.76
83	0.238	0.042	100.6	0.275	0.048	85.6	1.15
84	0.304	0.053	96.5	0.328	0.057	87.9	1.08
μ	0.290	0.051	96.0	0.304	0.053	93.5	1.12
σ	0.037	0.006	5.5	0.022	0.004	7.3	0.05

LTE=Load Transfer Efficiency
JSR=Joint Support Ratio
Averages (μ) and standard deviations (σ) include only slabs with LTE less than 105%

Table 13 I-490 East 50.3 kN (11.3 kip) FWD, Slabs 56-84, October 26, 2004, from Sargand and Morrison [2007]

Joint Number	Joint Approach			Joint Leave			JSR
	Deflection		LTE	Deflection		LTE	
	(μm/kN)	(mil/kip)	(%)	(μm/kN)	(mil/kip)	(%)	
STD Dowel Bar Arrangement							
56	0.354	0.062	94.6	0.356	0.062	92.4	1.01
57	0.367	0.064	97.8	0.368	0.064	94.8	1.00
58	0.397	0.070	84.9	0.378	0.066	87.1	0.95
59	0.361	0.063	88.1	0.376	0.066	84.3	1.04
60	0.354	0.062	85.6	0.356	0.062	81.5	1.01
61	0.337	0.059	85.2	0.338	0.059	83.9	1.00
62	0.320	0.056	83.3	0.342	0.060	80.4	1.07
63	0.342	0.060	83.1	0.335	0.059	81.0	0.98
64	0.321	0.056	82.3	0.334	0.058	78.9	1.04
65	0.372	0.065	78.7	0.389	0.068	74.3	1.05
μ	0.353	0.062	86.3	0.357	0.063	83.9	1.01
σ	0.024	0.004	5.8	0.020	0.004	6.2	0.03
E1 Dowel Bar Arrangement							
66	0.328	0.057	94.8	0.358	0.063	76.2	1.09
67	0.317	0.056	84.2	0.329	0.058	80.3	1.04
68	0.343	0.060	82.5	0.346	0.061	79.3	1.01
69	0.317	0.056	82.1	0.319	0.056	80.4	1.01
70	0.338	0.059	76.5	0.313	0.055	79.7	0.93
71	0.301	0.053	97.7	0.301	0.053	78.5	1.00
72	0.307	0.054	76.7	0.309	0.054	76.8	1.01
73	0.283	0.050	94.0	0.274	0.048	85.1	0.97
74	0.336	0.059	91.2	0.286	0.050	88.5	0.85
75	0.303	0.053	83.1	0.300	0.053	84.8	0.99
μ	0.317	0.056	86.3	0.313	0.055	81.0	0.99
σ	0.019	0.003	7.6	0.026	0.005	3.9	0.06
E2 Dowel Bar Arrangement							
76	0.297	0.052	81.7	0.299	0.052	80.2	1.00
77	0.296	0.052	100.0	0.317	0.056	84.9	1.07
78	0.366	0.064	91.3	0.391	0.068	83.7	1.07
79	0.394	0.069	89.9	0.384	0.067	88.5	0.97
80	0.396	0.069	84.2	0.373	0.065	87.2	0.94
81	0.351	0.061	89.0	0.366	0.064	84.5	1.04
82	0.341	0.060	85.0	0.335	0.059	83.7	0.98
83	0.330	0.058	83.5	0.328	0.057	83.4	0.99
84	0.375	0.066	87.0	0.371	0.065	87.2	0.99
μ	0.350	0.061	88.0	0.351	0.061	84.8	1.01
σ	0.037	0.006	5.5	0.033	0.006	2.5	0.04

LTE=Load Transfer Efficiency

JSR=Joint Support Ratio

Averages (μ) and standard deviations (σ) include only slabs with LTE less than 105%

3.3 October 2006 testing results

Testing on the west bound lanes was conducted on October 11, 2006; the weather was windy and raining which did not allow us to collect any dipstick data. Mice were discovered nesting in the pull box and data acquisition box, with damage to the instrumentation wires. The data acquisition systems were connected to the sensors and data acquisition was initiated. Falling weight deflectometer tests were conducted both in the morning and afternoon according to the previously illustrated pattern, but due to traffic control limits, the outer wheel path could not be collected. No distress was observed in the 1.6 km (1 mi) traffic control zone that was provided. A summary of the data from the westbound lanes is in Table 14. The full set of data is provided in Appendix G.

Testing on the eastbound lanes was conducted on October 12, 2006; the weather conditions were clear but cold. Falling weight load transfer measurements as well as mid-panel drops on the dowel bar test sections were conducted. Due to traffic control limitations, the FWD vehicle could not be positioned safely to collect any meaningful data from the tie bar sections. A summary of the results is provided in Table 15.

The test section was inspected for distresses but none were observed.

Table 14. FWD data averages and standard deviations for I-490 West, Monroe, Rochester on morning and afternoon of Oct. 11, 2006.

	Load		DO L		DO M		LTE L	SPR	D3/D0 M
Morning	**(kip)**	**(kN)**	**(mil/kip)**	**(µm/kN)**	**(mil/kip)**	**(µm/kN)**			
Average	10	44	0.9208	5.2581	0.6029	3.4426	82.96%	84.58%	0.9388
Std. Dev.	0	0	0.3010	1.7189	0.2693	1.5377	1.09%	7.36%	0.0352
Average	13	58	0.9208	5.2581	0.6029	3.4426	82.96%	84.58%	0.9388
Std. Dev.	0	0	0.3010	1.7189	0.2693	1.5377	1.09%	7.36%	0.0352
Average	16	71	0.8604	4.9129	0.5731	3.2725	82.65%	84.43%	0.9327
Std. Dev.	0	0	0.2495	1.4245	0.2402	1.3718	1.04%	7.05%	0.0346
Afternoon									
Average	10	44	0.9698	5.5375	0.6192	3.5358	83.77%	83.77%	0.9432
Std. Dev.	0	0	0.2986	1.7048	0.2939	1.6782	1.81%	7.20%	0.0496
Average	13	58	0.9451	5.3966	0.6114	3.4913	83.44%	83.66%	0.9343
Std. Dev.	0	0	0.2763	1.5780	0.2800	1.5989	1.77%	6.98%	0.0494
Average	16	71	0.9069	5.1785	0.5919	3.3799	83.35%	83.73%	0.9366
Std. Dev.	0	0	0.2553	1.4575	0.2651	1.5136	1.79%	6.72%	0.0487

Table 15. FWD data averages and standard deviations for I-490 East, Monroe, Rochester on October 12, 2006 for different dowel bar configurations.

Standard dowels	Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/D0 M	JSR
	(kip)	(kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)					
Average	10	44	0.5888	3.3619	0.5657	3.2305	0.2471	1.4109	82.39%	80.25%	86.26%	0.9286	0.9817
Std. Dev.	0	0	0.1530	0.8735	0.1823	1.0411	0.0347	0.1979	0.88%	0.85%	7.40%	0.0269	0.0971
Average	13	58	0.5820	3.3233	0.5641	3.2210	0.2523	1.4406	82.10%	80.05%	86.07%	0.9218	0.9818
Std. Dev.	0	0	0.1415	0.8079	0.1721	0.9829	0.0336	0.1918	1.00%	1.04%	7.01%	0.0291	0.0906
Average	16	71	0.5694	3.2513	0.5534	3.1601	0.2535	1.4475	81.92%	80.04%	86.03%	0.9186	0.9825
Std. Dev.	0	0	0.1324	0.7561	0.1567	0.8947	0.0328	0.1871	0.81%	0.79%	6.83%	0.0259	0.0792
E1 dowel bar configuration													
Average	10	44	0.5646	3.2238	0.5600	3.1974	0.2533	1.4464	82.22%	80.06%	84.26%	0.9261	0.9581
Std. Dev.	0	0	0.1297	0.5523	0.1197	0.6833	0.0256	0.1462	1.11%	1.29%	1.99%	0.0148	0.0641
Average	13	58	0.5581	3.1868	0.5533	3.1595	0.2571	1.4681	82.02%	80.18%	83.80%	0.9203	0.9591
Std. Dev.	0	0	0.1188	0.5109	0.1106	0.6313	0.0248	0.1417	0.92%	1.25%	1.81%	0.0139	0.0603
Average	16	71	0.5440	3.1065	0.5426	3.0981	0.2574	1.4699	81.89%	80.09%	83.65%	0.9227	0.9608
Std. Dev.	0	0	0.1060	0.4593	0.1010	0.5770	0.0241	0.1378	0.92%	1.13%	1.75%	0.0116	0.0561
E2 dowel bar configuration													
Average	10	44	0.4914	2.8058	0.4709	2.6888	0.2411	1.3766	82.37%	80.21%	84.19%	0.9220	0.9939
Std. Dev.	0	0	0.0809	0.2001	0.0366	0.2088	0.0123	0.0701	0.59%	1.00%	1.06%	0.0094	0.0834
Average	13	58	0.4884	2.7887	0.4678	2.6714	0.2446	1.3970	82.15%	80.38%	83.78%	0.9197	0.9926
Std. Dev.	0	0	0.0753	0.1957	0.0343	0.1958	0.0134	0.0765	0.82%	1.10%	0.98%	0.0082	0.0764
Average	16	71	0.4803	2.7427	0.4639	2.6490	0.2447	1.3973	82.02%	79.94%	83.81%	0.9165	0.9914
Std. Dev.	0	0	0.0684	0.1837	0.0320	0.1829	0.0159	0.0909	0.55%	0.88%	1.11%	0.0109	0.0740

3.4 September 2007 testing results

Testing on the westbound lanes was conducted on September 11, 2007. Sensors were again connected to the data acquisition systems but very little useful information was extracted again due to the previous damage to the sensor wires. Strain gages installed to collect data due to dynamic loading had already exceeded their fatigue life. No visible distress was recorded on the instrumented slabs, but in the traffic control zone, east of the instrumentation section, three slabs had corner breaks. No faulting was recorded.

Testing on the eastbound lanes was conducted on September 12, 2007. FWD testing was conducted on the dowel bar test sections. Faultmeter readings were conducted on the tie bar sections but no faulting was recorded.

3.5 September 2008 testing results

Testing on the westbound lanes was conducted on September 24, 2008. Falling weight deflectometer testing was conducted on the sections, with the falling weight applying loads on the approach and leave of each joint as well as mid panel drops. A summary of the data from the westbound lanes is in Table 16. The full set of data is provided in Appendix H. Testing on the eastbound lanes was conducted on September 25, 2008; the weather conditions were clear but cold. Falling weight load transfer measurements as well as mid-panel drops on the dowel bar test sections were conducted. Due to traffic control limitations, the FWD vehicle could not be positioned safely to collect any meaningful data from the tie bar sections. A summary of the results is provided in Table 17.

A comprehensive distress survey was also conducted on September 24, 2008 starting at westbound station 36.4 to include all visible lanes of traffic. The distress summary is presented in Table 18. A comprehensive distress survey of the eastbound lanes was conducted on the following day and the results are given in Table 19. Multiple slabs had “pop outs” but these were noted as minor and not affecting the overall quality of the pavement.

Table 16. FWD data averages and standard deviations for I-490 West, Monroe, Rochester on September 24, 2008.

	Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/D0 M	JSR
	(kip)	(kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)					
Average	10	44	0.6701	3.8263	0.6198	3.5389	0.2268	1.2951	80.77%	83.11%	88.18%	0.9325	1.0002
Std. Dev.	0	0	0.1082	0.6178	0.1013	0.5785	0.0296	0.1693	1.41%	1.66%	4.27%	0.0301	0.1299
Average	13	58	0.6583	3.7592	0.6128	3.4995	0.2291	1.3084	80.90%	82.90%	88.53%	0.9302	0.9991
Std. Dev.	0	0	0.1053	0.6011	0.0943	0.5387	0.0294	0.1677	1.26%	1.30%	4.40%	0.0231	0.1192
Average	16	71	0.6280	3.5862	0.5867	3.3503	0.2244	1.2815	83.14%	69.73%	87.87%	0.9338	0.9983
Std. Dev.	0	0	0.0959	0.5474	0.0874	0.4988	0.0274	0.1565	1.16%	31.10%	4.86%	0.0247	0.1133

Table 17. FWD data averages and standard deviations for I-490 East, Monroe, Rochester on September 25, 2008 for different dowel bar configurations.

Standard dowels	Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/D0 M	JSR
	(kip)	(kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)					
Average	10	44	0.4118	2.3515	0.3797	2.1680	0.1960	1.1193	80.84%	83.79%	80.52%	0.9232	1.0712
Std. Dev.	0	0	0.2327	1.3286	0.2075	1.1849	0.0560	0.3196	1.25%	2.77%	13.16%	0.0437	0.3995
Average	13	58	0.4087	2.3337	0.3843	2.1945	0.2019	1.1527	80.94%	83.44%	80.20%	0.9392	1.0550
Std. Dev.	0	0	0.2285	1.3050	0.2022	1.1547	0.0553	0.3158	2.42%	3.86%	12.85%	0.0235	0.3732
Average	16	71	0.3204	1.8297	0.2934	1.6755	0.1273	0.7269	81.46%	83.64%	46.68%	0.4824	0.7247
Std. Dev.	0	0	0.1037	0.5923	0.1023	0.5842	0.0828	0.4726	2.33%	1.86%	38.89%	0.5183	0.3909
E1 dowel bar configuration													
Average	10	44	0.3539	2.0209	0.3249	1.8554	0.2010	1.1479	80.54%	82.94%	78.24%	0.8905	0.9454
Std. Dev.	0	0	0.1572	0.8976	0.1393	0.7956	0.0431	0.2462	1.98%	2.04%	10.51%	0.1804	0.1422
Average	13	58	0.3506	2.0017	0.3222	1.8398	0.1982	1.1318	81.02%	83.21%	80.29%	0.9284	0.9566
Std. Dev.	0	0	0.1527	0.8718	0.1319	0.7533	0.0588	0.3356	1.64%	1.58%	8.21%	0.0254	0.1445
Average	16	71	0.3406	1.9450	0.3007	1.7171	0.1982	1.1318	80.90%	83.42%	80.29%	0.9284	0.9587
Std. Dev.	0	0	0.1372	0.7836	0.1323	0.7556	0.0588	0.3356	1.85%	1.70%	8.21%	0.0254	0.1255
E2 dowel bar configuration													
Average	10	44	0.2316	1.3227	0.1883	1.0750	0.1555	0.8880	82.45%	85.13%	77.57%	0.9238	1.0652
Std. Dev.	0	0	0.0914	0.5218	0.0521	0.2976	0.0517	0.2952	2.52%	8.21%	10.13%	0.0284	0.3037
Average	13	58	0.2338	1.3353	0.2064	1.1786	0.1611	0.9199	82.60%	84.31%	79.85%	0.9247	1.0363
Std. Dev.	0	0	0.0914	0.5217	0.0354	0.2019	0.0409	0.2337	2.37%	2.13%	6.85%	0.0334	0.1680
Average	16	71	0.2405	1.3733	0.2162	1.2344	0.1701	0.9715	82.71%	84.67%	81.54%	0.9180	1.0230
Std. Dev.	0	0	0.0816	0.4660	0.0346	0.1976	0.0282	0.1609	1.87%	2.05%	4.49%	0.0226	0.1285

Table 18. Distress Survey, I 490 Westbound September 2008

Slab No.	Distress Type
0	*Start Station W 36.4*
1	North west corner crack in center lane
7	Transverse mark in inner lane (Crack or finish error)
8	Small crack on the north edge
10	South East corner minor crack in center lane
15	South West corner, 1 foot minor edge crack in the center lane
16	*4901 4403 1106 Sign - Slab 0*
4	Outer lane center spalling
9	Inner lane finish problem
11	Inner lane finish problem
12	North East corner center lane corner crack 600 mm (2 ft) length x 150 mm (6 in)
15	North East corner center lane corner crack 300 m (1ft) length x 75 mm (3 in)
16	*Station W 36.3*
1	North West corner crack in center lane w/ missing concrete 75 mm (3 in) x 50 mm (2 in)
2	Inner lane finish problem
3	Inner lane, polished aggregate slab
4	Inner lane, polished aggregate slab
5	Inner lane, polished aggregate slab
6	Inner lane, polished aggregate slab
7	Inner lane, polished aggregate slab
8	inner lane, polished aggregate slab (25%)
14	*4901 4403 1005 sign -Slab 0*
6	Center lane spalling in center
10	Inner lane finish problem
16	Inner lane finish problem
18	*Station W 36.2*
1	Inner lane, polished aggregate
2	Inner lane, polished aggregate
3	Inner lane, polished aggregate
4	Inner lane, polished aggregate
5	Inner lane, polished aggregate
6	Inner lane, polished aggregate
7	Inner lane, polished aggregate
8	Inner lane, polished aggregate
9	Inner lane, polished aggregate
10	Inner lane, polished aggregate
11	Inner lane, polished aggregate
12	Inner lane, polished aggregate

Table 19. Distress survey, I490 eastbound September 2008

Slab No.	Distress Type
0	*Station E 36.3*
6	Joint inner lane, minor crack
15	Joint installation problem
21	South East Corner crack outer lane 200 mm (8 in) x 150 mm (6 in)
32	*Station E 36.2*
15	Edge joint blow up (Due to truck accident) 300 mm (1 ft) x 75 mm (3 in)
31	*Station E 36.1*
5	Small blowup (25 mm (1 in) x 75 mm (3 in))
7	Longitudinal crack inner lane
8	Longitudinal crack inner lane
10	Longitudinal crack inner lane
13	Longitudinal crack inner lane
48	Edge joint 50 mm (2 in) x 25 mm (1 in) Center lane South West Corner
64	*Station E 35.9*

3.6 August 2009 testing results

The westbound sections were tested on August 18th; the distress survey results are tabulated in Table 20. Pictures of the corner cracks are in Figure 10. Average pavement temperature during this test was 88ºF (31ºC). During this site visit the sensors were checked but were still non-responsive.

Table 20. I490W Distress survey, August 2009

Slab No.	**Distress Type**
0	*Station W 36.4*
1	Corner crack - 2nd lane
2	Corner crack - 3rd lane
10	Corner crack - 3rd lane
29	Corner crack - 2nd lane
32	Corner crack - 2nd lane
33	Corner crack - 2nd lane
34	Corner crack - 2nd lane
36	Corner crack - 2nd lane
116	*Edge of Rest Area , Past Station W 36.1*

The eastbound lanes on I490 were tested on August 19, 2009. The distress is documented in Table 21. Falling weight deflectometer readings were conducted on the dowel bar test sections. The FWD data averages and standard deviations by dowel bar configuration are presented in Table 22. The full set of data is provided in Appendix I.

Table 21. I490E Distress survey, August 2009

Slab No.	**Distress Type**
0	Station W 36.2
W 35.6	2 slabs, center lane, concrete missing
General	Some construction pop outs, polished aggregates, minor surface cracks

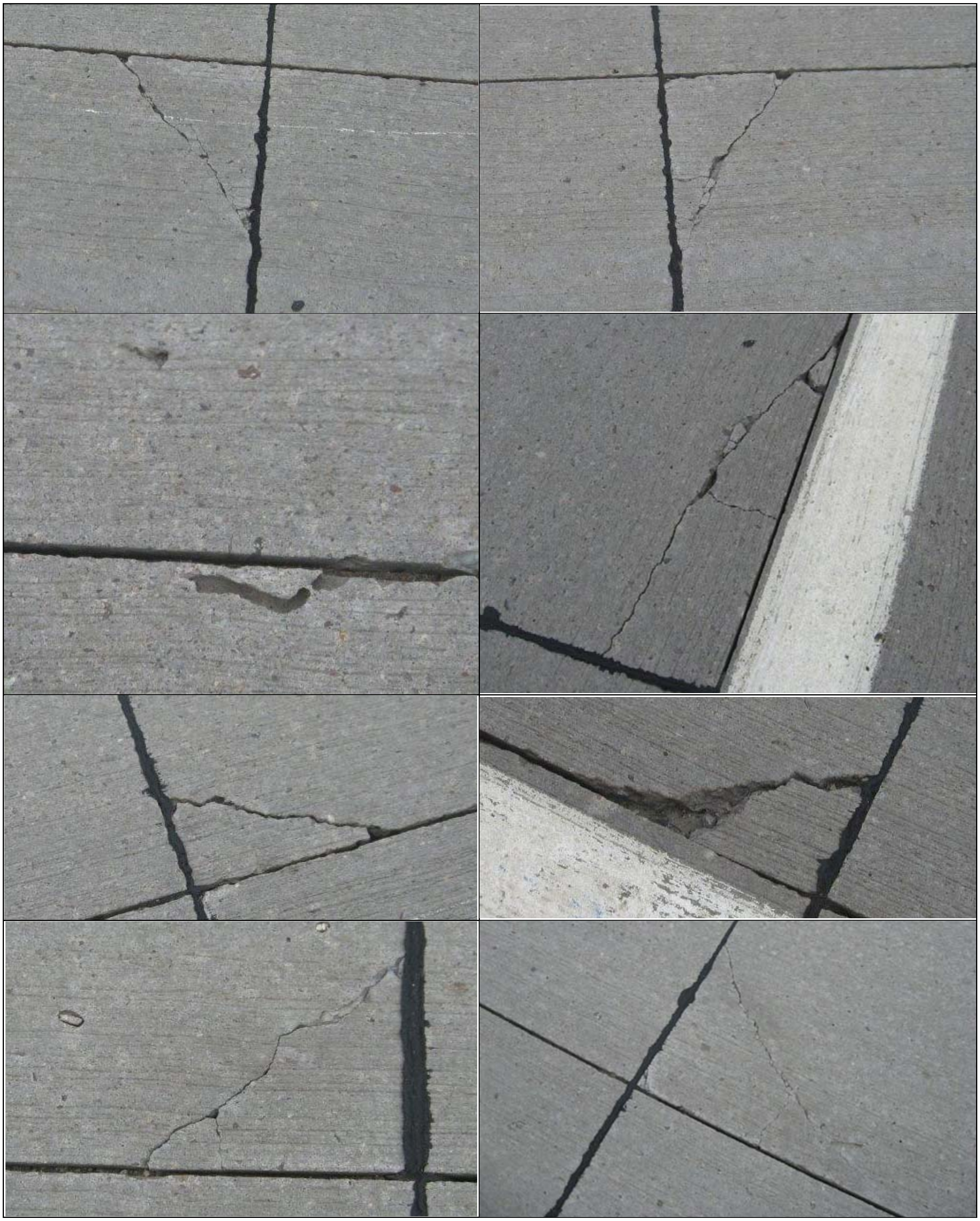

Figure 10. Corner cracks identified on I490W distress survey, August 2009.

Table 22. FWD data averages and standard deviations for I-490 East, Monroe, Rochester on Aug. 19, 2009 for different dowel bar configurations.

Standard dowels	Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/D0 M	JSR
	(kip)	(kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)					
Average	10	44	0.2547	1.4545	0.2596	1.4825	0.1558	0.8899	82.86%	83.16%	82.29%	0.9298	0.9884
Std. Dev.	0	0	0.0527	0.3007	0.0551	0.3147	0.0186	0.1063	3.08%	6.78%	6.43%	0.0532	0.1230
Average	13	58	0.2569	1.4671	0.2588	1.4777	0.1582	0.9036	83.16%	82.94%	78.99%	0.8679	0.9920
Std. Dev.	0	0	0.0538	0.3072	0.0564	0.3220	0.0176	0.1008	2.54%	5.68%	6.96%	0.2330	0.1301
Average	18	80	0.2506	1.4307	0.2532	1.4456	0.1547	0.8836	83.16%	82.61%	84.35%	0.9052	0.9864
Std. Dev.	0	0	0.0484	0.2762	0.0493	0.2817	0.0167	0.0954	1.17%	3.87%	5.83%	0.0175	0.1091
E1 dowel bar configuration													
Average	10	44	0.2923	1.6689	0.2913	1.6632	0.1787	1.0204	83.03%	79.25%	83.89%	0.9053	1.0090
Std. Dev.	0	0	0.0704	0.4019	0.0687	0.3921	0.0104	0.0593	2.79%	6.31%	4.53%	0.0336	0.1825
Average	13	58	0.2955	1.6874	0.2918	1.6665	0.1796	1.0254	83.50%	82.36%	83.77%	0.9223	1.0101
Std. Dev.	0	0	0.0689	0.3934	0.0686	0.3920	0.0105	0.0597	2.48%	6.26%	8.50%	0.0255	0.1673
Average	18	80	0.2860	1.6332	0.2832	1.6170	0.1766	1.0084	83.54%	83.98%	82.19%	0.9196	1.0057
Std. Dev.	0	0	0.0642	0.3665	0.0613	0.3500	0.0086	0.0493	1.44%	5.51%	5.60%	0.0222	0.1619
E2 dowel bar configuration													
Average	10	44	0.2641	1.5083	0.2617	1.4941	0.1756	1.0028	84.17%	80.56%	83.37%	0.9083	0.9867
Std. Dev.	0	0	0.0577	0.3296	0.0588	0.3360	0.0166	0.0948	2.00%	8.79%	8.05%	0.0309	0.1507
Average	13	58	0.2655	1.5163	0.2626	1.4994	0.1775	1.0133	84.60%	83.39%	82.36%	0.9127	0.9896
Std. Dev.	0	0	0.0590	0.3368	0.0577	0.3297	0.0129	0.0739	1.33%	5.37%	9.31%	0.0158	0.1545
Average	18	80	0.2568	1.4662	0.2580	1.4731	0.1722	0.9831	85.43%	82.79%	85.24%	0.9184	0.9876
Std. Dev.	0	0	0.0523	0.2988	0.0530	0.3029	0.0114	0.0648	2.74%	4.91%	5.58%	0.0166	0.1467

3.7 June 2011 testing results

The eastbound lanes were tested on June 21, 2011. Falling weight deflectometer testing as well as faulting and distress survey were conducted on these sections. Due to delays in traffic control implementation, the section testing did not start until 11:00 AM. The traffic control configuration also excluded the standard dowel bar configuration sections from testing. The surface temperature at that time was 40.6°C (105ºF). Distress survey did not show any additional distress beyond what was documented in the previous visits. Faulting survey did not indicate any faulting at any of the joints. At mid-day, the falling weight machine suffered an electrical failure and testing was stopped for the day.

The westbound sections were scheduled to be tested on June 22, 2011. Traffic control closed the lanes, but the FWD machine was not available for testing. Distress survey did not show any additional distress beyond what was documented previously. Prior to starting faultmeter readings, a severe thunderstorm went through the area and the traffic control operation had to be discontinued. Further testing was not able to be scheduled due to time and effort conflicts with the NYDOT office in Rochester.

FWD data summary from the eastbound lanes is shown in Table 23. As can be seen from this table the load transfer efficiencies are on average around 80% after more than 11 years of service. The full set of data is given in Appendix J.

3.8Summary of FWD results

Table 24 and Table 25 respectively summarize the approach and leave data collected using the FWD over the course of the project. For each treatment on each date, the data include the load, the average load transfer efficiency, the standard deviation, and the standard deviation of the mean (the standard deviation divided by the square root of the number of measurements made). Figure 11 shows a graphic comparison of the three dowel bar treatments, plotting the load transfer efficiency in the approach (left) and leave (right) configurations as a function of date and load, with error bars indicating standard deviation of the mean. While the last data points, taken in June 2011 appear to show that the E2 configuration has the highest LTE, it should be noted that only two measurements of E2 LTEs (compared to 25 or more of the other configurations) were conducted before the FWD malfunctioned. On earlier dates the LTEs of the three configurations are comparable. In all cases, the LTEs are at or above the 80% criterion, within error limits, except for E1 in June 2011, which was about 76% at all loads.

Table 23. FWD data averages and standard deviations for I-490 East, Monroe, Rochester on June 21, 2011 for different dowel bar configurations.

E1 dowels	Load (kip)	Load (kN)	DO L (mil/kip)	DO L (µm/kN)	DO A (mil/kip)	DO A (µm/kN)	DO M (mil/kip)	DO M (µm/kN)	LTE L	LTE A	SPR	D3/D0 M	JSR
Average	10	44	0.3786	2.1621	0.3589	2.0491	0.1676	0.9571	82.92%	80.12%	90.74%	0.9193	1.0571
Std. Dev.	0	0	0.0597	0.3412	0.0595	0.3396	0.0122	0.0696	1.28%	1.63%	3.85%	0.0124	0.0378
Average	13	58	0.3774	2.1548	0.3573	2.0400	0.1684	0.9617	82.63%	80.92%	89.30%	0.9232	1.0597
Std. Dev.	0	0	0.0558	0.3188	0.0582	0.3324	0.0114	0.0654	0.94%	1.30%	3.25%	0.0138	0.0390
Average	18	80	0.3618	2.0660	0.3442	1.9657	0.1657	0.9463	81.86%	80.17%	89.31%	0.9088	1.0549
Std. Dev.	0	0	0.0510	0.2913	0.0534	0.3049	0.0098	0.0562	1.04%	1.09%	2.85%	0.0134	0.0375
E2 dowel bar configuration													
Average	10	44	0.2601	1.4853	0.2481	1.4164	0.1687	0.9631	79.66%	75.66%	81.88%	0.8896	1.0490
Std. Dev.	0	0	0.0197	0.1123	0.0183	0.1046	0.0093	0.0531	1.32%	1.90%	2.29%	0.0108	0.0350
Average	13	58	0.2633	1.5032	0.2484	1.4186	0.1706	0.9741	79.45%	76.56%	80.76%	0.8954	1.0600
Std. Dev.	0	0	0.0186	0.1065	0.0180	0.1026	0.0084	0.0479	1.10%	1.37%	1.58%	0.0115	0.0267
Average	18	80	0.2618	1.4947	0.2485	1.4190	0.1728	0.9870	78.76%	76.00%	80.66%	0.8831	1.0540
Std. Dev.	0	0	0.0169	0.0964	0.0168	0.0962	0.0086	0.0490	0.80%	1.14%	1.17%	0.0095	0.0296
E1 dowel bar configuration													
Average	10	44	0.2268	1.2953	0.2343	1.3382	0.1832	1.0459	89.89%	86.39%	86.37%	0.9075	0.9658
Std. Dev.	0	0	0.0368	0.2102	0.0299	0.1710	0.0091	0.0522	2.81%	0.48%	6.42%	0.0169	0.0337
Average	13	58	0.2308	1.3180	0.2359	1.3468	0.1852	1.0575	90.32%	87.61%	85.14%	0.9159	0.9766
Std. Dev.	0	0	0.0374	0.2134	0.0311	0.1774	0.0119	0.0680	2.03%	2.03%	5.88%	0.0158	0.0298
Average	18	80	0.2200	1.2563	0.2269	1.2954	0.1814	1.0359	89.66%	86.67%	84.81%	0.1814	0.9670
Std. Dev.	0	0	0.0365	0.2086	0.0265	0.1511	0.0092	0.0523	3.50%	0.74%	5.76%	0.0092	0.0482

Table 24. Summary of average approach LTEs by date, with standard deviation and standard deviation of the mean.

Standard dowels	Load (kip)	Load (kN)	Direction	Average	Std. Dev.	SD of M	Load (kip)	Load (kN)	Average	Std. Dev.	SD of M	Load (kip)	Load (kN)	Average	Std. Dev.	SD of M
26-Oct-04	8.4	37.4	A	90.55%	9.86%	2.15%	11.3	50.3	86.08%	4.58%	0.92%					
12-Oct-06	10	44	A	80.25%	0.85%	0.20%	13	58	80.05%	1.04%	0.25%	16	71	80.04%	0.79%	0.19%
25-Sep-08	10	44	A	83.79%	2.77%	0.55%	13	58	83.44%	3.86%	0.77%	16	71	83.64%	1.86%	0.37%
19-Aug-09	10	44	A	83.16%	6.78%	1.70%	13	58	82.94%	5.68%	1.42%	18	80	82.61%	3.87%	0.97%
21-Jun-11	10	44	A	80.11%	1.67%	0.33%	13	58	80.89%	1.27%	0.25%	18	80	80.23%	1.16%	0.23%
E1 dowel bar configuration																
26-Oct-04	8.4	37.4	A	93.38%	10.05%	2.19%	11.3	50.3	84.51%	7.99%	1.46%					
12-Oct-06	10	44	A	80.06%	1.29%	0.26%	13	58	80.18%	1.25%	0.25%	16	71	80.09%	1.13%	0.23%
25-Sep-08	10	44	A	80.54%	1.98%	0.39%	13	58	81.02%	1.64%	0.32%	16	71	83.42%	1.70%	0.33%
19-Aug-09	10	44	A	79.25%	6.31%	1.45%	13	58	82.36%	6.26%	1.40%	18	80	83.98%	5.51%	1.23%
21-Jun-11	10	44	A	75.58%	1.84%	0.36%	13	58	76.45%	1.32%	0.26%	18	80	75.98%	1.22%	0.24%
E2 dowel bar configuration																
26-Oct-04	8.4	37.4	A	93.81%	3.74%	1.00%	11.3	50.3	90.08%	5.98%	1.11%					
12-Oct-06	10	44	A	80.21%	1.00%	0.20%	13	58	80.38%	1.10%	0.22%	16	71	79.94%	0.88%	0.18%
25-Sep-08	10	44	A	85.13%	8.21%	1.52%	13	58	84.31%	2.13%	0.40%	16	71	84.67%	2.05%	0.38%
19-Aug-09	10	44	A	80.56%	8.79%	1.97%	13	58	83.39%	5.37%	1.20%	18	80	82.79%	4.91%	1.10%
21-Jun-11	10	44	A	86.39%	0.48%	0.34%	13	58	87.61%	2.03%	1.44%	18	80	86.67%	0.74%	0.52%

Table 25. Summary of average leave LTEs by date, with standard deviation and standard deviation of the mean.

Standard dowels	Load (kip)	Load (kN)	Direction	Average	Std. Dev.	SD of M	Load (kip)	Load (kN)	Average	Std. Dev.	SD of M	Load (kip)	Load (kN)	Average	Std. Dev.	SD of M
26-Oct-04	8.4	37.4	L	90.35%	6.79%	1.65%	11.3	50.3	82.40%	5.07%	1.01%					
12-Oct-06	10	44	L	82.39%	0.88%	0.21%	13	58	82.10%	1.00%	0.24%	16	71	81.92%	0.81%	0.19%
25-Sep-08	10	44	L	80.84%	1.25%	0.25%	13	58	80.94%	2.42%	0.48%	16	71	81.46%	2.33%	0.47%
19-Aug-09	10	44	L	82.86%	3.08%	0.80%	13	58	83.16%	2.54%	0.66%	18	80	83.16%	1.17%	0.30%
21-Jun-11	10	44	L	83.16%	1.10%	0.22%	13	58	82.87%	0.95%	0.19%	18	80	82.15%	0.98%	0.19%
E1 dowel bar configuration																
26-Oct-04	8.4	37.4	L	91.10%	9.07%	1.89%	11.3	50.3	80.99%	5.23%	1.02%					
12-Oct-06	10	44	L	82.22%	1.11%	0.23%	13	58	82.02%	0.92%	0.19%	16	71	81.89%	0.92%	0.19%
25-Sep-08	10	44	L	80.54%	1.98%	0.38%	13	58	81.02%	1.64%	0.32%	16	71	80.90%	1.85%	0.36%
19-Aug-09	10	44	L	83.03%	2.79%	0.62%	13	58	83.50%	2.48%	0.55%	18	80	83.54%	1.44%	0.32%
21-Jun-11	10	44	L	79.75%	1.48%	0.29%	13	58	79.44%	1.24%	0.24%	18	80	78.75%	0.91%	0.18%
E2 dowel bar configuration																
26-Oct-04	8.4	37.4	L	91.28%	8.40%	2.10%	11.3	50.3	86.79%	4.02%	0.77%					
12-Oct-06	10	44	L	82.37%	0.59%	0.12%	13	58	82.15%	0.82%	0.16%	16	71	82.02%	0.55%	0.11%
25-Sep-08	10	44	L	82.45%	2.52%	0.47%	13	58	82.60%	2.37%	0.44%	16	71	82.71%	1.87%	0.35%
19-Aug-09	10	44	L	84.17%	2.00%	0.45%	13	58	84.60%	1.33%	0.30%	18	80	85.43%	2.74%	0.61%
21-Jun-11	10	44	L	89.89%	2.81%	1.99%	13	58	90.32%	2.03%	1.44%	18	80	89.66%	3.50%	2.47%

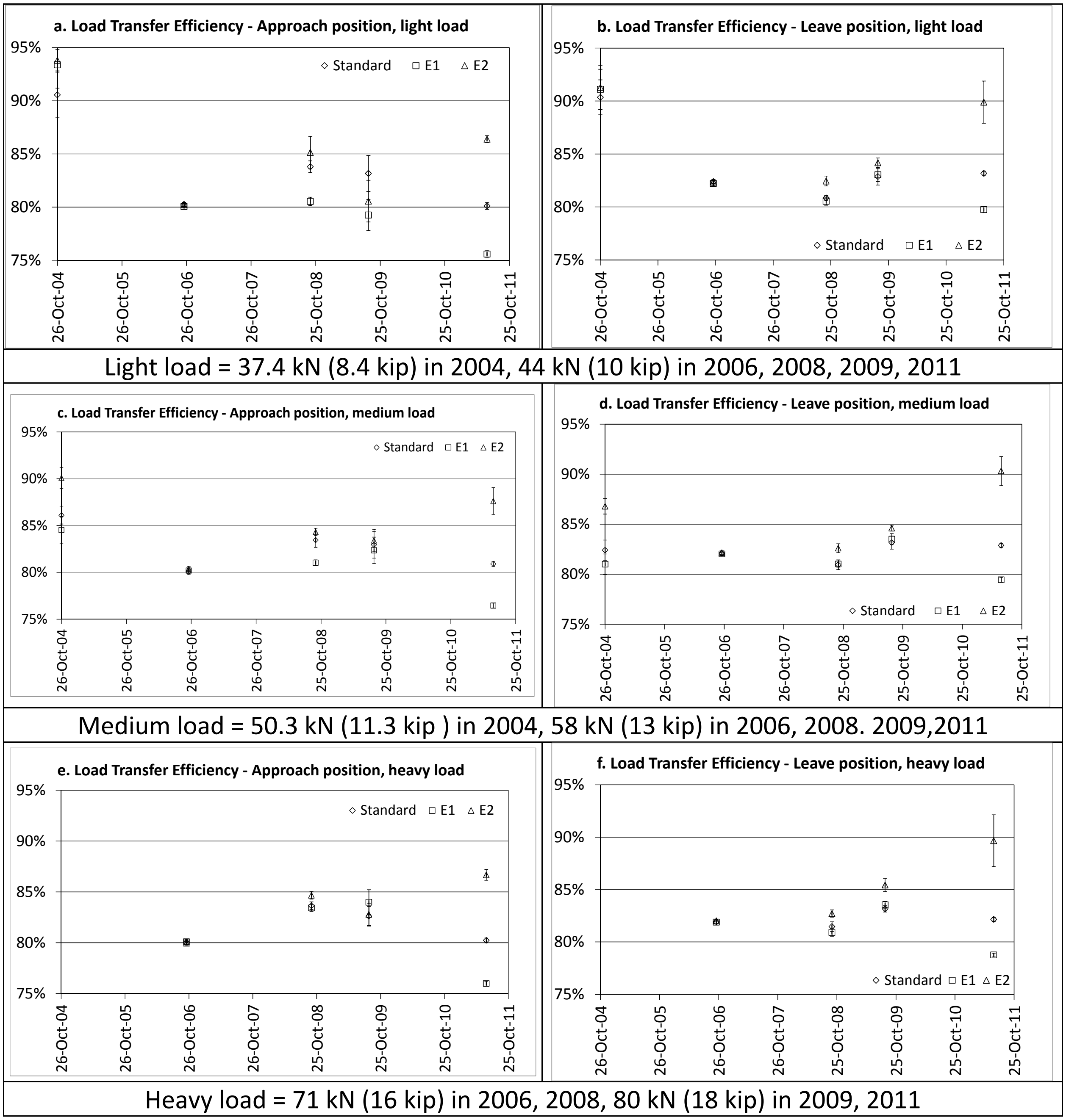

Figure 11. Summary comparison of FWD data on dowel bars on I490E.

In order to compare the means of the three dowel bar configurations simultaneously, an analysis of variance (ANOVA) was utilized to determine if the means for approaching and leaving the slab under light (10 kip or 44 kN), medium (13 kip or 58 kN) and heavy (16 kip or 71 kN) loads were similar. The level of confidence utilized for the ANOVA was 95% or an alpha equal to 0.05. The ANOVA determines the level of confidence based upon the number of dependent variable categories that are being compared. To perform the ANOVA, an F-statistic is calculated which is equal to the mean squares between the groups divided by the mean squares within the groups. If F-calculated was greater than F-critical, obtained in available statistical tables, the difference in the means was statistically significant. When conducting the ANOVA test, the Levene's test for equal variances was performed simultaneously. Since the Levene's test indicated that the variances were not equal for the medium load leaving the slab, the Welch's modification to the ANOVA was utilized and the calculated F-statistic based upon an asymptotically distribution was reported.

The null hypothesis for the statistical analysis stated that the mean load transfer efficiencies for the dowel bar configurations were similar. Based upon the statistical analyses, the null hypothesis was not rejected for the six analysis tests, indicating that the load transfer efficiencies were not impacted by the dowel bar configuration utilized. Even though the results are not statistically significant, the dowel bar configuration E2 exhibited higher load transfer efficiencies under every condition than the other two dowel bar configurations. The results of the statistical analyses are provided in Table 26.

Table 26. Dowel Bar Configuration Statistical Analyses.

Source of Variation	Sum of Squares (SS)	Degrees of Freedom (df)	Mean Squares (MS)	F-Calculated	Test Result
Comparison of Approach with Light Loading					
Between Groups	29.916	2	14.958	0.475	p=0.633
Within Groups	377.807	12	31.484		
Total	407.723	14	-		
Comparison of Approach with Medium Loading					
Between Groups	45.562	2	22.781	2.383	p=0.134
Within Groups	114.738	12	9.561		
Total	160.300	14	-		
Comparison of Approach with Heavy Loading					
Between Groups	14.889	2	7.444	0.896	p=0.442
Within Groups	74.778	9	8.309		
Total	89.667	11	-		
Comparison of Leaving with Light Loading					
Between Groups	20.204	2	10.102	0.579	p=0.575
Within Groups	209.303	12	17.442		
Total	229.507	14	-		
Comparison of Leaving with Medium Loading					
Between Groups	41.654	2	20.827	2.616	p=0.144
Within Groups	57.035	6.79	4.753		
Total	98.689	8.79	-		
Comparison of Leaving with Heavy Loading					
Between Groups	29.515	2	14.757	2.678	p=0.122
Within Groups	49.589	9	5.510		
Total	79.103	11	-		

4 I490 Conclusions

In this chapter, general conclusions are arrived at from the data presented in the previous chapters. The objectives of the project were met through the research performed. Following the results of this project, recommendations are offered for future research in these fields.

4.1 PCC Pavement Response Conclusions

A major cause of loss of support was found to be warping due to accelerated moisture loss resulting from high air temperatures and solar radiation during curing. The pavement deformations resulting from these factors may be great enough that the warping may not be reversed by even the most extreme temperature gradients.

When pavements are placed in hot weather a positive built-in temperature gradient develops. This causes the slab to reach its flattest possible position when the top of the slab is warmer than the bottom. As a result, significant upward deflections of the pavement corners may develop as early as the second day after placement. This leads to the development of high tensile stresses in the top of the pavement with a long term result of top down cracks in the pavement.

When observing the overall loss of support in the instrumented slabs, the FWD data were found to be consistent with the other data collected. This verifies that FWD testing is a valid method for determining loss of support for PCC pavements. Throughout the testing, the LVDT data coincided with the temperature data. When a positive gradient was present in the slab, the slab flattened thus increasing the support from the base. In contrast, the pavement corners curled up when the slab experienced a negative gradient thereby separating the slab from the base and increasing potential deflection of the slab.

4.2 Dowel Bar Arrangement Conclusions

Throughout the testing period it was found that the STD slabs, with the largest dowel bar diameter, widest spacing, and greatest cross-sectional area of steel throughout 1/3 of the slab width, exhibited the greatest amount of curling. In contrast, the E2 slabs with the smallest dowel bar diameter, narrowest spacing, and least amount of steel throughout 1/3 of the slab cross section, curled the least. The amount of curl experienced by all dowel bar layout types reduced as the air temperature increased throughout the testing. Even though the temperature gradient of slabs was not monitored directly, from pavement behavior observed in the I490 West testing it can be assumed that the pavement developed a positive temperature gradient as the air temperature increased.

When the pavement gradient was negative the LTE varied more among the various dowel bar configurations. The E2 sections typically had the highest LTE with the negative gradient present and also experienced the least deflection. This followed the general trend found throughout the testing period that the slabs with higher LTE performance generally deflected less. The E1 sections deflected less and had higher LTEs than the STD sections for Slabs 1 through 25. However, for Slabs 26 through 55 the STD sections slightly outperformed the E1 sections. Overall the E2 sections exhibited superior performance with the least curl and deflection as well as the highest LTEs.

After the air temperature rose and the pavement gradient became positive, the LTEs for all dowel bar arrangements became less varied. When the pavement was in this state, the E1 sections performed best, followed by the STD sections and finally the E2 sections. However, for the 37.4 kN (8.4 kip) loading the LTEs experienced by all dowel bar configurations was greater than 93%. Pavement performance in this state is not as critical as during the negative pavement gradient because the slab is more fully supported by the base. In this state the slab does not act as a cantilever, thereby reducing the stresses experienced by the slab as well as the likelihood of top down cracking.

The limited data collected in this project indicated that in the short term, the performance of the E2 dowel bar arrangement was better than those of the other two. However, the amount of data from the E2 arrangement in the last set of FWD drops in 2011 was extremely limited (only 2 joints compared to over 20 for the other two configurations), and this is where the difference was largest. Also, a longer-term investigation is needed to determine whether any difference in performance will be maintained as the effects of aggregate interlock diminish over time.

4.3 Tie Bar Arrangement Conclusions

Traffic control at the project site did not permit dropping the FWD weight in positions that could gather quantitative data on tie bar performance. Thus the assessment of tie bar performance is limited to qualitative observations from distress surveys. The distress surveys did not show obvious differences between the tie bar treatments. Additional measurements with more traffic control, or at the least an extended period of periodic distress survey collection, are required to differentiate between the treatments.

5 Monitoring of Pavement Response to Heavy Load Traffic at the Future Freedom Tower Site

5.1 General Statement

Several numerical models are available to predict the stress and deflection of pavements under heavy loads. Such models are a tool that can be used to predict the likelihood of damage to pavements from heavy loads. With an increasing number of heavy trucks, particularly overloaded trucks (whether permitted or not), on the road system, the incidence of load-induced damage is expected to increase. These numerical models will enable improvements in road design methods, whether for new or rehabilitated pavements, that will help mitigate the problems of load-induced damage.

However, most of these models have not been calibrated against actual data obtained under realistic conditions. Several instrumented pavements in the SHRP program, such as the Ohio SHRP Test Road on US Route 23 in Delaware County Ohio (DEL-23), the Minnesota test road (MnRoad) on I94, and test pavements in New York, have gathered stress and deflection data and have been the focus of intensive research efforts that allow for the fullest possible characterization of the pavement response. However, after construction the incidence of heavy traffic is sporadic and limited, and thus the amount of data available is relatively limited, primarily to data gathered under controlled vehicle load (CVL) tests. The upcoming construction of the Freedom Tower on the former World Trade Center site offers an excellent opportunity for gathering data from heavy truck traffic.

Roads leading into the site are expected to see a significant amount of heavily loaded construction vehicles carting materials into and out of the site as construction continues. If instrumented test sections are built into these roads, the Freedom Tower construction traffic can be monitored and data gathered as a byproduct of the Freedom Tower construction process. The test sections will be instrumented to monitor strain, soil pressure, deflection, and pavement temperature. The pavement construction process will also be monitored, and the materials used in the pavement will be tested in the laboratory to ascertain material property information. The data collected will be sufficient to enable calibration in three parameters: strain, and deflection. Pavement systems are highly nonlinear in their responses to loads. The field data collected at Freedom Tower will help indicate which parameters need to be emphasized in the model to describe the response to heavy loads. Data from the laboratory tests will be input to the model to predict the road response. The predicted response will be compared to the measured response. A sensitivity analysis will also be conducted to help determine which parameters should be adjusted to best fit actual conditions.

Short-term benefits of the project will include a better understanding of the effects of heavy loads on pavement structures. In particular, the research results can be used to better determine when and how to assign overload permits for heavy vehicles, and how to compute fees to properly account for resulting road maintenance. The data can also be used to modify the designs of currently planned roads if expected levels of heavy traffic warrant. In the long term, the calibrated model can be used in conjunction with existing Mechanistic-Empirical (ME) design models and to improve the ME design method. The data can be put into a format directly useful to ME designers, and will extend the range of loads for which data have been collected.

5.2 Project location and Instrumentation

Due to the sensitivity of the site location, and proximity to a high profile project, care had to be taken in choosing the instrumentation site. Several high level meetings were required to choose the location of the instrumentation section. In addition to the location, the lack of space in which preparations for instrumentation could take place placed a high premium on being ready and completing the sensor installation in a timely manner. Figure 9 shows the location of the instrumentation section on RT9A (West Side Highway).

On May 28th, the instrumentation of the test sections started. Multiple trips to the site and delays took place due to the location and work schedule, until June 12th 2008, when the instrumentation of the section was completed,

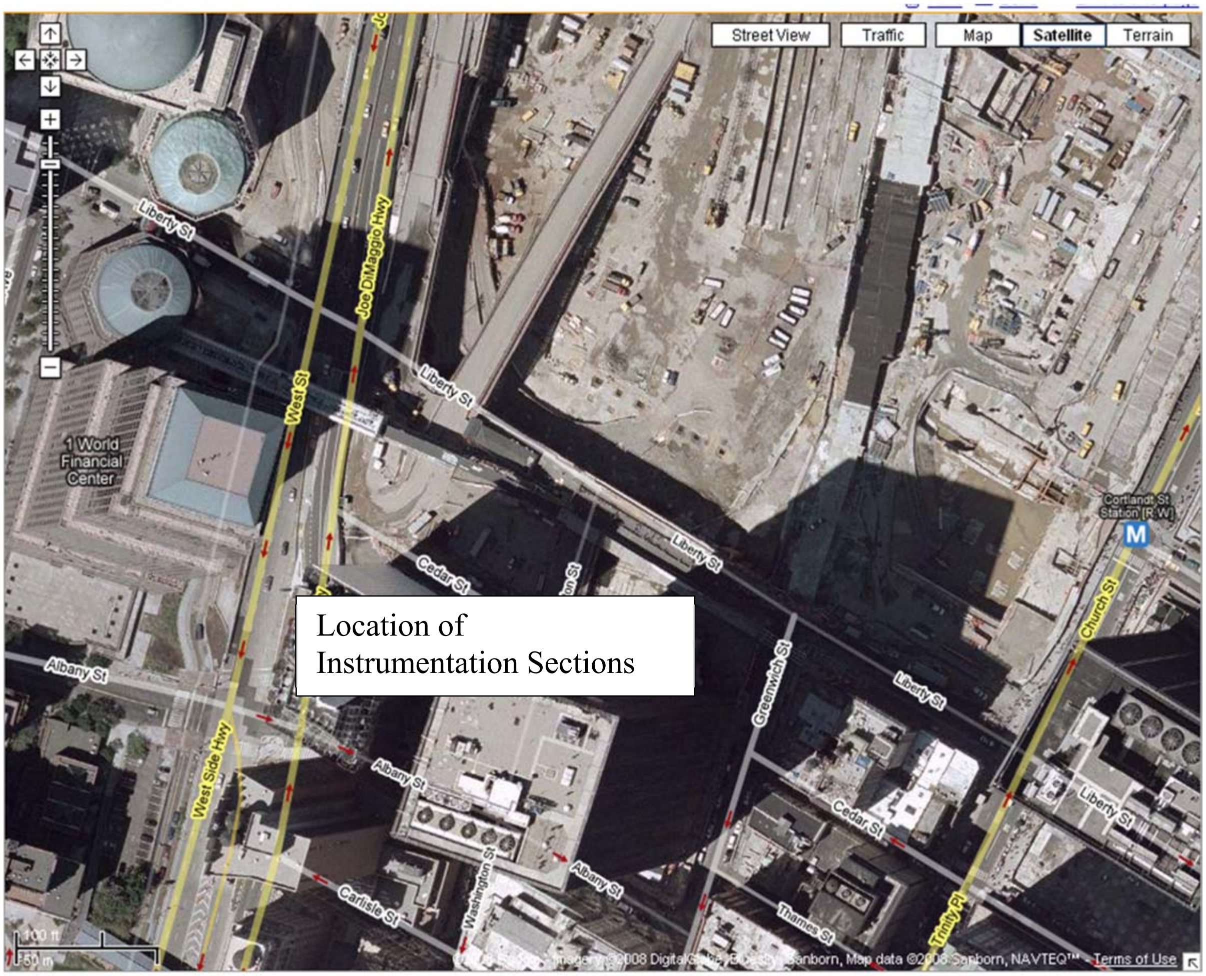

Figure 12 Location of RT9A (West Side Highway) Instrumentation Section. (Google Maps 2008)

5.3 Sensor installation

5.3.1 Introduction

The Ohio Research Institute for Transportation and the Environment (ORITE) at Ohio University has successfully installed hundreds of sensors in pavement around the nation. This procedure is a summary of what needs to take place in order to complete a successful sensor installation program. Some steps in this procedure can be modified to accommodate site and construction conditions as they occur in the field. A review of these procedures with the DOT and contractor personnel is strongly recommended prior to finalizing the field instrumentation.

Figure 10 shows the plan and profile view of the three slabs proposed for instrumentation. A 76 mm (3 in) plastic conduit was placed at mid-slab approximately 0.3 m (1 ft) from the edge of the slab connecting to an in-ground pull box for each slab. The conduit was used to connect sensor wires from the instrumented slabs outwards towards a water-tight above-ground instrumentation box. The final location of all conduits was clearly marked and identified.

5.3.2 Instrumentation Coordinate System

An instrumentation coordinate system for the test section was constructed to reference each gauge in an organized and simple manner. The second joint in the instrumentation slab was used as the origin to reference the location of the sensors. This joint was marked with the OU letters in the concrete. The x-axis will run longitudinally along the wheel-path, the y-axis runs perpendicular to the x-axis and laterally across the road surface, and the z-axis runs vertically into the ground. Locations toward the center of the road will be considered positive y value, and locations in the pavement structure will be negative z values.

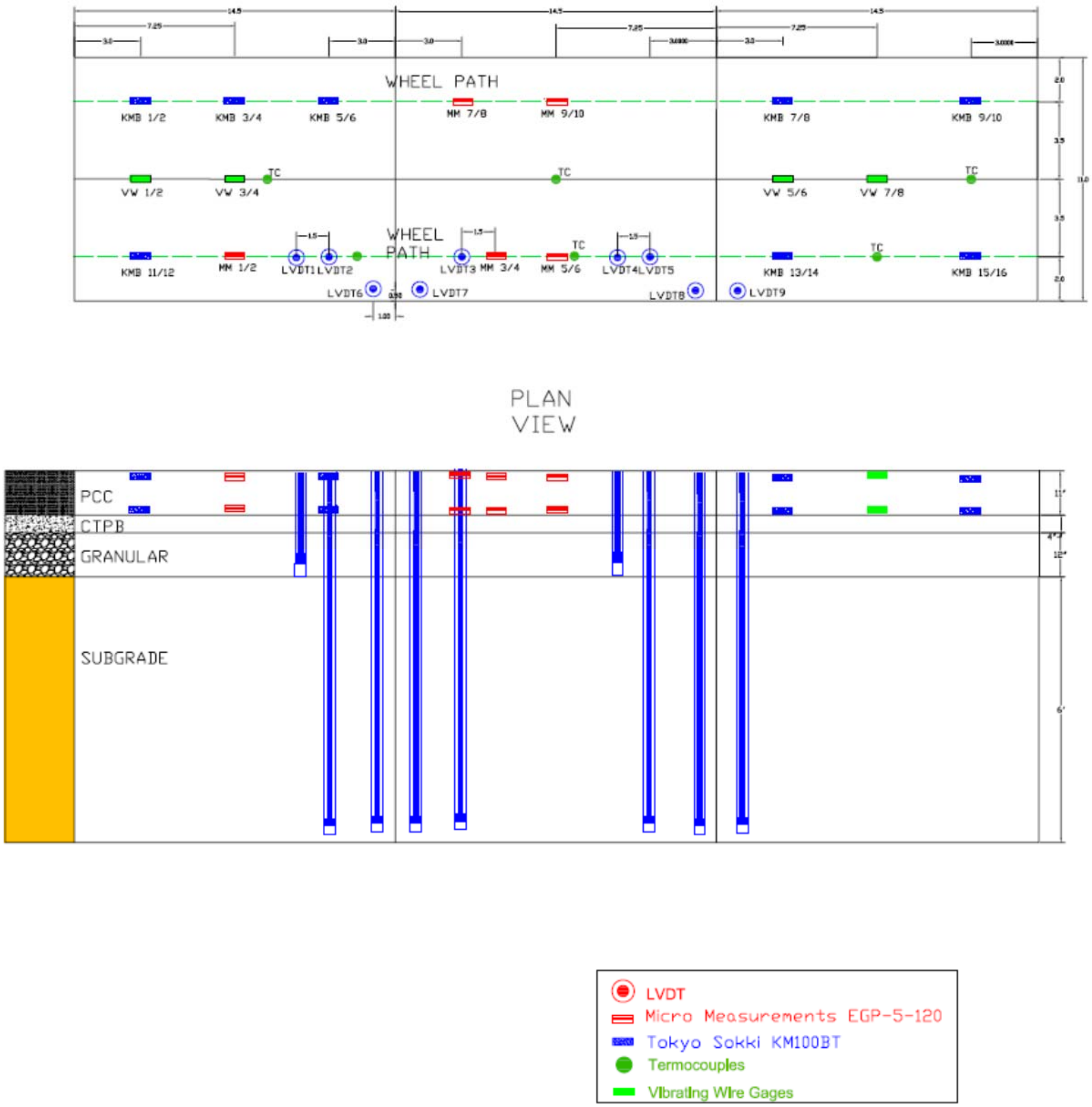

Figure 13 Plan and Profile Views of Instrumentation on RT9A.

5.3.3 Site Preparation

Before the installation of any sensors, the test section site had to be properly prepared. Tight construction controls were enforced during preparation of the subgrade, base, and pavement layers. These controls helped limit the number of variables that would need to be accounted for in the evaluation and comparison of different sections. The contractor, under the supervision of the NYDOT, was responsible for proper construction of the pavement layers. Before any preparation could take place, the roadway has to be surveyed and staked; a grade line was then set up as a reference for elevations. This grade line assisted in establishing targets for thickness and surface elevation for each pavement layer. The subgrade had to meet elevation, crown, density, and moisture requirements as per NYDOT requirements.

5.3.4 Section Preparation

Once the subgrade and aggregate base were approved, sensor locations were marked. LVDT reference rods were installed prior to placement of the second base material. Station markers will be located 4.27 m (14 ft) from the edge of the pavement and spaced 7.6 m (25 ft) apart. Nails were driven in the top and side of the stakes to provide precise stationing and elevations.

Because the contractor is usually permitted to place station markers within ± 152 mm (6 in), the construction joint between two instrumented slabs on PCC sections was located first, and subsequent measurements were made from this location. At the appropriate location, a 19 mm (0.75 in) diameter × 762 mm (30 in) long steel reference pin was hammered into the ground leaving approximately 450 mm (18 in) of the pin exposed. From this point, a transit was set up to lay out the middle joint and locate the reference pin on the opposite side of the road. A 90° angle was then turned to locate the joint at the end of one slab. In this line of sight, 4.6 m (15 ft) (approximately, depending on slab size) was measured from the reference pin and an end joint reference pin placed. After turning a 180° angle on the transit, the reference pin for the end of the other slab was placed using the same procedure. Using a tape measure and measuring off the middle joint reference pin, the remaining reference pins were located on the opposite side of the road. This reference pin setup was checked and confirmed to have the correct dimensions, and painted with a highly visible paint to avoid being hit or removed by the contractor. String lines were then tied to the reference pins to simulate the three transverse joints and define the instrumented PCC slabs.

A string line connecting the nails on top of the survey stakes was used as a reference from which to make measurements. Following the simulated transverse joints, measurements were taken from the survey stake line to locate the edge of the pavement, both wheel paths and the center of the slab. At the correct distance along the joint, a plumb bob was used to locate the proper points, which will be marked with a nail and highly visible paint. At each location, the previously mentioned procedure was used to identify sensor locations. The same measurements and procedures were also used along the remaining two transverse joints to mark off the LVDT locations, wheel paths, and center of slab.

5.3.5LVDT Reference Installation

Once the LVDT positions were marked, the ORITE portable drill rig was brought in to bore the deep reference holes. The holes were bored with a 76 mm (3 in) diameter auger bit to a depth of approximately 1.8 m (6 ft). This limited depth was necessary since other utilities were buried below that point. To achieve an accurate drill location, two references were measured off and marked from the nail identifying the LVDT location. The auger bit will be started in the base material, but before the boring is continued, the references will be checked to assure that the hole is being dug in the correct place. After a hole was bored and the measurements are checked to be correct, a reference rod will placed in the hole. The reference rod consisted of a 19 mm (0.75 in) or 25 mm (1 in) diameter, 2.1 m (7 ft) long steel rod with a 38 mm (1.50 in) diameter, 25 mm (1 in) thick stainless steel tip welded to the end to provide a smooth, clean surface for the LVDT.

To permanently fix the rod in the hole, a spacer cut from 19 mm (0.75 in) thick plastic was slipped onto the rod and positioned just under the tip. The rod was then dropped into the center of the hole and driven approximately one-foot into the subgrade placing the tip at the proper elevation. A non-shrink grout was poured to the bottom of the hole using a large funnel and a length of 38 mm (1.5 in) diameter plastic hose to a depth of only one-foot leaving 1.5 m (5 ft) of the steel rod exposed. Immediately following this and to prevent subgrade material from caving in, a length of 51 mm (2 in) PVC pipe was placed around the rod and spacer assembly, lowered to just below the stainless steel tip, and centered in the hole by filling the gap around the pipe with cement sand. Sand was vibrated around the pipe to assure all gaps were filled and proper compaction is achieved. A 76 mm (3 in) to 51 mm (2 in) plastic reducer, shown in Figure 14, was placed on the end of the PVC pipe.

Figure 14. LVDT Reference Rod and PVC Reducer

Reference plates for the shallow LVDTs are constructed of 150 mm (6 in) square by 12.6 mm (0.5 in) thick steel plate with a 38 mm (1.5 in) diameter stainless steel tip welded in the middle on one side. The tips will be located at the same elevation in all sections. Tip elevation was determined by the thickness of the concrete and base layers. Because the top surface of the plates rested evenly with the surface of the subgrade, the distance to the top of the pavement varied. Tips of varying height were manufactured and prepared for use on the rods and reference plates as needed when the final LVDT installation occurs.

Sand was used under the reference plates to provide them with a smooth even surface to rest on. The plates will be placed on top of the subgrade layer, below the aggregate base. A string line was pulled across the tops of both deep rods and shallow plates in the edge or wheelpath to make sure all tips lined up. Any plate or rod that did not line up will be repositioned in its proper location.

5.3.6 **Preparation of the Base**

Before any sensors could be installed, the base layer had to be properly graded and compacted. LVDT references and all other sensors were located in the concrete slabs. To begin the sensor location, transverse joints were laid out, and the wheel paths and center of the slab were located as described above. Figure 12 shows the section prior to sensor installation with the base properly prepared and ready for installation.

Figure 15 Instrumentation section with prepared base

5.3.7 **PCC Sensor Installation**

Sensors for measuring pavement strain make up the largest group of sensors. This group consists of, TML KM-100A/B, Geokon Vibrating Wire Strain Gages, and Micro-Measurements EGP-5-120 strain gauges. All strain gauges in PCC sections are held in position with a specially designed stand unit. Two stands made up a unit. These stands are constructed of 0.25-inch diameter cold rolled steel. Each type of strain gauge had its own special stand, which places the gauge at its proper depth in the concrete. The two stands in the unit are independent of one another to give the gauges freedom of motion to respond in concert with the PCC layer whenever strains are induced.

Before a strain gauge could be affixed to the unit, the stand has to be set in its proper positions and anchored to the base. All stands will be oriented such that the strain gauges would lie longitudinally in the roadway.

A non-shrinking, fast setting epoxy was used to anchor the stands. The epoxy was applied over the feet of the stands. The gauge anchors are secured to the stands with plastic cable ties at the middle around the strain gauge portion of the sensors (Figures 13 and 14). Special care had to be taken to assure that the strain gauge rested on the stands and that it was not being stressed in any way.

The strain gages transducers were placed one-inch from both the top and bottom of the PCC layer in the center lane of the second slab. The two transducers at each location were identified by different color schemes

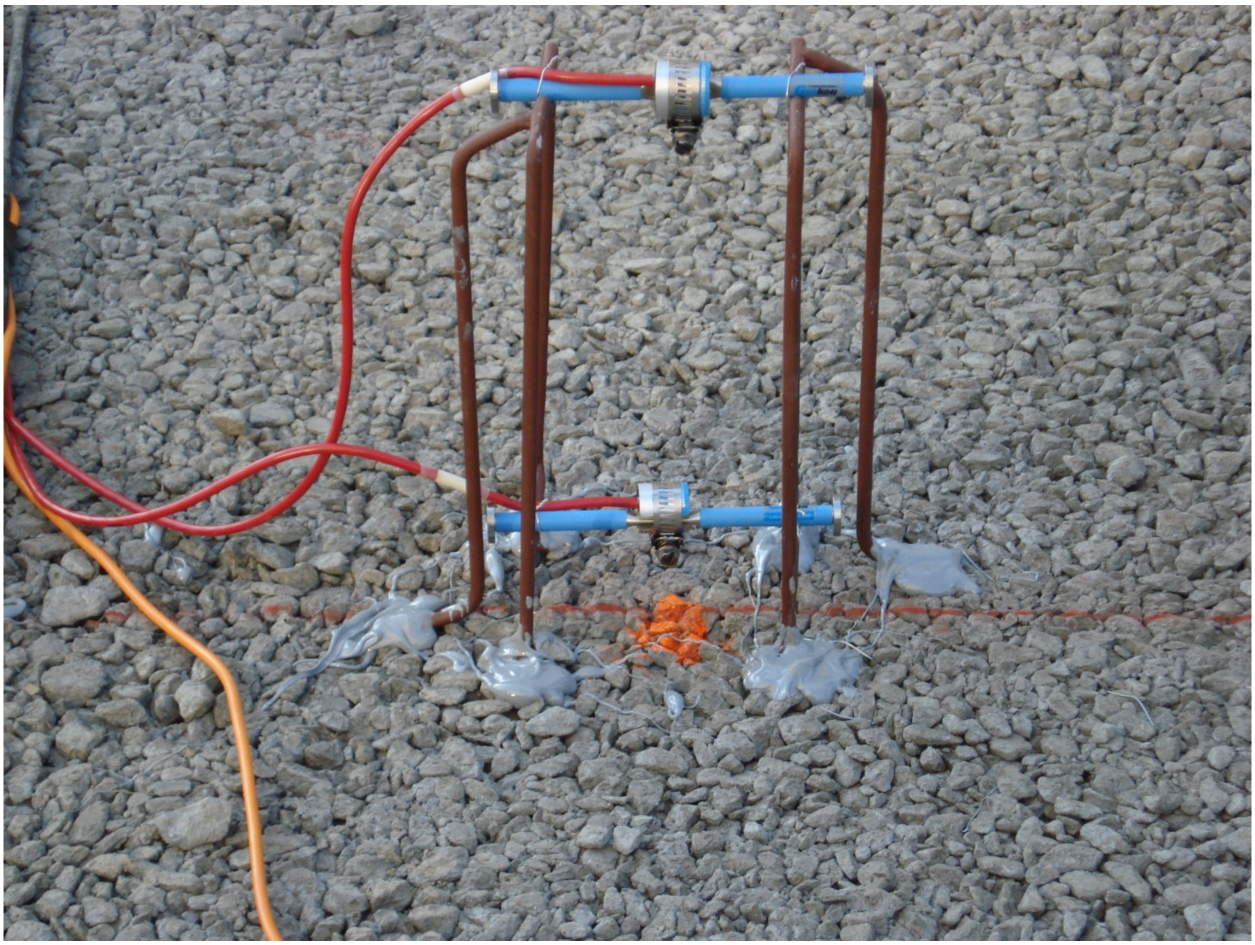

Figure 16 Vibrating Wire Strain Gauges Epoxied to Base

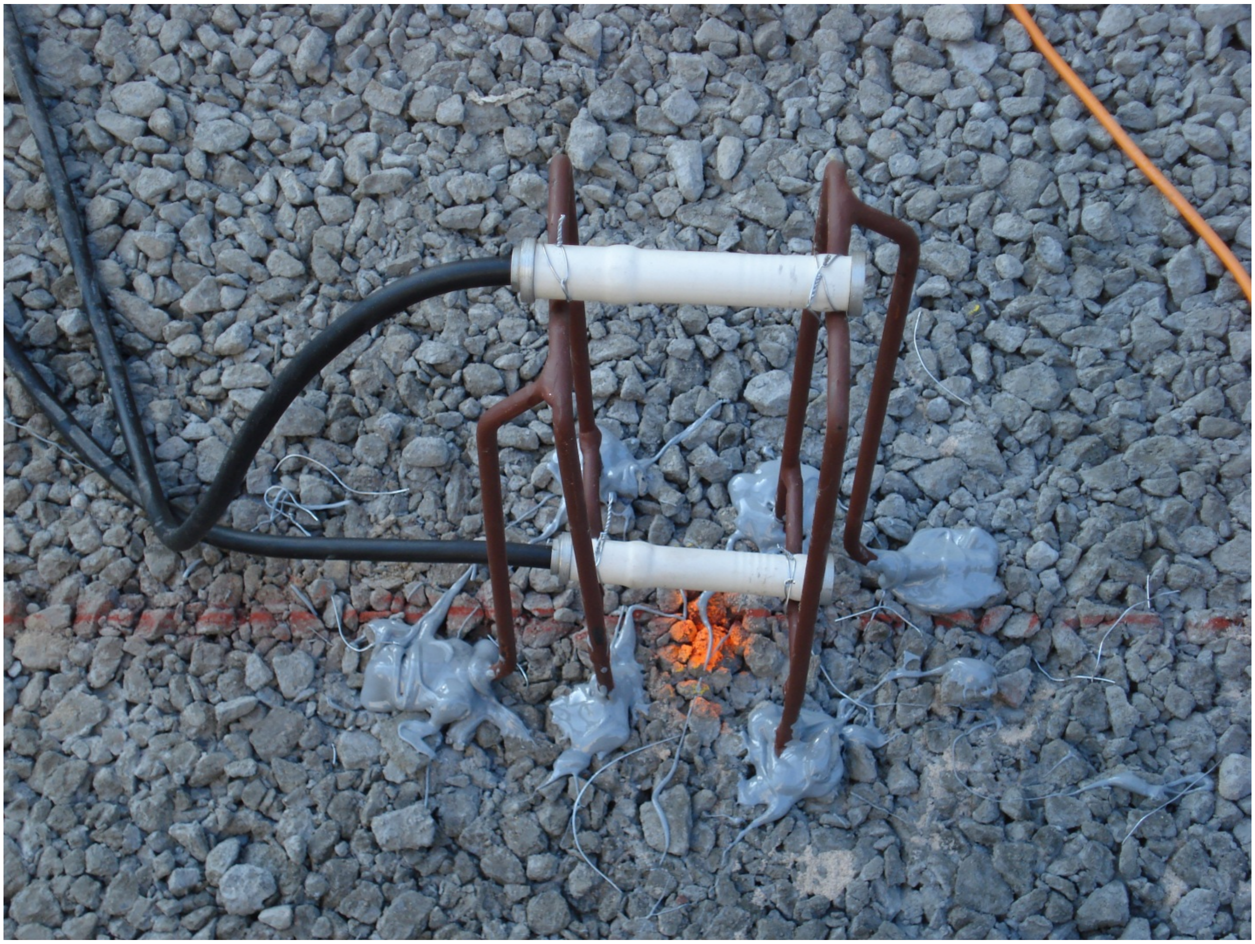

Figure 17 KMB Strain Gauges Attached to Stands

The electromagnetic coils used for the vibrating wire strain gages were secured onto the steel anchor with a steel clamp in such a way that the lead wire would be pushed in the direction of the coil by the paving operation. Care had to be taken to assure that the coil is affixed in such a way to allow overall maximum coverage of the VWSG gauge. In general the gauges were oriented in such a manner so that the lead wires were pushed in the direction of the gauge by the paver.

From previous experience projects, it is known that forces exerted during paving are sufficient to move the sensors. Since a paver was not used in the this paving operation, LVDTs, thermocouples and strain gages, were protected by piling green concrete around them 15 minutes prior to concrete placement. An amount of concrete from a cement truck was dumped in front of the instrumented slabs. The concrete was shoveled by hand to the instrument location, and gently piled and vibrated around the instrument to assure consolidation. This process is continued until the instruments were completely covered with concrete. Researchers monitored the gauges continuously during the paving process to assure proper gauge operation.

5.3.8 Temperature Sensors

Temperature on the instrumented section was measured with thermocouples sticks. Individual sensors are located in the appropriate locations at different elevations to measure slab gradients. To properly position these sensors, a 6.4 mm (0.25 in) diameter round spike, approximately 380 mm (15 in) long, is driven into the base material. The sensors are then tied to the spike with plastic cable ties. Figure 15 shows a thermocouple assembly.

Figure 18 Thermocouple assembly

5.3.9 **LVDT Installation**

Prior to concrete placement, the LVDT pits were set in place, and the LVDTs wires are soldered to the extension cables. LVDT elevation was measured to the appropriate height. The LVDTs were mounted to the supplied brackets, which was securely anchored to the SLD. The LVDTs were set as close to the zero position as possible, this is was accomplished using the data acquisition system and adjusting the brackets. Care had to be taken in order not to move the SLD from its position or disturb the base. Once this was done and the pit was closed with the supplied brass caps. Figure 16 shows the finished section with all sensors set and ready for paving operations.

Figure 19 Finished instrumentation section

5.3.10 **Wire Management**

Once all the sensors were installed in their final location on the base, the wires from sensors on each slab were taped and taken to the location of the preinstalled conduits (Figure 17). The wire, which includes all wires form all sensors, was run through the conduits to the first pull-box installed. The final destination of the wires would be across the street, but to date the DOT had not contacted us to let us know when that location would be ready. Wire location services of New York City surveyed the location of the sensors and wires.

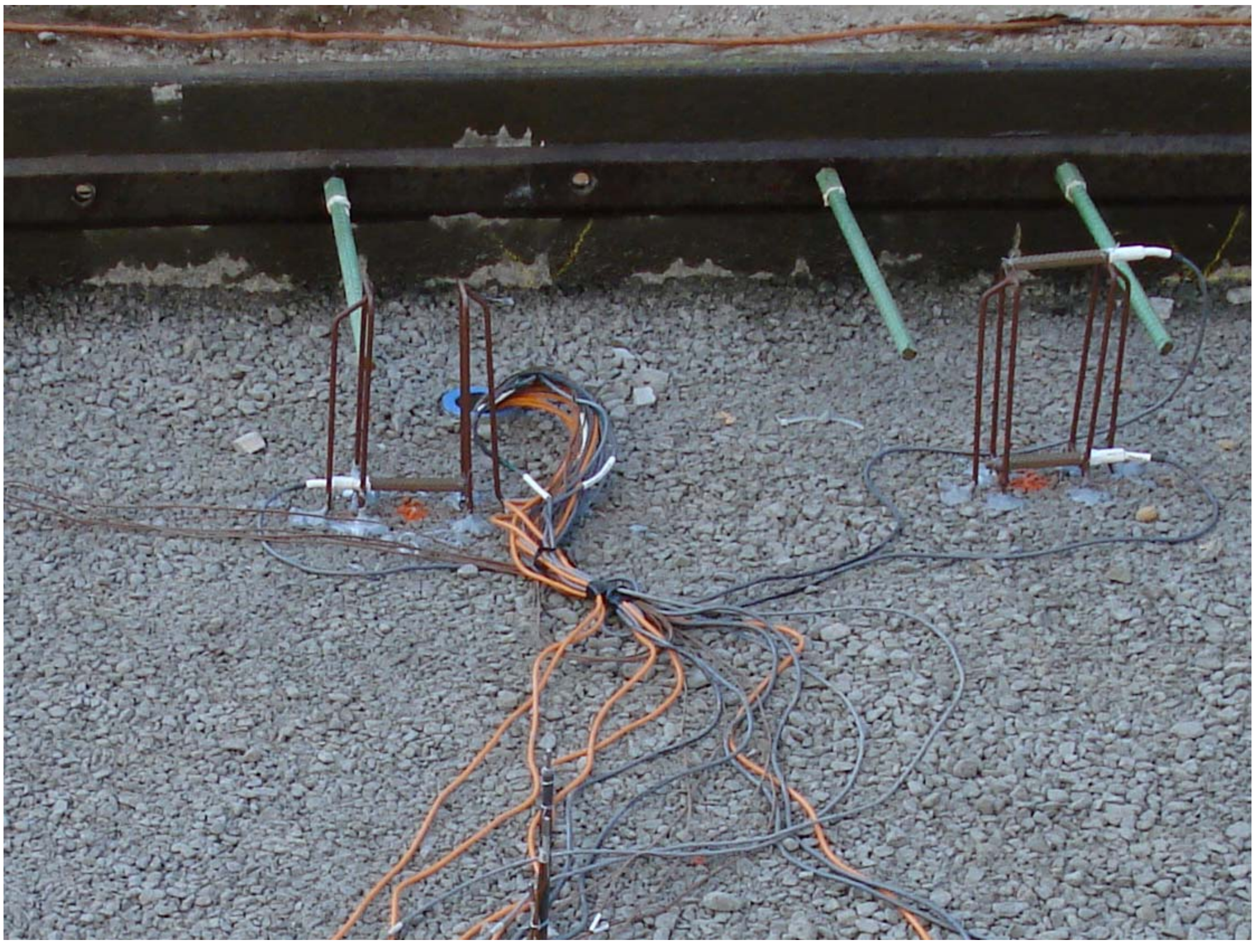

Figure 20 Wires going through the conduit.

5.4 Data Presentation

5.4.1 **Introduction**

Data collection from the LVDTs, Vibrating Wire Strain Gages, KMB transducers and the thermocouples was initiated prior to placement of the concrete on June 12th 2008 and continued for a 24 hour period, but due to the lack of power and proper storage had to be stopped. The next data acquisition trip was on August 7th and 8th 2008, during which FWD data and sensor data were collected. The next data acquisition trip was on December 10th 2008, when data were collected from the vibrating wire, thermocouples and LVDT data was collected. The trip was scheduled to also collect FWD data but the FWD machine did not function and the trip had to be further postponed. On April 28 2009, the last trip to the site, data from FWD and all other sensors was collected. The sections below give a summary of the data collected.

5.4.2 Concrete Properties

It was not possible to transport the samples the long distance to the ORITE laboratory at Ohio University for testing and also conform to ASTM standards. Instead, samples of concrete were collected and tested by the NYDOT for this project. Table 27 presents modulus of rupture test results from the 28 day old concrete beams conducted by the NYDOT.

Table 27. Concrete test results for RT9A (1 in = 25.4 mm, 1 lb = 4.45 N, 1 psi = 6900 Pa).

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BUREAU

FLEXURAL STRENGTH OF CONCRETE (USING SIMPLE BEAM WITH THIRD POINT LOADING) AASHTO T 97-03

			REPORT TO :	W. Cuerdon
AGE OF BEAM:	28	days	MEMO NO:	08P-45
SPAN OF BEAM, l:	18	in	TEST NO:	08SU-30-35

SPECIMEN ID	WIDTH, in				DEPTH, in				MAXIMUM LOAD, lb P	MODULUS OF RUPTURE, psi $R=Pl/bd^2$
	BOTTOM*	CENTER*	TOP*	AVERAGE b	BOTTOM**	CENTER**	TOP**	AVERAGE d		
08SU-30	6.05	6.05	6.00	6.0333	5.90	6.00	6.05	5.9833	6999	583.26
08SU-31	5.90	5.90	5.90	5.9000	6.10	6.15	6.15	6.1333	7086	574.68
08SU-32	6.10	6.20	6.30	6.2000	6.10	6.00	6.00	6.0333	7556	602.64
08SU-33	5.95	6.00	6.00	5.9833	6.35	6.30	6.20	6.2833	7095	540.63
08SU-34	6.05	6.15	6.10	6.1000	6.10	6.05	5.95	6.0333	7131	578.07
08SU-35	6.10	6.10	6.10	6.1000	5.95	5.95	5.95	5.9500	6566	547.28

* Designations BOTTOM, CENTER and TOP in WIDTH column indicate the width of the sample as positioned in the testing machine.
** Designations BOTTOM, CENTER and TOP in DEPTH column indicate the width of the sample as oriented during fabrication and curing. The specimen is turned on its side during testing. What was the width in the mold has become the depth in the testing machine.

5.4.3 Data Presentation

This section presents some of the data collected at the RT9A site at the time of construction in June 2008 and at the first data acquisition trip in August 2008. The data were collected from the sensors during the construction process and for a 24 hour period following as well as data collected during the subsequent August 2008 field trip.

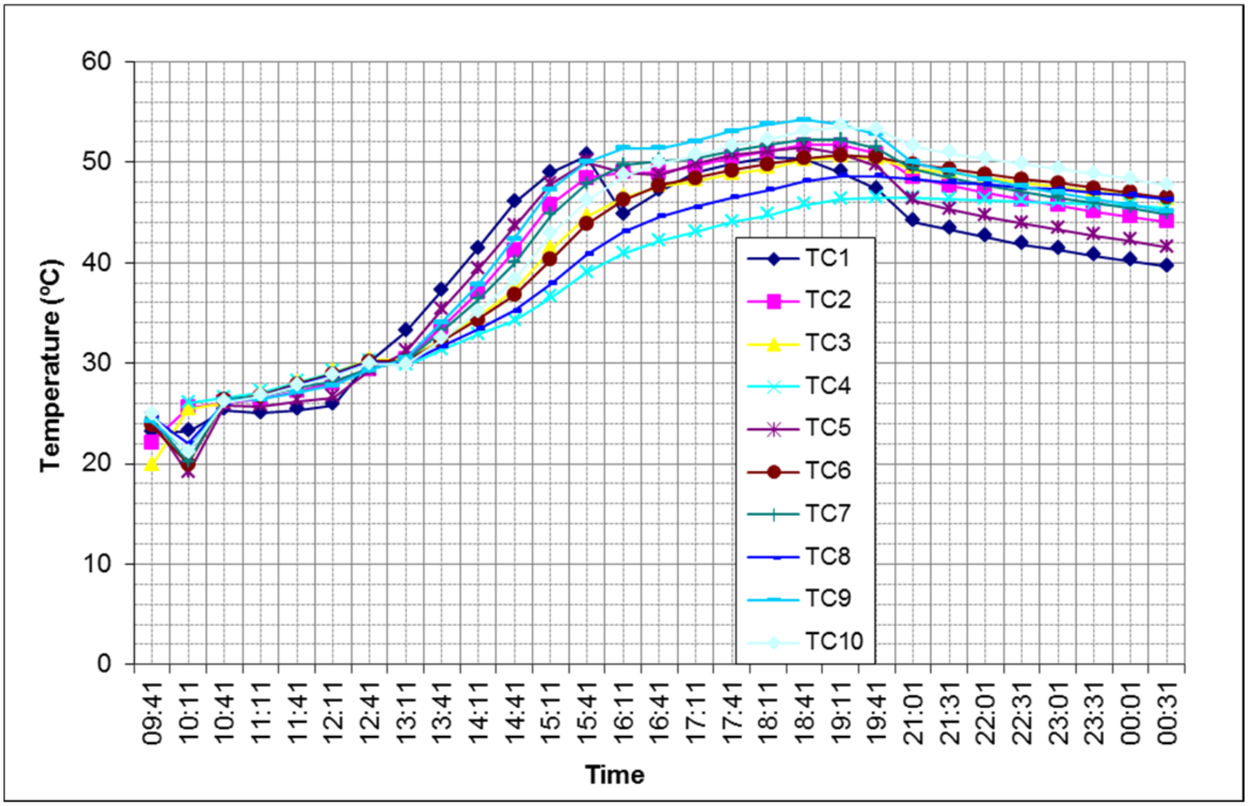

Figure 21 Thermocouple data prior to and following construction June 2008 (0°C = 32°F, 60°C=140°F)

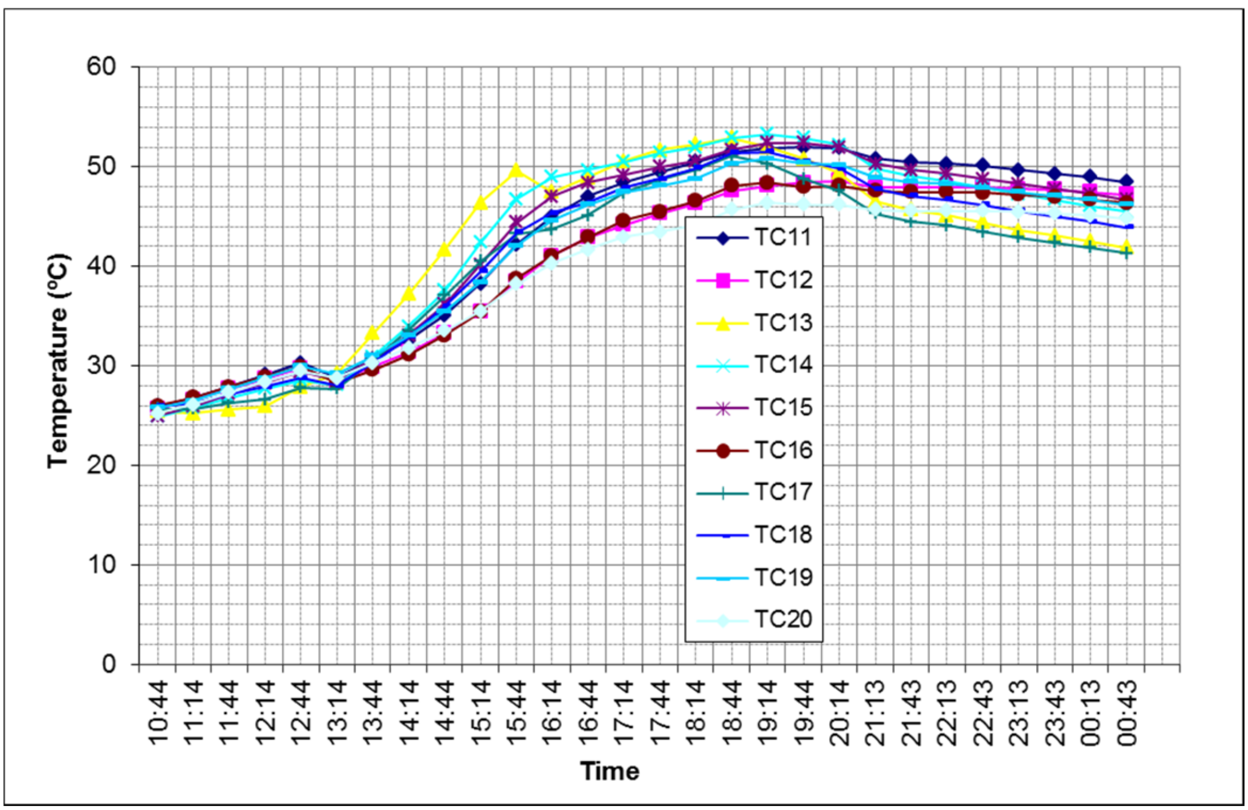

Figure 22 Thermocouple data prior to and following construction June 2008, cont. (0°C = 32°F, 60°C=140°F)

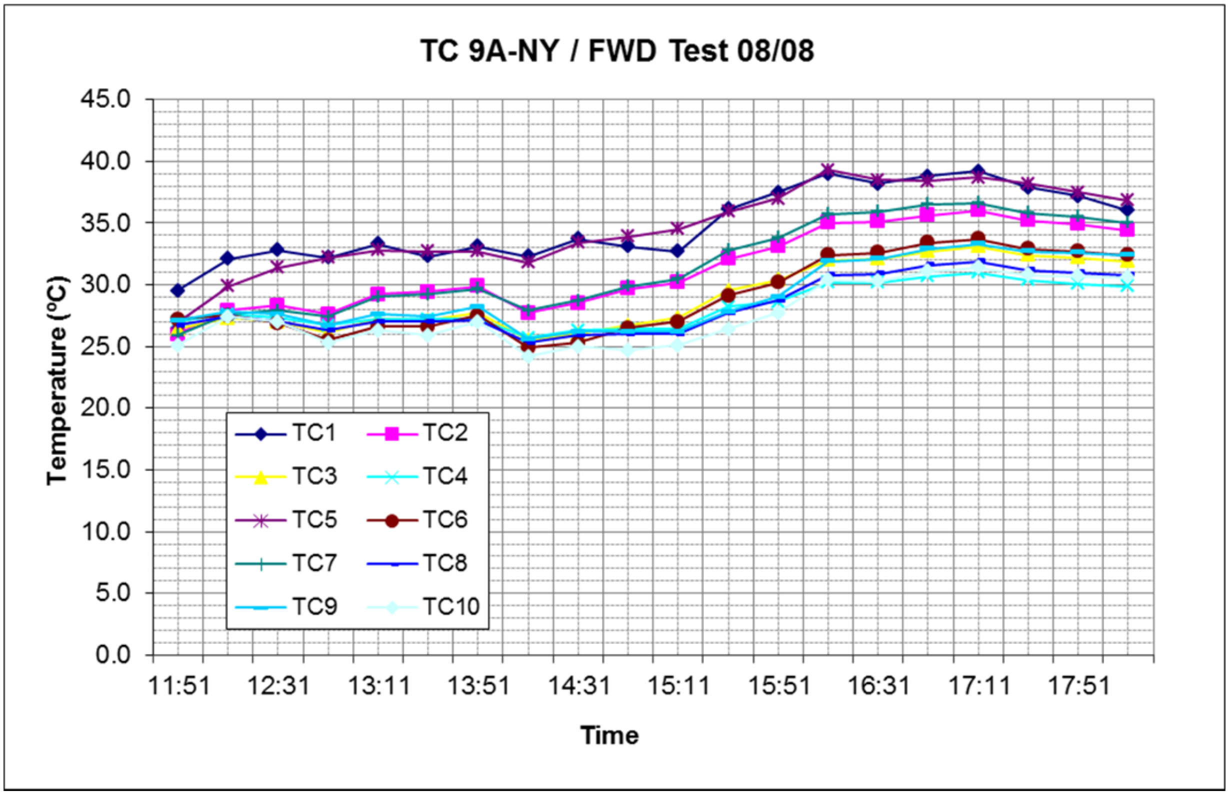

Figure 23 Thermocouple data during FWD testing, August 2008. (0°C = 32°F, 45°C=113°F)

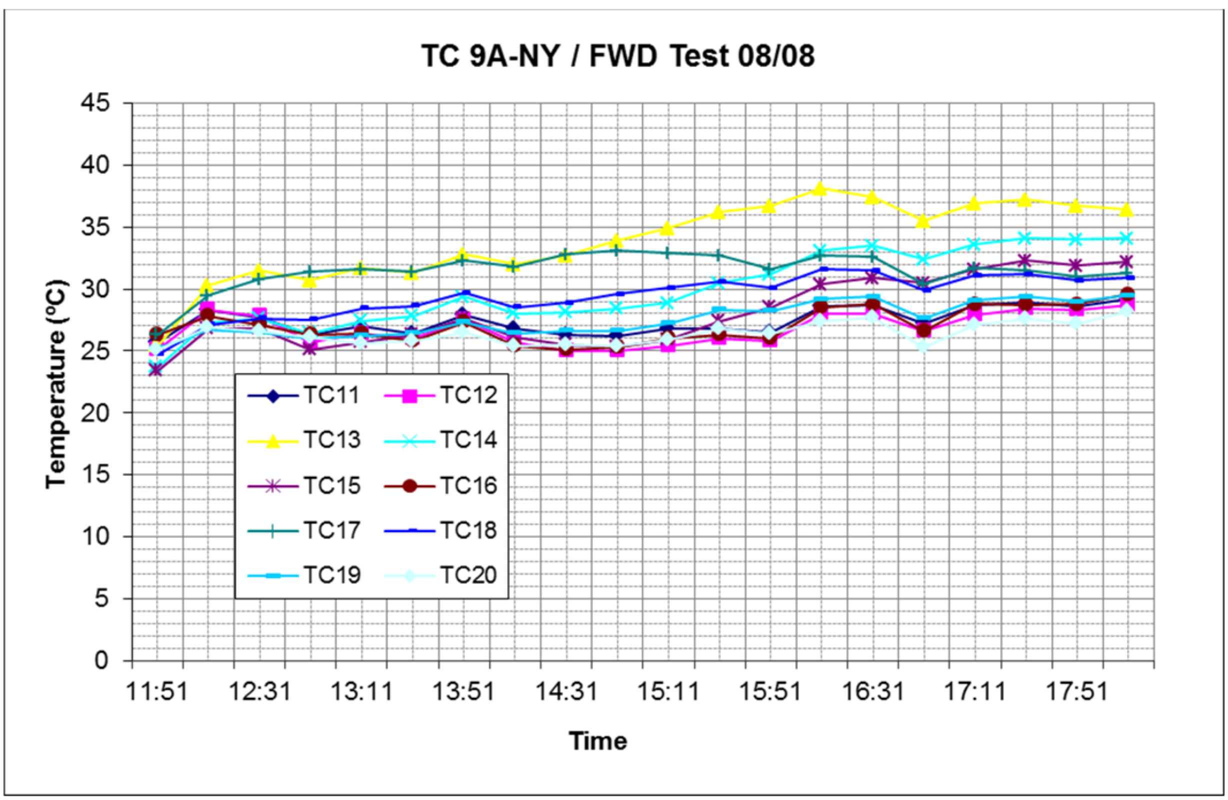

Figure 24 Thermocouple data during FWD testing, August 2008, cont. (0°C = 32°F, 45°C=113°F)

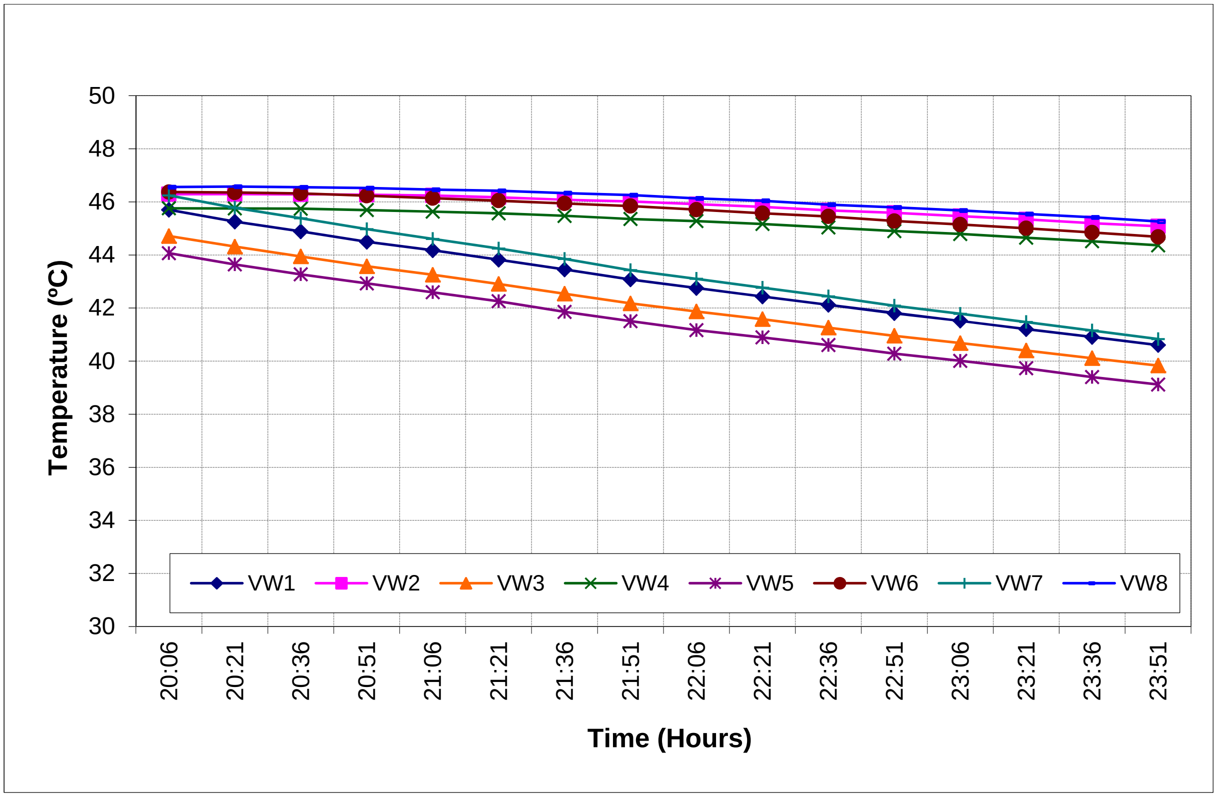

Figure 25 Vibrating Wire Sensor data during construction June 12, 2008 (34°C = 93.2°F, 48°C=118.4°F)

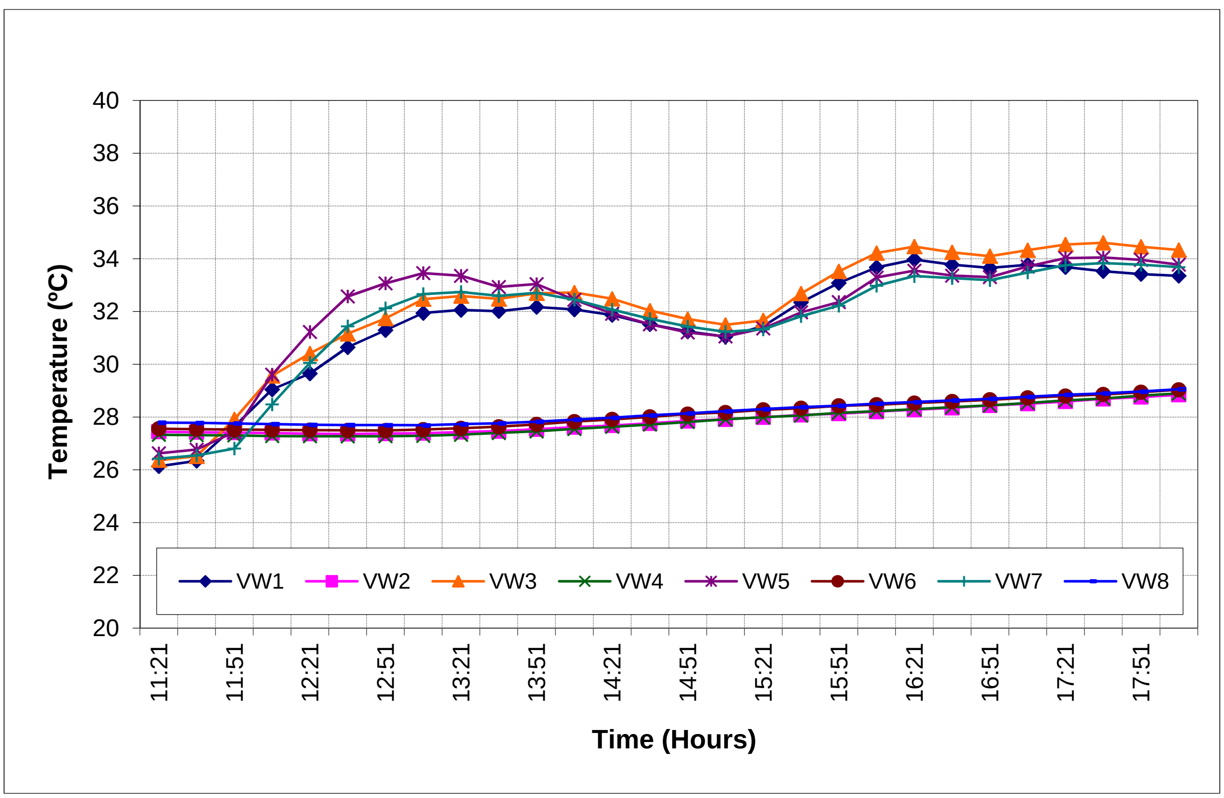

Figure 26 Vibrating Wire Data, August 7, 2008 (0°C = 32°F, 40°C=104°F)

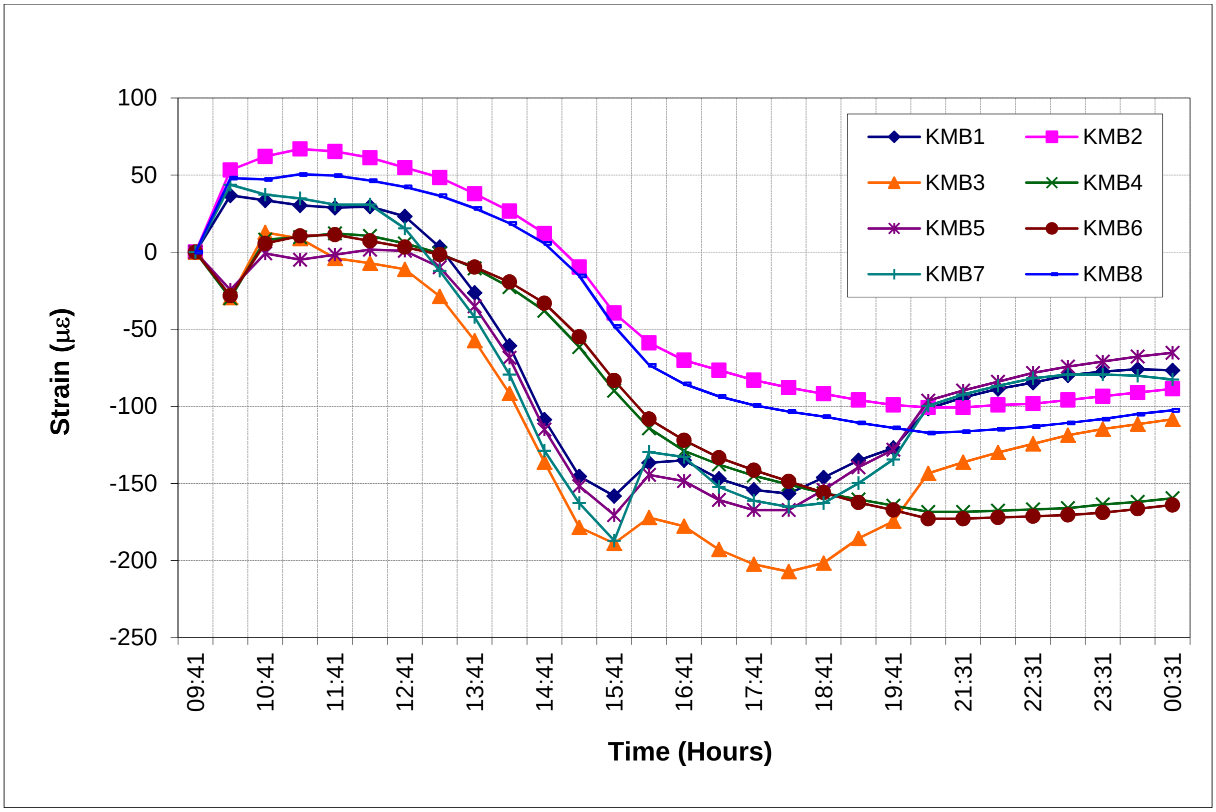

Figure 27 KMB Data during construction June 12, 2008

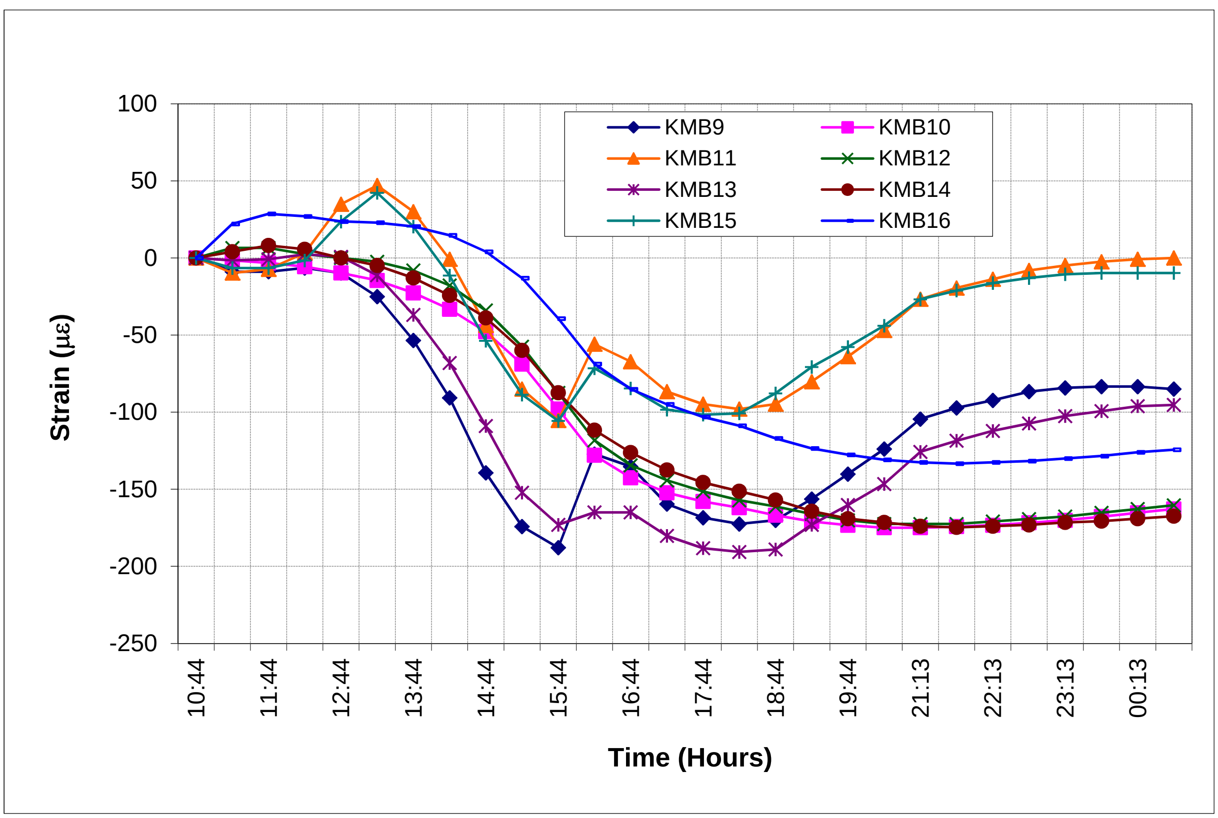

Figure 28 KMB Data during construction June 12, 2008 cont.

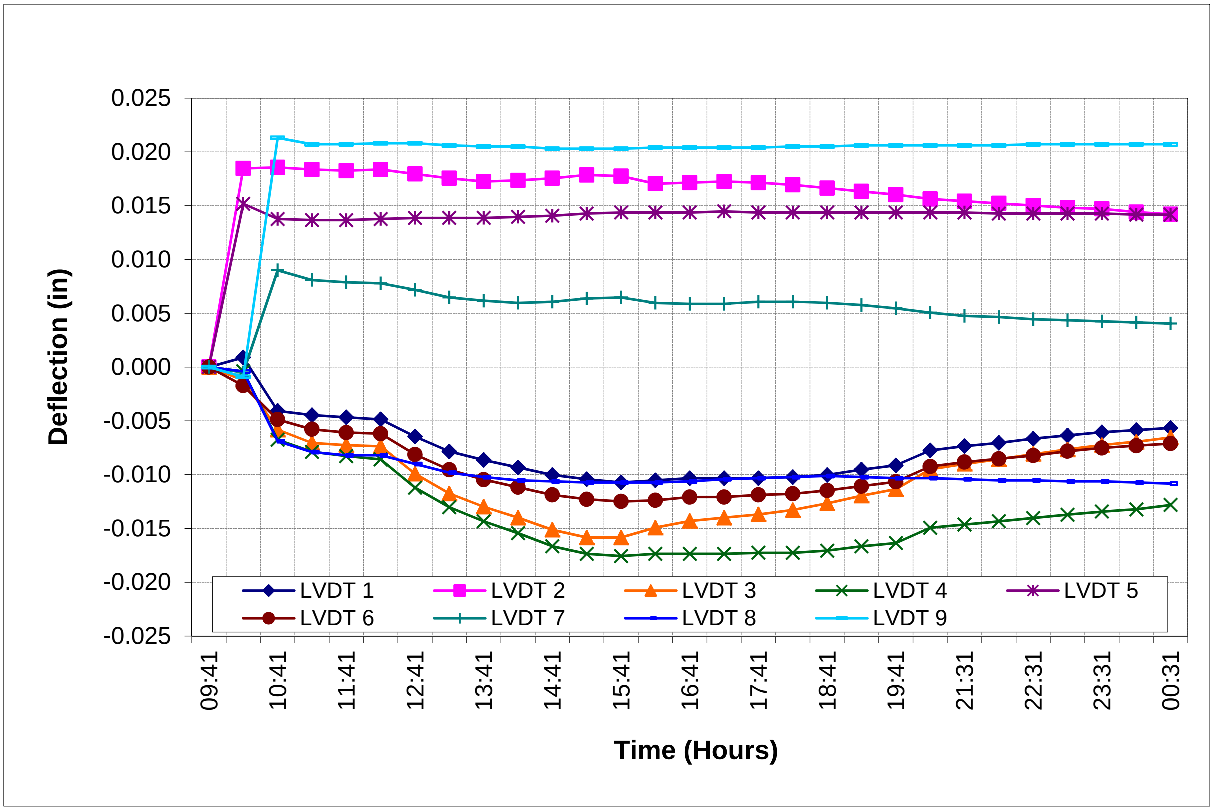

Figure 29 LVDT Data during construction June 12, 2008 (0.01 in = 0.254 mm)

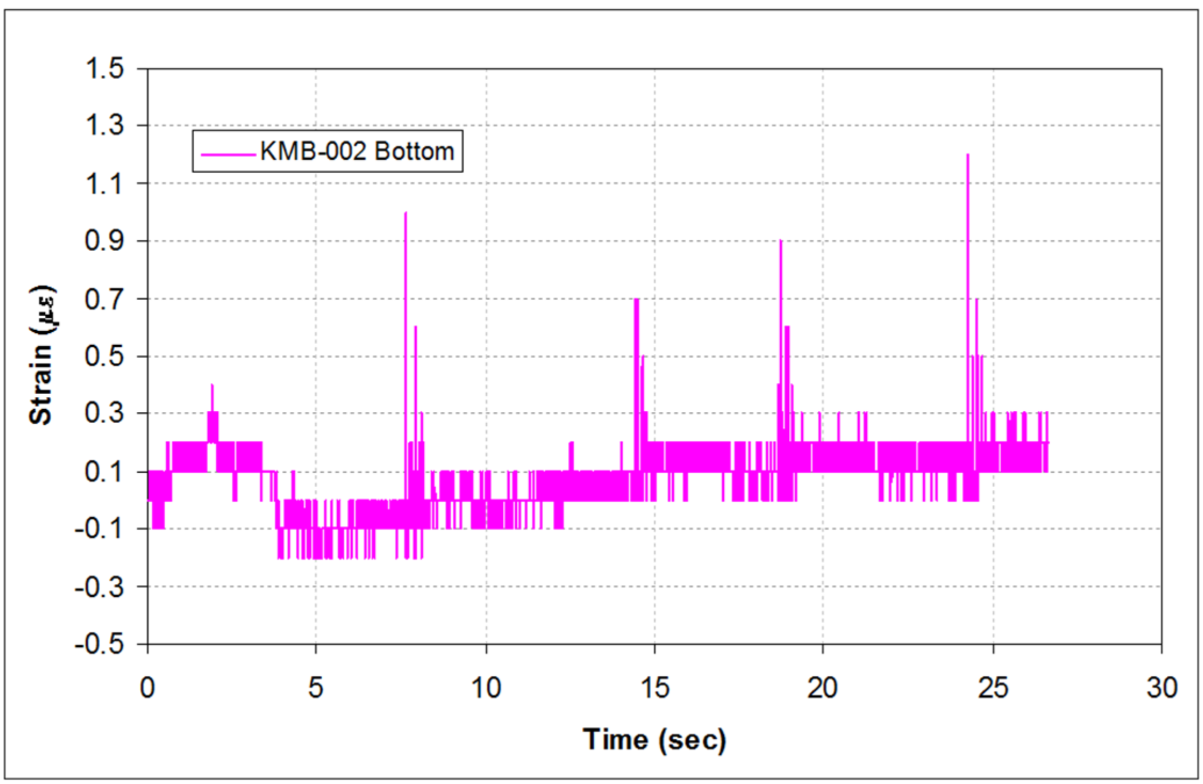

Figure 30 KM2 Response to FWD loading August 7, 2008

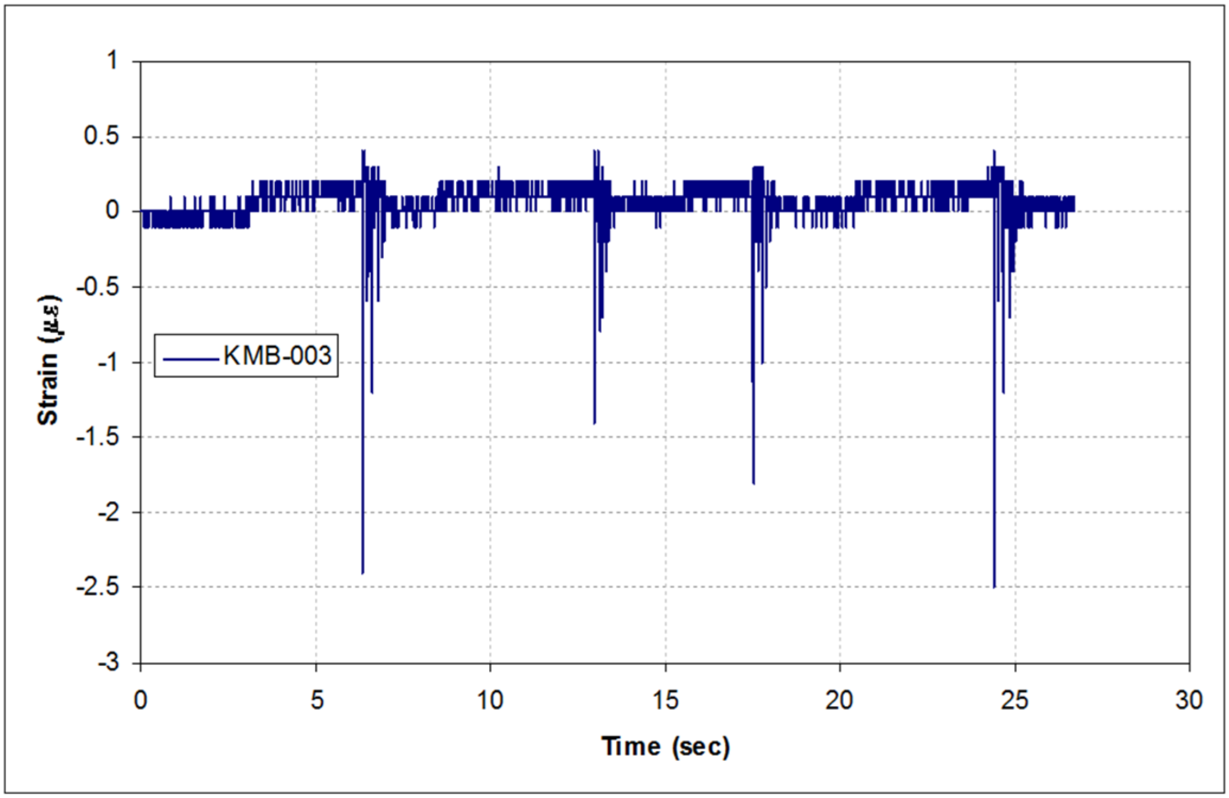

Figure 31 KMB3 response to FWD loading August 7, 2008

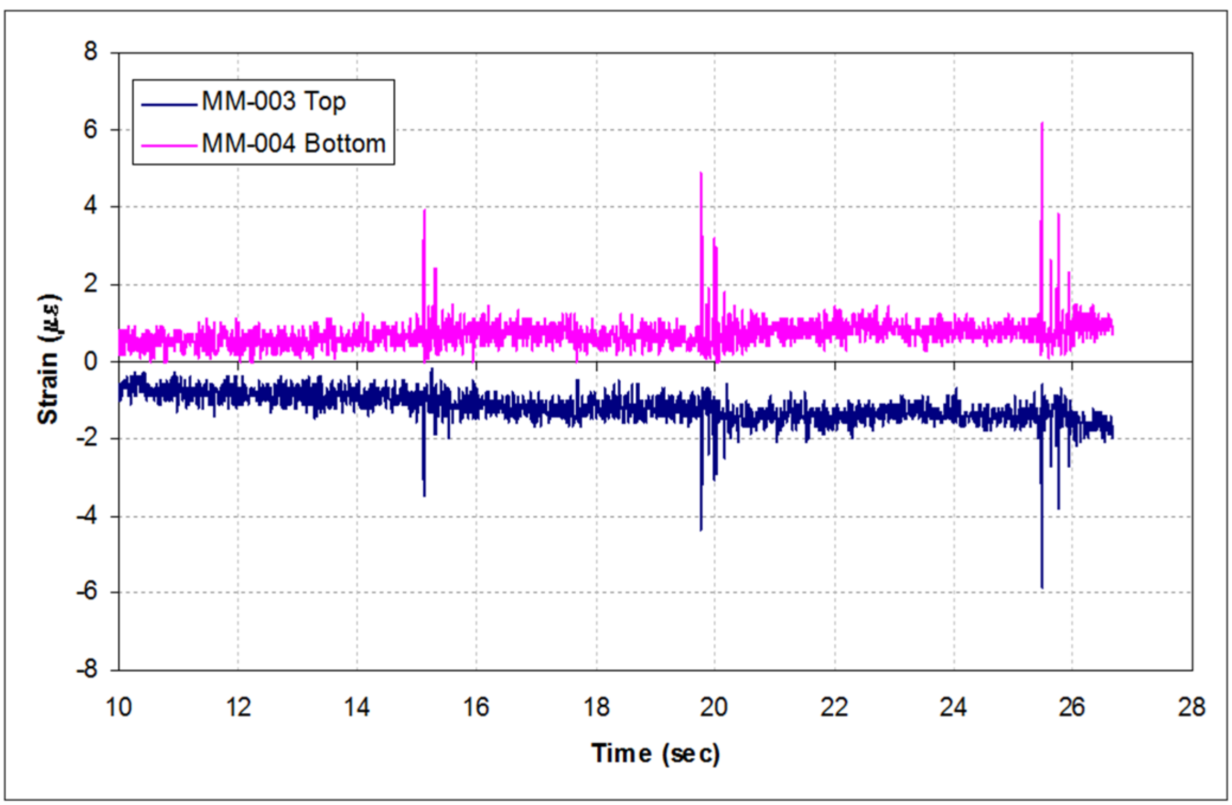

Figure 32 MM strain gage response to FWD loading, August 7, 2008

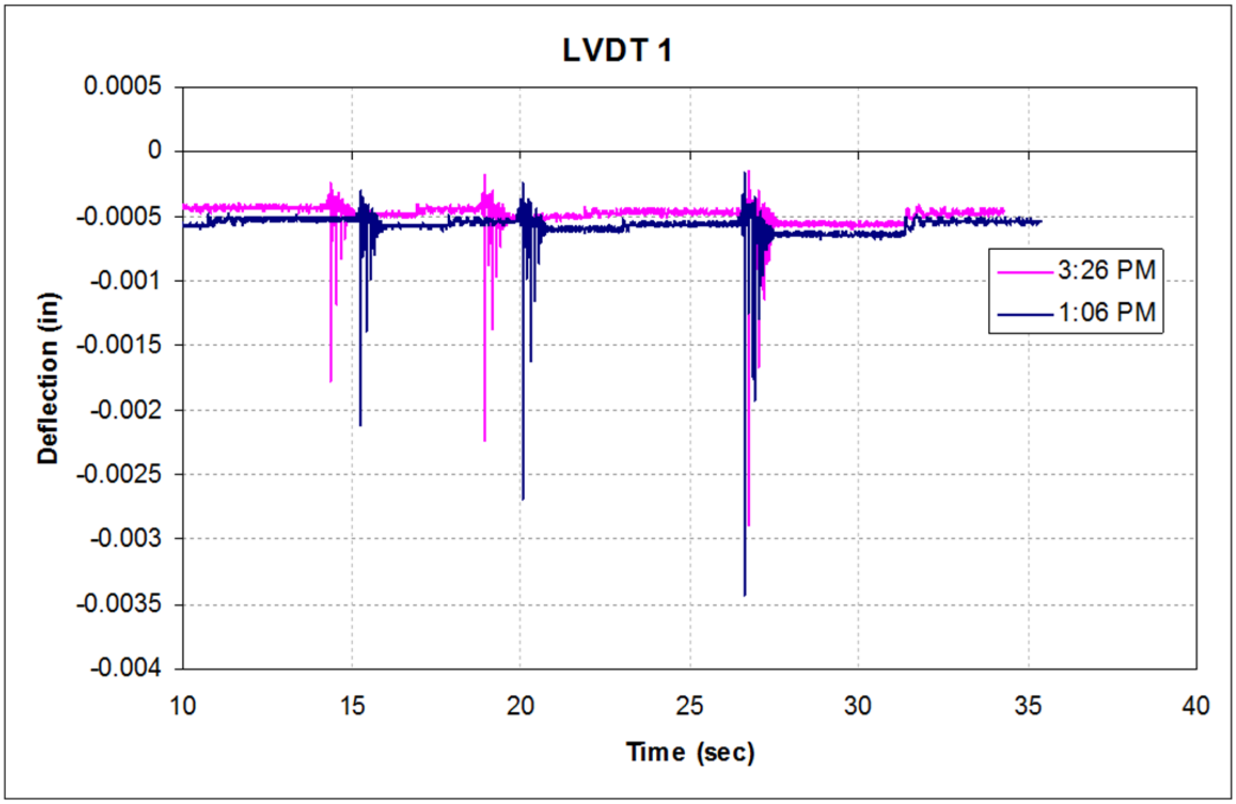

Figure 33 LVDT Response to FWD loading, August 7, 2008 (0.01 in = 0.254 mm)

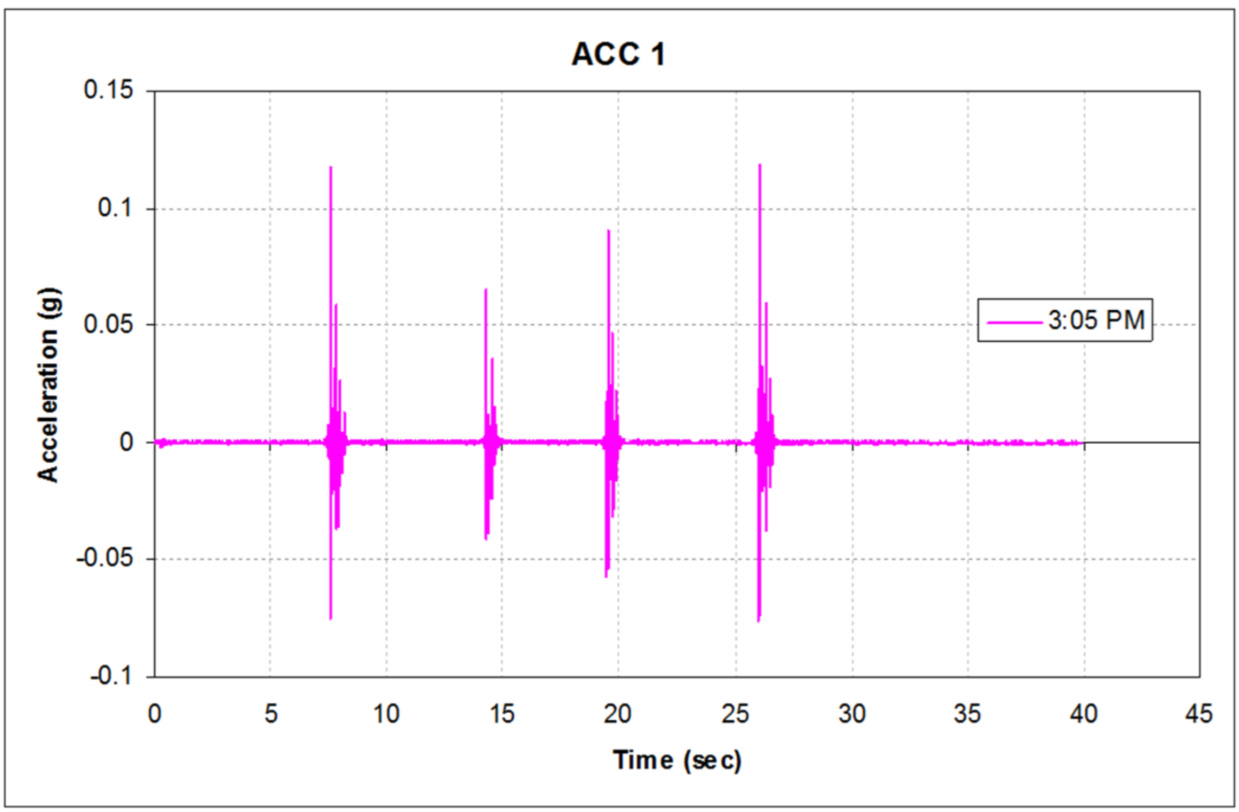

Figure 34 Accelerometer Response to FWD Loading August 7, 2008 (1g = 9.8 m/s^2 = 32 ft/s^2).

The data presented in this section represent the baseline data set for the RT9A project. This establishes the condition of the section immediately after construction and prior to heavy traffic and environmental effects. The temperature data for the first 24 hours established the baseline for measurement of curling and warping of the concrete slabs and gives the ability to calculate the built-in curling temperature of the slabs. The data response from the FWD loading establishes the condition of the PCC slabs prior to traffic loading. The deflection of 76 µm (3 mil) from the LVDTs and average strain readings of 3µε are within the range expected under a 71.2 kN (16 kip) load.

The subsequent data collection trip in December 2008 did not result in any data collected due to mechanical problems with the FWD machine. Environmental data collection had to be postponed since we were not given permission by the contractor and DOT to stay on site after the FWD left. During second data collection trip, April 2009, traffic to the mid-town tunnel had been routed on the test sections and traffic control was not possible. Falling Weight testing was conducted in traffic sporadically trough the morning. Trying to apply loads on precise location on the test sections with traffic behind the FWD equipment proved to be very challenging and after a few hours the FWD operator decided to abort the data collection for safety reasons.

5.5 RT9A Conclusions

Two test sections were successfully instrumented on RT9A (West Side Highway) in New York City, to study the effect of heavy loading on pavement with low weight fill. LVDTs, strain gages and thermocouples were installed to measure both the environmental effects on the pavement as well as the pavement response due too heavy loading. Initial data was collected during the construction process and immediately afterwards to establish a baseline from which further pavement analysis can be conducted. In subsequent data acquisition trips, mechanical issues and problems with traffic control prevented us from collecting full data sets that can be analyzed for pavement condition. In addition, the wires are still in a temporary pull box waiting to be transferred to the more permanent control box where long term data collection can take place.

6 Asphalt Pavement Sections on I86, NY

6.1Site and Instrumentation Description

Two asphalt concrete test section were instrumented on Interstate 86 in New York. The purpose of the instrumentation and monitoring of these sections was to validate the designs used by the NYDOT for these sections and to collect information from these test section to assist in the validation and calibration for the Mechanistic-Empirical Pavement Design Guide (MEPDG).

The first section was instrumented as part of the reconstruction of I86 East bound close to the PCC sections, and the second section was designed as a perpetual pavement section was later instrumented further west on I 86. Figure 35 depicts the location of both asphalt instrumentation sections.

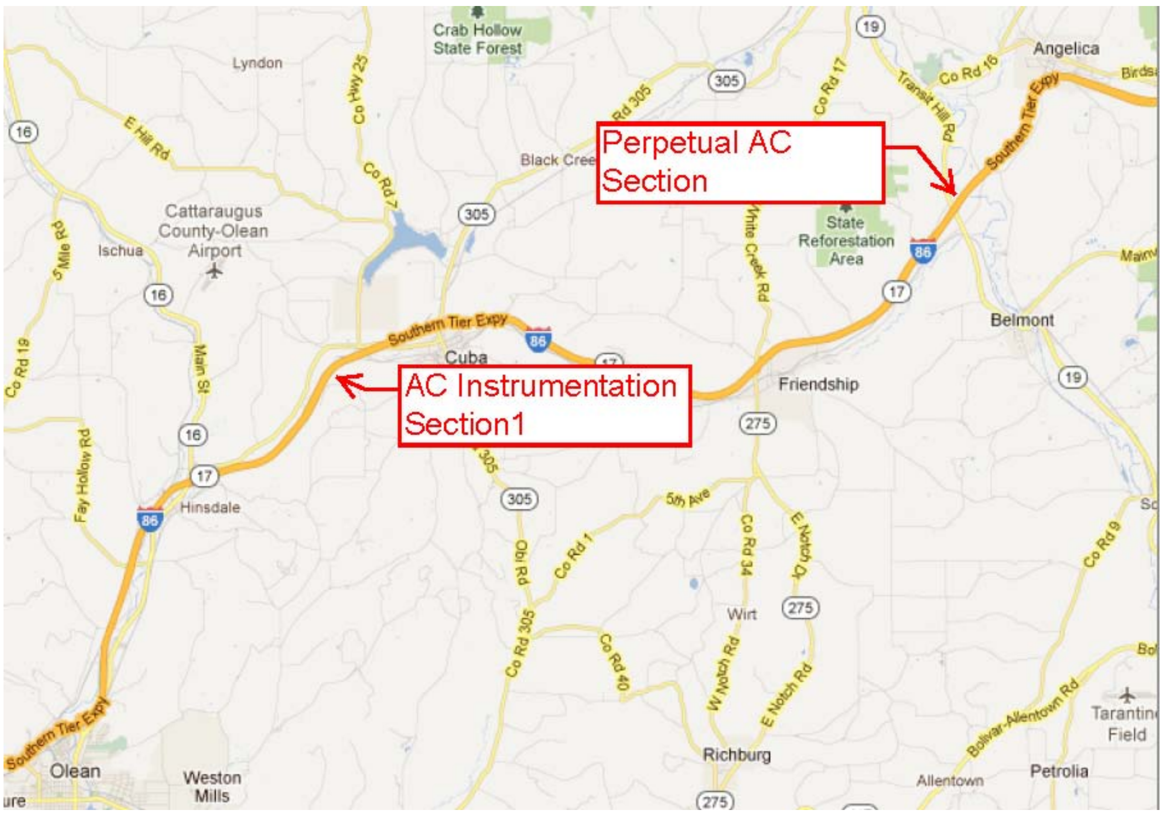

Figure 35 Location of AC instrumentation section on I86. (From Google Maps 2012)

The PCC sections were placed as part of the reconstruction of I86. The project design was placement of 205 mm (8 in) of asphalt pavement on top of rubblized existing PCC. One section east of the PCC sections was chosen to be instrumented. The instrumentation for this section is shown in Figure 36.

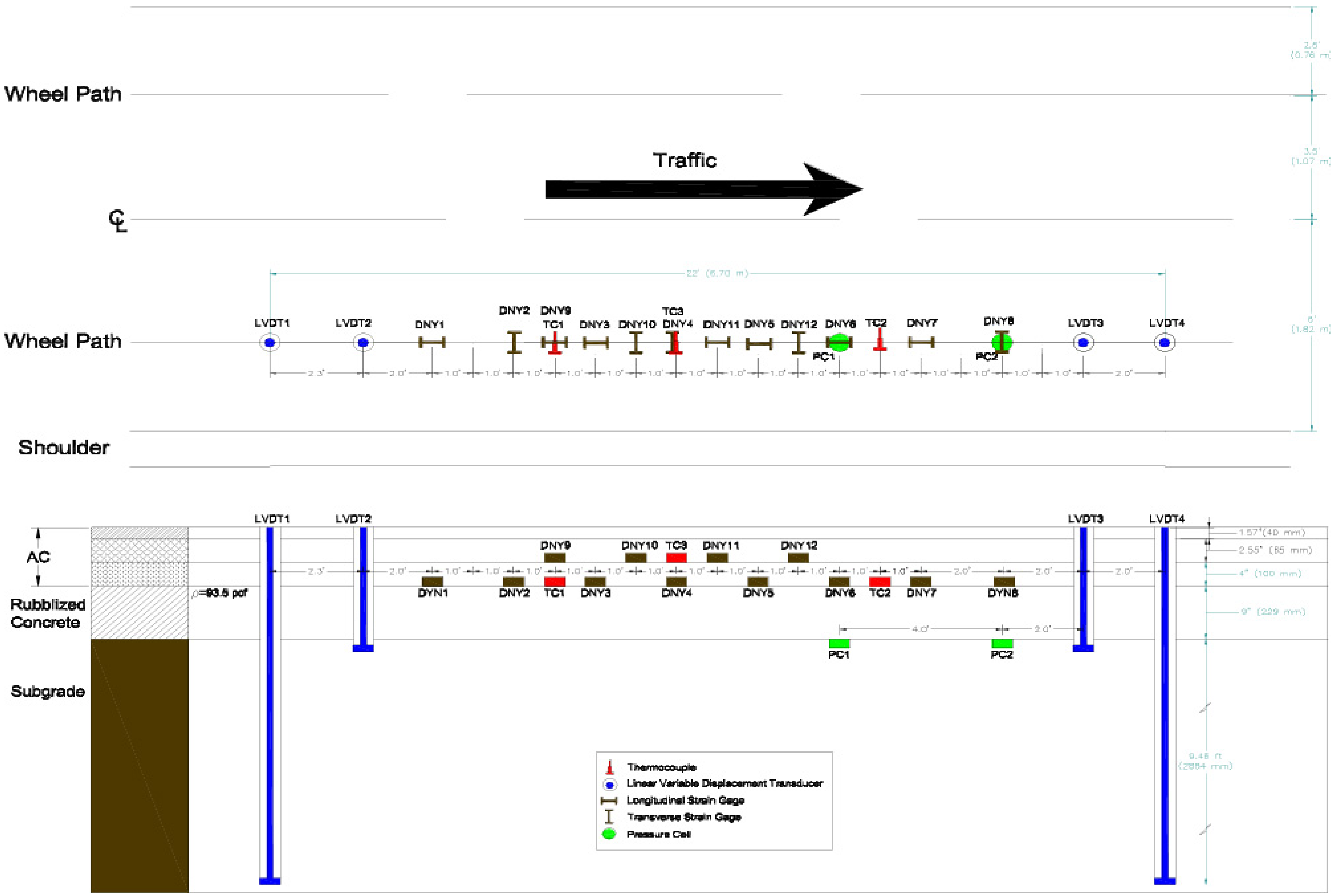

Figure 36 I86 AC Section 1 Instrumentation

The asphalt concrete perpetual pavement section on Interstate 86 is located approximately 5 km (3 mi) west of Angelica, New York. The perpetual pavement is built on an existing Portland Cement Concrete (PCC) of 229 mm (9 in) thick which was rubblized. The new structure is composed of 4 layers of Asphalt Concrete (AC): the first layer, above the rubblized concrete, is 100 mm thick (3.94 in); the second and the third layers are each 50 mm (1.97 in) thick; and finally, the surface course is 40 mm (1.57 in) thick. The perpetual pavement section instrumentation plan and profile views are shown also in Figure 37.

Both sections have four LVDT's, two pressure cells (PC), thermocouples (TC), and strain gages. The reference points for the deep LVDTs (LVDT1 and LVDT4) is located approximately 3.35 m (11 ft) below the surface course; the other two shallow LVDTs (LVDT2 and LVDT3) have their reference point just below the rubblized concrete. Strain gages were installed at the bottom of the first AC layer, 0.61 m (2 ft) apart from each other; in addition thermocouples were also installed. Similarly, above the first layer of asphalt concrete a second set of sensors were installed. Figure 38 shows Dynatest strain gages, thermocouples and PMF strain gages ready for installation at the Angelica site. Layout lines were drawn on the base to indicate the desired location for the sensor. Prior to the asphalt paver passing over the sensors, an amount of asphalt was used to embed the gages as shown in Figure 39. This hot asphalt was also compacted so that the gages would not move once the paver went over the location of the gages. The paver was then allowed to pass of the area of the sensors. Rolling compactors were then used to achieve the required asphalt density on the sections. Figure 40 shows the paving operation on I 86.

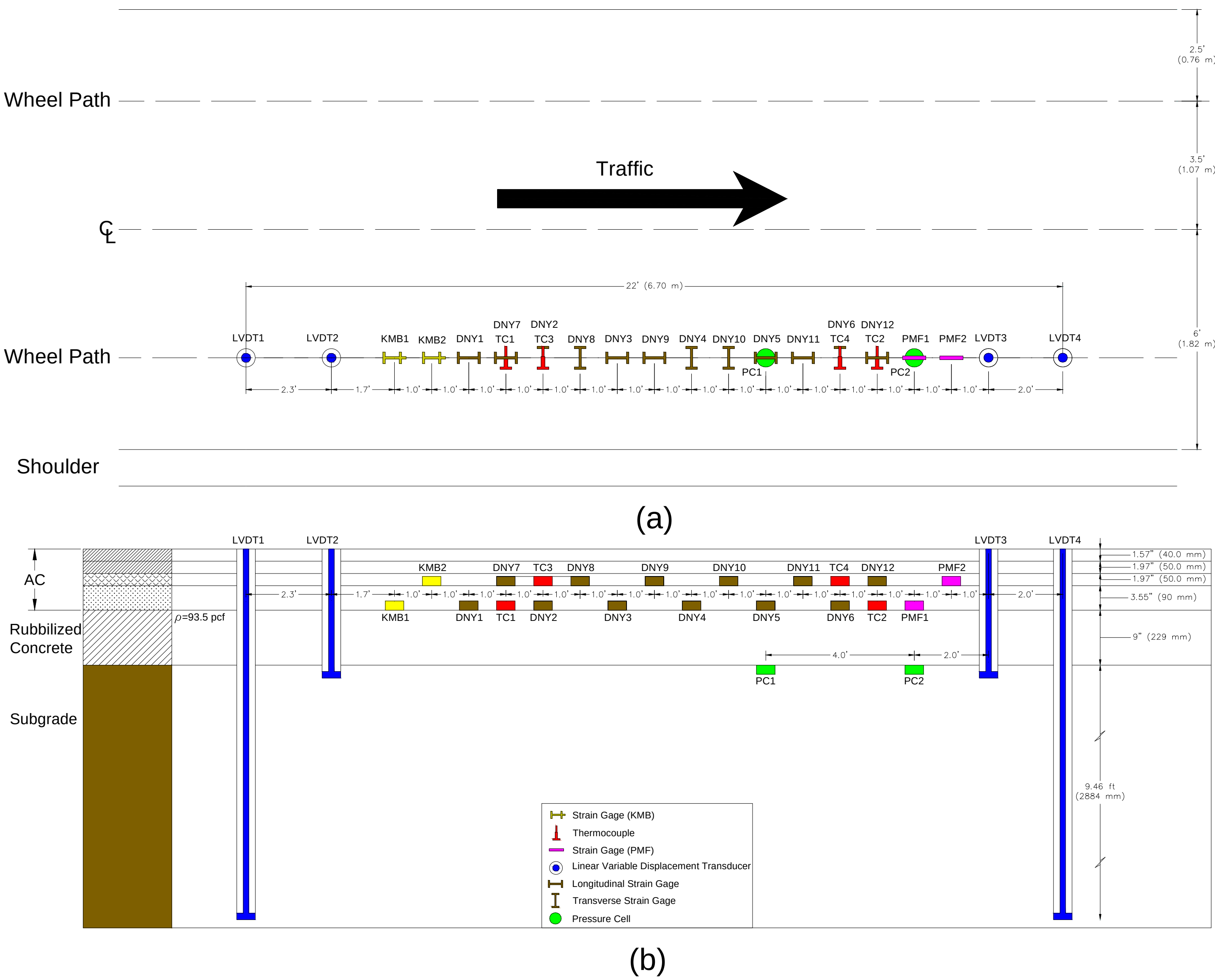

Figure 37 Perpetual pavement section I86 Angelica (a) Plan view of instrumentation; (b) Profile view of instrumentation


Figure 38 Sensor installation on first AC layer


Figure 39 Gauges embedded in Asphalt

Figure 40 Paving Operation on I86

6.2 Data Collection and Testing

The first AC test section was instrumented in the July and August of 2006. The LVDTs were installed in November of 2006 at which time the first Falling Weight Deflectometer tests were conducted. Data from this site was subsequently collected in March 2007, October 2007, May 2008, October 2008, May 2009, June 2010, and finally in August 2011. Longitudinal cracks were documented for this section starting with the March 2007 visit. Strain gage data was collected for the November 2006, March and October 2007 trips, but in subsequent data collection trips, gages closer to the surface were no longer functioning due to fatigue failure, but FWD data collection continued. Typical strain gage plots from November 2006 and October 2007 are shown in Figure 41, through Figure 43. Figure 41 shows the response of DYN 4 to impact loading by FWD. The NYDOT FWD equipment applied 4 seating drops prior to applying the three actual load drops. Figure 41 shows the complete loading cycle. Figure 42 shows the same data but with only the last load of 62.3 kN (14,000 lb). It should be noted that the pavement temperature for the November 2006 and October 2007 tests was approximately 21°C (70ºF).

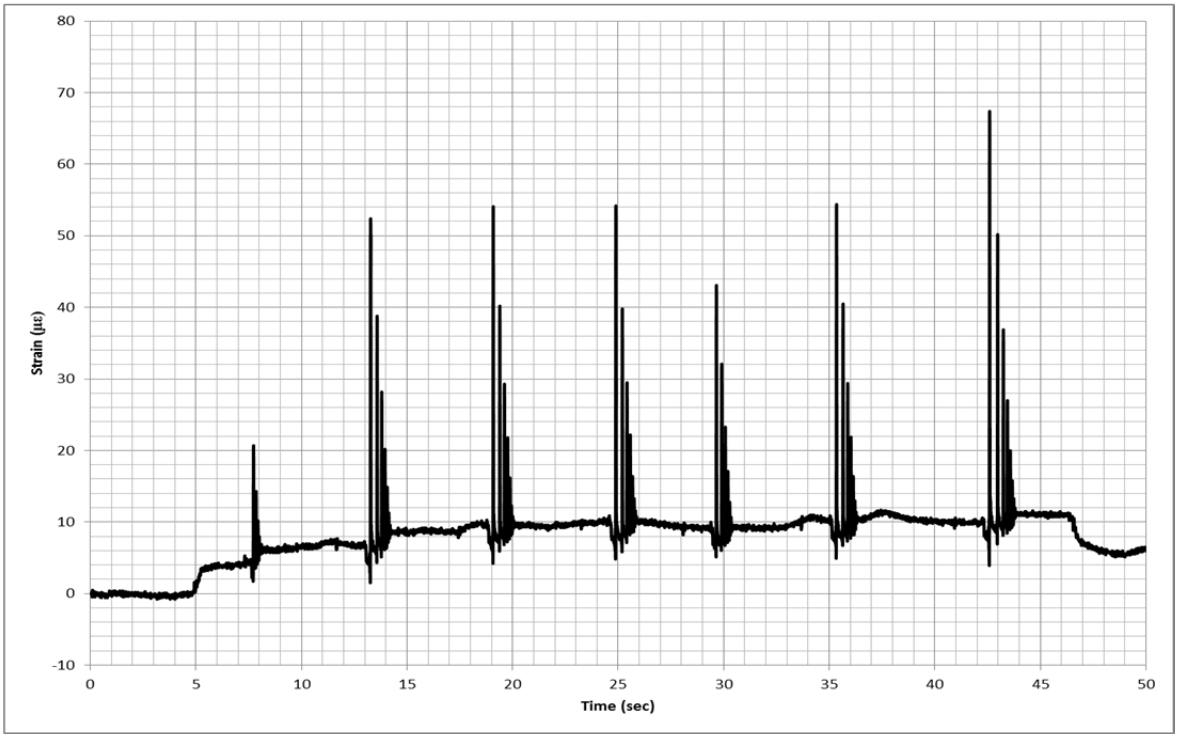

Figure 41 DYN4 response to FWD loading, Nov 2006 Test.

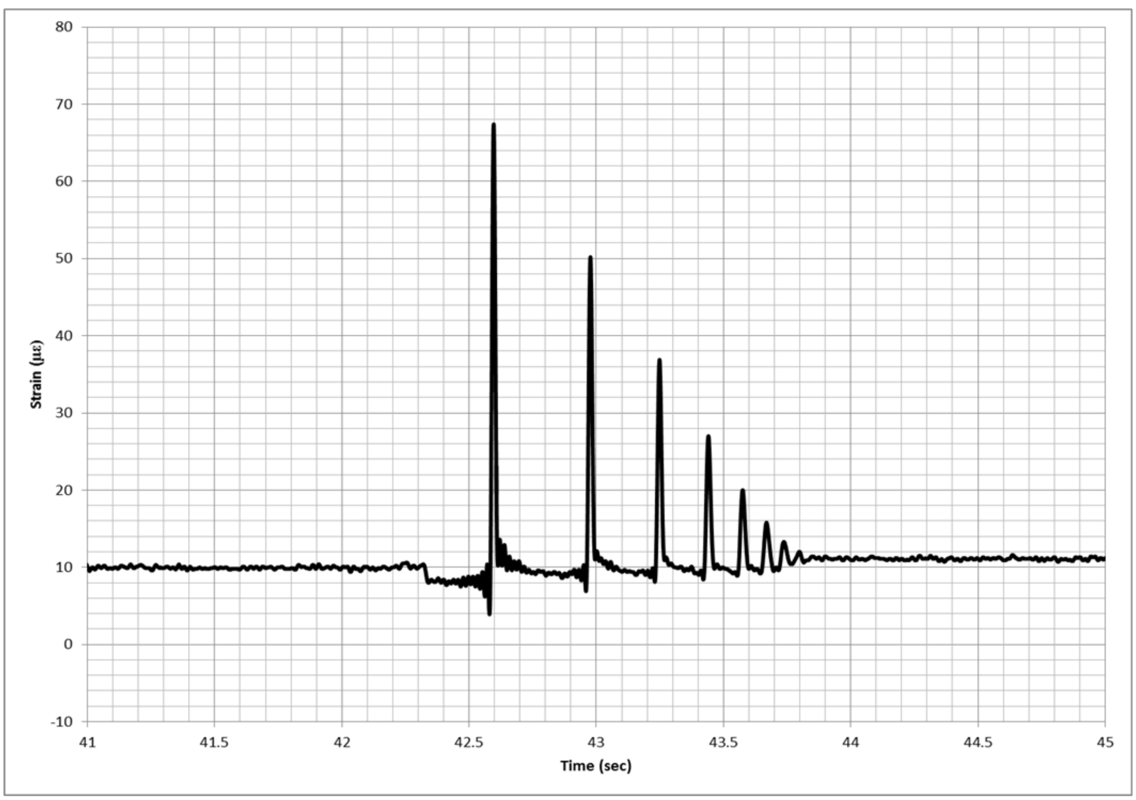

Figure 42 DYN4 response to FWD testing, Nov 2006 test, 14,000 lb. load.

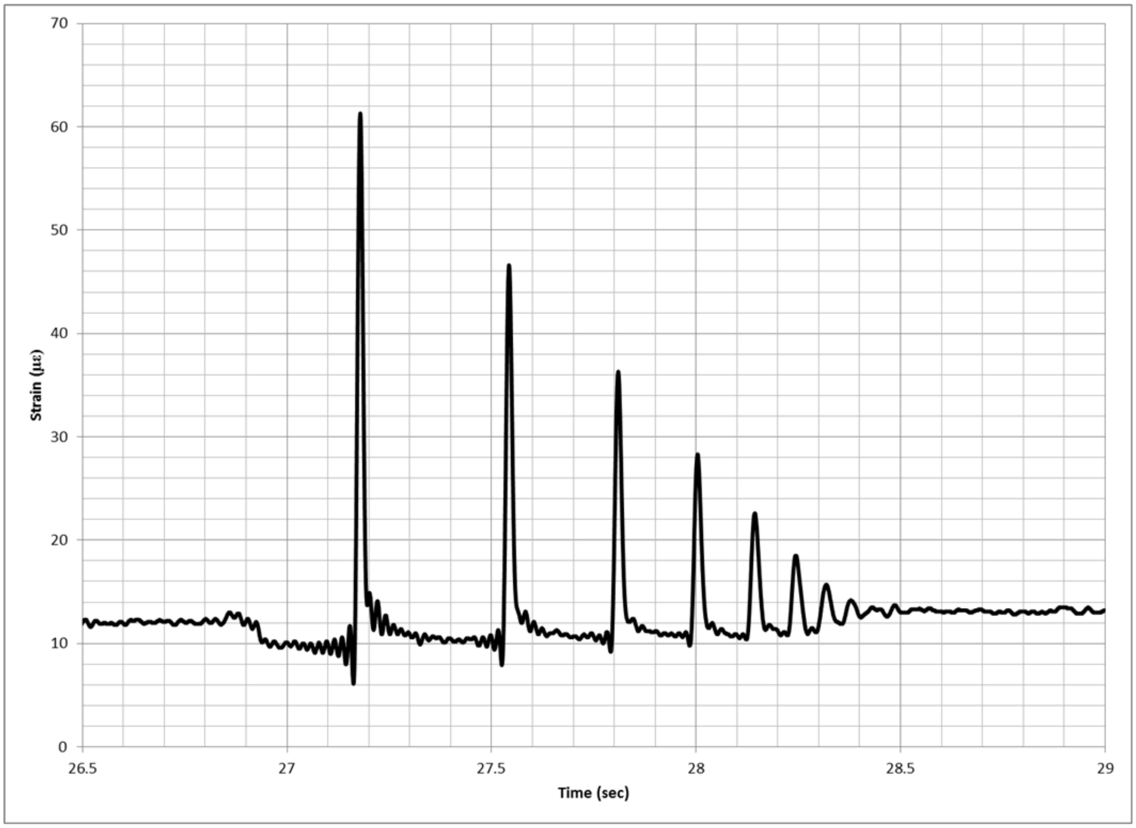

Figure 43 DYN3 Response to FWD testing, October 2007.

As previously mentioned, Falling Weight Deflectometer testing was performed on the test section on a regular basis. In addition to applying loads on the sensor location, FWD loading was applied at 30.5 m (100 ft) intervals. Figure 44 shows the maximum deflection, both with SI and English unit, from the FWD loading on the section for the August 2011 testing. This test shows typical deflection results for the first test section.

The perpetual AC test section was instrumented in September 2008, and the first set of Falling Weight Deflectometer (FWD) tests was performed prior to opening the road to traffic in October 2008. The data collection included FWD drops on the sensor locations to collect data. Since then regular visits to inspect and collect FWD and sensor response have been conducted. In August of 2011 the ORITE and NYDOT team conducted a set of tests on this pavement section. Distress survey of the section showed no distresses and no measureable rutting on the section. Fourteen of the 16 strain gages initially installed were functioning properly, as well as all LVDT's, pressure cells and thermocouples. Falling Weight Deflectometer testing is conducted on a 152.4 m (500 ft) section adjacent to the test section. In addition FWD loading was applied on the location of the strain gages. Results from the strain gage response from the initial test in October 2008 and the last test in August 2011 are shown in Figure 45 through Figure 48.

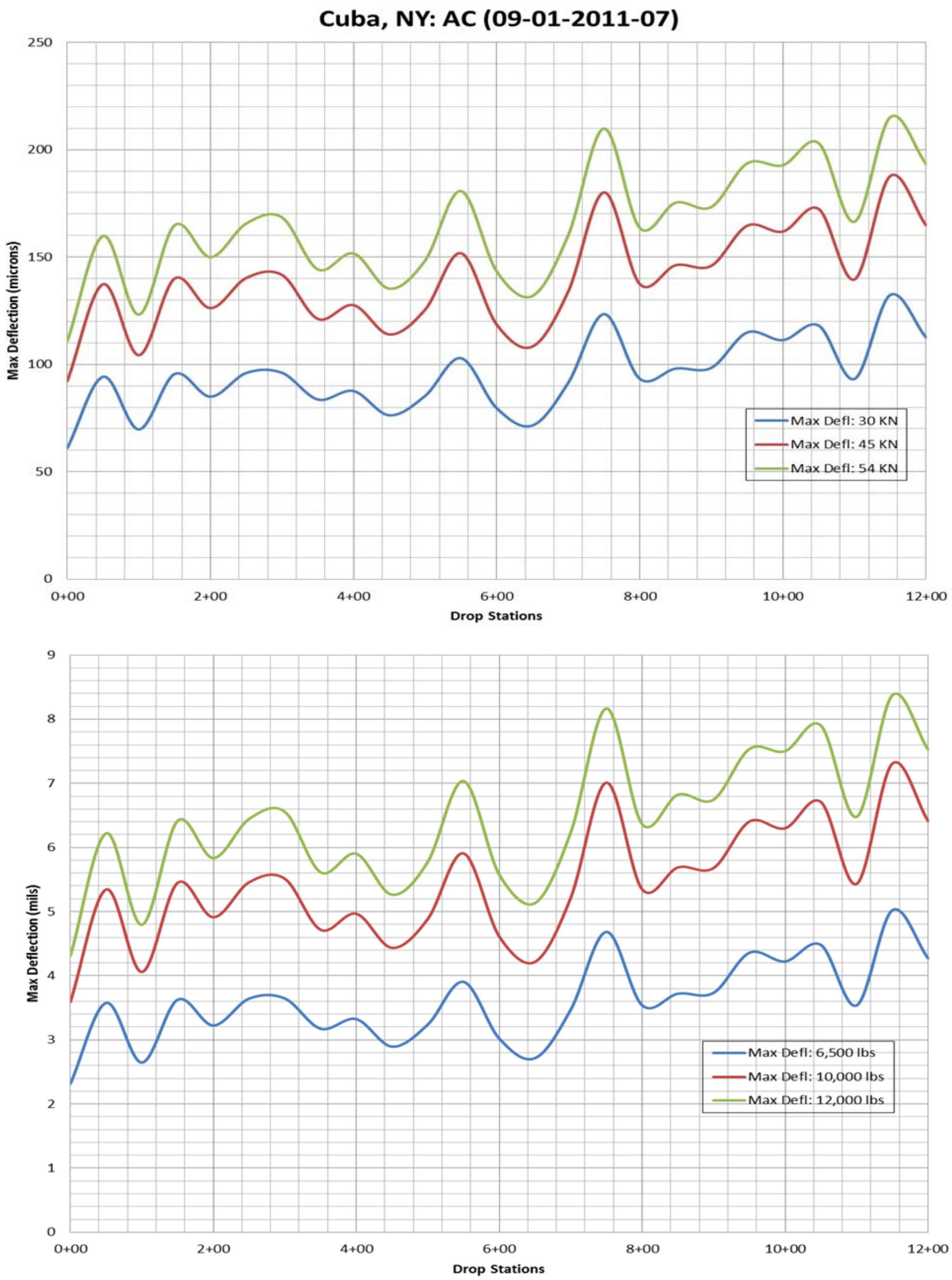

Figure 44 Maximum Deflection from FWD Testing August 2011, AC Section (SI units at top, English units at bottom)

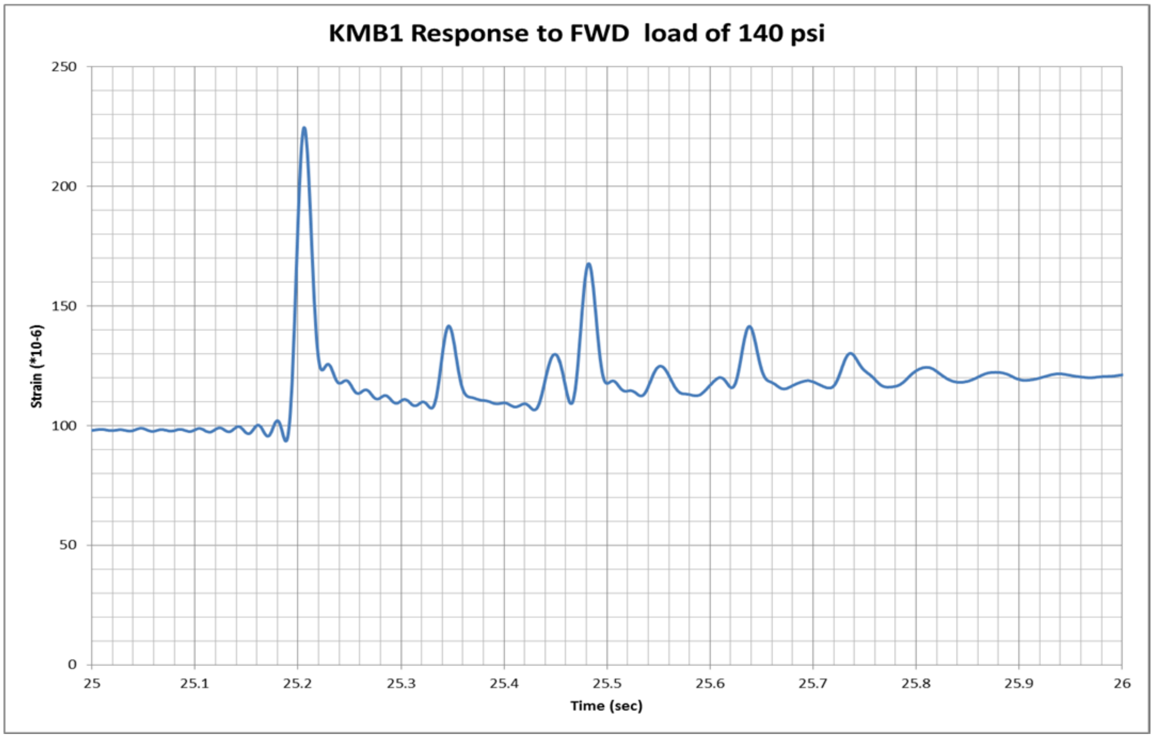

Figure 45 KMB1 Response to FWD Load October 2008

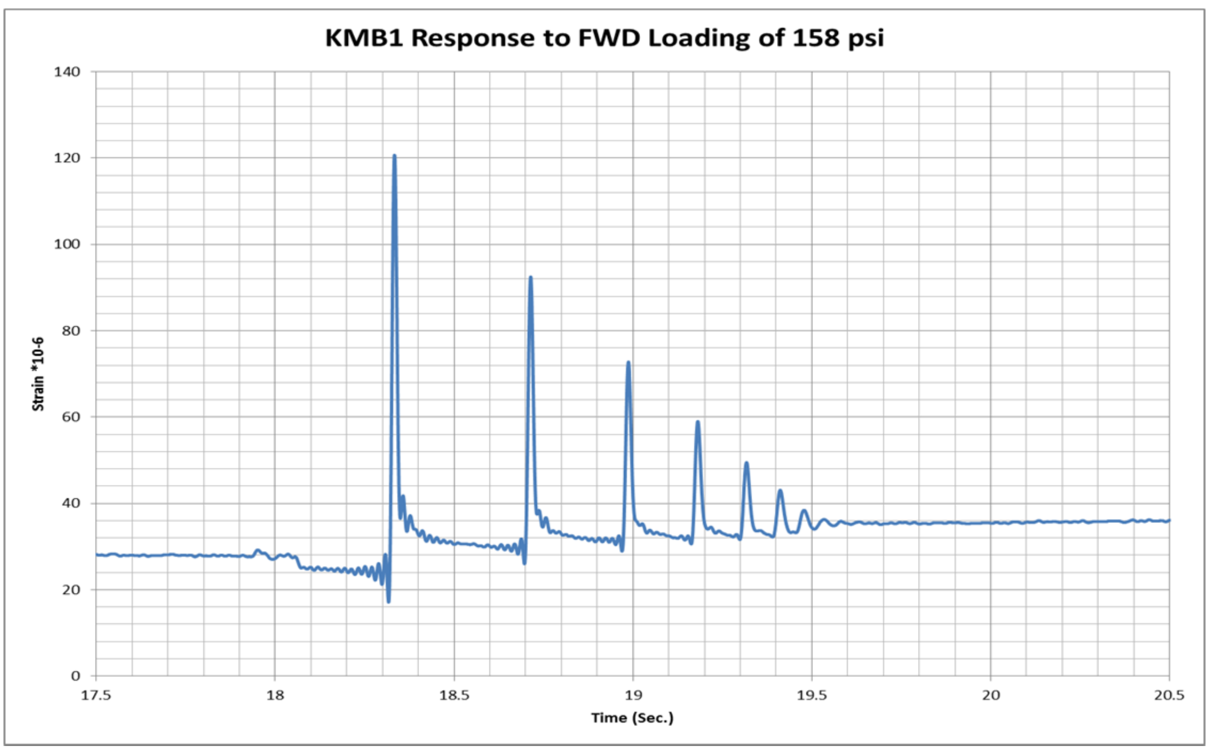

Figure 46 KMB1 response to FWD Loading August 2011

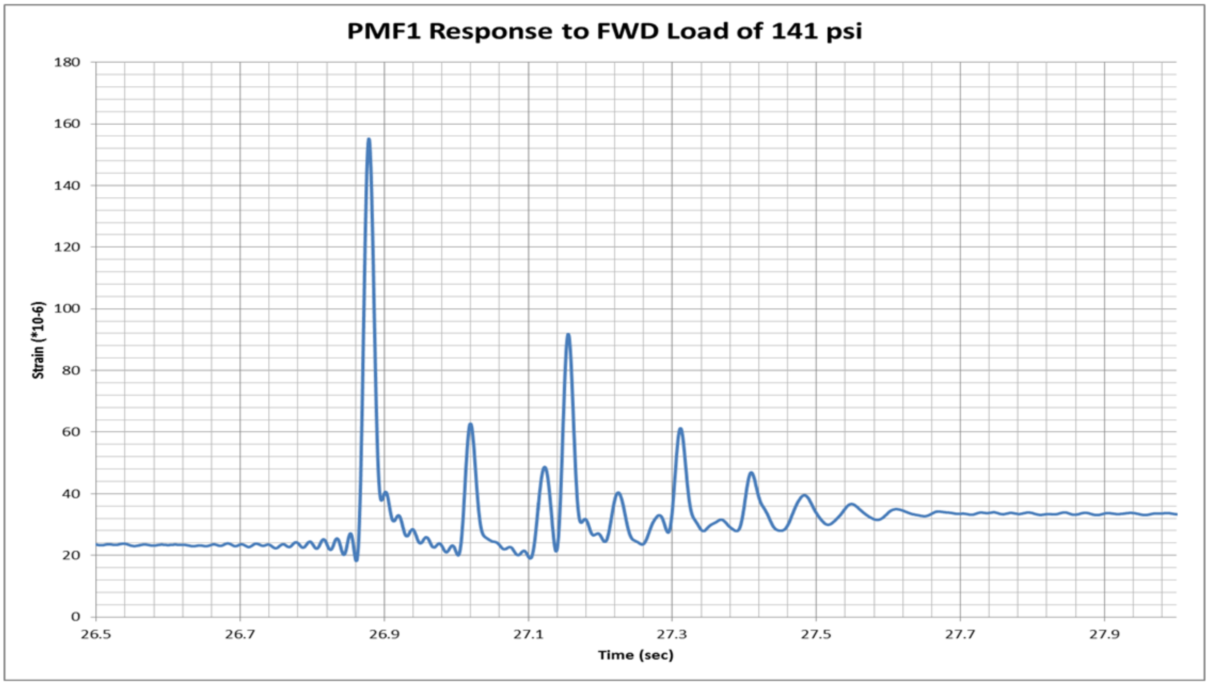

Figure 47 PMF1 Response to FWD Loading October 2008

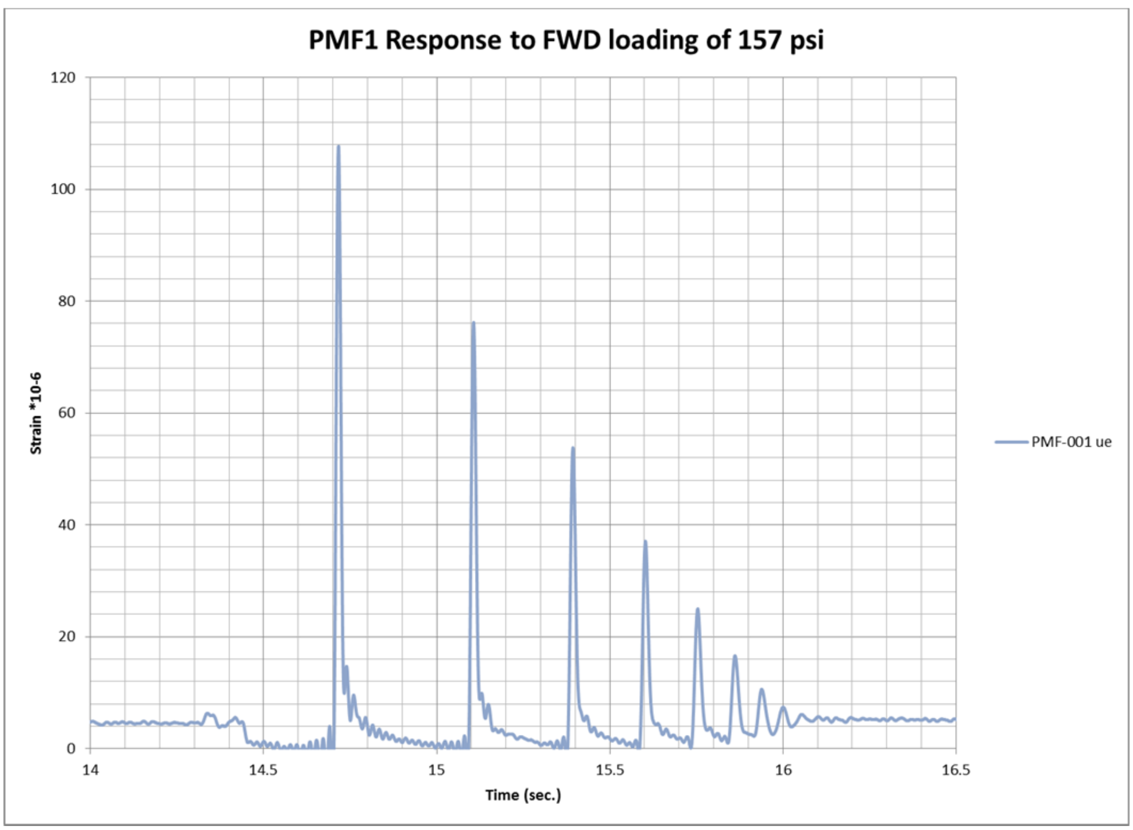

Figure 48 PMF01 Response to FWD Loading August 2011

From the strain gage response it can be seen that the maximum strain experience at the bottom of the asphalt layer is approximately 100με, when subjected to an impact of approximately 71 kN (16 kip) a much larger load application than possible from truck traffic. In both tests the pavement temperature was approximately 29°C (84°F). Figure 49 shows the maximum deflection from FWD loading on the test section in August of 2011. These deflection curves are typical of the data collected prior to this date.

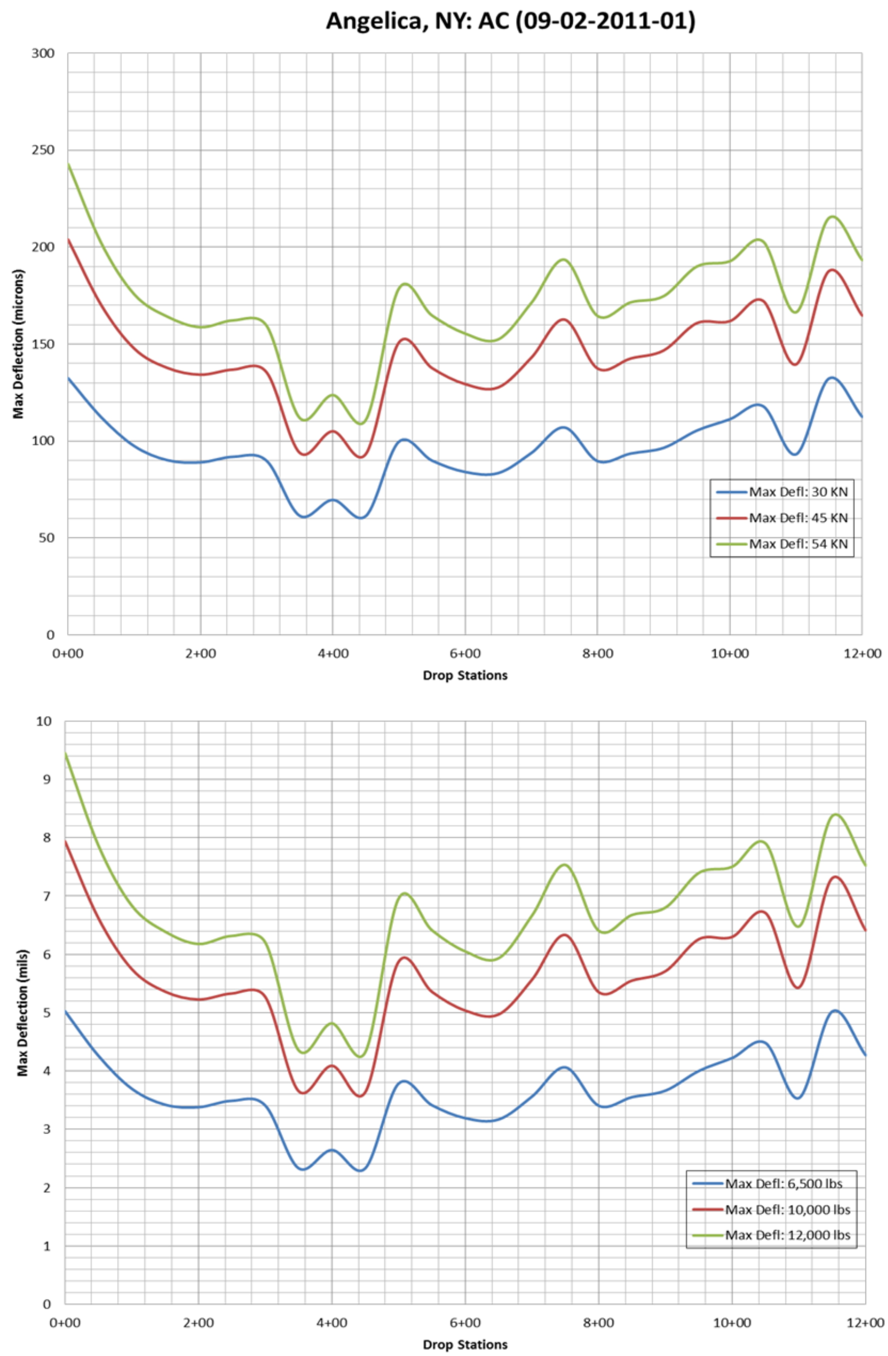

Figure 49 Maximum Deflection from FWD loading on the Perpetual AC test Section, August 2011 (SI units at top, English units at bottom)

6.3I86 AC Pavement Conclusions

Asphalt pavement sections were instrumented on I 86 in Cuba and Angelica New York. Data from the NYSDOT standard design section in Cuba were collected starting in the fall of 2006 and continued until 2011. Data from the perpetual pavement AC section, which was constructed in September 2008 in Angelica, were collected from 2008 through 2011.

Both sections were subjected to wide weather variations and heavy truck loading. Some distress has been observed in the original design section, but none that would require immediate attention or reconstruction. Deflection values from FWD testing shows that the section's stiff base is contributing to the structural capacity of the asphalt.

As of August of 2011 no distress has been observed in the perpetual AC design section, and the strains measured at the bottom of the asphalt generally are below the design limits for perpetual pavements. In addition the strain gages installed have a limited fatigue life, and usually are nonfunctioning within a year of installation, but on this pavement these gauges are still intact after more than 3 years of service. The data were generally comparable to that obtained in Ohio on other sites monitored by ORITE, and the perpetual pavement design concept is validated by these results.

6.4 Perpetual Pavement Implementation

As indicated in a previous report published by ORITE on perpetual pavements [Sargand, Figueroa, and Romanello, 2008], perpetual pavements can be built in New York 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.

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Appendix A: I-490 West Data June 2002

[Sargand and Morrison, 2007]

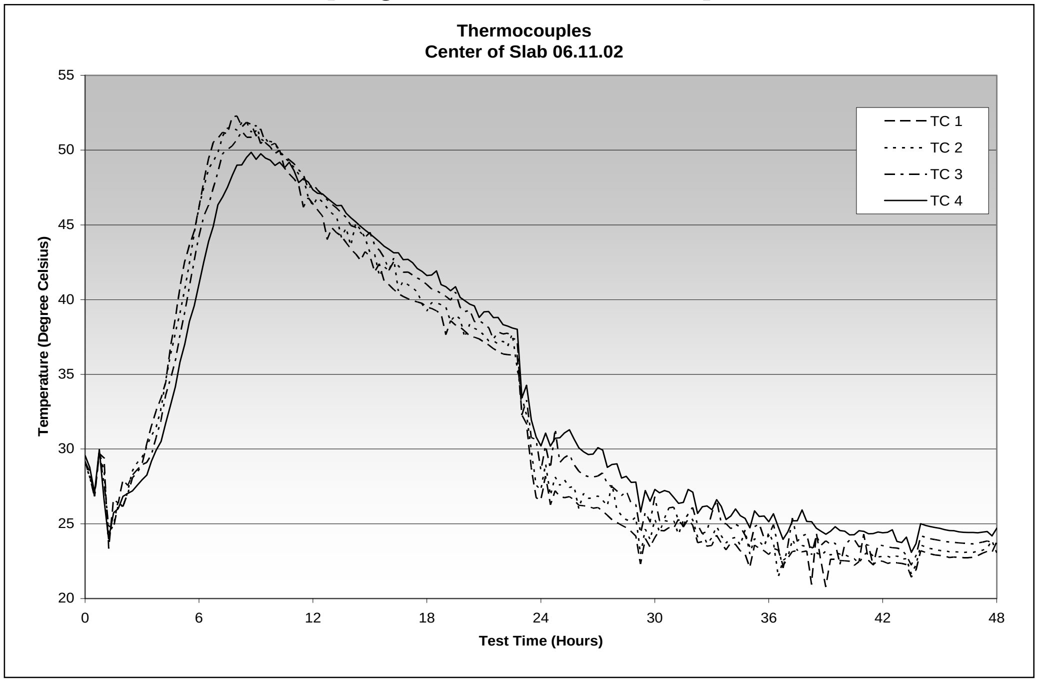

Figure A.1 I-490 Thermocouple readings, center of slab, 6.11.02 (20°C = 68°F, 55°C=131°F)

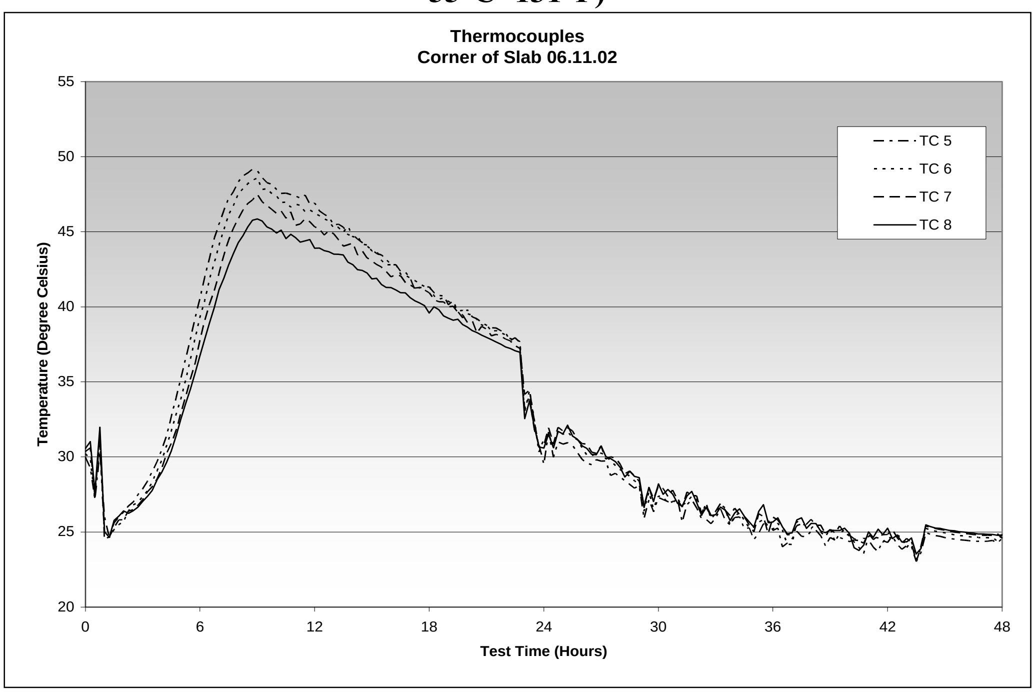

Figure A.2 Thermocouple readings, corner of slab, 6.11.02 (20°C = 68°F, 55°C=131°F)

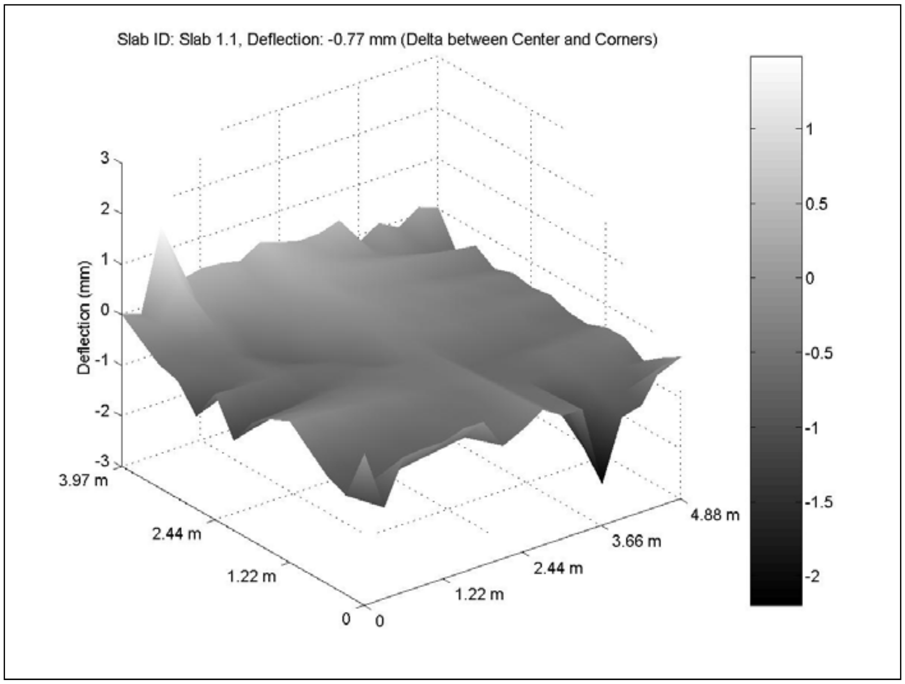

Figure A.3 Slab 1 profile at 7pm, 6.11.02, referenced before joints were sawcut (1 mm = 39 mil, 1m = 39 in)

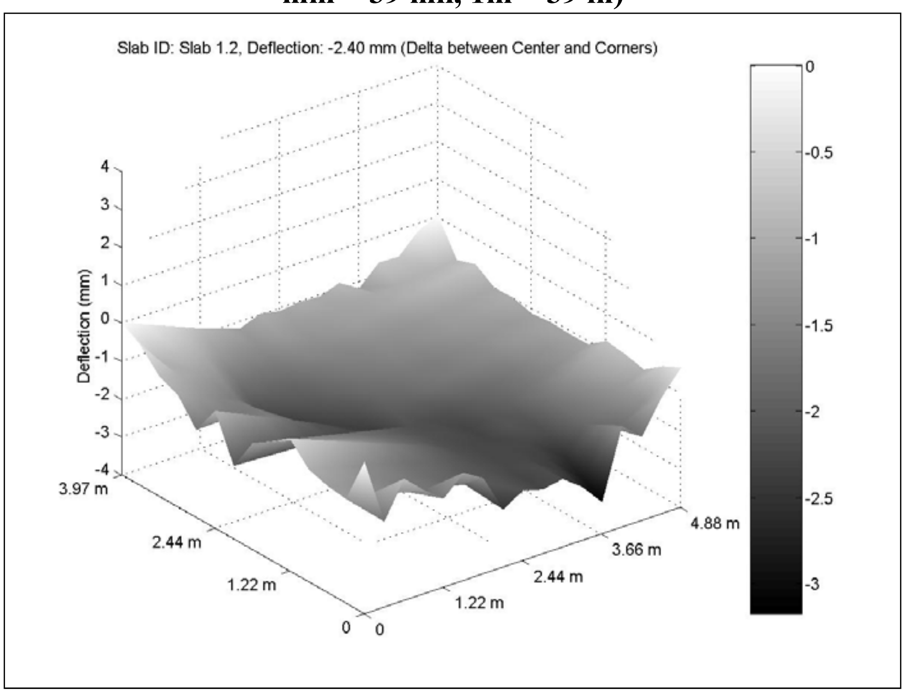

Figure A.4 Slab 1 profile at 3pm, 6.12.02, referenced before joints were sawcut (1 mm = 39 mil, 1m = 39 in)

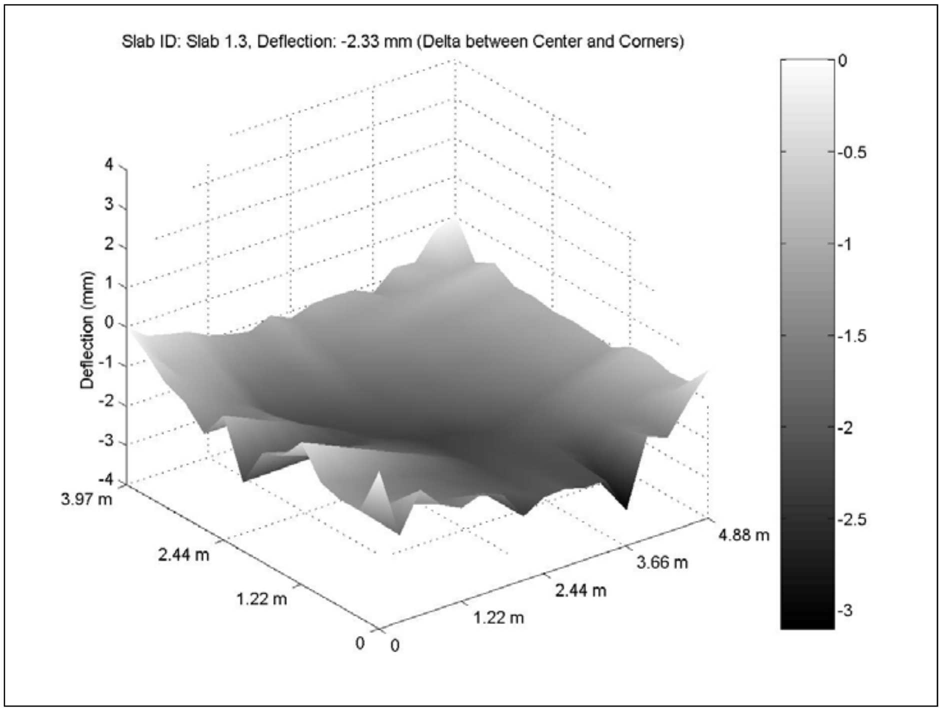

Figure A.5 Slab 1 profile at 9am, 6.13.02, referenced before joints were sawcut (1 mm = 39 mil, 1m = 39 in)

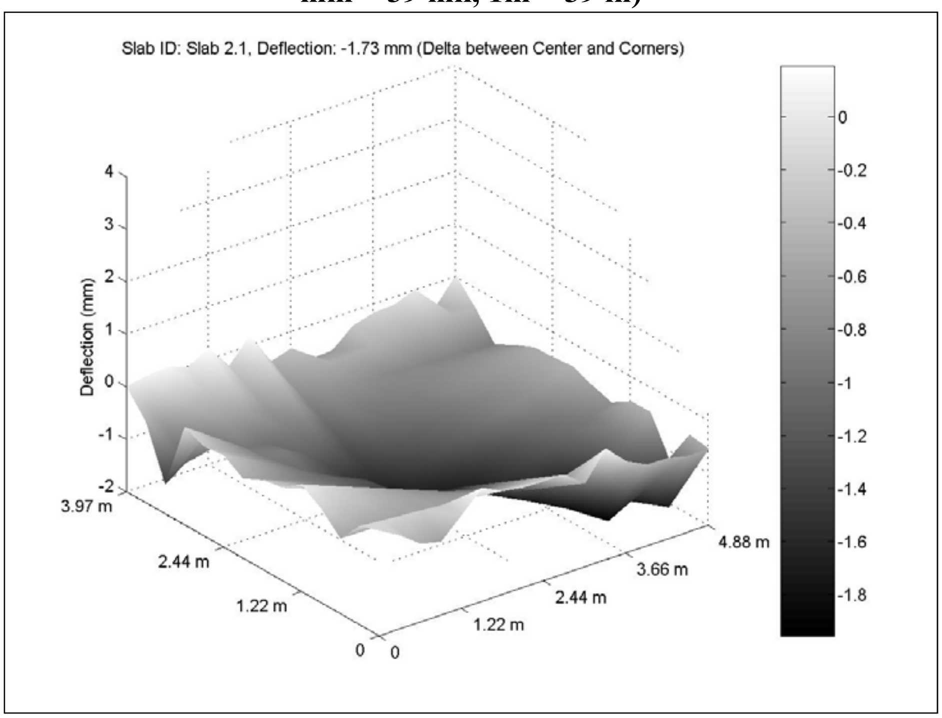

Figure A.6 Slab 2 profile at 7pm, 6.11.02, referenced before joints were sawcut (1 mm = 39 mil, 1m = 39 in)

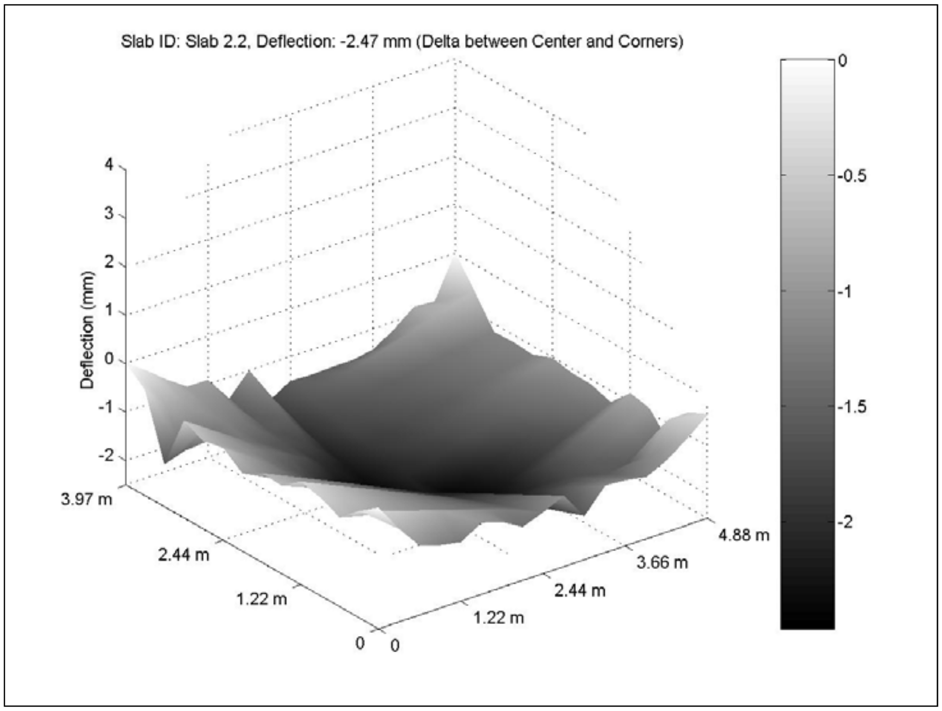

Figure A.7 Slab 2 profile at 3pm, 6.12.02, referenced before joints were sawcut (1 mm = 39 mil, 1m = 39 in)

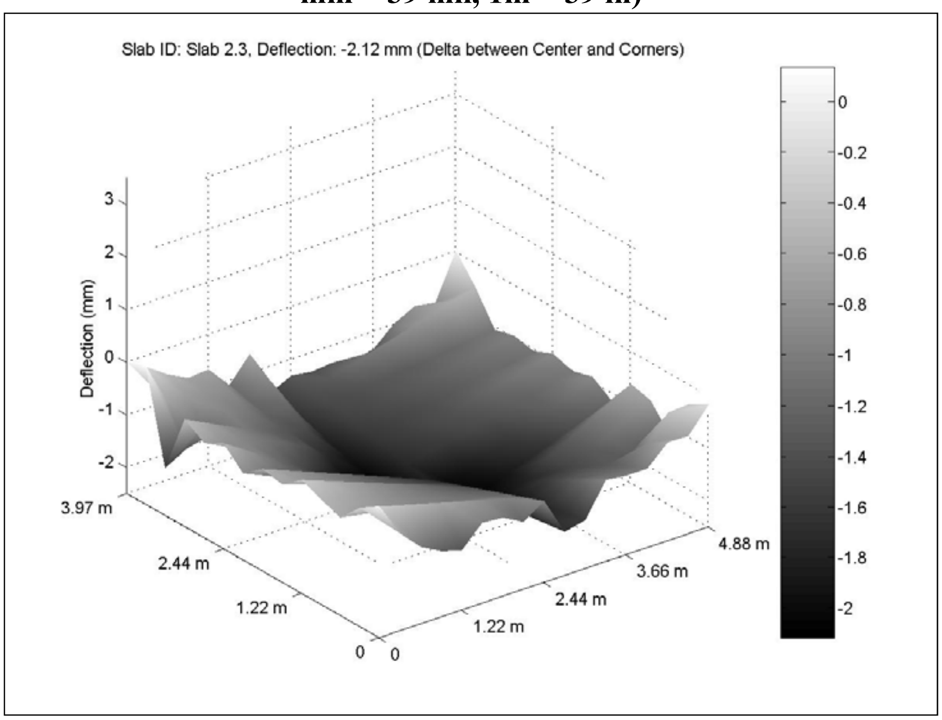

Figure A.8 Slab 2 profile at 9am, 6.13.02, referenced before joints were sawcut (1 mm = 39 mil, 1m = 39 in)

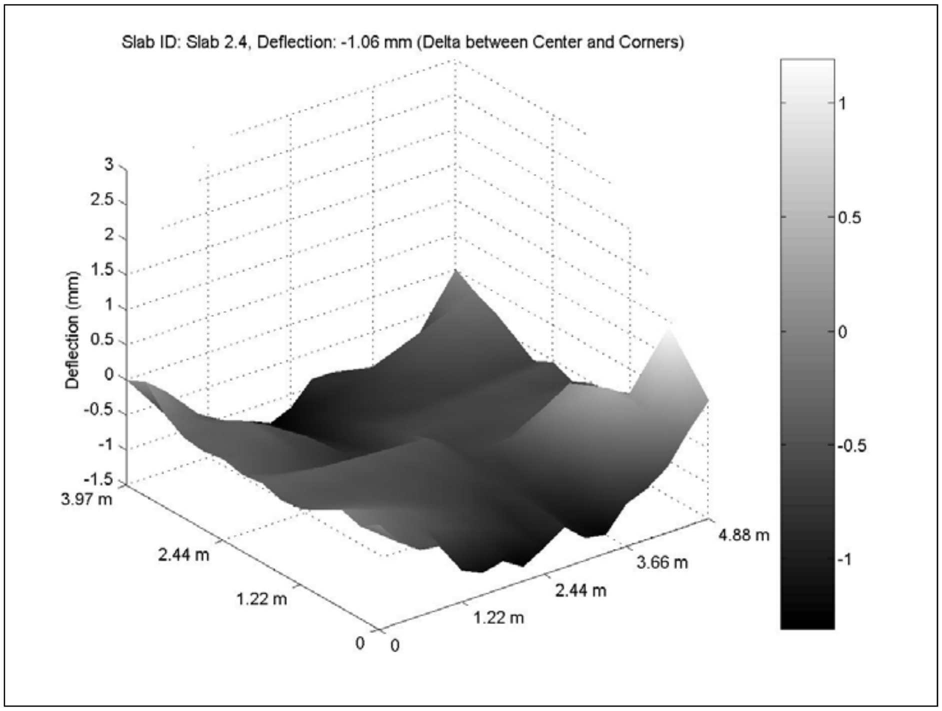

Figure A.9 **Slab 2 profile at 3pm, 6.12.02, referenced after joints were sawcut (1 mm = 39 mil, 1m = 39 in)**

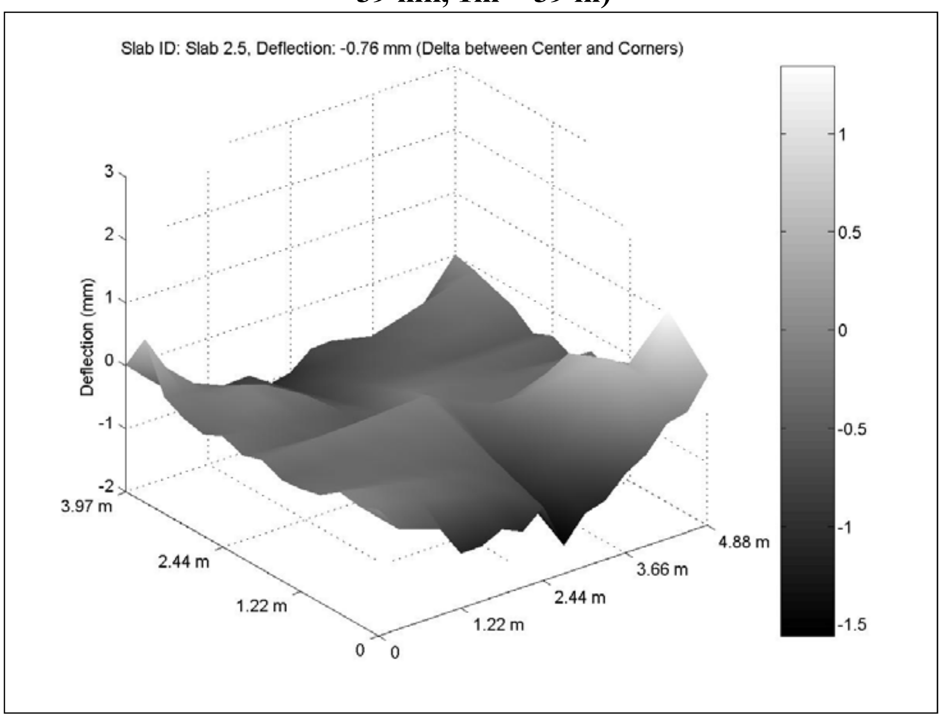

Figure A.10 **Slab 2 profile at 9am, 6.13.02, referenced after joints were sawcut (1 mm = 39 mil, 1m = 39 in)**

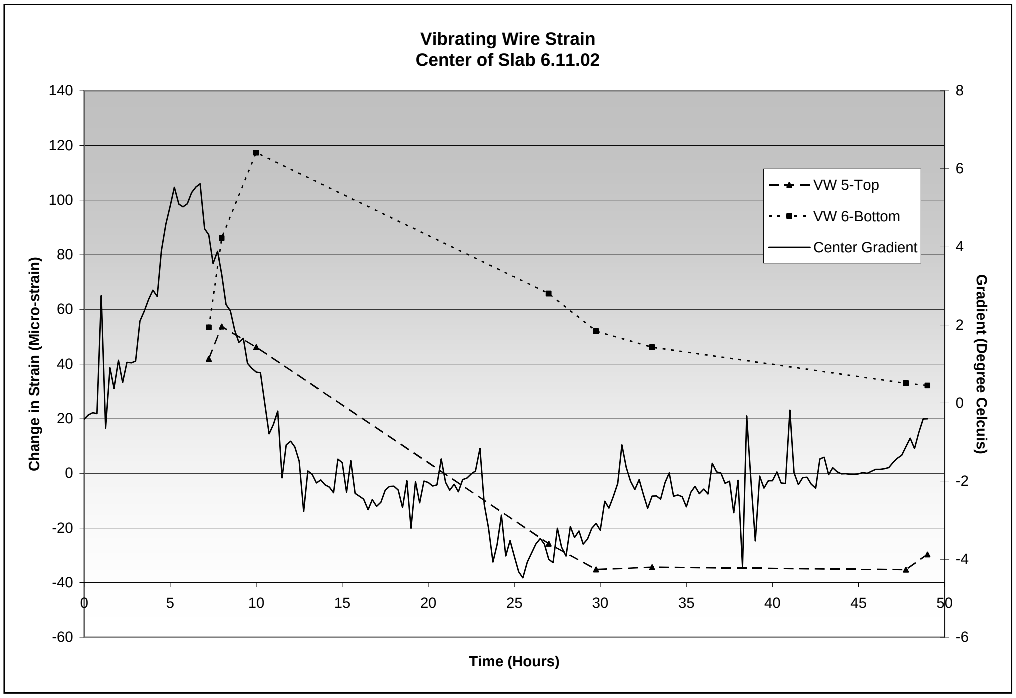

Figure A.11 Vibrating wire strain, center of slab, 6.11.02 (1 C°= 1.8 °F)

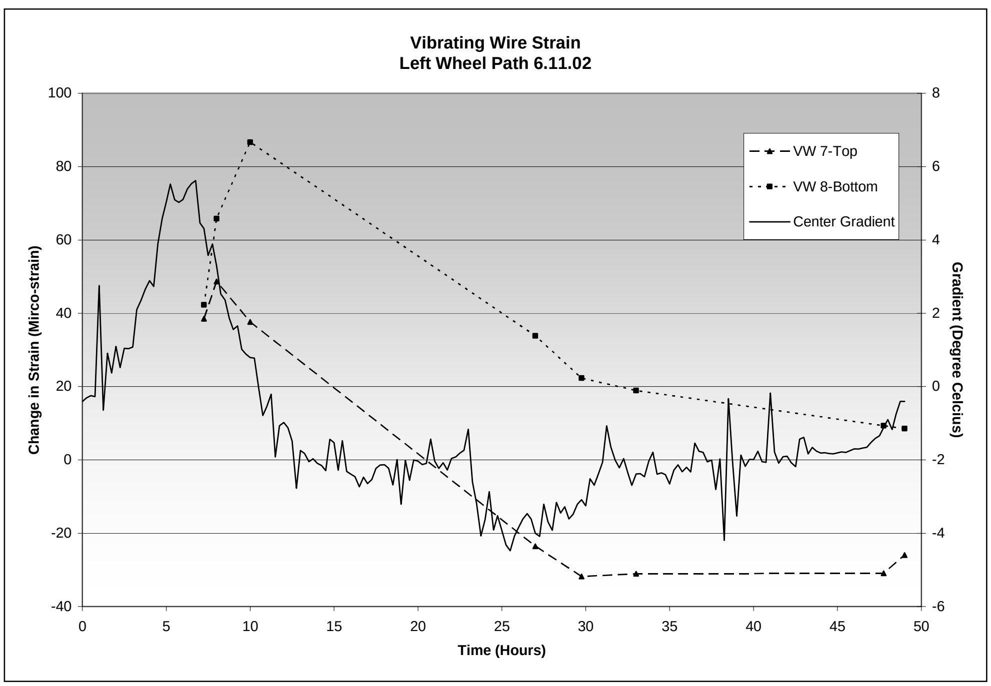

Figure A.12 Vibrating wire strain, left wheel path, 6.11.02 (1 C°= 1.8 °F)

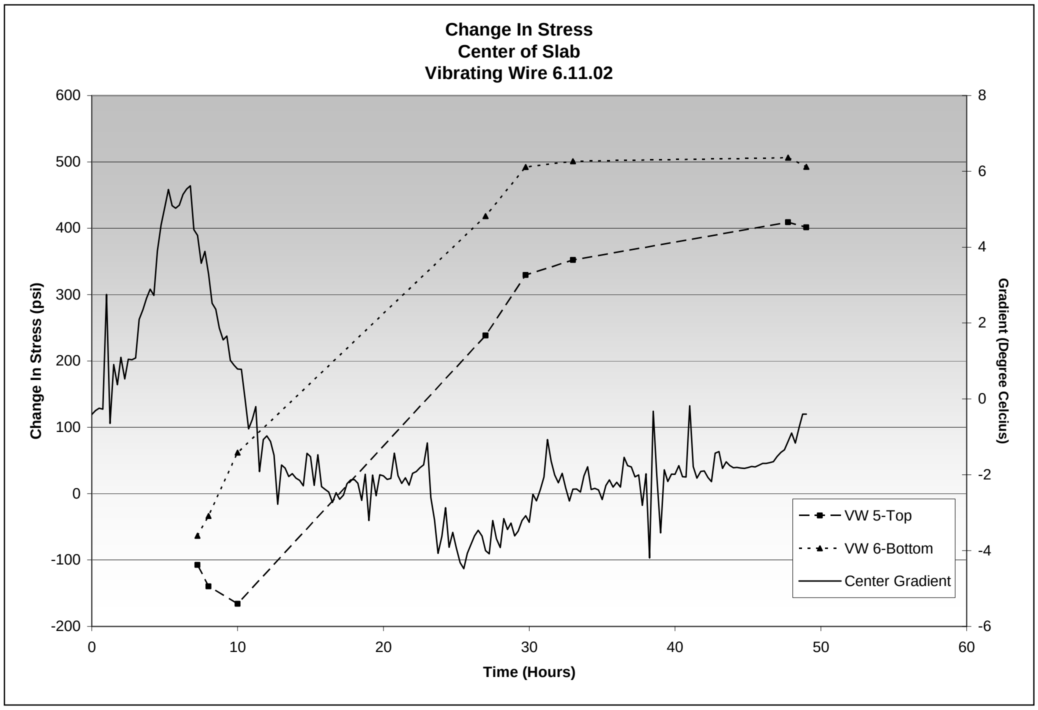

Figure A.13 Vibrating wire stress, center of slab, 6.11.02 (1 psi = 6900 Pa, 1 C°= 1.8 °F)

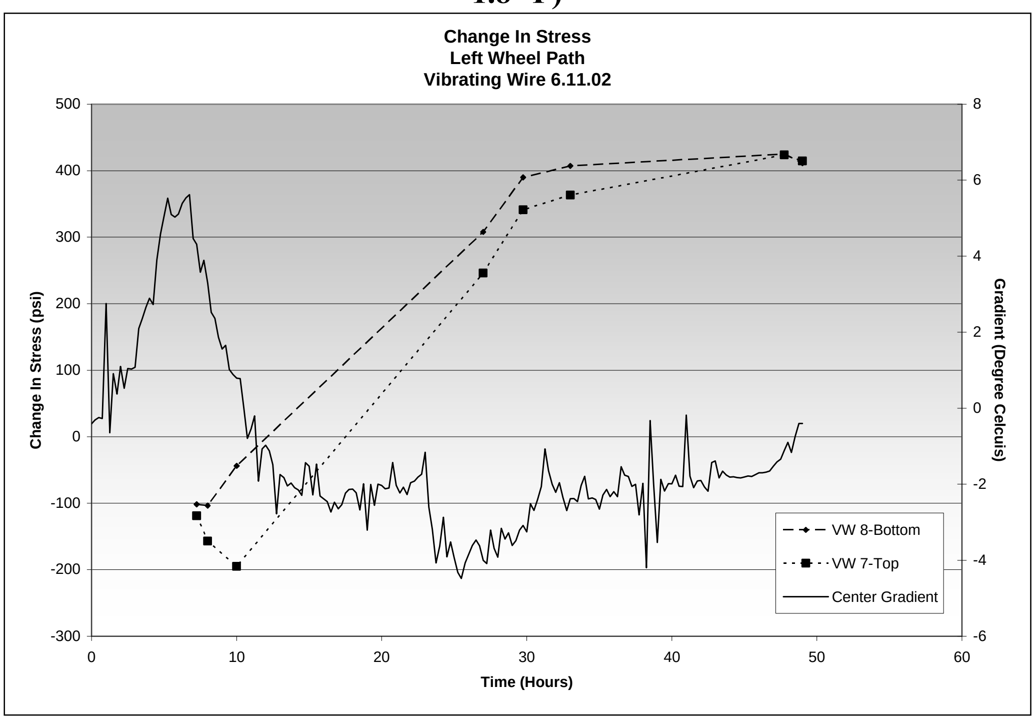

Figure A.14 Vibrating wire stress, left wheel path, 6.11.02 (1 psi = 6900 Pa, 1 C°= 1.8 °F)

Appendix B: I-490 West Data July 2002

[Sargand and Morrison, 2007]

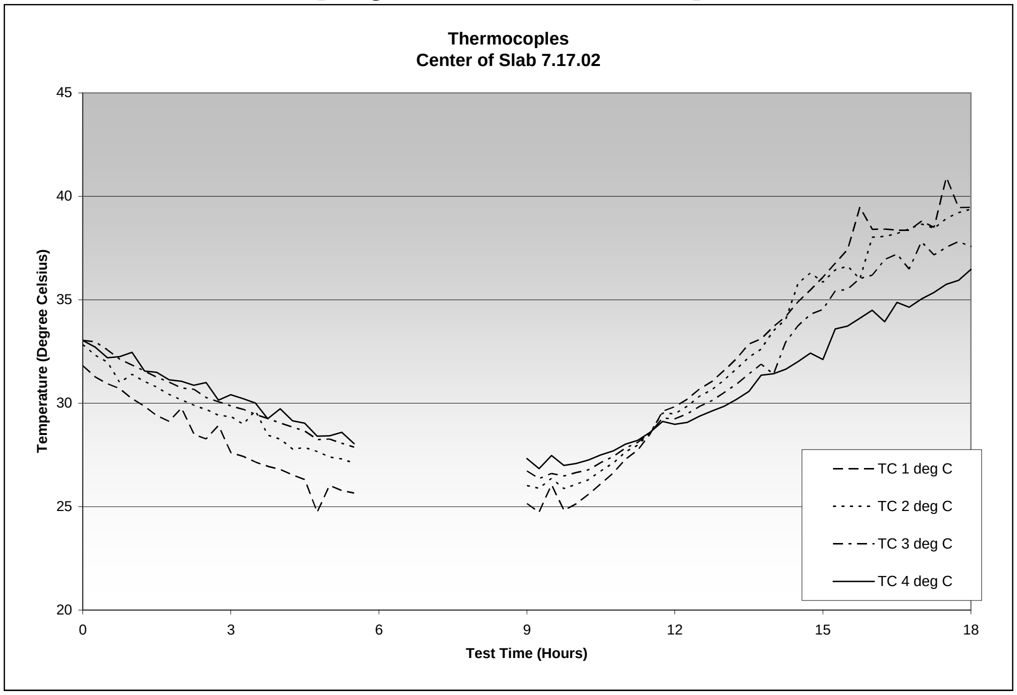

Figure B.1 I-490 thermocouple readings, center of slab, 7.17.02 (20°C = 68°F, 45°C=113°F)

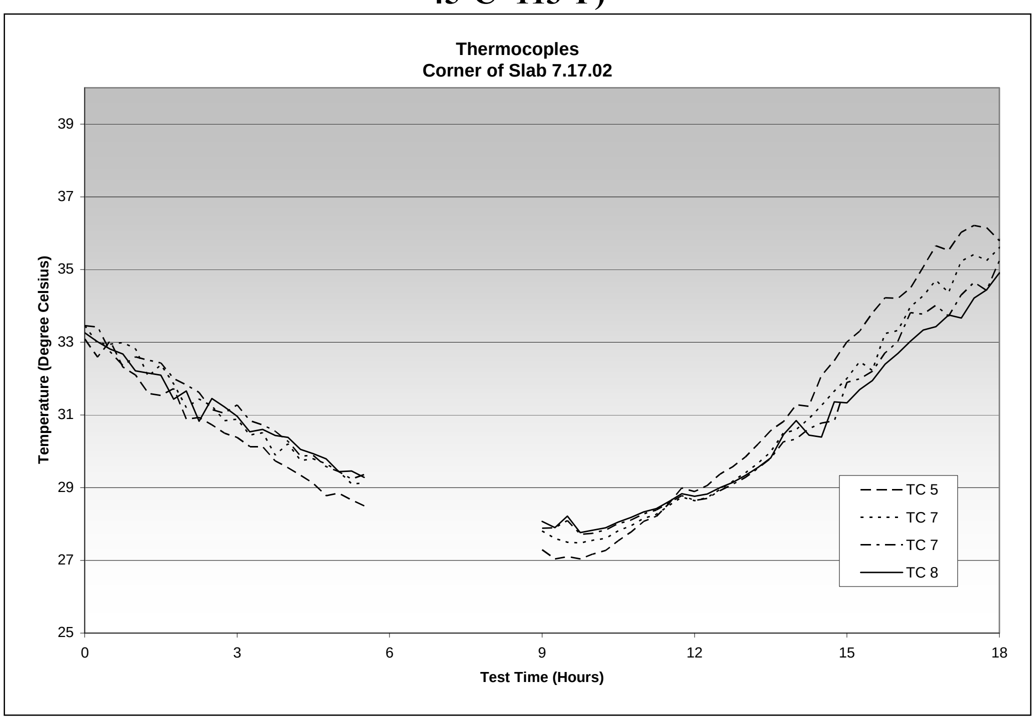

Figure B.2 I-490 thermocouple readings, corner of slab, 7.17.02(25°C = 77°F, 40°C=104°F)

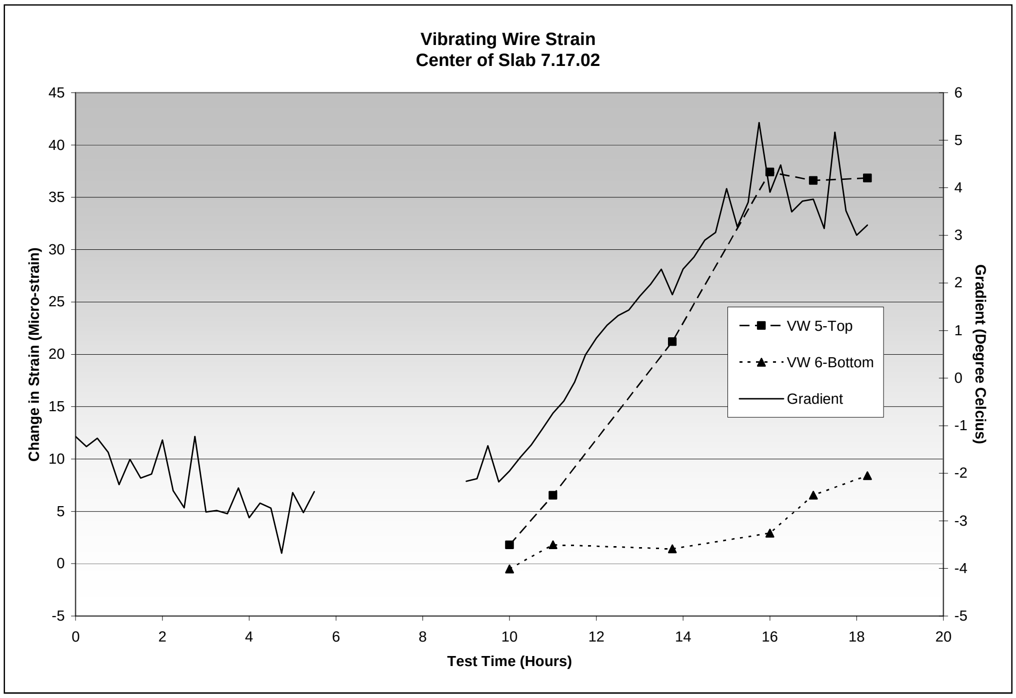

Figure B.3 Vibrating wire strain, center of slab, 7.17.02 (1 C°= 1.8 °F)

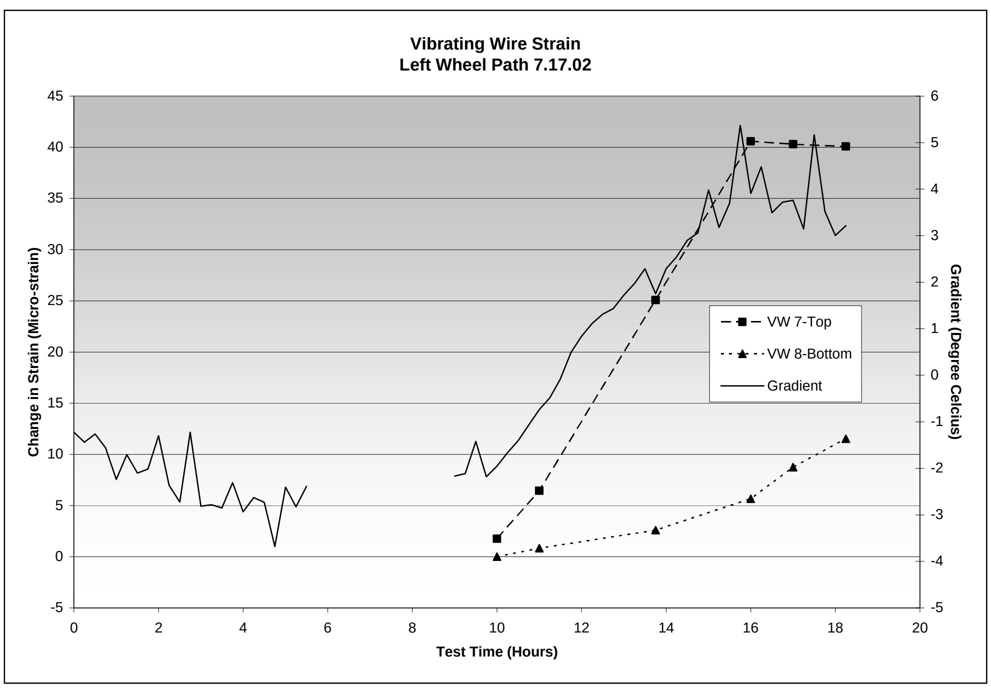

Figure B.4 Vibrating wire strain, left wheel path, 7.17.02 (1 C°= 1.8 °F)

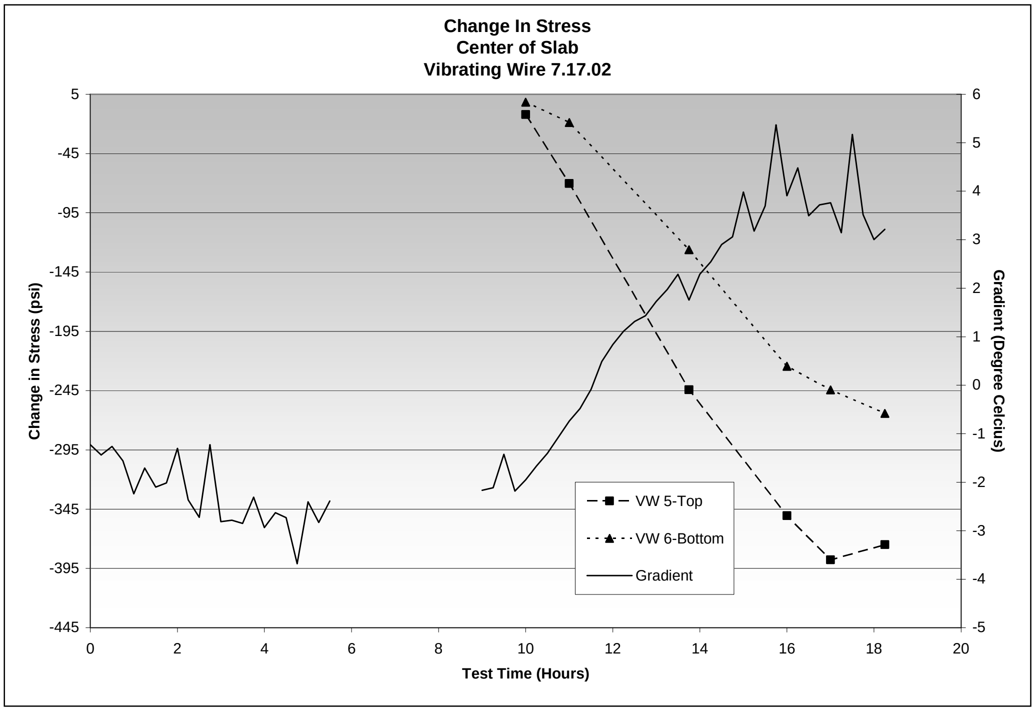

Figure B.5 Vibrating wire stress, center of slab, 7.17.02 (1 psi = 6900 Pa, 1 C°= 1.8 °F)

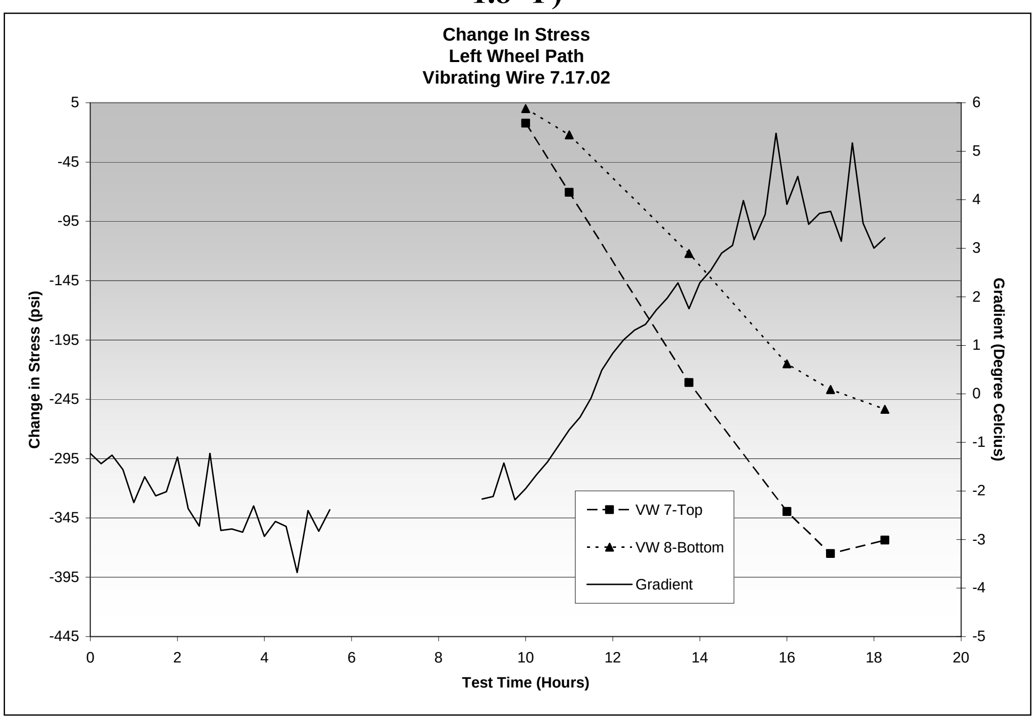

Figure B.6 Vibrating wire stress, left wheel path, 7.17.02 (1 psi = 6900 Pa, 1 C°= 1.8 °F)

Appendix C: I-490 West Data June 2003

[Sargand and Morrison, 2007]

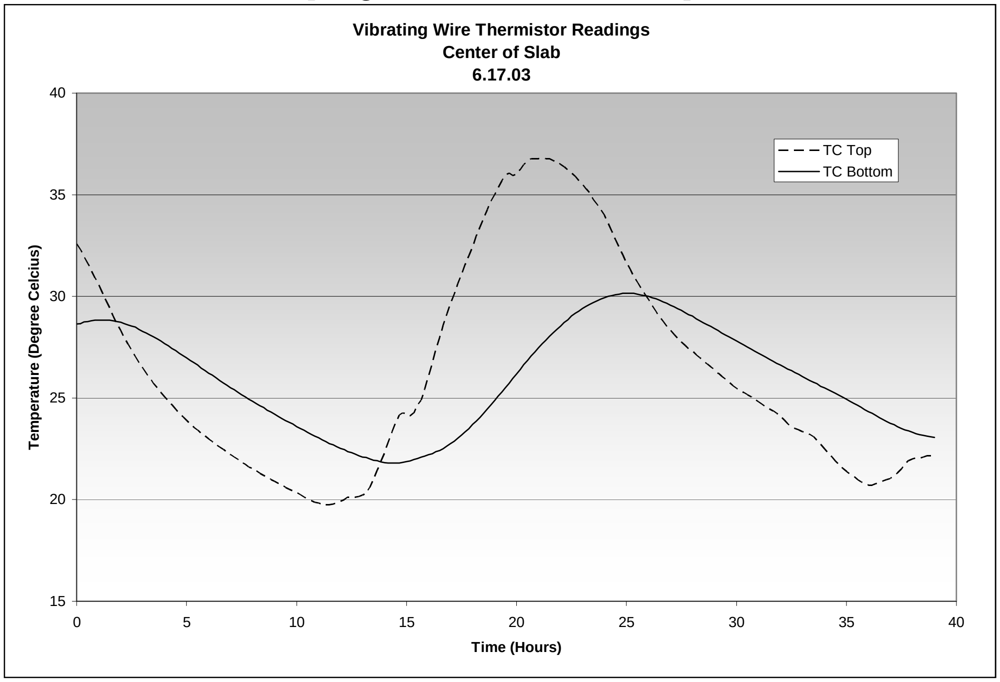

Figure C.1 I-490 vibrating wire thermistor readings, center of slab, 6.17.03 (15°C = 59°F, 40°C=104°F)

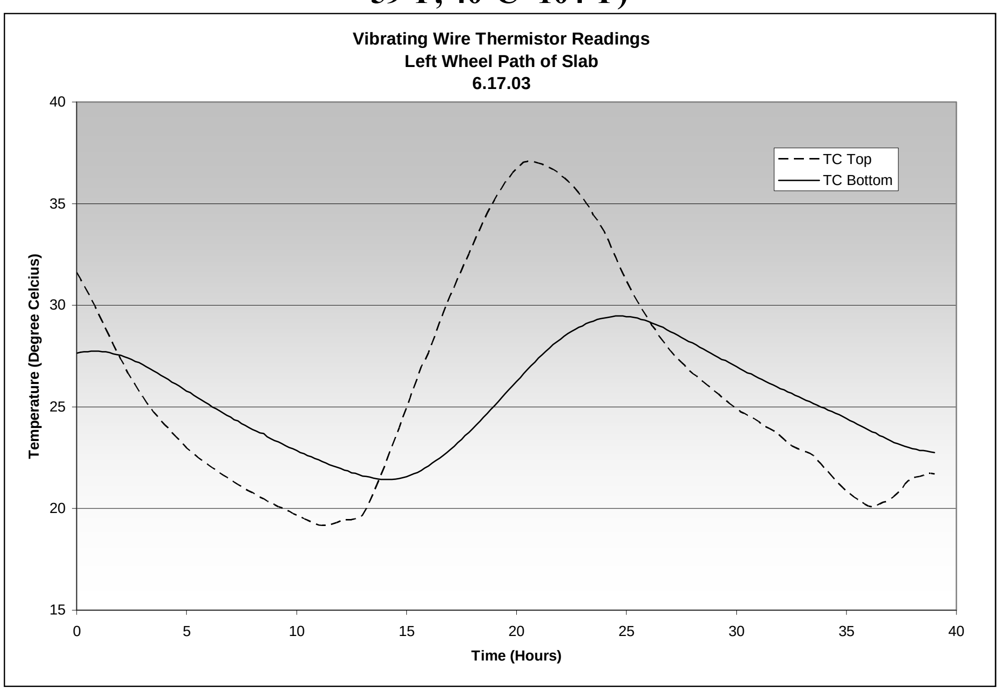

Figure C.2 I-490 vibrating wire thermistor readings, left wheel path, 6.15.03 (15°C = 59°F, 40°C=104°F)

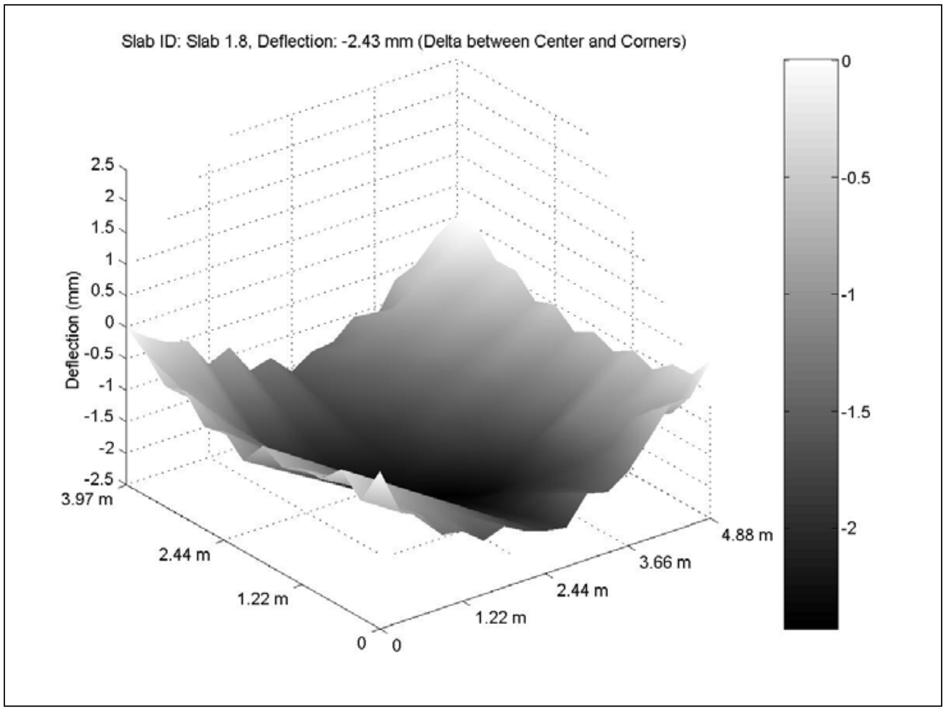

Figure C.3 Slab 1 profile difference between extreme gradients, 8am, 6.18.03 (1 mm = 39 mil, 1m = 39 in)

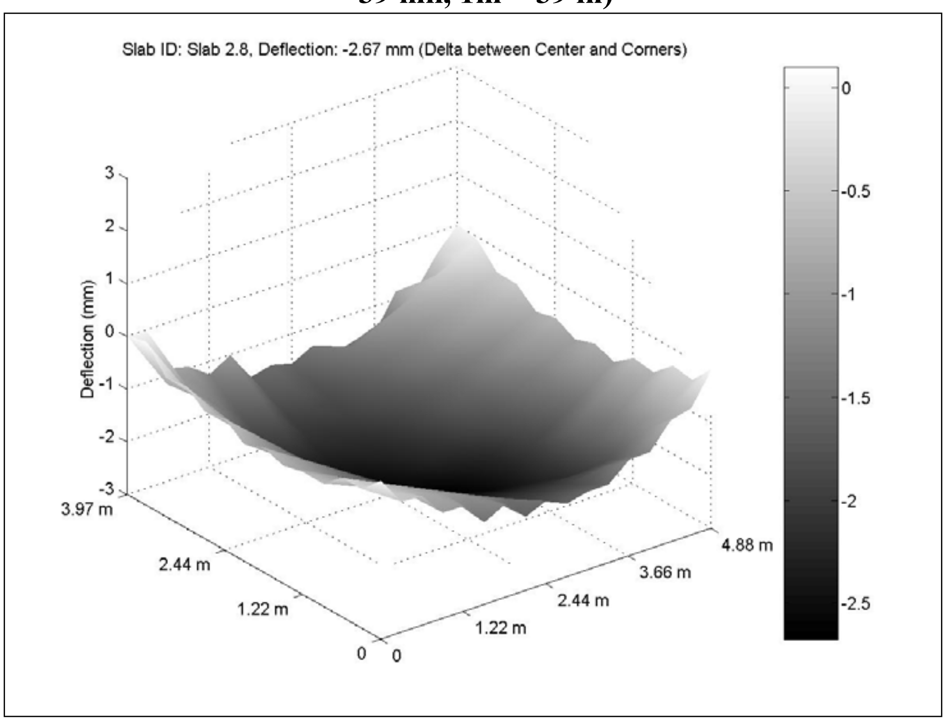

Figure C.4 Slab 2 profile difference between extreme gradients, 8am, 6.18.03 (1 mm = 39 mil, 1m = 39 in)

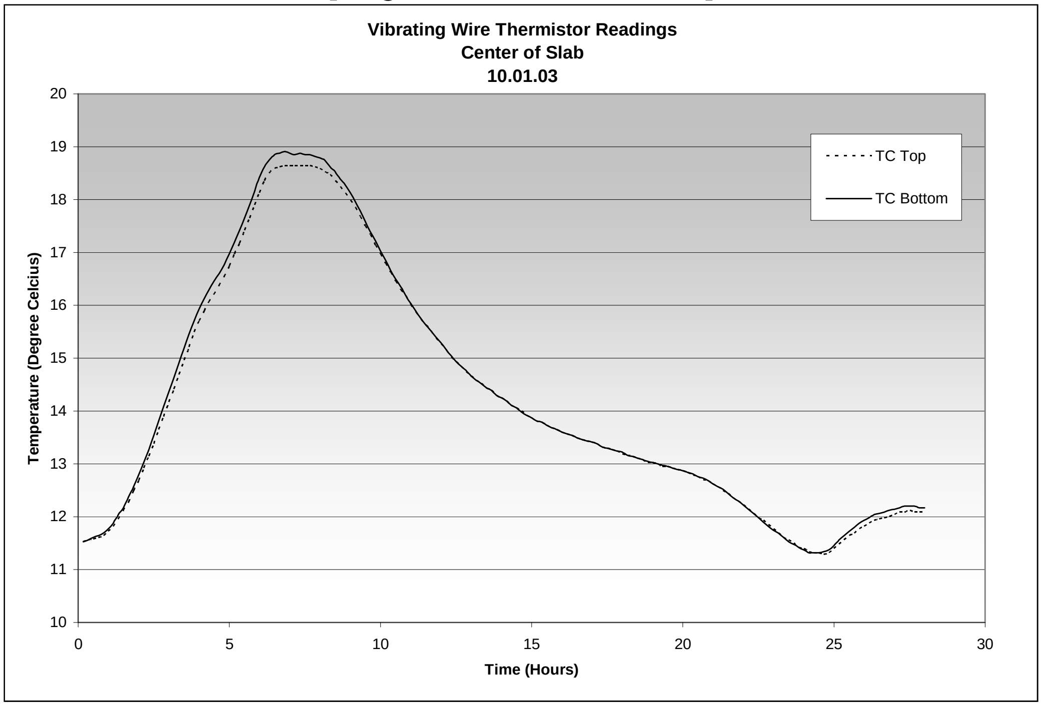

Figure D.1 I-490 vibrating wire thermistor readings, center of slab, 10.01.03 (10°C = 50°F, 20°C=68°F)

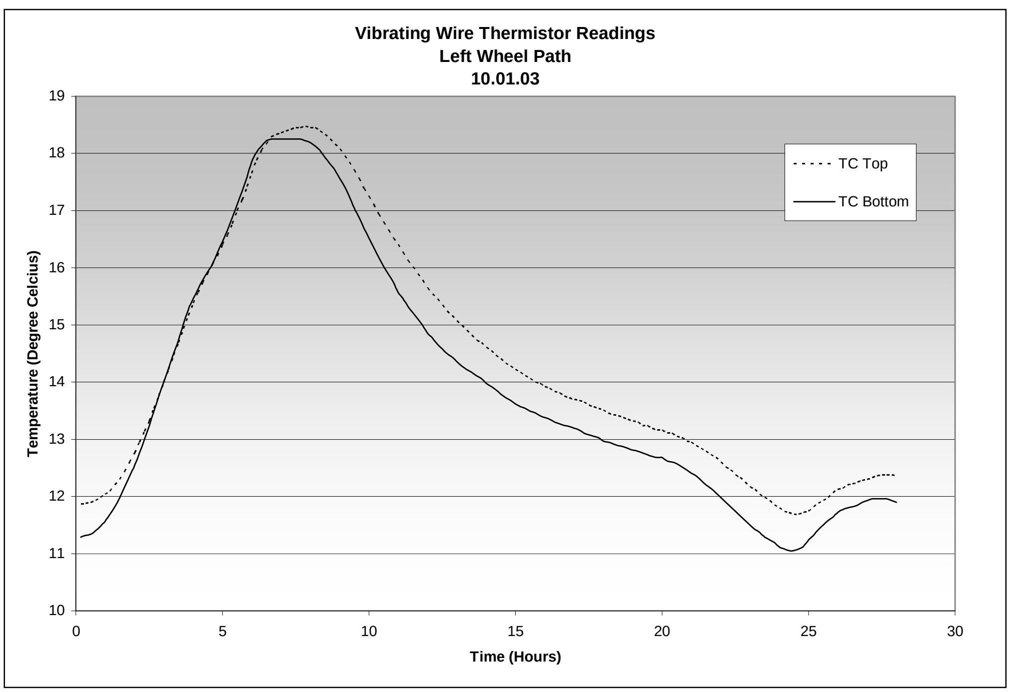

Figure D.2 I-490 vibrating wire thermistor readings, left wheel path, 10.01.03 (10°C = 50°F, 19°C=66°F)

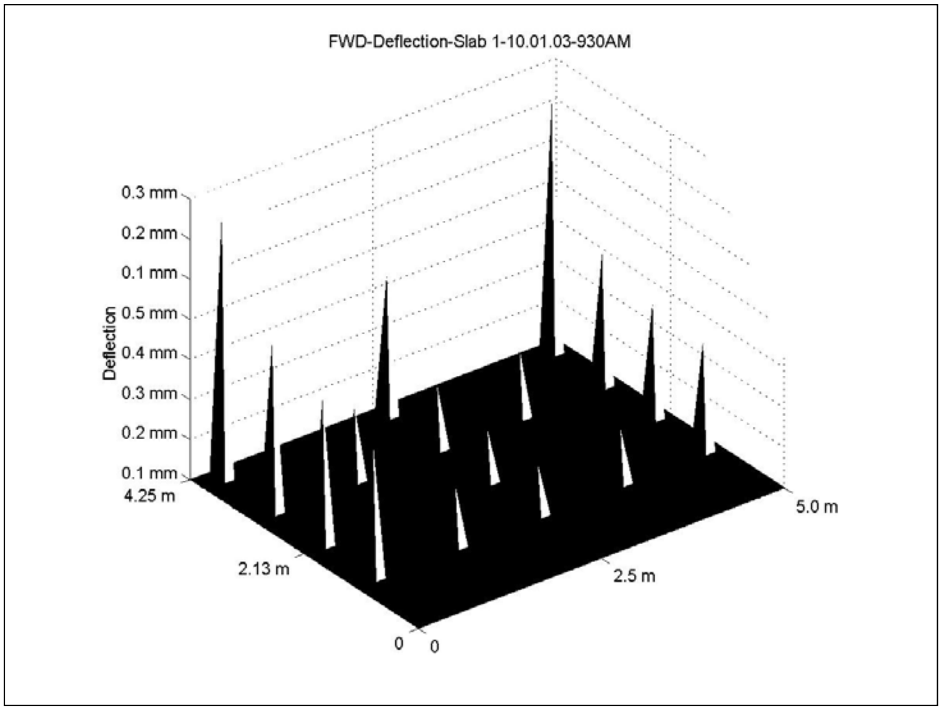

Figure D.3 Slab 1 deflection from FWD at 930am, 10.01.03 (1 mm = 39 mil, 1m = 39 in)

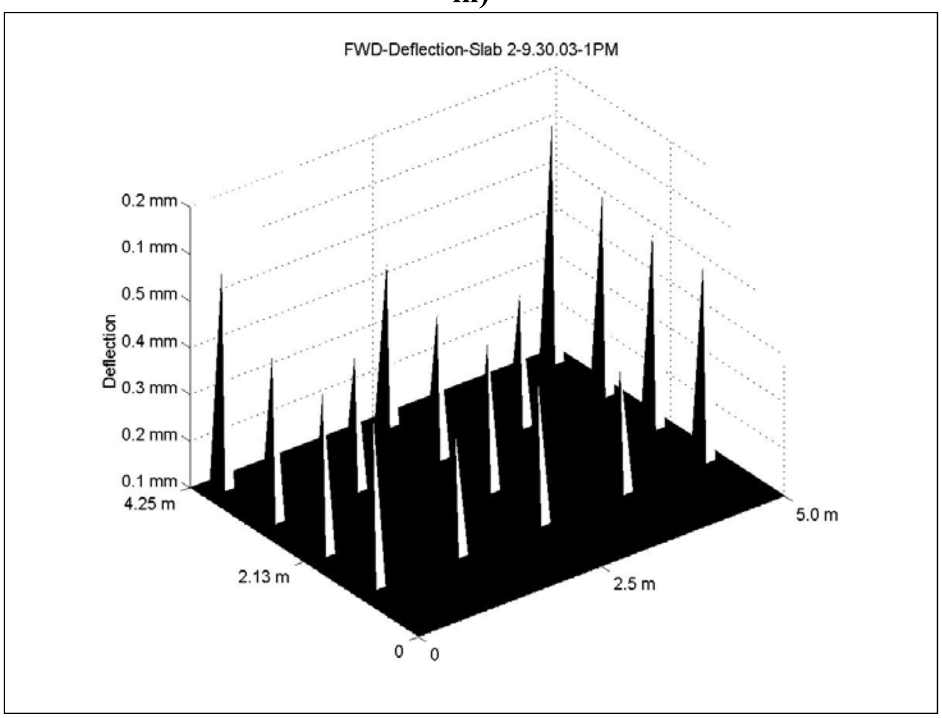

Figure D.4 Slab 2 deflection from FWD at 1pm, 9.30.03 (1 mm = 39 mil, 1m = 39 in)

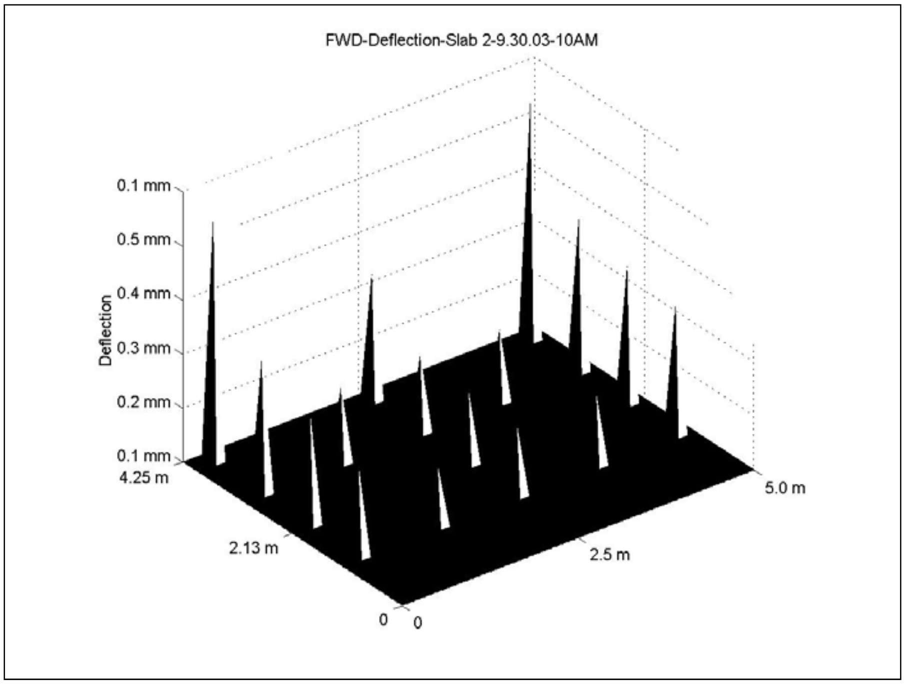

Figure D.5 Slab 2 deflection from FWD at 10am, 9.30.03 (1 mm = 39 mil, 1m = 39 in)

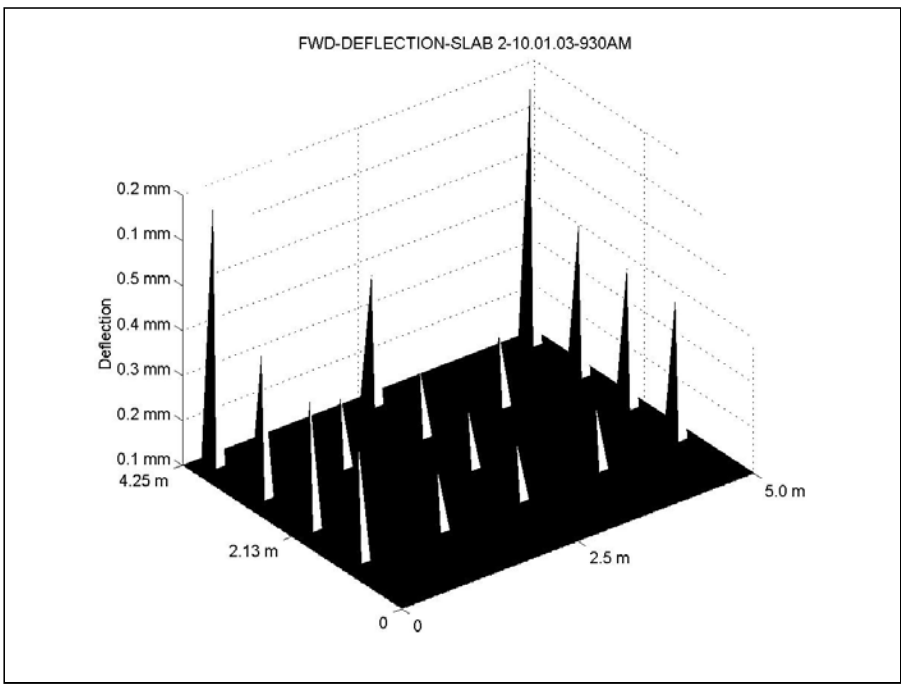

Figure D.6 Slab 2 deflection from FWD at 930 am, 10.01.03 (1 mm = 39 mil, 1m = 39 in)

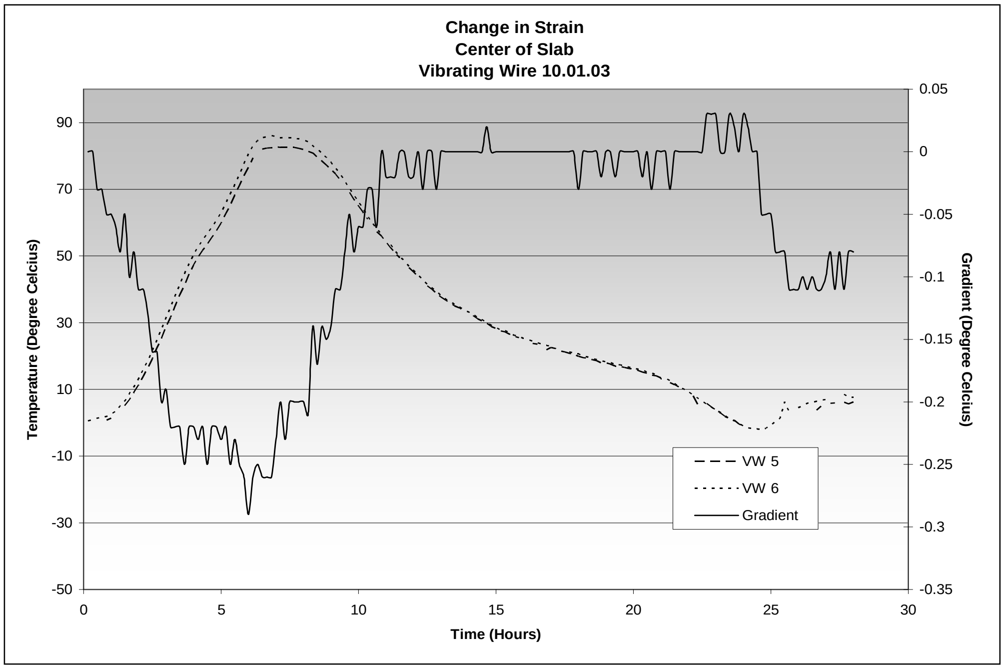

Figure D.7 Vibrating wire strain, center of slab, 10.01.03 (1 C°= 1.8 °F) (-50°C = -58°F, 95°C=203°F)

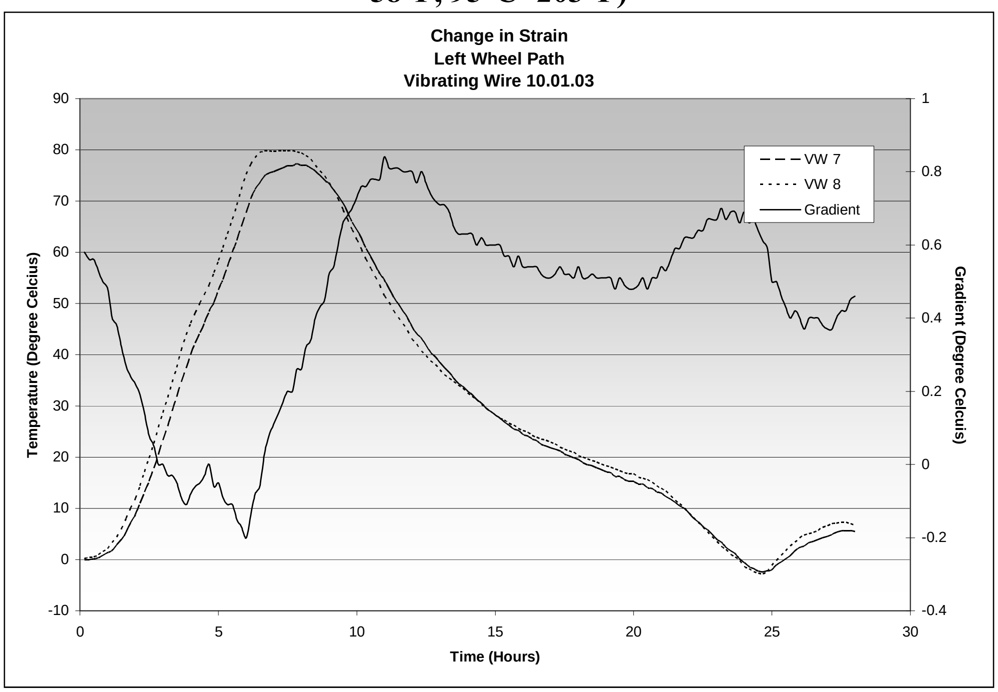

Figure D.8 Vibrating wire strain, left wheel path, 10.01.03 (1 C°= 1.8 °F) (-10°C = 14°F, 90°C=194°F)

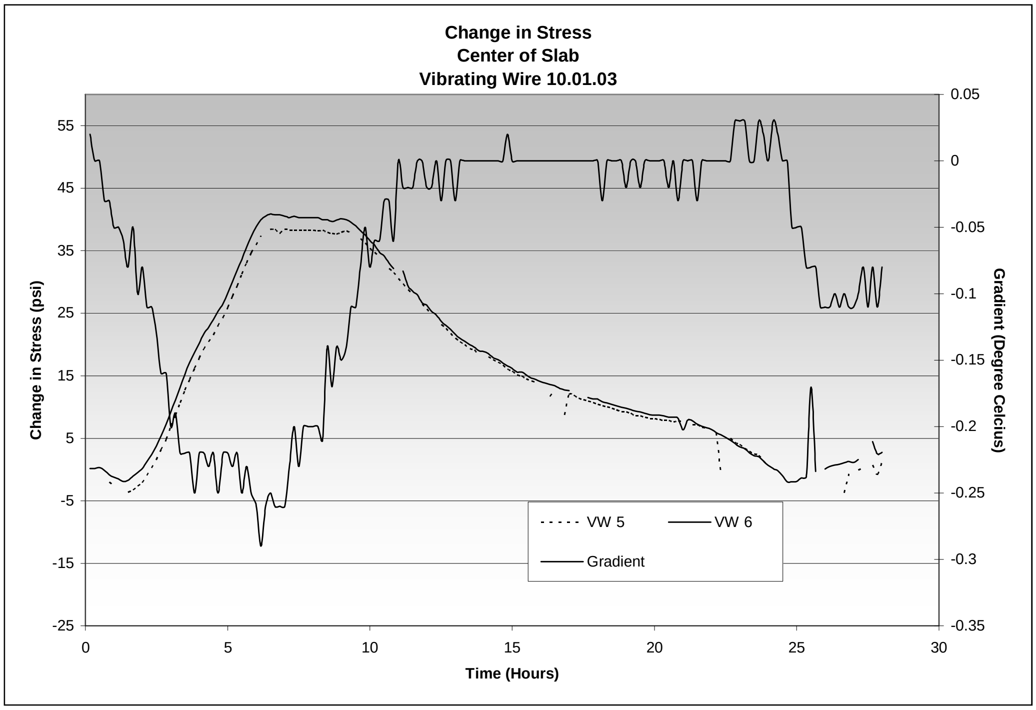

Figure D.9 Vibrating wire stress, center of slab, 10.01.03 (1 psi = 6900 Pa, 1 C°= 1.8 °F)

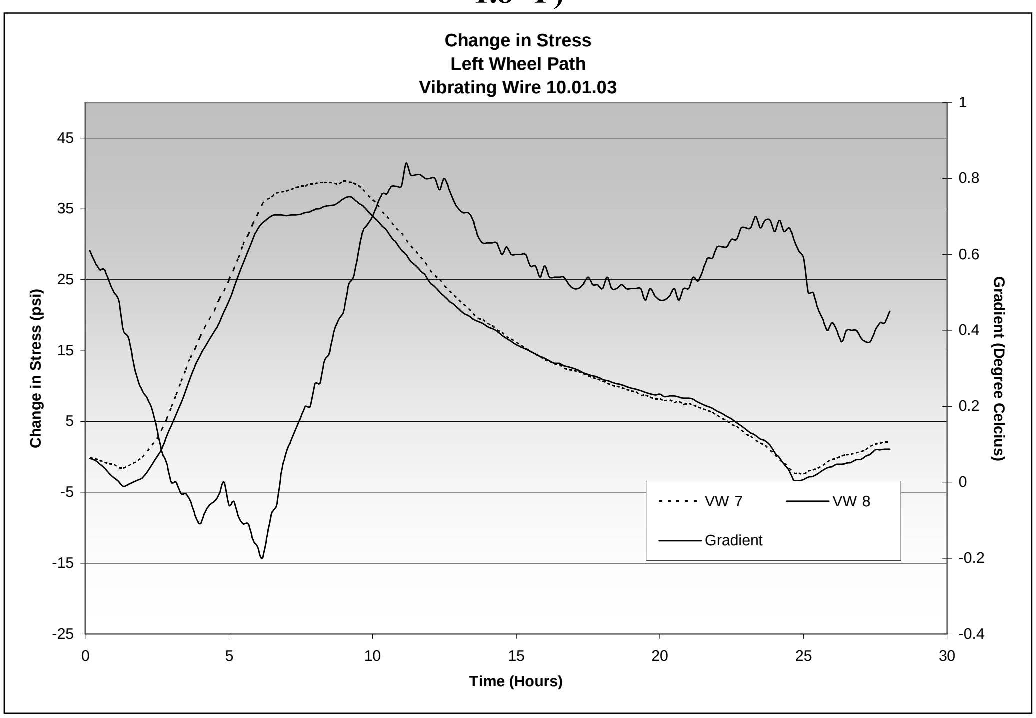

Figure D.10 Vibrating wire stress, left wheel path, 10.01.03 (1 psi = 6900 Pa, 1 C°= 1.8 °F)

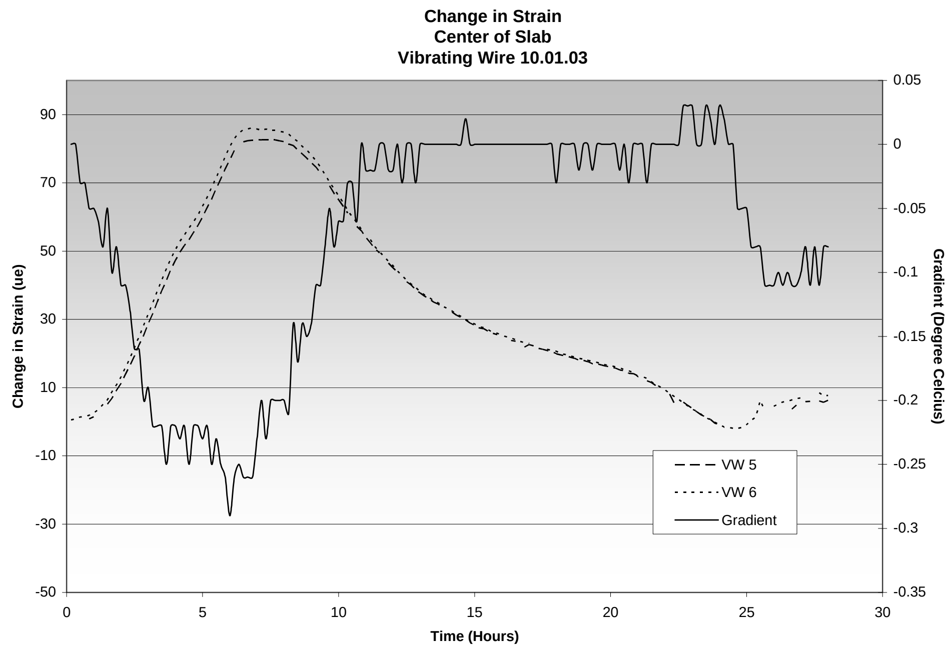

Figure D.11 Vibrating wire strain, center of slab, 10.01.03 (1 C°= 1.8 °F)

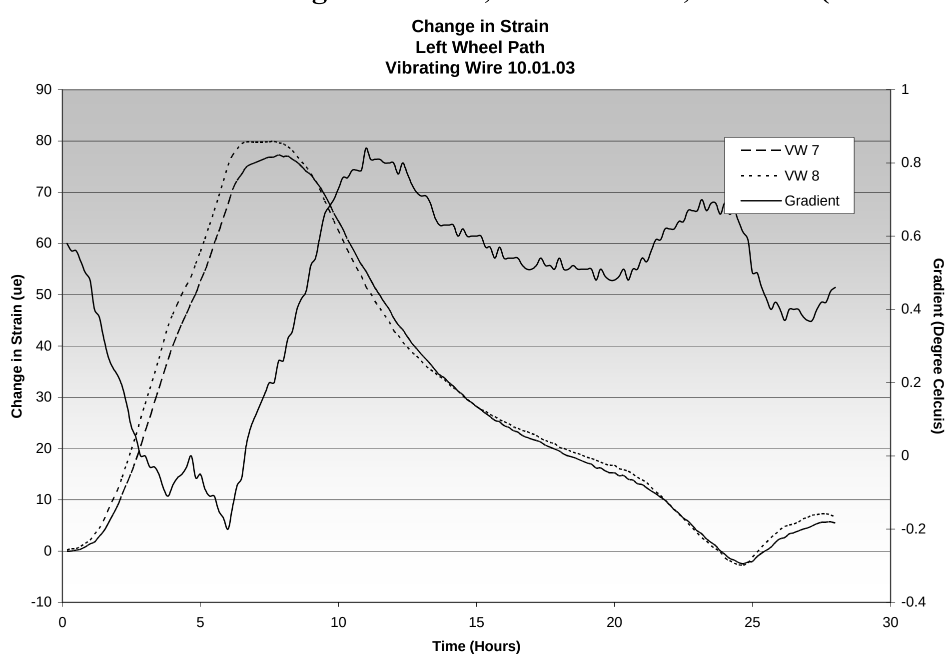

Figure D.12 Vibrating wire strain, left wheel path, 10.01.03 (1 C°= 1.8 °F)

Appendix E: I-490 West Data October 2004

[Sargand and Morrison, 2007]

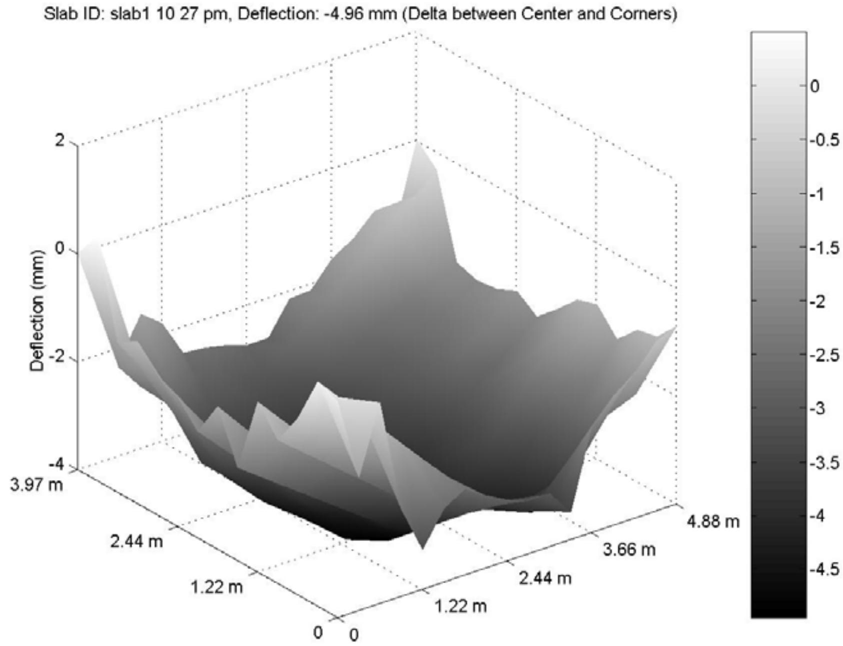

Figure E.1 Slab 1 profile at 10:30 am 10.27.04, referenced after joints sawcut (1 mm = 39 mil, 1m = 39 in)

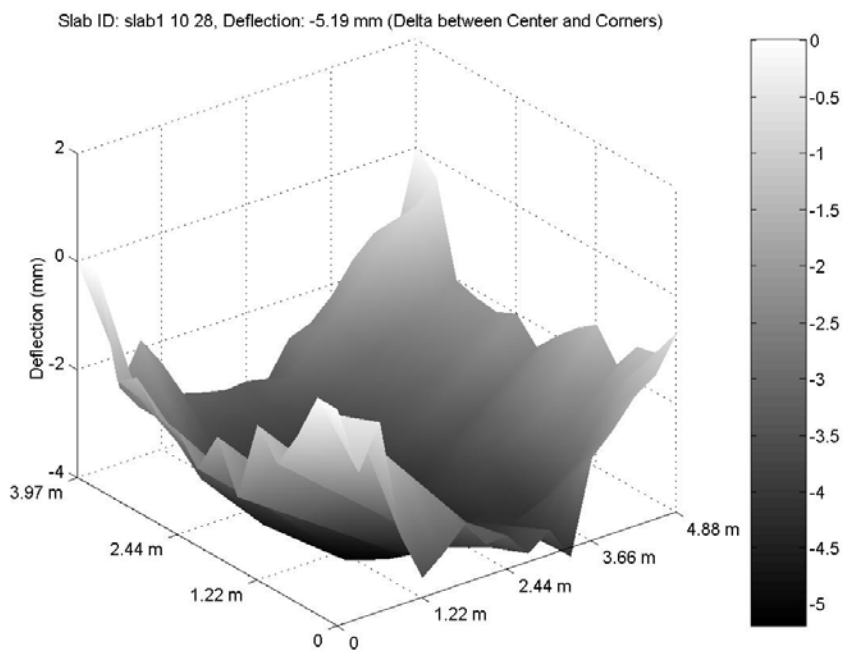

Figure E.2 Slab 1 profile at 10:30 am 10.28.04, referenced after joints sawcut (1 mm = 39 mil, 1m = 39 in)

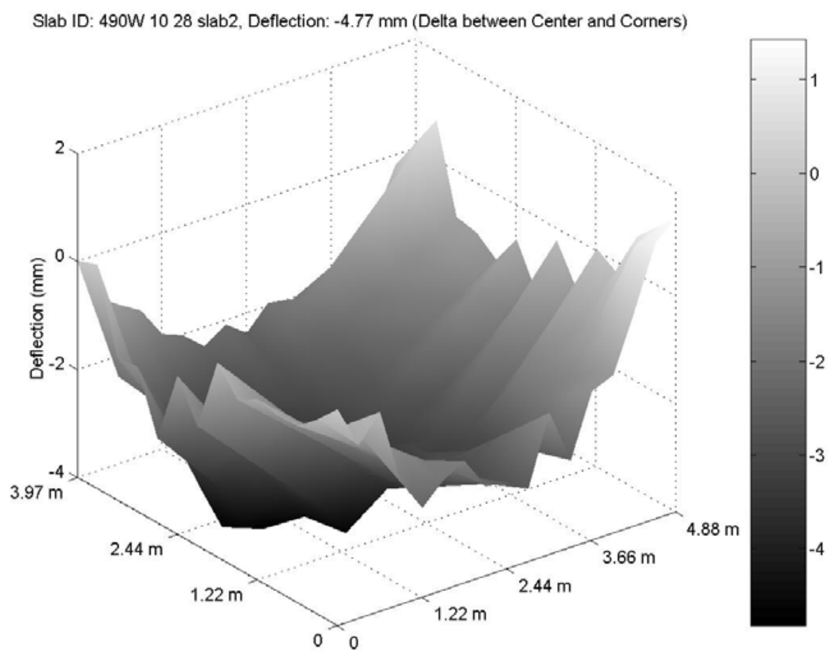

Figure E.3 Slab 2 profile at 10:30 am 10.28.04, referenced after joints sawcut (1 mm = 39 mil, 1m = 39 in)

Appendix F: I-490 East Data October 2004
[Sargand and Morrison, 2007]

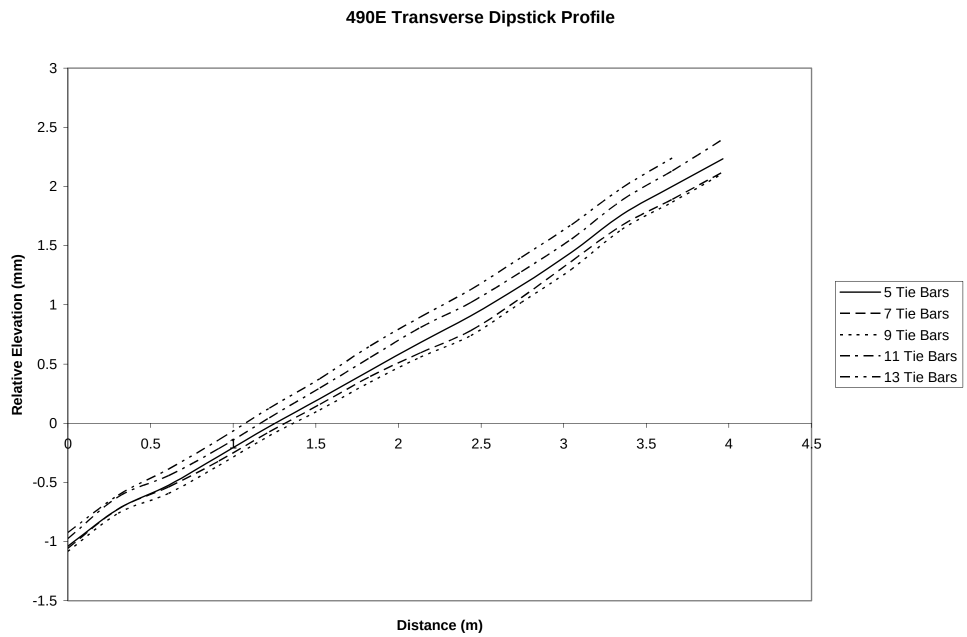

Figure F.1 I-490 East Transverse Dipstick Profile (1 mm = 39 mil, 1m = 39 in)

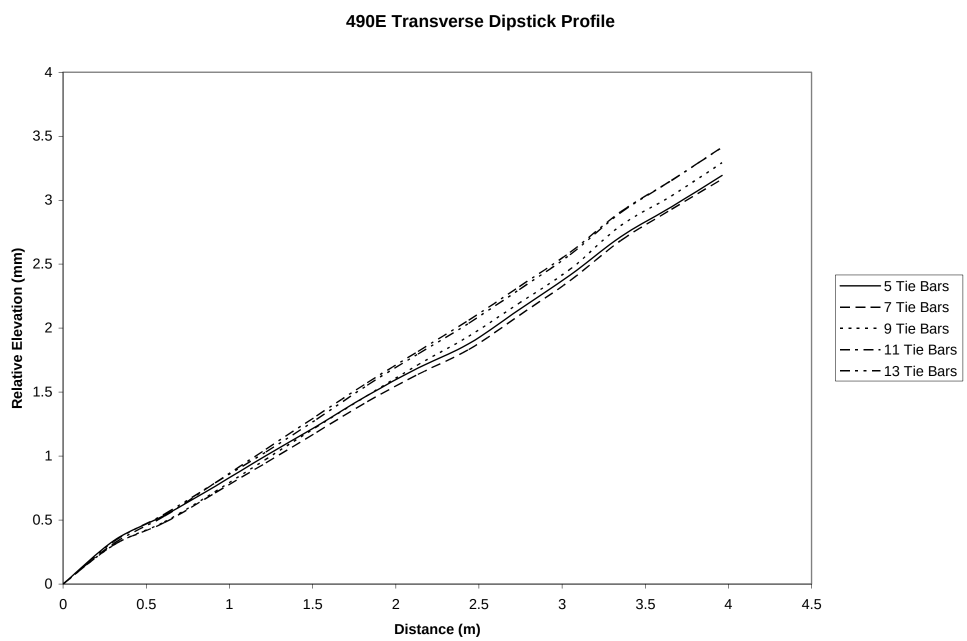

Figure F.2 I-490 East Transverse Dipstick Profile (1 mm = 39 mil, 1m = 39 in)

Table G.1 FWD data for I-490 West, Monroe, Rochester on morning of Oct. 11, 2006, with nominal load 44 kN (10 kip).

Load		DO L		DO M		LTE L	SPR	D3/D0 M
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)			
10	44	1.3433	7.6706	0.7862	4.4896	84.40%	75.30%	0.9112
10	44	1.4196	8.1059	0.6765	3.8628	84.34%	83.87%	0.9316
10	44	1.2614	7.2029	0.7490	4.2767	83.89%	93.16%	0.9831
10	44	1.2374	7.0658	1.2153	6.9396	84.42%	79.21%	0.8784
10	44	0.7824	4.4678	0.7587	4.3323	83.63%	75.10%	0.9125
10	44	0.8045	4.5940	0.6352	3.6269	82.61%	81.65%	0.9339
10	44	0.7190	4.1054	0.6544	3.7368	81.91%	92.94%	0.9806
10	44	0.8244	4.7073	1.0761	6.1446	82.17%	80.70%	0.9295
10	44	0.6630	3.7858	0.7379	4.2135	82.59%	78.26%	0.9379
10	44	0.6879	3.9282	0.6940	3.9626	82.23%	80.73%	0.9101
10	44	0.5944	3.3942	0.7005	4.0001	81.61%	91.36%	0.9804
10	44	0.7126	4.0691	1.1520	6.5778	81.79%	79.14%	0.8757
10	44			0.3016	1.7224		83.42%	0.9271
10	44			0.3378	1.9289		101.87%	0.9814
10	44			0.7097	4.0524		86.11%	0.9807
10	44			0.3547	2.0254		71.79%	0.8902
10	44			0.3122	1.7825		83.00%	0.9392
10	44			0.3150	1.7985		94.00%	0.9633
10	44			0.6096	3.4808		86.00%	0.9810
10	44			0.3336	1.9050		80.50%	0.9340
10	44			0.3682	2.1026		101.52%	0.9857
10	44			0.7222	4.1241		86.70%	0.9956
10	44			0.2599	1.4839		83.60%	0.9150
10	44			0.6650	3.7975		83.02%	0.9329
10	44			0.2770	1.5815		80.96%	0.8977
10	44			0.5703	3.2564		81.57%	0.9182
10	44			0.3054	1.7441		88.08%	0.9410
Average		**0.9208**	**5.2581**	**0.6029**	**3.4426**	**82.96%**	**84.58%**	**0.9388**
Std. Dev.		**0.3010**	**1.7189**	**0.2693**	**1.5377**	**1.09%**	**7.36%**	**0.0352**

Table G.2 FWD data for I-490 West, Monroe, Rochester on morning of Oct. 11, 2006, with nominal load 58 kN (13 kip).

Load		DO L		DO M		LTE L	SPR	D3/D0 M
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)			
13	58	1.3056	7.4550	0.7753	4.4273	83.84%	75.73%	0.9059
13	58	1.3271	7.5781	0.6650	3.7974	84.32%	83.88%	0.9341
13	58	1.2026	6.8673	0.7328	4.1844	83.48%	92.91%	0.9771
13	58	1.1962	6.8307	1.1703	6.6826	84.24%	78.76%	0.8693
13	58	0.7799	4.4534	0.7525	4.2968	83.11%	74.59%	0.9011
13	58	0.7922	4.5238	0.6282	3.5874	82.33%	81.35%	0.9276
13	58	0.7143	4.0787	0.6442	3.6787	81.63%	92.44%	0.9727
13	58	0.8158	4.6583	1.0281	5.8706	82.01%	80.62%	0.9201
13	58	0.6603	3.7703	0.7081	4.0434	82.37%	78.22%	0.9321
13	58	0.6705	3.8285	0.6770	3.8656	82.13%	81.66%	0.9059
13	58	0.5926	3.3840	0.6832	3.9012	81.50%	91.55%	0.9742
13	58	0.7094	4.0509	1.1168	6.3773	81.40%	78.70%	0.8668
13	58			0.3078	1.7577		84.27%	0.9154
13	58			0.3424	1.9552		99.76%	0.9469
13	58			0.7061	4.0319		86.57%	0.9763
13	58			0.3558	2.0320		72.15%	0.8894
13	58			0.3210	1.8331		83.33%	0.9238
13	58			0.3203	1.8292		93.91%	0.9578
13	58			0.6052	3.4559		86.11%	0.9725
13	58			0.3390	1.9359		81.39%	0.9209
13	58			0.3706	2.1160		100.53%	0.9787
13	58			0.7147	4.0813		86.87%	0.9878
13	58			0.2657	1.5172		83.64%	0.9050
13	58			0.6589	3.7625		83.21%	0.9262
13	58			0.2865	1.6357		81.30%	0.8984
13	58			0.5608	3.2022		82.08%	0.9137
13	58			0.2913	1.6634		84.66%	0.9133
Average		**0.8972**	**5.1233**	**0.5936**	**3.3897**	**82.70%**	**84.45%**	**0.9301**
Std. Dev.		**0.2755**	**1.5730**	**0.2557**	**1.4604**	**1.06%**	**6.99%**	**0.0344**

Table G.3 FWD data for I-490 West, Monroe, Rochester on morning of Oct. 11, 2006, with nominal load 71 kN (16 kip).

Load		**DO L**		**DO M**		**LTE L**	**SPR**	**D3/D0 M**
(kip)	**(kN)**	**(mil/kip)**	**(μm/kN)**	**(mil/kip)**	**(μm/kN)**			
16	71	1.2243	6.9908	0.7346	4.1948	83.99%	75.93%	0.9101
16	71	1.2494	7.1342	0.6410	3.6600	84.05%	83.73%	0.9338
16	71	1.1309	6.4575	0.7024	4.0109	83.51%	93.01%	0.9757
16	71	1.1423	6.5227	1.1192	6.3908	84.08%	78.49%	0.8595
16	71	0.7606	4.3430	0.7190	4.1056	82.97%	75.19%	0.9090
16	71	0.7680	4.3855	0.6042	3.4501	82.11%	81.18%	0.9364
16	71	0.6934	3.9592	0.6202	3.5414	81.48%	92.36%	0.9733
16	71	0.7876	4.4974	0.9730	5.5562	81.95%	80.74%	0.9152
16	71	0.6471	3.6948	0.6764	3.8621	82.63%	78.44%	0.9347
16	71	0.6567	3.7501	0.6460	3.6886	81.95%	81.49%	0.9078
16	71	0.5804	3.3144	0.6562	3.7469	81.62%	91.94%	0.9767
16	71	0.6839	3.9051	1.0778	6.1541	81.42%	78.31%	0.8607
16	71			0.3069	1.7524		84.54%	0.9214
16	71			0.3325	1.8985		100.70%	0.9657
16	71			0.6729	3.8426		86.20%	0.9775
16	71			0.3506	2.0018		72.88%	0.8940
16	71			0.3176	1.8133		82.96%	0.9302
16	71			0.3166	1.8078		93.83%	0.9617
16	71			0.5859	3.3454		85.81%	0.9703
16	71			0.3356	1.9165		81.07%	0.9267
16	71			0.3643	2.0801		100.77%	0.9786
16	71			0.6909	3.9454		86.71%	0.9825
16	71			0.2685	1.5332		83.24%	0.9170
16	71			0.6361	3.6321		82.86%	0.9242
16	71			0.2876	1.6425		81.00%	0.9083
16	71			0.5490	3.1347		81.81%	0.9102
16	71			0.2888	1.6492		84.53%	0.9215
Average		**0.8604**	**4.9129**	**0.5731**	**3.2725**	**82.65%**	**84.43%**	**0.9327**
Std. Dev.		**0.2495**	**1.4245**	**0.2402**	**1.3718**	**1.04%**	**7.05%**	**0.0346**

Table G.4 FWD data for I-490 West, Monroe, Rochester on afternoon of Oct. 11, 2006, with nominal load 44 kN (10 kip).

Load		DO L		DO M		LTE L	SPR	D3/D0 M
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)			
10	44	1.2730	7.2689	0.7868	4.4926	85.47%	74.66%	0.9170
10	44	1.2979	7.4115	0.6811	3.8891	85.76%	85.67%	0.9468
10	44	1.4240	8.1311	1.1953	6.8251	86.07%	84.99%	1.0767
10	44	1.2592	7.1903	0.8222	4.6951	86.84%	77.20%	0.9210
10	44	1.3505	7.7113	0.6876	3.9262	84.77%	83.77%	0.9495
10	44	0.8382	4.7860	0.7640	4.3625	83.02%	92.19%	0.9794
10	44	0.7948	4.5387	1.1905	6.7981	83.24%	78.26%	0.8712
10	44	0.7365	4.2053	0.8872	5.0661	82.01%	77.74%	0.9277
10	44	0.8659	4.9445	0.8224	4.6957	82.53%	87.85%	0.9564
10	44	0.6886	3.9317	1.2475	7.1232	83.75%	76.87%	0.8458
10	44	0.7285	4.1600	0.3837	2.1909	81.76%	70.89%	0.8932
10	44	0.6018	3.4366	0.3113	1.7777	82.01%	83.55%	0.9327
10	44	0.7480	4.2713	0.3481	1.9880	81.71%	104.37%	0.9939
10	44			0.7356	4.2003		86.13%	0.9885
10	44			0.3682	2.1026		72.78%	0.8971
10	44			0.3338	1.9062		84.60%	0.9272
10	44			0.3393	1.9375		98.02%	0.9534
10	44			0.6537	3.7328		85.24%	0.9725
10	44			0.3434	1.9609		78.93%	0.9264
10	44			0.3348	1.9120		81.68%	0.9214
10	44			0.7205	4.1143		87.30%	1.0030
10	44			0.2559	1.4610		82.98%	0.9174
10	44			0.6503	3.7134		88.46%	1.0148
10	44			0.2855	1.6304		82.90%	0.9033
10	44			0.6048	3.4533		81.71%	0.8989
10	44			0.2947	1.6827		84.12%	0.9245
10	44			0.6707	3.8296		88.80%	1.0064
Average		**0.9698**	**5.5375**	**0.6192**	**3.5358**	**83.77%**	**83.77%**	**0.9432**
Std. Dev.		**0.2986**	**1.7048**	**0.2939**	**1.6782**	**1.81%**	**7.20%**	**0.0496**

Table G.5 FWD data for I-490 West, Monroe, Rochester on afternoon of Oct. 11, 2006, with nominal load 58 kN (13 kip).

Load		DO L		DO M		LTE L	SPR	D3/D0 M
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)			
13	58	1.2197	6.9648	0.7682	4.3868	85.03%	75.06%	0.9182
13	58	1.2549	7.1654	0.6679	3.8138	85.12%	85.16%	0.9448
13	58	1.3598	7.7646	1.1595	6.6209	86.09%	85.02%	1.0734
13	58	1.2134	6.9287	0.7986	4.5601	86.50%	77.22%	0.9187
13	58	1.2985	7.4148	0.6900	3.9403	84.37%	83.24%	0.9498
13	58	0.8361	4.7740	0.7521	4.2948	82.86%	92.18%	0.9734
13	58	0.7948	4.5386	1.1553	6.5969	82.67%	77.80%	0.8634
13	58	0.7338	4.1902	0.8514	4.8613	82.18%	77.16%	0.9206
13	58	0.8464	4.8332	0.7965	4.5479	82.09%	87.79%	0.9510
13	58	0.6670	3.8086	1.2150	6.9376	82.94%	76.73%	0.8387
13	58	0.7203	4.1130	0.3884	2.2179	82.33%	71.90%	0.8841
13	58	0.6040	3.4487	0.3214	1.8354	81.16%	84.38%	0.9238
13	58	0.7376	4.2118	0.3580	2.0440	81.39%	103.54%	0.9756
13	58			0.7281	4.1578		86.50%	0.9738
13	58			0.3675	2.0983		72.82%	0.8925
13	58			0.3380	1.9302		83.51%	0.9021
13	58			0.3399	1.9410		97.32%	0.9509
13	58			0.6358	3.6302		85.35%	0.9701
13	58			0.3473	1.9830		79.48%	0.9159
13	58			0.3356	1.9166		81.77%	0.9106
13	58			0.7226	4.1259		87.32%	1.0000
13	58			0.2712	1.5485		84.23%	0.9035
13	58			0.6307	3.6011		88.14%	1.0089
13	58			0.2955	1.6875		82.16%	0.8952
13	58			0.5983	3.4165		81.61%	0.8973
13	58			0.2976	1.6995		83.15%	0.9019
13	58			0.6778	3.8703		88.36%	0.9667
Average		**0.9451**	**5.3966**	**0.6114**	**3.4913**	**83.44%**	**83.66%**	**0.9343**
Std. Dev.		**0.2763**	**1.5780**	**0.2800**	**1.5989**	**1.77%**	**6.98%**	**0.0494**

Table G.6 FWD data for I-490 West, Monroe, Rochester on afternoon of Oct. 11, 2006, with nominal load 71 kN (16 kip).

Load		DO L		DO M		LTE L	SPR	D3/D0 M
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)			
16	71	1.1581	6.6128	0.7256	4.1433	84.90%	76.06%	0.9189
16	71	1.1850	6.7666	0.6404	3.6567	85.01%	85.24%	0.9459
16	71	1.2880	7.3549	1.1030	6.2984	86.11%	84.84%	1.0760
16	71	1.1507	6.5707	0.7619	4.3506	86.55%	77.60%	0.9195
16	71	1.2466	7.1185	0.6647	3.7954	84.36%	83.20%	0.9452
16	71	0.8169	4.6645	0.7277	4.1555	82.70%	91.98%	0.9772
16	71	0.7700	4.3970	1.1150	6.3670	82.26%	77.78%	0.8625
16	71	0.7100	4.0543	0.8179	4.6704	81.80%	77.16%	0.9211
16	71	0.8147	4.6523	0.7749	4.4246	81.99%	88.84%	0.9511
16	71	0.6579	3.7566	1.1754	6.7119	82.76%	76.87%	0.8348
16	71	0.6963	3.9758	0.3862	2.2050	82.10%	71.95%	0.8932
16	71	0.5910	3.3745	0.3197	1.8255	81.22%	84.76%	0.9168
16	71	0.7044	4.0223	0.3448	1.9687	81.84%	102.20%	0.9755
16	71			0.7060	4.0316		86.57%	0.9733
16	71			0.3615	2.0640		73.32%	0.8950
16	71			0.3311	1.8909		83.22%	0.9129
16	71			0.3339	1.9066		97.01%	0.9551
16	71			0.6238	3.5622		85.07%	0.9653
16	71			0.3457	1.9737		80.04%	0.9221
16	71			0.3410	1.9471		82.98%	0.9156
16	71			0.6954	3.9708		86.65%	0.9896
16	71			0.2719	1.5524		84.92%	0.9183
16	71			0.6005	3.4288		88.51%	1.0040
16	71			0.2943	1.6804		81.09%	0.9057
16	71			0.5765	3.2916		81.02%	0.8907
16	71			0.2980	1.7014		83.84%	0.9137
16	71			0.6449	3.6827		87.92%	0.9904
Average		**0.9069**	**5.1785**	**0.5919**	**3.3799**	**83.35%**	**83.73%**	**0.9366**
Std. Dev.		**0.2553**	**1.4575**	**0.2651**	**1.5136**	**1.79%**	**6.72%**	**0.0487**

Table G.7 FWD data for I-490 East, Monroe, Rochester on October 12, 2006 with standard dowel bar configuration under nominal load of 44 kN (10 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/D0 M	JSR
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)					
10	44	0.8803	5.0267	0.8874	5.0673	0.2856	1.6310	83.55%	81.63%	87.25%	0.9319	1.0507
10	44	0.8873	5.0664	0.9324	5.3242	0.3327	1.9000	83.06%	80.98%	108.85%	0.9969	1.0042
10	44	0.8859	5.0588	0.9363	5.3466	0.2737	1.5629	83.10%	80.84%	85.76%	0.9163	0.7077
10	44	0.6348	3.6249	0.6627	3.7838	0.2855	1.6303	82.30%	79.78%	98.10%	0.9638	1.0997
10	44	0.7280	4.1569	0.7287	4.1609	0.2765	1.5789	82.66%	80.17%	96.44%	0.9511	
10	44	0.4768	2.7225	0.4533	2.5882	0.2425	1.3848	82.24%	79.58%	82.36%	0.9134	1.0599
10	44	0.5456	3.1153	0.4804	2.7431	0.2402	1.3718	81.40%	80.31%	83.81%	0.9170	1.1011
10	44	0.5926	3.3841	0.5290	3.0205	0.2235	1.2760	82.17%	81.08%	83.47%	0.9343	1.0428
10	44	0.5931	3.3870	0.5516	3.1498	0.2377	1.3571	82.35%	79.85%	81.33%	0.9336	0.9083
10	44	0.5283	3.0168	0.5010	2.8608	0.2036	1.1625	82.57%	80.30%	82.94%	0.9639	0.9045
10	44	0.4868	2.7797	0.4531	2.5876	0.2123	1.2120	81.48%	80.37%	82.51%	0.9059	1.0005
10	44	0.4997	2.8532	0.4534	2.5889	0.2158	1.2321	82.52%	78.69%	81.26%	0.9073	0.9717
10	44	0.4963	2.8338	0.4406	2.5157	0.2151	1.2281	80.51%	78.99%	81.66%	0.9069	0.9791
10	44	0.4664	2.6631	0.4313	2.4631	0.2053	1.1722	80.78%	79.46%	80.67%	0.8808	0.9394
10	44	0.4470	2.5525	0.4052	2.3138	0.2227	1.2717	82.66%	79.47%	84.42%	0.9190	
10	44	0.4922	2.8107	0.4558	2.6024	0.2604	1.4870	82.90%	81.59%	84.64%	0.9344	0.9765
10	44	0.4831	2.7588	0.4451	2.5413	0.2572	1.4687	83.70%	81.19%	83.36%	0.9167	0.9799
10	44	0.4733	2.7027	0.4361	2.4901	0.2572	1.4687	83.14%	80.30%	83.76%	0.9212	
Average		**0.5888**	**3.3619**	**0.5657**	**3.2305**	**0.2471**	**1.4109**	**82.39%**	**80.25%**	**86.26%**	**0.9286**	**0.9817**
Std. Dev.		**0.1530**	**0.8735**	**0.1823**	**1.0411**	**0.0347**	**0.1979**	**0.88%**	**0.85%**	**7.40%**	**0.0269**	**0.0971**

Table G.8 FWD data for I-490 East, Monroe, Rochester on October 12, 2006 with standard dowel bar configuration under nominal load of 58 kN (13 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/D0 M	JSR
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)					
13	58	0.8541	4.8768	0.8711	4.9741	0.2954	1.6869	83.52%	81.19%	86.72%	0.9423	1.0455
13	58	0.8295	4.7364	0.9107	5.2004	0.3378	1.9286	82.54%	80.31%	108.04%	1.0023	0.9976
13	58	0.8731	4.9855	0.9086	5.1882	0.2806	1.6023	82.96%	80.38%	84.75%	0.9222	0.7261
13	58	0.6546	3.7381	0.6597	3.7670	0.2913	1.6633	82.55%	79.83%	97.75%	0.9625	1.0840
13	58	0.7052	4.0267	0.7151	4.0835	0.2756	1.5736	82.83%	80.37%	93.87%	0.9545	
13	58	0.4789	2.7346	0.4518	2.5796	0.2473	1.4120	82.18%	80.03%	81.55%	0.9016	1.0744
13	58	0.5426	3.0981	0.4854	2.7717	0.2410	1.3761	81.37%	79.19%	83.12%	0.9088	1.0973
13	58	0.5808	3.3167	0.5326	3.0414	0.2326	1.3284	81.36%	79.23%	86.05%	0.9161	1.0258
13	58	0.5846	3.3379	0.5464	3.1200	0.2505	1.4306	82.57%	79.51%	82.26%	0.8969	0.9287
13	58	0.5328	3.0422	0.5074	2.8976	0.2220	1.2678	81.39%	78.57%	83.16%	0.9081	0.9179
13	58	0.4902	2.7992	0.4658	2.6596	0.2144	1.2242	80.45%	78.95%	81.77%	0.9048	0.9871
13	58	0.4977	2.8417	0.4598	2.6254	0.2203	1.2579	82.32%	78.97%	81.61%	0.8964	0.9956
13	58	0.4972	2.8390	0.4578	2.6139	0.2222	1.2688	79.87%	78.47%	82.03%	0.8972	0.9389
13	58	0.4666	2.6642	0.4298	2.4541	0.2112	1.2062	81.22%	80.59%	81.10%	0.8885	0.9392
13	58	0.4523	2.5825	0.4036	2.3049	0.2289	1.3069	81.75%	80.40%	84.62%	0.9063	
13	58	0.4937	2.8190	0.4563	2.6054	0.2589	1.4786	82.64%	81.28%	84.19%	0.9329	0.9849
13	58	0.4745	2.7092	0.4494	2.5660	0.2596	1.4826	83.67%	81.55%	83.18%	0.9141	0.9840
13	58	0.4679	2.6717	0.4422	2.5250	0.2516	1.4368	82.65%	82.05%	83.45%	0.9373	
Average		**0.5820**	**3.3233**	**0.5641**	**3.2210**	**0.2523**	**1.4406**	**82.10%**	**80.05%**	**86.07%**	**0.9218**	**0.9818**
Std. Dev.		**0.1415**	**0.8079**	**0.1721**	**0.9829**	**0.0336**	**0.1918**	**1.00%**	**1.04%**	**7.01%**	**0.0291**	**0.0906**

Table G.9 FWD data for I-490 East, Monroe, Rochester on October 12, 2006 with standard dowel bar configuration under nominal load of 71 kN (16 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/D0 M	JSR
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)					
16	71	0.8138	4.6468	0.8340	4.7625	0.2960	1.6899	83.04%	81.01%	86.77%	0.9310	1.0354
16	71	0.8212	4.6893	0.8635	4.9308	0.3376	1.9277	82.68%	80.56%	107.76%	0.9929	1.0012
16	71	0.8292	4.7350	0.8645	4.9366	0.2799	1.5981	82.54%	80.57%	84.73%	0.9147	0.7539
16	71	0.6380	3.6429	0.6518	3.7216	0.2880	1.6447	82.08%	80.04%	96.79%	0.9564	1.0689
16	71	0.6955	3.9711	0.6966	3.9778	0.2783	1.5894	82.35%	80.14%	93.63%	0.9438	
16	71	0.4737	2.7047	0.4563	2.6053	0.2517	1.4370	81.96%	79.37%	81.69%	0.8998	1.0589
16	71	0.5295	3.0234	0.4831	2.7587	0.2435	1.3906	81.29%	79.60%	83.61%	0.9044	1.0860
16	71	0.5588	3.1908	0.5247	2.9959	0.2316	1.3223	82.08%	79.27%	85.93%	0.9203	1.0104
16	71	0.5701	3.2552	0.5301	3.0272	0.2494	1.4241	81.98%	79.98%	81.94%	0.9048	0.9446
16	71	0.5218	2.9795	0.5008	2.8595	0.2254	1.2872	82.04%	79.17%	83.11%	0.9101	0.9250
16	71	0.4838	2.7626	0.4632	2.6450	0.2181	1.2455	81.22%	79.22%	82.42%	0.9068	0.9828
16	71	0.4959	2.8319	0.4553	2.5996	0.2194	1.2526	81.60%	79.74%	81.78%	0.8997	1.0028
16	71	0.4928	2.8141	0.4565	2.6069	0.2259	1.2902	79.88%	79.08%	81.55%	0.8997	0.9433
16	71	0.4634	2.6463	0.4307	2.4592	0.2141	1.2227	80.36%	80.14%	80.92%	0.8788	0.9535
16	71	0.4507	2.5737	0.4107	2.3449	0.2277	1.3000	82.12%	79.17%	83.58%	0.9013	
16	71	0.4846	2.7674	0.4530	2.5868	0.2604	1.4867	82.24%	80.85%	84.89%	0.9271	0.9856
16	71	0.4643	2.6511	0.4465	2.5496	0.2591	1.4793	82.86%	81.59%	83.28%	0.9192	0.9857
16	71	0.4619	2.6374	0.4401	2.5130	0.2568	1.4664	82.22%	81.30%	84.11%	0.9238	
Average		**0.5694**	**3.2513**	**0.5534**	**3.1601**	**0.2535**	**1.4475**	**81.92%**	**80.04%**	**86.03%**	**0.9186**	**0.9825**
Std. Dev.		**0.1324**	**0.7561**	**0.1567**	**0.8947**	**0.0328**	**0.1871**	**0.81%**	**0.79%**	**6.83%**	**0.0259**	**0.0792**

Table G.10 FWD data for I-490 East, Monroe, Rochester on October 12, 2006 with E1 dowel bar configuration under nominal load of 44 kN (10 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/D0 M	JSR
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)					
10	44	0.7261	4.1460	0.7162	4.0894	0.2776	1.5853	82.34%	80.38%	86.57%	0.9363	0.9930
10	44	0.7443	4.2503	0.7112	4.0608	0.2464	1.4070	82.10%	80.82%	93.08%	0.9574	0.3465
10	44	0.6328	3.6136	0.7275	4.1539	0.2564	1.4643	83.19%	81.12%	89.29%	0.9472	0.9262
10	44	0.6882	3.9298	0.6738	3.8474	0.2667	1.5229	82.77%	79.78%	87.51%	0.9333	1.0560
10	44	0.7055	4.0283	0.7115	4.0628	0.2924	1.6694	83.38%	80.33%	86.31%	0.9065	1.0327
10	44	0.7301	4.1690	0.7348	4.1957	0.2950	1.6846	83.31%	80.98%	86.31%	0.9359	1.0556
10	44	0.7792	4.4495	0.7757	4.4291	0.2972	1.6973	82.63%	80.08%	85.74%	0.9364	0.9937
10	44	0.7694	4.3934	0.7708	4.4013	0.3074	1.7552	82.60%	80.08%	79.60%	0.9147	1.0148
10	44	0.7231	4.1289	0.7822	4.4663	0.2729	1.5584	81.94%	80.00%	84.11%	0.9035	0.8824
10	44	0.5069	2.8947	0.6902	3.9410	0.2560	1.4620	81.26%	80.92%	85.19%	0.9375	
10	44	0.4769	2.7232	0.4883	2.7880	0.2466	1.4083	81.98%	76.60%	85.17%	0.9351	0.9248
10	44	0.5020	2.8667	0.4515	2.5782	0.2546	1.4540	82.77%	80.71%	85.05%	0.9289	1.0488
10	44	0.5485	3.1322	0.4735	2.7040	0.2563	1.4637	83.20%	80.77%	82.64%	0.9378	1.0683
10	44	0.4639	2.6491	0.5059	2.8886	0.2506	1.4307	82.72%	81.43%	83.05%	0.9444	0.9085
10	44	0.4789	2.7345	0.4596	2.6243	0.2551	1.4565	83.04%	80.74%	83.36%	0.9247	0.9873
10	44	0.4679	2.6719	0.4538	2.5911	0.2450	1.3992	83.14%	80.47%	84.41%	0.9391	1.0205
10	44	0.4628	2.6428	0.4631	2.6443	0.2506	1.4309	82.64%	80.05%	83.02%	0.9319	0.9522
10	44	0.4431	2.5299	0.4410	2.5179	0.2455	1.4016	82.77%	80.63%	83.74%	0.9130	0.9899
10	44	0.4657	2.6593	0.4365	2.4925	0.2391	1.3651	82.80%	80.88%	82.38%	0.9241	0.9813
10	44	0.4627	2.6421	0.4283	2.4458	0.2300	1.3134	80.14%	80.80%	82.83%	0.9116	
10	44	0.4219	2.4092	0.4420	2.5240	0.2125	1.2134	80.76%	78.74%	81.02%	0.8990	0.9067
10	44	0.4702	2.6849	0.4008	2.2884	0.2094	1.1960	81.46%	80.05%	79.43%	0.9031	1.1002
10	44	0.4510	2.5751	0.4409	2.5176	0.2070	1.1817	79.95%	78.54%	78.81%	0.9021	0.9691
10	44	0.4283	2.4458	0.4273	2.4398	0.2089	1.1930	80.30%	78.89%	83.53%	0.9239	0.9194
10	44			0.3928	2.2432				77.66%			
Average		**0.5646**	**3.2238**	**0.5600**	**3.1974**	**0.2533**	**1.4464**	**82.22%**	**80.06%**	**84.26%**	**0.9261**	**0.9581**
Std. Dev.		**0.1297**	**0.5523**	**0.1197**	**0.6833**	**0.0256**	**0.1462**	**1.11%**	**1.29%**	**1.99%**	**0.0148**	**0.0641**

Table G.11 FWD data for I-490 East, Monroe, Rochester on October 12, 2006 with E1 dowel bar configuration under nominal load of 58 kN (13 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/D0 M	JSR
(kip)	(kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)					
13	58	0.7094	4.0506	0.7032	4.0156	0.2871	1.6396	82.63%	80.02%	87.32%	0.9264	0.9828
13	58	0.7191	4.1060	0.6911	3.9464	0.2495	1.4246	82.24%	81.16%	89.77%	0.9375	0.3610
13	58	0.6197	3.5387	0.7052	4.0269	0.2590	1.4792	83.31%	81.12%	88.63%	0.9396	0.9453
13	58	0.6702	3.8272	0.6667	3.8068	0.2696	1.5394	82.92%	79.57%	86.82%	0.9333	1.0373
13	58	0.6840	3.9058	0.6916	3.9489	0.2949	1.6839	83.12%	80.48%	86.10%	0.9122	1.0062
13	58	0.7097	4.0522	0.6959	3.9735	0.2995	1.7103	83.74%	80.62%	85.56%	0.9319	1.0815
13	58	0.7541	4.3058	0.7526	4.2974	0.3020	1.7242	82.59%	80.32%	85.89%	0.9377	0.9937
13	58	0.7475	4.2685	0.7478	4.2703	0.3096	1.7679	82.29%	80.19%	79.06%	0.9137	1.0117
13	58	0.7043	4.0215	0.7566	4.3202	0.2718	1.5523	82.34%	80.57%	83.00%	0.9159	0.8935
13	58	0.5105	2.9153	0.6760	3.8599	0.2621	1.4965	81.38%	81.01%	83.75%	0.9154	
13	58	0.4795	2.7381	0.4925	2.8121	0.2523	1.4404	80.93%	76.26%	84.83%	0.9279	0.9276
13	58	0.5038	2.8770	0.4568	2.6086	0.2607	1.4884	82.08%	80.63%	84.80%	0.9184	1.0440
13	58	0.5471	3.1243	0.4769	2.7234	0.2623	1.4977	82.90%	81.00%	83.44%	0.9311	1.0624
13	58	0.4720	2.6952	0.5067	2.8933	0.2526	1.4425	82.55%	81.53%	82.44%	0.9346	0.9064
13	58	0.4737	2.7049	0.4593	2.6224	0.2569	1.4668	82.24%	80.55%	83.56%	0.9202	0.9961
13	58	0.4724	2.6973	0.4575	2.6122	0.2469	1.4097	82.52%	81.31%	84.53%	0.9361	1.0060
13	58	0.4617	2.6366	0.4602	2.6279	0.2493	1.4233	82.79%	80.69%	83.07%	0.9274	0.9767
13	58	0.4476	2.5558	0.4495	2.5665	0.2466	1.4082	81.59%	80.25%	82.38%	0.9199	0.9734
13	58	0.4637	2.6480	0.4375	2.4984	0.2446	1.3966	81.37%	80.69%	82.90%	0.9129	0.9917
13	58	0.4650	2.6554	0.4339	2.4776	0.2357	1.3459	81.20%	80.66%	81.74%	0.8993	
13	58	0.4277	2.4420	0.4444	2.5373	0.2201	1.2569	80.11%	79.43%	80.82%	0.8925	0.9039
13	58	0.4666	2.6641	0.4017	2.2935	0.2186	1.2484	81.29%	79.76%	79.74%	0.8881	1.0937
13	58	0.4559	2.6031	0.4393	2.5084	0.2131	1.2168	80.31%	78.77%	79.35%	0.9037	0.9838
13	58	0.4289	2.4488	0.4322	2.4677	0.2057	1.1748	80.04%	78.68%	81.79%	0.9119	0.9205
13	58			0.3978	2.2716				79.28%			
Average		**0.5581**	**3.1868**	**0.5533**	**3.1595**	**0.2571**	**1.4681**	**82.02%**	**80.18%**	**83.80%**	**0.9203**	**0.9591**
Std. Dev.		**0.1188**	**0.5109**	**0.1106**	**0.6313**	**0.0248**	**0.1417**	**0.92%**	**1.25%**	**1.81%**	**0.0139**	**0.0603**

Table G.12 FWD data for I-490 East, Monroe, Rochester on October 12, 2006 with E1 dowel bar configuration under nominal load of 71 kN (16 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/D0 M	JSR
(kip)	(kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)					
16	71	0.6838	3.9047	0.6760	3.8599	0.2847	1.6254	82.07%	80.25%	87.69%	0.9389	0.9897
16	71	0.6851	3.9121	0.6690	3.8200	0.2474	1.4125	82.08%	80.91%	89.48%	0.9424	0.3698
16	71	0.6029	3.4428	0.6723	3.8388	0.2601	1.4854	82.82%	80.71%	88.10%	0.9379	0.9578
16	71	0.6418	3.6651	0.6439	3.6769	0.2719	1.5525	82.79%	79.55%	86.79%	0.9300	1.0349
16	71	0.6466	3.6923	0.6664	3.8052	0.2963	1.6920	83.15%	80.22%	85.91%	0.9116	1.0053
16	71	0.6810	3.8888	0.6699	3.8252		1.7005	83.30%	80.29%	85.52%	0.9337	1.0747
16	71	0.7186	4.1035	0.7199	4.1108	0.3003	1.7150	82.33%	80.15%	85.18%	0.9343	1.0000
16	71	0.7134	4.0738	0.7199	4.1106	0.3089	1.7638	82.03%	79.90%	80.01%	0.9130	1.0139
16	71	0.6747	3.8527	0.7299	4.1676	0.2747	1.5687	82.13%	80.16%	83.75%	0.9091	0.8990
16	71	0.5061	2.8898	0.6561	3.7467	0.2613	1.4923	80.98%	80.88%	83.46%	0.9226	
16	71	0.4764	2.7203	0.4908	2.8027	0.2556	1.4593	81.14%	76.57%	84.80%	0.9306	0.9294
16	71	0.4947	2.8247	0.4562	2.6049	0.2599	1.4838	82.59%	79.92%	85.15%	0.9222	1.0437
16	71	0.5398	3.0826	0.4761	2.7186	0.2638	1.5063	82.91%	81.38%	83.10%	0.9371	1.0594
16	71	0.4667	2.6648	0.5044	2.8800	0.2568	1.4661	82.18%	81.59%	83.02%	0.9352	0.9108
16	71	0.4690	2.6778	0.4594	2.6230	0.2566	1.4650	82.40%	80.44%	82.84%	0.9145	1.0019
16	71	0.4712	2.6908	0.4602	2.6279	0.2371	1.3540	82.74%	80.83%	81.74%	0.9325	0.9981
16	71	0.4567	2.6079	0.4593	2.6229	0.2501	1.4284	82.48%	80.57%	83.15%	0.9335	0.9597
16	71	0.4426	2.5271	0.4408	2.5172	0.2468	1.4091	81.67%	80.30%	82.76%	0.9181	0.9910
16	71	0.4571	2.6099	0.4369	2.4946	0.2403	1.3721	81.05%	80.79%	81.71%	0.9163	0.9884
16	71	0.4634	2.6463	0.4318	2.4658	0.2392	1.3656	80.18%	80.25%	82.32%	0.9104	
16	71	0.4245	2.4240	0.4431	2.5300	0.2220	1.2678	80.59%	79.16%	79.88%	0.9037	0.9192
16	71	0.4609	2.6317	0.4073	2.3256	0.2187	1.2489	81.06%	79.79%	79.16%	0.9027	1.0857
16	71	0.4480	2.5583	0.4422	2.5249	0.2162	1.2344	80.59%	79.27%	79.65%	0.9096	0.9747
16	71	0.4315	2.4637	0.4310	2.4611	0.2117	1.2087	80.19%	79.14%	82.54%	0.9050	0.9311
16	71			0.4013	2.2916				79.17%			
Average		**0.5440**	**3.1065**	**0.5426**	**3.0981**	**0.2574**	**1.4699**	**81.89%**	**80.09%**	**83.65%**	**0.9227**	**0.9608**
Std. Dev.		**0.1060**	**0.4593**	**0.1010**	**0.5770**	**0.0241**	**0.1378**	**0.92%**	**1.13%**	**1.75%**	**0.0116**	**0.0561**

Table G.13 FWD data for I-490 East, Monroe, Rochester on October 12, 2006 with E2 dowel bar configuration under nominal load of 44 kN (10 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/D0 M	JSR
(kip)	(kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)					
10	44	0.6848	3.9101	0.7024	4.0111	0.2400	1.3707	82.20%	78.97%	88.35%	0.9083	1.0120
10	44	0.7125	4.0687	0.7109	4.0593	0.2486	1.4198	82.47%	80.21%	83.74%	0.9202	0.8417
10	44	0.6524	3.7251	0.5983	3.4166	0.2393	1.3663	81.85%	79.79%	83.04%	0.8991	0.9215
10	44	0.5380	3.0720	0.5514	3.1484	0.2276	1.2997	81.34%	78.03%	82.03%	0.9074	0.8689
10	44	0.5170	2.9523	0.4791	2.7355	0.2314	1.3211	82.21%	79.30%	80.84%	0.9091	0.9388
10	44	0.4557	2.6024	0.4497	2.5681	0.2287	1.3059	83.37%	80.47%	85.77%	0.9220	1.0106
10	44	0.4613	2.6343	0.4545	2.5952	0.2227	1.2717	81.84%	79.30%	82.41%	0.9143	1.0398
10	44	0.4618	2.6368	0.4726	2.6985	0.2348	1.3410	82.34%	78.56%	86.70%	0.9099	0.8770
10	44	0.4548	2.5972	0.4145	2.3666	0.2378	1.3577	82.24%	81.54%	84.59%	0.9248	1.0879
10	44	0.4437	2.5336	0.4509	2.5745	0.2405	1.3734	82.86%	79.20%	84.06%	0.9127	
10	44	0.4672	2.6680	0.4425	2.5270	0.2362	1.3486	81.84%	78.99%	85.82%	0.9273	1.0613
10	44	0.4932	2.8165	0.4697	2.6819	0.2487	1.4199	82.61%	80.73%	83.93%	0.9227	0.9381
10	44	0.4652	2.6566	0.4406	2.5158	0.2366	1.3508	82.22%	80.68%	83.12%	0.9186	0.9557
10	44	0.4507	2.5738	0.4211	2.4043	0.2315	1.3218	82.38%	80.87%	84.77%	0.9309	1.0037
10	44	0.4508	2.5741	0.4226	2.4132	0.2396	1.3684	82.90%	81.22%	82.96%	0.9241	1.0942
10	44	0.4752	2.7133	0.4624	2.6405	0.2539	1.4498	82.58%	80.47%	84.11%	0.9289	1.0109
10	44	0.5089	2.9056	0.4674	2.6691	0.2467	1.4087	81.97%	80.91%	84.14%	0.9145	0.9561
10	44	0.4692	2.6791	0.4469	2.5521	0.2489	1.4212	82.05%	79.86%	84.29%	0.9407	1.0096
10	44	0.4729	2.7003	0.4512	2.5767	0.2544	1.4527	83.37%	81.32%	83.78%	0.9417	1.0517
10	44	0.5238	2.9910	0.4746	2.7099	0.2575	1.4703	83.23%	81.96%	82.53%	0.9300	
10	44	0.3776	2.1564	0.3517	2.0085	0.2156	1.2310	81.07%	79.09%	84.80%	0.9208	0.9944
10	44	0.3923	2.2401	0.3498	1.9972	0.2310	1.3190	82.02%	80.18%	85.28%	0.9217	1.2022
10	44	0.4532	2.5877	0.4205	2.4011	0.2663	1.5207	83.45%	80.96%	85.87%	0.9398	1.0783
10	44	0.4699	2.6834	0.4534	2.5891	0.2565	1.4649	82.38%	81.75%	83.79%	0.9253	0.9115
10	44	0.4319	2.4662	0.4133	2.3601	0.2521	1.4394	82.38%	80.78%	84.12%	0.9364	
Average		**0.4914**	**2.8058**	**0.4709**	**2.6888**	**0.2411**	**1.3766**	**82.37%**	**80.21%**	**84.19%**	**0.9220**	**0.9939**
Std. Dev.		**0.0809**	**0.2001**	**0.0366**	**0.2088**	**0.0123**	**0.0701**	**0.59%**	**1.00%**	**1.06%**	**0.0094**	**0.0834**

Table G.14 FWD data for I-490 East, Monroe, Rochester on October 12, 2006 with E2 dowel bar configuration under nominal load of 58 kN (13 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/D0 M	JSR
(kip)	(kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)					
13	58	0.6675	3.8113	0.6864	3.9193	0.2620	1.4960	82.07%	79.40%	85.83%	0.9189	1.0127
13	58	0.6914	3.9479	0.6951	3.9692	0.2544	1.4529	82.47%	79.61%	83.44%	0.9198	0.8385
13	58	0.6346	3.6234	0.5829	3.3283	0.2412	1.3775	81.90%	80.03%	82.57%	0.9055	0.9443
13	58	0.5394	3.0800	0.5504	3.1428	0.2362	1.3485	81.18%	78.21%	81.74%	0.8904	0.8676
13	58	0.5118	2.9223	0.4775	2.7266	0.2366	1.3508	82.87%	79.50%	81.40%	0.9073	0.9506
13	58	0.4601	2.6272	0.4539	2.5918	0.2322	1.3256	82.56%	80.31%	85.13%	0.9291	0.9878
13	58	0.4573	2.6113	0.4483	2.5601	0.2253	1.2865	82.07%	79.44%	82.10%	0.9094	1.0460
13	58	0.4643	2.6512	0.4690	2.6780	0.2351	1.3423	82.28%	79.05%	85.67%	0.9200	0.8849
13	58	0.4542	2.5937	0.4150	2.3697	0.2378	1.3580	80.98%	80.04%	84.39%	0.9305	1.0834
13	58	0.4471	2.5528	0.4496	2.5673	0.2459	1.4039	82.54%	79.82%	82.88%	0.9105	
13	58	0.4680	2.6723	0.4453	2.5428	0.2396	1.3683	81.19%	79.22%	85.51%	0.9211	1.0346
13	58	0.4865	2.7783	0.4607	2.6307	0.2466	1.4082	82.22%	81.24%	84.17%	0.9295	0.9561
13	58	0.4601	2.6270	0.4405	2.5151	0.2380	1.3591	82.24%	80.94%	82.33%	0.9236	0.9491
13	58	0.4572	2.6105	0.4181	2.3871	0.2359	1.3473	81.31%	81.25%	84.00%	0.9200	1.0078
13	58	0.4492	2.5649	0.4213	2.4058	0.2436	1.3912	82.36%	80.98%	83.59%	0.9159	1.0857
13	58	0.4740	2.7064	0.4574	2.6121	0.2619	1.4953	81.97%	79.97%	84.15%	0.9157	1.0339
13	58	0.5121	2.9240	0.4730	2.7007	0.2492	1.4227	81.14%	80.30%	83.24%	0.9180	0.9447
13	58	0.4759	2.7174	0.4468	2.5513	0.2588	1.4777	81.54%	80.32%	83.63%	0.9116	1.0100
13	58	0.4752	2.7137	0.4513	2.5769	0.2541	1.4507	82.61%	81.13%	84.20%	0.9346	1.0335
13	58	0.5199	2.9684	0.4664	2.6633	0.2583	1.4749	83.38%	82.31%	82.53%	0.9207	
13	58	0.3794	2.1665	0.3580	2.0440	0.2126	1.2139	80.83%	79.20%	83.36%	0.9145	0.9829
13	58	0.3948	2.2542	0.3519	2.0091	0.2304	1.3155	82.53%	80.41%	85.19%	0.9384	1.1907
13	58	0.4475	2.5555	0.4189	2.3923	0.2638	1.5066	82.95%	82.01%	85.06%	0.9251	1.0610
13	58	0.4538	2.5912	0.4445	2.5382	0.2621	1.4964	83.07%	81.85%	84.84%	0.9339	0.9303
13	58	0.4284	2.4462	0.4135	2.3613	0.2548	1.4548	83.43%	82.92%	83.50%	0.9288	
Average		**0.4884**	**2.7887**	**0.4678**	**2.6714**	**0.2446**	**1.3970**	**82.15%**	**80.38%**	**83.78%**	**0.9197**	**0.9926**
Std. Dev.		**0.0753**	**0.1957**	**0.0343**	**0.1958**	**0.0134**	**0.0765**	**0.82%**	**1.10%**	**0.98%**	**0.0082**	**0.0764**

Table G.15 FWD data for I-490 East, Monroe, Rochester on October 12, 2006 with E2 dowel bar configuration under nominal load of 71 kN (16 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/D0 M	JSR
(kip)	(kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)					
16	71	0.6409	3.6594	0.6672	3.8098	0.2623	1.4975	81.99%	78.99%	86.25%	0.9176	0.9954
16	71	0.6652	3.7985	0.6641	3.7921	0.2570	1.4672	82.64%	80.13%	83.22%	0.9227	0.8596
16	71	0.6102	3.4843	0.5708	3.2596	0.2422	1.3832	81.87%	79.89%	82.43%	0.9064	0.9478
16	71	0.5268	3.0082	0.5411	3.0895	0.2351	1.3425	81.07%	78.05%	81.91%	0.8995	0.8741
16	71	0.5052	2.8848	0.4730	2.7007	0.2384	1.3614	82.31%	79.62%	82.04%	0.9030	0.9549
16	71	0.4542	2.5938	0.4516	2.5790	0.2338	1.3352	82.65%	79.66%	84.81%	0.9192	0.9983
16	71	0.4519	2.5804	0.4509	2.5745	0.2263	1.2925	81.79%	78.86%	82.24%	0.9031	1.0284
16	71	0.4534	2.5889	0.4637	2.6477	0.2308	1.3176	82.26%	78.59%	85.82%	0.9128	0.8811
16	71	0.4499	2.5687	0.4086	2.3330	0.2396	1.3682	81.83%	80.70%	83.96%	0.9204	1.0930
16	71	0.4456	2.5446	0.4466	2.5500	0.2482	1.4175	81.95%	79.36%	83.41%	0.9137	
16	71	0.4596	2.6243	0.4458	2.5453	0.2387	1.3632	81.14%	78.85%	85.54%	0.9185	1.0252
16	71	0.4780	2.7296	0.4570	2.6094	0.2461	1.4055	82.44%	80.34%	83.72%	0.9209	0.9494
16	71	0.4498	2.5682	0.4339	2.4775	0.2331	1.3309	82.14%	80.68%	83.20%	0.9213	0.9557
16	71	0.4494	2.5663	0.4147	2.3678	0.2317	1.3228	81.76%	80.77%	84.36%	0.9237	1.0112
16	71	0.4433	2.5313	0.4193	2.3943	0.2412	1.3770	82.10%	80.60%	83.87%	0.9218	1.0757
16	71	0.4672	2.6675	0.4511	2.5756	0.2634	1.5043	82.25%	79.95%	83.28%	0.9182	1.0523
16	71	0.5039	2.8773	0.4747	2.7103	0.2514	1.4356	81.94%	80.23%	82.92%	0.9214	0.9541
16	71	0.4757	2.7163	0.4529	2.5859	0.2611	1.4908	81.87%	79.92%	83.91%	0.9190	0.9917
16	71	0.4682	2.6736	0.4491	2.5643	0.2585	1.4763	82.56%	80.91%	84.09%	0.9304	1.0340
16	71	0.5132	2.9306	0.4644	2.6515	0.2616	1.4937	83.14%	82.16%	82.42%	0.9248	
16	71	0.3805	2.1725	0.3655	2.0872	0.2033	1.1608	80.79%	78.83%	82.00%	0.8805	0.9840
16	71	0.3935	2.2467	0.3597	2.0537	0.2351	1.3423	81.21%	79.60%	85.72%	0.9162	1.1718
16	71	0.4438	2.5344	0.4214	2.4064	0.2644	1.5095	82.41%	80.43%	85.32%	0.9195	1.0503
16	71	0.4520	2.5808	0.4427	2.5276	0.2639	1.5067	82.20%	80.56%	85.04%	0.9239	0.9223
16	71	0.4266	2.4360	0.4082	2.3312	0.2506	1.4312	82.22%	80.70%	83.64%	0.9341	
Average		**0.4803**	**2.7427**	**0.4639**	**2.6490**	**0.2447**	**1.3973**	**82.02%**	**79.94%**	**83.81%**	**0.9165**	**0.9914**
Std. Dev.		**0.0684**	**0.1837**	**0.0320**	**0.1829**	**0.0159**	**0.0909**	**0.55%**	**0.88%**	**1.11%**	**0.0109**	**0.0740**

Appendix H. FWD Data from I490 September 24-25, 2008

Table H.1 FWD data for I-490 West, Monroe, Rochester on September 24, 2008 with nominal load 44 kN (10 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/DO M	JSR
(kip)	(kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)					
10	44	0.6274	3.5825	0.5676	3.2412	0.2066	1.1796	78.48%	80.88%	88.34%	0.8913	1.2012
10	44	0.7413	4.2329	0.6818	3.8934	0.2003	1.1435	80.18%	80.03%	85.50%	0.9282	0.9991
10	44	0.7416	4.2344	0.6812	3.8899	0.2088	1.1925	79.43%	79.28%	88.95%	0.9110	0.9756
10	44	0.7418	4.2357	0.6646	3.7951	0.2069	1.1814	78.88%	81.88%	98.91%	0.9206	1.0603
10	44	0.7832	4.4720	0.7047	4.0240	0.2020	1.1532	80.06%	79.67%	89.16%	0.9565	1.0159
10	44	0.7926	4.5258	0.7159	4.0878	0.2201	1.2569	80.70%	83.67%	95.31%	0.9703	1.1157
10	44	0.8271	4.7231	0.7987	4.5607	0.2144	1.2241	79.97%	83.26%	89.76%	0.9235	0.9598
10	44	0.8247	4.7093	0.7666	4.3776	0.2239	1.2784	81.36%	82.21%	85.51%	0.9272	1.0554
10	44	0.8460	4.8306	0.8091	4.6201	0.2301	1.3141	81.41%	84.06%	88.26%	0.9333	0.9670
10	44	0.8456	4.8282	0.7824	4.4676	0.2188	1.2496	81.08%	83.82%	89.72%	0.9461	0.8649
10	44	0.7162	4.0898	0.6767	3.8642	0.1843	1.0526	82.44%	82.68%	93.10%	0.9240	0.8844
10	44	0.6351	3.6265	0.5985	3.4175	0.1633	0.9325	78.72%	83.88%	86.11%	0.8627	0.9889
10	44	0.6450	3.6830	0.5918	3.3794	0.1727	0.9860	80.94%	82.14%	95.13%	0.9816	0.9959
10	44	0.6060	3.4603	0.5894	3.3655	0.1911	1.0914	79.18%	83.12%	88.62%	0.9261	0.7574
10	44	0.4745	2.7093	0.4464	2.5490	0.2016	1.1514	79.45%	80.78%	89.95%	0.8763	1.1858
10	44	0.5772	3.2956	0.5293	3.0226	0.2329	1.3299	81.02%	82.00%	94.91%	0.9769	1.1597
10	44	0.6415	3.6628	0.6139	3.5052	0.2249	1.2844	83.79%	83.83%	81.59%	0.9143	0.7921
10	44	0.5308	3.0311	0.4863	2.7766	0.2522	1.4403	82.04%	85.87%	88.74%	0.9359	1.2999
10	44	0.7253	4.1414	0.6321	3.6094	0.2694	1.5383	83.99%	84.64%	89.49%	0.9398	1.1826
10	44	0.8161	4.6603	0.7476	4.2686	0.2347	1.3401	81.72%	85.44%	84.24%	0.9815	0.8341
10	44	0.6824	3.8967	0.6235	3.5605	0.2340	1.3361	81.48%	84.72%	84.29%	0.9206	0.9074
10	44	0.5948	3.3966	0.5658	3.2308	0.2513	1.4351	80.59%	84.18%	86.07%	0.9152	1.0228
10	44	0.6036	3.4469	0.5787	3.3046	0.2617	1.4942	80.22%	83.43%	79.15%	0.9072	0.9330
10	44	0.5946	3.3954	0.5399	3.0830	0.2499	1.4267	79.85%	83.47%	87.24%	0.9640	1.0797
10	44	0.6428	3.6703	0.5829	3.3286	0.2708	1.5461	80.92%	84.75%	88.69%	0.9456	1.0823
10	44	0.6720	3.8370	0.6309	3.6027	0.2714	1.5498	80.37%	83.39%	82.47%	0.9508	0.9305
10	44	0.6705	3.8288	0.5870	3.3521	0.2714	1.5497	80.54%	85.28%	87.06%	0.9407	1.0538
10	44	0.6483	3.7020	0.6186	3.5324	0.2535	1.4475	83.85%	82.94%	84.22%	0.8863	0.8060
10	44	0.5302	3.0272	0.4986	2.8470	0.2484	1.4182	81.46%	83.72%	86.22%	0.9693	0.9110
10	44	0.4943	2.8222	0.4542	2.5938	0.2330	1.3303	79.87%	84.08%	88.83%	0.9486	0.9852
10	44	0.5005	2.8580	0.4475	2.5552			80.00%	83.42%			
Average		**0.6701**	**3.8263**	**0.6198**	**3.5389**	**0.2268**	**1.2951**	**80.77%**	**83.11%**	**88.18%**	**0.9325**	**1.0002**
Std. Dev.		**0.1082**	**0.6178**	**0.1013**	**0.5785**	**0.0296**	**0.1693**	**1.41%**	**1.66%**	**4.27%**	**0.0301**	**0.1299**

Table H.2 FWD data for I-490 West, Monroe, Rochester on September 24, 2008 with nominal load 58 kN (13 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/DO M	JSR
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)					
13	58	0.6192	3.5360	0.5776	3.2984	0.2045	1.1676	79.00%	79.48%	84.23%	0.8971	1.1721
13	58	0.7373	4.2101	0.6771	3.8661	0.2062	1.1774	79.75%	80.25%	88.59%	0.9720	0.9791
13	58	0.7227	4.1270	0.6629	3.7855	0.2070	1.1819	79.53%	80.48%	91.26%	0.9370	0.9878
13	58	0.7332	4.1867	0.6548	3.7393	0.2123	1.2122	78.64%	81.61%	98.49%	0.9222	1.0298
13	58	0.7723	4.4098	0.6744	3.8507	0.2054	1.1726	80.68%	81.92%	89.72%	0.9280	1.0438
13	58	0.7808	4.4586	0.7039	4.0193	0.2241	1.2798	80.28%	81.93%	93.60%	0.9044	1.1279
13	58	0.8092	4.6204	0.7939	4.5335	0.2198	1.2553	80.37%	82.07%	91.37%	0.9478	0.9471
13	58	0.8170	4.6654	0.7520	4.2939	0.2281	1.3022	79.65%	82.09%	89.91%	0.9321	1.0586
13	58	0.8364	4.7761	0.7960	4.5453	0.2339	1.3356	81.33%	83.55%	88.89%	0.9271	0.9334
13	58	0.8258	4.7153	0.7430	4.2427	0.2109	1.2042	81.14%	83.90%	89.91%	0.9455	0.8706
13	58	0.7137	4.0755	0.6469	3.6939	0.1839	1.0499	81.59%	83.40%	92.47%	0.9286	0.9340
13	58	0.6250	3.5691	0.6042	3.4500	0.1744	0.9961	80.50%	83.99%	87.85%	0.9170	0.9823
13	58	0.6278	3.5849	0.5935	3.3888	0.1804	1.0302	80.74%	82.37%	92.76%	0.9619	0.9948
13	58	0.5988	3.4190	0.5904	3.3712	0.1883	1.0755	80.85%	82.72%	88.84%	0.9215	0.7595
13	58	0.4743	2.7085	0.4484	2.5605	0.2084	1.1899	79.64%	82.47%	94.70%	0.9481	1.1732
13	58	0.5684	3.2459	0.5261	3.0039	0.2369	1.3527	79.81%	82.09%	96.82%	0.9542	1.1209
13	58	0.6283	3.5878	0.5897	3.3670	0.2239	1.2782	83.85%	84.79%	83.53%	0.9483	0.8534
13	58	0.5281	3.0154	0.5032	2.8734	0.2546	1.4540	82.45%	83.36%	88.57%	0.9360	1.2220
13	58	0.6994	3.9935	0.6149	3.5114	0.2717	1.5517	83.71%	84.65%	91.40%	0.9427	1.2042
13	58	0.8022	4.5807	0.7405	4.2282	0.2406	1.3737	82.09%	83.74%	85.19%	0.9387	0.8380
13	58	0.6530	3.7289	0.6205	3.5434	0.2403	1.3722	82.29%	84.16%	85.19%	0.9161	0.8842
13	58	0.5845	3.3377	0.5487	3.1332	0.2507	1.4314	80.11%	84.38%	84.14%	0.9088	1.0595
13	58	0.5952	3.3987	0.5813	3.3195	0.2719	1.5524	80.75%	83.29%	78.37%	0.8961	0.9254
13	58	0.5910	3.3749	0.5379	3.0717	0.2638	1.5061	79.17%	83.03%	86.83%	0.9329	1.0929
13	58	0.6324	3.6113	0.5879	3.3570	0.2739	1.5642	81.34%	84.43%	83.86%	0.9360	1.0852
13	58	0.6446	3.6810	0.6380	3.6429	0.2703	1.5435	81.78%	83.67%	83.97%	0.9362	0.9168
13	58	0.6487	3.7040	0.5849	3.3399	0.2769	1.5809	81.65%	82.05%	87.91%	0.9583	1.0344
13	58	0.6284	3.5880	0.6050	3.4547	0.2455	1.4021	81.58%	83.79%	84.72%	0.8601	0.7961
13	58	0.5236	2.9897	0.4817	2.7504	0.2340	1.3359	81.36%	83.25%	84.29%	0.9053	0.9612
13	58	0.4870	2.7808	0.4630	2.6437	0.2318	1.3237	80.17%	83.09%	88.59%	0.9468	0.9850
13	58	0.5000	2.8548	0.4560	2.6039			82.05%	83.80%			
Average		**0.6583**	**3.7592**	**0.6128**	**3.4995**	**0.2291**	**1.3084**	**80.90%**	**82.90%**	**88.53%**	**0.9302**	**0.9991**
Std. Dev.		**0.1053**	**0.6011**	**0.0943**	**0.5387**	**0.0294**	**0.1677**	**1.26%**	**1.30%**	**4.40%**	**0.0231**	**0.1192**

Table H.3 FWD data for I-490 West, Monroe, Rochester on September 24, 2008 with nominal load 71 kN (16 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/DO M	JSR
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)					
16	71	0.5953	3.3993	0.5606	3.2011	0.2053	1.1721	79.16%	81.29%	85.92%	0.9080	1.1511
16	71	0.6975	3.9828	0.6453	3.6848	0.2047	1.1688	79.62%	80.49%	87.36%	0.9069	0.9801
16	71	0.6871	3.9233	0.6325	3.6115	0.2046	1.1683	79.47%			0.9313	0.9835
16	71	0.6924	3.9536	0.6220	3.5519	0.2060	1.1764	78.73%	81.18%	98.40%	0.9760	1.0392
16	71	0.7384	4.2164	0.6464	3.6910	0.2027	1.1573	80.80%		90.87%	0.9367	1.0401
16	71	0.7412	4.2324	0.6723	3.8391	0.2189	1.2499	80.22%	82.43%	92.87%	0.9440	1.1123
16	71	0.7766	4.4345	0.7478	4.2701	0.2128	1.2151	80.05%	82.52%	89.97%	0.9456	0.9626
16	71	0.7690	4.3913	0.7199	4.1106	0.2239	1.2785	79.79%	81.99%	88.79%	0.9342	1.0600
16	71	0.7913	4.5184	0.7631	4.3572	0.2271	1.2965	80.69%	83.17%	88.15%	0.9519	0.9391
16	71	0.7789	4.4478	0.7166	4.0920	0.2158	1.2324	81.07%	83.83%	88.75%	0.9266	0.8616
16	71	0.6811	3.8890	0.6175	3.5257	0.1840	1.0505	80.60%		91.75%	0.9399	0.9403
16	71	0.6062	3.4615	0.5806	3.3152	0.1704	0.9728	81.35%	82.77%	88.43%	0.9122	0.9670
16	71	0.6035	3.4460	0.5614	3.2057	0.1747	0.9978	80.06%	82.59%	91.36%	0.9272	0.9852
16	71	0.5672	3.2387	0.5531	3.1581	0.1864	1.0645	83.61%	83.12%	89.34%	0.9404	0.7846
16	71	0.4604	2.6292	0.4339	2.4779	0.2035	1.1620	79.36%	83.00%	89.81%	0.9402	1.1641
16	71	0.5470	3.1235	0.5051	2.8845	0.2322	1.3262	80.60%	82.42%	96.50%	0.9726	1.1294
16	71	0.6019	3.4371	0.5705	3.2576	0.2245	1.2822	83.56%	85.36%	83.09%	0.9301	0.8437
16	71	0.5092	2.9078	0.4813	2.7483	0.2497	1.4256	81.91%	83.82%	88.83%	0.9581	1.2038
16	71	0.6568	3.7503	0.5794	3.3082	0.2617	1.4942	82.46%	84.62%	90.84%	0.9603	1.2018
16	71	0.7419	4.2361	0.6963	3.9757	0.2373	1.3553	82.33%		85.27%	0.9462	0.8471
16	71	0.6295	3.5947	0.5898	3.3678	0.2338	1.3350	81.32%	84.98%	85.13%	0.9231	0.8881
16	71	0.5597	3.1962	0.5238	2.9909	0.2480	1.4160	81.09%	83.63%	84.37%	0.9234	1.0776
16	71	0.5662	3.2332	0.5644	3.2229	0.2609	1.4897	80.73%	83.87%	70.53%	0.9301	0.9344
16	71	0.5742	3.2787	0.5274	3.0116	0.2557	1.4599	81.36%	83.49%	86.56%	0.9478	1.0640
16	71	0.6036	3.4465	0.5612	3.2043	0.2666	1.5220	80.97%	84.55%	87.20%	0.9346	1.0691
16	71	0.6139	3.5054	0.5999	3.4256	0.2611	1.4910	81.13%	82.56%	84.91%	0.9311	0.9460
16	71	0.6216	3.5497	0.5675	3.2404	0.2700	1.5417	81.61%	0.00%	86.94%	0.9289	1.0368
16	71	0.6039	3.4481	0.5883	3.3595	0.2377	1.3570	82.74%	83.49%	83.26%	0.8349	0.7942
16	71	0.5008	2.8597	0.4673	2.6683	0.2325	1.3274	80.90%	83.94%	85.22%	0.9316	0.9679
16	71	0.4720	2.6949	0.4523	2.5827	0.2206	1.2596	80.37%	83.73%	87.70%	0.9389	0.9750
16	71	0.4810	2.7466	0.4410	2.5182			81.96%	82.68%			
Average		**0.6280**	**3.5862**	**0.5867**	**3.3503**	**0.2244**	**1.2815**	**80.96%**	**83.14%**	**87.87%**	**0.9338**	**0.9983**
Std. Dev.		**0.0959**	**0.5474**	**0.0874**	**0.4988**	**0.0274**	**0.1565**	**1.20%**	**1.16%**	**4.86%**	**0.0247**	**0.1133**

Table H.4 FWD data for I-490 East, Monroe, Rochester on Sep. 25, 2008 with standard dowel bar configuration under nominal load of 44 kN (10 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/DO M	JSR
(kip)	(kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)					
10	44	0.7726	4.4119	0.6943	3.9643	0.2300	1.3133	79.16%	81.70%	88.47%	0.9350	0.9942
10	44	0.6818	3.8934	0.6902	3.9412	0.2514	1.4356	79.62%	83.28%	87.94%	0.9221	1.1580
10	44	0.8470	4.8367	0.7992	4.5638	0.2894	1.6524	79.47%	83.64%	99.72%	0.9545	0.8895
10	44	0.7218	4.1216	0.7109	4.0596	0.2314	1.3212	78.73%	84.35%	100.12%	1.0048	0.7861
10	44	0.8230	4.6992	0.5588	3.1911	0.2275	1.2990	80.80%	83.18%	93.00%	0.9589	1.2053
10	44	0.6957	3.9723	0.6736	3.8463	0.2509	1.4327	80.22%	83.12%	96.33%	0.9507	0.9422
10	44	0.6909	3.9453	0.6347	3.6240	0.2579	1.4727	80.05%	84.37%	88.94%	0.9367	0.4290
10	44	0.5244	2.9941	0.2723	1.5546	0.1923	1.0982	79.79%	84.30%	91.42%	0.9686	1.3275
10	44	0.3868	2.2087	0.3614	2.0638	0.1425	0.8139	80.69%	81.19%	91.83%	0.9259	1.0733
10	44	0.4514	2.5774	0.3879	2.2151	0.1672	0.9548	81.07%	82.92%	91.48%	0.9608	1.1365
10	44	0.1798	1.0268	0.4409	2.5174	0.1119	0.6389	80.60%	82.52%	68.70%	0.9286	1.1415
10	44	0.2270	1.2963	0.1978	1.1293	0.1205	0.6883	81.35%	86.18%	72.02%	0.9497	0.6815
10	44	0.1369	0.7815	0.1348	0.7696	0.0933	0.5327	80.06%	83.21%	66.18%	0.8660	1.0409
10	44	0.2033	1.1607	0.1403	0.8011	0.0998	0.5701	83.61%	79.34%	51.50%	0.9006	2.0748
10	44	0.2007	1.1458	0.2911	1.6621	0.0879	0.5021	79.36%	77.93%	60.61%	0.8953	0.4699
10	44	0.1933	1.1036	0.1368	0.7811	0.2028	1.1579	80.60%	83.07%	62.24%	0.7871	2.2571
10	44	0.3451	1.9708	0.3087	1.7629	0.2158	1.2320	83.56%	77.99%	71.14%	0.9375	1.0312
10	44	0.3385	1.9330	0.3184	1.8179	0.2305	1.3159	81.91%	84.75%	70.15%	0.9272	0.9371
10	44	0.3366	1.9218	0.2983	1.7035	0.2068	1.1808	82.46%	85.87%	68.36%	0.8495	0.9787
10	44	0.3363	1.9201	0.2920	1.6671	0.2460	1.4048	82.33%	88.97%	89.17%	0.9050	1.2170
10	44	0.2522	1.4400	0.2344	1.3385	0.2042	1.1658	81.32%	86.31%	82.67%	0.9476	1.0649
10	44	0.2573	1.4695	0.2496	1.4254	0.2133	1.2181	81.09%	88.19%	79.39%	0.9189	0.9059
10	44	0.2437	1.3913	0.2261	1.2912	0.2161	1.2342	80.73%	86.32%	84.94%	0.9450	0.9778
10	44	0.2189	1.2500	0.2211	1.2625	0.2051	1.1712	81.36%	86.25%	78.35%	0.8837	0.9882
10	44	0.2303	1.3152	0.2185	1.2476	0.2062	1.1772	80.97%	85.84%	78.39%	0.9213	
Average		**0.4118**	**2.3515**	**0.3797**	**2.1680**	**0.1960**	**1.1193**	**80.84%**	**83.79%**	**80.52%**	**0.9232**	**1.0712**
Std. Dev.		**0.2327**	**1.3286**	**0.2075**	**1.1849**	**0.0560**	**0.3196**	**1.25%**	**2.77%**	**13.16%**	**0.0437**	**0.3995**

Table H.5 FWD data for I-490 East, Monroe, Rochester on Sep. 25, 2008 with standard dowel bar configuration under nominal load of 58 kN (13 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/DO M	JSR
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)					
13	58	0.7694	4.3936	0.7012	4.0038	0.2356	1.3454	79.31%	81.48%	88.25%	0.9324	1.0084
13	58	0.6614	3.7765	0.7071	4.0376	0.2552	1.4573	79.49%	82.73%	89.62%	0.9484	1.0988
13	58	0.8215	4.6910	0.7769	4.4363	0.2891	1.6508	80.41%	82.88%	94.84%	0.9570	0.9064
13	58	0.7075	4.0400	0.7042	4.0212	0.2450	1.3993	80.49%	84.36%	95.32%	0.9562	0.8189
13	58	0.8428	4.8125	0.5767	3.2931	0.2561	1.4625	81.09%	84.24%	96.77%	0.9530	1.0800
13	58	0.6821	3.8949	0.6228	3.5565	0.2534	1.4468	81.44%	84.17%	91.50%	0.9605	1.0263
13	58	0.6906	3.9432	0.6392	3.6501	0.2672	1.5259	80.25%	83.68%	88.85%	0.9448	0.6127
13	58	0.4954	2.8288	0.3917	2.2366	0.2012	1.1491	80.06%	83.29%	88.59%	0.9203	0.8722
13	58	0.3731	2.1305	0.3416	1.9508	0.1612	0.9207	81.14%	82.66%	91.35%	0.9634	1.1635
13	58	0.4539	2.5919	0.3975	2.2697	0.1646	0.9397	81.16%	83.91%	92.35%	0.9557	1.0808
13	58	0.1731	0.9885	0.4296	2.4531	0.1452	0.8291	83.20%	82.84%	63.78%	0.8924	1.1303
13	58	0.2249	1.2845	0.1914	1.0930	0.1170	0.6680	80.16%	84.48%	62.03%	0.9170	0.7886
13	58	0.1609	0.9188	0.1509	0.8619	0.0914	0.5220	75.70%	85.44%	92.55%	0.9777	0.8770
13	58	0.1710	0.9762	0.1324	0.7559	0.1002	0.5724	79.65%	85.85%	58.70%	0.8991	2.1701
13	58	0.1994	1.1386	0.2873	1.6404	0.0983	0.5610	78.25%	82.98%	53.29%	0.9125	0.5125
13	58	0.2065	1.1790	0.1472	0.8407	0.2157	1.2319	81.17%	82.30%	72.62%	0.9738	2.1243
13	58	0.3487	1.9909	0.3127	1.7858	0.2182	1.2458	79.36%	85.71%	70.90%	0.9349	1.0189
13	58	0.3433	1.9604	0.3187	1.8196	0.2305	1.3161	79.51%	83.42%	63.59%	0.9239	0.9981
13	58	0.3417	1.9513	0.3181	1.8161	0.2161	1.2338	80.34%	82.77%	67.32%	0.8996	0.9151
13	58	0.3286	1.8766	0.2911	1.6620	0.2397	1.3688	77.66%	66.29%	80.72%	0.9271	1.2319
13	58	0.2547	1.4545	0.2459	1.4039	0.2067	1.1803	82.88%	85.43%	83.31%	0.9507	1.0252
13	58	0.2584	1.4757	0.2521	1.4393	0.2127	1.2145	85.07%	85.83%	78.72%	0.9327	0.9276
13	58	0.2395	1.3678	0.2338	1.3351	0.2193	1.2522	84.80%	86.53%	77.47%	0.9553	0.9382
13	58	0.2385	1.3620	0.2194	1.2526	0.2054	1.1727	85.59%	86.94%	80.51%	0.9601	0.9953
13	58	0.2301	1.3137	0.2183	1.2467	0.2016	1.1509	85.21%	85.85%	82.12%	0.9307	
Average		**0.4087**	**2.3337**	**0.3843**	**2.1945**	**0.2019**	**1.1527**	**80.94%**	**83.44%**	**80.20%**	**0.9392**	**1.0550**
Std. Dev.		**0.2285**	**1.3050**	**0.2022**	**1.1547**	**0.0553**	**0.3158**	**2.42%**	**3.86%**	**12.85%**	**0.0235**	**0.3732**

Table H.6 FWD data for I-490 East, Monroe, Rochester on Sep. 25, 2008 with standard dowel bar configuration under nominal load of 71 kN (16 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/DO M	JSR
(kip)	(kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)					
16	71	0.7162	4.0894	0.6707	3.8297	0.2281	1.3025	79.91%	82.59%	89.56%	0.9397	0.9170
16	71	0.6165	3.5203	0.6150	3.5118	0.2478	1.4149	79.59%	82.99%		0.9624	1.2009
16	71	0.7605	4.3423	0.7386	4.2174	0.2690	1.5363	84.92%	82.55%	95.07%	0.9752	0.8753
16	71	0.6336	3.6180	0.6464	3.6913	0.1657	0.9464	80.23%	83.35%	93.08%	0.9706	1.0234
16	71	0.7951	4.5400	0.6615	3.7775	0.2388	1.3634	80.94%	84.03%	96.90%	0.9848	0.9310
16	71	0.6724	3.8393	0.6159	3.5169	0.2517	1.4371	80.35%	84.19%	93.35%	0.9348	0.8975
16	71	0.6431	3.6722	0.5528	3.1563	0.2585	1.4759	81.31%	84.28%	89.10%	0.9491	0.7024
16	71	0.5255	3.0008	0.3882	2.2169	0.2014	1.1500	80.90%	83.60%	89.12%	0.9330	0.8739
16	71	0.3674	2.0978	0.3393	1.9374	0.1568	0.8954	80.40%	82.97%	90.68%	0.9373	1.0817
16	71	0.4343	2.4801	0.3670	2.0957	0.1652	0.9435	80.50%	83.11%	92.08%	0.9526	1.1446
16	71	0.2152	1.2288	0.4201	2.3987	0.1506	0.8602	81.10%	82.22%	83.96%	0.8932	1.1239
16	71	0.2207	1.2603	0.1950	1.1137	0.1308	0.7469	81.34%	82.11%	78.96%	0.9130	0.9906
16	71	0.2124	1.2131	0.1932	1.1032	0.1414	0.8077	81.38%	82.91%	62.14%	0.8617	1.0697
16	71	0.2173	1.2408	0.2067	1.1801	0.1257	0.7176	80.11%	80.08%	64.28%	0.8835	1.3092
16	71	0.2292	1.3087	0.2706	1.5449	0.1268	0.7241	78.43%	82.31%	53.13%	0.9263	0.6980
16	71	0.2158	1.2322	0.1889	1.0784	0.2066	1.1799	80.47%	83.44%	74.24%	0.8581	1.6300
16	71	0.3406	1.9451	0.3078	1.7578	0.2138	1.2206	80.33%	80.92%	81.41%	0.9238	1.0203
16	71	0.3347	1.9114	0.3141	1.7936	0.2201	1.2566	78.99%	83.27%	68.77%	0.9211	0.9781
16	71	0.3278	1.8716	0.3072	1.7543	0.2139	1.2213	79.39%	83.27%	74.30%	0.9184	0.9291
16	71	0.3180	1.8158	0.2854	1.6299	0.2274	1.2982	79.25%	84.06%	79.37%	0.9208	1.2067
16	71	0.2497	1.4256	0.2371	1.3538	0.2025	1.1566	84.30%	84.88%	80.94%	0.9404	1.0189
16	71	0.2465	1.4077	0.2416	1.3795	0.2053	1.1723	85.39%	86.97%	82.56%	0.9212	0.9501
16	71	0.2395	1.3674	0.2295	1.3107	0.0000	0.0000	85.71%	87.30%			0.9403
16	71	0.2384	1.3611	0.2158	1.2324	0.2096	1.1966	86.62%	88.49%	80.22%	0.9012	0.9924
16	71	0.2163	1.2348	0.2142	1.2231	0.1990	1.1366	84.62%	85.14%	80.20%	0.9275	
Average		**0.3995**	**2.2810**	**0.3769**	**2.1522**	**0.1903**	**1.0864**	**81.46%**	**83.64%**	**81.45%**	**0.9271**	**1.0210**
Std. Dev.		**0.2029**	**1.1587**	**0.1821**	**1.0395**	**0.0579**	**0.3308**	**2.33%**	**1.86%**	**11.36%**	**0.0320**	**0.1933**

Table H.7 FWD data for I-490 East, Monroe, Rochester on Sep. 25, 2008 with E1 dowel bar configuration under nominal load of 44 kN (10 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/DO M	JSR
(kip)	(kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)					
10	44	0.5459	3.1170	0.5033	2.8737	0.2186	1.2482	77.75%	83.26%	85.51%	0.9158	1.1176
10	44	0.5330	3.0438	0.5624	3.2115	0.2223	1.2692	79.44%	83.50%	91.37%	0.9592	0.9030
10	44	0.5867	3.3501	0.5079	2.9002	0.2145	1.2246	80.93%	83.00%	91.57%	0.9583	1.0321
10	44	0.5107	2.9163	0.5242	2.9933	0.2081	1.1883	80.60%	83.23%	91.76%	0.9794	0.9693
10	44	0.6742	3.8496	0.5081	2.9013	0.2488	1.4205	81.59%	84.30%	88.95%	0.9437	0.9862
10	44	0.5412	3.0903	0.5011	2.8611	0.2334	1.3327	77.98%	83.48%	86.89%	0.9577	0.9674
10	44	0.5557	3.1730	0.4847	2.7678	0.2404	1.3725	80.69%	81.10%	89.33%	0.9775	0.8852
10	44	0.5071	2.8954	0.4291	2.4499	0.2258	1.2896	78.66%	83.33%	86.58%	0.9623	0.9373
10	44	0.4343	2.4800	0.4021	2.2962	0.2131	1.2170	81.62%	81.56%	85.77%	0.9303	1.0103
10	44	0.4417	2.5225	0.4063	2.3200	0.1849	1.0560	80.60%	81.36%	87.26%	0.9429	0.5664
10	44	0.4133	2.3598	0.3553	2.0289	0.2740	1.5647	79.73%	80.19%	62.35%	0.9231	0.9588
10	44	0.3513	2.0062	0.3407	1.9452	0.2801	1.5995	82.28%	85.34%	81.27%	0.9170	1.1771
10	44	0.3914	2.2348	0.4010	2.2898	0.1411	0.8057	81.92%	83.00%	79.87%	0.9195	0.5841
10	44	0.2601	1.4850	0.2342	1.3376	0.1781	1.0168	82.13%	84.19%	63.82%	0.9444	1.1000
10	44	0.2730	1.5588	0.2577	1.4713	0.2120	1.2108	82.29%	83.40%	63.86%	0.9296	0.9776
10	44	0.2768	1.5808	0.2519	1.4382	0.1721	0.9827	77.78%	83.73%	55.34%	0.0000	0.7144
10	44	0.1859	1.0616	0.1799	1.0275	0.1269	0.7247		79.49%	82.88%	0.9041	0.9213
10	44	0.2415	1.3789	0.1658	0.9466	0.1359	0.7760	82.33%	84.58%	58.67%	0.9159	0.8548
10	44	0.1534	0.8761	0.1417	0.8092	0.1257	0.7177	82.16%	77.35%	68.30%	0.9163	1.0350
10	44	0.1470	0.8392	0.1467	0.8376	0.1260	0.7194	84.68%	87.77%	75.25%	0.8718	0.9743
10	44	0.2312	1.3202	0.2226	1.2709	0.2010	1.1480	80.59%	83.04%	72.51%	0.8792	0.8985
10	44	0.2117	1.2089	0.2000	1.1419	0.2085	1.1903	79.63%	84.88%	77.48%	0.8952	1.0479
10	44	0.2254	1.2870	0.2096	1.1966	0.2448	1.3980	82.30%	83.94%	75.52%	0.9224	1.0464
10	44	0.2258	1.2893	0.2193	1.2521	0.2175	1.2421	81.42%	84.40%	76.87%	0.8904	0.9329
10	44	0.1962	1.1203	0.2045	1.1680	0.2188	1.2496	81.22%	80.98%	75.89%	0.8773	1.0389
10	44	0.2242	1.2804	0.2125	1.2135	0.1832	1.0461	77.88%	83.26%	77.65%	0.9135	0.9446
10	44	0.2170	1.2391	0.2007	1.1462	0.1719	0.9816	75.81%	81.68%	79.95%	0.8973	
Average		**0.3539**	**2.0209**	**0.3249**	**1.8554**	**0.2010**	**1.1479**	**80.54%**	**82.94%**	**78.24%**	**0.8905**	**0.9454**
Std. Dev.		**0.1572**	**0.8976**	**0.1393**	**0.7956**	**0.0431**	**0.2462**	**1.98%**	**2.04%**	**10.51%**	**0.1804**	**0.1422**

Table H.8 FWD data for I-490 East, Monroe, Rochester on Sep. 25, 2008 with E1 dowel bar configuration under nominal load of 58 kN (13 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/DO M	JSR
(kip)	(kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)					
13	58	0.5485	3.1318	0.4856	2.7726	0.2192	1.2514	82.56%	83.33%	87.40%	0.9534	1.1159
13	58	0.5225	2.9837	0.5418	3.0940	0.2194	1.2529	80.48%	82.97%	89.38%	0.9846	0.8810
13	58	0.5716	3.2640	0.4774	2.7258	0.2212	1.2633	79.97%	83.65%	91.49%	0.9394	1.1054
13	58	0.5024	2.8689	0.5277	3.0130	0.2135	1.2190	81.48%	84.35%	93.12%	0.9699	0.9425
13	58	0.6669	3.8079	0.4973	2.8399	0.2509	1.4327	80.89%	84.21%	88.05%	0.9443	0.9766
13	58	0.5390	3.0777	0.4857	2.7734	0.2398	1.3693	80.31%	83.03%	85.51%	0.9689	0.9898
13	58	0.5388	3.0768	0.4808	2.7452	0.2447	1.3971	80.22%	82.00%	88.40%	0.9595	0.8461
13	58	0.4972	2.8388	0.4068	2.3226	0.2260	1.2908	80.32%	83.24%	88.67%	0.9639	1.0608
13	58	0.4154	2.3722	0.4315	2.4639	0.2163	1.2353	81.49%	81.47%	87.14%	0.9356	0.8730
13	58	0.4374	2.4975	0.3767	2.1511	0.2020	1.1537	80.40%	82.15%	87.94%	0.9112	0.7846
13	58	0.4093	2.3372	0.3586	2.0474	0.2718	1.5519	78.54%	78.69%	63.52%	0.9174	0.9732
13	58	0.3477	1.9851	0.3490	1.9926	0.2840	1.6220	81.25%	82.25%	80.81%	0.9238	1.0979
13	58	0.3942	2.2510	0.3831	2.1877	0.1444	0.8247	81.95%	83.15%	79.04%	0.9184	0.5343
13	58	0.2315	1.3217	0.2047	1.1689	0.2234	1.2758	81.45%	83.05%	76.83%	0.9076	1.2591
13	58	0.2778	1.5865	0.2577	1.4718	0.2134	1.2187	80.52%	85.43%	61.71%	0.9264	1.0220
13	58	0.2523	1.4404	0.2634	1.5042	0.0000	0.0000	81.75%	81.55%			0.7913
13	58	0.1803	1.0297	0.2084	1.1902	0.1279	0.7302	80.42%	84.63%	74.55%	0.8852	0.8080
13	58	0.2389	1.3642	0.1684	0.9617	0.1294	0.7391	80.65%	85.16%	69.03%	0.9262	0.8730
13	58	0.1533	0.8756	0.1470	0.8396	0.1265	0.7224	82.25%	85.45%	79.62%	0.9247	1.0348
13	58	0.1610	0.9194	0.1522	0.8688	0.1249	0.7132	86.92%	84.19%	73.94%	0.9025	0.9809
13	58	0.2401	1.3709	0.2243	1.2806	0.2118	1.2097	81.56%	83.49%	75.31%	0.9112	0.9051
13	58	0.2152	1.2289	0.2030	1.1590	0.2076	1.1856	82.03%	84.88%	78.07%	0.9082	1.1059
13	58	0.2347	1.3400	0.2245	1.2817	0.2464	1.4071	82.12%	80.62%	76.48%	0.9246	1.0124
13	58	0.2316	1.3225	0.2273	1.2977	0.2181	1.2454	79.81%	82.50%	76.99%	0.9032	0.8754
13	58	0.2026	1.1569	0.1989	1.1359	0.2160	1.2334	81.53%	85.36%	74.77%	0.8944	1.0807
13	58	0.2297	1.3114	0.2150	1.2276	0.1818	1.0379	78.22%	83.61%	78.06%	0.9151	0.9422
13	58	0.2250	1.2850	0.2026	1.1567	0.1708	0.9751	78.34%	82.37%	81.61%	0.9186	
Average		**0.3506**	**2.0017**	**0.3222**	**1.8398**	**0.1982**	**1.1318**	**81.02%**	**83.21%**	**80.29%**	**0.9284**	**0.9566**
Std. Dev.		**0.1527**	**0.8718**	**0.1319**	**0.7533**	**0.0588**	**0.3356**	**1.64%**	**1.58%**	**8.21%**	**0.0254**	**0.1445**

Table H.9 FWD data for I-490 East, Monroe, Rochester on Sep. 24, 2008 with E1 dowel bar configuration under nominal load of 71 kN (16 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/DO M	JSR
(kip)	(kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)					
16	71	0.5023	2.8682	0.4721	2.6958	0.2192	1.2514	80.46%	83.29%	87.40%	0.9534	1.0771
16	71	0.5236	2.9899	0.5085	2.9038	0.2194	1.2529	80.07%	83.54%	89.38%	0.9846	0.9173
16	71	0.5414	3.0914	0.4665	2.6637	0.2212	1.2633	80.30%	84.39%	91.49%	0.9394	1.1394
16	71	0.4839	2.7630	0.5315	3.0352	0.2135	1.2190	80.08%	83.91%	93.12%	0.9699	0.9049
16	71	0.6169	3.5226	0.4810	2.7467	0.2509	1.4327	80.76%	83.44%	88.05%	0.9443	
16	71	0.5102	2.9130	0.0000	0.0000	0.2398	1.3693	80.59%		85.51%	0.9689	
16	71	0.5161	2.9469	0.4566	2.6071	0.2447	1.3971	80.35%	82.42%	88.40%	0.9595	0.8685
16	71	0.4639	2.6491	0.3965	2.2642	0.2260	1.2908	81.67%	82.26%	88.67%	0.9639	1.0483
16	71	0.4048	2.3116	0.4157	2.3736	0.2163	1.2353	80.71%	82.58%	87.14%	0.9356	0.9134
16	71	0.4179	2.3863	0.3797	2.1679	0.2020	1.1537	78.09%	81.18%	87.94%	0.9112	0.7494
16	71	0.3945	2.2527	0.3445	1.9669	0.2718	1.5519	78.10%	78.69%	63.52%	0.9174	0.9733
16	71	0.3419	1.9525	0.3353	1.9144	0.2840	1.6220	81.24%	83.64%	80.81%	0.9238	1.0852
16	71	0.3737	2.1340	0.3638	2.0775	0.1444	0.8247	82.27%	82.85%	79.04%	0.9184	0.6241
16	71	0.2362	1.3487	0.2271	1.2965	0.2234	1.2758	82.32%	84.64%	76.83%	0.9076	1.1356
16	71	0.2726	1.5564	0.2578	1.4723	0.2134	1.2187	81.66%	83.68%	61.71%	0.9264	0.9986
16	71	0.2476	1.4141	0.2575	1.4703	0.0000	0.0000	80.23%	83.30%			0.7624
16	71	0.2069	1.1814	0.1963	1.1210	0.1279	0.7302	84.98%	85.65%	74.55%	0.8852	0.9376
16	71	0.2187	1.2487	0.1841	1.0510	0.1294	0.7391	82.06%	85.68%	69.03%	0.9262	0.9681
16	71	0.1883	1.0753	0.1782	1.0175	0.1265	0.7224	82.07%	87.64%	79.62%	0.9247	0.9912
16	71	0.1912	1.0921	0.1766	1.0085	0.1249	0.7132	81.45%	81.99%	73.94%	0.9025	0.9920
16	71	0.2318	1.3235	0.2222	1.2687	0.2118	1.2097	81.98%	82.65%	75.31%	0.9112	0.9055
16	71	0.2104	1.2013	0.2012	1.1488	0.2076	1.1856	83.25%	85.79%	78.07%	0.9082	1.1287
16	71	0.2324	1.3271	0.2271	1.2966	0.2464	1.4071	83.22%	83.33%	76.48%	0.9246	0.9886
16	71	0.2287	1.3061	0.2245	1.2818	0.2181	1.2454	80.00%	83.10%	76.99%	0.9032	0.8956
16	71	0.2025	1.1566	0.2010	1.1480	0.2160	1.2334	82.31%	83.94%	74.77%	0.8944	1.0577
16	71	0.2177	1.2432	0.2126	1.2142	0.1818	1.0379	77.12%	83.21%	78.06%	0.9151	0.9466
16	71	0.2208	1.2608	0.2013	1.1494	0.1708	0.9751	76.83%	82.12%	81.61%	0.9186	
Average		**0.3406**	**1.9450**	**0.3007**	**1.7171**	**0.1982**	**1.1318**	**80.90%**	**83.42%**	**80.29%**	**0.9284**	**0.9587**
Std. Dev.		**0.1372**	**0.7836**	**0.1323**	**0.7556**	**0.0588**	**0.3356**	**1.85%**	**1.70%**	**8.21%**	**0.0254**	**0.1255**

Table H.10 FWD data for I-490 East, Monroe, Rochester on Sep. 25, 2008 with E2 dowel bar configuration under nominal load of 44 kN (10 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/DO M	JSR
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)					
10	44	0.3543	2.0233	0.2301	1.3139	0.1429	0.8161	79.10%	83.25%	86.37%	0.9563	0.7019
10	44	0.2623	1.4977	0.1615	0.9223	0.0892	0.5093	81.75%	85.00%	85.08%	0.9784	1.0521
10	44	0.2103	1.2008	0.1699	0.9704	0.1041	0.5946	77.57%	84.84%	81.55%	0.9080	1.4027
10	44	0.2128	1.2152	0.2384	1.3612	0.1342	0.7664	79.45%	77.63%	81.66%	0.9240	0.5459
10	44	0.2736	1.5625	0.1301	0.7431	0.1321	0.7541	77.49%	84.42%	83.05%	0.9371	1.2054
10	44	0.6428	3.6703	0.1569	0.8957	0.0735	0.4199	80.92%	81.56%	78.18%	0.9425	1.3266
10	44	0.1665	0.9509	0.2081	1.1882	0.1216	0.6942	82.49%	83.99%	91.93%	0.9082	0.9216
10	44	0.1443	0.8241	0.1918	1.0950	0.1086	0.6200	81.98%	82.38%	82.82%	0.9135	0.9937
10	44	0.1699	0.9703	0.1906	1.0882	0.1153	0.6581	81.56%	84.15%	82.77%	0.9144	0.8731
10	44	0.2530	1.4448	0.1664	0.9501	0.1372	0.7834	81.85%	84.13%	83.74%	0.9681	1.1886
10	44	0.1628	0.9294	0.1429	0.8160	0.1496	0.8542	80.16%	85.46%	81.36%	0.8489	1.1556
10	44	0.1818	1.0382	0.1652	0.9430	0.1544	0.8816	82.52%	87.88%	63.73%	0.9155	1.0660
10	44	0.1816	1.0367	0.1761	1.0053	0.0000	0.0000	88.26%	86.11%	41.19%		0.5606
10	44	0.1648	0.9408	0.0987	0.5635	0.1390	0.7935	85.77%	119.31%	57.07%	0.9246	2.1925
10	44	0.2003	1.1437	0.2164	1.2355	0.1726	0.9855	81.61%	62.10%	78.00%	0.9346	0.9130
10	44	0.1903	1.0868	0.1975	1.1280	0.1649	0.9417	85.27%	86.64%	71.86%	0.9352	1.1355
10	44	0.2380	1.3592	0.2243	1.2808	0.1876	1.0713	81.43%	84.35%	62.65%	0.8810	0.9103
10	44	0.2466	1.4082	0.2042	1.1659	0.1920	1.0964	84.86%	86.50%	73.28%	0.8980	1.1577
10	44	0.2435	1.3907	0.2364	1.3498	0.1950	1.1133	81.37%	83.95%	73.03%	0.9216	0.9858
10	44	0.2394	1.3671	0.2330	1.3306	0.1970	1.1248	84.86%	85.48%	78.77%	0.9665	1.0059
10	44	0.1633	0.9327	0.1592	0.9090	0.1573	0.8980	82.99%	85.79%	81.55%	0.9255	1.1768
10	44	0.1813	1.0354	0.1873	1.0696	0.2042	1.1660	79.72%	84.04%	79.86%	0.9198	
10	44	0.2090	1.1933	0.0000	0.0000	0.1849	1.0558	83.84%		82.33%	0.9439	
10	44	0.1813	1.0352	0.2071	1.1825	0.1577	0.9004	85.49%	87.24%	80.57%	0.8959	1.0722
10	44	0.2312	1.3202	0.2220	1.2679	0.2017	1.1517	83.21%	83.79%	80.97%	0.9179	0.9822
10	44	0.2414	1.3787	0.2181	1.2454	0.2128	1.2150	82.68%	86.72%	81.69%	0.9231	1.0408
10	44	0.2410	1.3759	0.2270	1.2961	0.2207	1.2603	85.20%	87.67%	82.26%	0.9024	1.0718
10	44	0.2589	1.4781	0.2433	1.3892	0.2240	1.2789	82.85%	86.10%	82.70%	0.9659	1.0578
10	44	0.2710	1.5475	0.2574	1.4696	0.2361	1.3479	84.74%	83.05%	79.63%	0.8945	
Average		**0.2316**	**1.3227**	**0.1883**	**1.0750**	**0.1555**	**0.8880**	**82.45%**	**85.13%**	**77.57%**	**0.9238**	**1.0652**
Std. Dev.		**0.0914**	**0.5218**	**0.0521**	**0.2976**	**0.0517**	**0.2952**	**2.52%**	**8.21%**	**10.13%**	**0.0284**	**0.3037**

Table H.11 FWD data for I-490 East, Monroe, Rochester on Sep. 25, 2008 with E2 dowel bar configuration under nominal load of 58 kN (13 kip).

Load		**DO L**		**DO A**		**DO M**		**LTE L**	**LTE A**	**SPR**	**D3/DO M**	**JSR**
(kip)	**(kN)**	**(mil/kip)**	**(μm/kN)**	**(mil/kip)**	**(μm/kN)**	**(mil/kip)**	**(μm/kN)**					
13	58	0.4059	2.3178	0.2955	1.6876	0.1715	0.9795	79.19%	81.03%	87.61%	0.9286	0.6303
13	58	0.2394	1.3668	0.1863	1.0638	0.1027	0.5865	81.64%	82.49%	85.76%	0.9683	0.9595
13	58	0.2135	1.2189	0.1788	1.0207	0.1094	0.6249	77.65%	81.80%	80.71%	0.8884	1.4217
13	58	0.2025	1.1561	0.2541	1.4512	0.1396	0.7971	80.25%	82.77%	85.33%	0.9637	0.6799
13	58	0.2693	1.5379	0.1728	0.9866	0.1250	0.7136	78.44%	84.24%	85.14%	0.9221	1.2662
13	58	0.6324	3.6113	0.2188	1.2492	0.1016	0.5799	81.34%	82.50%	81.76%	0.9036	1.0010
13	58	0.1942	1.1088	0.2190	1.2505	0.1127	0.6436	80.33%	82.28%	86.66%	0.9016	0.8472
13	58	0.1592	0.9090	0.1855	1.0595	0.1109	0.6331	82.61%	83.71%	82.31%	0.8884	1.0721
13	58	0.1722	0.9831	0.1989	1.1359	0.1179	0.6733	81.19%	80.89%	77.28%	0.9356	0.8254
13	58	0.2389	1.3643	0.1642	0.9375	0.1216	0.6944	81.40%	83.29%	79.71%	0.9237	1.1658
13	58	0.1620	0.9251	0.1493	0.8523	0.1447	0.8261	81.10%	82.62%	76.27%	0.8808	1.1413
13	58	0.1850	1.0561	0.1703	0.9727	0.1480	0.8452	85.87%	86.23%	67.24%	0.9273	1.0054
13	58	0.1783	1.0179	0.1713	0.9780	0.1317	0.7521	83.51%	86.82%	72.71%	1.0337	1.0308
13	58	0.1735	0.9904	0.1766	1.0081	0.1381	0.7885	81.53%	79.11%	53.32%	0.9431	1.2069
13	58	0.1987	1.1348	0.2131	1.2167	0.1672	0.9545	82.02%	83.57%	70.03%	0.9734	0.9238
13	58	0.2071	1.1823	0.1968	1.1240	0.1598	0.9124	84.79%	86.96%	82.27%	0.9136	1.0948
13	58	0.2361	1.3481	0.2155	1.2305	0.1862	1.0634	83.50%	84.91%	82.31%	0.8624	1.0469
13	58	0.2503	1.4291	0.2256	1.2882	0.1996	1.1398	86.07%	84.73%	81.38%	0.9306	1.0691
13	58	0.2349	1.3412	0.2412	1.3773	0.1945	1.1105	82.68%	86.21%	83.07%	0.9193	1.0026
13	58	0.2432	1.3884	0.2418	1.3809	0.1933	1.1035	84.51%	85.80%	77.74%	0.9175	1.0167
13	58	0.1621	0.9255	0.1534	0.8759	0.1545	0.8820	84.56%	86.26%	81.03%	0.8846	1.1379
13	58	0.1822	1.0401	0.1745	0.9967	0.2002	1.1431	86.62%	84.01%	81.58%	0.9299	1.2715
13	58	0.2040	1.1648	0.2219	1.2673	0.1831	1.0453	85.29%	86.58%	83.10%	0.9404	0.8604
13	58	0.1761	1.0055	0.1910	1.0904	0.1527	0.8721	85.83%	86.89%	81.36%	0.9052	1.0900
13	58	0.2291	1.3082	0.2080	1.1874	0.2042	1.1660	82.83%	85.55%	81.92%	0.9459	1.0565
13	58	0.2435	1.3902	0.2197	1.2546	0.2166	1.2369	83.66%	87.21%	81.32%	0.9424	1.0408
13	58	0.2495	1.4247	0.2287	1.3058	0.2143	1.2237	83.85%	85.85%	81.40%	0.9137	1.0870
13	58	0.2645	1.5101	0.2486	1.4194	0.2288	1.3066	79.53%	85.05%	83.48%	0.9150	1.0653
13	58	0.2743	1.5665	0.2648	1.5120	0.2416	1.3799	83.52%	85.59%	81.92%	0.9140	
Average		**0.2338**	**1.3353**	**0.2064**	**1.1786**	**0.1611**	**0.9199**	**82.60%**	**84.31%**	**79.85%**	**0.9247**	**1.0363**
Std. Dev.		**0.0914**	**0.5217**	**0.0354**	**0.2019**	**0.0409**	**0.2337**	**2.37%**	**2.13%**	**6.85%**	**0.0334**	**0.1680**

Table H.12. FWD data for I-490 East, Monroe, Rochester on Sep. 24, 2008 with E2 dowel bar configuration under nominal load of 71 kN (16 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/DO M	JSR
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)					
16	71	0.3769	2.1524	0.2845	1.6247	0.1822	1.0402	80.24%	81.87%	87.93%	0.9381	0.8594
16	71	0.2973	1.6978	0.2445	1.3963	0.1394	0.7960	79.23%	81.83%	83.47%	0.9006	0.8808
16	71	0.2681	1.5310	0.2154	1.2298	0.1321	0.7546	80.24%	83.14%	81.97%	0.9167	1.2256
16	71	0.2219	1.2673	0.2640	1.5072	0.1424	0.8131	80.11%	83.08%	83.92%	0.9335	1.1759
16	71	0.2613	1.4922	0.3104	1.7723	0.1349	0.7703	81.25%	85.21%	83.26%	0.9303	0.6677
16	71	0.6036	3.4465	0.2073	1.1835	0.1440	0.8221	80.97%	84.06%	84.73%	0.9235	1.0071
16	71	0.2205	1.2593	0.2087	1.1919	0.1341	0.7657	80.11%	82.42%	86.02%	0.9058	0.9744
16	71	0.2093	1.1950	0.2034	1.1614	0.1354	0.7733	82.85%	84.08%	83.64%	0.9307	1.0622
16	71	0.2060	1.1763	0.2160	1.2337	0.1405	0.8020	81.03%	82.27%	78.57%	0.9188	0.9154
16	71	0.2348	1.3409	0.1978	1.1292	0.1416	0.8088	80.61%	84.12%	85.33%	0.9020	0.9862
16	71	0.1934	1.1046	0.1752	1.0005	0.1611	0.9199	81.86%	83.26%	82.76%	0.9089	1.0387
16	71	0.1922	1.0972	0.1820	1.0391	0.1582	0.9034	85.14%	85.59%	61.05%	0.9249	1.0331
16	71	0.1967	1.1231	0.1880	1.0735	0.1769	1.0104	81.74%	85.06%	82.36%	0.8249	0.8427
16	71	0.1825	1.0419	0.1584	0.9046	0.1529	0.8731	84.79%	91.49%	80.15%	0.9173	1.2453
16	71	0.1933	1.1040	0.1973	1.1266	0.1644	0.9388	83.95%	84.74%	83.40%	0.9293	1.0209
16	71	0.1919	1.0959	0.2014	1.1502	0.1717	0.9805	84.26%	86.98%	79.75%	0.9032	1.0886
16	71	0.2313	1.3206	0.2193	1.2520	0.1852	1.0574	82.53%	82.90%	81.61%	0.8974	1.0188
16	71	0.2520	1.4387	0.2234	1.2755	0.1932	1.1034	82.28%	83.26%	83.59%	0.9229	1.0604
16	71	0.2326	1.3279	0.2369	1.3526	0.1876	1.0712	83.30%	84.87%	78.74%	0.9216	0.9971
16	71	0.2416	1.3795	0.2362	1.3487	0.1903	1.0865	84.12%	84.38%	79.88%	0.9346	1.0038
16	71	0.1627	0.9288	0.1553	0.8868	0.1591	0.9086	85.28%	85.88%	80.04%	0.8974	1.1536
16	71	0.1802	1.0292	0.1792	1.0231	0.1894	1.0815	84.79%	82.66%	80.41%	0.9265	1.2481
16	71	0.2029	1.1584	0.2236	1.2769	0.1881	1.0741	83.74%	86.04%	82.94%	0.9218	0.8606
16	71	0.1946	1.1112	0.1925	1.0990	0.1685	0.9620	83.86%	86.78%	81.87%	0.9233	1.0821
16	71	0.2333	1.3324	0.2083	1.1891	0.1876	1.0714	83.09%	84.53%	81.03%	0.9351	1.0608
16	71	0.2388	1.3634	0.2209	1.2615	0.2109	1.2045	85.14%	86.07%	80.73%	0.9215	1.0211
16	71	0.2383	1.3606	0.2256	1.2881	0.2097	1.1972	85.31%	87.17%	81.96%	0.9462	1.0749
16	71	0.2519	1.4384	0.2425	1.3847	0.2197	1.2546	82.33%	85.01%	82.53%	0.9510	1.0374
16	71	0.2644	1.5100	0.2516	1.4364	0.2328	1.3295	84.37%	86.71%	80.88%	0.9130	
Average		**0.2405**	**1.3733**	**0.2162**	**1.2344**	**0.1701**	**0.9715**	**82.71%**	**84.67%**	**81.54%**	**0.9180**	**1.0230**
Std. Dev.		**0.0816**	**0.4660**	**0.0346**	**0.1976**	**0.0282**	**0.1609**	**1.87%**	**2.05%**	**4.49%**	**0.0226**	**0.1285**

Appendix I: FWD data from I490 East, August 19, 2009.

Table I.1 FWD data for I-490 East, Monroe, Rochester on Aug. 19, 2009 with standard dowel bar configuration under nominal load of 44 kN (10 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/DO M	JSR
(kip)	(kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)					
10	44	0.3125	1.7846	0.3216	1.8365	0.1640	0.9365	84.62%	91.98%	76.38%	0.9114	1.0254
10	44	0.3339	1.9065	0.3298	1.8832	0.1713	0.9781	83.18%	91.48%	91.99%	0.8788	0.8744
10	44	0.3020	1.7244	0.2884	1.6467	0.1733	0.9897	83.39%	70.48%	80.12%	0.9434	1.1177
10	44	0.3388	1.9346	0.3223	1.8405	0.1895	1.0821	83.13%	76.31%	89.97%	0.9394	1.1171
10	44	0.2886	1.6482	0.3601	2.0560	0.1765	1.0080	83.28%	74.93%	93.46%	0.8935	
10	44	0.2240	1.2793	0.2837	1.6202	0.1579	0.9019	82.82%	83.57%	80.17%	0.8726	0.7556
10	44	0.2097	1.1974	0.2144	1.2242	0.1520	0.8681	78.24%	87.50%	82.91%	1.0000	0.9891
10	44	0.2425	1.3844	0.2120	1.2108	0.1461	0.8343	85.54%	70.91%	89.71%	1.0867	1.2310
10	44	0.2417	1.3799	0.2610	1.4906	0.1441	0.8227	83.13%	89.59%	85.77%	0.9122	0.9453
10	44	0.2238	1.2781	0.2468	1.4091	0.1441	0.8230	73.59%	85.71%		0.8993	0.8736
10	44	0.1956	1.1168	0.2156	1.2310	0.1364	0.7787	85.17%	81.53%	73.92%	0.8889	0.9309
10	44	0.2055	1.1736	0.2007	1.1459	0.1368	0.7813	84.86%	86.26%	76.38%	0.9097	1.0295
10	44	0.1961	1.1198	0.2066	1.1797	0.1347	0.7694	84.06%	84.26%	74.15%	0.9648	0.9620
10	44	0.2022	1.1548	0.1988	1.1349	0.1328	0.7583	84.91%	82.94%	80.41%	0.9433	0.9974
10	44	0.3037	1.7343	0.1982	1.1320	0.1485	0.8480	83.02%	89.05%	79.49%	0.9103	
10	44			0.2940	1.6787	0.1853	1.0583		84.09%	79.57%	0.9231	
Average		**0.2547**	**1.4545**	**0.2596**	**1.4825**	**0.1558**	**0.8899**	**82.86%**	**83.16%**	**82.29%**	**0.9298**	**0.9884**
Std. Dev.		**0.0527**	**0.3007**	**0.0551**	**0.3147**	**0.0186**	**0.1063**	**3.08%**	**6.78%**	**6.43%**	**0.0532**	**0.1230**

Table I.2 FWD data for I-490 East, Monroe, Rochester on Aug. 19, 2009 with standard dowel bar configuration under nominal load of 58 kN (13 kip)

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/DO M	JSR
(kip)	(kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)					
13	58	0.3188	1.8206	0.3205	1.8301	0.1684	0.9614	82.82%	89.35%	75.38%	0.9383	1.04
13	58	0.3385	1.9331	0.3337	1.9056	0.1722	0.9832	82.20%	78.17%		0.9264	0.87
13	58	0.3040	1.7358	0.2900	1.6559	0.1756	1.0029	83.38%	84.11%	94.18%	0.9389	1.10
13	58	0.3338	1.9060	0.3200	1.8271	0.1926	1.1000	82.81%	77.02%	85.88%	0.9781	1.13
13	58	0.2871	1.6392	0.3619	2.0664	0.1692	0.9664	82.96%	83.30%	81.33%	0.9644	
13	58	0.2281	1.3023	0.2830	1.6161	0.1585	0.9050	83.85%	77.61%	78.45%	0.9140	0.76
13	58	0.2190	1.2503	0.2150	1.2277	0.1542	0.8804	83.54%	91.39%	84.69%	0.9727	0.98
13	58	0.2762	1.5769	0.2105	1.2018	0.1562	0.8921	78.23%	84.82%	77.03%	0.0000	1.23
13	58	0.2474	1.4126	0.2589	1.4784	0.1551	0.8859	83.52%	84.32%	67.24%	0.9148	0.96
13	58	0.1801	1.0282	0.2487	1.4199	0.1456	0.8314	90.42%	80.00%	78.77%	0.9095	0.79
13	58	0.1996	1.1398	0.1969	1.1246	0.1383	0.7895	85.14%	96.84%	77.54%	0.8932	1.01
13	58	0.2099	1.1984	0.1996	1.1399	0.1372	0.7834	83.23%	81.69%	65.63%	0.8971	1.02
13	58	0.2017	1.1517	0.2044	1.1669	0.1370	0.7821	81.61%	81.67%	75.47%	0.9212	0.98
13	58	0.2114	1.2071	0.2009	1.1474	0.1358	0.7755	81.09%	79.60%	81.50%	0.8966	1.01
13	58	0.2986	1.7048	0.2028	1.1580	0.1507	0.8607	82.61%	75.08%	81.04%	0.9186	
13	58			0.2938	1.6779	0.1851	1.0572		81.99%	80.65%	0.9022	
Average		**0.2569**	**1.4671**	**0.2588**	**1.4777**	**0.1582**	**0.9036**	**83.16%**	**82.94%**	**78.99%**	**0.8679**	**0.99**
Std. Dev.		**0.0538**	**0.3072**	**0.0564**	**0.3220**	**0.0176**	**0.1008**	**2.54%**	**5.68%**	**6.96%**	**0.2330**	**0.13**

Table I.3 FWD data for I-490 East, Monroe, Rochester on Aug. 19, 2009 with standard dowel bar configuration under nominal load of 80 kN (18 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/DO M	JSR
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)					
18	80	0.3048	1.7404	0.3124	1.7840	0.1627	0.9291	84.24%	82.60%	83.78%	0.9226	1.0310
18	80	0.3296	1.8819	0.3221	1.8393	0.1696	0.9683	82.08%	80.82%	83.85%	0.9058	0.8884
18	80	0.2987	1.7055	0.2862	1.6341	0.1730	0.9876	83.14%	78.28%	97.43%	0.9115	1.0893
18	80	0.3229	1.8439	0.3117	1.7800	0.1826	1.0424	82.44%	82.77%	93.88%	0.9070	1.0649
18	80	0.2764	1.5786	0.3320	1.8956	0.1713	0.9784	82.70%	79.49%	94.62%	0.9323	
18	80	0.2212	1.2633	0.2749	1.5697	0.1555	0.8879	83.33%	80.92%	80.90%	0.9020	0.7770
18	80	0.2174	1.2415	0.2136	1.2196	0.1503	0.8584	82.06%	88.94%	83.46%	0.8493	0.9593
18	80	0.2489	1.4212	0.2049	1.1699	0.1493	0.8527	83.85%	84.83%	79.67%	0.9028	1.2274
18	80	0.2399	1.3697	0.2515	1.4359	0.1520	0.8678	82.80%	85.42%	85.32%	0.9088	0.9400
18	80	0.1970	1.1247	0.2364	1.3498	0.1398	0.7982	83.76%	87.66%	81.68%	0.9164	0.8898
18	80	0.1963	1.1207	0.2103	1.2010	0.1352	0.7719	85.28%	78.74%	81.09%	0.8905	0.9761
18	80	0.2075	1.1848	0.2053	1.1723	0.1354	0.7734	84.13%	88.11%	78.13%	0.9084	0.9897
18	80	0.2037	1.1632	0.2032	1.1603	0.1367	0.7805	80.34%	85.47%	82.62%	0.9061	0.9925
18	80	0.2059	1.1760	0.2017	1.1515	0.1333	0.7609	83.74%	75.86%	78.26%	0.9037	0.9981
18	80	0.2881	1.6451	0.2013	1.1494	0.1488	0.8500	83.54%	79.01%	83.82%	0.9091	
18	80			0.2831	1.6165	0.1805	1.0306		82.75%	81.14%	0.9063	
Average		**0.2506**	**1.4307**	**0.2532**	**1.4456**	**0.1547**	**0.8836**	**83.16%**	**82.61%**	**84.35%**	**0.9052**	**0.9864**
Std. Dev.		**0.0484**	**0.2762**	**0.0493**	**0.2817**	**0.0167**	**0.0954**	**1.17%**	**3.87%**	**5.83%**	**0.0175**	**0.1091**

Table I.4 FWD data for I-490 East, Monroe, Rochester on Aug. 19, 2009 with E1 dowel bar configuration under nominal load of 44 kN (10 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/DO M	JSR
(kip)	(kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)					
10	44	0.3413	1.9488	0.3289	1.8782	0.1779	1.0159	80.80%	74.60%	84.54%	0.9112	0.8881
10	44	0.2949	1.6842	0.2921	1.6680	0.1665	0.9509	85.40%	83.58%	85.24%	0.9156	0.8944
10	44	0.2750	1.5702	0.2613	1.4919	0.1662	0.9489	83.14%	80.00%	91.04%	0.9020	1.3130
10	44	0.3384	1.9325	0.3430	1.9588	0.1680	0.9596	84.59%	82.69%	72.32%	0.8397	1.3450
10	44	0.4629	2.6432	0.4614	2.6346	0.1834	1.0473	83.37%	76.05%	84.22%	0.9080	0.7706
10	44	0.3582	2.0455	0.3555	2.0302	0.1768	1.0097	83.94%	81.76%	86.11%	0.9308	0.9825
10	44	0.3727	2.1282	0.3493	1.9947	0.1865	1.0648	82.21%	76.58%	83.98%	0.9042	0.9469
10	44	0.3307	1.8886	0.3308	1.8889	0.1958	1.1180	82.78%		88.10%	0.8977	1.0509
10	44	0.3483	1.9888	0.3476	1.9850	0.1905	1.0878	83.54%	69.97%	80.92%	0.9048	1.0254
10	44	0.3514	2.0067	0.3565	2.0355	0.1781	1.0170	82.37%	90.60%	85.56%	0.8889	
10	44	0.2198	1.2553	0.2284	1.3042	0.1793	1.0238	83.12%	81.25%	90.68%	0.9282	1.3837
10	44	0.3038	1.7350	0.3160	1.8046	0.1928	1.1009	82.57%	81.65%	75.78%	0.9048	0.8799
10	44	0.2743	1.5663	0.2781	1.5878	0.1913	1.0924	81.51%		83.49%	0.8794	0.9014
10	44	0.2630	1.5015	0.2507	1.4313	0.1738	0.9922	77.49%	86.00%	86.74%	0.9448	0.9436
10	44	0.2322	1.3260	0.2365	1.3505	0.1830	1.0451	80.42%	85.71%	85.49%	0.9053	0.9040
10	44	0.2429	1.3869	0.2138	1.2208	0.1875	1.0704	77.78%	68.33%	85.49%	0.8316	1.2226
10	44	0.2185	1.2478	0.2614	1.4926	0.1707	0.9747	88.74%	67.16%	82.32%	0.9310	0.8365
10	44	0.2244	1.2815	0.2187	1.2485	0.1625	0.9279	84.07%	77.03%	79.86%	0.9818	0.9310
10	44	0.1881	1.0743	0.2036	1.1623	0.1646	0.9400	88.54%	83.50%	81.99%	0.8916	0.9419
10	44	0.2044	1.1669	0.1917	1.0948			84.13%	80.00%			
Average		**0.2923**	**1.6689**	**0.2913**	**1.6632**	**0.1787**	**1.0204**	**83.03%**	**79.25%**	**83.89%**	**0.9053**	**1.0090**
Std. Dev.		**0.0704**	**0.4019**	**0.0687**	**0.3921**	**0.0104**	**0.0593**	**2.79%**	**6.31%**	**4.53%**	**0.0336**	**0.1825**

Table I.5 FWD data for I-490 East, Monroe, Rochester on Aug. 19, 2009 with E1 dowel bar configuration under nominal load of 58 kN (13 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/DO M	JSR
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)					
13	58	0.3346	1.9107	0.3234	1.8466	0.1765	1.0078	83.33%	76.40%	80.42%	0.9353	0.8957
13	58	0.2925	1.6704	0.2897	1.6540	0.1650	0.9422	85.19%	89.39%	96.92%	0.9019	0.9141
13	58	0.2757	1.5742	0.2648	1.5120	0.1763	1.0067	84.83%	79.71%	98.09%	0.8839	1.3073
13	58	0.3401	1.9419	0.3462	1.9766	0.1679	0.9585	84.07%	86.11%	89.79%	0.9630	1.3564
13	58	0.4640	2.6495	0.4695	2.6810	0.1821	1.0400	81.14%	82.16%	77.10%	0.8839	0.7664
13	58	0.3630	2.0727	0.3599	2.0548	0.1834	1.0474	82.44%	79.78%		0.9298	1.0143
13	58	0.3783	2.1603	0.3650	2.0841	0.1891	1.0797	84.06%	74.43%	93.37%	0.9447	0.8907
13	58	0.3301	1.8850	0.3251	1.8562	0.1989	1.1356	84.03%	88.47%	72.41%	0.9157	1.0303
13	58	0.3593	2.0515	0.3349	1.9125	0.1977	1.1286	83.37%	81.11%	92.03%	0.9461	1.0433
13	58	0.3517	2.0082	0.3494	1.9953	0.1759	1.0045	82.94%	92.22%	79.50%	0.9269	
13	58	0.2231	1.2737	0.2333	1.3323	0.1841	1.0512	84.24%	84.35%	75.76%	0.9692	1.3213
13	58	0.3063	1.7491	0.3083	1.7605	0.1884	1.0758	80.65%	80.79%	79.61%	0.9423	0.9242
13	58	0.2763	1.5779	0.2849	1.6271	0.1835	1.0476	84.43%	86.48%	88.75%	0.9213	0.9192
13	58	0.2340	1.3360	0.2619	1.4957	0.1762	1.0060	88.76%	80.55%	79.52%	0.9027	0.9190
13	58	0.2374	1.3555	0.2407	1.3746	0.1801	1.0282	87.43%	87.68%	92.91%	0.9234	0.8931
13	58	0.2409	1.3757	0.2150	1.2276	0.1677	0.9576	78.22%	65.38%	82.24%	0.9333	1.1036
13	58	0.2659	1.5186	0.2373	1.3547	0.1874	1.0701	79.16%	88.86%	72.41%	0.8773	0.9436
13	58	0.2311	1.3197	0.2239	1.2783	0.1721	0.9826	82.26%	81.70%	73.27%	0.9139	0.8721
13	58	0.1997	1.1402	0.1952	1.1148	0.1598	0.9126	85.16%	76.17%	83.75%	0.9091	1.0679
13	58	0.2062	1.1773	0.2085	1.1905			84.25%	85.47%			
Average		**0.2955**	**1.6874**	**0.2918**	**1.6665**	**0.1796**	**1.0254**	**83.50%**	**82.36%**	**83.77%**	**0.9223**	**1.0101**
Std. Dev.		**0.0689**	**0.3934**	**0.0686**	**0.3920**	**0.0105**	**0.0597**	**2.48%**	**6.26%**	**8.50%**	**0.0255**	**0.1673**

Table I.6 FWD data for I-490 East, Monroe, Rochester on Aug. 19, 2009 with E1 dowel bar configuration under nominal load of 80 kN (18 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/DO M	JSR
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)					
18	80	0.3261	1.8623	0.3147	1.7968	0.1745	0.9964	81.87%	88.33%		0.9167	0.8801
18	80	0.2829	1.6157	0.2769	1.5813	0.1628	0.9296	84.10%	83.10%	80.72%	0.9201	0.9309
18	80	0.2681	1.5310	0.2578	1.4720	0.1654	0.9443	83.69%	81.40%	86.30%	0.9414	1.2656
18	80	0.3284	1.8750	0.3263	1.8630	0.1659	0.9473	83.04%	85.01%	79.24%	0.9132	1.3408
18	80	0.4413	2.5198	0.4374	2.4979	0.1746	0.9969	83.33%	79.22%	89.19%	0.9155	0.7873
18	80	0.3486	1.9905	0.3444	1.9667	0.1744	0.9956	84.24%	81.63%	86.48%	0.9195	1.0224
18	80	0.3638	2.0776	0.3521	2.0107	0.1852	1.0577	82.30%	89.90%	85.35%	0.9333	0.8727
18	80	0.3247	1.8540	0.3073	1.7547	0.1913	1.0924	84.87%	83.07%	79.15%	0.9352	1.0789
18	80	0.3385	1.9330	0.3315	1.8931	0.1935	1.1051	83.39%	92.04%		0.9441	1.0123
18	80	0.3384	1.9320	0.3356	1.9163	0.1745	0.9962	82.74%	89.86%	77.08%	0.9088	
18	80	0.2186	1.2483	0.2288	1.3067	0.1807	1.0320	82.42%	76.75%	82.91%	0.9566	1.3016
18	80	0.2934	1.6754	0.2978	1.7007	0.1768	1.0095	82.68%	84.04%	79.03%	0.9396	0.9141
18	80	0.2682	1.5317	0.2723	1.5547	0.1773	1.0126	84.00%	84.25%		0.9312	0.9371
18	80	0.2484	1.4184	0.2551	1.4569	0.1743	0.9952	83.30%	88.52%	76.87%	0.9275	0.9253
18	80	0.2345	1.3390	0.2361	1.3481	0.1777	1.0147	84.45%	88.10%	83.41%	0.9167	0.9292
18	80	0.2283	1.3037	0.2194	1.2527	0.1865	1.0651	84.56%	76.85%	77.30%	0.8670	1.1687
18	80	0.2537	1.4486	0.2564	1.4640	0.1770	1.0110	79.63%	80.93%	74.65%	0.8824	0.8416
18	80	0.2183	1.2463	0.2158	1.2321	0.1799	1.0272	86.05%	71.81%	96.59%	0.8876	0.9467
18	80	0.1940	1.1080	0.2043	1.1664	0.1631	0.9312	85.83%	93.11%	80.80%	0.9151	0.9477
18	80	0.2021	1.1543	0.1936	1.1055			84.40%	81.77%			
Average		**0.2860**	**1.6332**	**0.2832**	**1.6170**	**0.1766**	**1.0084**	**83.54%**	**83.98%**	**82.19%**	**0.9196**	**1.0057**
Std. Dev.		**0.0642**	**0.3665**	**0.0613**	**0.3500**	**0.0086**	**0.0493**	**1.44%**	**5.51%**	**5.60%**	**0.0222**	**0.1619**

Table I.7 FWD data for I-490 East, Monroe, Rochester on Aug. 19, 2009 with E2 dowel bar configuration under nominal load of 44 kN (10 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/DO M	JSR
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)					
10	44	0.3935	2.2469	0.3941	2.2501	0.1857	1.0606	84.27%	80.45%	97.55%	0.9231	1.0775
10	44	0.4216	2.4071	0.4246	2.4245	0.1841	1.0515	82.15%	71.76%	87.60%	0.9337	0.6965
10	44	0.3010	1.7185	0.2957	1.6886	0.1696	0.9685	87.55%	75.82%		0.9231	0.7850
10	44	0.2444	1.3958	0.2321	1.3255	0.1647	0.9402	79.09%	73.83%	88.89%	0.8693	1.1366
10	44	0.2708	1.5461	0.2638	1.5066	0.1611	0.9199	85.04%	90.20%	79.72%	0.9281	0.9439
10	44	0.2417	1.3803	0.2490	1.4221	0.1543	0.8810	83.69%	70.42%	101.68%	0.8993	1.1930
10	44	0.3136	1.7910	0.2971	1.6965	0.1573	0.8982	82.41%	73.94%		0.8846	0.8962
10	44	0.2716	1.5509	0.2662	1.5203	0.1661	0.9484	84.47%	86.31%	82.15%	0.9576	1.0597
10	44	0.2696	1.5393	0.2822	1.6111	0.1709	0.9759	83.27%	70.65%	88.33%	0.8750	0.7768
10	44	0.2186	1.2483	0.2192	1.2515	0.1538	0.8781	87.61%	84.72%	79.59%	0.9675	
10	44	0.1996	1.1396	0.2080	1.1878	0.1743	0.9954	83.33%	82.95%	70.46%	0.8610	0.9366
10	44	0.2065	1.1793	0.1948	1.1125	0.1696	0.9685	84.55%	98.07%	84.48%	0.9337	1.1421
10	44	0.2216	1.2656	0.2225	1.2706	0.1735	0.9905	81.86%	92.02%	85.89%	0.9121	0.9540
10	44	0.2294	1.3100	0.2123	1.2121	0.1872	1.0687	83.19%	74.31%	79.99%	0.8804	0.9899
10	44	0.2163	1.2353	0.2101	1.1998	0.2002	1.1429	86.89%	63.11%	73.16%	0.8925	1.1771
10	44	0.2437	1.3915	0.2473	1.4123	0.2246	1.2824	85.02%	86.03%	75.54%	0.8632	0.9932
10	44	0.2522	1.4403	0.2457	1.4027	0.1844	1.0527	85.12%	86.27%	83.14%	0.8956	0.9869
10	44	0.2379	1.3586	0.2424	1.3844	0.1803	1.0295	84.65%	83.54%	73.27%	0.9076	1.1860
10	44	0.2853	1.6293	0.2875	1.6418	0.1706	0.9739	84.01%	77.89%	86.32%	0.9438	0.8290
10	44	0.2437	1.3918	0.2384	1.3612	0.1801	1.0285	85.20%	88.84%	82.86%	0.9149	
Average		**0.2641**	**1.5083**	**0.2617**	**1.4941**	**0.1756**	**1.0028**	**84.17%**	**80.56%**	**83.37%**	**0.9083**	**0.9867**
Std. Dev.		**0.0577**	**0.3296**	**0.0588**	**0.3360**	**0.0166**	**0.0948**	**2.00%**	**8.79%**	**8.05%**	**0.0309**	**0.1507**

Table I.8 FWD data for I-490 East, Monroe, Rochester on Aug. 19, 2009 with E2 dowel bar configuration under nominal load of 58 kN (13 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/DO M	JSR
(kip)	(kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)					
13	58	0.3966	2.2647	0.3906	2.2303	0.1895	1.0819	84.73%	85.71%	80.14%	0.9322	1.0777
13	58	0.4272	2.4391	0.4209	2.4035	0.1863	1.0636	83.49%	77.63%	74.62%	0.9174	0.7087
13	58	0.3060	1.7474	0.2983	1.7033	0.1688	0.9637	82.14%	79.43%	84.41%	0.9078	0.8118
13	58	0.2442	1.3946	0.2421	1.3827	0.1637	0.9345	85.03%	76.04%	97.71%	0.8990	1.1289
13	58	0.2732	1.5600	0.2734	1.5609	0.1638	0.9353	86.03%	81.79%	73.19%	0.9091	0.8915
13	58	0.2470	1.4103	0.2437	1.3915	0.1560	0.8906	83.83%	87.31%	109.04%	0.9296	1.2251
13	58	0.3106	1.7738	0.2985	1.7046	0.1611	0.9198	81.69%	88.24%	91.36%	0.9234	0.8852
13	58	0.2750	1.5705	0.2643	1.5090	0.1713	0.9779	84.76%	77.90%	80.60%	0.8903	1.0684
13	58	0.2785	1.5905	0.2824	1.6123	0.1731	0.9883	83.77%	78.81%	81.15%	0.8992	0.8067
13	58	0.2299	1.3127	0.2278	1.3007	0.1738	0.9922	85.17%	82.86%	83.53%	0.9295	
13	58	0.2027	1.1577	0.2122	1.2115	0.1738	0.9925	84.56%	83.06%	90.69%	0.8769	0.9779
13	58	0.2013	1.1495	0.2075	1.1847	0.1724	0.9843	85.67%	88.03%	77.30%	0.9261	1.0773
13	58	0.2181	1.2456	0.2235	1.2763	0.1768	1.0097	83.28%	75.83%	80.63%	0.9049	0.9489
13	58	0.2226	1.2710	0.2121	1.2110	0.1810	1.0337	85.39%	84.59%	70.77%	0.9027	0.9119
13	58	0.2209	1.2615	0.1934	1.1044	0.2000	1.1420	85.62%	95.26%	74.90%	0.9122	1.2259
13	58	0.2408	1.3752	0.2371	1.3538	0.2100	1.1993	87.38%	93.53%	79.05%	0.9418	1.0689
13	58	0.2562	1.4632	0.2534	1.4471	0.1825	1.0421	84.10%	79.82%	72.41%	0.9102	0.9376
13	58	0.2344	1.3383	0.2376	1.3568	0.1838	1.0494	85.33%	86.53%	79.81%	0.9198	1.2160
13	58	0.2838	1.6203	0.2889	1.6498	0.1802	1.0290	84.60%	82.65%	77.74%	0.9011	0.8445
13	58	0.2415	1.3793	0.2440	1.3932	0.1814	1.0357	85.43%	82.81%	88.18%	0.9211	
Average		**0.2655**	**1.5163**	**0.2626**	**1.4994**	**0.1775**	**1.0133**	**84.60%**	**83.39%**	**82.36%**	**0.9127**	**0.9896**
Std. Dev.		**0.0590**	**0.3368**	**0.0577**	**0.3297**	**0.0129**	**0.0739**	**1.33%**	**5.37%**	**9.31%**	**0.0158**	**0.1545**

Table I.9 FWD data for I-490 East, Monroe, Rochester on Aug. 19, 2009 with E2 dowel bar configuration under nominal load of 80 kN (18 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/DO M	JSR
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)					
18	80	0.3607	2.0599	0.3766	2.1507	0.1868	1.0669	94.61%	78.55%	91.92%	0.9241	1.0745
18	80	0.4086	2.3332	0.4047	2.3109	0.1803	1.0293	82.87%	86.88%	84.18%	0.9156	0.7184
18	80	0.2940	1.6790	0.2907	1.6601	0.1682	0.9606	82.94%	80.31%	82.22%	0.9252	0.8093
18	80	0.2434	1.3898	0.2353	1.3435	0.1646	0.9397	83.88%	80.00%	77.29%	0.9414	1.1247
18	80	0.2655	1.5163	0.2646	1.5110	0.1575	0.8995	84.30%	85.56%	88.39%	0.9336	0.9136
18	80	0.2414	1.3786	0.2418	1.3804	0.1548	0.8841	83.52%	88.96%	95.14%	0.9271	1.2060
18	80	0.2975	1.6987	0.2916	1.6648	0.1577	0.9003	83.39%	83.74%	78.57%	0.9119	0.8955
18	80	0.2628	1.5005	0.2611	1.4908	0.1682	0.9605	84.46%	82.02%	92.51%	0.8924	1.0577
18	80	0.2709	1.5469	0.2761	1.5767	0.1677	0.9575	84.46%	83.88%	86.32%	0.8917	0.8143
18	80	0.2248	1.2837	0.2249	1.2840	0.1730	0.9879	85.14%	77.30%	82.91%	0.8954	
18	80	0.1983	1.1323	0.2105	1.2021	0.1597	0.9118	85.35%	92.55%	90.12%	0.9536	0.9648
18	80	0.2038	1.1636	0.2031	1.1598	0.1648	0.9412	87.07%	80.39%	82.73%	0.9192	1.0896
18	80	0.2227	1.2716	0.2213	1.2638	0.1705	0.9738	81.96%	75.95%	93.08%	0.9206	0.9775
18	80	0.2143	1.2236	0.2163	1.2353	0.1749	0.9989	85.11%	91.67%	75.07%	0.9080	0.9364
18	80	0.2112	1.2060	0.2026	1.1568	0.1889	1.0789	87.05%	77.89%	77.94%	0.9184	1.2082
18	80	0.2343	1.3377	0.2448	1.3976	0.1989	1.1359	87.11%	83.26%	84.38%	0.9022	1.0288
18	80	0.2504	1.4295	0.2518	1.4379	0.1804	1.0301	86.58%	77.78%	86.44%	0.9193	0.9168
18	80	0.2294	1.3102	0.2309	1.3183	0.1787	1.0204	86.13%	86.91%	87.12%	0.9429	1.2046
18	80	0.2698	1.5405	0.2781	1.5880	0.1733	0.9895	84.37%	85.14%	86.00%	0.9193	0.8370
18	80	0.2315	1.3218	0.2328	1.3292	0.1742	0.9946	88.38%	77.07%	82.51%	0.9060	
Average		**0.2568**	**1.4662**	**0.2580**	**1.4731**	**0.1722**	**0.9831**	**85.43%**	**82.79%**	**85.24%**	**0.9184**	**0.9876**
Std. Dev.		**0.0523**	**0.2988**	**0.0530**	**0.3029**	**0.0114**	**0.0648**	**2.74%**	**4.91%**	**5.58%**	**0.0166**	**0.1467**

Appendix J: I490 Eastbound FWD data collected June 21, 2011

Table J.1 FWD data for I-490 East, Monroe, Rochester on June 21, 2011 with E1 dowel bar configuration under nominal load of 44 kN (10 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/D0 M	JSR
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)					
10	44	0.3707	2.1166	0.3622	2.0684	0.1665	0.9505	82.97%	80.61%	90.59%	0.9222	1.0393
10	44	0.3765	2.1497	0.3993	2.2802	0.1646	0.9397	82.93%	78.34%	88.66%	0.9146	1.0652
10	44	0.4254	2.4289	0.3634	2.0751	0.1820	1.0391	83.81%	82.83%	91.62%	0.9337	1.0771
10	44	0.3914	2.2351	0.3067	1.7511	0.1684	0.9614	84.24%	80.66%	84.52%	0.9162	1.0669
10	44	0.3272	1.8682	0.3276	1.8704	0.1616	0.9225	82.30%	79.69%	91.60%	0.8994	1.0533
10	44	0.3450	1.9700	0.3585	2.0472	0.1546	0.8828	82.30%	80.79%	92.05%	0.9221	1.0645
10	44	0.3816	2.1792	0.3376	1.9279	0.1660	0.9480	84.00%	76.88%	89.11%	0.9080	1.0337
10	44	0.3490	1.9929	0.3424	1.9552	0.1785	1.0195	83.92%	79.82%	95.66%	0.9091	1.0521
10	44	0.3603	2.0571	0.3617	2.0653	0.1632	0.9319	81.74%	78.87%	88.89%	0.9136	1.0615
10	44	0.3840	2.1924	0.3059	1.7470	0.1623	0.9266	82.06%	78.81%	89.76%	0.9130	1.0511
10	44	0.3216	1.8363	0.4324	2.4691	0.1676	0.9568	83.17%	78.04%	83.44%	0.9152	0.9336
10	44	0.4037	2.3052	0.3945	2.2524	0.1590	0.9082	80.86%	81.79%	97.63%	0.9114	1.0659
10	44	0.4204	2.4008	0.3738	2.1346	0.1959	1.1188	85.23%	80.22%	89.41%	0.9067	1.0502
10	44	0.3926	2.2417	0.3790	2.1642	0.1724	0.9844	83.38%	82.26%	91.76%	0.9408	1.0810
10	44	0.4097	2.3395	0.3551	2.0280	0.1962	1.1201	84.00%	82.29%	92.45%	0.9433	1.0600
10	44	0.3764	2.1495	0.2652	1.5146	0.1516	0.8656	83.60%	79.92%	88.05%	0.9200	1.0703
10	44	0.2839	1.6211	0.4243	2.4230	0.1575	0.8995	82.56%	81.67%	98.30%	0.9167	1.1374
10	44	0.4826	2.7558	0.5527	3.1558	0.1775	1.0137	82.98%	77.86%	92.26%	0.9371	1.0129
10	44	0.5598	3.1966	0.3915	2.2355	0.1728	0.9866	81.60%	79.74%	91.37%	0.9471	1.0748
10	44	0.4208	2.4028	0.3647	2.0825	0.1810	1.0334	83.25%	81.11%	90.52%	0.9167	1.0434
10	44	0.3805	2.1728	0.3818	2.1799	0.1636	0.9341	81.60%	78.13%	97.26%	0.9006	1.0947
10	44	0.4179	2.3863	0.3201	1.8276	0.1591	0.9087	80.79%	78.73%	85.57%	0.9172	1.1241
10	44	0.3598	2.0544	0.2671	1.5250	0.1476	0.8429	80.00%	82.06%	86.15%	0.9167	1.0465
10	44	0.2795	1.5959	0.3024	1.7266	0.1586	0.9058	83.88%	81.97%	93.65%	0.9226	1.0165
10	44	0.3074	1.7551	0.3013	1.7207	0.1624	0.9273	84.62%	79.86%	88.19%	0.9182	1.0520
10	44	0.3170	1.8102					84.14%				
Average		**0.3786**	**2.1621**	**0.3589**	**2.0491**	**0.1676**	**0.9571**	**82.92%**	**80.12%**	**90.74%**	**0.9193**	**1.0571**
Std. Dev.		**0.0597**	**0.3412**	**0.0595**	**0.3396**	**0.0122**	**0.0696**	**1.28%**	**1.63%**	**3.85%**	**0.0124**	**0.0378**

Table J.2 FWD data for I-490 East, Monroe, Rochester on June 21, 2011 with E1 dowel bar configuration under nominal load of 58 kN (13 kip).

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/D0 M	JSR
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)					
13	58	0.3682	2.1023	0.3658	2.0888	0.1640	0.9367	83.61%	80.17%	89.27%	0.9406	1.0100
13	58	0.3694	2.1096	0.4057	2.3166	0.1665	0.9510	82.65%	78.88%	87.28%	0.9182	1.0414
13	58	0.4225	2.4126	0.3676	2.0990	0.1760	1.0050	83.06%	82.89%	86.76%	0.9402	1.0336
13	58	0.3799	2.1695	0.3056	1.7448	0.1728	0.9865	83.20%	81.28%	86.16%	0.9127	1.0681
13	58	0.3264	1.8637	0.3273	1.8692	0.1610	0.9194	82.52%	79.72%	90.99%	0.9194	1.0727
13	58	0.3512	2.0052	0.3588	2.0488	0.1548	0.8840	82.43%	80.08%	92.63%	0.9175	1.0764
13	58	0.3862	2.2052	0.3310	1.8903	0.1723	0.9840	82.84%	81.52%	90.03%	0.9159	1.0702
13	58	0.3543	2.0230	0.3437	1.9624	0.1746	0.9973	83.30%	81.15%	90.37%	0.9127	1.0440
13	58	0.3588	2.0488	0.3645	2.0816	0.1648	0.9412	82.24%	80.21%	87.48%	0.9083	1.0500
13	58	0.3828	2.1857	0.3050	1.7413	0.1630	0.9307	81.94%	80.15%	89.17%	0.9263	1.0681
13	58	0.3257	1.8599	0.4341	2.4787	0.1734	0.9902	82.52%	78.92%	84.21%	0.9043	0.9256
13	58	0.4018	2.2944	0.3899	2.2264	0.1679	0.9587	80.34%	81.71%	94.22%	0.9103	1.0822
13	58	0.4219	2.4093	0.3743	2.1371	0.1938	1.1069	84.39%	81.78%	88.46%	0.9216	1.0480
13	58	0.3922	2.2398	0.3785	2.1613	0.1940	1.1075	84.05%	82.29%	93.53%	0.9449	1.0739
13	58	0.4065	2.3211	0.3504	2.0008	0.1861	1.0627	83.46%	83.01%	90.23%	0.9350	1.0626
13	58	0.3723	2.1260	0.2674	1.5266	0.1539	0.8787	83.43%	80.39%	85.56%	0.9171	1.0753
13	58	0.2875	1.6417	0.4189	2.3918	0.1572	0.8975	82.46%	81.64%	95.23%	0.9423	1.1441
13	58	0.4792	2.7365	0.5412	3.0901	0.1750	0.9991	82.70%	79.47%	93.41%	0.9524	1.0085
13	58	0.5457	3.1162	0.3842	2.1937	0.1738	0.9923	81.64%	80.51%	89.00%	0.9430	1.0791
13	58	0.4146	2.3674	0.3615	2.0642	0.1747	0.9973	83.24%	81.99%	89.05%	0.9274	1.0613
13	58	0.3837	2.1907	0.3758	2.1458	0.1620	0.9253	82.64%	78.96%	93.83%	0.9167	1.0792
13	58	0.4056	2.3158	0.3227	1.8425	0.1592	0.9089	81.46%	79.77%	83.47%	0.9202	1.0898
13	58	0.3517	2.0080	0.2657	1.5173	0.1501	0.8574	80.65%	83.52%	84.89%	0.9040	1.0667
13	58	0.2834	1.6184	0.2967	1.6941	0.1574	0.8987	83.24%	81.59%	90.02%	0.9187	1.0640
13	58	0.3157	1.8025	0.2956	1.6877	0.1619	0.9245	82.52%	81.38%	87.35%	0.9116	1.0971
13	58	0.3243	1.8516					81.78%				
Average		**0.3774**	**2.1548**	**0.3573**	**2.0400**	**0.1684**	**0.9617**	**82.63%**	**80.92%**	**89.30%**	**0.9232**	**1.0597**
Std. Dev.		**0.0558**	**0.3188**	**0.0582**	**0.3324**	**0.0114**	**0.0654**	**0.94%**	**1.30%**	**3.25%**	**0.0138**	**0.0390**

Table J.3 FWD data for I-490 East, Monroe, Rochester on June 21, 2011 with E1 dowel bar configuration under nominal load of 80 kN (18 kip)

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/D0 M	JSR
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)					
18	80	0.3473	1.9833	0.3438	1.9631	0.1608	0.9180	82.66%	80.16%	90.61%	0.9308	1.0218
18	80	0.3513	2.0058	0.3813	2.1772	0.1621	0.9257	82.01%	78.82%	87.17%	0.8969	1.0424
18	80	0.3975	2.2696	0.3470	1.9812	0.1763	1.0065	82.50%	82.01%	90.01%	0.9238	1.0508
18	80	0.3646	2.0818	0.2941	1.6795	0.1673	0.9552	82.82%	80.38%	85.54%	0.9027	1.0705
18	80	0.3148	1.7978	0.3164	1.8067	0.1583	0.9042	81.15%	78.33%	90.46%	0.8932	1.0353
18	80	0.3276	1.8705	0.3409	1.9463	0.1500	0.8567	81.00%	80.27%	91.65%	0.9104	1.0661
18	80	0.3634	2.0749	0.3182	1.8168	0.1655	0.9453	82.84%	80.04%	90.67%	0.9078	1.0471
18	80	0.3331	1.9023	0.3315	1.8928	0.1722	0.9833	82.91%	80.34%	90.82%	0.9082	1.0518
18	80	0.3486	1.9908	0.3488	1.9917	0.1616	0.9225	81.30%	79.32%	87.51%	0.9021	1.0582
18	80	0.3691	2.1075	0.2949	1.6839	0.1623	0.9270	81.38%	79.85%	89.06%	0.8962	1.0619
18	80	0.3131	1.7881	0.4207	2.4020	0.1690	0.9651	82.15%	78.35%	85.08%	0.8997	0.9187
18	80	0.3864	2.2067	0.3781	2.1588	0.1659	0.9476	79.91%	80.84%	93.83%	0.9044	1.0574
18	80	0.3998	2.2828	0.3624	2.0692	0.1903	1.0866	83.95%	81.32%	87.90%	0.9102	1.0451
18	80	0.3787	2.1624	0.3673	2.0975	0.1784	1.0187	82.78%	81.37%	88.58%	0.9265	1.0733
18	80	0.3943	2.2513	0.3394	1.9378	0.1799	1.0274	82.53%	82.24%	89.50%	0.9243	1.0598
18	80	0.3597	2.0537	0.2636	1.5055	0.1533	0.8754	82.52%	80.04%	84.85%	0.9037	1.0812
18	80	0.2851	1.6277	0.4037	2.3054	0.1563	0.8925	81.40%	81.17%	95.74%	0.9275	1.1315
18	80	0.4568	2.6085	0.5116	2.9214	0.1747	0.9977	82.34%	79.29%	92.98%	0.9349	1.0071
18	80	0.5153	2.9423	0.3708	2.1174	0.1723	0.9840	80.97%	80.03%	89.01%	0.9180	1.0785
18	80	0.3999	2.2835	0.3504	2.0007	0.1745	0.9961	82.45%	81.13%	87.37%	0.9065	1.0393
18	80	0.3641	2.0793	0.3637	2.0768	0.1630	0.9306	81.85%	78.63%	93.55%	0.8993	1.0789
18	80	0.3924	2.2406	0.3146	1.7966	0.1601	0.9142	80.20%	78.82%	85.97%	0.8982	1.0880
18	80	0.3423	1.9548	0.2625	1.4987	0.1502	0.8578	79.53%	81.13%	86.31%	0.8783	1.0583
18	80	0.2778	1.5862	0.2905	1.6588	0.1562	0.8917	82.38%	79.80%	90.31%	0.9094	1.0597
18	80	0.3078	1.7578	0.2899	1.6556	0.1624	0.9271	81.99%	80.63%	88.15%	0.9056	1.0911
18	80	0.3163	1.8064					80.72%				
Average		**0.3618**	**2.0660**	**0.3442**	**1.9657**	**0.1657**	**0.9463**	**81.86%**	**80.17%**	**89.31%**	**0.9088**	**1.0549**
Std. Dev.		**0.0510**	**0.2913**	**0.0534**	**0.3049**	**0.0098**	**0.0562**	**1.04%**	**1.09%**	**2.85%**	**0.0134**	**0.0375**

Table J.4 FWD data for I-490 East, Monroe, Rochester on June 21, 2011 with E2 dowel bar configuration under nominal load of 44 kN (10 kip)

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/D0 M	JSR
(kip)	(kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)					
10	44	0.3032	1.7316	0.2959	1.6897	0.1691	0.9653	81.36%	78.35%	77.85%	0.8848	1.0248
10	44	0.2419	1.3813	0.2329	1.3297	0.1549	0.8843	81.70%	75.98%	82.96%	0.8882	1.0388
10	44	0.2783	1.5894	0.2539	1.4498	0.1558	0.8897	78.60%	73.90%	84.48%	0.8750	1.0963
10	44	0.2731	1.5594	0.2425	1.3848	0.1641	0.9369	78.79%	78.81%	79.83%	0.8938	1.1261
10	44	0.2812	1.6059	0.2755	1.5734	0.1668	0.9526	79.12%	72.59%	80.14%	0.8834	1.0207
10	44	0.2469	1.4096	0.2256	1.2884	0.1755	1.0019	78.01%	72.40%	82.33%	0.8721	1.0941
10	44	0.2740	1.5647	0.2516	1.4364	0.1732	0.9892	79.70%	75.20%	86.81%	0.8947	1.0893
10	44	0.2857	1.6313	0.2558	1.4609	0.1736	0.9914	79.14%	78.57%	82.36%	0.8882	1.1167
10	44	0.2632	1.5031	0.2465	1.4077	0.1570	0.8964	77.82%	75.10%	83.80%	0.8831	1.0678
10	44	0.2525	1.4416	0.2348	1.3405	0.1695	0.9681	79.03%	75.00%	80.39%	0.9102	1.0754
10	44	0.2790	1.5929	0.2637	1.5056	0.1844	1.0530	79.27%	75.10%	80.85%	0.8895	1.0580
10	44	0.2518	1.4377	0.2464	1.4068	0.1746	0.9970	81.38%	76.54%	82.42%	0.9059	1.0220
10	44	0.2581	1.4737	0.2499	1.4271	0.1832	1.0460	82.68%	75.92%	84.27%	0.8944	1.0326
10	44	0.2502	1.4287	0.2364	1.3496	0.1805	1.0305	80.99%	78.11%	84.68%	0.9034	1.0586
10	44	0.3020	1.7242	0.2866	1.6368	0.1776	1.0139	78.62%	74.38%	83.61%	0.8908	1.0534
10	44	0.2666	1.5223	0.2681	1.5307	0.1691	0.9653	82.10%	75.77%	77.70%	0.8848	0.9945
10	44	0.2348	1.3408	0.2272	1.2974	0.1721	0.9826	79.13%	73.42%	80.40%	0.8810	1.0335
10	44	0.2531	1.4453	0.2395	1.3677	0.1676	0.9573	78.28%	75.54%	83.54%	0.8834	1.0568
10	44	0.2392	1.3659	0.2307	1.3175	0.1632	0.9318	78.45%	76.00%	84.44%	0.8994	1.0367
10	44	0.2453	1.4006	0.2413	1.3778	0.1742	0.9945	80.75%	74.89%	80.38%	0.8698	1.0165
10	44	0.2475	1.4130	0.2506	1.4311	0.1606	0.9169	79.67%	77.46%	81.95%	0.8782	0.9874
10	44	0.2487	1.4200	0.2413	1.3778	0.1643	0.9381	79.25%	77.02%	80.66%	0.9000	1.0306
10	44	0.2404	1.3725	0.2388	1.3636	0.1534	0.8759	79.74%	75.00%	79.35%	0.8851	1.0065
10	44	0.2271	1.2967	0.2161	1.2341	0.1797	1.0261	79.00%	72.99%	82.40%	0.9080	1.0507
10	44	0.2605	1.4874	0.2503	1.4295	0.1530	0.8738	80.08%	78.93%	79.29%	0.8919	1.0405
10	44	0.2590	1.4792	0.2475	1.4133			78.57%	74.07%			1.0466
Average		**0.2601**	**1.4853**	**0.2481**	**1.4164**	**0.1687**	**0.9631**	**79.66%**	**75.66%**	**81.88%**	**0.8896**	**1.0490**
Std. Dev.		**0.0197**	**0.1123**	**0.0183**	**0.1046**	**0.0093**	**0.0531**	**1.32%**	**1.90%**	**2.29%**	**0.0108**	**0.0350**

Table J.5 FWD data for I-490 East, Monroe, Rochester on June 21, 2011 with E2 dowel bar configuration under nominal load of 58 kN (13 kip)

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/D0 M	JSR
(kip)	(kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)	(mil/kip)	(µm/kN)					
13	58	0.2985	1.7047	0.2905	1.6585	0.1708	0.9752	81.28%	78.96%	77.88%	0.8978	1.0278
13	58	0.2441	1.3936	0.2313	1.3209	0.1558	0.8896	81.56%	76.70%	82.10%	0.9034	1.0550
13	58	0.2748	1.5690	0.2550	1.4560	0.1567	0.8950	78.57%	75.52%	81.92%	0.8750	1.0776
13	58	0.2765	1.5789	0.2522	1.4403	0.1691	0.9653	78.79%	76.28%	79.67%	0.8750	1.0962
13	58	0.2850	1.6274	0.2783	1.5892	0.1698	0.9696	78.28%	74.39%	78.77%	0.8850	1.0240
13	58	0.2502	1.4284	0.2249	1.2842	0.1768	1.0093	78.42%	75.59%	80.32%	0.8809	1.1123
13	58	0.2742	1.5659	0.2534	1.4471	0.1760	1.0050	79.44%	74.78%	84.17%	0.9103	1.0821
13	58	0.2855	1.6300	0.2604	1.4870	0.1740	0.9933	78.84%	77.91%	81.22%	0.9048	1.0962
13	58	0.2691	1.5367	0.2458	1.4035	0.1573	0.8982	76.75%	75.91%	82.23%	0.8900	1.0949
13	58	0.2533	1.4463	0.2333	1.3321	0.1738	0.9925	79.46%	76.55%	80.09%	0.9091	1.0857
13	58	0.2794	1.5953	0.2616	1.4936	0.1730	0.9876	79.78%	77.52%	79.01%	0.8922	1.0681
13	58	0.2568	1.4662	0.2426	1.3855	0.1770	1.0109	80.83%	78.88%	79.56%	0.8889	1.0583
13	58	0.2734	1.5610	0.2516	1.4368	0.1847	1.0544	79.28%	76.19%	80.79%	0.8984	1.0864
13	58	0.2562	1.4631	0.2435	1.3907	0.1829	1.0442	80.78%	77.81%	81.55%	0.9091	1.0521
13	58	0.3010	1.7185	0.2846	1.6253	0.1755	1.0019	80.57%	76.33%	80.86%	0.9095	1.0573
13	58	0.2842	1.6231	0.2693	1.5377	0.1719	0.9815	77.63%	76.34%	78.22%	0.8855	1.0556
13	58	0.2417	1.3803	0.2276	1.2995	0.1725	0.9847	79.56%	76.08%	80.53%	0.8908	1.0622
13	58	0.2553	1.4580	0.2412	1.3774	0.1766	1.0087	78.81%	77.36%	84.51%	0.8932	1.0585
13	58	0.2436	1.3908	0.2302	1.3144	0.1690	0.9647	79.75%	75.74%	81.36%	0.8834	1.0581
13	58	0.2492	1.4229	0.2453	1.4009	0.1756	1.0029	80.49%	74.15%	81.14%	0.8913	1.0157
13	58	0.2506	1.4307	0.2380	1.3591	0.1595	0.9109	79.03%	77.14%	79.79%	0.9009	1.0526
13	58	0.2527	1.4432	0.2381	1.3599	0.1687	0.9632	79.10%	77.99%	80.61%	0.9018	1.0612
13	58	0.2441	1.3939	0.2427	1.3860	0.1604	0.9158	79.50%	75.78%	79.99%	0.8915	1.0057
13	58	0.2276	1.2994	0.2166	1.2366	0.1807	1.0319	79.26%	75.09%	81.86%	0.9198	1.0508
13	58	0.2599	1.4841	0.2529	1.4440	0.1568	0.8955	80.35%	79.46%	80.74%	0.8986	1.0278
13	58	0.2580	1.4732	0.2483	1.4180			79.59%	76.20%			1.0389
Average		**0.2633**	**1.5032**	**0.2484**	**1.4186**	**0.1706**	**0.9741**	**79.45%**	**76.56%**	**80.76%**	**0.8954**	**1.0600**
Std. Dev.		**0.0186**	**0.1065**	**0.0180**	**0.1026**	**0.0084**	**0.0479**	**1.10%**	**1.37%**	**1.58%**	**0.0115**	**0.0267**

Table J.6 FWD data for I-490 East, Monroe, Rochester on June 21, 2011 with E2 dowel bar configuration under nominal load of 80 kN (18 kip)

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/D0 M	JSR
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)					
18	80	0.2939	1.6782	0.2866	1.6364	0.1728	0.9868	79.77%	78.17%	79.35%	0.8808	1.0256
18	80	0.2422	1.3830	0.2325	1.3277	0.1594	0.9104	80.14%	75.97%	82.24%	0.8790	1.0416
18	80	0.2717	1.5517	0.2538	1.4493	0.1579	0.9015	78.08%	75.67%	81.67%	0.8741	1.0707
18	80	0.2758	1.5748	0.2488	1.4207	0.1713	0.9783	77.29%	77.12%	79.84%	0.8775	1.1084
18	80	0.2845	1.6244	0.2777	1.5854	0.1722	0.9830	77.62%	73.61%	78.50%	0.8651	1.0246
18	80	0.2519	1.4386	0.2276	1.2996	0.1803	1.0294	78.13%	73.82%	80.11%	0.8675	1.1070
18	80	0.2723	1.5549	0.2526	1.4422	0.1807	1.0318	79.16%	75.06%	82.33%	0.8959	1.0781
18	80	0.2828	1.6150	0.2570	1.4677	0.1781	1.0169	78.23%	77.78%	81.61%	0.8885	1.1004
18	80	0.2645	1.5102	0.2448	1.3976	0.1606	0.9169	77.37%	75.75%	80.70%	0.8768	1.0806
18	80	0.2553	1.4578	0.2327	1.3285	0.1770	1.0108	78.79%	76.72%	80.48%	0.8939	1.0974
18	80	0.2772	1.5829	0.2612	1.4916	0.1753	1.0012	78.85%	75.92%	80.59%	0.8814	1.0612
18	80	0.2527	1.4428	0.2456	1.4025	0.1796	1.0257	79.68%	75.87%	79.43%	0.8857	1.0288
18	80	0.2705	1.5445	0.2518	1.4379	0.1882	1.0747	80.17%	76.01%	80.53%	0.8855	1.0741
18	80	0.2564	1.4641	0.2429	1.3870	0.1835	1.0478	79.50%	77.65%	80.78%	0.8913	1.0556
18	80	0.2944	1.6810	0.2836	1.6191	0.1803	1.0294	79.17%	75.96%	81.12%	0.8921	1.0382
18	80	0.2762	1.5772	0.2687	1.5343	0.1723	0.9841	79.17%	75.80%	78.11%	0.8841	1.0280
18	80	0.2448	1.3979	0.2298	1.3123	0.1726	0.9853	78.40%	75.87%	81.00%	0.8820	1.0652
18	80	0.2547	1.4543	0.2391	1.3654	0.1721	0.9827	77.48%	76.56%	82.09%	0.8808	1.0651
18	80	0.2438	1.3922	0.2331	1.3310	0.1720	0.9823	78.40%	76.16%	81.28%	0.8738	1.0459
18	80	0.2494	1.4239	0.2442	1.3942	0.1783	1.0181	79.54%	74.07%	80.95%	0.8803	1.0213
18	80	0.2504	1.4301	0.2394	1.3670	0.1637	0.9345	78.72%	76.67%	79.59%	0.8789	1.0461
18	80	0.2506	1.4308	0.2406	1.3739	0.1702	0.9720	78.78%	75.99%	80.94%	0.8937	1.0414
18	80	0.2449	1.3985	0.2462	1.4061	0.1603	0.9152	78.55%	74.83%	79.24%	0.8754	0.9946
18	80	0.2284	1.3042	0.2174	1.2415	0.1836	1.0483	79.15%	75.39%	82.36%	0.9088	1.0506
18	80	0.2610	1.4906	0.2560	1.4618	0.1590	0.9077	78.95%	77.43%	81.68%	0.8853	1.0197
18	80	0.2556	1.4596	0.2473	1.4124			78.76%	76.24%			1.0334
Average		**0.2618**	**1.4947**	**0.2485**	**1.4190**	**0.1728**	**0.9870**	**78.76%**	**76.00%**	**80.66%**	**0.8831**	**1.0540**
Std. Dev.		**0.0169**	**0.0964**	**0.0168**	**0.0962**	**0.0086**	**0.0490**	**0.80%**	**1.14%**	**1.17%**	**0.0095**	**0.0296**

Table J.7 FWD data for I-490 East, Monroe, Rochester on June 21, 2011 with E1 dowel bar configuration under nominal load of 44 kN (10 kip)

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/D0 M	JSR
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)					
10	44	0.2529	1.4440	0.2555	1.4591	0.1883	1.0751	87.90%	86.06%	81.44%	0.9149	0.9897
10	44	0.2008	1.1467	0.2132	1.2173	0.1891	1.0800	91.88%	86.73%	95.82%	0.9355	0.9420
10	44					0.1923	1.0983			83.46%	0.9110	
10	44					0.1851	1.0572			91.72%	0.9076	
10	44					0.1869	1.0673			90.88%	0.9081	
10	44					0.1704	0.9729			78.29%	0.8935	
10	44					0.1700	0.9706			83.02%	0.8817	
Average		**0.2268**	**1.2953**	**0.2343**	**1.3382**	**0.1832**	**1.0459**	**89.89%**	**86.39%**	**86.37%**	**0.9075**	**0.9658**
Std. Dev.		**0.0368**	**0.2102**	**0.0299**	**0.1710**	**0.0091**	**0.0522**	**2.81%**	**0.48%**	**6.42%**	**0.0169**	**0.0337**

Table J.8 FWD data for I-490 East, Monroe, Rochester on June 21, 2011 with E1 dowel bar configuration under nominal load of 58 kN (13 kip)

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/D0 M	JSR
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)					
13	58	0.2572	1.4689	0.2578	1.4722	0.1950	1.1135	88.89%	86.18%	79.75%	0.9027	0.9977
13	58	0.2044	1.1670	0.2139	1.2214	0.1880	1.0735	91.76%	89.05%	94.87%	0.9474	0.9555
13	58					0.2002	1.1430			83.22%	0.9163	
13	58					0.1867	1.0661			88.78%	0.9184	
13	58					0.1881	1.0743			88.89%	0.9190	
13	58					0.1692	0.9659			78.75%	0.9058	
13	58					0.1692	0.9662			81.71%	0.9013	
Average		**0.2308**	**1.3180**	**0.2359**	**1.3468**	**0.1852**	**1.0575**	**90.32%**	**87.61%**	**85.14%**	**0.9159**	**0.9766**
Std. Dev.		**0.0374**	**0.2134**	**0.0311**	**0.1774**	**0.0119**	**0.0680**	**2.03%**	**2.03%**	**5.88%**	**0.0158**	**0.0298**

Table J.9 FWD data for I-490 East, Monroe, Rochester on June 21, 2011 with E1 dowel bar configuration under nominal load of 80 kN (18 kip)

Load		DO L		DO A		DO M		LTE L	LTE A	SPR	D3/D0 M	JSR
(kip)	(kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)	(mil/kip)	(μm/kN)					
18	80	0.2459	1.4038	0.2456	1.4023	0.1878	1.0724	87.19%	86.14%	79.68%	0.1878	1.0011
18	80	0.1942	1.1088	0.2081	1.1885	0.1835	1.0476	92.13%	87.19%	94.68%	0.1835	0.9329
18	80					0.1951	1.1139			83.62%	0.1951	
18	80					0.1821	1.0398			87.92%	0.1821	
18	80					0.1820	1.0391			87.90%	0.1820	
18	80					0.1695	0.9679			78.02%	0.1695	
18	80					0.1700	0.9709			81.82%	0.1700	
Average		**0.2200**	**1.2563**	**0.2269**	**1.2954**	**0.1814**	**1.0359**	**89.66%**	**86.67%**	**84.81%**	**0.1814**	**0.9670**
Std. Dev.		**0.0365**	**0.2086**	**0.0265**	**0.1511**	**0.0092**	**0.0523**	**3.50%**	**0.74%**	**5.76%**	**0.0092**	**0.0482**

ORITE • 141 Stocker Center • Athens, Ohio 45701-2979 • 740-593-2476
Fax: 740-593-0625 • orite@ohio.edu • http://www.ohio.edu/orite/