REPORT ON DRILLED SHAFT
LOAD TESTING (OSTERBERG METHOD)

Broadway Viaduct - Council Bluffs, IA - TS 3
Project Number - LT - 9640-2

Prepared for: **Longfellow Drilling**
1260 County Highway J23
Clearfield, IA 50840

Attention: **Mr. Jay Pool**

Report Date: **May 26, 2010**

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May 26, 2010

Longfellow Drilling
1260 County Highway J23
Clearfield, IA 50840

Attention: Mr. Jay Pool

Load Test Report: Broadway Viaduct - Council Bluffs, IA - TS 3

Dear Mr. Pool,

The enclosed report contains the data and analysis summary for the O-cell test performed on Broadway Viaduct - Council Bluffs, IA - TS 3 (LTI project LT - 9640-2) on May 20, 2010. For your convenience, we have included an executive summary of the test results in addition to our standard detailed data report.

We would like to express our gratitude for the on-site and off-site assistance provided by your team and we look forward to working with you on future projects.

We trust that this information will meet your current project needs. If you have any questions, please do not hesitate to contact us at (800) 368-1138.

Best Regards,

Robert Simpson
LOADTEST, Inc.

EXECUTIVE SUMMARY

LOADTEST, Inc. tested a 60-inch (1524-mm) drilled shaft on May 20, 2010. Mr. Bill Ryan of LOADTEST, Inc. carried out the test. Longfellow Drilling completed construction of the 75.2-foot (22.9-meter) deep shaft (from ground surface) on May 5, 2010. Sub-surface conditions at the test shaft location consist primarily of sands and silty clay. Representatives of the Iowa Department of Transportation observed construction of the shaft.

The maximum bi-directional load applied to the shaft was 1308 kips (5.82 MN). At the maximum load, the displacements above and below the O-cell were 0.812 inches (20.62 mm) and 4.65 inches (118.1 mm), respectively. Average unit shear data calculated from strain gages included a calculated net unit side shear of 4.3 ksf (205 kPa), occurring between the Level 3 Strain Gages and the O-cell. We also calculate a maximum applied end bearing pressure of 39.7 ksf (1,900 kPa).

Using the procedures described in the report text and in Appendix C, we constructed an equivalent top load curve for the test shaft. For a top loading of 965 kips (4.29 MN), the adjusted test data indicate this shaft would settle approximately 0.250 inches (6.35 mm) of which 0.064 inches (1.63 mm) is estimated elastic compression (see Figure 8).

LIMITATIONS OF EXECUTIVE SUMMARY

We include this executive summary to provide a very brief presentation of some of the key elements of this O-cell test. It is by no means intended to be a comprehensive or stand-alone representation of the test results. The full text of the report and the attached appendices contain important information which the engineer can use to come to more informed conclusions about the data presented herein.

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SITE CONDITIONS AND SHAFT CONSTRUCTION

Site Sub-surface Conditions: The sub-surface stratigraphy at the general location of the test shaft is reported to consist of sand and silty clay. The generalized subsurface profile is included in Figure A and a boring log indicating conditions near the shaft is presented in Appendix E. More detailed geologic information can be obtained from the Iowa Department of Transportation.

Test Shaft Construction: Longfellow Drilling completed construction of the test shaft on May 5, 2010. The shaft was constructed with a total length of 75.2 feet (22.91 meters) (from ground surface). The test shaft was constructed wet using polymer to a tip depth of -75.2 feet (-22.9 meters). An auger was used for drilling the shaft. The bottom of the shaft was cleaned with a cleaning bucket after drilling. Concrete was placed by tremie. Table B contains a summary of dimensions, elevations and shaft properties used in the data evaluations.

OSTERBERG CELL TESTING

Shaft Instrumentation: Test shaft instrumentation and assembly was carried out under the direction of Andy Skiffington of LOADTEST, Inc. The loading assembly consisted of a single 24-inch (610-mm) diameter O-cell located 14.8 feet (4.50 meters) above the tip of shaft. The Osterberg cell was calibrated to 2,940 kips (13.08 MN) and welded closed prior to shipping by American Equipment and Fabricating Corporation (see Appendix B).

Standard O-cell instrumentation included three LVWDTs (Linear Vibrating Wire Displacement Transducers - Geokon Model 4450 series) positioned between the lower and upper plates of the O-cell assembly to measure expansion (Appendix A, Page 2). Two lengths of ½-inch steel pipe were attached to the rebar cage, diametrically opposed, to measure compression of the shaft between the O-cell and the top of the shaft with traditional telltales that were installed on the day of the test.

Strain gages were used to assess the side shear load transfer along the shaft. One level of four and one level of three sister bar vibrating wire strain gages were installed, equally spaced on each level, in the shaft below the base of the O-cell assembly and five levels of three were installed in the shaft above it. Details concerning the strain gage placement appear in Table B and Figure A. The strain gages were positioned as directed by the Iowa Department of Transportation.

The test shaft assembly also included two lines of steel pipe, starting at the top-of-shaft and terminating at the top of the bottom plate to vent the break in the shaft between upward and downward movement and the resulting annular void. If desired they permit the application of excess fluid pressure to reduce the possibility of soil entering the void.

Test Arrangement: Throughout the load test, key elements of shaft response were monitored using the equipment and instruments described herein. Shaft compression was measured using telltales (described under Shaft Instrumentation) monitored by Linear Vibrating Wire Displacement Transducers (LVWDTs) (Geokon - 4450). Two automated digital survey levels (Leica NA3003) were used to monitor the top of shaft movement during testing from a distance of approximately 22 feet (6.7 meters) (Appendix A, Page 1).

Both a Bourdon pressure gage and a vibrating wire pressure transducer were used to measure the pressure applied to the O-cell at each load interval. We used the pressure transducer for setting and maintaining loads, data analysis and for real time plotting. The Bourdon gage was used as a check on the pressure transducer. There was close agreement between the Bourdon gage and the pressure transducer throughout the test.

Data Acquisition: All of the movement indicators, LVWDTs and strain gages were connected to a data logger (Data Electronics - Model 615 Datataker®). The data logger, in turn, was connected to a laptop computer. This arrangement allowed movement indicator, LVWDT and strain gage readings to be recorded and stored automatically at 30 second intervals during the test. It also allowed the automatic importation of all test data into a laptop computer for real-time display and additional data back-up. The Leica (NA3003) data was imported real-time directly to the same lap top computer set to the same time as the data logging system.

Testing Procedures: As with all of our tests, we begin by loading the O-cell in order to break the tack welds that hold it closed (for handling and for placement in the shaft) and to form the fracture plane in the concrete surrounding the base of the O-cell. After the break occurs, we immediately release the load and then begin the loading procedure. Zero readings for all instrumentation are taken prior to the preliminary weld-breaking load-unload cycle, which in this case involved a maximum O-cell load of 279 kips (1.2 MN).

The Osterberg cell load test was conducted as follows: The 24-inch (610-mm) diameter O-cell located 14.8 feet (4.50 meters) above the tip of shaft was loaded to assess the base resistance below the O-cell assembly and the side shear above it. The O-cell was loaded in 11 increments to 1,308 kips (5.82 MN). The loading was halted after load interval 1L-11 because the shear resistance was approaching ultimate capacity The O-cell was then depressurized in four decrements and the test was concluded. It should be noted that the final increment was half of the previous ten due to rapid displacement.

We applied the load increments using the Quick Load Test Method for Individual Piles (ASTM D1143 *Standard Test Method for Piles Under Static Axial Load*), holding each successive load increment constant for eight minutes by manually adjusting the O-cell pressure. We used approximately 60 seconds to move between increments. The data logger automatically recorded the instrument readings every 30 seconds, but herein we report only the one, two, four and eight-minute readings during each increment of maintained load. The various plotted results generally use the one, two, four and eight minute readings, but the creep results use the difference between the four and eight-minute readings.

TEST RESULTS AND ANALYSES

General: The loads applied by the O-cell act in two opposing directions, resisted by the capacity of the shaft above and below. Theoretically, the O-cell does not impose an additional upward load until its expansion force exceeds the buoyant weight of the shaft above the O-cell. Therefore, *net load*, which is defined as gross O-cell load minus the buoyant weight of the shaft above, is used to determine side shear resistance above the O-cell and to construct the equivalent top-loaded load-settlement curve. For this test we calculated a buoyant weight of shaft of 139 kips (0.62 MN) above the O-cell.

Side Shear Resistance: The maximum upward ***net load*** applied to the side shear was 1,168 kips (5.2 MN) which occurred at load interval 1L-11 (Appendix A, Page 3, Figures 1, 2 and 3). At this loading, the total upward movement of the top of the O-cell assembly was 0.812 inches (20.62 mm). The following net unit side shear estimates are based on the strain gage data which appear in Appendix A, Pages 4 to 7 and the shaft stiffnesses computed below.

At the time of testing, the concrete unconfined compressive strength was reported to be 6,010 psi (41.4 MPa). We used the ACI formula ($E_c = 57{,}000\sqrt{f'c}$) to calculate an elastic modulus for the concrete. This, combined with the area of reinforcing steel and shaft diameter, was used to determine a weighted average shaft stiffness of 14,000,000 kips (62,300 MN) for the shaft. The unit stiffnesses vary somewhat throughout the shaft due to diameter (see caliper report) and percent steel variations. Therefore different stiffnesses are used when computing load from different strain gage levels. The various stiffnesses for each zone are given in Table B. Estimated net unit side shear values for the shaft based on the strain gage data, estimated shaft stiffnesses and shaft area are as follows:

Table A: Mobilized Average Net Unit Side Shear Values for 1L-11[1]

Load Transfer Zone	Load Direction	Net Unit Side Shear[2]
Top of Shaft to Strain Gage Level 7	↑ @ 0.80 inches	0.20 ksf (10 kPa)
Strain Gage Level 7 to Strain Gage Level 6	↑ @ 0.80 inches	0.31 ksf (15 kPa)
Strain Gage Level 6 to Strain Gage Level 5	↑ @ 0.80 inches	1.85 ksf (89 kPa)
Strain Gage Level 5 to Strain Gage Level 4	↑ @ 0.81 inches	1.37 ksf (65 kPa)
Strain Gage Level 4 to Strain Gage Level 3	↑ @ 0.81 inches	1.25 ksf (60 kPa)
Strain Gage Level 3 to O-cell	↑ @ 0.81 inches	4.29 ksf (205 kPa)
O-cell to Strain Gage Level 2	↓ @ 4.65 inches	3.92 ksf (188 kPa)
Strain Gage Level 2 to Strain Gage Level 1	↓ @ 4.65 inches	1.29 ksf (62 kPa)

[1]At the maximum displacement either up or down reported herein. See Figures 5 and 6 for net unit shear vs. displacement plots.
[2]For upward loaded shear, the buoyant weight of shaft in each zone has been subtracted from the load shed in the respective zone.

Side shear load distribution curves generated from strain gage data are shown in Figure 4. A unit side shear value for the shaft between the Level 2 strain gages and the Level 1 strain gages was calculated for 1L-11 to obtain an estimate of the base shear component of resistance to the downward movement between the Level 1 strain gages and the tip of shaft.

Combined End Bearing and Lower Side Shear Resistance: The maximum O-cell load applied to the base of the shaft was 1,308 kips (5.82 MN) which occurred at load interval 1L-11 (Appendix A, Page 3, Figure 1). At this loading, the total downward movement of the O-cell base was 4.651 inches (118.1 mm). The base resistance includes a small component of base shear (as discussed above) which must be subtracted to obtain unit end bearing values. The shear component of resistance for the shaft section the between the Level 1 strain gages and the tip of shaft is calculated to be 36 kips (0.2 MN) assuming a unit side shear value of 1.29 ksf (62 kPa) and a nominal shaft diameter of 60 inches (1524 mm). The applied load to end bearing is then 805 kips (3.58 MN) and the end-bearing pressure applied at the tip of the shaft is calculated to be 39.7 ksf (1,900 kPa).

Creep Limit: See Appendix D for our O-cell method for determining creep limit. The upward side shear creep data (Appendix A, Page 3) indicate that a creep limit of 800 kips (3.56 MN) was reached at a movement of 0.23 inches (5.8 mm) (Appendix D, Figure 1). The combined end bearing and lower side shear creep data (Appendix A, Page 3) indicate that a creep limit of 470 kips (2.09 MN) was reached at a movement of 0.30 inches (7.6 mm) (Appendix D, Figure 2). The engineer should come to his own conclusions with regard to the suitability of the creep limit analysis to address long term creep which may be an important design consideration.

Equivalent Top Load: Figure 2 presents the equivalent top load curve. The unadjusted lighter curve, described in Procedure Part I of Appendix C, was generated by using the measured upward top of O-cell and downward base of O-cell data. Because it can be an important component of the settlements involved, the equivalent top load curve includes an adjustment for the additional elastic compression which would occur in a top-load test. The darker curve as described in Procedure Part II of Appendix C includes such an adjustment.

We mobilized a combined end bearing and side shear resistance of 2,476 kips (11.01 MN) during the test. For a top loading of 965 kips (4.29 MN), the adjusted test data indicate this shaft would settle approximately 0.250 inches (6.35 mm) of which 0.064 inches (1.63 mm) is estimated elastic compression (see Figure 2).

Shaft Compression Comparison: The measured maximum shaft compression, averaged from 2 telltales, is 0.022 inches (0.57 mm). Using the nominal shaft diameter(s) (Table B and Figure A), a weighted average shaft stiffness of 14,000,000 kips (62,300 MN) and the load distribution in Figure 3, we calculated an elastic compression of 0.018 inches (0.46 mm) over the length of the compression telltales.

LIMITATIONS AND STANDARD OF CARE

The instrumentation, testing services and data analysis provided by LOADTEST, Inc., outlined in this report, were performed in accordance with the accepted standards of care recognized by professionals in the drilled shaft and foundation engineering industry.

Please note that some of the information contained in this report is based on data (i.e. shaft diameter, elevations and concrete strength) provided by others. The engineer, therefore, should come to his or her own conclusions with regard to the analyses as they depend on this information. In particular, LOADTEST, Inc. typically does not observe and record drilled shaft construction details to the level of precision that the project engineer may require. In many cases, we may not be present for the entire duration of shaft construction. Since construction technique can play a significant role in determining the load bearing capacity of a drilled shaft, the engineer should pay close attention to the drilled shaft construction details that were recorded elsewhere.

We trust that this information will meet your current project needs. If you have any questions, please do not hesitate to contact us at (800) 368-1138.

Prepared for LOADTEST, Inc. by

Robert C. Simpson
Senior Engineer

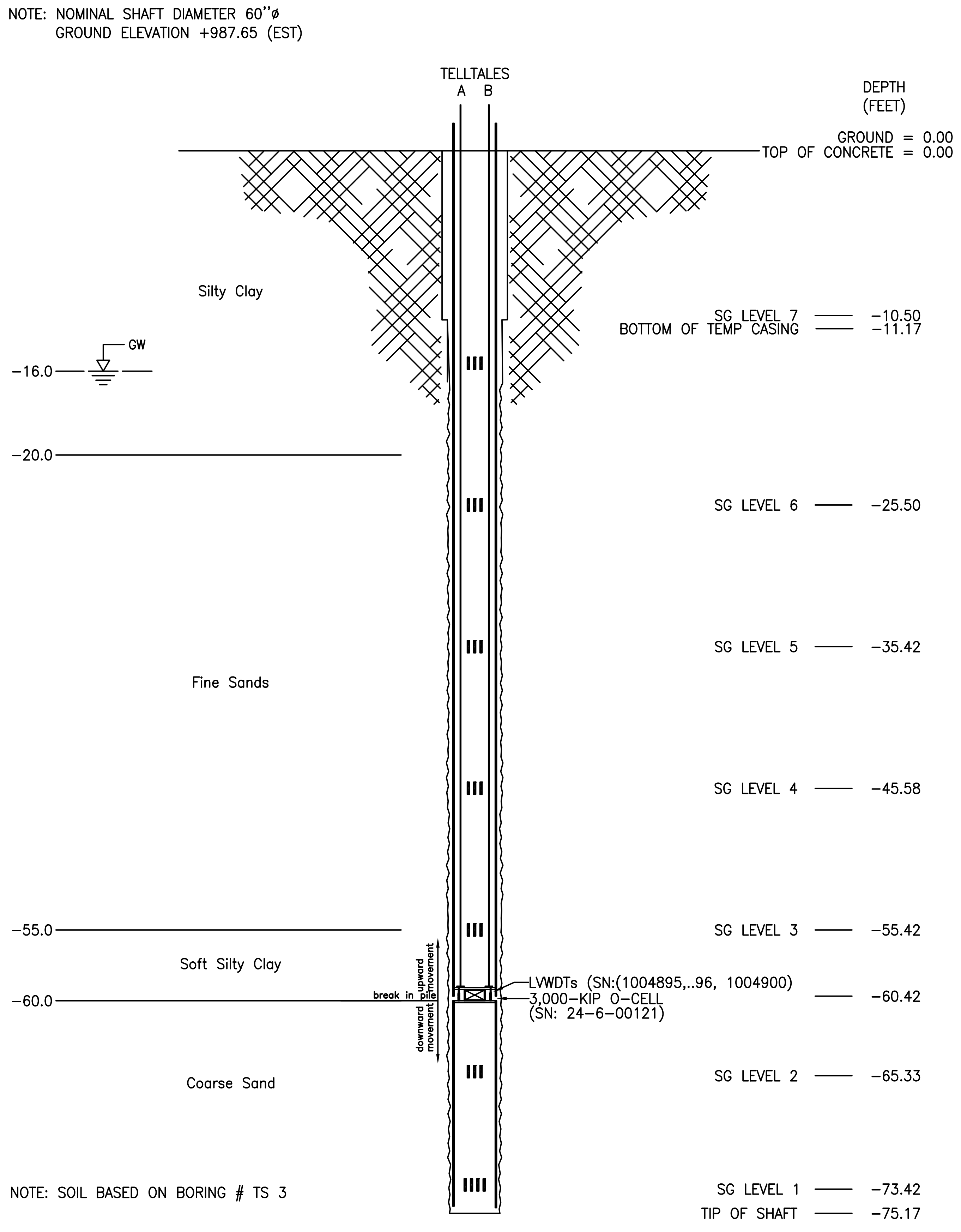
Reviewed for LOADTEST, Inc. by

David J. Jakstis, P.E.
Geotechnical Engineer

TABLE B: SUMMARY OF DIMENSIONS, DEPTHS, AREAS & PROPERTIES FOR ANALYSIS PURPOSES

Shaft: (TS 3, Broadway Viaduct, Council Bluffs, IA, LT-9640-2)			
Nominal shaft diameter: +0.00 ft to -11.17 ft[1]	=	66 inches	1676 mm
Nominal shaft diameter: -11.17 ft to -75.17 ft[1]	=	60 inches	1524 mm
O-cell size: (Serial no.: 24-6-00121)	=	24 inches	610 mm
Length of concrete from break at base of cell to tip	=	14.8 feet	4.5 meters
Shaft shear area from break at base of cell to tip	=	231.7 $feet^2$	21.52 $meters^2$
Shaft end area	=	19.6 $feet^2$	1.82 $meters^2$
Weight of shaft from break at base of cell to top of shaft	=	139.3 kips	0.62 MN
Estimated shaft unit stiffness: +0.00 ft to -8.00 ft	=	1.56E+07 kips	69.5 GN
Estimated shaft unit stiffness: -8.00 ft to -11.17 ft	=	1.38E+07 kips	61.6 GN
Estimated shaft unit stiffness: -11.17 ft to -22.00 ft	=	1.43E+07 kips	63.5 GN
Estimated shaft unit stiffness: -22.00 ft to -34.00 ft	=	1.38E+07 kips	61.6 GN
Estimated shaft unit stiffness: -34.00 ft to -75.00 ft	=	1.34E+07 kips	59.7 GN
Depth of top of shaft concrete	=	+0.00 feet	+0.00 meters
Depth of ground surface	=	+0.00 feet	+0.00 meters
Water depth	=	-16.00 feet	-4.88 meters
Depth of break at base of O-cell	=	-60.42 feet	-18.42 meters
Depth of shaft tip	=	-75.17 feet	-22.91 meters
Casings:			
Depth of top of inner temporary casing: 66 inches O.D.	=	+0.83 feet	0.25 meters
Depth of bottom of inner temporary casing: 66 inches O.D.	=	-11.17 feet	-3.40 meters
Measured Compression Zones:			
Depth of top of zone	=	+0.00 feet	+0.00 meters
Depth of bottom of telltale (bottom of zone)	=	-59.12 feet	-18.02 meters
Strain Gages:			
Depth of strain gage level 7 (AE = 15,300,000)	=	-10.50 feet	-3.20 meters
Depth of strain gage level 6 (AE = 13,800,000)	=	-25.50 feet	-7.77 meters
Depth of strain gage level 5 (AE = 13,400,000)	=	-35.42 feet	-10.80 meters
Depth of strain gage level 4 (AE = 13,400,000)	=	-45.58 feet	-13.89 meters
Depth of strain gage level 3 (AE = 13,400,000)	=	-55.42 feet	-16.89 meters
Depth of strain gage level 2 (AE = 13,400,000)	=	-65.33 feet	-19.91 meters
Depth of strain gage level 1 (AE = 13,400,000)	=	-73.42 feet	-22.38 meters
Miscellaneous:			
Top plate diameter	=	47.75 inches	1213 mm
Top plate thickness	=	2.0 inches	50.8 mm
Bottom plate diameter	=	47.75 inches	1213 mm
Bottom plate thickness	=	2.0 inches	50.8 mm
Vertical rebar size	=	# 11	36M
Number of vertical rebars	=	19	19
Hoop rebar size	=	# 4	13M
Number of hoops	=	85	85
LVWDT radii - no: 1004895	=	17.0 inches	432 mm
LVWDT orientation - no.: 1004895	=	0 degrees	
LVWDT radii - no: 1004896	=	17.0 inches	432 mm
LVWDT orientation - no.: 1004896	=	180 degrees	
LVWDT radii - no: 1004900	=	20.0 inches	508 mm
LVWDT orientation - no.: 1004900	=	270 degrees	

[1]Actual diameter varies based on caliper data, See caliper report.



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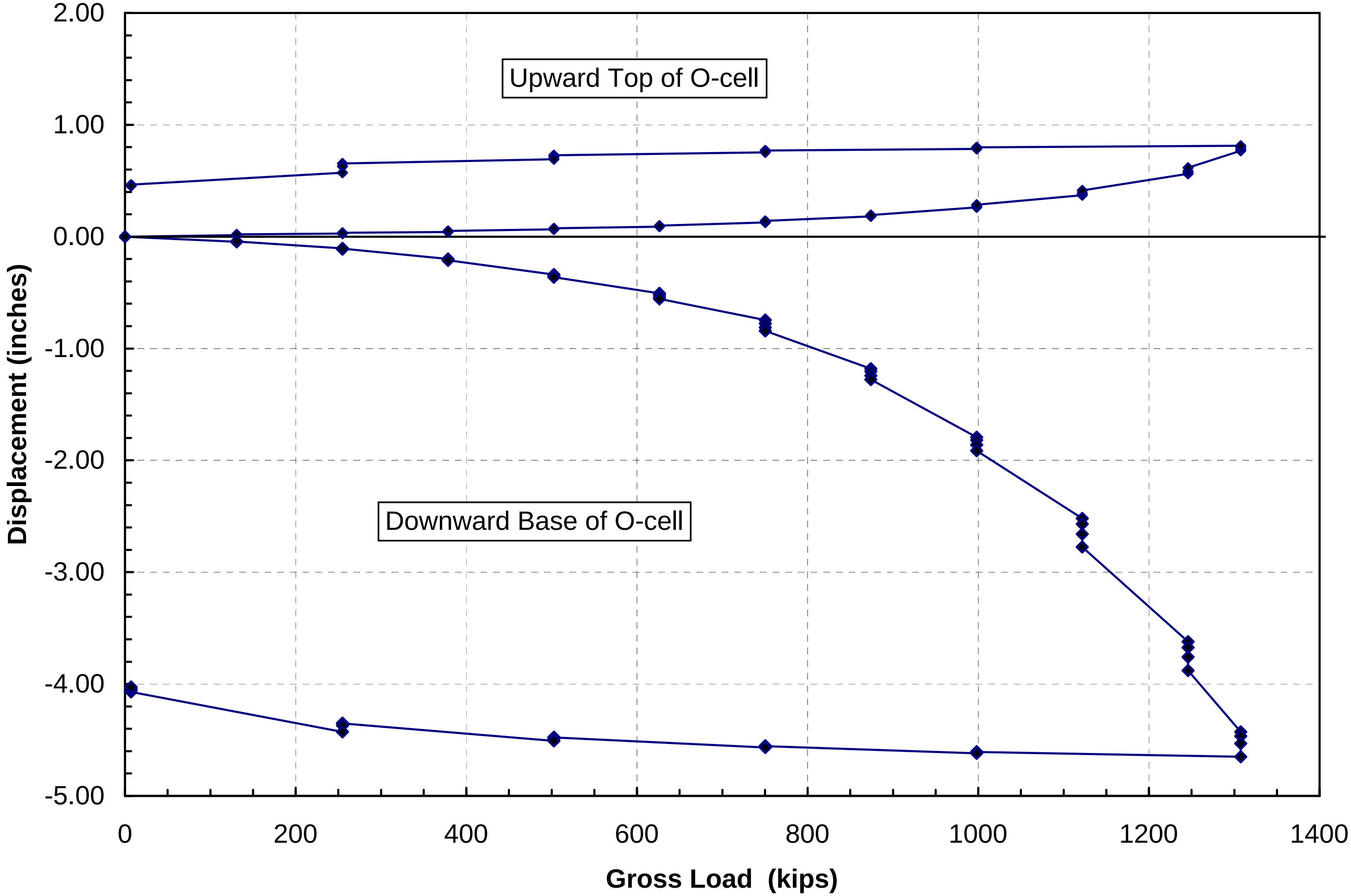
SCHEMATIC SECTION OF TEST SHAFT 3

Broadyway Viaduct − Council Bluffs, IA

DWN BY: BDH	DATE: 06 Nov 2009	CHECKED BY:	LT−9640−2
REVISED BY: AJS	DATE: 10 May 2010	SCALE: NTS	FIGURE A

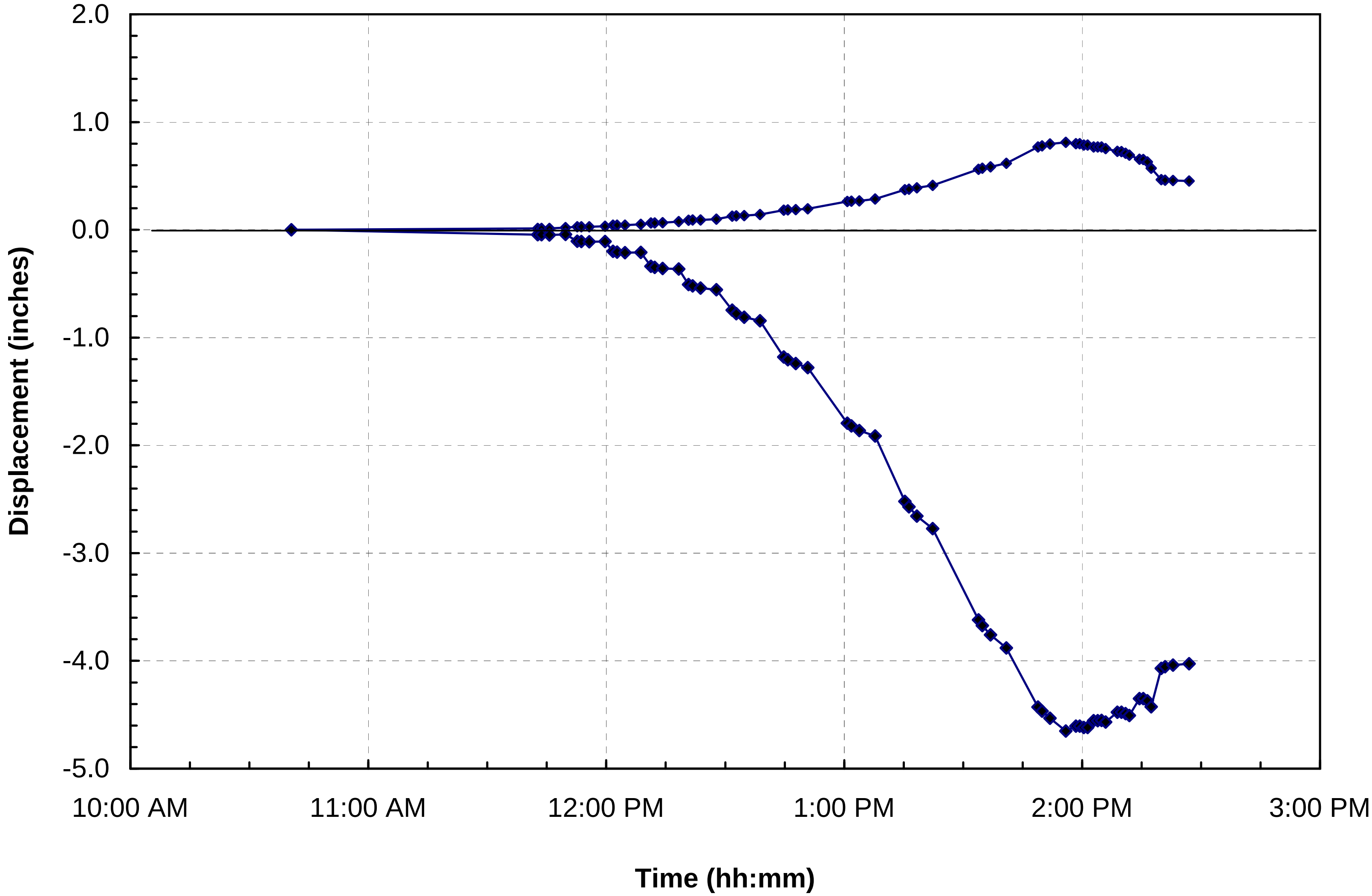
Osterberg Cell Load vs.Displacement Plots

Broadway Viaduct - Council Bluffs, IA - TS 3



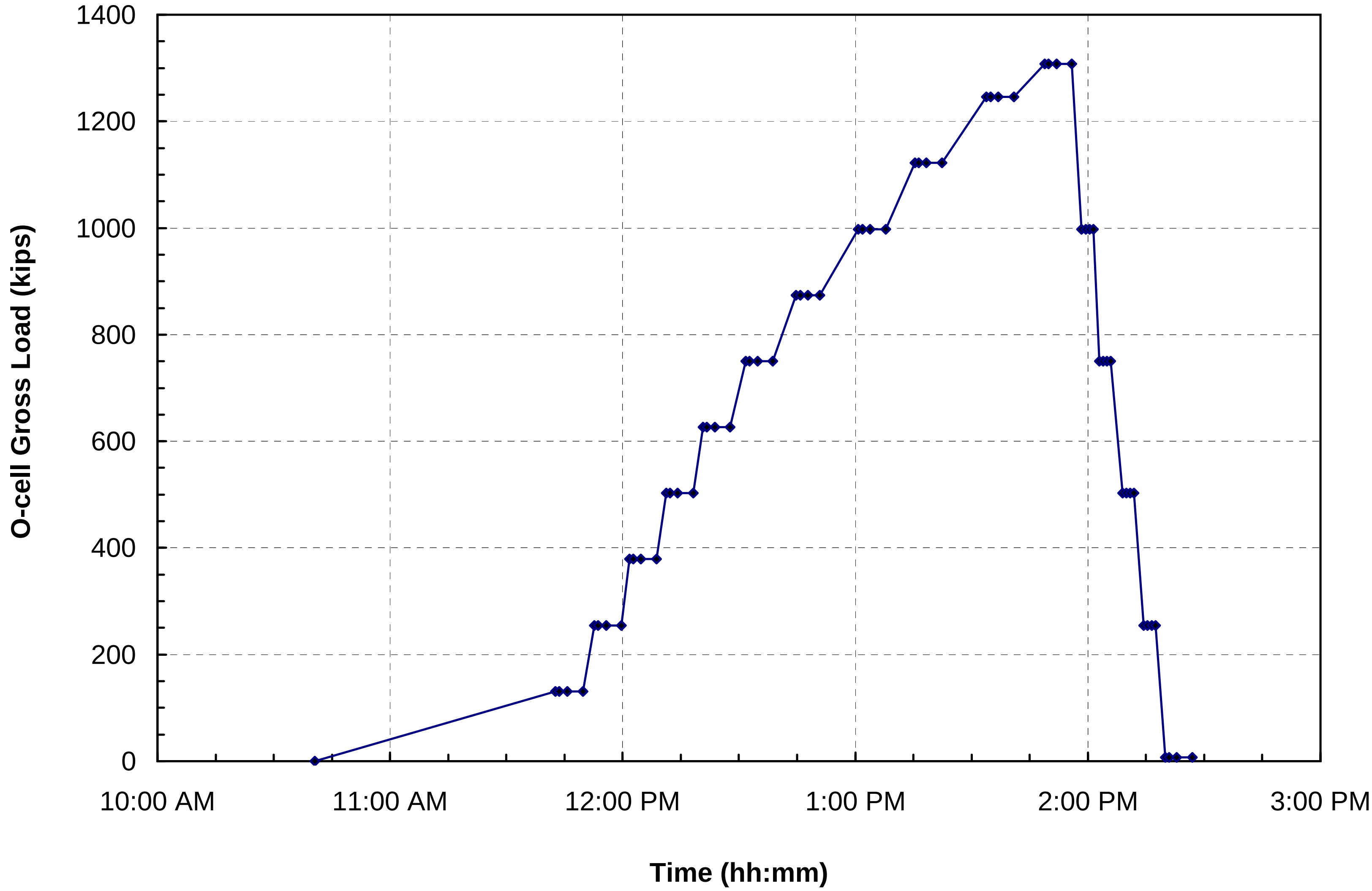
Osterberg Cell Time vs. Displacement Plots

Broadway Viaduct - Council Bluffs, IA - TS 3



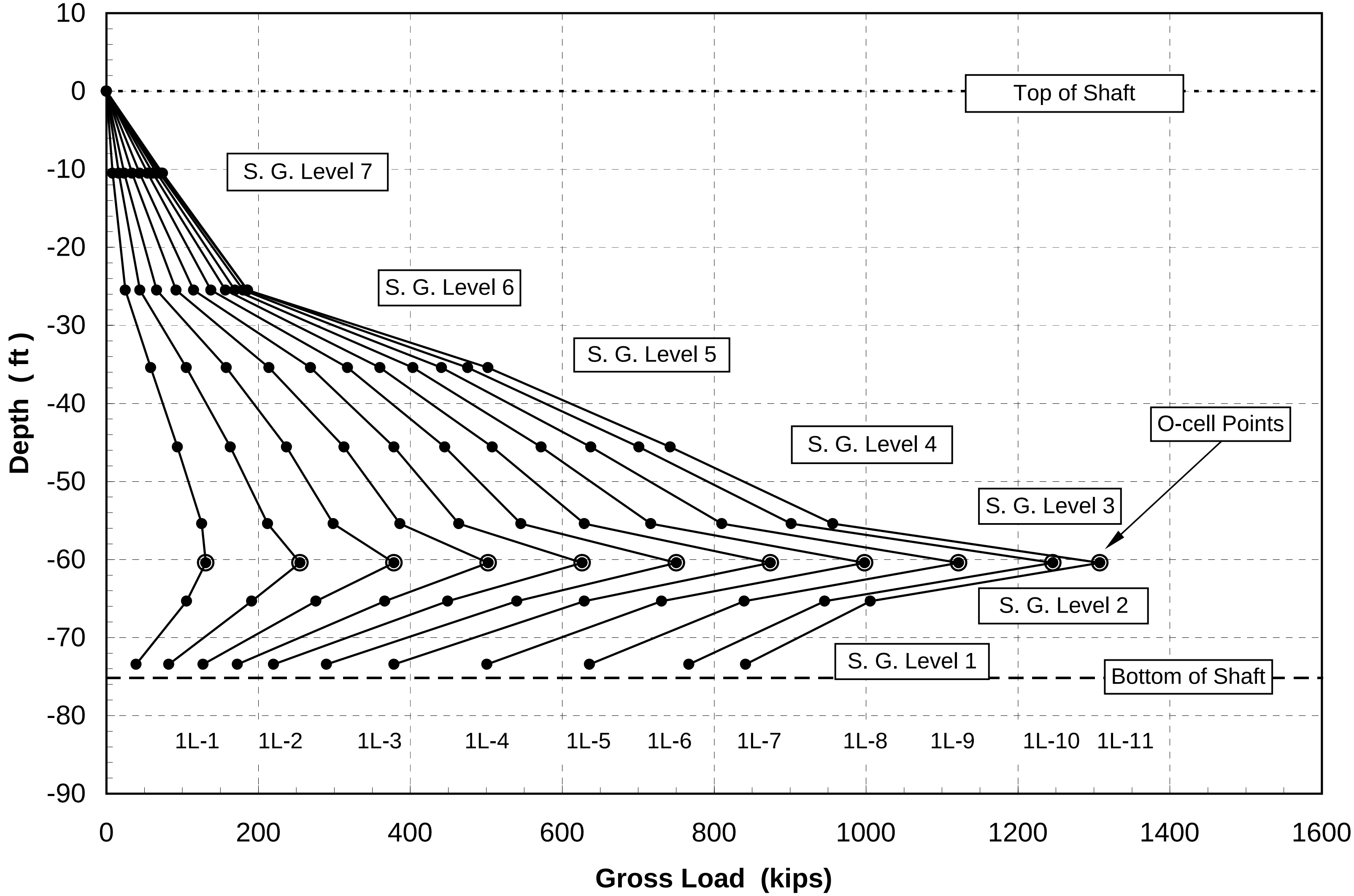
Osterberg Cell Load vs. Time

Broadway Viaduct - Council Bluffs, IA - TS 3



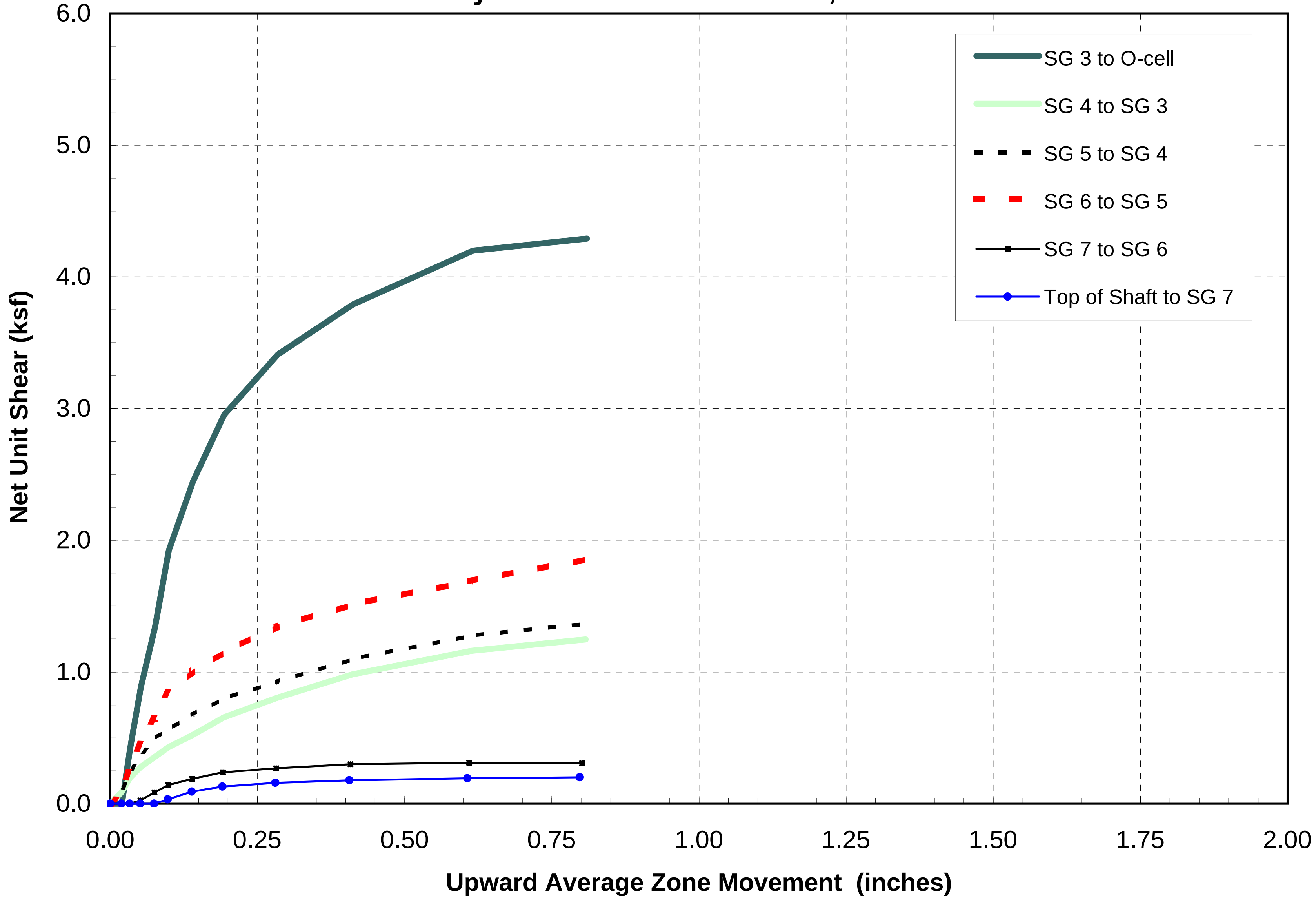
Strain Gage Load Distribution Plots

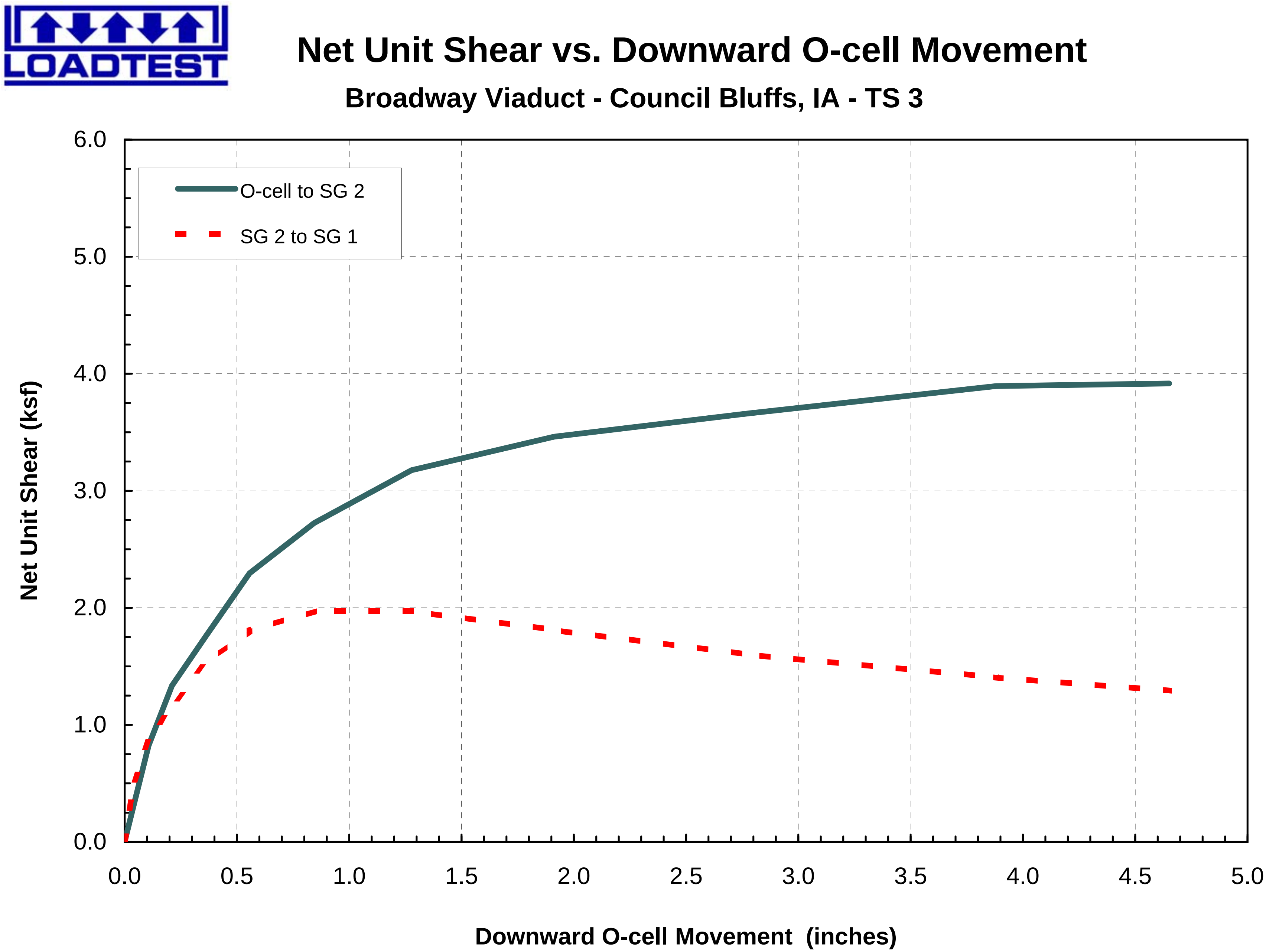
Broadway Viaduct - Council Bluffs, IA - TS 3



Net Unit Shear vs. Upward Average Zone Movement

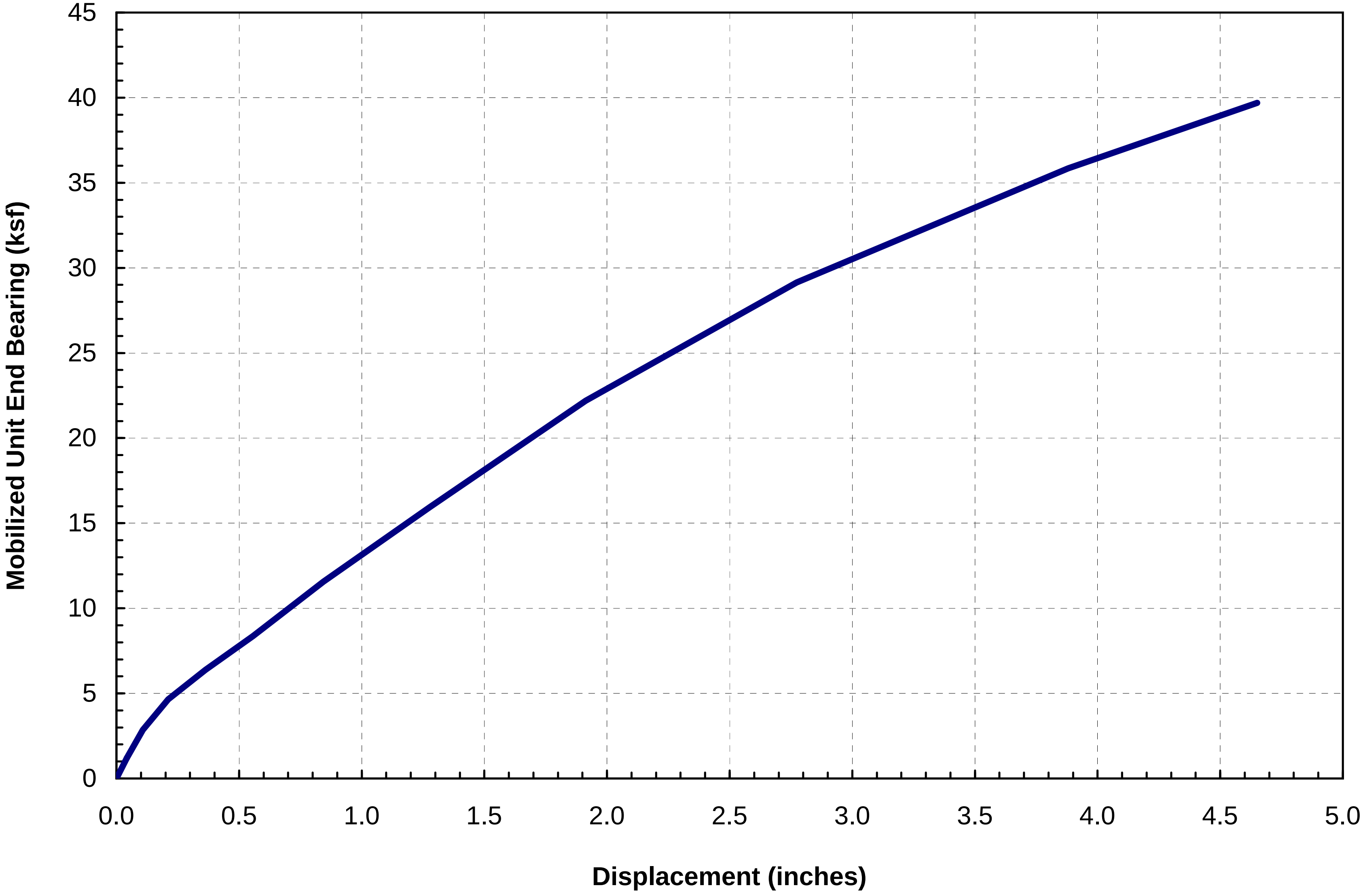
Broadway Viaduct - Council Bluffs, IA - TS 3




LOADTEST
Net Unit Shear vs. Downward O-cell Movement
Broadway Viaduct - Council Bluffs, IA - TS 3
O-cell to SG 2
SG 2 to SG 1
Net Unit Shear (ksf)
Downward O-cell Movement (inches)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0

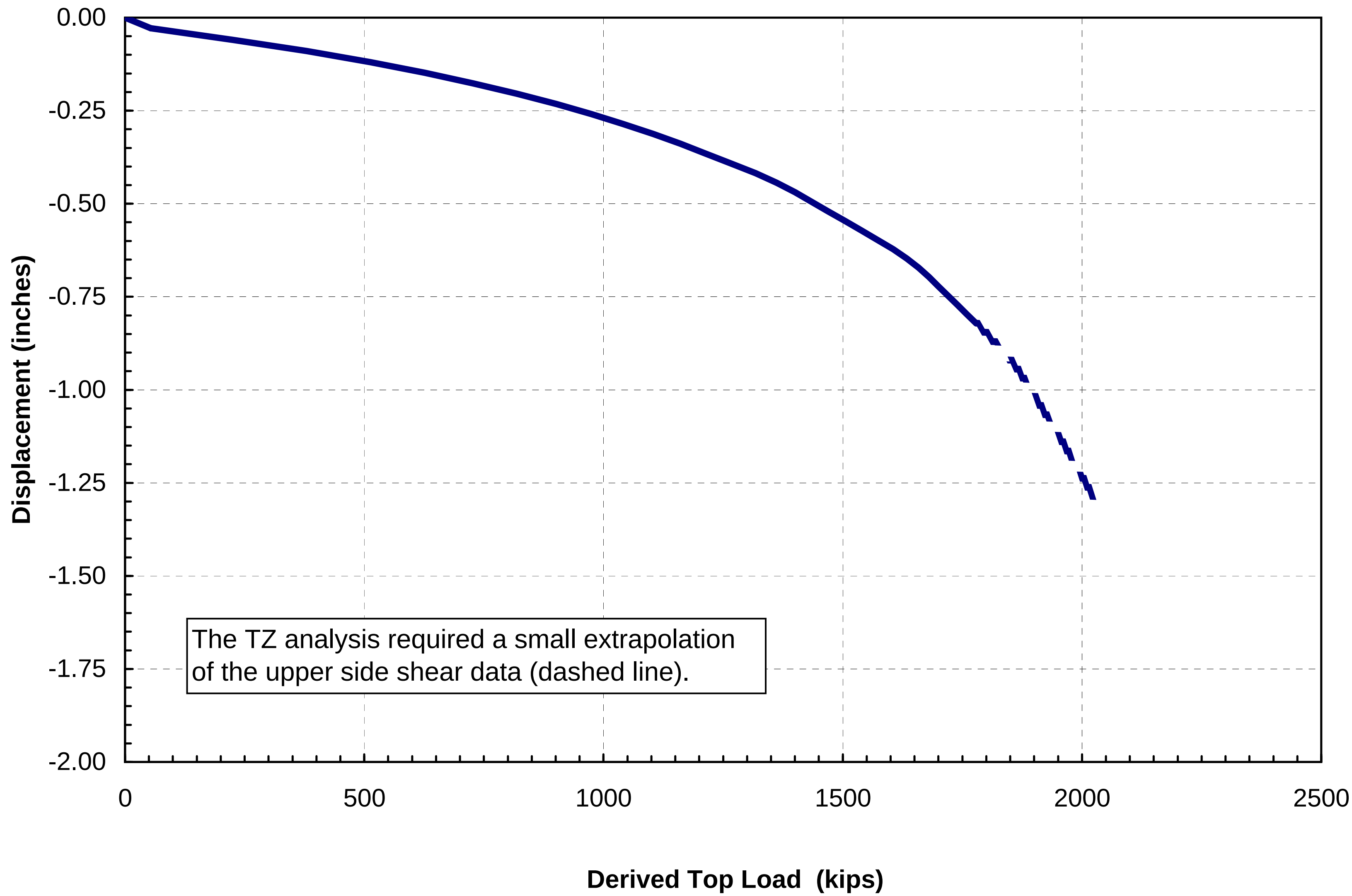
Mobilized Unit End Bearing vs. Downward O-cell Displacement

Broadway Viaduct - Council Bluffs, IA - TS 3



Derived Top Load-Displacement Plots

Broadway Viaduct - Council Bluffs, IA - TS 3



APPENDIX A

FIELD DATA & DATA REDUCTION

Top of Shaft Movement and Compression

Broadway Viaduct - Council Bluffs, IA - TS 3

Load	Time	Time After	O-cell	Applied	Net	TOS Indicator Readings			Telltale Compression		
Test		Start	Pressure	Load	Load	Side A	Side B	Average	Side A	Side B	Average
Increment	(h:m:s)	Minutes	(psi)	(kips)	(kips)	(inches)	(inches)	(inches)	(inches)	(inches)	(inches)
1L -0	10:41:00	0	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000
1L -1	11:43:00	1	400	131	0	0.011	0.012	0.011	0.002	0.003	0.003
1L -1	11:44:00	2	400	131	0	0.011	0.012	0.011	0.002	0.003	0.003
1L -1	11:46:00	4	400	131	0	0.011	0.012	0.011	0.003	0.003	0.003
1L -1	11:50:00	8	400	131	0	0.012	0.022	0.017	0.003	0.003	0.003
1L -2	11:53:00	1	800	255	115	0.022	0.023	0.022	0.004	0.005	0.005
1L -2	11:54:00	2	800	255	115	0.022	0.023	0.022	0.004	0.005	0.005
1L -2	11:56:00	4	800	255	115	0.022	0.023	0.022	0.004	0.005	0.005
1L -2	12:00:00	8	800	255	115	0.022	0.036	0.029	0.004	0.005	0.005
1L -3	12:02:00	1	1,200	379	239	0.035	0.036	0.036	0.006	0.007	0.007
1L -3	12:03:00	2	1,200	379	239	0.035	0.037	0.036	0.006	0.007	0.007
1L -3	12:05:00	4	1,200	379	239	0.036	0.037	0.037	0.006	0.007	0.007
1L -3	12:09:00	8	1,200	379	239	0.036	0.054	0.045	0.006	0.008	0.007
1L -4	12:11:30	1	1,600	503	363	0.054	0.057	0.056	0.008	0.010	0.009
1L -4	12:12:30	2	1,600	503	363	0.054	0.057	0.056	0.008	0.010	0.009
1L -4	12:14:30	4	1,600	503	363	0.055	0.057	0.056	0.009	0.010	0.009
1L -4	12:18:30	8	1,600	503	363	0.056	0.077	0.067	0.009	0.010	0.009
1L -5	12:21:00	1	2,000	626	487	0.076	0.081	0.079	0.010	0.012	0.011
1L -5	12:22:00	2	2,000	626	487	0.078	0.081	0.079	0.010	0.012	0.011
1L -5	12:24:00	4	2,000	626	487	0.079	0.082	0.081	0.010	0.012	0.011
1L -5	12:28:00	8	2,000	626	487	0.081	0.095	0.088	0.011	0.013	0.012
1L -6	12:32:00	1	2,400	750	611	0.109	0.116	0.113	0.012	0.015	0.014
1L -6	12:33:00	2	2,400	750	611	0.112	0.117	0.115	0.012	0.015	0.014
1L -6	12:35:00	4	2,400	750	611	0.115	0.119	0.117	0.012	0.015	0.014
1L -6	12:39:00	8	2,400	750	611	0.118	0.136	0.127	0.012	0.015	0.014
1L -7	12:45:00	1	2,800	874	735	0.163	0.170	0.167	0.014	0.018	0.016
1L -7	12:46:00	2	2,800	874	735	0.166	0.171	0.169	0.014	0.018	0.016
1L -7	12:48:00	4	2,800	874	735	0.169	0.174	0.172	0.014	0.018	0.016
1L -7	12:51:00	8	2,800	874	735	0.172	0.184	0.178	0.014	0.018	0.016
1L -8	13:01:00	1	3,200	998	859	0.241	0.250	0.246	0.015	0.020	0.017
1L -8	13:02:00	2	3,200	998	859	0.244	0.253	0.249	0.015	0.020	0.017
1L -8	13:04:00	4	3,200	998	859	0.248	0.256	0.252	0.015	0.020	0.018
1L -8	13:08:00	8	3,200	998	859	0.254	0.282	0.268	0.015	0.020	0.018
1L -9	13:15:30	1	3,600	1,122	983	0.344	0.362	0.353	0.016	0.021	0.019
1L -9	13:16:30	2	3,600	1,122	983	0.351	0.368	0.360	0.016	0.021	0.019
1L -9	13:18:30	4	3,600	1,122	983	0.363	0.378	0.371	0.016	0.021	0.019
1L -9	13:22:30	8	3,600	1,122	983	0.379	0.410	0.395	0.016	0.022	0.019
1L -10	13:34:00	1	4,000	1,246	1,107	0.529	0.554	0.542	0.016	0.025	0.021
1L -10	13:35:00	2	4,000	1,246	1,107	0.540	0.562	0.551	0.017	0.025	0.021
1L -10	13:37:00	4	4,000	1,246	1,107	0.554	0.575	0.564	0.016	0.025	0.021
1L -10	13:41:00	8	4,000	1,246	1,107	0.579	0.614	0.597	0.016	0.025	0.021
1L -11	13:49:00	1	4,200	1,308	1,168	0.733	0.759	0.746	0.017	0.028	0.022
1L -11	13:50:00	2	4,200	1,308	1,168	0.743	0.769	0.756	0.017	0.028	0.022
1L -11	13:52:00	4	4,200	1,308	1,168	0.761	0.787	0.774	0.017	0.028	0.022
1L -11	13:56:00	8	4,200	1,308	1,168	0.794	0.785	0.790	0.017	0.028	0.022
1U - 1	13:58:30	1	3,200	998	859	0.775	0.784	0.780	0.013	0.026	0.019
1U - 1	13:59:30	2	3,200	998	859	0.776	0.784	0.780	0.013	0.026	0.019
1U - 1	14:00:30	3	3,200	998	859	0.774	0.762	0.768	0.013	0.026	0.019
1U - 1	14:01:30	4	3,200	998	859	0.774	0.758	0.766	0.013	0.026	0.019
1U - 2	14:03:00	1	2,400	750	611	0.748	0.757	0.753	0.010	0.025	0.018
1U - 2	14:04:00	2	2,400	750	611	0.748	0.757	0.753	0.010	0.025	0.018
1U - 2	14:05:00	3	2,400	750	611	0.748	0.757	0.753	0.010	0.025	0.018
1U - 2	14:06:00	4	2,400	750	611	0.747	0.725	0.736	0.010	0.025	0.018
1U - 3	14:09:00	1	1,600	503	363	0.709	0.717	0.713	0.007	0.021	0.014
1U - 3	14:10:00	2	1,600	503	363	0.708	0.717	0.713	0.007	0.021	0.014
1U - 3	14:11:00	3	1,600	503	363	0.708	0.687	0.698	0.007	0.021	0.014
1U - 3	14:12:00	4	1,600	503	363	0.708	0.650	0.679	0.007	0.021	0.014
1U - 4	14:14:30	1	800	255	115	0.640	0.647	0.644	0.005	0.017	0.011
1U - 4	14:15:30	2	800	255	115	0.639	0.646	0.643	0.005	0.017	0.011
1U - 4	14:16:30	3	800	255	115	0.639	0.598	0.619	0.005	0.017	0.011
1U - 4	14:17:30	4	800	255	115	0.639	0.482	0.560	0.005	0.017	0.011
1U - 5	14:20:00	1	0	0	0	0.460	0.458	0.459	0.002	0.010	0.006
1U - 5	14:21:00	2	0	0	0	0.455	0.455	0.455	0.002	0.010	0.006
1U - 5	14:23:00	4	0	0	0	0.449	0.453	0.451	0.002	0.010	0.006
1U - 5	14:27:00	8	0	0	0	0.445	0.449	0.447	0.002	0.010	0.006

O-cell Expansion

Broadway Viaduct - Council Bluffs, IA - TS 3

Load Test Increment	Time (h:m:s)	Time After Start Minutes	O-cell Pressure (psi)	Applied Load (kips)	Net Load (kips)	LVWDT Readings (Expansion) 1004895 (inches)	1004896 (inches)	1004900 (inches)	Average[1] (inches)
1L -0	10:41:00	0	0	0	0	0.000	0.000	0.000	0.000
1L -1	11:43:00	1	400	131	0	0.058	0.060	0.055	0.059
1L -1	11:44:00	2	400	131	0	0.059	0.061	0.056	0.060
1L -1	11:46:00	4	400	131	0	0.059	0.062	0.056	0.061
1L -1	11:50:00	8	400	131	0	0.061	0.063	0.058	0.062
1L -2	11:53:00	1	800	255	115	0.131	0.134	0.131	0.133
1L -2	11:54:00	2	800	255	115	0.134	0.137	0.134	0.135
1L -2	11:56:00	4	800	255	115	0.136	0.139	0.136	0.138
1L -2	12:00:00	8	800	255	115	0.140	0.142	0.139	0.141
1L -3	12:02:00	1	1,200	379	239	0.241	0.244	0.243	0.242
1L -3	12:03:00	2	1,200	379	239	0.247	0.250	0.249	0.249
1L -3	12:05:00	4	1,200	379	239	0.254	0.257	0.256	0.255
1L -3	12:09:00	8	1,200	379	239	0.261	0.264	0.263	0.263
1L -4	12:11:30	1	1,600	503	363	0.401	0.407	0.407	0.404
1L -4	12:12:30	2	1,600	503	363	0.410	0.416	0.417	0.413
1L -4	12:14:30	4	1,600	503	363	0.422	0.428	0.428	0.425
1L -4	12:18:30	8	1,600	503	363	0.436	0.442	0.442	0.439
1L -5	12:21:00	1	2,000	626	487	0.593	0.601	0.603	0.597
1L -5	12:22:00	2	2,000	626	487	0.609	0.616	0.619	0.612
1L -5	12:24:00	4	2,000	626	487	0.629	0.636	0.639	0.632
1L -5	12:28:00	8	2,000	626	487	0.652	0.660	0.664	0.656
1L -6	12:32:00	1	2,400	750	611	0.868	0.877	0.884	0.873
1L -6	12:33:00	2	2,400	750	611	0.900	0.910	0.918	0.905
1L -6	12:35:00	4	2,400	750	611	0.938	0.947	0.955	0.943
1L -6	12:39:00	8	2,400	750	611	0.980	0.989	0.998	0.985
1L -7	12:45:00	1	2,800	874	735	1.356	1.368	1.379	1.362
1L -7	12:46:00	2	2,800	874	735	1.384	1.396	1.407	1.390
1L -7	12:48:00	4	2,800	874	735	1.423	1.436	1.448	1.429
1L -7	12:51:00	8	2,800	874	735	1.465	1.478	1.490	1.472
1L -8	13:01:00	1	3,200	998	859	2.049	2.066	2.084	2.057
1L -8	13:02:00	2	3,200	998	859	2.078	2.094	2.114	2.086
1L -8	13:04:00	4	3,200	998	859	2.124	2.140	2.159	2.132
1L -8	13:08:00	8	3,200	998	859	2.190	2.207	2.222	2.198
1L -9	13:15:30	1	3,600	1,122	983	2.880	2.901	2.928	2.890
1L -9	13:16:30	2	3,600	1,122	983	2.937	2.958	2.986	2.947
1L -9	13:18:30	4	3,600	1,122	983	3.037	3.057	3.087	3.047
1L -9	13:22:30	8	3,600	1,122	983	3.177	3.197	3.225	3.187
1L -10	13:34:00	1	4,000	1,246	1,107	4.171	4.195	4.233	4.183
1L -10	13:35:00	2	4,000	1,246	1,107	4.232	4.256	4.296	4.244
1L -10	13:37:00	4	4,000	1,246	1,107	4.332	4.356	4.396	4.344
1L -10	13:41:00	8	4,000	1,246	1,107	4.485	4.510	4.549	4.498
1L -11	13:49:00	1	4,200	1,308	1,168	5.184	5.210	5.243	5.197
1L -11	13:50:00	2	4,200	1,308	1,168	5.232	5.257	5.290	5.245
1L -11	13:52:00	4	4,200	1,308	1,168	5.315	5.340	5.370	5.327
1L -11	13:56:00	8	4,200	1,308	1,168	5.450	5.476	5.511	5.463
1U - 1	13:58:30	1	3,200	998	859	5.392	5.418	5.469	5.405
1U - 1	13:59:30	2	3,200	998	859	5.392	5.418	5.468	5.405
1U - 1	14:00:30	3	3,200	998	859	5.392	5.418	5.468	5.405
1U - 1	14:01:30	4	3,200	998	859	5.392	5.417	5.468	5.405
1U - 2	14:03:00	1	2,400	750	611	5.311	5.338	5.388	5.325
1U - 2	14:04:00	2	2,400	750	611	5.311	5.337	5.386	5.324
1U - 2	14:05:00	3	2,400	750	611	5.309	5.336	5.386	5.323
1U - 2	14:06:00	4	2,400	750	611	5.308	5.335	5.384	5.322
1U - 3	14:09:00	1	1,600	503	363	5.192	5.217	5.269	5.204
1U - 3	14:10:00	2	1,600	503	363	5.190	5.216	5.268	5.203
1U - 3	14:11:00	3	1,600	503	363	5.189	5.215	5.267	5.202
1U - 3	14:12:00	4	1,600	503	363	5.188	5.214	5.267	5.201
1U - 4	14:14:30	1	800	255	115	4.994	5.017	5.068	5.005
1U - 4	14:15:30	2	800	255	115	4.991	5.015	5.066	5.003
1U - 4	14:16:30	3	800	255	115	4.989	5.012	5.063	5.001
1U - 4	14:17:30	4	800	255	115	4.987	5.010	5.061	4.998
1U - 5	14:20:00	1	0	0	0	4.523	4.547	4.595	4.535
1U - 5	14:21:00	2	0	0	0	4.503	4.528	4.576	4.516
1U - 5	14:23:00	4	0	0	0	4.485	4.509	4.555	4.497
1U - 5	14:27:00	8	0	0	0	4.467	4.491	4.535	4.479

[1]LVWDT 1004900 not included in average due to its orientation. LVWDT 1004895 and 1004896 are oriented 180 degrees opposed.

Upward and Downward Movement and Creep

Broadway Viaduct - Council Bluffs, IA - TS 3

Load Test Increment	Time 0 (h:m:s)	Time After Start Minutes	O-cell Pressure (psi)	Applied Load (kips)	Net Load (kips)	Top O-cell Movement (inches)	Upward Creep (inches)	Bottom O-cell Movement (inches)	Downward Creep (inches)
1L -0	10:41:00	0	0	0	0	0.000		0.000	
1L -1	11:43:00	1	400	131	0	0.014		-0.045	
1L -1	11:44:00	2	400	131	0	0.014		-0.046	
1L -1	11:46:00	4	400	131	0	0.014		-0.047	
1L -1	11:50:00	8	400	131	0	0.020	0.006	-0.042	0.000
1L -2	11:53:00	1	800	255	115	0.027		-0.106	
1L -2	11:54:00	2	800	255	115	0.027		-0.108	
1L -2	11:56:00	4	800	255	115	0.027		-0.111	
1L -2	12:00:00	8	800	255	115	0.034	0.007	-0.107	0.000
1L -3	12:02:00	1	1,200	379	239	0.042		-0.200	
1L -3	12:03:00	2	1,200	379	239	0.043		-0.206	
1L -3	12:05:00	4	1,200	379	239	0.043		-0.212	
1L -3	12:09:00	8	1,200	379	239	0.052	0.009	-0.211	0.000
1L -4	12:11:30	1	1,600	503	363	0.065		-0.339	
1L -4	12:12:30	2	1,600	503	363	0.065		-0.348	
1L -4	12:14:30	4	1,600	503	363	0.065		-0.359	
1L -4	12:18:30	8	1,600	503	363	0.076	0.011	-0.363	0.003
1L -5	12:21:00	1	2,000	626	487	0.090		-0.507	
1L -5	12:22:00	2	2,000	626	487	0.091		-0.521	
1L -5	12:24:00	4	2,000	626	487	0.092		-0.541	
1L -5	12:28:00	8	2,000	626	487	0.100	0.008	-0.556	0.016
1L -6	12:32:00	1	2,400	750	611	0.126		-0.747	
1L -6	12:33:00	2	2,400	750	611	0.128		-0.777	
1L -6	12:35:00	4	2,400	750	611	0.131		-0.812	
1L -6	12:39:00	8	2,400	750	611	0.141	0.010	-0.844	0.032
1L -7	12:45:00	1	2,800	874	735	0.182		-1.180	
1L -7	12:46:00	2	2,800	874	735	0.184		-1.206	
1L -7	12:48:00	4	2,800	874	735	0.187		-1.242	
1L -7	12:51:00	8	2,800	874	735	0.194	0.007	-1.278	0.036
1L -8	13:01:00	1	3,200	998	859	0.263		-1.794	
1L -8	13:02:00	2	3,200	998	859	0.266		-1.820	
1L -8	13:04:00	4	3,200	998	859	0.270		-1.862	
1L -8	13:08:00	8	3,200	998	859	0.286	0.016	-1.913	0.050
1L -9	13:15:30	1	3,600	1,122	983	0.372		-2.519	
1L -9	13:16:30	2	3,600	1,122	983	0.378		-2.569	
1L -9	13:18:30	4	3,600	1,122	983	0.389		-2.658	
1L -9	13:22:30	8	3,600	1,122	983	0.413	0.024	-2.774	0.116
1L -10	13:34:00	1	4,000	1,246	1,107	0.562		-3.621	
1L -10	13:35:00	2	4,000	1,246	1,107	0.572		-3.672	
1L -10	13:37:00	4	4,000	1,246	1,107	0.585		-3.759	
1L -10	13:41:00	8	4,000	1,246	1,107	0.617	0.032	-3.880	0.121
1L -11	13:49:00	1	4,200	1,308	1,168	0.768		-4.429	
1L -11	13:50:00	2	4,200	1,308	1,168	0.778		-4.466	
1L -11	13:52:00	4	4,200	1,308	1,168	0.796		-4.531	
1L -11	13:56:00	8	4,200	1,308	1,168	0.812		-4.651	
1U - 1	13:58:30	1	3,200	998	859	0.799		-4.606	
1U - 1	13:59:30	2	3,200	998	859	0.799		-4.606	
1U - 1	14:00:30	3	3,200	998	859	0.787		-4.617	
1U - 1	14:01:30	4	3,200	998	859	0.785		-4.619	
1U - 2	14:03:00	1	2,400	750	611	0.770		-4.555	
1U - 2	14:04:00	2	2,400	750	611	0.770		-4.554	
1U - 2	14:05:00	3	2,400	750	611	0.770		-4.553	
1U - 2	14:06:00	4	2,400	750	611	0.754		-4.568	
1U - 3	14:09:00	1	1,600	503	363	0.727		-4.477	
1U - 3	14:10:00	2	1,600	503	363	0.727		-4.476	
1U - 3	14:11:00	3	1,600	503	363	0.712		-4.490	
1U - 3	14:12:00	4	1,600	503	363	0.693		-4.507	
1U - 4	14:14:30	1	800	255	115	0.654		-4.351	
1U - 4	14:15:30	2	800	255	115	0.653		-4.350	
1U - 4	14:16:30	3	800	255	115	0.629		-4.371	
1U - 4	14:17:30	4	800	255	115	0.571		-4.427	
1U - 5	14:20:00	1	0	0	0	0.465		-4.070	
1U - 5	14:21:00	2	0	0	0	0.461		-4.055	
1U - 5	14:23:00	4	0	0	0	0.457		-4.040	
1U - 5	14:27:00	8	0	0	0	0.453		-4.026	

Strain Gage Readings and Loads at Levels 1 and 2

Broadway Viaduct - Council Bluffs, IA - TS 3

Load Test Increment	Time (h:m:s)	Time After Start Minutes	O-cell Pressure (psi)	Applied Load (kips)	Level 1					Level 2			
					1004816 με	1004817 με	1004818 με	1004819 με	Av. Load (kips)	1004823 με	1004824 με	1004825 με	Av. Load (kips)
1L -0	10:41:00	0	0	0	0	0	0	0	0	0	0	0	0
1L -1	11:43:00	1	400	131	2	3	4	3	40	8	7	9	105
1L -1	11:44:00	2	400	131	2	3	4	4	40	8	7	9	105
1L -1	11:46:00	4	400	131	2	2	4	4	38	8	7	9	105
1L -1	11:50:00	8	400	131	2	2	4	3	39	8	7	9	106
1L -2	11:53:00	1	800	255	4	5	8	7	82	14	13	15	188
1L -2	11:54:00	2	800	255	4	5	8	7	80	15	13	15	188
1L -2	11:56:00	4	800	255	4	5	8	7	81	15	13	15	191
1L -2	12:00:00	8	800	255	4	5	8	7	82	15	13	15	191
1L -3	12:02:00	1	1,200	379	7	8	13	10	127	22	18	21	272
1L -3	12:03:00	2	1,200	379	7	8	13	10	127	22	18	21	275
1L -3	12:05:00	4	1,200	379	7	8	13	10	128	22	18	21	275
1L -3	12:09:00	8	1,200	379	7	8	13	10	127	22	18	21	276
1L -4	12:11:30	1	1,600	503	9	10	18	14	171	29	24	27	360
1L -4	12:12:30	2	1,600	503	9	10	18	14	172	30	24	27	362
1L -4	12:14:30	4	1,600	503	9	11	18	14	172	30	24	27	363
1L -4	12:18:30	8	1,600	503	9	11	18	13	172	30	24	28	367
1L -5	12:21:00	1	2,000	626	12	13	22	17	217	37	29	33	442
1L -5	12:22:00	2	2,000	626	13	13	22	17	219	37	29	33	444
1L -5	12:24:00	4	2,000	626	12	14	23	17	218	37	29	33	447
1L -5	12:28:00	8	2,000	626	13	14	23	17	220	37	29	34	449
1L -6	12:32:00	1	2,400	750	16	18	28	20	278	45	34	39	530
1L -6	12:33:00	2	2,400	750	17	19	28	21	283	45	35	40	534
1L -6	12:35:00	4	2,400	750	17	19	28	21	285	46	35	40	536
1L -6	12:39:00	8	2,400	750	17	19	29	21	290	46	35	40	540
1L -7	12:45:00	1	2,800	874	23	26	35	26	368	53	40	46	623
1L -7	12:46:00	2	2,800	874	23	26	35	26	370	53	40	46	623
1L -7	12:48:00	4	2,800	874	23	27	35	26	374	54	40	47	628
1L -7	12:51:00	8	2,800	874	24	27	36	26	379	54	40	47	629
1L -8	13:01:00	1	3,200	998	32	36	44	33	485	61	46	54	720
1L -8	13:02:00	2	3,200	998	32	36	44	33	488	61	46	54	720
1L -8	13:04:00	4	3,200	998	32	37	45	33	493	62	46	55	725
1L -8	13:08:00	8	3,200	998	33	37	45	33	501	62	46	55	731
1L -9	13:15:30	1	3,600	1,122	41	46	55	40	610	70	52	62	821
1L -9	13:16:30	2	3,600	1,122	42	46	55	41	616	71	52	62	824
1L -9	13:18:30	4	3,600	1,122	42	47	56	41	624	71	52	63	834
1L -9	13:22:30	8	3,600	1,122	43	48	57	42	636	72	53	63	840
1L -10	13:34:00	1	4,000	1,246	50	55	68	49	745	80	59	69	931
1L -10	13:35:00	2	4,000	1,246	50	55	68	50	750	80	59	69	936
1L -10	13:37:00	4	4,000	1,246	51	56	69	50	756	81	60	70	940
1L -10	13:41:00	8	4,000	1,246	51	57	70	51	767	81	60	70	945
1L -11	13:49:00	1	4,200	1,308	55	62	77	55	834	86	63	74	1002
1L -11	13:50:00	2	4,200	1,308	55	62	77	55	833	86	63	74	1002
1L -11	13:52:00	4	4,200	1,308	55	62	77	55	834	86	63	74	1002
1L -11	13:56:00	8	4,200	1,308	55	63	78	55	842	87	64	74	1006
1U - 1	13:58:30	1	3,200	998	47	53	65	47	714	71	52	60	818
1U - 1	13:59:30	2	3,200	998	47	53	65	47	712	71	52	60	819
1U - 1	14:00:30	3	3,200	998	47	53	65	47	712	71	52	60	818
1U - 1	14:01:30	4	3,200	998	47	53	65	47	710	71	52	60	818
1U - 2	14:03:00	1	2,400	750	40	44	54	39	591	57	41	48	655
1U - 2	14:04:00	2	2,400	750	40	44	54	39	592	57	41	48	654
1U - 2	14:05:00	3	2,400	750	40	44	54	39	591	57	41	48	654
1U - 2	14:06:00	4	2,400	750	40	44	53	39	590	57	41	48	654
1U - 3	14:09:00	1	1,600	503	30	33	40	31	452	41	31	35	482
1U - 3	14:10:00	2	1,600	503	31	33	40	31	453	42	31	36	485
1U - 3	14:11:00	3	1,600	503	31	33	40	31	453	41	31	36	482
1U - 3	14:12:00	4	1,600	503	31	33	40	31	452	41	31	36	482
1U - 4	14:14:30	1	800	255	20	22	26	20	294	25	20	23	303
1U - 4	14:15:30	2	800	255	20	22	26	20	295	25	20	23	305
1U - 4	14:16:30	3	800	255	20	21	26	20	294	25	20	23	302
1U - 4	14:17:30	4	800	255	20	22	26	20	294	25	20	23	301
1U - 5	14:20:00	1	0	0	7	8	11	8	112	7	8	10	112
1U - 5	14:21:00	2	0	0	7	8	10	8	111	7	8	9	110
1U - 5	14:23:00	4	0	0	6	8	10	8	109	7	8	9	108
1U - 5	14:27:00	8	0	0	7	8	10	8	108	7	8	9	107

Strain Gage Readings and Loads at Levels 3 and 4

Broadway Viaduct - Council Bluffs, IA - TS 3

Load Test Increment	Time (h:m:s)	Time After Start Minutes	O-cell Pressure (psi)	Applied Load (kips)	Level 3				Level 4			
					1004829 με	1004830 με	1004831 με	Av. Load (kips)	1004835 με	1004836 με	1004837 με	Av. Load (kips)
1L -0	10:41:00	0	0	0	0	0	0	0	0	0	0	0
1L -1	11:43:00	1	400	131	9	8	11	124	7	7	7	91
1L -1	11:44:00	2	400	131	9	8	10	124	7	7	7	92
1L -1	11:46:00	4	400	131	9	8	10	124	7	6	7	91
1L -1	11:50:00	8	400	131	9	8	11	126	7	7	8	94
1L -2	11:53:00	1	800	255	17	13	17	210	12	11	13	160
1L -2	11:54:00	2	800	255	17	13	17	210	13	11	13	162
1L -2	11:56:00	4	800	255	18	13	17	212	13	11	13	162
1L -2	12:00:00	8	800	255	18	13	17	212	13	11	13	163
1L -3	12:02:00	1	1,200	379	26	17	23	296	19	15	18	234
1L -3	12:03:00	2	1,200	379	26	17	23	295	19	15	18	234
1L -3	12:05:00	4	1,200	379	26	17	23	296	19	15	18	235
1L -3	12:09:00	8	1,200	379	26	17	23	299	20	15	19	237
1L -4	12:11:30	1	1,600	503	34	22	29	382	26	19	24	308
1L -4	12:12:30	2	1,600	503	34	22	29	381	26	19	24	309
1L -4	12:14:30	4	1,600	503	34	22	30	385	26	19	24	311
1L -4	12:18:30	8	1,600	503	34	23	30	387	26	19	24	313
1L -5	12:21:00	1	2,000	626	41	27	35	457	32	23	29	372
1L -5	12:22:00	2	2,000	626	41	27	35	460	32	23	29	375
1L -5	12:24:00	4	2,000	626	41	27	35	461	32	23	29	375
1L -5	12:28:00	8	2,000	626	41	27	35	464	32	23	29	378
1L -6	12:32:00	1	2,400	750	48	31	41	539	38	27	34	439
1L -6	12:33:00	2	2,400	750	49	31	41	541	38	27	34	441
1L -6	12:35:00	4	2,400	750	49	31	41	541	38	27	34	443
1L -6	12:39:00	8	2,400	750	49	32	41	546	39	27	34	445
1L -7	12:45:00	1	2,800	874	56	36	47	623	44	30	39	505
1L -7	12:46:00	2	2,800	874	56	36	47	623	44	30	39	505
1L -7	12:48:00	4	2,800	874	56	36	48	628	44	30	39	508
1L -7	12:51:00	8	2,800	874	56	36	48	629	44	30	40	508
1L -8	13:01:00	1	3,200	998	63	41	55	710	50	33	45	570
1L -8	13:02:00	2	3,200	998	64	41	55	712	50	33	45	570
1L -8	13:04:00	4	3,200	998	64	41	55	714	50	32	45	570
1L -8	13:08:00	8	3,200	998	64	41	55	717	50	33	45	572
1L -9	13:15:30	1	3,600	1,122	71	45	62	796	55	35	51	629
1L -9	13:16:30	2	3,600	1,122	71	46	62	801	55	35	52	630
1L -9	13:18:30	4	3,600	1,122	72	46	63	807	55	35	52	636
1L -9	13:22:30	8	3,600	1,122	72	46	63	810	55	35	52	638
1L -10	13:34:00	1	4,000	1,246	79	50	70	890	60	36	59	694
1L -10	13:35:00	2	4,000	1,246	79	50	70	891	60	36	59	697
1L -10	13:37:00	4	4,000	1,246	79	51	71	896	61	36	60	700
1L -10	13:41:00	8	4,000	1,246	79	51	71	901	61	36	60	701
1L -11	13:49:00	1	4,200	1,308	84	54	75	953	64	36	65	741
1L -11	13:50:00	2	4,200	1,308	84	54	75	953	64	36	65	741
1L -11	13:52:00	4	4,200	1,308	84	54	75	953	64	36	65	741
1L -11	13:56:00	8	4,200	1,308	84	54	76	956	64	36	65	742
1U - 1	13:58:30	1	3,200	998	67	43	63	776	54	28	57	622
1U - 1	13:59:30	2	3,200	998	67	43	63	776	54	28	57	622
1U - 1	14:00:30	3	3,200	998	68	43	63	776	54	28	57	622
1U - 1	14:01:30	4	3,200	998	67	43	63	776	54	28	57	623
1U - 2	14:03:00	1	2,400	750	53	34	52	623	44	22	49	515
1U - 2	14:04:00	2	2,400	750	53	34	52	622	44	21	49	514
1U - 2	14:05:00	3	2,400	750	53	34	52	622	44	21	49	513
1U - 2	14:06:00	4	2,400	750	53	33	52	620	44	21	49	512
1U - 3	14:09:00	1	1,600	503	39	25	40	462	34	15	40	397
1U - 3	14:10:00	2	1,600	503	39	25	40	463	34	15	40	397
1U - 3	14:11:00	3	1,600	503	39	25	40	464	34	15	40	398
1U - 3	14:12:00	4	1,600	503	39	24	40	462	34	15	40	397
1U - 4	14:14:30	1	800	255	24	16	28	301	22	9	30	271
1U - 4	14:15:30	2	800	255	24	16	28	302	22	9	30	272
1U - 4	14:16:30	3	800	255	24	16	28	299	22	9	30	271
1U - 4	14:17:30	4	800	255	24	16	28	301	22	9	30	271
1U - 5	14:20:00	1	0	0	7	6	15	128	8	3	18	128
1U - 5	14:21:00	2	0	0	7	7	15	127	7	3	18	126
1U - 5	14:23:00	4	0	0	7	6	15	125	7	3	18	125
1U - 5	14:27:00	8	0	0	6	6	15	122	7	3	18	124

Strain Gage Readings and Loads at Levels 5 and 6

Broadway Viaduct - Council Bluffs, IA - TS 3

Load Test Increment	Time (h:m:s)	Time After Start Minutes	O-cell Pressure (psi)	Applied Load (kips)	Level 5 1004841 με	Level 5 1004842 με	Level 5 1004843 με	Level 5 Av. Load (kips)	Level 6 1004847 με	Level 6 1004848 με	Level 6 1004849 με	Level 6 Av. Load (kips)
1L -0	10:41:00	0	0	0	0	0	0	0	0	0	0	0
1L -1	11:43:00	1	400	131	4	5	4	59	3	3	0	25
1L -1	11:44:00	2	400	131	5	4	4	57	3	3	0	25
1L -1	11:46:00	4	400	131	5	4	4	57	3	3	0	25
1L -1	11:50:00	8	400	131	4	5	4	58	3	3	0	25
1L -2	11:53:00	1	800	255	8	8	7	102	5	5	0	44
1L -2	11:54:00	2	800	255	8	8	8	105	5	5	0	44
1L -2	11:56:00	4	800	255	8	8	7	104	5	5	0	45
1L -2	12:00:00	8	800	255	8	8	8	105	5	5	0	44
1L -3	12:02:00	1	1,200	379	12	11	12	156	7	7	0	66
1L -3	12:03:00	2	1,200	379	12	11	12	158	7	8	0	66
1L -3	12:05:00	4	1,200	379	12	11	12	156	7	8	0	66
1L -3	12:09:00	8	1,200	379	12	11	12	158	7	7	0	66
1L -4	12:11:30	1	1,600	503	16	14	16	210	9	10	0	89
1L -4	12:12:30	2	1,600	503	16	15	16	211	9	10	0	90
1L -4	12:14:30	4	1,600	503	17	15	16	213	10	10	0	91
1L -4	12:18:30	8	1,600	503	17	15	17	214	10	10	0	92
1L -5	12:21:00	1	2,000	626	21	18	20	262	12	12	0	113
1L -5	12:22:00	2	2,000	626	21	18	21	264	12	12	0	113
1L -5	12:24:00	4	2,000	626	21	18	21	263	12	12	0	114
1L -5	12:28:00	8	2,000	626	21	18	21	269	12	13	0	115
1L -6	12:32:00	1	2,400	750	25	21	25	313	15	14	0	136
1L -6	12:33:00	2	2,400	750	25	20	25	313	15	14	0	137
1L -6	12:35:00	4	2,400	750	25	20	25	313	15	15	0	138
1L -6	12:39:00	8	2,400	750	25	21	25	318	15	14	0	137
1L -7	12:45:00	1	2,800	874	29	23	29	358	18	16	0	156
1L -7	12:46:00	2	2,800	874	29	23	29	358	18	16	0	156
1L -7	12:48:00	4	2,800	874	29	22	29	357	18	16	0	156
1L -7	12:51:00	8	2,800	874	29	23	29	360	18	16	0	157
1L -8	13:01:00	1	3,200	998	33	23	33	398	20	17	0	171
1L -8	13:02:00	2	3,200	998	33	23	33	399	20	17	0	170
1L -8	13:04:00	4	3,200	998	33	23	33	399	20	17	0	170
1L -8	13:08:00	8	3,200	998	33	23	34	404	20	16	0	169
1L -9	13:15:30	1	3,600	1,122	36	23	37	435	23	16	0	181
1L -9	13:16:30	2	3,600	1,122	37	23	38	438	23	16	0	181
1L -9	13:18:30	4	3,600	1,122	37	23	38	440	23	16	0	181
1L -9	13:22:30	8	3,600	1,122	37	23	39	441	23	16	0	180
1L -10	13:34:00	1	4,000	1,246	41	22	43	474	26	15	0	188
1L -10	13:35:00	2	4,000	1,246	41	23	43	476	26	15	0	188
1L -10	13:37:00	4	4,000	1,246	41	22	43	476	26	15	0	187
1L -10	13:41:00	8	4,000	1,246	41	22	44	476	26	14	0	186
1L -11	13:49:00	1	4,200	1,308	43	21	47	499	27	13	0	188
1L -11	13:50:00	2	4,200	1,308	43	21	47	499	27	13	0	188
1L -11	13:52:00	4	4,200	1,308	43	21	47	499	27	13	0	188
1L -11	13:56:00	8	4,200	1,308	44	21	48	502	28	13	0	186
1U - 1	13:58:30	1	3,200	998	37	15	43	425	25	10	0	160
1U - 1	13:59:30	2	3,200	998	37	16	43	428	25	10	0	160
1U - 1	14:00:30	3	3,200	998	37	15	42	425	25	10	0	161
1U - 1	14:01:30	4	3,200	998	37	16	43	427	25	10	0	160
1U - 2	14:03:00	1	2,400	750	32	11	38	362	22	7	0	136
1U - 2	14:04:00	2	2,400	750	32	11	38	359	22	7	0	136
1U - 2	14:05:00	3	2,400	750	31	11	38	356	22	7	0	135
1U - 2	14:06:00	4	2,400	750	31	11	38	358	22	8	0	136
1U - 3	14:09:00	1	1,600	503	25	6	32	283	19	5	0	108
1U - 3	14:10:00	2	1,600	503	25	7	32	285	19	5	0	109
1U - 3	14:11:00	3	1,600	503	25	7	32	284	19	5	0	109
1U - 3	14:12:00	4	1,600	503	25	7	32	286	19	5	0	110
1U - 4	14:14:30	1	800	255	18	3	24	200	14	3	0	77
1U - 4	14:15:30	2	800	255	17	3	24	197	14	3	0	78
1U - 4	14:16:30	3	800	255	17	3	24	196	14	3	0	78
1U - 4	14:17:30	4	800	255	17	3	24	197	14	3	0	77
1U - 5	14:20:00	1	0	0	6	1	14	93	6	2	0	35
1U - 5	14:21:00	2	0	0	5	1	14	90	6	2	0	35
1U - 5	14:23:00	4	0	0	6	1	14	91	6	2	0	35
1U - 5	14:27:00	8	0	0	127	1	14	634	6	2	0	36

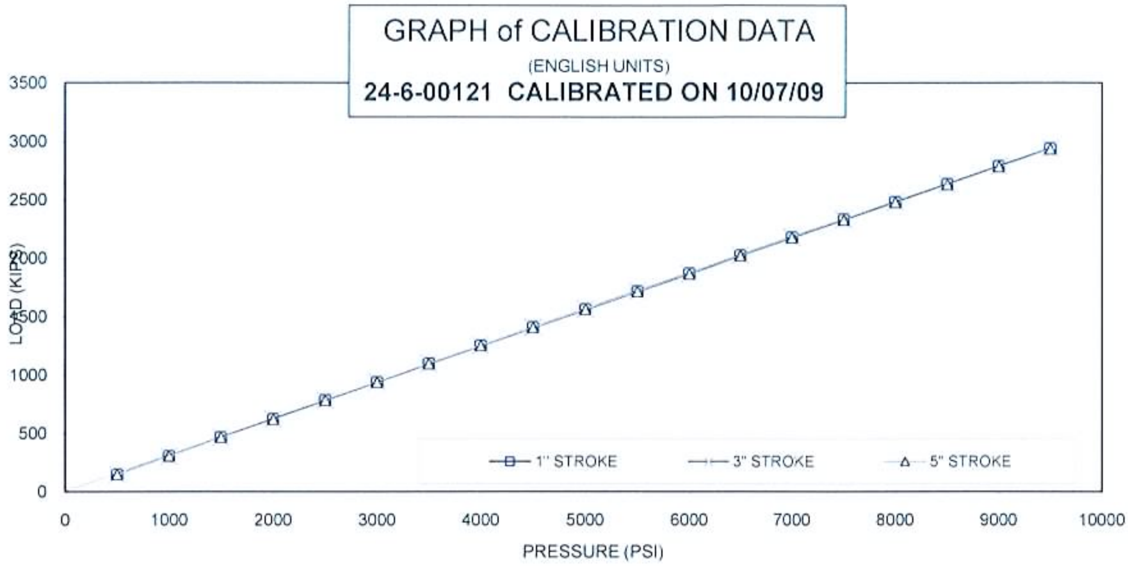
Strain Gage Readings and Loads at Level 7

Broadway Viaduct - Council Bluffs, IA - TS 3

Load Test Increment	Time 0 (h:m:s)	Time After Start Minutes	O-cell Pressure (psi)	Applied Load (kips)	Level 7 1004853 με	1004948 με	1004949 με	Av. Load (kips)
1L -0	10:41:00	0	0	0	0	0	0	0
1L -1	11:43:00	1	400	131	0	1	0	9
1L -1	11:44:00	2	400	131	0	1	1	10
1L -1	11:46:00	4	400	131	0	1	0	8
1L -1	11:50:00	8	400	131	0	1	1	8
1L -2	11:53:00	1	800	255	1	1	1	16
1L -2	11:54:00	2	800	255	1	1	1	15
1L -2	11:56:00	4	800	255	1	1	1	15
1L -2	12:00:00	8	800	255	1	1	1	16
1L -3	12:02:00	1	1,200	379	1	2	2	26
1L -3	12:03:00	2	1,200	379	1	2	2	24
1L -3	12:05:00	4	1,200	379	1	2	2	24
1L -3	12:09:00	8	1,200	379	1	2	2	24
1L -4	12:11:30	1	1,600	503	1	3	2	33
1L -4	12:12:30	2	1,600	503	1	3	3	34
1L -4	12:14:30	4	1,600	503	1	3	3	34
1L -4	12:18:30	8	1,600	503	1	3	2	34
1L -5	12:21:00	1	2,000	626	2	4	3	43
1L -5	12:22:00	2	2,000	626	2	4	3	44
1L -5	12:24:00	4	2,000	626	2	4	3	43
1L -5	12:28:00	8	2,000	626	2	4	3	44
1L -6	12:32:00	1	2,400	750	2	4	4	53
1L -6	12:33:00	2	2,400	750	2	4	4	53
1L -6	12:35:00	4	2,400	750	2	4	4	54
1L -6	12:39:00	8	2,400	750	2	4	4	54
1L -7	12:45:00	1	2,800	874	3	5	4	62
1L -7	12:46:00	2	2,800	874	3	5	4	62
1L -7	12:48:00	4	2,800	874	3	5	4	63
1L -7	12:51:00	8	2,800	874	3	5	4	61
1L -8	13:01:00	1	3,200	998	3	5	5	69
1L -8	13:02:00	2	3,200	998	3	5	5	67
1L -8	13:04:00	4	3,200	998	3	5	5	68
1L -8	13:08:00	8	3,200	998	3	5	5	66
1L -9	13:15:30	1	3,600	1,122	4	5	5	71
1L -9	13:16:30	2	3,600	1,122	4	5	5	72
1L -9	13:18:30	4	3,600	1,122	4	5	5	72
1L -9	13:22:30	8	3,600	1,122	4	5	5	70
1L -10	13:34:00	1	4,000	1,246	4	5	5	73
1L -10	13:35:00	2	4,000	1,246	4	5	5	73
1L -10	13:37:00	4	4,000	1,246	4	5	5	73
1L -10	13:41:00	8	4,000	1,246	4	4	5	72
1L -11	13:49:00	1	4,200	1,308	5	4	6	73
1L -11	13:50:00	2	4,200	1,308	5	4	6	73
1L -11	13:52:00	4	4,200	1,308	5	4	6	73
1L -11	13:56:00	8	4,200	1,308	5	4	6	74
1U - 1	13:58:30	1	3,200	998	4	3	5	65
1U - 1	13:59:30	2	3,200	998	4	3	5	64
1U - 1	14:00:30	3	3,200	998	4	3	5	65
1U - 1	14:01:30	4	3,200	998	5	3	5	66
1U - 2	14:03:00	1	2,400	750	4	3	4	57
1U - 2	14:04:00	2	2,400	750	4	3	4	58
1U - 2	14:05:00	3	2,400	750	4	3	5	59
1U - 2	14:06:00	4	2,400	750	4	3	5	58
1U - 3	14:09:00	1	1,600	503	4	2	4	48
1U - 3	14:10:00	2	1,600	503	4	2	4	48
1U - 3	14:11:00	3	1,600	503	4	2	4	47
1U - 3	14:12:00	4	1,600	503	4	2	4	49
1U - 4	14:14:30	1	800	255	3	1	3	36
1U - 4	14:15:30	2	800	255	3	1	3	37
1U - 4	14:16:30	3	800	255	3	1	3	37
1U - 4	14:17:30	4	800	255	3	1	3	35
1U - 5	14:20:00	1	0	0	2	0	1	12
1U - 5	14:21:00	2	0	0	2	-1	1	11
1U - 5	14:23:00	4	0	0	2	0	1	10
1U - 5	14:27:00	8	0	0	2	0	1	10

APPENDIX B

O-CELL AND INSTRUMENTATION CALIBRATION SHEETS



STROKE:	1 INCH	3 INCH	5 INCH
PRESSURE PSI	LOAD KIPS	LOAD KIPS	LOAD KIPS
0	0	0	0
500	149	150	148
1000	306	307	307
1500	469	468	466
2000	624	623	622
2500	786	784	784
3000	940	941	939
3500	1098	1099	1097
4000	1254	1254	1252
4500	1408	1411	1407
5000	1563	1566	1563
5500	1718	1721	1716
6000	1870	1872	1867
6500	2026	2027	2022
7000	2178	2181	2177
7500	2331	2334	2328
8000	2481	2484	2479
8500	2636	2636	2631
9000	2787	2788	2784
9500	2939	2940	2935

24" O-CELL, SERIAL # 24-6-00121

LOAD CONVERSION FORMULA

LOAD = PRESSURE * 0.3097 + (7.15)
{KIPS} {PSI}

Regression Output:

Constant	7.1529 kips
X Coefficient	0.3097 kip / psi
R Square	0.9999
No. of Observations	57
Degrees of Freedom	55
Std Err of Y Est	7.25
Std Err of X Coeff	0.0004

CALIBRATION STANDARDS:

All data presented are derived from 6" dia. certified hydraulic pressure gauges and electronic load transducer, manufactured and calibrated by the University of Illinois at Champaign, Illinois. All calibrations and certifications are traceable through the Laboratory Master Deadweight Gauges directly to the National Institute of Standards and Technology. No specific guidelines exist for calibration of load test jacks and equipment but procedures comply with similar guidelines for calibration of gages, ANSI specifications B40.1.

* AE & FC CUSTOMER: LOADTEST Inc	* CONTRACTOR.: LONGFELLOW DRILLING
* AE & FC JOB NO: SO5813	* JOB LOCATION: CLEARFIELD, IA
* CUSTOMER P.O. NO.: LT9640	* DATED: 03/23/10

SERVICE ENGINEER: [signature] DATE: 3-23-10

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Vibrating Wire Displacement Transducer Calibration Report

Range: 150 mm

Serial Number: 1004895

Calibration Date: February 25, 2010

Temperature: 24.2 °C

Calibration Instruction: CI-4400

Technician: KSRogers

GK-401 Reading Position B

Actual Displacement (mm)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Displacement (Linear)	Error Linear (%FS)	Calculated Displacement (Polynomial)	Error Polynomial (%FS)
0.0	2592	2591	2592	-0.38	-0.26	-0.04	-0.03
30.0	3561	3561	3561	30.16	0.11	30.09	0.06
60.0	4516	4516	4516	60.25	0.16	59.98	-0.02
90.0	5468	5467	5468	90.22	0.15	89.96	-0.03
120.0	6416	6414	6415	120.07	0.05	120.01	0.01
150.0	7355	7354	7355	149.67	-0.22	150.01	0.01

(mm) Linear Gage Factor (G): 0.03150 (mm/ digit) **Regression Zero: 2604**

Polynomial Gage Factors: A: 1.11702E-07 B: 0.03039 C: -79.555

(inches) Linear Gage Factor (G): 0.001240 (inches/ digit)

Polynomial Gage Factors: A: 4.39773E-09 B: 0.001197 C: -3.1321

Calculated Displacement: **Linear, $D = G(R_1 - R_0)$**

Polynomial, $D = AR_1^2 + BR_1 + C$

Refer to manual for temperature correction information.

Function Test at Shipment:

GK-401 Pos. B : 5036 Temp(T_0): 23.2 °C Date: March 24, 2010

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Vibrating Wire Displacement Transducer Calibration Report

Range: 150 mm

Serial Number: 1004896

Calibration Date: February 25, 2010

Temperature: 24.2 °C

Calibration Instruction: CI-4400

Technician: KSRogers

GK-401 Reading Position B

Actual Displacement (mm)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Displacement (Linear)	Error Linear (%FS)	Calculated Displacement (Polynomial)	Error Polynomial (%FS)
0.0	2632	2625	2629	-0.42	-0.28	-0.03	-0.02
30.0	3602	3597	3600	30.14	0.09	30.06	0.04
60.0	4558	4558	4558	60.30	0.20	59.99	-0.01
90.0	5511	5510	5511	90.28	0.19	89.97	-0.02
120.0	6460	6454	6457	120.07	0.04	120.00	0.00
150.0	7396	7396	7396	149.62	-0.25	150.01	0.01

(mm) Linear Gage Factor (G): 0.03147 (mm/ digit) **Regression Zero: 2642**

Polynomial Gage Factors: A: 1.28659E-07 B: 0.03018 C: -80.249

(inches) Linear Gage Factor (G): 0.001239 (inches/ digit)

Polynomial Gage Factors: A: 5.06532E-09 B: 0.001188 C: -3.1594

Calculated Displacement: **Linear, $D = G(R_1 - R_0)$**

Polynomial, $D = AR_1^2 + BR_1 + C$

Refer to manual for temperature correction information.

Function Test at Shipment:

GK-401 Pos. B : 5067 Temp(T_0): 23.1 °C Date: March 24, 2010

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Vibrating Wire Displacement Transducer Calibration Report

Range: 150 mm

Serial Number: 1004900

Calibration Date: February 25, 2010

Temperature: 24.2 °C

Calibration Instruction: CI-4400

Technician: KS Rogers

GK-401 Reading Position B

Actual Displacement (mm)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Displacement (Linear)	Error Linear (%FS)	Calculated Displacement (Polynomial)	Error Polynomial (%FS)
0.0	2631	2627	2629	-0.35	-0.24	-0.04	-0.03
30.0	3596	3593	3595	30.16	0.10	30.09	0.06
60.0	4547	4545	4546	60.22	0.15	59.98	-0.02
90.0	5495	5495	5495	90.21	0.14	89.97	-0.02
120.0	6440	6439	6440	120.05	0.03	120.00	0.00
150.0	7378	7378	7378	149.71	-0.20	150.02	0.01

(mm) Linear Gage Factor (G): **0.03160** **(mm/ digit)** **Regression Zero:** **2640**

Polynomial Gage Factors: **A: 1.0207E-07** **B: 0.03058** **C: -81.135**

(inches) Linear Gage Factor (G): **0.001244** **(inches/ digit)**

Polynomial Gage Factors: **A: 4.01848E-09** **B: 0.001204** **C: -3.1943**

Calculated Displacement: **Linear, $D = G(R_1 - R_0)$**

Polynomial, $D = AR_1^2 + BR_1 + C$

Refer to manual for temperature correction information.

Function Test at Shipment:

GK-401 Pos. B : 5060 Temp(T_0): 22.4 °C Date: March 24, 2010

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Sister Bar Calibration Report

Model Number : 4911-4

Date of Calibration: March 9, 2010

Serial Number: 1004816

Cable Length: 93 ft.

Prestress: 35,000 psi

Factory Zero Reading: 7037

Temperature: 21.4 °C

Regression Zero: 7064

Calibration Instruction: CI-VW Rebar

Technician: ERice

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7112	7116	7114		
1,500	7770	7773	7772	658	-0.12
3,000	8485	8486	8486	714	-0.01
4,500	9201	9200	9201	715	0.13
6,000	9905	9908	9907	706	-0.04
100	7116				

For conversion factor, load to strain, refer to table C-2 of the Installation Manual.

Gage Factor: 0.354 microstrain/ digit (GK-401 Pos."B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load-Applied Load)/ Max.Applied Load) X 100 percent

The above instrument was found to be In Tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Sister Bar Calibration Report

Model Number : 4911-4

Serial Number: 1004817

Prestress: 35,000 psi

Temperature: 21.7 °C

Calibration Instruction: CI-VW Rebar

Date of Calibration: March 9, 2010

Cable Length: 93 ft.

Factory Zero Reading: 6881

Regression Zero: 6892

Technician: Erica

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	6949	6945	6947		
1,500	7605	7606	7606	659	-0.20
3,000	8328	8329	8329	723	-0.07
4,500	9050	9052	9051	723	0.05
6,000	9772	9772	9772	721	0.11
100	6945				

For conversion factor, load to strain, refer to table C-2 of the Installation Manual.

Gage Factor: 0.351 microstrain/ digit (GK-401 Pos."B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

<u>Users are advised to establish their own zero conditions.</u>

Linearity: ((Calculated Load-Applied Load)/ Max.Applied Load) X 100 percent

The above instrument was found to be In Tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Sister Bar Calibration Report

Model Number : 4911-4

Serial Number: 1004818

Prestress: 35,000 psi

Temperature: 21.8 °C

Calibration Instruction: CI-VW Rebar

Date of Calibration: March 9, 2010

Cable Length: 93 ft.

Factory Zero Reading: 7067

Regression Zero: 7076

Technician: Elisa

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7123	7124	7124		
1,500	7787	7787	7787	664	0.08
3,000	8494	8492	8493	706	-0.02
4,500	9205	9205	9205	712	0.10
6,000	9913	9909	9911	706	0.00
100	7123				

For conversion factor, load to strain, refer to table C-2 of the Installation Manual.

Gage Factor: 0.354 microstrain/ digit (GK-401 Pos."B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load-Applied Load)/ Max.Applied Load) X 100 percent

The above instrument was found to be In Tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Sister Bar Calibration Report

Model Number : 4911-4

Date of Calibration: March 9, 2010

Serial Number: 1004819

Cable Length: 93 ft.

Prestress: 35,000 psi

Factory Zero Reading: 6994

Temperature: 21.8 °C

Regression Zero: 7010

Calibration Instruction: CI-VW Rebar

Technician: Erica

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7070	7067	7069		
1,500	7729	7726	7728	659	-0.26
3,000	8452	8450	8451	724	-0.31
4,500	9192	9183	9188	737	0.09
6,000	9916	9913	9915	727	0.16
100	7068				

For conversion factor, load to strain, refer to table C-2 of the Installation Manual.

Gage Factor: 0.349 microstrain/ digit (GK-401 Pos."B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load-Applied Load)/ Max.Applied Load) X 100 percent

The above instrument was found to be In Tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Sister Bar Calibration Report

Model Number : 4911-4

Date of Calibration: March 9, 2010

Serial Number: 1004823

Cable Length: 85 ft.

Prestress: 35,000 psi

Factory Zero Reading: 7075

Temperature: 21.7 °C

Regression Zero: 7099

Calibration Instruction: CI-VW Rebar

Technician: Erica

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7149	7148	7149		
1,500	7814	7814	7814	666	-0.01
3,000	8528	8528	8528	714	-0.06
4,500	9248	9247	9248	720	0.09
6,000	9961	9960	9961	713	0.01
100	7149				

For conversion factor, load to strain, refer to table C-2 of the Installation Manual.

Gage Factor: 0.352 microstrain/ digit (GK-401 Pos."B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load-Applied Load)/ Max.Applied Load) X 100 percent
The above instrument was found to be In Tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Sister Bar Calibration Report

Model Number : 4911-4

Date of Calibration: March 9, 2010

Serial Number: 1004824

Cable Length: 85 ft.

Prestress: 35,000 psi

Factory Zero Reading: 7080

Temperature: 21.7 °C

Regression Zero: 7112

Calibration Instruction: CI-VW Rebar

Technician: ERice

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7165	7161	7163		
1,500	7832	7835	7834	671	-0.04
3,000	8554	8553	8554	720	-0.13
4,500	9282	9279	9281	727	0.02
6,000	10003	10006	10005	724	0.06
100	7161				

For conversion factor, load to strain, refer to table C-2 of the Installation Manual.

Gage Factor: 0.349 microstrain/ digit (GK-401 Pos."B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load-Applied Load)/ Max.Applied Load) X 100 percent

The above instrument was found to be In Tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Sister Bar Calibration Report

Model Number : 4911-4

Date of Calibration: March 9, 2010

Serial Number: 1004825

Cable Length: 85 ft.

Prestress: 35,000 psi

Factory Zero Reading: 6811

Temperature: 21.6 °C

Regression Zero: 6824

Calibration Instruction: CI-VW Rebar

Technician: ERice

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	6885	6881	6883		
1,500	7531	7533	7532	649	-0.46
3,000	8263	8263	8263	731	-0.12
4,500	8994	8989	8992	729	0.13
6,000	9712	9710	9711	720	0.06
100	6882				

For conversion factor, load to strain, refer to table C-2 of the Installation Manual.

Gage Factor: 0.350 microstrain/ digit (GK-401 Pos."B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load-Applied Load)/ Max.Applied Load) X 100 percent

The above instrument was found to be In Tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Sister Bar Calibration Report

Model Number : 4911-4

Date of Calibration: March 10, 2010

Serial Number: 1004829

Cable Length: 70 ft.

Prestress: 35,000 psi

Factory Zero Reading: 7016

Temperature: 22.3 °C

Regression Zero: 7048

Calibration Instruction: CI-VW Rebar

Technician: ERice

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7101	7101	7101		
1,500	7771	7768	7770	669	-0.09
3,000	8495	8493	8494	725	-0.07
4,500	9223	9223	9223	729	0.10
6,000	9945	9947	9946	723	0.06
100	7100				

For conversion factor, load to strain, refer to table C-2 of the Installation Manual.

Gage Factor: 0.349 microstrain/ digit (GK-401 Pos."B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load-Applied Load)/ Max.Applied Load) X 100 percent

The above instrument was found to be In Tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Sister Bar Calibration Report

Model Number : 4911-4

Date of Calibration: March 10, 2010

Serial Number: 1004830

Cable Length: 70 ft.

Prestress: 35,000 psi

Factory Zero Reading: 7060

Temperature: 22.2 °C

Regression Zero: 7079

Calibration Instruction: CI-VW Rebar

Technician: ERice

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7132	7134	7133		
1,500	7797	7795	7796	663	-0.23
3,000	8526	8523	8525	729	-0.07
4,500	9252	9254	9253	729	0.09
6,000	9976	9974	9975	722	0.03
100	7133				

For conversion factor, load to strain, refer to table C-2 of the Installation Manual.

Gage Factor: 0.349 microstrain/ digit (GK-401 Pos."B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load-Applied Load)/ Max.Applied Load) X 100 percent

The above instrument was found to be In Tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Sister Bar Calibration Report

Model Number : 4911-4

Date of Calibration: March 10, 2010

Serial Number: 1004831

Cable Length: 70 ft.

Prestress: 35,000 psi

Factory Zero Reading: 6888

Temperature: 22.5 °C

Regression Zero: 6917

Calibration Instruction: CI-VW Rebar

Technician: ERice

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	6974	6972	6973		
1,500	7645	7645	7645	672	-0.26
3,000	8387	8385	8386	741	-0.09
4,500	9125	9127	9126	740	0.06
6,000	9863	9861	9862	736	0.06
100	6972				

For conversion factor, load to strain, refer to table C-2 of the Installation Manual.

Gage Factor: 0.345 microstrain/ digit (GK-401 Pos."B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load-Applied Load)/ Max.Applied Load) X 100 percent

The above instrument was found to be In Tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Sister Bar Calibration Report

Model Number : 4911-4

Date of Calibration: March 10, 2010

Serial Number: 1004835

Cable Length: 60 ft.

Prestress: 35,000 psi

Factory Zero Reading: 6934

Temperature: 22.3 °C

Regression Zero: 6947

Calibration Instruction: CI-VW Rebar

Technician: ERice

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7005	7006	7006		
1,500	7652	7652	7652	647	-0.27
3,000	8363	8363	8363	711	-0.34
4,500	9088	9086	9087	724	0.05
6,000	9804	9804	9804	717	0.20
100	7006				

For conversion factor, load to strain, refer to table C-2 of the Installation Manual.

Gage Factor: 0.353 microstrain/ digit (GK-401 Pos."B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load-Applied Load)/ Max.Applied Load) X 100 percent

The above instrument was found to be In Tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Sister Bar Calibration Report

Model Number : 4911-4

Date of Calibration: March 10, 2010

Serial Number: 1004836

Cable Length: 60 ft.

Prestress: 35,000 psi

Factory Zero Reading: 7130

Temperature: 22.4 °C

Regression Zero: 7161

Calibration Instruction: CI-VW Rebar

Technician: ERice

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7219	7222	7221		
1,500	7858	7863	7861	640	-0.38
3,000	8576	8572	8574	714	-0.26
4,500	9295	9294	9295	721	0.10
6,000	10007	10006	10007	712	0.17
100	7222				

For conversion factor, load to strain, refer to table C-2 of the Installation Manual.

Gage Factor: 0.354 microstrain/ digit (GK-401 Pos."B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load-Applied Load)/ Max.Applied Load) X 100 percent

The above instrument was found to be In Tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Sister Bar Calibration Report

Model Number : 4911-4

Date of Calibration: March 10, 2010

Serial Number: 1004837

Cable Length: 60 ft.

Prestress: 35,000 psi

Factory Zero Reading: 6809

Temperature: 22.5 °C

Regression Zero: 6831

Calibration Instruction: CI-VW Rebar

Technician: ERice

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	6888	6888	6888		
1,500	7555	7551	7553	665	-0.20
3,000	8282	8279	8281	728	-0.20
4,500	9017	9014	9016	735	0.05
6,000	9748	9745	9747	731	0.16
100	6888				

For conversion factor, load to strain, refer to table C-2 of the Installation Manual.

Gage Factor: 0.348 microstrain/ digit (GK-401 Pos."B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load-Applied Load)/ Max.Applied Load) X 100 percent

The above instrument was found to be In Tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Sister Bar Calibration Report

Model Number : 4911-4

Date of Calibration: March 10, 2010

Serial Number: 1004841

Cable Length: 50 ft.

Prestress: 35,000 psi

Factory Zero Reading: 6903

Temperature: 22.0 °C

Regression Zero: 6918

Calibration Instruction: CI-VW Rebar

Technician: ERice

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	6971	6972	6972		
1,500	7643	7643	7643	672	-0.05
3,000	8368	8367	8368	725	-0.12
4,500	9098	9097	9098	730	0.00
6,000	9828	9828	9828	731	0.14
100	6972				

For conversion factor, load to strain, refer to table C-2 of the Installation Manual.

Gage Factor: 0.348 microstrain/ digit (GK-401 Pos."B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load-Applied Load)/ Max.Applied Load) X 100 percent

The above instrument was found to be In Tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Sister Bar Calibration Report

Model Number : 4911-4

Date of Calibration: March 10, 2010

Serial Number: 1004842

Cable Length: 50 ft.

Prestress: 35,000 psi

Factory Zero Reading: 7128

Temperature: 22.3 °C

Regression Zero: 7143

Calibration Instruction: CI-VW Rebar

Technician: ERice

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7190	7195	7193		
1,500	7865	7870	7868	675	-0.02
3,000	8590	8595	8593	725	-0.02
4,500	9319	9322	9321	728	0.09
6,000	10041	10044	10043	722	-0.01
100	7194				

For conversion factor, load to strain, refer to table C-2 of the Installation Manual.

Gage Factor: 0.349 microstrain/ digit (GK-401 Pos."B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load-Applied Load)/ Max.Applied Load) X 100 percent

The above instrument was found to be In Tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Sister Bar Calibration Report

Model Number : 4911-4

Date of Calibration: March 10, 2010

Serial Number: 1004843

Cable Length: 50 ft.

Prestress: 35,000 psi

Factory Zero Reading: 7069

Temperature: 22.3 °C

Regression Zero: 7062

Calibration Instruction: CI-VW Rebar

Technician: ERice

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7118	7118	7118		
1,500	7777	7778	7778	660	-0.18
3,000	8496	8496	8496	719	-0.26
4,500	9228	9225	9227	731	0.09
6,000	9951	9946	9949	722	0.13
100	7118				

For conversion factor, load to strain, refer to table C-2 of the Installation Manual.

Gage Factor: 0.350 microstrain/ digit (GK-401 Pos."B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load-Applied Load)/ Max.Applied Load) X 100 percent

The above instrument was found to be In Tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Sister Bar Calibration Report

Model Number : 4911-4

Date of Calibration: March 10, 2010

Serial Number: 1004847

Cable Length: 40 ft.

Prestress: 35,000 psi

Factory Zero Reading: 6951

Temperature: 22.3 °C

Regression Zero: 6969

Calibration Instruction: CI-VW Rebar

Technician: Elice

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7027	7028	7028		
1,500	7677	7679	7678	651	-0.28
3,000	8394	8400	8397	719	-0.21
4,500	9119	9121	9120	723	-0.01
6,000	9841	9846	9844	724	0.22
100	7028				

For conversion factor, load to strain, refer to table C-2 of the Installation Manual.

Gage Factor: 0.351 microstrain/ digit (GK-401 Pos."B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load-Applied Load)/ Max.Applied Load) X 100 percent

The above instrument was found to be In Tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Sister Bar Calibration Report

Model Number : 4911-4

Serial Number: 1004848

Prestress: 35,000 psi

Temperature: 22.3 °C

Calibration Instruction: CI-VW Rebar

Date of Calibration: March 10, 2010

Cable Length: 40 ft.

Factory Zero Reading: 6881

Regression Zero: 6897

Technician: ERice

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	6958	6958	6958		
1,500	7622	7624	7623	665	-0.34
3,000	8358	8360	8359	736	-0.33
4,500	9107	9106	9107	748	0.06
6,000	9847	9845	9846	740	0.18
100	6958				

For conversion factor, load to strain, refer to table C-2 of the Installation Manual.

Gage Factor: 0.345 microstrain/ digit (GK-401 Pos."B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load-Applied Load)/ Max.Applied Load) X 100 percent

The above instrument was found to be In Tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Sister Bar Calibration Report

Model Number : 4911-4

Date of Calibration: March 10, 2010

Serial Number: 1004849

Cable Length: 40 ft.

Prestress: 35,000 psi

Factory Zero Reading: 7017

Temperature: 22.0 °C

Regression Zero: 7039

Calibration Instruction: CI-VW Rebar

Technician: Erica

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7088	7093	7091		
1,500	7768	7767	7768	677	-0.10
3,000	8503	8500	8502	734	-0.02
4,500	9236	9232	9234	733	0.01
6,000	9967	9965	9966	732	0.03
100	7093				

For conversion factor, load to strain, refer to table C-2 of the Installation Manual.

Gage Factor: 0.346 microstrain/ digit (GK-401 Pos."B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load-Applied Load)/ Max.Applied Load) X 100 percent

The above instrument was found to be In Tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Sister Bar Calibration Report

Model Number : 4911-4

Date of Calibration: March 10, 2010

Serial Number: 1004853

Cable Length: 30 ft.

Prestress: 35,000 psi

Factory Zero Reading: 7019

Temperature: 23.1 °C

Regression Zero: 7040

Calibration Instruction: CI-VW Rebar

Technician: Erica

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7096	7099	7098		
1,500	7754	7755	7755	657	-0.25
3,000	8479	8480	8480	725	-0.14
4,500	9206	9203	9205	725	-0.02
6,000	9934	9931	9933	728	0.20
100	7099				

For conversion factor, load to strain, refer to table C-2 of the Installation Manual.

Gage Factor: 0.350 microstrain/ digit (GK-401 Pos."B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load-Applied Load)/ Max.Applied Load) X 100 percent

The above instrument was found to be In Tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Sister Bar Calibration Report

Model Number : 4911-4

Date of Calibration: March 16, 2010

Serial Number: 1004948

Cable Length: 30 ft.

Prestress: 35,000 psi

Factory Zero Reading: 7101

Temperature: 23.8 °C

Regression Zero: 7105

Calibration Instruction: CI-VW Rebar

Technician: ERice

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7163	7161	7162		
1,500	7824	7825	7825	663	-0.24
3,000	8553	8551	8552	728	-0.20
4,500	9287	9283	9285	733	0.03
6,000	10014	10016	10015	730	0.15
100	7161				

For conversion factor, load to strain, refer to table C-2 of the Installation Manual.

Gage Factor: 0.348 microstrain/ digit (GK-401 Pos."B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load-Applied Load)/ Max.Applied Load) X 100 percent

The above instrument was found to be In Tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Sister Bar Calibration Report

Model Number : 4911-4

Serial Number: 1004949

Prestress: 35,000 psi

Temperature: 22.5 °C

Calibration Instruction: CI-VW Rebar

Date of Calibration: March 16, 2010

Cable Length: 35 m

Factory Zero Reading: 7093

Regression Zero: 7103

Technician: Erica

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7156	7157	7157		
1,500	7815	7813	7814	658	-0.12
3,000	8528	8529	8529	715	-0.11
4,500	9247	9248	9248	719	0.05
6,000	9964	9963	9964	716	0.11
100	7156				

For conversion factor, load to strain, refer to table C-2 of the Installation Manual.

Gage Factor: 0.352 microstrain/ digit (GK-401 Pos."B")

Calculated Strain = Gage Factor(Current Reading - Zero Reading)

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

Linearity: ((Calculated Load-Applied Load)/ Max.Applied Load) X 100 percent

The above instrument was found to be In Tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

APPENDIX C

CONSTRUCTION OF THE EQUIVALENT TOP-LOADED LOAD-SETTLEMENT CURVE

CONSTRUCTION OF THE LOADTEST TOP LOAD PLOT FROM THE RESULTS OF AN O-CELL TEST (March, 2009)

Introduction: The specific advantage of the O-cell load test method is that it separates load displacement responses into multiple zones. End bearing and side shear are separated in many cases. Some engineers find it useful to see the results of an O-cell load test in the more traditional form of a plot showing the load versus displacement of a shaft loaded from the top. Simplified and advanced methods of constructing the top load displacement for this test shaft are described below.

Assumptions: We make the following assumptions, which we consider both reasonable and usually conservative:

1. The upward and downward load displacement plots generated by the O-cell test accurately represent the load bearing capacity for the given shaft installation technique and dimensions, and are similar to load displacement plots which would be generated by a traditional compression or tension load test. For upward O-cell loading, the net load is used to compute the load displacement plot for a given zone (subtract buoyant weight of the given shaft zone above the O-cell).

2. The load displacement plot in a top loaded shaft has the same net shear multiplied by an adjustment factor 'F', for a given downward displacement as occurred in the O-cell test for that same displacement at the top of the O-cell in the upward direction. Unless noted otherwise, we use the following adjustment factors: (a) F = 1.00 in all rock sockets and for primarily cohesive soils in compression (b) F = 0.95 in primarily cohesionless soils (c) F = 0.80 for all soils in top load tension tests.

Simplified Method: Refer to the attached Figure C-1 showing the O-cell test results and to Figure C-2, the calculated top load displacement plot. Note that each of the plots shown in Figure C-1 has points numbered from 1 to 8 such that the same point number on each plot has the same magnitude of displacement. For example, point 5 (load increment 1L-11) has an upward and downward displacement of 0.810 inches in Figure C-1 and the same 0.810 inches downward in Figure C-2.

Using the above assumptions construct the top load plot as follows: Select an arbitrary displacement such as 0.810 inches to give point 5 on the upward load displacement plot in Figure C-1 and record the 1,168 kip load at that displacement. Because we have assumed a rigid shaft, the top of shaft must move downward the same as the bottom. Therefore, find point 5 with 0.810 inches of displacement on the downward plot in Figure C-1 and record the corresponding load of 737 kips. Adding these two loads will give the total load of 1,905 kips at the same displacement and thus gives point 5 on the Figure C-2 derived top load displacement plot.

One can use the above procedure to obtain all the points in Figure C-2 up to the component that moved the least at the end of the test, in this case point 5 of upward displacement in Figure C-1. The upward displacement can be extrapolated using a suitable hyperbolic method to the maximum downward displacement and the top load plot then extended to that displacement. The results, shown in Figure C-2 as points 6 to 8 (dashed line) signify that this part of the calculated top load displacement plot depends partly on extrapolated data.

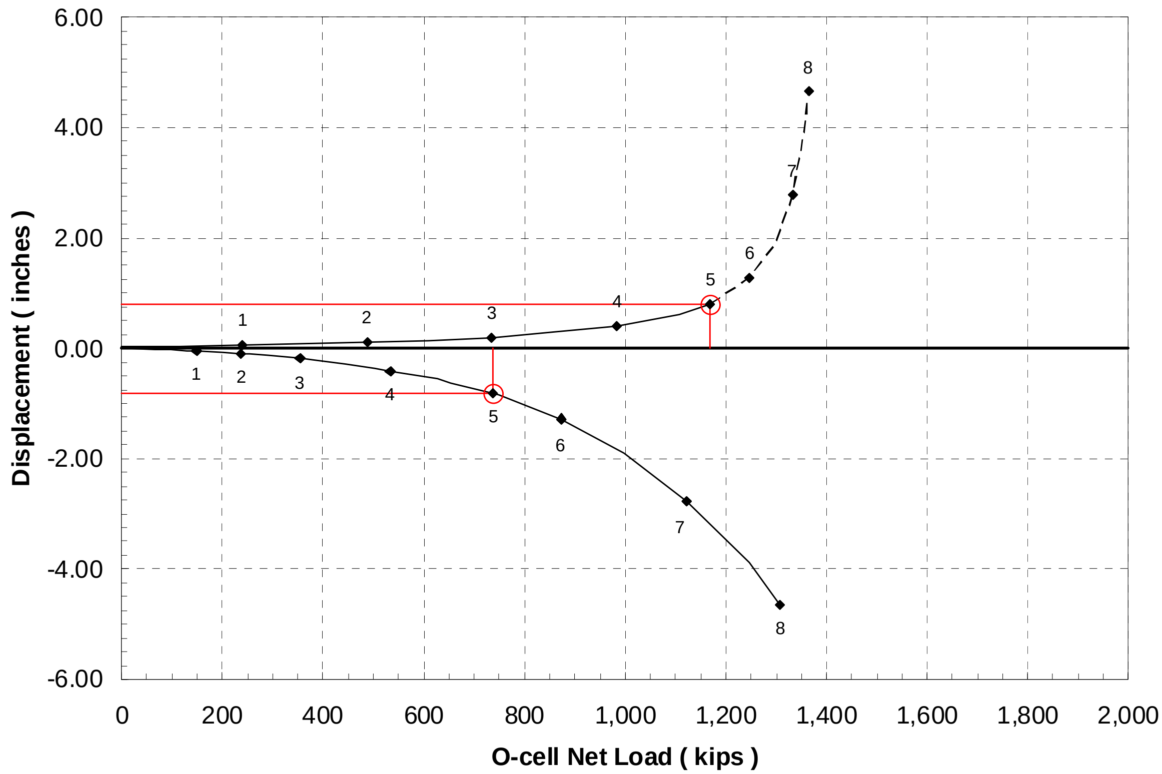


Figure C- 1

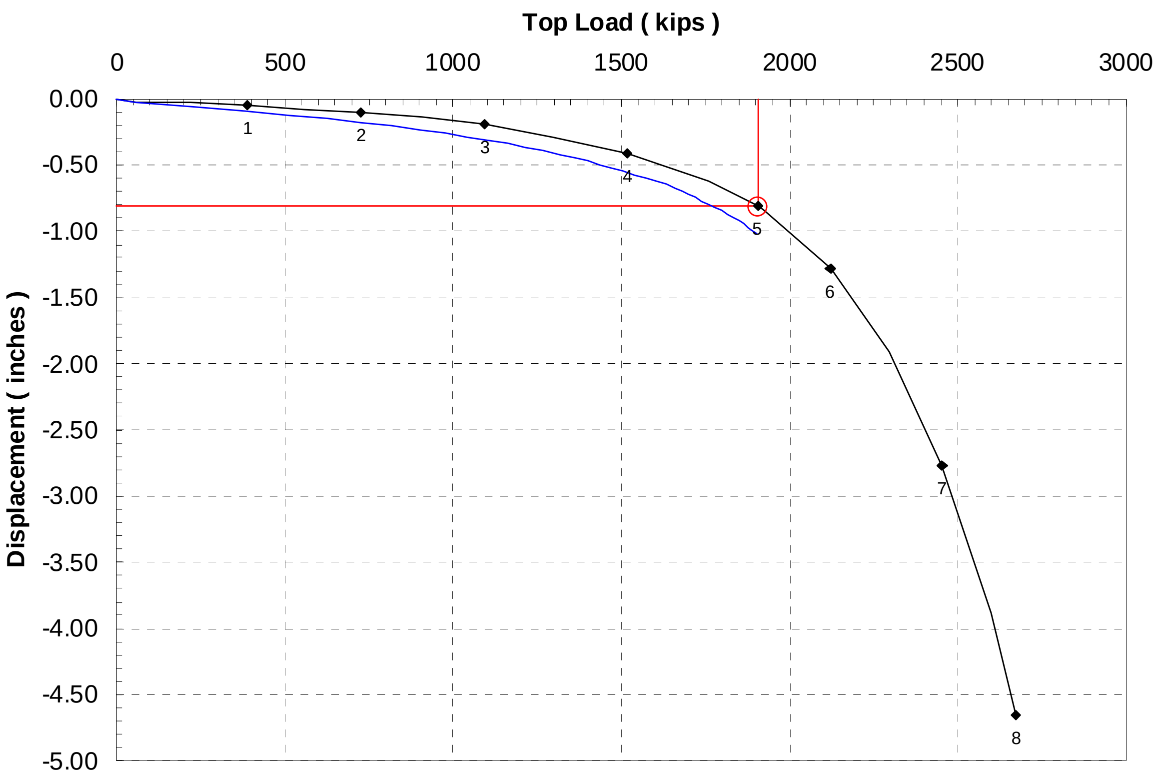


Figure C- 2

<u>Advanced Method</u>: Using the advantages of the O-cell load test method to full benefit, a more exact solution of the calculated top load displacement plot can be derived using the t-z method (see references below). The shaft is sub-divided into a number of distinct zones, based on data collected from the embedded strain gauges and load displacement plots. The input for the t-z analysis is the unit shear and end bearing plots presented in <u>Figures 5, 6 & 7</u> of the Data Report.

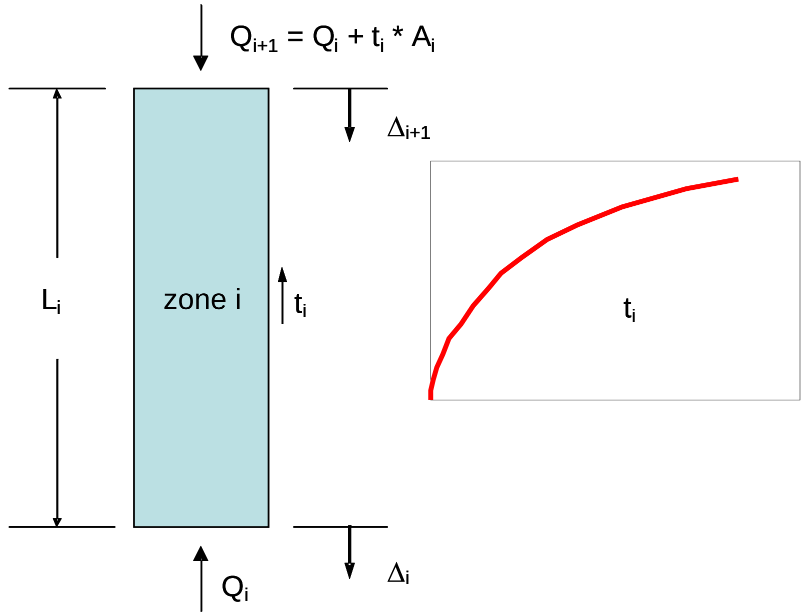


Figure C- 3

Figure C-3 above illustrates a sample shaft segment zone. The zone has an associated unit shear capacity plot t_i (which is a non-linear function of displacement), shaft dimensions and properties L_i and AE_i, computed elastic compression δ_i, and computed loads and displacements at the top and bottom of the zone, Δ_i, Q_i and Δ_{i+1}, Q_{i+1}, respectively. For each zone i, the following three equations are solved in an iterative fashion until the output displacement and load Δ_{i+1} and Q_{i+1} match the input.

$$\text{I)}\quad \delta_i = \frac{(Q_i + Q_{i+1})}{2} \cdot \frac{L_i}{AE_i} \qquad \text{II)}\quad \Delta_{i+1} = \Delta_i + \delta_i \qquad \text{III)}\quad Q_{i+1} = Q_i + t\left(\frac{\Delta_i + \Delta_{i+1}}{2}\right) \cdot A_i$$

The next zone i+1 is then analyzed, until the load transfer mechanism of the full shaft length is modeled. Additionally, there is an end-bearing capacity plot q which must also be considered. For comparison purposes, at a shaft head displacement of 0.810 inches at the sample calculation point 5 from the Simplified Method, the t-z method calculated load capacity is 1,770 kips.

Extrapolation: The TZ curves above the O-cell that are used to generate the LOADTEST top load plot contain a small extrapolation. This was done to extend the plot given that the lower shear and end bearing displaced more than the upper shear during the test.

Limitations: The engineer using these results should judge the conservatism, or lack thereof, of the aforementioned assumptions and extrapolation(s) before utilizing the results for design purposes. For example, brittle failure behavior may produce displacement plots with abrupt changes in curvature (not hyperbolic). The presentation of the *Estimated Top Load Plot* in this report is meant to simulate a load test where load is applied from the top for this test shaft only.

References:

Lee, Jong-Sub and Park, Yung-Ho "Equivalent Shaft Load-Head Settlement Curve Using a Bi-Directional Shaft Load Test", *Computers and Geotechnics*, Volume 35, Issue 2, March 2008, Pages 124-133.

Meyer, P. L., Holmquist, D. V. and Matlock, H. "Computer predictions for axially-loaded Shafts with Non-linear Supports", *Proceedings of the 7th Offshore Technology Conference*, Paper No. 2186, Houston, Texas 1975.

APPENDIX D

O-CELL METHOD FOR DETERMINING CREEP LIMIT LOADING

O-CELL METHOD FOR DETERMINING A CREEP LIMIT LOADING ON THE EQUIVALENT TOP-LOADED SHAFT (September, 2000)

Background: O-cell testing provides a sometimes useful method for evaluating that load beyond which a top-loaded drilled shaft might experience significant unwanted creep behavior. We refer to this load as the "creep limit," also sometimes known as the "yield limit" or "yield load".

To our knowledge, Housel (1959) first proposed the method described below for determining the creep limit. Stoll (1961), Bourges and Levillian (1988), and Fellenius (1996) provide additional references. This method also follows from long experience with the pressuremeter test (PMT). Figure 8 and section 9.4 from ASTM D4719-94, reproduced below, show and describe the creep curve routinely determined from the PMT. The creep curve shows how the movement or strain obtained over a fixed time interval, 30 to 60 seconds, changes versus the applied pressure. One can often detect a distinct break in the curve at the pressure P_e in Figure 8. Plastic deformations may become significant beyond this break loading and progressively more severe creep can occur.

Definition: Similarly with O-cell testing using the ASTM Quick Method, one can conveniently measure the additional movement occurring over the final time interval at each constant load step, typically 4 to 8 minutes. A break in the curve of load vs. movement (as at P_e with the PMT) indicates the creep limit.

We usually indicate such a creep limit in the O-cell test for either one, or both, of the side shear and end bearing components, and herein designate the corresponding movements as M_{CL1} and M_{CL2}. We then combine the creep limit data to predict a creep limit load for the equivalent top loaded shaft.

Procedure if both M_{CL1} and M_{CL2} available: Creep cannot begin until the shaft movement exceeds the M_{CL} values. A conservative approach would assume that creep begins when movements exceed the lesser of the M_{CL} values. However, creep can occur freely only when the shaft has moved the greater of the two M_{CL} values. Although less conservative, we believe the latter to match behavior better and therefore set the creep limit as that load on the equivalent top-loaded movement curve that matches the greater M_{CL}.

Procedure if only M_{CL1} available: If we cannot determine a creep limit in the second component before it reaches its maximum movement M_x, we treat M_x as M_{CL2}. From the above method one can say that the creep limit load exceeds, by some unknown amount, that obtained when using $M_{CL2} = M_x$.

Procedure if no creep limit observed: Then, according to the above, the creep limit for the equivalent top-loaded shaft will exceed, again by some unknown amount, that load on the equivalent curve that matches the movement of the component with the maximum movement.

Limitations: The accuracy in estimating creep limits depends, in part, on the scatter of the data in the creep limit plots. The more scatter, the more difficult to define a limit. The user should make his or her own interpretation if he or she intends to make important use of the creep limit interpretations. Sometimes we obtain excessive scatter of the data and do not attempt an interpretation for a creep limit and will indicate this in the report.

Excerpts from ASTM D4719
"Standard Test Method for Pressuremeter Testing in Soils"

9.4 For Procedure A, plot the volume increase readings (V_{60}) between the 30 s and 60 s reading on a separate graph. Generally, a part of the same graph is used, see Fig. 8. For Procedure B, plot the pressure decrease reading between the 30 s and 60 s reading on a separate graph. The test curve shows an almost straight line section within the range of either low volume increase readings (V_{60}) for Procedure A or low pressure decrease for Procedure B. In this range, a constant soil deformation modulus can be measured. Past the so-called creep pressure, plastic deformations become prevalent.

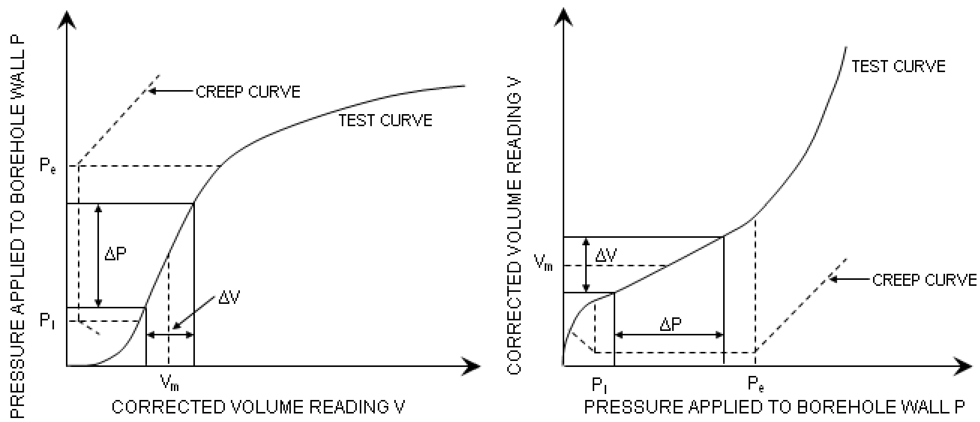


FIG. 8 Pressuremeter Test Curves for Procedure A

References

Housel, W.S. (1959), "Dynamic & Static Resistance of Cohesive Soils", ASTM STP 254, pp. 22-23.

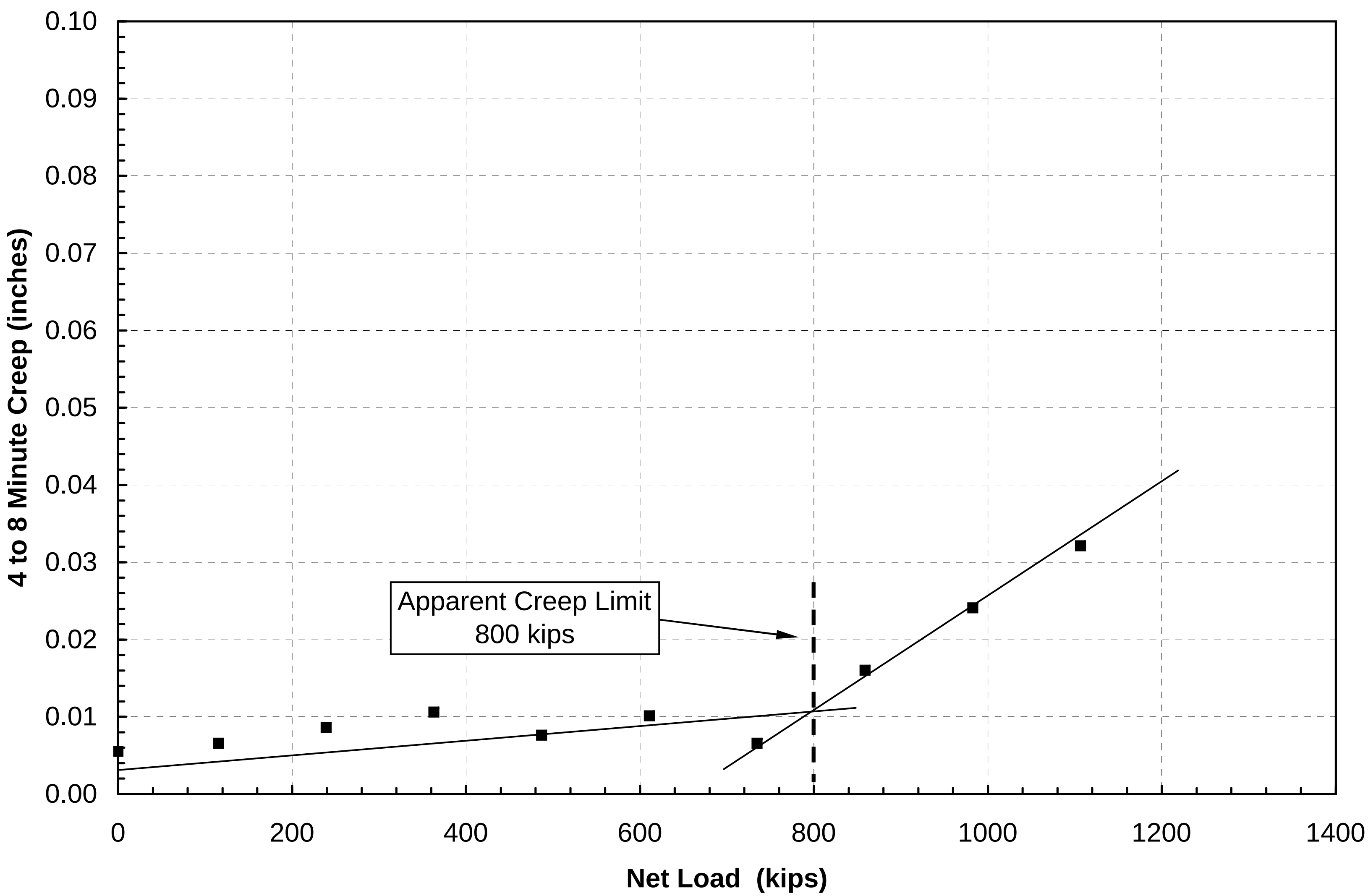
Stoll, M.U.W. (1961, Discussion, Proc. 5th ICSMFE, Paris, Vol. III, pp. 279-281.

Bourges, F. and Levillian, J-P (1988), "force portante des rideaux plans metalliques charges verticalmement," Bull. No. 158, Nov.-Dec., des laboratoires des ponts et chaussees, p. 24.

Fellenius, Bengt H. (1996), Basics of Foundation Design, BiTech Publishers Ltd., p.79.

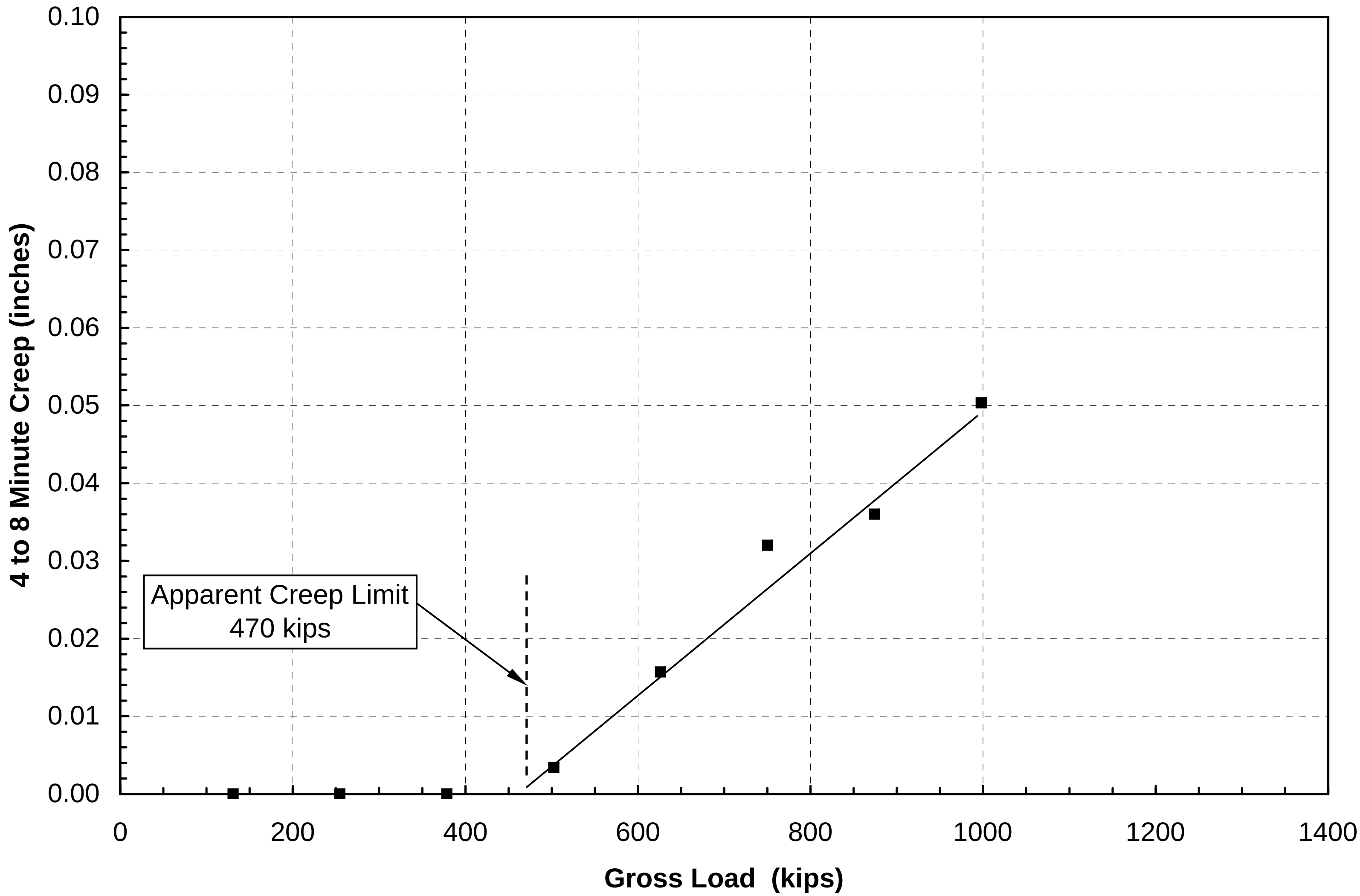
Side Shear Creep Limit

Broadway Viaduct - Council Bluffs, IA - TS 3



Base Creep Limit

Broadway Viaduct - Council Bluffs, IA - TS 3



APPENDIX E

SOIL BORING LOG

3/29/10 POST TEST LOCATION GROUTED

LOG OF BORING NO. TS-3

CLIENT: **Longfellow Drilling Inc.**

SITE: **Council Bluffs, IA**

PROJECT: **Broadway Viaduct**

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY, in.	SAMPLES SPT - N ** BLOWS / ft.	TESTS WATER CONTENT, %	TESTS DRY UNIT WT pcf	TESTS UNCONFINED STRENGTH, psf
	(FILL) LEAN CLAY Dark grayish brown				HS					
		5		1	SS	6	4			
					HS					
10	Trace brick fragments, grayish brown at about 8.5 feet	10		2	SS	12	10			
	FINE SAND with silt Grayish brown, loose				HS					
	▽	15	SP	3	SS	18	4			
18.5					HS					
	SILTY CLAY Grayish brown, soft	20	CL	4	SS	20	3			
23.5					HS					
	FINE SAND Grayish brown, medium dense	25	SP	5	SS	12	10			
					HS					
		30	SP	6	SS	18	14			
					HS					
	Very loose at about 33.5 feet	35	SP	7	SS	10	2			
					HS					
	Loose at about 38.5 feet	40	SP	8	SS	20	5			
					HS					
	Trace lignite below about 43.5 feet	45	SP	9	SS	15	12			
					HS					
		50	SP	10	SS	15	10			
					HS					
		55	SP	11	SS	18	13			

Continued Next Page

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*Calibrated Hand Penetrometer
**CME Automatic Hammer

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 15	WD	▼
WL	▼		▽
WL			

Terracon

BORING STARTED			3-26-10
BORING COMPLETED			3-26-10
RIG	96	FOREMAN	JM
APPROVED	DAM	JOB #	05105037

LOG OF BORING NO. TS-3

CLIENT	
Longfellow Drilling Inc.	
SITE: Council Bluffs, IA	PROJECT: Broadway Viaduct

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES: NUMBER	TYPE	RECOVERY, in.	SPT - N ** BLOWS / ft.	TESTS: WATER CONTENT, %	DRY UNIT WT pcf	UNCONFINED STRENGTH, psf
	FINE SAND, trace grayish brown fat clay layers, trace gravel Gray Loose at about 63.5 feet Becoming fine to coarse sand, trace sandy clay layers, trace gravel below about 63.5 feet				HS					
		60	SP	12	SS	20	11			
					HS					
		65	SP	13	SS	12	7			
					HS					
		70	SP	14	SS	20	11			
					HS					
		75	SP	15	SS	15	10			
					HS					
		80	SP	16	SS	18	17			
					HS					
		85	SP	17	SS	15	13			
					HS					
	90	90	SP	18	SS	12	11			
	BOTTOM OF BORING									

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*Calibrated Hand Penetrometer
**CME Automatic Hammer

WATER LEVEL OBSERVATIONS, ft				BORING STARTED	3-26-10		
WL	∇ 15	WD	▼	BORING COMPLETED	3-26-10		
WL	▼		∇	RIG	96	FOREMAN	JM
WL				APPROVED	DAM	JOB #	05105037

Terracon

BOREHOLE 05105037 LOGS.GPJ TERRACON.GDT 3/29/10