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LOADTEST

REPORT ON DRILLED SHAFT LOAD TESTING (OSTERBERG METHOD)

Test Shaft - I-80 over Missouri River Council Bluffs, IA (LT-9433)

Prepared for: **Jensen Construction**
5550 NE 22nd Street
Des Moines, IA 50313

Attention: **Mr. Dan Timmons**

PROJECT NUMBER: LT-9433, April 30, 2008

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DEEP FOUNDATION TESTING, EQUIPMENT & SERVICES • SPECIALIZING IN OSTERBERG CELL (O-cell®) TECHNOLOGY

April 30, 2008

Jensen Construction
5550 NE 22nd Street
Des Moines, IA 50313

Attention: Mr. Dan Timmons

Load Test Report: Test Shaft - I-80 over Missouri River
Location: Council Bluffs, IA (LT-9433)

Dear Mr. Timmons,

The enclosed report contains the data and analysis summary for the Osterberg Cell (O-cell) test performed on Test Shaft - I-80 over Missouri River, on April 24, 2008. 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 the information contained herein will suit your current project needs. If you have any questions or require further technical assistance, please do not hesitate to contact us at 800-368-1138.

Best Regards,

William G. Ryan, B.S.C.M.
Regional Manager, LOADTEST Inc.

EXECUTIVE SUMMARY

On April 24, 2008, LOADTEST Inc. performed an O-cell test on a nominal 66-inch diameter test shaft constructed by Jensen Construction. Mr. Jon Sinnreich and Mr. Aaron M. King of LOADTEST Inc. carried out the test. Jensen Construction constructed the 106.99-foot deep shaft socketed in limestone under water on April 19, 2008. Representatives of the Iowa DOT observed construction and testing of the shaft.

The maximum sustained bi-directional load applied to the shaft was 9,057 kips. At the maximum load, the displacements above and below the O-cell assembly were 0.352 inches and 0.088 inches, respectively. Unit shear data indicated an average net unit side shear of 36.5 ksf in the rock socket and a maximum end bearing pressure of 347 ksf.

Using the procedures described in the report text and in Appendix C, an equivalent top load curve for the test shaft was constructed. For a top loading of 2,250 kips, the adjusted test data indicate this shaft would settle approximately 0.15 inches.

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.

TABLE OF CONTENTS

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 alluvium down to an approximate elevation of +883 feet underlain by limestone rock. 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 DOT.

Test Shaft Construction: Jensen Construction excavated the dedicated test shaft socketed in rock on April 16 and 17, and performed the final cleanout and concreting on April 19, 2008. Shaft construction proceeded as follows: A 109.25-inch O.D., 50-foot long surface casing was installed to a tip elevation of +928.2 feet using a vibratory hammer, and the interior soils excavated. Next, an 85.5-inch O.D., 91-foot long outer casing was installed using a vibratory hammer to the top of rock, and the interior soils excavated. A 73.5-inch O.D., 95-foot long inner casing was then screwed approximately 3.5 feet into the top of rock to seal the excavation. The 66-inch diameter rock socket was excavated to a tip elevation of +868.3 ft using a rock auger and core barrel, under natural seepage water. The bottom of the shaft was airlifted and pumped dry after drilling. After cleaning the base, a seating layer of concrete was delivered to the base via tremie, and the reinforcing cage with attached O-cell assembly was inserted into the excavation and seated into the fresh concrete. Concrete was then delivered by tremie into the shaft until the top of the concrete reached an elevation of +883.0 ft. Representatives of the Iowa DOT observed construction of the shaft.

OSTERBERG CELL TESTING

Shaft Instrumentation: Test shaft instrumentation and assembly was carried out under the direction of Mr. William G. Ryan of LOADTEST Inc. The loading assembly consisted of one 34-inch O-cell, located 1.40 feet above the tip of shaft. The Osterberg cells were calibrated to 3,075 kips and then welded closed prior to shipping by American Equipment and Fabricating Corporation. Calibrations of the O-cell and instrumentation used for this test are included in Appendix B.

O-cell testing instrumentation included two Linear Vibrating Wire Displacement Transducers (LVWDTs, Geokon Model 4450 series) positioned between the lower and upper plates of the O-cell assembly to measure expansion (Appendix A, Pages 1 and 2). Two telltale casings (nominal ½-inch steel pipe) were attached to the reinforcing cage, diametrically opposed, extending from the top of the O-cell assembly to beyond the top of concrete.

Strain gauges were used to assess the side shear load transfer of the shaft above the O-cell assembly. Two levels of two sister bar vibrating wire strain gauges (Geokon Model 4911 Series) were installed, diametrically opposed, in the shaft above the base of the O-cell assembly. Details concerning the strain gauge placement appear in Table B and Figure A. The strain gauges were positioned as recommended by LOADTEST Inc. and approved by the Iowa DOT.

One length of steel pipe was also installed, extending from the top of the shaft to the top of the bottom plate, to vent the break in the pile formed by the expansion of the O-cell.

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 ¼-inch telltales installed in the ½-inch steel pipes (described under Shaft Instrumentation) and monitored by LVWDTs attached to the top of shaft. Two automated digital survey levels (Leica NA3000 series) were used to monitor the top of shaft movement during testing from a distance of approximately 30.5 feet.

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

Data Acquisition: All instrumentation were connected through a data logger (Data Electronics 615 GeoLogger) to a laptop computer allowing data to be recorded and stored automatically at 30 second intervals and displayed in real time. The same laptop computer synchronized to the data logging system was used to acquire the Leica NA3000 data.

Testing Procedures: The test was begun by pressurizing 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, the pressure was immediately released and the testing commenced. Zero readings for all instrumentation were taken prior to the preliminary weld-breaking load-unload cycle, which in this case involved a maximum applied load of 1,300 kips.

The Osterberg cell load test was conducted as follows: The 34-inch diameter O-cell, with its base located 1.40 feet above the tip of shaft, was pressurized to assess the combined end bearing and lower side shear resistance of the shaft section below the O-cell and the upper side shear above. The shaft was loaded in 20 equal loading increments to a bi-directional gross O-cell load of 9,057 kips. The loading was halted after load interval 1L-20 because the anticipated ultimate loads and rated hydraulic system capacity had both already been exceeded. The shaft was then unloaded in five decrements and the test was concluded.

The load increments were applied using the Quick Load Test Method for Individual Piles (ASTM D1143 *Standard Test Method for Piles Under Static Axial Load*). Each successive load increment was held constant for eight minutes by manually adjusting the O-cell pressure. Approximately one minute was used to move between increments. The data logger automatically recorded the instrument readings every 30 seconds, but herein only the 1, 2, 4 and 8 minute readings during each increment of maintained load are reported.

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 a shaft buoyant weight of 428 kips above the O-cell was calculated.

Upper Side Shear Resistance: The maximum upward applied *net load* to the upper side shear was 8,629 kips which occurred at load interval 1L-20 (Appendix A, Page 4, Figure 1). At this loading, the upward movement of the top of the O-cell was 0.352 inches.

The strain gauge data appear in Appendix A, Pages 5 and 6. On the day of the test, the concrete unconfined compressive strength was reported to be 3,800 psi. The ACI formula ($E_c=57000\sqrt{f'_c}$) was used to calculate an elastic modulus for the concrete. This, combined with the area of reinforcing steel and nominal shaft diameter, provided an average shaft stiffness (AE) of 19,608,000 kips in the upper cased shaft section and 13,054,000 kips in the uncased shaft section. Average net unit side shear curves based on the strain gauge data and estimated shaft stiffness are presented in Figure 3. Shear values for load increment 1L-20 follow in Table A:

TABLE A: Average Net Unit Side Shear Values for 1L-20

Load Transfer Zone	Displacement *	Net Unit Side Shear **
Zero Shear to Strain Gauge Level 2	↑ 0.35 inches	5.2 ksf (6.0 ksf at 1L-14)
Strain Gauge Level 2 to Strain Gauge Level 1		9.4 ksf
Strain Gauge Level 1 to O-cell		62.8 ksf

* O-cell displacement.

** For upward-loaded shear, the buoyant weight of shaft in each zone has been subtracted from the load shed in the respective zone.

NOTE: Net unit shear values derived from the strain gages may not be ultimate values. See Figure 3 for mobilized unit shear vs. displacement plots.

Combined End Bearing and Lower Side Shear Resistance: The maximum downward applied load was 9,057 kips which occurred at load interval 1L-20 (Appendix A, Page 4, Figure 1). At this loading, the average downward movement of the O-cell base was 0.088 inches. The side shear capacity of the 1.40-foot shaft section below the O-cell is calculated to be 821 kips assuming a unit side shear value of 34 ksf (based on the unit shear in the load transfer zone above the O-cell at compatible upward displacement) and a nominal shaft diameter of 66 inch. The maximum applied load to end bearing is then 8,236 kips and the unit end bearing at the base of the shaft is calculated to be 347 ksf at the above noted displacement. A unit end bearing curve is presented in Figure 4.

Equivalent Top Load: Figure 5 presents the equivalent top-loaded load-settlement curves. The 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. The settlement curves are calculated assuming the top load is applied at ground elevation (+973.5 ft), and that the shear capacity between ground and the top of the limestone (+883.00 ft) is assumed to be zero (free-standing column). Because it is often an important component of the settlements involved, the equivalent top load curve requires an adjustment for the additional elastic compression that would occur in a top-load test. The darker curve as described in Procedure Part II of Appendix C includes this adjustment.

The test shaft was mobilized to a combined side shear and end-bearing resistance of 13,800 kips. For a top loading of 2,250 kips, the adjusted test data indicate this shaft would settle approximately 0.15 inches of which 0.14 inches is estimated elastic compression. For a top loading of 4,500 kips the adjusted test data indicate this shaft would settle approximately 0.27 inches of which 0.25 inches is estimated elastic compression.

Note that, as explained previously, the equivalent top load curve applies to incremental loading durations of eight minutes. Creep effects will reduce the ultimate resistance of both components and increase shaft top movement for a given loading over longer times. The Engineer can estimate such additional creep effects by suitable extrapolation of time effects using the creep data presented herein.

Creep Limit: See Appendix D for our O-cell method for determining creep limit loading. The combined end bearing and lower side shear creep data (Appendix A, Pages 3 and 4) indicate that no apparent creep limit was reached at a maximum movement of 0.088 inches (Figure D-1). The upper side shear creep data (Appendix A, Pages 3 and 4) indicates that a creep limit of 7,450 kips was reached at a movement of 0.23 inches (Figure D-2). A top loaded shaft will not begin creep until both components begin creep movement. This will occur at the maximum of the movements required to reach the creep limit for each component. Due to the absence of a clearly defined combined end bearing and lower side shear creep limit, a creep limit for the equivalent top-loaded pile cannot be estimated. The engineer should come to his or her own conclusions regarding the suitability of the creep limit analysis to address long-term creep which may be an important design consideration.

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

Jon Sinnreich

Jon Sinnreich, M. Eng.
Project Manager

Reviewed by

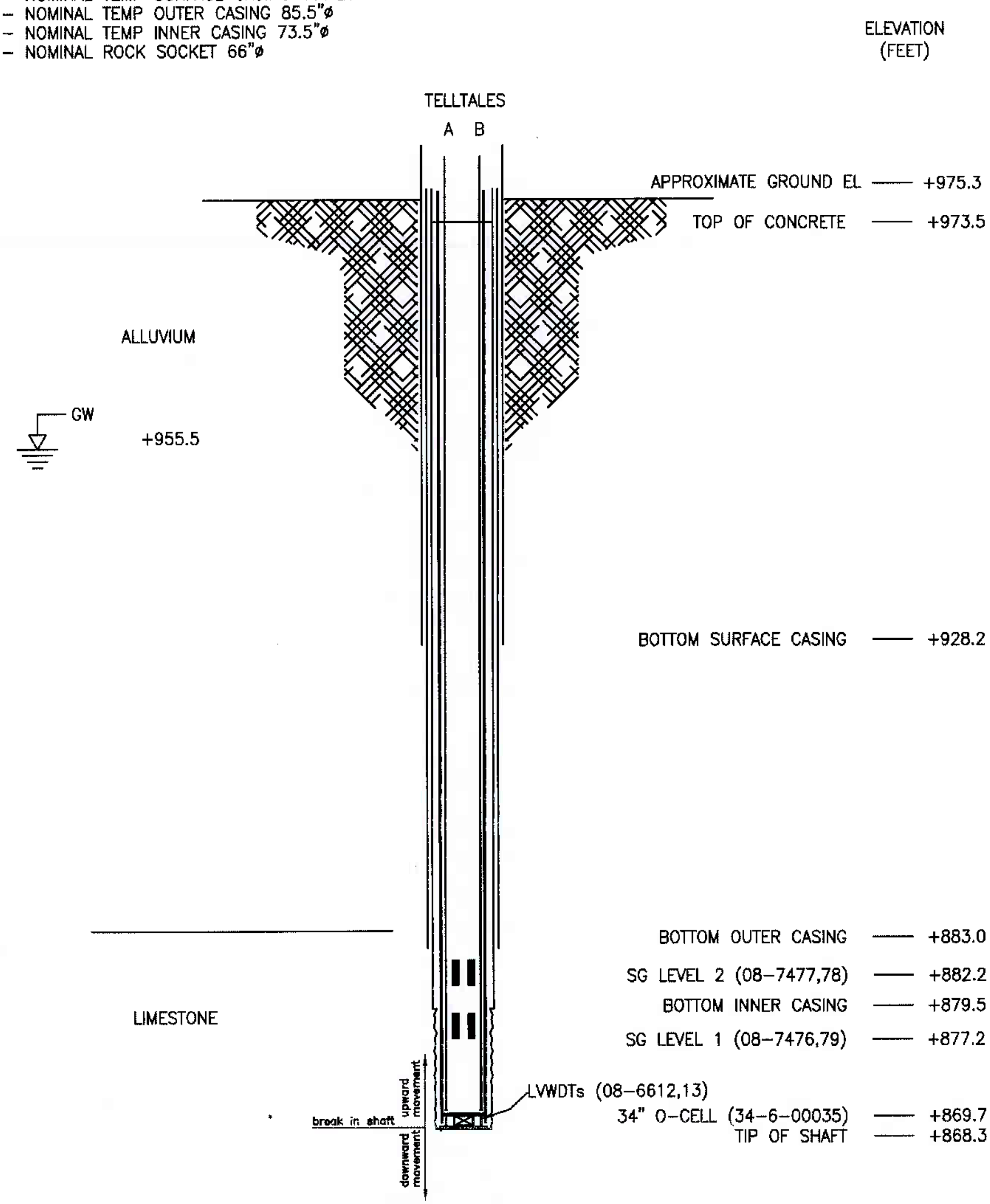
D. Tilson

for Denton A. Kort, P.E.
Geotechnical Engineer

TABLE B
SUMMARY OF DIMENSIONS, ELEVATIONS & SHAFT PROPERTIES

Shaft:		
Nominal shaft diameter (EL +883.0 ft to +879.5 ft)	=	73.5 inch
Nominal shaft diameter (EL +879.5 ft to +868.3 ft)	=	66.0 inch
O-cell: 34-6-00035	=	34 inch
Length of side shear above break at base of O-cell	=	13.30 ft
Length of side shear below break at base of O-cell	=	1.40 ft
Side shear area above O-cell base	=	236.7 ft^2
Side shear area below O-cell base	=	24.2 ft^2
Shaft base area	=	23.8 ft^2
Bouyant weight of shaft above base of O-cell	=	428 kips
Estimated shaft stiffness, AE (EL +883.0 ft to +879.5 ft)	=	19,608,000 kips
Estimated shaft stiffness, AE (EL +879.5 ft to +868.3 ft)	=	13,054,000 kips
Elevation of ground surface	=	+975.3 ft
Elevation of top of shaft concrete	=	+973.5 ft
Elevation of water table	=	+955.5 ft
Elevation of Zero Shear (assumed to be at tip of Outer Casing)	=	+883.0 ft
Elevation of base of O-cell assembly (The break between upward and downward movement)	=	+869.7 ft
Elevation of shaft tip	=	+868.3 ft
Casings:		
Elevation of top of surface permanent casing (109.25 inch O.D., 0.625 inch thick)	=	+978.5 ft
Elevation of bottom of surface permanent casing	=	+928.2 ft
Elevation of top of outer permanent casing (85.5 inch O.D., 0.75 inch thick)	=	+974.3 ft
Elevation of bottom of outer permanent casing	=	+883.0 ft
Elevation of top of inner permanent casing (73.5 inch O.D., 0.75 inch thick)	=	+974.5 ft
Elevation of bottom of inner permanent casing	=	+879.5 ft
Telltale Sections:		
Elevation of top of telltale used for upper shaft compression	=	+973.5 ft
Elevation of bottom of telltale used for upper shaft compression	=	+870.7 ft
Strain Gauges:		
Elevation of Strain Gauge Level 2 (AE = 19608000 kips)	=	+882.2 ft
Elevation of Strain Gauge Level 1 (AE = 13054000 kips)	=	+877.2 ft
Miscellaneous:		
Top plate diameter (2.0 inches thick)	=	55.25 inch
Bottom plate diameter (2.0 inches thick)	=	58.75 inch
Rebar size (18 No.)	=	# 14
Spiral size (10 inch spacing)	=	# 5
Rebar cage diameter	=	60.0 inch
5 day unconfined compressive concrete strength	=	3,800 psi

NOTE:
- NOMINAL TEMP SURFACE CASING 109.25"ø
- NOMINAL TEMP OUTER CASING 85.5"ø
- NOMINAL TEMP INNER CASING 73.5"ø
- NOMINAL ROCK SOCKET 66"ø



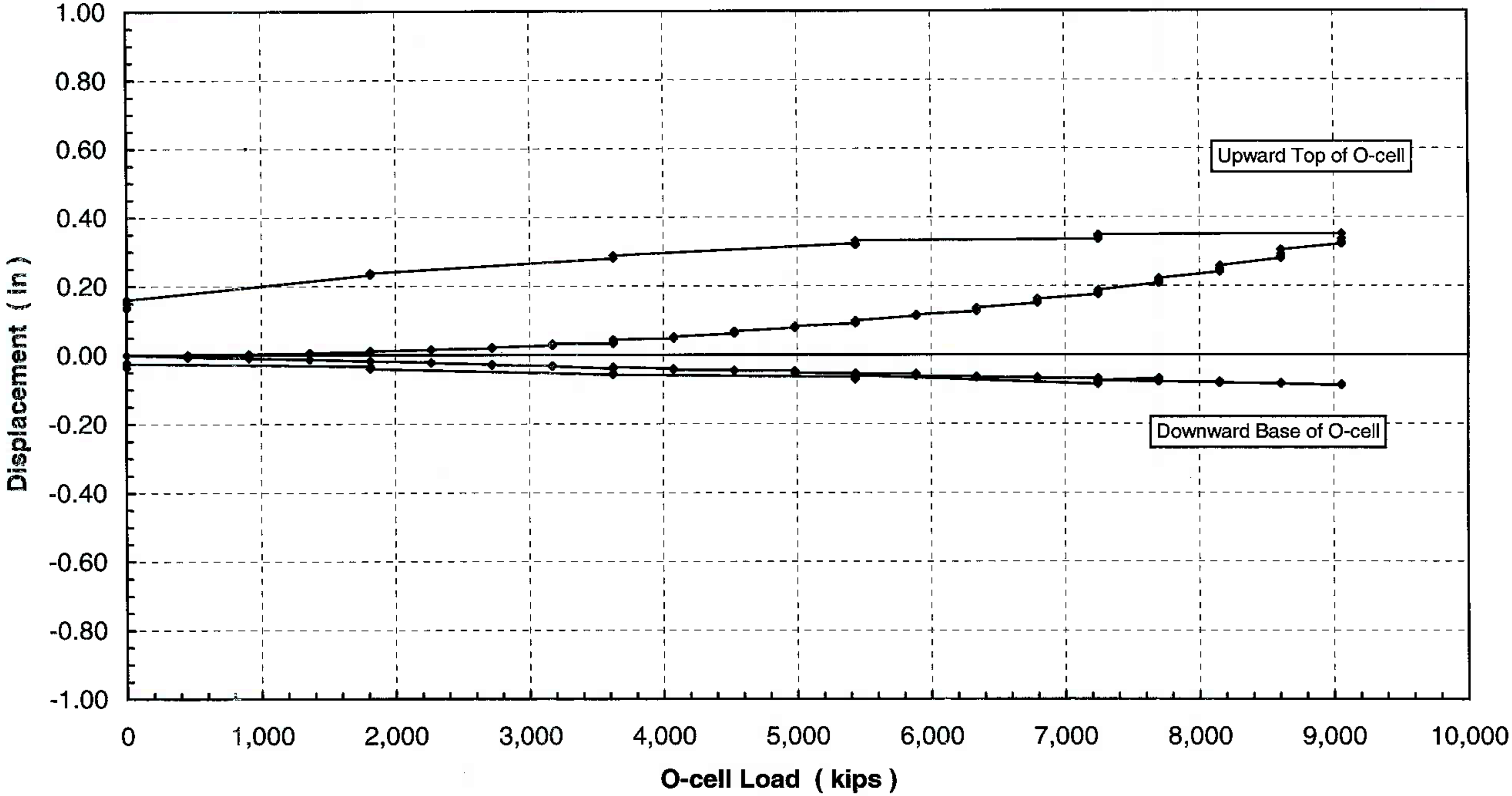
LOADTEST
2631-D NW 41st St.
Gainesville, FL 32606
Phone 800-368-1138
FAX 352-378-3934

SCHEMATIC SECTION OF 66"ø TEST SHAFT
I-80 over Missouri River – Pottawattamie County, IA

DRAWN BY: SCB	DATE: 01/09/08	CHECKED BY: WGR	LT-9433
REVISED BY: SCB	DATE: 4/23/08	SCALE: NTS	FIGURE A

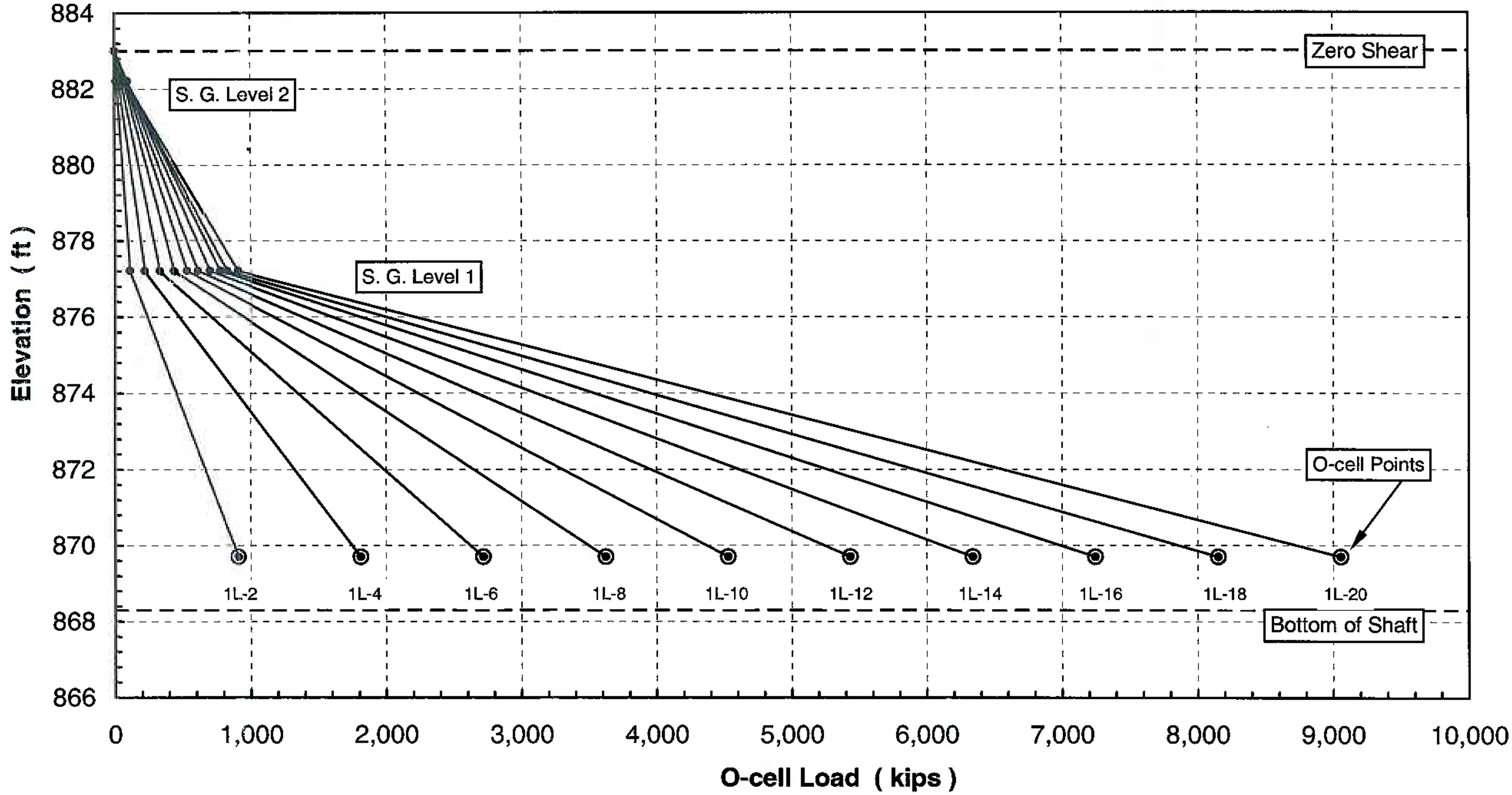
Osterberg Cell Load-Movement

Test Shaft - I-80 over Missouri River - Council Bluffs, IA



Strain Gauge Load Distribution

Test Shaft - I-80 over Missouri River - Council Bluffs, IA

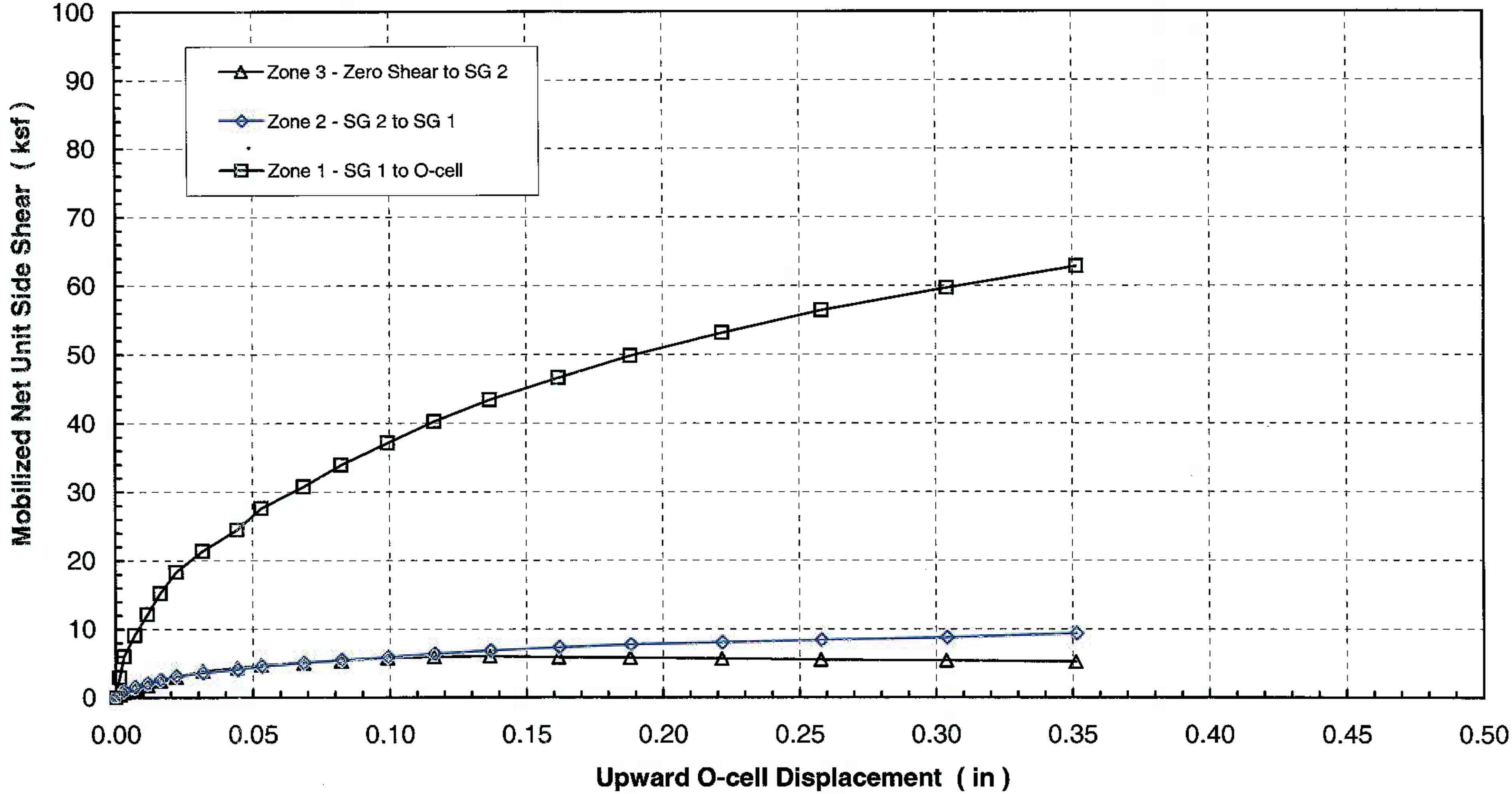


LOADTEST Inc. Project No. LT-9433

Figure 2 of 5

Mobilized Net Unit Side Shear

Test Shaft - I-80 over Missouri River - Council Bluffs, IA

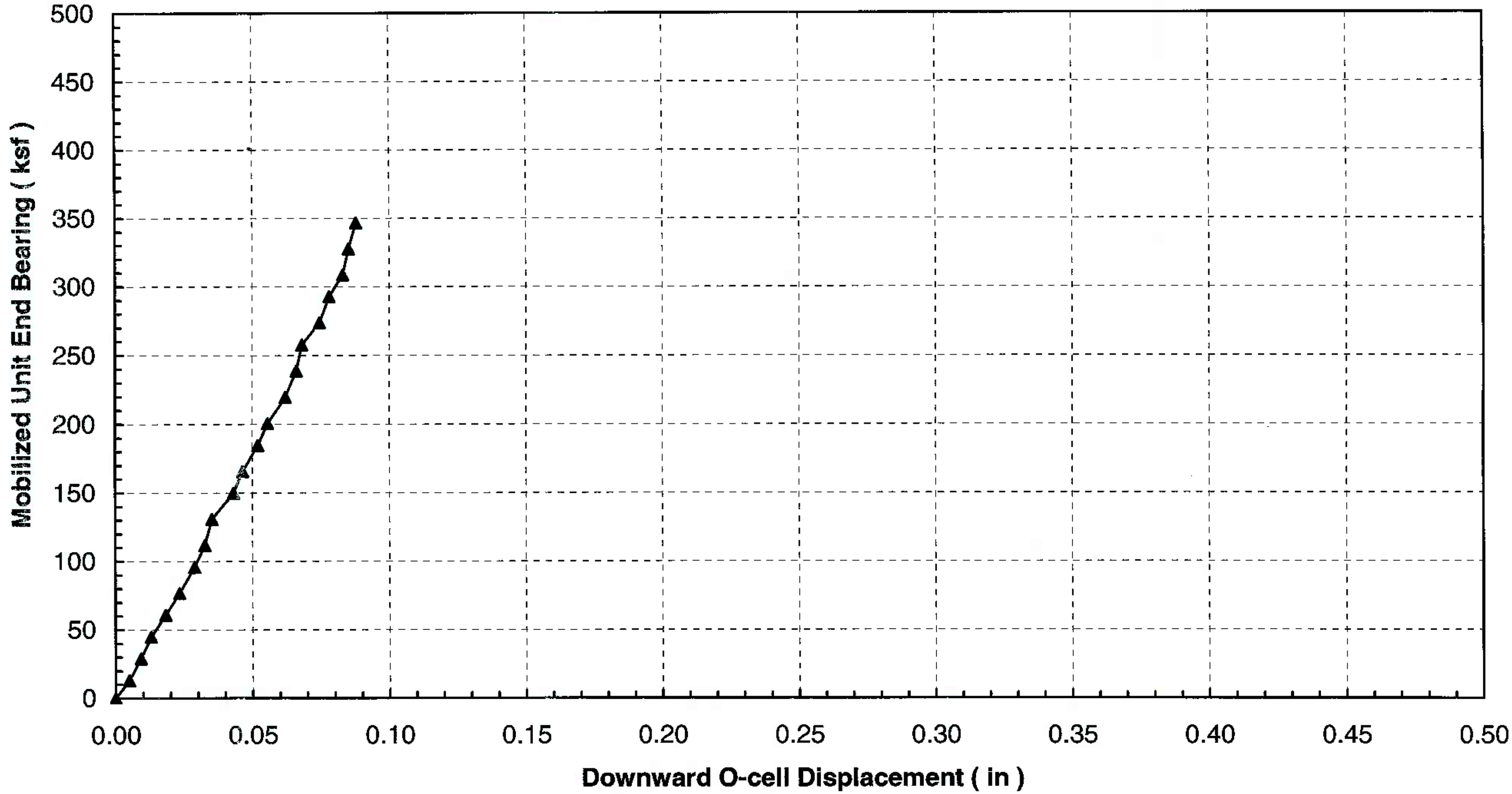


LOADTEST Inc. Project No. LT-9433

Figure 3 of 5

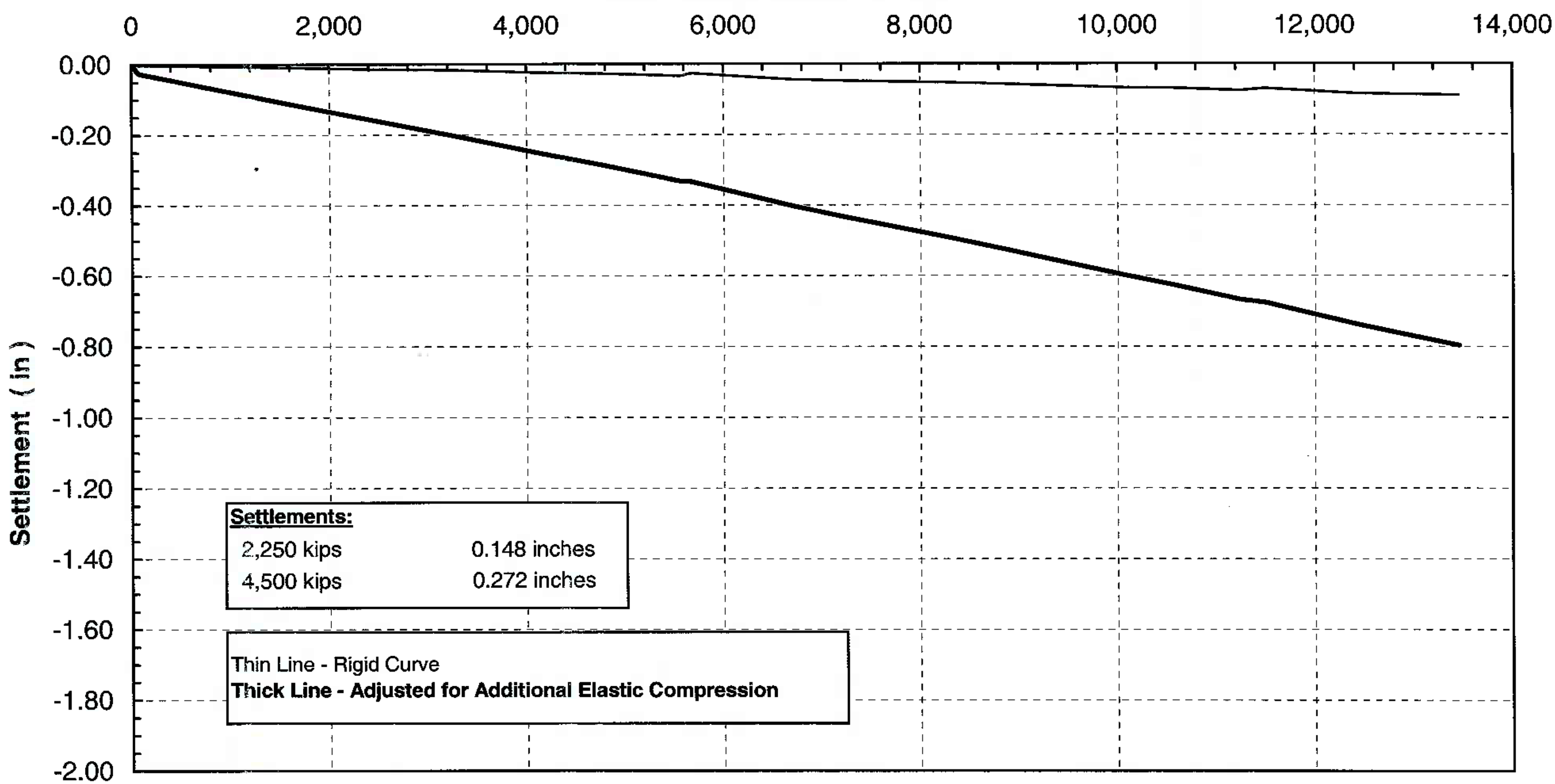
Mobilized Unit End Bearing

Test Shaft - I-80 over Missouri River - Council Bluffs, IA



Equivalent Top Load-Settlement

Test Shaft - I-80 over Missouri River - Council Bluffs, IA



APPENDIX A

FIELD DATA & DATA REDUCTION

Upward Top of Shaft Movement, Shaft Compression and O-cell Expansion
Test Shaft - I-80 over Missouri River - Council Bluffs, IA

Load	Hold		O-cell		Top of Shaft			Compression Telltales			O-cell Expansion		
Test Increment	Time (minutes)	Time (hh:mm:ss)	Pressure (psi)	Load (kips)	A - NA3000 (in)	B - NA3000 (in)	Average* (in)	A - 08-1928 (in)	B - 08-1926 (in)	Average (in)	A - 08-6612 (in)	B - 08-6613 (in)	Average (in)
1 L - 0	-	12:07:00	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.00
1 L - 1	1	12:25:30	750	454	0.002	0.001	0.001	0.000	0.000	0.000	0.00	0.01	0.01
1 L - 1	2	12:26:30	750	454	-0.001	0.003	0.001	0.000	0.000	0.000	0.00	0.01	0.01
1 L - 1	4	12:28:30	750	454	-0.003	0.001	-0.001	0.000	0.000	0.000	0.01	0.01	0.01
1 L - 1	8	12:32:30	750	454	0.000	0.003	0.002	0.000	0.000	0.000	0.01	0.01	0.01
1 L - 2	1	12:34:30	1,500	907	0.002	0.003	0.002	0.000	0.000	0.000	0.01	0.01	0.01
1 L - 2	2	12:35:30	1,500	907	0.001	0.004	0.003	0.000	0.000	0.000	0.01	0.01	0.01
1 L - 2	4	12:37:30	1,500	907	0.001	0.004	0.003	0.000	0.000	0.000	0.01	0.01	0.01
1 L - 2	8	12:41:30	1,500	907	0.003	0.004	0.003	0.000	0.000	0.000	0.01	0.01	0.01
1 L - 3	1	12:44:00	2,250	1,360	0.003	0.006	0.005	0.000	0.000	0.000	0.02	0.02	0.02
1 L - 3	2	12:45:00	2,250	1,360	0.006	0.006	0.005	0.000	0.000	0.000	0.02	0.02	0.02
1 L - 3	4	12:47:00	2,250	1,360	0.006	0.006	0.006	0.000	0.000	0.000	0.02	0.02	0.02
1 L - 3	8	12:51:00	2,250	1,360	0.008	0.006	0.007	0.000	0.000	0.000	0.02	0.02	0.02
1 L - 4	1	12:53:00	3,000	1,813	0.003	0.012	0.009	0.000	0.000	0.000	0.02	0.03	0.03
1 L - 4	2	12:54:00	3,000	1,813	0.006	0.010	0.010	0.000	0.000	0.000	0.02	0.03	0.03
1 L - 4	4	12:56:00	3,000	1,813	0.011	0.012	0.010	0.000	0.000	0.000	0.02	0.03	0.03
1 L - 4	8	13:00:00	3,000	1,813	0.005	0.016	0.011	0.000	0.001	0.000	0.03	0.03	0.03
1 L - 5	1	13:02:00	3,750	2,265	0.019	0.014	0.015	0.000	0.000	0.000	0.03	0.04	0.04
1 L - 5	2	13:03:00	3,750	2,265	0.015	0.017	0.015	0.000	0.000	0.000	0.03	0.04	0.04
1 L - 5	4	13:05:00	3,750	2,265	0.016	0.016	0.016	0.000	0.001	0.000	0.03	0.04	0.04
1 L - 5	8	13:09:00	3,750	2,265	0.016	0.016	0.016	0.000	0.000	0.000	0.03	0.04	0.04
1 L - 6	1	13:10:30	4,500	2,718	0.019	0.018	0.019	0.001	0.001	0.001	0.04	0.05	0.05
1 L - 6	2	13:11:30	4,500	2,718	0.020	0.023	0.019	0.001	0.001	0.001	0.04	0.05	0.05
1 L - 6	4	13:13:30	4,500	2,718	0.025	0.020	0.020	0.001	0.001	0.001	0.04	0.05	0.05
1 L - 6	8	13:17:30	4,500	2,718	0.019	0.022	0.021	0.001	0.001	0.001	0.05	0.06	0.05
1 L - 7	1	13:19:00	5,250	3,171	0.027	0.027	0.027	0.001	0.001	0.001	0.05	0.06	0.06
1 L - 7	2	13:20:00	5,250	3,171	0.030	0.028	0.028	0.001	0.001	0.001	0.05	0.07	0.06
1 L - 7	4	13:22:00	5,250	3,171	0.031	0.032	0.029	0.001	0.001	0.001	0.06	0.07	0.06
1 L - 7	8	13:26:00	5,250	3,171	0.032	0.030	0.030	0.001	0.001	0.001	0.06	0.07	0.06
1 L - 8	1	13:28:00	6,000	3,624	0.034	0.026	0.031	0.002	0.002	0.002	0.07	0.08	0.07
1 L - 8	2	13:29:00	6,000	3,624	0.027	0.033	0.034	0.003	0.004	0.003	0.07	0.08	0.07
1 L - 8	4	13:31:00	6,000	3,624	0.042	0.034	0.037	0.003	0.003	0.003	0.07	0.08	0.08
1 L - 8	8	13:35:00	6,000	3,624	0.036	0.043	0.041	0.003	0.004	0.003	0.07	0.09	0.08
1 L - 9	1	13:37:00	6,750	4,076	0.051	0.052	0.045	0.003	0.004	0.003	0.08	0.10	0.09
1 L - 9	2	13:38:00	6,750	4,076	0.045	0.051	0.047	0.003	0.004	0.003	0.08	0.10	0.09
1 L - 9	4	13:40:00	6,750	4,076	0.054	0.054	0.048	0.003	0.004	0.003	0.08	0.10	0.09
1 L - 9	8	13:44:00	6,750	4,076	0.052	0.053	0.050	0.003	0.003	0.003	0.09	0.11	0.10
1 L - 10	1	13:45:30	7,500	4,529	0.057	0.064	0.059	0.003	0.004	0.003	0.10	0.12	0.11
1 L - 10	2	13:46:30	7,500	4,529	0.058	0.076	0.061	0.003	0.004	0.004	0.10	0.12	0.11
1 L - 10	4	13:48:30	7,500	4,529	0.062	0.062	0.063	0.003	0.004	0.004	0.10	0.12	0.11
1 L - 10	8	13:52:30	7,500	4,529	0.062	0.063	0.065	0.004	0.004	0.004	0.10	0.13	0.12
1 L - 11	1	13:54:00	8,250	4,982	0.082	0.068	0.074	0.004	0.004	0.004	0.11	0.14	0.12
1 L - 11	2	13:55:00	8,250	4,982	0.080	0.068	0.076	0.004	0.005	0.004	0.12	0.14	0.13
1 L - 11	4	13:57:00	8,250	4,982	0.087	0.063	0.077	0.004	0.005	0.005	0.12	0.14	0.13
1 L - 11	8	14:01:00	8,250	4,982	0.078	0.070	0.078	0.005	0.005	0.005	0.12	0.15	0.13
1 L - 12	1	14:03:00	9,000	5,435	0.101	0.070	0.086	0.005	0.005	0.005	0.13	0.16	0.15
1 L - 12	2	14:04:00	9,000	5,435	0.088	0.085	0.089	0.005	0.005	0.005	0.13	0.16	0.15
1 L - 12	4	14:06:00	9,000	5,435	0.096	0.091	0.091	0.006	0.005	0.006	0.14	0.16	0.15
1 L - 12	8	14:10:00	9,000	5,435	0.090	0.097	0.094	0.006	0.005	0.006	0.14	0.17	0.16

Upward Top of Shaft Movement, Shaft Compression and O-cell Expansion
Test Shaft - I-80 over Missouri River - Council Bluffs, IA

Load Test Increment	Hold Time (minutes)	Time (hh:mm:ss)	O-cell Pressure (psi)	O-cell Load (kips)	Top of Shaft A - NA3000 (in)	Top of Shaft B - NA3000 (in)	Top of Shaft Average* (in)	Compression Telltales A - 08-1928 (in)	Compression Telltales B - 08-1926 (in)	Compression Telltales Average (in)	O-cell Expansion A - 08-6612 (in)	O-cell Expansion B - 08-6613 (in)	O-cell Expansion Average (in)
1 L - 13	1	14:12:00	9,750	5,888	0.107	0.108	0.107	0.006	0.005	0.006	0.15	0.18	0.17
1 L - 13	2	14:13:00	9,750	5,888	0.108	0.116	0.108	0.006	0.006	0.006	0.16	0.18	0.17
1 L - 13	4	14:15:00	9,750	5,888	0.106	0.109	0.109	0.007	0.006	0.006	0.16	0.19	0.17
1 L - 13	8	14:19:00	9,750	5,888	0.108	0.119	0.110	0.007	0.006	0.006	0.16	0.19	0.18
1 L - 14	1	14:20:30	10,500	6,340	0.127	0.119	0.120	0.007	0.006	0.006	0.17	0.20	0.19
1 L - 14	2	14:21:30	10,500	6,340	0.122	0.122	0.123	0.007	0.006	0.006	0.18	0.21	0.19
1 L - 14	4	14:23:30	10,500	6,340	0.129	0.126	0.126	0.007	0.006	0.006	0.18	0.21	0.20
1 L - 14	8	14:27:30	10,500	6,340	0.134	0.135	0.129	0.009	0.006	0.008	0.19	0.22	0.20
1 L - 15	1	14:29:30	11,250	6,793	0.142	0.144	0.142	0.009	0.006	0.007	0.20	0.23	0.21
1 L - 15	2	14:30:30	11,250	6,793	0.144	0.146	0.145	0.008	0.006	0.007	0.20	0.23	0.22
1 L - 15	4	14:32:30	11,250	6,793	0.146	0.151	0.150	0.008	0.006	0.007	0.21	0.24	0.22
1 L - 15	8	14:36:30	11,250	6,793	0.155	0.156	0.155	0.009	0.006	0.007	0.21	0.25	0.23
1 L - 16	1	14:38:30	12,000	7,246	0.164	0.172	0.167	0.010	0.007	0.008	0.23	0.26	0.24
1 L - 16	2	14:39:30	12,000	7,246	0.170	0.169	0.170	0.010	0.007	0.008	0.23	0.26	0.25
1 L - 16	4	14:41:30	12,000	7,246	0.169	0.179	0.175	0.010	0.007	0.008	0.23	0.27	0.25
1 L - 16	8	14:45:30	12,000	7,246	0.177	0.183	0.180	0.010	0.007	0.008	0.24	0.28	0.26
1 L - 17	1	14:47:00	12,750	7,699	0.186	0.193	0.201	0.010	0.006	0.008	0.26	0.30	0.28
1 L - 17	2	14:48:00	12,750	7,699	0.212	0.209	0.205	0.010	0.006	0.008	0.26	0.30	0.28
1 L - 17	4	14:50:00	12,750	7,699	0.205	0.209	0.210	0.010	0.006	0.008	0.27	0.31	0.29
1 L - 17	8	14:54:00	12,750	7,699	0.207	0.221	0.214	0.010	0.005	0.007	0.28	0.32	0.30
1 L - 18	1	14:56:00	13,500	8,151	0.234	0.233	0.233	0.010	0.005	0.007	0.30	0.34	0.32
1 L - 18	2	14:57:00	13,500	8,151	0.246	0.232	0.237	0.010	0.005	0.007	0.30	0.34	0.32
1 L - 18	4	14:59:00	13,500	8,151	0.244	0.243	0.243	0.010	0.005	0.007	0.31	0.35	0.33
1 L - 18	8	15:03:00	13,500	8,151	0.247	0.252	0.251	0.010	0.005	0.007	0.32	0.36	0.34
1 L - 19	1	15:05:30	14,250	8,604	0.274	0.276	0.272	0.010	0.005	0.008	0.34	0.38	0.36
1 L - 19	2	15:06:30	14,250	8,604	0.281	0.278	0.277	0.010	0.005	0.008	0.34	0.39	0.37
1 L - 19	4	15:08:30	14,250	8,604	0.284	0.282	0.285	0.010	0.005	0.008	0.35	0.40	0.38
1 L - 19	8	15:12:30	14,250	8,604	0.299	0.303	0.296	0.010	0.005	0.008	0.37	0.41	0.39
1 L - 20	1	15:15:00	15,000	9,057	0.319	0.321	0.314	0.012	0.005	0.008	0.39	0.44	0.41
1 L - 20	2	15:16:00	15,000	9,057	0.318	0.328	0.319	0.012	0.005	0.008	0.39	0.44	0.42
1 L - 20	4	15:18:00	15,000	9,057	0.325	0.328	0.328	0.012	0.005	0.008	0.40	0.45	0.42
1 L - 20	8	15:22:00	15,000	9,057	0.342	0.357	0.343	0.012	0.005	0.009	0.41	0.46	0.44
1 U - 1	1	15:23:30	12,000	7,246	0.348	0.335	0.342	0.012	0.002	0.007	0.40	0.45	0.42
1 U - 1	2	15:24:30	12,000	7,246	0.332	0.339	0.336	0.012	0.002	0.007	0.40	0.45	0.42
1 U - 1	4	15:26:30	12,000	7,246	0.323	0.335	0.329	0.012	0.002	0.007	0.40	0.45	0.42
1 U - 2	1	15:28:30	9,000	5,435	0.348	0.306	0.327	0.010	0.000	0.005	0.37	0.41	0.39
1 U - 2	2	15:29:30	9,000	5,435	0.321	0.307	0.314	0.010	0.000	0.005	0.37	0.41	0.39
1 U - 2	4	15:31:30	9,000	5,435	0.314	0.322	0.318	0.010	0.000	0.005	0.36	0.41	0.39
1 U - 3	1	15:33:30	6,000	3,624	0.288	0.283	0.286	0.007	-0.003	0.002	0.32	0.37	0.35
1 U - 3	2	15:34:30	6,000	3,624	0.292	0.280	0.286	0.007	-0.003	0.002	0.32	0.36	0.34
1 U - 3	4	15:36:30	6,000	3,624	0.276	0.279	0.278	0.007	-0.003	0.002	0.31	0.36	0.34
1 U - 4	1	15:38:30	3,000	1,813	0.216	0.259	0.238	0.003	-0.004	0.000	0.26	0.30	0.28
1 U - 4	2	15:39:30	3,000	1,813	0.233	0.239	0.236	0.003	-0.004	-0.001	0.25	0.29	0.27
1 U - 4	4	15:41:30	3,000	1,813	0.229	0.239	0.234	0.001	-0.005	-0.002	0.25	0.29	0.27
1 U - 5	1	15:43:00	0	0	0.159	0.169	0.164	-0.002	-0.005	-0.003	0.18	0.19	0.19
1 U - 5	2	15:44:00	0	0	0.158	0.152	0.155	-0.002	-0.005	-0.003	0.17	0.19	0.18
1 U - 5	4	15:46:00	0	0	0.139	0.137	0.138	-0.002	-0.005	-0.003	0.16	0.18	0.17
1 U - 5	8	15:50:00	0	0	0.142	0.146	0.144	-0.002	-0.005	-0.003	0.15	0.17	0.16

* Average Top of Shaft data is smoothed using curve-fit to the raw data

O-cell Plate Movements and Creep (calculated)
Test Shaft - I-80 over Missouri River - Council Bluffs, IA

Load Test Increment	Hold Time (minutes)	Time (hh:mm:ss)	O-cell Pressure (psi)	O-cell Load (kips)	Top of Shaft Movement (in)	Total Comp. (in)	Upward Movement (in)	O-cell Expansion (in)	Downward Movement (in)	Creep Up Per Hold (in)	Creep Dn Per Hold (in)
1L-0	-	12:07:00	0	0	0.000	0.000	0.000	0.000	0.000		
1L-1	1	12:25:30	750	454	0.001	0.000	0.001	0.006	-0.004		
1L-1	2	12:26:30	750	454	0.001	0.000	0.001	0.006	-0.005		
1L-1	4	12:28:30	750	454	-0.001	0.000	-0.001	0.006	-0.007		
1L-1	8	12:32:30	750	454	0.002	0.000	0.001	0.006	-0.005	0.002	0.000
1L-2	1	12:34:30	1,500	907	0.002	0.000	0.002	0.011	-0.008		
1L-2	2	12:35:30	1,500	907	0.003	0.000	0.003	0.011	-0.008		
1L-2	4	12:37:30	1,500	907	0.003	0.000	0.003	0.012	-0.009		
1L-2	8	12:41:30	1,500	907	0.003	0.000	0.003	0.012	-0.009	0.000	0.000
1L-3	1	12:44:00	2,250	1,360	0.005	0.000	0.005	0.018	-0.013		
1L-3	2	12:45:00	2,250	1,360	0.005	0.000	0.005	0.018	-0.013		
1L-3	4	12:47:00	2,250	1,360	0.006	0.000	0.006	0.019	-0.013		
1L-3	8	12:51:00	2,250	1,360	0.007	0.000	0.007	0.020	-0.013	0.001	0.000
1L-4	1	12:53:00	3,000	1,813	0.009	0.000	0.009	0.026	-0.018		
1L-4	2	12:54:00	3,000	1,813	0.010	0.000	0.010	0.027	-0.017		
1L-4	4	12:56:00	3,000	1,813	0.010	0.000	0.011	0.028	-0.017		
1L-4	8	13:00:00	3,000	1,813	0.011	0.000	0.012	0.030	-0.018	0.001	0.001
1L-5	1	13:02:00	3,750	2,265	0.015	0.000	0.015	0.036	-0.021		
1L-5	2	13:03:00	3,750	2,265	0.015	0.000	0.016	0.037	-0.021		
1L-5	4	13:05:00	3,750	2,265	0.016	0.000	0.016	0.038	-0.022		
1L-5	8	13:09:00	3,750	2,265	0.016	0.000	0.016	0.040	-0.023	0.000	0.001
1L-6	1	13:10:30	4,500	2,718	0.019	0.001	0.020	0.046	-0.027		
1L-6	2	13:11:30	4,500	2,718	0.019	0.001	0.020	0.048	-0.027		
1L-6	4	13:13:30	4,500	2,718	0.020	0.001	0.021	0.049	-0.028		
1L-6	8	13:17:30	4,500	2,718	0.021	0.001	0.022	0.051	-0.029	0.001	0.001
1L-7	1	13:19:00	5,250	3,171	0.027	0.001	0.028	0.059	-0.031		
1L-7	2	13:20:00	5,250	3,171	0.028	0.001	0.029	0.060	-0.031		
1L-7	4	13:22:00	5,250	3,171	0.029	0.001	0.030	0.062	-0.032		
1L-7	8	13:26:00	5,250	3,171	0.030	0.001	0.032	0.064	-0.033	0.002	0.001
1L-8	1	13:28:00	6,000	3,624	0.031	0.002	0.033	0.073	-0.040		
1L-8	2	13:29:00	6,000	3,624	0.034	0.003	0.037	0.075	-0.038		
1L-8	4	13:31:00	6,000	3,624	0.037	0.003	0.040	0.077	-0.037		
1L-8	8	13:35:00	6,000	3,624	0.041	0.003	0.044	0.080	-0.035	0.004	0.000
1L-9	1	13:37:00	6,750	4,076	0.045	0.003	0.048	0.088	-0.040		
1L-9	2	13:38:00	6,750	4,076	0.047	0.003	0.050	0.090	-0.041		
1L-9	4	13:40:00	6,750	4,076	0.048	0.003	0.052	0.093	-0.041		
1L-9	8	13:44:00	6,750	4,076	0.050	0.003	0.053	0.096	-0.043	0.001	0.002
1L-10	1	13:45:30	7,500	4,529	0.059	0.003	0.062	0.106	-0.044		
1L-10	2	13:46:30	7,500	4,529	0.061	0.004	0.064	0.108	-0.044		
1L-10	4	13:48:30	7,500	4,529	0.063	0.004	0.067	0.111	-0.045		
1L-10	8	13:52:30	7,500	4,529	0.065	0.004	0.069	0.115	-0.046	0.002	0.002
1L-11	1	13:54:00	8,250	4,982	0.074	0.004	0.078	0.125	-0.046		
1L-11	2	13:55:00	8,250	4,982	0.076	0.004	0.080	0.127	-0.047		
1L-11	4	13:57:00	8,250	4,982	0.077	0.005	0.081	0.131	-0.049		
1L-11	8	14:01:00	8,250	4,982	0.078	0.005	0.082	0.134	-0.052	0.001	0.003
1L-12	1	14:03:00	9,000	5,435	0.086	0.005	0.091	0.145	-0.054		
1L-12	2	14:04:00	9,000	5,435	0.089	0.005	0.093	0.147	-0.054		
1L-12	4	14:06:00	9,000	5,435	0.091	0.006	0.097	0.150	-0.053		
1L-12	8	14:10:00	9,000	5,435	0.094	0.006	0.099	0.155	-0.056	0.002	0.002

O-cell Plate Movements and Creep (calculated)
Test Shaft - I-80 over Missouri River - Council Bluffs, IA

Load Test Increment	Hold Time (minutes)	Time (hh:mm:ss)	O-cell Pressure (psi)	O-cell Load (kips)	Top of Shaft Movement (in)	Total Comp. (in)	Upward Movement (in)	O-cell Expansion (in)	Downward Movement (in)	Creep Up Per Hold (in)	Creep Dn Per Hold (in)
1 L - 13	1	14:12:00	9,750	5,888	0.107	0.006	0.113	0.167	-0.055		
1 L - 13	2	14:13:00	9,750	5,888	0.108	0.006	0.114	0.170	-0.056		
1 L - 13	4	14:15:00	9,750	5,888	0.109	0.006	0.116	0.173	-0.058		
1 L - 13	8	14:19:00	9,750	5,888	0.110	0.006	0.116	0.178	-0.062	0.001	0.004
1 L - 14	1	14:20:30	10,500	6,340	0.120	0.006	0.126	0.189	-0.063		
1 L - 14	2	14:21:30	10,500	6,340	0.123	0.006	0.129	0.192	-0.063		
1 L - 14	4	14:23:30	10,500	6,340	0.126	0.006	0.132	0.196	-0.064		
1 L - 14	8	14:27:30	10,500	6,340	0.129	0.008	0.137	0.203	-0.066	0.005	0.002
1 L - 15	1	14:29:30	11,250	6,793	0.142	0.007	0.150	0.215	-0.065		
1 L - 15	2	14:30:30	11,250	6,793	0.145	0.007	0.153	0.218	-0.065		
1 L - 15	4	14:32:30	11,250	6,793	0.150	0.007	0.157	0.223	-0.066		
1 L - 15	8	14:36:30	11,250	6,793	0.155	0.007	0.162	0.230	-0.068	0.005	0.002
1 L - 16	1	14:38:30	12,000	7,246	0.167	0.008	0.175	0.244	-0.068		
1 L - 16	2	14:39:30	12,000	7,246	0.170	0.008	0.179	0.247	-0.069		
1 L - 16	4	14:41:30	12,000	7,246	0.175	0.008	0.183	0.253	-0.070		
1 L - 16	8	14:45:30	12,000	7,246	0.180	0.008	0.188	0.263	-0.074	0.005	0.004
1 L - 17	1	14:47:00	12,750	7,699	0.201	0.008	0.208	0.277	-0.068		
1 L - 17	2	14:48:00	12,750	7,699	0.205	0.008	0.213	0.281	-0.068		
1 L - 17	4	14:50:00	12,750	7,699	0.210	0.008	0.218	0.288	-0.071		
1 L - 17	8	14:54:00	12,750	7,699	0.214	0.007	0.222	0.300	-0.078	0.004	0.007
1 L - 18	1	14:56:00	13,500	8,151	0.233	0.007	0.240	0.318	-0.077		
1 L - 18	2	14:57:00	13,500	8,151	0.237	0.007	0.244	0.322	-0.078		
1 L - 18	4	14:59:00	13,500	8,151	0.243	0.007	0.251	0.329	-0.078		
1 L - 18	8	15:03:00	13,500	8,151	0.251	0.007	0.258	0.341	-0.083	0.008	0.005
1 L - 19	1	15:05:30	14,250	8,604	0.272	0.008	0.280	0.362	-0.082		
1 L - 19	2	15:06:30	14,250	8,604	0.277	0.008	0.285	0.367	-0.083		
1 L - 19	4	15:08:30	14,250	8,604	0.285	0.008	0.293	0.376	-0.083		
1 L - 19	8	15:12:30	14,250	8,604	0.296	0.008	0.304	0.389	-0.085	0.012	0.002
1 L - 20	1	15:15:00	15,000	9,057	0.314	0.008	0.322	0.411	-0.089		
1 L - 20	2	15:16:00	15,000	9,057	0.319	0.008	0.327	0.417	-0.090		
1 L - 20	4	15:18:00	15,000	9,057	0.328	0.008	0.336	0.422	-0.085		
1 L - 20	8	15:22:00	15,000	9,057	0.343	0.009	0.352	0.439	-0.088	0.015	0.002
1 U - 1	1	15:23:30	12,000	7,246	0.342	0.007	0.349	0.423	-0.075		
1 U - 1	2	15:24:30	12,000	7,246	0.336	0.007	0.343	0.421	-0.079		
1 U - 1	4	15:26:30	12,000	7,246	0.329	0.007	0.336	0.421	-0.085		
1 U - 2	1	15:28:30	9,000	5,435	0.327	0.005	0.332	0.392	-0.060		
1 U - 2	2	15:29:30	9,000	5,435	0.314	0.005	0.319	0.389	-0.071		
1 U - 2	4	15:31:30	9,000	5,435	0.318	0.005	0.323	0.387	-0.064		
1 U - 3	1	15:33:30	6,000	3,624	0.286	0.002	0.288	0.345	-0.057		
1 U - 3	2	15:34:30	6,000	3,624	0.286	0.002	0.288	0.341	-0.053		
1 U - 3	4	15:36:30	6,000	3,624	0.278	0.002	0.280	0.337	-0.057		
1 U - 4	1	15:38:30	3,000	1,813	0.238	0.000	0.237	0.277	-0.040		
1 U - 4	2	15:39:30	3,000	1,813	0.236	-0.001	0.235	0.272	-0.037		
1 U - 4	4	15:41:30	3,000	1,813	0.234	-0.002	0.232	0.266	-0.034		
1 U - 5	1	15:43:00	0	0	0.164	-0.003	0.161	0.185	-0.025		
1 U - 5	2	15:44:00	0	0	0.155	-0.003	0.152	0.179	-0.027		
1 U - 5	4	15:46:00	0	0	0.138	-0.003	0.135	0.171	-0.036		
1 U - 5	8	15:50:00	0	0	0.144	-0.003	0.141	0.162	-0.022		

Strain Gauge Readings and Loads at Levels 1 and 2
Test Shaft - I-80 over Missouri River - Council Bluffs, IA

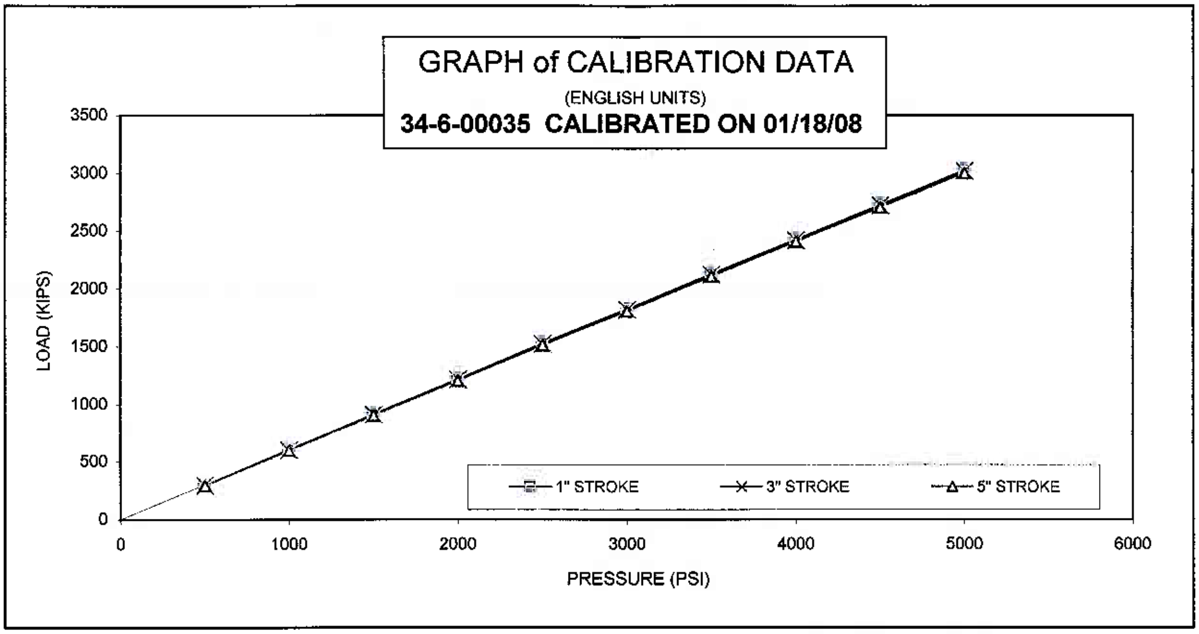
Load Test Increment	Hold Time (minutes)	Time (hh:mm:ss)	O-cell Pressure (psi)	O-cell Load (kips)	Level 1 1A - 08-7476 (με)	Level 1 1B - 08-7479 (με)	Level 1 Av. Strain (με)	Level 1 Av. Load (kips)	Level 2 2A - 08-7478 (με)	Level 2 2B - 08-7477 (με)	Level 2 Av. Strain (με)	Level 2 Av. Load (kips)
1 L - 0	-	12:07:00	0	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0
1 L - 1	1	12:25:30	750	454	4.9	3.0	4.0	52	0.4	0.2	0.3	6
1 L - 1	2	12:26:30	750	454	5.0	3.1	4.1	53	0.5	0.3	0.4	7
1 L - 1	4	12:28:30	750	454	5.1	2.8	4.0	52	0.4	0.3	0.4	7
1 L - 1	8	12:32:30	750	454	5.3	3.5	4.4	57	0.4	0.5	0.4	9
1 L - 2	1	12:34:30	1,500	907	9.5	6.3	7.9	103	0.7	0.7	0.7	15
1 L - 2	2	12:35:30	1,500	907	9.6	6.5	8.0	105	0.6	0.8	0.7	13
1 L - 2	4	12:37:30	1,500	907	9.7	6.7	8.2	107	0.7	0.7	0.7	14
1 L - 2	8	12:41:30	1,500	907	10.1	6.9	8.5	111	0.6	0.8	0.7	14
1 L - 3	1	12:44:00	2,250	1,360	13.9	10.1	12.0	157	0.9	1.3	1.1	21
1 L - 3	2	12:45:00	2,250	1,360	14.0	10.3	12.1	159	0.9	1.3	1.1	21
1 L - 3	4	12:47:00	2,250	1,360	14.4	10.7	12.5	163	1.0	1.4	1.2	23
1 L - 3	8	12:51:00	2,250	1,360	14.7	10.6	12.7	165	0.8	1.3	1.0	20
1 L - 4	1	12:53:00	3,000	1,813	18.5	13.8	16.2	211	1.3	1.7	1.5	30
1 L - 4	2	12:54:00	3,000	1,813	18.8	14.0	16.4	214	1.4	1.9	1.6	32
1 L - 4	4	12:56:00	3,000	1,813	18.9	14.5	16.7	218	1.4	1.8	1.6	32
1 L - 4	8	13:00:00	3,000	1,813	19.3	14.4	16.8	220	1.4	1.7	1.5	30
1 L - 5	1	13:02:00	3,750	2,265	22.6	18.2	20.4	266	1.8	2.0	1.9	38
1 L - 5	2	13:03:00	3,750	2,265	22.8	18.5	20.6	269	1.7	2.0	1.9	37
1 L - 5	4	13:05:00	3,750	2,265	22.8	18.6	20.7	270	1.8	2.4	2.1	41
1 L - 5	8	13:09:00	3,750	2,265	22.9	19.3	21.1	276	1.7	2.4	2.1	40
1 L - 6	1	13:10:30	4,500	2,718	25.9	22.8	24.4	318	2.0	2.7	2.4	46
1 L - 6	2	13:11:30	4,500	2,718	26.3	23.3	24.8	324	2.0	2.9	2.4	47
1 L - 6	4	13:13:30	4,500	2,718	26.4	23.8	25.1	328	2.1	2.7	2.4	47
1 L - 6	8	13:17:30	4,500	2,718	26.5	24.0	25.2	329	2.1	2.8	2.5	49
1 L - 7	1	13:19:00	5,250	3,171	29.6	27.6	28.6	373	2.4	3.5	3.0	58
1 L - 7	2	13:20:00	5,250	3,171	29.6	28.0	28.8	376	2.5	3.6	3.1	60
1 L - 7	4	13:22:00	5,250	3,171	29.7	28.4	29.1	379	2.6	3.4	3.0	59
1 L - 7	8	13:26:00	5,250	3,171	30.1	28.8	29.5	385	2.6	3.7	3.2	62
1 L - 8	1	13:28:00	6,000	3,624	32.9	32.0	32.4	424	2.7	4.0	3.4	66
1 L - 8	2	13:29:00	6,000	3,624	32.9	32.8	32.8	429	2.8	4.0	3.4	66
1 L - 8	4	13:31:00	6,000	3,624	33.1	32.9	33.0	430	2.8	4.1	3.4	67
1 L - 8	8	13:35:00	6,000	3,624	33.1	33.5	33.3	435	2.8	4.2	3.5	69
1 L - 9	1	13:37:00	6,750	4,076	35.7	36.6	36.2	472	3.1	4.7	3.9	77
1 L - 9	2	13:38:00	6,750	4,076	35.8	37.3	36.5	477	3.2	4.7	4.0	78
1 L - 9	4	13:40:00	6,750	4,076	35.7	37.5	36.6	478	3.1	4.9	4.0	78
1 L - 9	8	13:44:00	6,750	4,076	35.8	38.1	36.9	482	2.9	4.8	3.8	75
1 L - 10	1	13:45:30	7,500	4,529	38.0	41.5	39.8	519	3.1	5.3	4.2	82
1 L - 10	2	13:46:30	7,500	4,529	37.8	42.0	39.9	521	3.2	5.2	4.2	83
1 L - 10	4	13:48:30	7,500	4,529	37.8	42.4	40.1	524	3.1	5.4	4.2	83
1 L - 10	8	13:52:30	7,500	4,529	38.1	43.0	40.5	529	3.0	5.2	4.1	80
1 L - 11	1	13:54:00	8,250	4,982	40.1	46.0	43.0	562	3.0	5.9	4.4	87
1 L - 11	2	13:55:00	8,250	4,982	40.0	46.7	43.3	566	3.1	5.8	4.5	87
1 L - 11	4	13:57:00	8,250	4,982	39.8	47.2	43.5	568	3.1	5.9	4.5	88
1 L - 11	8	14:01:00	8,250	4,982	39.7	47.5	43.6	569	2.8	5.8	4.3	85
1 L - 12	1	14:03:00	9,000	5,435	41.6	51.0	46.3	605	2.8	6.2	4.5	89
1 L - 12	2	14:04:00	9,000	5,435	41.6	51.6	46.6	608	2.8	6.3	4.6	89
1 L - 12	4	14:06:00	9,000	5,435	41.3	51.8	46.5	607	2.9	6.3	4.6	90
1 L - 12	8	14:10:00	9,000	5,435	41.3	52.0	46.7	609	2.8	6.5	4.7	91

Strain Gauge Readings and Loads at Levels 1 and 2
Test Shaft - I-80 over Missouri River - Council Bluffs, IA

Load Test Increment	Hold Time (minutes)	Time (hh:mm:ss)	O-cell Pressure (psi)	O-cell Load (kips)	Level 1 1A - 08-7476 (με)	Level 1 1B - 08-7479 (με)	Level 1 Av. Strain (με)	Level 1 Av. Load (kips)	Level 2 2A - 08-7478 (με)	Level 2 2B - 08-7477 (με)	Level 2 Av. Strain (με)	Level 2 Av. Load (kips)
1 L - 13	1	14:12:00	9,750	5,888	43.6	55.5	49.6	647	2.7	6.7	4.7	92
1 L - 13	2	14:13:00	9,750	5,888	43.7	55.7	49.7	649	2.6	7.0	4.8	94
1 L - 13	4	14:15:00	9,750	5,888	43.4	55.9	49.7	648	2.7	6.9	4.8	94
1 L - 13	8	14:19:00	9,750	5,888	43.6	56.7	50.2	655	2.4	7.1	4.8	94
1 L - 14	1	14:20:30	10,500	6,340	45.9	59.7	52.8	689	2.4	7.1	4.8	93
1 L - 14	2	14:21:30	10,500	6,340	45.9	59.9	52.9	690	2.4	7.3	4.8	95
1 L - 14	4	14:23:30	10,500	6,340	45.5	60.7	53.1	693	2.4	7.4	4.9	96
1 L - 14	8	14:27:30	10,500	6,340	45.2	61.7	53.4	697	2.3	7.4	4.9	95
1 L - 15	1	14:29:30	11,250	6,793	47.1	64.4	55.8	728	2.0	7.7	4.9	95
1 L - 15	2	14:30:30	11,250	6,793	47.0	64.7	55.8	729	2.1	7.6	4.9	95
1 L - 15	4	14:32:30	11,250	6,793	46.8	65.6	56.2	734	2.0	7.7	4.9	96
1 L - 15	8	14:36:30	11,250	6,793	46.5	66.6	56.5	738	1.8	7.6	4.7	93
1 L - 16	1	14:38:30	12,000	7,246	48.5	69.2	58.9	768	1.7	7.7	4.7	92
1 L - 16	2	14:39:30	12,000	7,246	48.1	69.7	58.9	769	1.7	7.8	4.7	93
1 L - 16	4	14:41:30	12,000	7,246	47.1	71.6	59.3	775	1.5	7.9	4.7	93
1 L - 16	8	14:45:30	12,000	7,246	45.3	73.3	59.3	774	1.1	8.3	4.7	92
1 L - 17	1	14:47:00	12,750	7,699	46.2	77.0	61.6	804	0.7	8.5	4.6	91
1 L - 17	2	14:48:00	12,750	7,699	45.5	77.7	61.6	804	0.6	8.9	4.7	92
1 L - 17	4	14:50:00	12,750	7,699	43.7	78.9	61.3	800	0.3	8.9	4.6	90
1 L - 17	8	14:54:00	12,750	7,699	42.1	80.0	61.0	797	0.2	8.9	4.6	89
1 L - 18	1	14:56:00	13,500	8,151	43.7	82.6	63.2	824	-0.1	9.1	4.5	88
1 L - 18	2	14:57:00	13,500	8,151	43.1	82.8	63.0	822	-0.2	9.2	4.5	89
1 L - 18	4	14:59:00	13,500	8,151	42.7	83.4	63.0	823	-0.3	9.2	4.5	88
1 L - 18	8	15:03:00	13,500	8,151	41.9	84.5	63.2	825	-0.5	9.5	4.5	87
1 L - 19	1	15:05:30	14,250	8,604	43.5	86.9	65.2	852	-1.0	9.7	4.4	86
1 L - 19	2	15:06:30	14,250	8,604	43.5	87.2	65.3	853	-0.9	9.8	4.5	87
1 L - 19	4	15:08:30	14,250	8,604	43.3	87.6	65.4	854	-1.1	10.0	4.4	87
1 L - 19	8	15:12:30	14,250	8,604	42.8	88.4	65.6	856	-1.5	10.3	4.4	86
1 L - 20	1	15:15:00	15,000	9,057	45.4	90.9	68.1	889	-1.9	10.6	4.3	85
1 L - 20	2	15:16:00	15,000	9,057	45.5	91.2	68.3	892	-1.9	10.6	4.4	86
1 L - 20	4	15:18:00	15,000	9,057	45.1	91.0	68.1	889	-2.0	10.7	4.3	85
1 L - 20	8	15:22:00	15,000	9,057	46.1	92.5	69.3	905	-2.3	10.8	4.2	83
1 U - 1	1	15:23:30	12,000	7,246	31.5	83.0	57.3	748	-2.6	10.7	4.0	79
1 U - 1	2	15:24:30	12,000	7,246	31.6	83.0	57.3	748	-2.7	10.5	3.9	77
1 U - 1	4	15:26:30	12,000	7,246	31.6	83.3	57.5	750	-2.5	10.8	4.1	81
1 U - 2	1	15:28:30	9,000	5,435	18.9	70.7	44.8	585	-2.2	10.4	4.1	80
1 U - 2	2	15:29:30	9,000	5,435	18.1	70.1	44.1	576	-2.5	10.2	3.8	75
1 U - 2	4	15:31:30	9,000	5,435	18.2	69.9	44.1	575	-2.5	10.0	3.8	74
1 U - 3	1	15:33:30	6,000	3,624	6.9	55.0	30.9	404	-2.5	9.3	3.4	67
1 U - 3	2	15:34:30	6,000	3,624	6.6	54.1	30.3	396	-2.7	9.4	3.3	66
1 U - 3	4	15:36:30	6,000	3,624	6.9	54.1	30.5	398	-2.6	9.3	3.4	66
1 U - 4	1	15:38:30	3,000	1,813	-1.4	35.8	17.2	224	-2.7	8.6	3.0	58
1 U - 4	2	15:39:30	3,000	1,813	-0.9	35.3	17.2	225	-2.6	8.3	2.9	56
1 U - 4	4	15:41:30	3,000	1,813	-0.4	35.9	17.8	232	-2.6	8.3	2.9	56
1 U - 5	1	15:43:00	0	0	-7.0	14.6	3.8	49	-2.2	6.1	2.0	38
1 U - 5	2	15:44:00	0	0	-6.5	15.3	4.4	57	-1.9	6.0	2.0	40
1 U - 5	4	15:46:00	0	0	-5.6	16.6	5.5	72	-1.9	5.7	1.9	38
1 U - 5	8	15:50:00	0	0	-4.8	18.0	6.6	86	-1.6	5.7	2.0	40

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	297	297	297
1000	603	600	598
1500	913	911	906
2000	1215	1214	1205
2500	1525	1521	1512
3000	1822	1816	1804
3500	2128	2120	2107
4000	2426	2418	2408
4500	2725	2720	2703
5000	3025	3015	2999

34" O-CELL, SERIAL # 34-6-00035

LOAD CONVERSION FORMULA

LOAD = PRESSURE * 0.6037 + (1.52)
{KIPS} {PSI}

Regression Output:

Constant	1.5155	kips
X Coefficient	0.6037	kip / psi
R Square	0.9999	
No. of Observations	30	
Degrees of Freedom	28	
Std Err of Y Est	8.51	
Std Err of X Coeff	0.0011	

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.: JENSEN CONSTRUCTION
* AE & FC JOB NO: SO3463	* JOB LOCATION: DES MOINES, IA
* CUSTOMER P.O. NO.: LT-9433	* DATED: 04/08/08

SERVICE ENGINEER: ______ DATE: 4-9-08

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

Vibrating Wire Displacement Transducer Calibration Report

Range: 150 mm

Serial Number: 08-6612

Calibration Date: April 4, 2008

Temperature: 25.1 °C

Calibration Instruction: CI-4400

Technician: Erica

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	2642	2639	2641	-0.09	-0.06	0.00	0.00
30.0	3578	3578	3578	30.00	0.00	29.98	-0.01
60.0	4514	4517	4516	60.10	0.06	60.02	0.02
90.0	5451	5449	5450	90.10	0.06	90.02	0.01
120.0	6380	6381	6381	119.96	-0.02	119.95	-0.04
150.0	7313	7315	7314	149.93	-0.05	150.02	0.02

(mm) Linear Gage Factor (G): 0.03210 (mm/ digit) **Regression Zero: 2643**

Polynomial Gage Factors: A: 3.14928E-08 B: 0.03179 C: -84.154

(inches) Linear Gage Factor (G): 0.001264 (inches/ digit)

Polynomial Gage Factors: A: 1.23987E-09 B: 0.001251 C: -3.3131

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 : 5013 Temp(T_0): 23.9 °C Date: April 10, 2008

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: 08-6613

Calibration Date: April 4, 2008

Temperature: 25.1 °C

Calibration Instruction: CI-4400

Technician: Elise

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	2612	2611	2612	-0.23	-0.16	0.02	0.01
30.0	3560	3560	3560	30.01	0.01	29.96	-0.03
60.0	4508	4506	4507	60.21	0.14	60.01	0.00
90.0	5449	5448	5449	90.23	0.15	90.03	0.02
120.0	6383	6383	6383	120.03	0.02	119.98	-0.01
150.0	7315	7315	7315	149.75	-0.17	150.00	0.00

(mm) Linear Gage Factor (G): 0.03189 (mm/ digit) **Regression Zero: 2619**

Polynomial Gage Factors: **A: 8.52455E-08** **B: 0.03104** **C: -81.627**

(inches) Linear Gage Factor (G): 0.001255 (inches/ digit)

Polynomial Gage Factors: **A: 3.35612E-09** **B: 0.001222** **C: -3.2136**

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 : 4987 Temp(T_0): 23.5 °C Date: April 10, 2008

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: April 4, 2008

Serial Number: 08-7477

Cable Length: 101 ft.

Prestress: 35,000 psi

Factory Zero Reading: 6931

Temperature: 23.7 °C

Regression Zero: 6931

Calibration Instruction: CI-VW Rebar

Technician: Elice

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	6988	6987	6988		
1,500	7649	7648	7649	661	-0.09
3,000	8356	8357	8357	708	-0.50
4,500	9097	9096	9097	740	0.19
6,000	9815	9815	9815	719	0.14
100	6988				

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: April 4, 2008

Serial Number: 08-7478

Cable Length: 96 ft.

Prestress: 35,000 psi

Factory Zero Reading: 6772

Temperature: 23.8 °C

Regression Zero: 6778

Calibration Instruction: CI-VW Rebar

Technician: Erica

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	6839	6833	6836		
1,500	7522	7518	7520	684	-0.27
3,000	8280	8276	8278	758	-0.01
4,500	9031	9026	9029	751	-0.01
6,000	9785	9780	9783	754	0.12
100	6834				

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

Gage Factor: 0.340 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: April 4, 2008

Serial Number: 08-7476

Cable Length: 101 ft.

Prestress: 35,000 psi

Factory Zero Reading: 6896

Temperature: 23.7 °C

Regression Zero: 6912

Calibration Instruction: CI-VW Rebar

Technician: Erica

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	6972	6973	6973		
1,500	7642	7640	7641	669	-0.25
3,000	8381	8375	8378	737	-0.23
4,500	9121	9119	9120	742	-0.03
6,000	9865	9865	9865	745	0.26
100	6973				

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

Serial Number: 08-7479

Prestress: 35,000 psi

Temperature: 24.2 °C

Calibration Instruction: CI-VW Rebar

Date of Calibration: April 4, 2008

Cable Length: 96 ft.

Factory Zero Reading: 6783

Regression Zero: 6792

Technician: Erica

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	6851	6852	6852		
1,500	7514	7515	7515	663	-0.44
3,000	8262	8264	8263	749	0.01
4,500	8999	9000	9000	737	0.04
6,000	9736	9737	9737	737	0.10
100	6851				

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.

APPENDIX C

CONSTRUCTION OF THE EQUIVALENT TOP-LOADED LOAD-SETTLEMENT CURVE

CONSTRUCTION OF THE EQUIVALENT TOP-LOADED LOAD-SETTLEMENT CURVE FROM THE RESULTS OF AN O-CELL TEST (August, 2000)

Introduction: Some engineers find it useful to see the results of an O-cell load test in the form of a curve showing the load versus settlement of a top-loaded driven or bored pile (drilled shaft). We believe that an O-cell test can provide a good estimate of this curve when using the method described herein.

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

1. The end bearing load-movement curve in a top-loaded shaft has the same loads for a given movement as the net (subtract buoyant weight of pile above O-cell) end bearing load-movement curve developed by the bottom of the O-cell when placed at or near the bottom of the shaft.

2. The side shear load-movement curve in a top-loaded shaft has the same net shear, multiplied by an adjustment factor 'F', for a given downward movement as occurred in the O-cell test for that same movement at the top of the cell in the upward direction. The same applies to the upward movement in a top-loaded tension test. 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.

3. We initially assume the pile behaves as a rigid body, but include the elastic compressions that are part of the movement data obtained from an O-cell test (OLT). Using this assumption, we construct an equivalent top-load test (TLT) movement curve by the method described below in Procedure Part I. We then use the following Procedure Part II to correct for the effects of the additional elastic compressions in a TLT.

4. Consider the case with the O-cell, or the bottom O-cell of more than one level of cells, placed some distance above the bottom of the shaft. We assume the part of the shaft below the cell, now top-loaded, has the same load-movement behavior as when top-loading the entire shaft. For this case the subsequent "end bearing movement curve" refers to the movement of the entire length of shaft below the cell.

Procedure Part I: Please refer to the attached Figure A showing O-cell test results and to Figure B, the constructed equivalent top loaded settlement curve. Note that each of the curves shown has points numbered from 1 to 12 such that the same point number on each curve has the same magnitude of movement. For example, point 4 has an upward and downward movement of 0.40 inches in Figure A and the same 0.40 inches downward in Figure B.

Note: This report shows the O-cell movement data in a Figure similar to Fig. A, but uses the gross loads as obtained in the field. Fig. A uses net loads to make it easier for the reader to convert Fig. A into Fig. B without the complication of first converting gross to net loads. For conservative reconstruction of the top loaded settlement curve we first convert both of the O-cell components to net load.

Using the above assumptions, construct the equivalent curve as follows: Select an arbitrary movement such as the 0.40 inches to give point 4 on the shaft side shear load movement curve in Figure A and record the 2,090 ton load in shear at that movement. Because we have initially assumed a rigid pile, the top of pile moves downward the same as the bottom. Therefore, find point 4 with 0.40 inches of upward movement on the end bearing load movement curve and record the corresponding load of 1,060 tons. Adding these two loads will give the total load of 3,150 tons due to side shear plus end bearing at the same movement and thus gives point 4 on the Figure B load settlement curve for an equivalent top-loaded test.

One can use the above procedure to obtain all the points in Figure B up to the component that moved the least at the end of the test, in this case point 5 in side shear. To take advantage of the fact that the test produced end bearing movement data up to point 12, we need to make an extrapolation of the side shear curve. We usually use a convenient and suitable hyperbolic curve fitting technique for this extrapolation. Deciding on the maximum number of data points to provide a good fit (a high r^2 correlation coefficient) requires some judgment. In this case we omitted point 1 to give an $r^2 = 0.999$ (including point 1 gave an $r^2 = 0.966$) with the result shown as points 6 to 12 on the dotted extension of the measured side shear curve. Using the same movement matching procedure described earlier we can then extend the equivalent curve to points 6 to 12. The results, shown in Figure B as a dashed line, signify that this part of the equivalent curve depends partly on extrapolated data.

Sometimes, if the data warrants, we will use extrapolations of both side shear and end bearing to extend the equivalent curve to a greater movement than the maximum measured (point 12). An appendix in this report gives the details of the extrapolation(s) used with the present O-cell test and shows the fit with the actual data.

Procedure Part II: The elastic compression in the equivalent top load test always exceeds that in the O-cell test. It not only produces more top movement, but also additional side shear movement, which then generates more side shear, which produces more compression, etc . . . An exact solution of this load transfer problem requires knowing the side shear vs. vertical movement (t-y) curves for a large number of pile length increments and solving the resulting set of simultaneous equations or using finite element or finite difference simulations to obtain an approximate solution for these equations. We usually do not have the data to obtain the many accurate t-y curves required. Fortunately, the approximate solution described below usually suffices.

The attached analysis p. 6 gives the equations for the elastic compressions that occur in the OLT with one or two levels of O-cells. Analysis p. 7 gives the equations for the elastic compressions that occur in the equivalent TLT. Both sets of equations do not include the elastic compression below the O-cell because the same compression takes place in both the OLT and the TLT. This is equivalent to taking $L_3 = 0$. Subtracting the OLT from the TLT compression gives the desired additional elastic compression at the top of the TLT. We then add the additional elastic compression to the 'rigid' equivalent curve obtained from Part I to obtain the final, corrected equivalent load-settlement curve for the TLT on the same pile as the actual OLT.

Note that the above pp. 6 and 7 give equations for each of three assumed patterns of developed side shear stress along the pile. The pattern shown in the center of the three applies to any approximately determined side shear distribution. Experience has shown the initial solution for the additional elastic compression, as described above, gives an adequate and slightly conservative (high) estimate of the additional compression versus more sophisticated load-transfer analyses as described in the first paragraph of this Part II.

The analysis p. 8 provides an example of calculated results in English units on a hypothetical 1-stage, single level OLT using the simplified method in Part II with the centroid of the side shear distribution 44.1% above the base of the O-cell. Figure C compares the corrected with the rigid curve of Figure B. Page 9 contains an example equivalent to that above in SI units.

The final analysis p. 10 provides an example of calculated results in English units on a hypothetical 3-stage, multi level OLT using the simplified method in Part II with the centroid of the combined upper and middle side shear distribution 44.1% above the base of the bottom O-cell. The individual centroids of the upper and middle side shear distributions lie 39.6% and 57.9% above and below the middle O-cell, respectively. Figure E compares the corrected with the rigid curve. Page 11 contains an example equivalent to that above in SI units.

Other Tests: The example illustrated in Figure A has the maximum component movement in end bearing. The procedures remain the same if the maximum test movement occurred in side shear. Then we would have extrapolated end bearing to produce the dashed-line part of the reconstructed top-load settlement curve.

The example illustrated also assumes a pile top-loaded in compression. For a pile top-loaded in tension we would, based on Assumptions 2. and 3., use the upward side shear load curve in Figure A, multiplied by the F = 0.80 noted in Assumption 2., for the equivalent top-loaded displacement curve.

Expected Accuracy: We know of only five series of tests that provide the data needed to make a direct comparison between actual, full scale, top-loaded pile movement behavior and the equivalent behavior obtained from an O-cell test by the method described herein. These involve three sites in Japan and one in Singapore, in a variety of soils, with three compression tests on bored piles (drilled shafts), one compression test on a driven pile and one tension test on a bored pile. The largest bored pile had a 1.2-m diameter and a 37-m length. The driven pile had a 1-m increment modular construction and a 9-m length. The largest top loading = 28 MN (3,150 tons).

The following references detail the aforementioned Japanese tests and the results therefrom:

Kishida H. et al., 1992, "Pile Loading Tests at Osaka Amenity Park Project," Paper by Mitsubishi Co., also briefly described in Schmertmann (1993, see bibliography). Compares one drilled shaft in tension and another in compression.

Ogura, H. et al., 1995, "Application of Pile Toe Load Test to Cast-in-place

Concrete Pile and Precast Pile," special volume 'Tsuchi-to-Kiso' on Pile Loading Test, Japanese Geotechnical Society, Vol. 3, No. 5, Ser. No. 448. Original in Japanese. Translated by M. B. Karkee, GEOTOP Corporation. Compares one drilled shaft and one driven pile, both in compression.

We compared the predicted equivalent and measured top load at three top movements in each of the above four Japanese comparisons. The top movements ranged from ¼ inch (6 mm) to 40 mm, depending on the data available. The (equiv./meas.) ratios of the top load averaged 1.03 in the 15 comparisons with a coefficient of variation of less than 10%. We believe that these available comparisons help support the practical validity of the equivalent top load method described herein.

L. S. Peng, A. M. Koon, R. Page and C. W. Lee report the results of a class-A prediction by others of the TLT curve from an Osterberg cell test on a 1.2 m diameter, 37.2 m long bored pile in Singapore, compared to an adjacent pile with the same dimensions actually top-loaded by kentledge. They report about a 4% difference in ultimate capacity and less than 8% difference in settlements over the 1.0 to 1.5 times working load range -- comparable to the accuracy noted above. Their paper has the title "OSTERBERG CELL TESTING OF PILES", and was published in March 1999 in the Proceedings of the International Conference on Rail Transit, held in Singapore and published by the Association of Consulting Engineers Singapore.

B. H. Fellenius has made several finite element method (FEM) studies of an OLT in which he adjusted the parameters to produce good load-deflection matches with the OLT up and down load-deflection curves. He then used the same parameters to predict the TLT deflection curve. We compared the FEM-predicted curve with the equivalent load-deflection predicted by the previously described Part I and II procedures, with the results again comparable to the accuracy noted above. The ASCE has published a paper by Fellenius et. al. titled "O-Cell Testing and FE Analysis of 28-m-Deep Barrette in Manila, Philippines" in the Journal of Geotechnical and Geoenvironmental Engineering, Vol. 125, No. 7, July 1999, p. 566. It details one of his comparison studies.

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 movement curves with abrupt changes in curvature (not hyperbolic). However, we believe the hyperbolic fit method and our assumptions used usually produce reasonable equivalent top load settlement curves.

August, 2000

Example of the Construction of an Equivalent Top-Loaded Settlement Curve (Figure B) From Osterberg Cell Test Results (Figure A)

Figure A

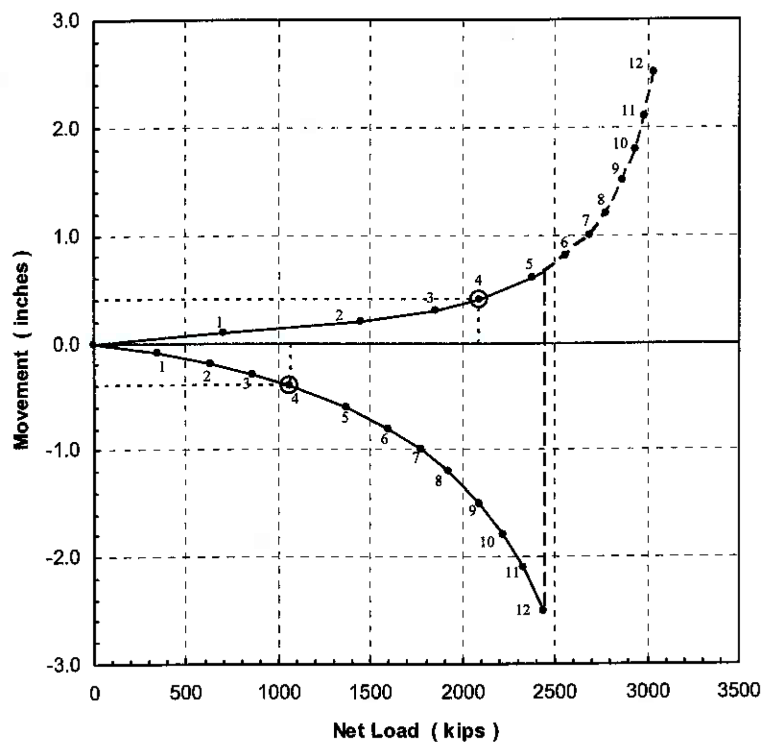
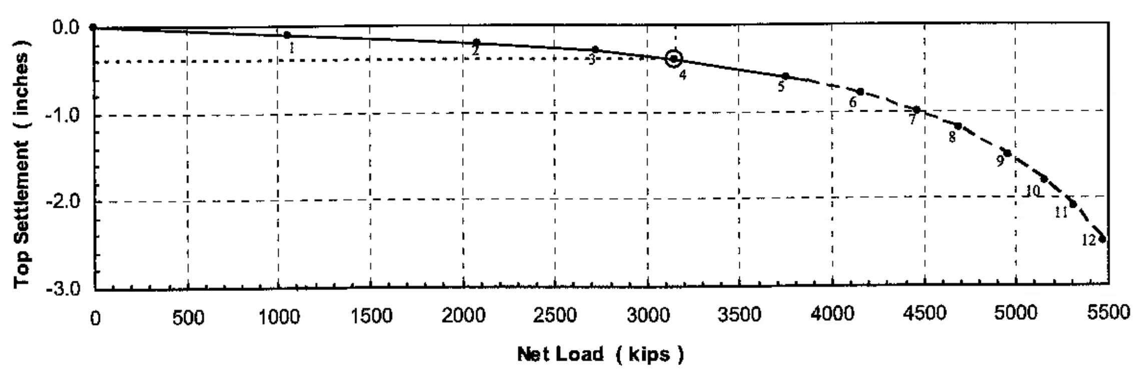
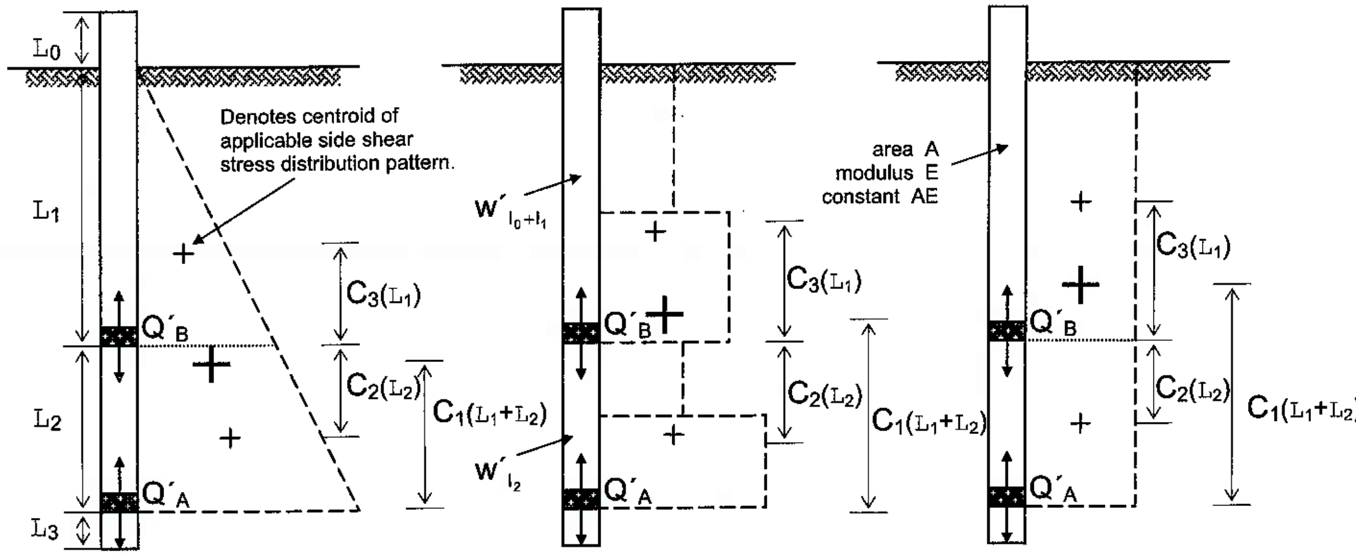


Figure B



Theoretical Elastic Compression in O-cell Test Based on Pattern of Developed Side Shear Stress



1-Stage Single Level Test (Q´A only):

$$\delta_{OLT} = \delta_{\uparrow(l_1+l_2)}$$

$C_1 = \frac{1}{3}$	Centroid Factor $= C_1$	$C_1 = \frac{1}{2}$
$\delta_{\uparrow(l_1+l_2)} = \frac{1}{3}\frac{Q'_{\uparrow A}(l_1+l_2)}{AE}$	$\delta_{\uparrow(l_1+l_2)} = C_1\frac{Q'_{\uparrow A}(l_1+l_2)}{AE}$	$\delta_{\uparrow(l_1+l_2)} = \frac{1}{2}\frac{Q'_{\uparrow A}(l_1+l_2)}{AE}$

3-Stage Multi Level Test (Q´A and Q´B): $\delta_{OLT} = \delta_{\uparrow l_1} + \delta_{\downarrow l_2}$

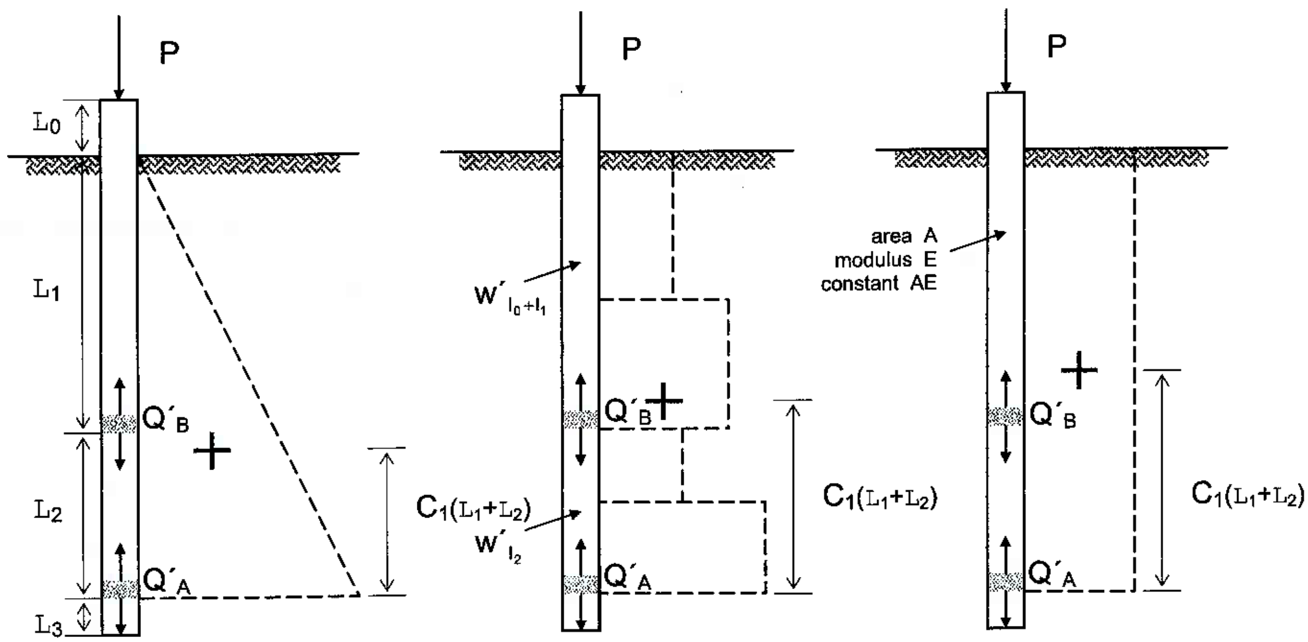
$C_3 = \frac{1}{3}$	Centroid Factor $= C_3$	$C_3 = \frac{1}{2}$
$\delta_{\uparrow l_1} = \frac{1}{3}\frac{Q'_{\uparrow B} l_1}{AE}$	$\delta_{\uparrow l_1} = C_3\frac{Q'_{\uparrow B} l_1}{AE}$	$\delta_{\uparrow l_1} = \frac{1}{3}\frac{Q'_{\uparrow B} l_1}{AE}$
$C_2 = \frac{1}{3}\left(\frac{3l_1+2l_2}{2l_1+l_2}\right)$	Centroid Factor $= C_2$	$C_2 = \frac{1}{2}$
$\delta_{\downarrow l_2} = \frac{1}{3}\left(\frac{3l_1+2l_2}{2l_1+l_2}\right)\frac{Q'_{\downarrow B} l_2}{AE}$	$\delta_{\downarrow l_2} = C_2\frac{Q'_{\downarrow B} l_2}{AE}$	$\delta_{\downarrow l_2} = \frac{1}{2}\frac{Q'_{\downarrow B} l_2}{AE}$

Net Loads:

$Q'_{\uparrow A} = Q_{\uparrow A} - W'_{l_0+l_1+l_2}$ $\quad Q'_{\uparrow B} = Q_{\uparrow B} - W'_{l_0+l_1}$ $\quad Q'_{\downarrow B} = Q'_{\downarrow B} + W'_{l_2}$

W' = pile weight, buoyant where below water table

Theoretical Elastic Compression in Top Loaded Test Based on Pattern of Developed Side Shear Stress



Top Loaded Test: $\delta_{TLT} = \delta_{\downarrow l_0} + \delta_{\downarrow l_1+l_2}$

$\delta_{\downarrow l_0} = \frac{Pl_0}{AE}$	$\delta_{\downarrow l_0} = \frac{Pl_0}{AE}$	$\delta_{\downarrow l_0} = \frac{Pl_0}{AE}$
$C_1 = \frac{1}{3}$	$\text{Centroid Factor} = C_1$	$C_1 = \frac{1}{2}$
$\delta_{\downarrow l_1+l_2} = \frac{(Q'_{\downarrow A}+2P)}{3}\frac{(l_2+l_2)}{AE}$	$\delta_{\downarrow l_1+l_2} = [(C_1)Q'_{\downarrow A}+(1-C_1)P]\frac{(l_1+l_2)}{AE}$	$\delta_{\downarrow l_1+l_2} = \frac{(Q'_{\downarrow A}+P)}{2}\frac{(l_1+l_2)}{AE}$

Net and Equivalent Loads:

$Q'_{\downarrow A} = Q_{\downarrow A} - W'_{l_0+l_1+l_2}$ $\qquad P_{single} = Q'_{\downarrow A} + Q'_{\uparrow A}$ $\qquad P_{multi} = Q'_{\downarrow A} + Q'_{\uparrow B} + Q'_{\downarrow B}$

Component loads Q selected at the same (±) Δ_{OLT}.

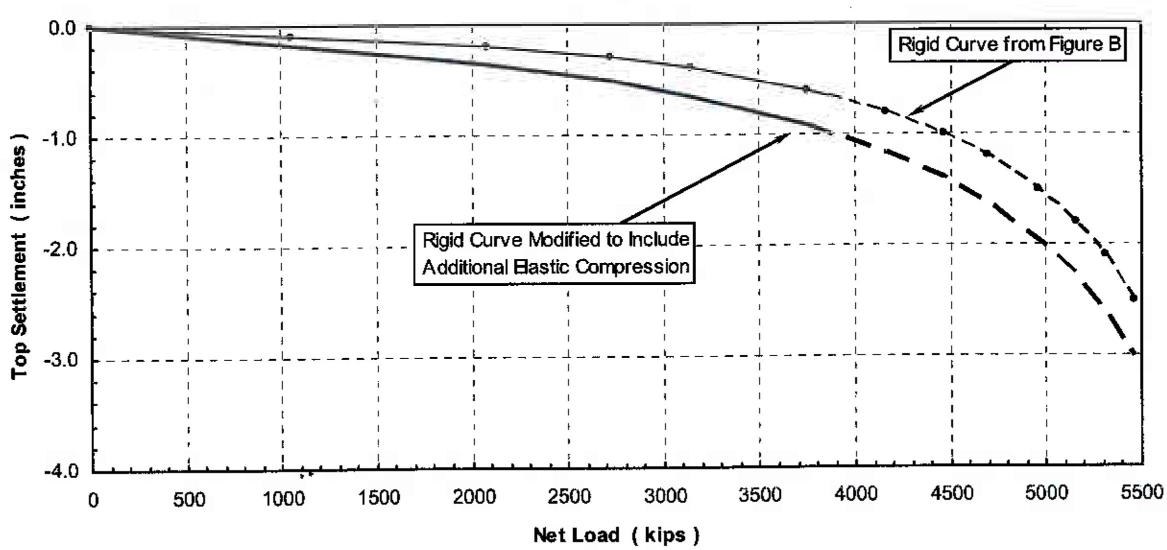
Example Calculation for the Additional Elastic Compression Correction For Single Level Test (English Units)

Given:

C_1	=	0.441
AE	=	3,820,000 kips (assumed constant throughout test)
I_0	=	5.9 ft
I_1	=	30.0 ft (embedded length of shaft above O-cell)
I_2	=	0.00 ft
I_3	=	0.0 ft
Shear reduction factor	=	1.00 (cohesive soil)

Δ_{OLT} (in)	$Q'_{\downarrow A}$ (kips)	$Q'_{\uparrow A}$ (kips)	P (kips)	δ_{TLT} (in)	δ_{OLT} (in)	Δ_δ (in)	$\Delta_{OLT} + \Delta_\delta$ (in)
0.000	0	0	0	0.000	0.000	0.000	0.000
0.100	352	706	1058	0.133	0.047	0.086	0.186
0.200	635	1445	2080	0.257	0.096	0.160	0.360
0.300	867	1858	2725	0.339	0.124	0.215	0.515
0.400	1061	2088	3149	0.396	0.139	0.256	0.656
0.600	1367	2382	3749	0.478	0.159	0.319	0.919
0.800	1597	2563	4160	0.536	0.171	0.365	1.165
1.000	1777	2685	4462	0.579	0.179	0.400	1.400
1.200	1921	2773	4694	0.613	0.185	0.427	1.627
1.500	2091	2867	4958	0.651	0.191	0.460	1.960
1.800	2221	2933	5155	0.680	0.196	0.484	2.284
2.100	2325	2983	5308	0.703	0.199	0.504	2.604
2.500	2434	3032	5466	0.726	0.202	0.524	3.024

Figure C



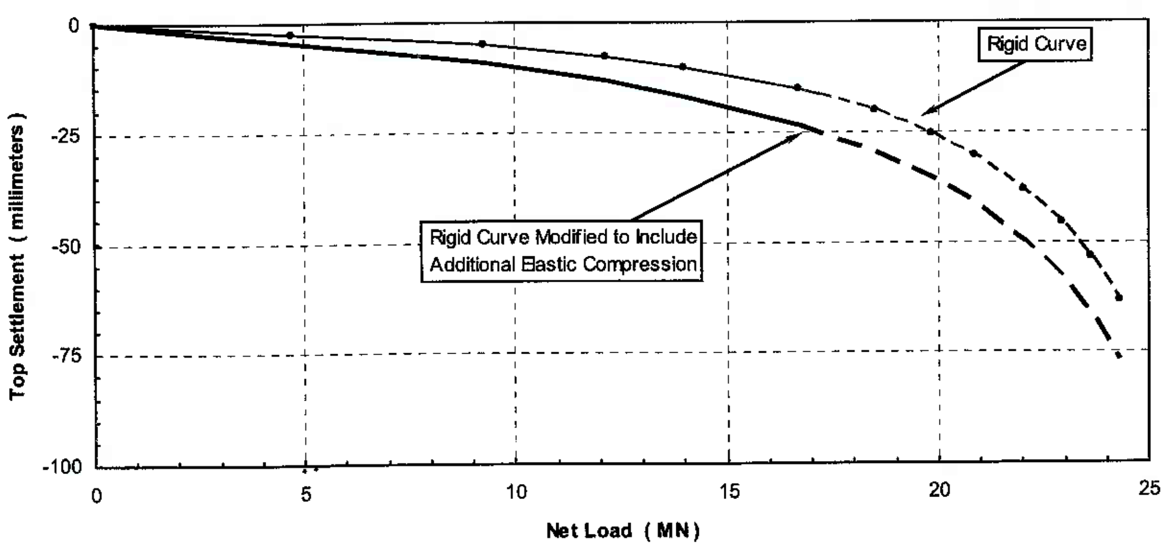
Example Calculation for the Additional Elastic Compression Correction For Single Level Test (SI Units)

Given:

C_1	=	0.441	
AE	=	17,000	MN (assumed constant throughout test)
I_0	=	1.80	m
I_1	=	14.69	m (embedded length of shaft above mid-cell)
I_2	=	0.00	m
I_3	=	0.0	m
Shear reduction factor	=	1.00	(cohesive soil)

Δ_{OLT} (mm)	$Q'_{\downarrow A}$ (MN)	$Q'_{\uparrow A}$ (mm)	P (MN)	δ_{TLT} (mm)	δ_{OLT} (mm)	Δ_{δ} (mm)	$\Delta_{OLT} + \Delta_{\delta}$ (mm)
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.54	1.57	3.14	4.71	3.37	1.20	2.17	4.71
5.08	2.82	6.43	9.25	6.52	2.45	4.07	9.15
7.62	3.86	8.27	12.12	8.61	3.15	5.46	13.08
10.16	4.72	9.29	14.01	10.05	3.54	6.51	16.67
15.24	6.08	10.60	16.68	12.14	4.04	8.10	23.34
20.32	7.11	11.40	18.50	13.60	4.34	9.26	29.58
25.40	7.90	11.94	19.85	14.70	4.55	10.15	35.55
30.48	8.55	12.33	20.88	15.55	4.70	10.85	41.33
38.10	9.30	12.75	22.05	16.53	4.86	11.67	49.77
45.72	9.88	13.05	22.93	17.27	4.97	12.29	58.01
53.34	10.34	13.27	23.61	17.84	5.06	12.79	66.13
63.50	10.83	13.48	24.31	18.44	5.14	13.30	76.80

Figure D



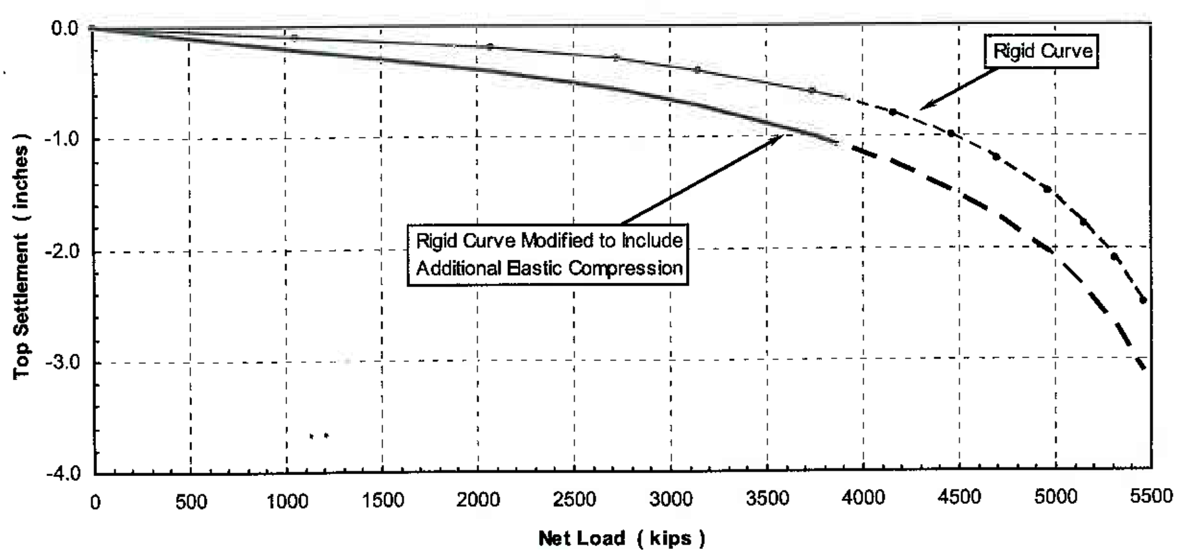
Example Calculation for the Additional Elastic Compression Correction For Multi Level Test (English Units)

Given:

	C_1	=	0.441	
	C_2	=	0.579	
	C_3	=	0.396	
	AE	=	3,820,000	kips (assumed constant throughout test)
	I_0	=	5.9	ft
	I_1	=	30.0	ft (embedded length of shaft above mid-cell)
	I_2	=	18.2	ft (embedded length of shaft between O-cells)
	I_3	=	0.0	ft
Shear reduction factor		=	1.00	(cohesive soil)

Δ_{OLT} (in)	$Q'_{\downarrow A}$ (kips)	$Q'_{\downarrow B}$ (kips)	$Q'_{\uparrow A}$ (kips)	P (kips)	δ_{TLT} (in)	δ_{OLT} (in)	Δ_δ (in)	$\Delta_{OLT} + \Delta_\delta$ (in)
0.000	0	0	0	0	0.000	0.000	0.000	0.000
0.100	352	247	459	1058	0.133	0.025	0.107	0.207
0.200	635	506	939	2080	0.257	0.052	0.205	0.405
0.300	867	650	1208	2725	0.339	0.067	0.272	0.572
0.400	1061	731	1357	3149	0.396	0.075	0.321	0.721
0.600	1367	834	1548	3749	0.478	0.085	0.393	0.993
0.800	1597	897	1666	4160	0.536	0.092	0.444	1.244
1.000	1777	940	1745	4462	0.579	0.096	0.483	1.483
1.200	1921	971	1802	4694	0.613	0.099	0.513	1.713
1.500	2091	1003	1864	4958	0.651	0.103	0.548	2.048
1.800	2221	1027	1907	5155	0.680	0.105	0.575	2.375
2.100	2325	1044	1939	5308	0.703	0.107	0.596	2.696
2.500	2434	1061	1971	5466	0.726	0.109	0.618	3.118

Figure E

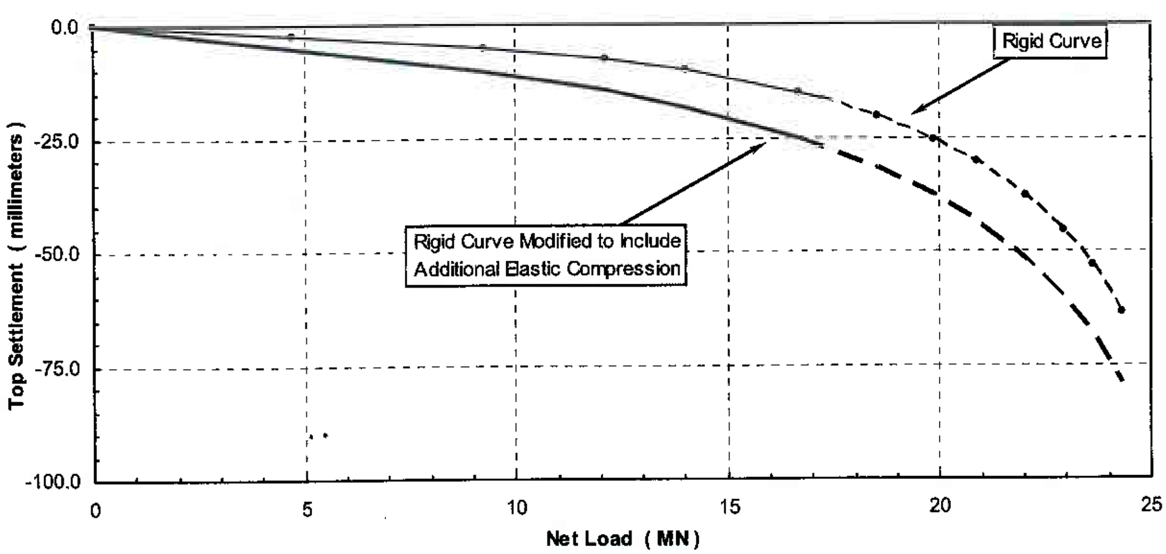


Example Calculation for the Additional Elastic Compression Correction For Multi Level Test (SI Units)

Given: C_1	=	0.441	
C_2	=	0.579	
C_3	=	0.396	
AE	=	17,000	MN (assumed constant throughout test)
I_0	=	1.80	m
I_1	=	9.14	m (embedded length of shaft above mid-cell)
I_2	=	5.55	m (embedded length of shaft between O-cells)
I_3	=	0.00	m
Shear reduction factor	=	1.00	(cohesive soil)

Δ_{OLT} (mm)	$Q'_{\downarrow A}$ (MN)	$Q'_{\downarrow B}$ (MN)	$Q'_{\uparrow B}$ (mm)	P (MN)	δ_{TLT} (mm)	δ_{OLT} (mm)	Δ_δ (mm)	$\Delta_{OLT} + \Delta_\delta$ (mm)
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.54	1.57	1.10	2.04	4.71	3.37	0.64	2.73	5.27
5.08	2.82	2.25	4.18	9.25	6.52	1.31	5.21	10.29
7.62	3.86	2.89	5.37	12.12	8.61	1.69	6.92	14.54
10.16	4.72	3.25	6.04	14.01	10.05	1.90	8.15	18.31
15.24	6.08	3.71	6.89	16.68	12.14	2.17	9.97	25.21
20.32	7.11	3.99	7.41	18.50	13.60	2.33	11.27	31.59
25.40	7.90	4.18	7.76	19.85	14.70	2.44	12.26	37.66
30.48	8.55	4.32	8.02	20.88	15.55	2.52	13.03	43.51
38.10	9.30	4.46	8.29	22.05	16.53	2.61	13.92	52.02
45.72	9.88	4.57	8.48	22.93	17.27	2.67	14.60	60.32
53.34	10.34	4.64	8.62	23.61	17.84	2.71	15.13	68.47
63.50	10.83	4.72	8.76	24.31	18.44	2.76	15.68	79.18

Figure F



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.

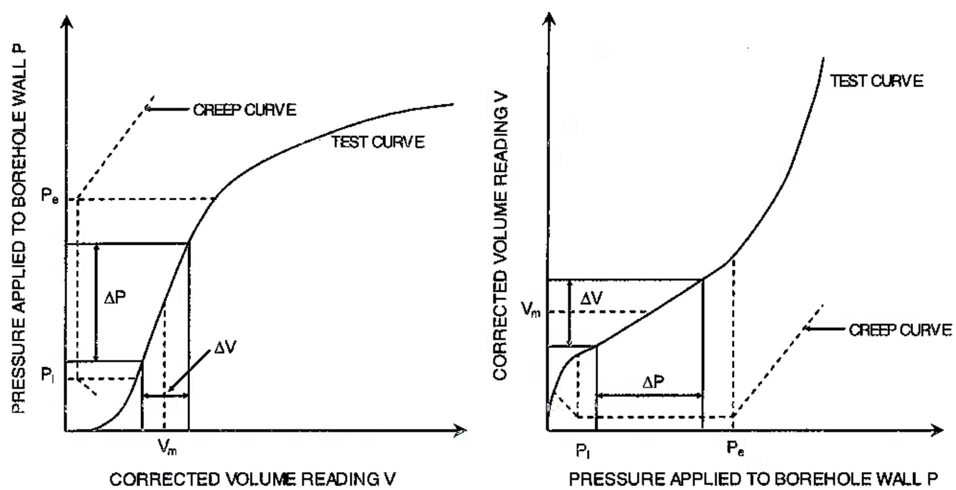


FIG. 8 Pressuremeter Test Curves for Procedure A

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.

Combined End Bearing and Lower Side Shear Creep Limit

Test Shaft - I-80 over Missouri River - Council Bluffs, IA

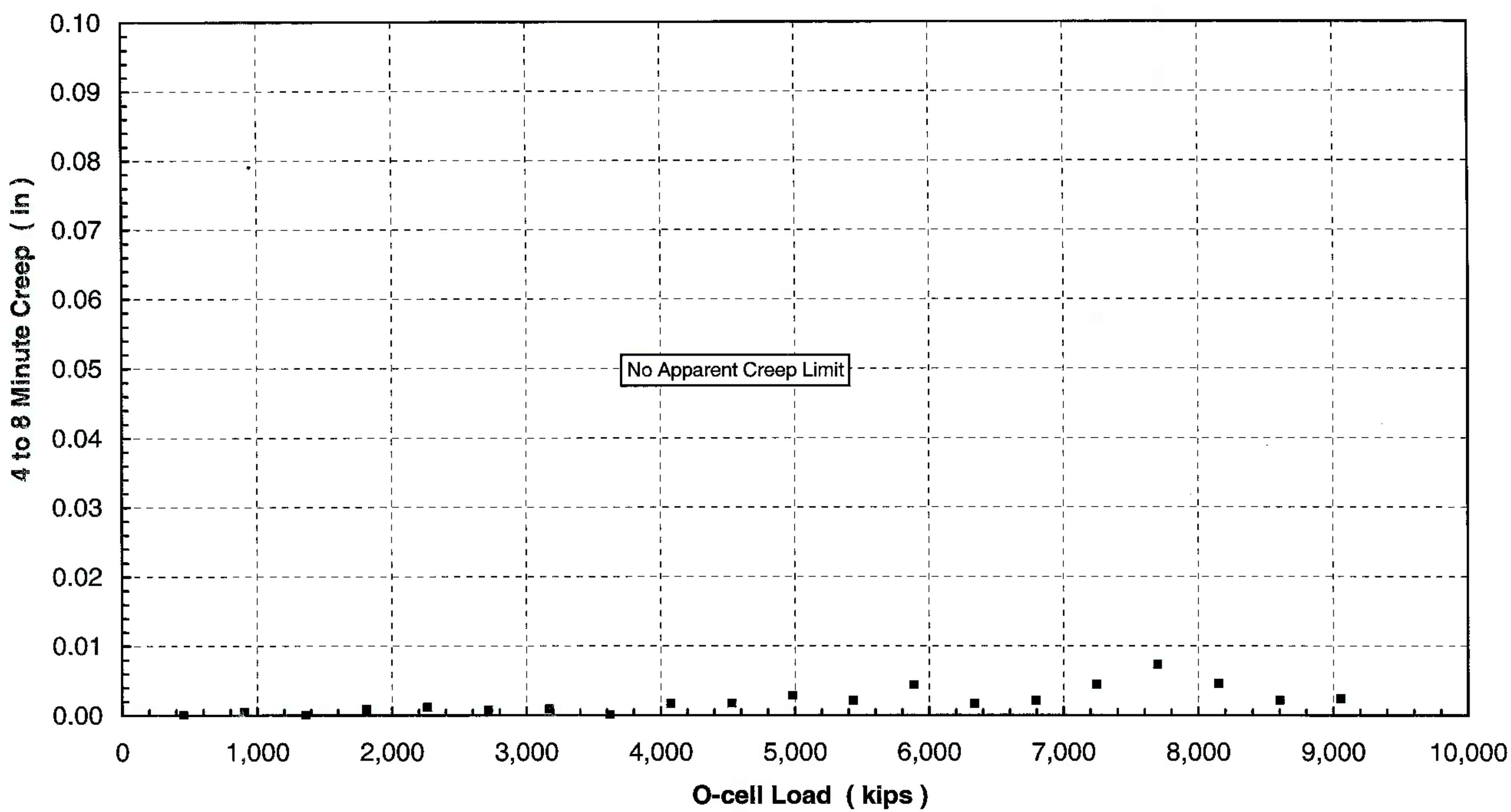


Figure D-1

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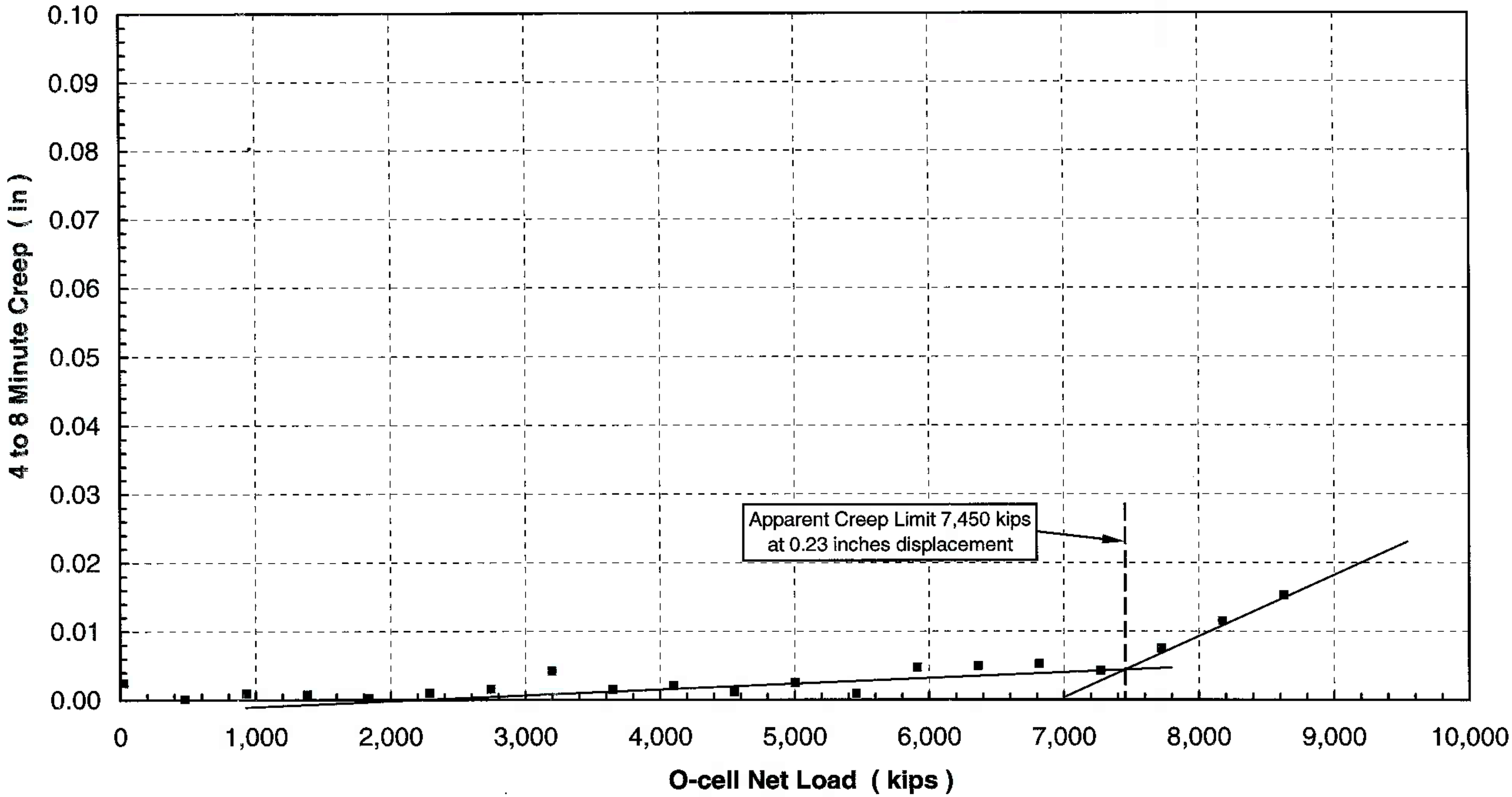
Upper Side Shear Creep Limit

Test Shaft - I-80 over Missouri River - Council Bluffs, IA



LOADTEST Inc. Project No. LT-9433

Figure D-2

APPENDIX E

SOIL BORING LOG

BORING LOG No. Demo Shaft

BORING NO.	LOCATION OF BORING	ELEVATION	DATUM	DRILLER	LOGGER
Demo Shaft	East River Bank	975.49 feet	IDOT Site Plan	DAH	JLW

WATER LEVEL OBSERVATIONS				TYPE OF SURFACE	DRILL RIG
WHILE DRILLING	END OF DRILLING	24 HOURS AFTER DRILLING		Bare Ground	Mobile B-57
				DRILLING METHOD	TOTAL DEPTH
N/A	N/A	N/A		3" NW Casing and NQ2 Coring	130.50 feet

DEP. FT.	SAMPLE NO. & TYPE	"N" BLOWS (FT)	% REC.	SOIL DESCRIPTION: COLOR, MOISTURE, CONSISTENCY / GEOLOGIC DESCRIPTION & OTHER REMARKS	USCS CLASS.	% MC	DRY DENS. pcf	Qu psi	ELEV. FT.
				Dark brown, Moist LEAN CLAY — FILL — 1.0'	CL				
	S1	16	95	Dark brown, Moist SILTY SAND	SM				970
10	S2	8	80	ALLUVIUM — 11.0'					
	S3	1	80	Gray, Moist to wet SILT with minor sand					960
20	S4	3	70		ML				
	S5	2	60	ALLUVIUM — 28.0'					950
30	S6	17	90	Gray to dark gray, Wet FINE TO MEDIUM SAND with fine gravel					
	S7	20	80						940
40	S8	20	70						
	S9	17	90						930
50	S10	28	80		SP				
	S11	29	80	Moist below 55 feet					920
60	S12	43	70						
	S13	52	95						910
70	S14	44	95	ALLUVIUM — 70.0'					
	S15	22	60	Gray to dark gray, Wet MEDIUM TO COARSE SAND with gravel					900
80	S16	22	60		SP				

GSI Geotechnical Services, Inc.
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(515) 270-6542 FAX (515) 270-1911

PROJECT: Section K Confirmation Borings
LOCATION: I-80 over Missouri River, Pottawattamie Co, IA
JOB NO.: 086040
DATE: 3-24-2008

BORING LOG No. Demo Shaft

BORING NO.	LOCATION OF BORING	ELEVATION	DATUM	DRILLER	LOGGER
Demo Shaft	East River Bank	975.49 feet	IDOT Site Plan	DAH	JLW

WATER LEVEL OBSERVATIONS				TYPE OF SURFACE	DRILL RIG
WHILE DRILLING	END OF DRILLING	24 HOURS AFTER DRILLING		Bare Ground	Mobile B-57
				DRILLING METHOD	TOTAL DEPTH
N/A	N/A	N/A		3" NW Casing and NQ2 Coring	130.50 feet

DEP. FT.	SAMPLE DATA: SAMPLE NO. & TYPE	"N" BLOWS (FT)	% REC.	SOIL DESCRIPTION: COLOR, MOISTURE, CONSISTENCY / GEOLOGIC DESCRIPTION & OTHER REMARKS	USCS CLASS.	LABORATORY DATA: % MC	DRY DENS. pcf	Qu psi	ELEV. FT.
	S17	18	40						890
90	S18	20	30	**ALLUVIUM** 91.5'					
	NQ2-1		100	Light gray to gray, Moist, Hard FRESH LIMESTONE RQD of Run 1 = 0.83 (START CORING @ 92')		0.5	161	6000	
				Minor joints between 93 and 93.5 feet		1.6	156	2590	880
	NQ2-2		100	SHALEY LIMESTONE with SHALE seams between 95.5 and 96 feet RQD of Run 2 = 0.62		1.3	156	3110	
100				Vertical joints between 96 and 98 feet Minor joints near 98.7 feet RQD of Run 3 = 0.55		3.6	147	2810	
	NQ2-3		96	Jointed WEATHERED SHALEY LIMESTONE with SHALE seams between 102 and 104 feet		2.5	152	2310	870
	NQ2-4		98	RQD of Run 4 = 0.90 WEATHERED SHALEY LIMESTONE between 106 and 106.5 feet		1.0	160	4180	
110				RQD of Run 5 = 0.93		0.2	165	3150	
	NQ2-5		98	**PENNSYLVANIAN BEDROCK** 114.7'		3.7	141	4200	860
	NQ2-6		46	Dark gray to greenish gray, Moist, Firm to moderately hard CLAY SHALE RQD of Run 6 = 0.30					
120				SHALEY LIMESTONE seams between 119.5 and 120 feet RQD of Run 7 = 0.90		3.9	149	3340	
	NQ2-7		100			10.1	133	580	850
	NQ2-8		100	Dark brown between 125.5 and 127.5 feet RQD of Run 8 = 0.78		9.7	134	830	
130				CLAY SHALE and LIMESTONE mixed 129'- 129.8' **PENNSYLVANIAN BEDROCK** 129.8'					
				Light gray, Moist, Hard FRESH LIMESTONE **PENNSYLVANIAN BEDROCK** 130.5'		0.5	162	2600	
				Bottom of Boring @ 130.5'					840
140									830
150									820
160									810

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