REPORT ON DRILLED SHAFT LOAD TESTING (OSTERBERG METHOD)

Test Shaft #1 - IL 5 / IL 84 Interchange
Rock Island Co., IL (LT-9405)

Prepared for: **Civil Constructors Inc.**
2283 Route 20 East
Freeport, IL 61032

Attention: **Mr. Ken Schrock**

PROJECT NUMBER: LT-9405, April 24, 2008

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April 24, 2008

Civil Constructors Inc.
2283 Route 20 East
Freeport, IL 61032

Attention: Mr. Ken Schrock

Load Test Report: Test Shaft #1 - IL 5 / IL 84 Interchange
Location: Rock Island Co., IL (LT-9405)

Dear Mr. Schrock,

The enclosed report contains the data and analysis summary for the O-cell test performed on Test Shaft #1 - IL 5 / IL 84 Interchange, on April 21, 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 21, 2008, we tested a nominal 42-inch (1,067-mm) diameter production test shaft constructed by Civil Constructors Inc. Mr. Jon Sinnreich and Mr. Aaron M. King of LOADTEST, Inc. carried out the test. Civil Constructors Inc. excavated the 37.5-foot (11.43-meter) deep shaft dry and performed final cleanout and concreting on April 15, 2008. Sub-surface conditions at the test shaft location consist primarily of clayey overburden soils underlain by shale and sandstone.

The maximum sustained bi-directional load applied to the shaft was 1,639 kips (7.29 MN). At the maximum load, the displacements above and below the O-cell were 0.458 inches (11.63 mm) and 0.860 inches (21.85 mm), respectively. Unit shear data calculated from strain gages indicated a maximum net unit side shear of 13.3 ksf (639 kPa) between the O-cell and strain gage level 1. We also calculated a maximum applied end bearing pressure of 97.3 ksf (4,661 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 1,431 kips (6.4 MN), the adjusted test data indicate this shaft would settle approximately 0.25 inches (6.4 mm) of which 0.07 inches (1.8 mm) is estimated elastic compression.

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 clayey overburden soils underlain by shale and sandstone. The generalized subsurface profile is included in Figure A and boring logs indicating conditions near the shaft are presented in Appendix E.

Test Shaft Construction: Civil Constructors Inc. constructed the production test shaft on April 15, 2008. We understand that the test shaft was excavated dry to a tip elevation of 585.4 feet (178.41 meters). The shaft was started with a 48-inch diameter auger down to elevation 607.9 feet (185.28 meters). At that point, the remainder of the excavation was drilled with a 42-inch diameter tool and then cleaned out. After overcoming some minor difficulties with water seepage and hanging the rebar cage, concrete was placed by freefall in the base of the excavation. The reinforcing cage with attached O-cell assembly was then inserted and temporarily supported at the surface while the remainder of the concrete was placed until reaching the cutoff elevation.

OSTERBERG CELL TESTING

Shaft Instrumentation: Test shaft instrumentation and assembly was carried out under the direction of Aaron King of LOADTEST, Inc. between April 14, 2008 and April 15, 2008. The loading assembly consisted of one 16-inch (410-mm) O-cell located 4.4 feet (1.35 meters) above the tip of shaft. Calibrations of the O-cell and instrumentation used for this test are included in Appendix B.

O-cell testing instrumentation included three 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 3 and 4). 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 gages were used to assess the side shear load transfer of the shaft above the Osterberg cell assembly. Three levels of two sister bar vibrating wire strain gages (Geokon Model 4911 Series) were installed, diametrically opposed, in the shaft above the base of the O-cell assembly. Details concerning the strain gage placement appear in Table B and Figures A & B. The strain gages were positioned as proposed by LOADTEST, Inc.

Two lengths of steel pipe were also installed, extending from the top of the shaft to the top of the bottom plate, to vent the break in the shaft formed by the expansion of the O-cell. The pipes also provide access for post-test grouting of the annular void surrounding the O-cell assembly as described in Appendix G.

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 (Geokon Model 4450 Series). Two automated digital survey levels (Leica NA 3000 Series) were used to monitor the top of shaft movement from a distance of approximately 33 feet (10.1 meters). (Appendix A, Pages 1 and 2).

A Bourdon pressure gage and electronic pressure transducers were used to measure the pressure applied to the O-cell at each load interval. We used the transducers for automatically setting and maintaining loads, data analysis and real time plotting. The Bourdon gage was used as a check on the transducers. There was close agreement between the Bourdon gage and the pressure transducers.

Data Acquisition: All instrumentation were connected through a data logger (Data Electronics - DT500/600 Series 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 sets.

Testing Procedures: As with all of our tests, we begin 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, we immediately release the pressure 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 applied load of 144 kips (0.6 MN) to the O-cell.

The Osterberg cell load test was conducted as follows: We pressurized the 16-inch (410-mm) diameter O-cell, with its base located 4.4 feet (1.35 meters) above the base of shaft to assess the combined end bearing and lower side shear below the O-cell and the upper side shear above. We loaded the shaft in 29 loading increments to a bi-directional gross O-cell load of 1,639 kips (7.29 MN). The loading was halted after load interval 1L-29 because the required loading had been achieved. The shaft was then unloaded in four decrements and the test was concluded.

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. The data logger automatically recorded the instrument readings every 30 seconds, but herein we report only the 1, 2, 4 and 8-minute readings (where applicable) during each increment of maintained load.

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 59 kips (0.26 MN) above the O-cell.

Upper Side Shear Resistance: The maximum upward applied *net load* to the upper side shear was 1,581 kips (7.03 MN) which occurred at load interval 1L-29. At this loading, the upward movement of the O-cell top was 0.458 inches (11.63 mm).

In order to assess the side shear resistance of the test shaft, loads are calculated based on the strain gage data (Appendix A, Pages 7 and 8) and an estimate of shaft stiffness (AE) which is presented below. We used the ACI formula (E_c=57000$\sqrt{f'_c}$) to calculate an elastic modulus for the concrete, where f'_c was reported to be 4,100 psi (28.27 MPa) on the day of the test. This, combined with the area of reinforcing steel and nominal shaft diameter, provided an average shaft stiffness (AE) of 7,630,000 kips (33,900 MN) in the nominal 48-inch diameter shaft above the O-cell, 6,080,000 kips (27,100 MN)) in the nominal 42-inch diameter shaft above the O-cell and 5,060,000 kips (22,500 MN) below the O-cell. Net unit shear curves are presented in Figure 3. Net unit shear values for loading increment 1L-29 follow in Table A:

TABLE A: Average Net Unit Side Shear Values for 1L-29

Load Transfer Zone	Displacement *	Net Unit Side Shear **
Strain Gage Level 3 to Strain Gage Level 4	↑ 0.440"	0.3 ksf (17 kPa)
Strain Gage Level 2 to Strain Gage Level 3	↑ 0.441"	1.4 ksf (69 kPa)
Strain Gage Level 1 to Strain Gage Level 2	↑ 0.443"	2.7 ksf (130 kPa)
O-cell to Strain Gage Level 1	↑ 0.451"	13.3 ksf (639 kPa)

* Average displacement of load transfer zone.

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

NOTE: Net unit shear values derived from the strain gages above the O-cell assembly may not be ultimate values. See Figure 3 for mobilized net unit shear vs. average shear zone displacement plots.

Combined End Bearing And Lower Side Shear Resistance: The maximum O-cell load applied to the combined end bearing and lower side shear was 1,639 kips (7.29 MN) which occurred at load interval 1L-29 (Appendix A, Page 6, Figure 1). At this loading, the average downward movement of the O-cell base was 0.860 inches (21.85 mm). The load taken in shear by the 4.4 feet (1.35 meters) of shaft section below the O-cell is calculated to be 703 kips (3.13 MN) using an extrapolated unit side shear value of 14.5 ksf (692 kPa) and a nominal 42-inch (1,067-mm) shaft diameter. The applied load to end bearing is then 937 kips (4.17 MN) and the unit end bearing at the base of the shaft is calculated to be 97.3 ksf (4,661 kPa) 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 curve is extended out to a settlement of 0.9 inches (22 mm) by extrapolating the top of O-cell data (Appendix F). 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.

We mobilized a combined end bearing and side shear resistance of 3,220 kips (14.3 MN) during the test. For an equivalent top loading of 1,431 kips (6.4 MN), the adjusted test data indicate this shaft would settle approximately 0.25 inches (6.4 mm) of which 0.07 inches (1.8 mm) is estimated elastic compression. For an equivalent top loading of 2,004 kips (8.9 MN) the adjusted test data indicate this shaft would settle approximately 0.50 inches (12.7 mm) of which 0.10 inches (2.6 mm) 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. The combined end bearing and lower side shear creep data (Appendix A, Pages 5 and 6) indicate that no apparent creep limit was reached was reached at a movement of 0.86 inches (21.9 mm) (Appendix D, Figure 1). The upper side shear creep data (Appendix A, Pages 5 and 6) indicate that no apparent creep limit was reached was reached at a movement of 0.46 inches (11.6 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.

POST-TEST O-CELL GROUTING

Since the test shaft is intended to carry structural loading (i.e., a production shaft), the contractor needs to fill the O-cell and annular void in the shaft created as a result of the expansion of the cell. The shaft includes the hoses and piping to permit filling the O-cell and void with grout. If not already grouted, we recommend that this be done as soon as possible according to the procedures in Appendix G.

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

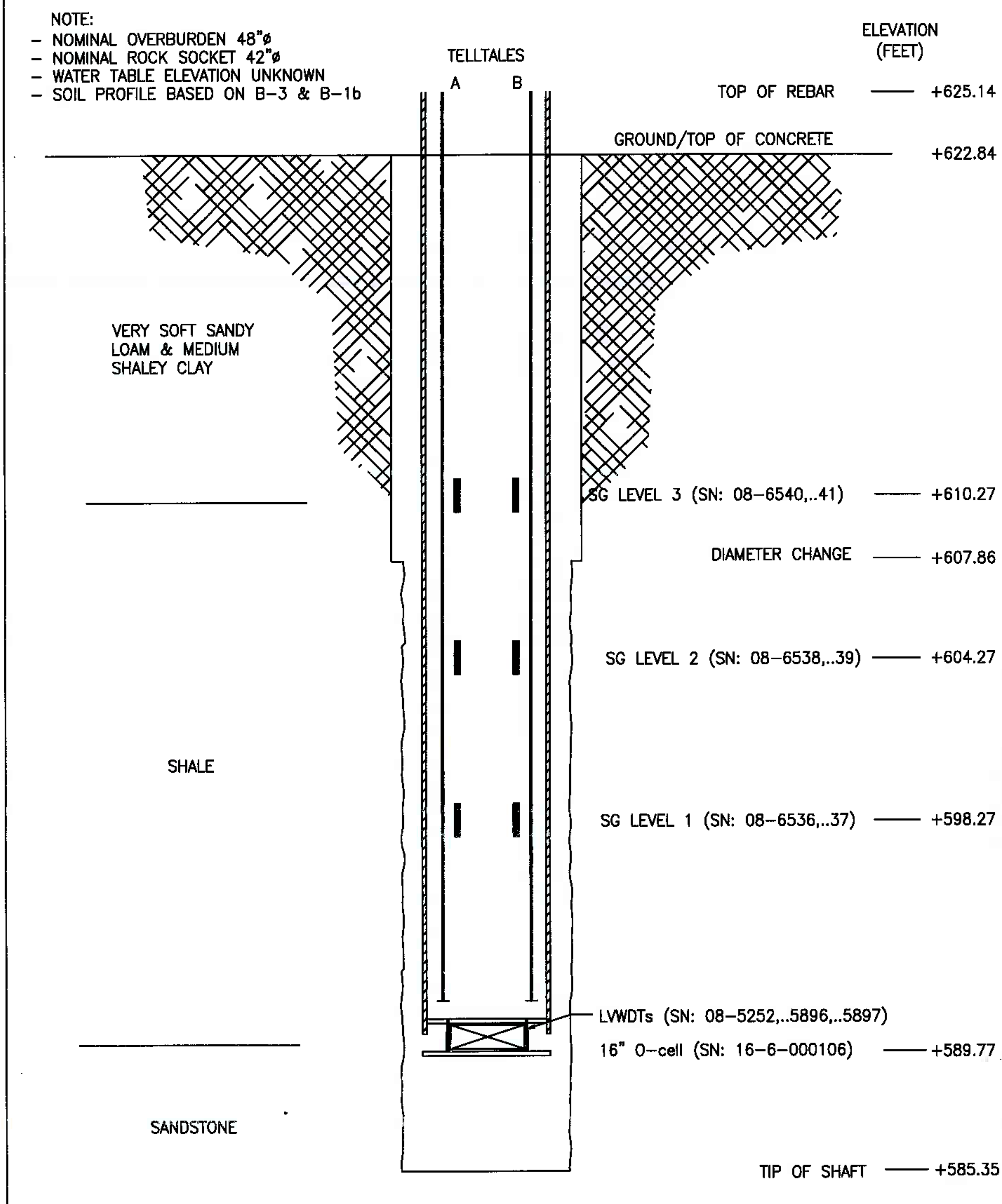
Michael D. Ahrens, M.Eng., P.E.
Geotechnical Engineer

Reviewed by

Denton A. Kort, P.E.
Geotechnical Engineer

TABLE B:
SUMMARY OF DIMENSIONS, ELEVATIONS & SHAFT PROPERTIES

Shaft:			
Nominal shaft diameter (EL +622.8 ft to +607.9 ft)	=	48 in	1219 mm
Nominal shaft diameter (EL +607.9 ft to +585.4 ft)	=	42 in	1067 mm
O-cell: 16-6-000106	=	16 in	410 mm
Bouyant weight of pile above base of O-cell	=	59 kips	0.26 MN
Estimated shaft stiffness, AE (EL +622.8 ft to +607.9 ft)	=	7,630,000 kips	33,900 MN
Estimated shaft stiffness, AE (EL +607.9 ft to +589.8 ft)	=	6,080,000 kips	27,100 MN
Estimated shaft stiffness, AE (EL +589.8 ft to +585.4 ft)	=	5,060,000 kips	22,500 MN
Elevation of top of ground surface / shaft concrete	=	+622.8 ft	+189.84 m
Elevation of base of O-cell (The break between upward and downward movement.)	=	+589.8 ft	+179.76 m
Elevation of shaft tip	=	+585.4 ft	+178.41 m
Elevation of water table	=	Unknown	
Compression Sections:			
Elevation of top of compression section used for upper shaft compression	=	+622.8 ft	+189.84 m
Elevation of bottom of compression section used for upper shaft compression	=	+590.9 ft	+180.11 m
Strain Gages:			
Elevation of strain gage Level 3	=	+610.3 ft	+186.01 m
Elevation of strain gage Level 2	=	+604.3 ft	+184.18 m
Elevation of strain gage Level 1	=	+598.3 ft	+182.35 m
Miscellaneous:			
Top plate diameter (2-inch thickness)	=	33.8 in	857 mm
Bottom plate diameter (2-inch thickness)	=	38.0 in	965 mm
ReBar size (32 No.)	=	# 10	M 32
Spiral size (4.5 inch spacing)	=	# 5	M 16
ReBar cage diameter	=	38 in	965 mm
Unconfined compressive concrete strength	=	4100 psi	28.3 MPa
O-cell LVWDTs @ 0°, 180° and 270° with radius	=	10.0 in	254 mm



LOADTEST

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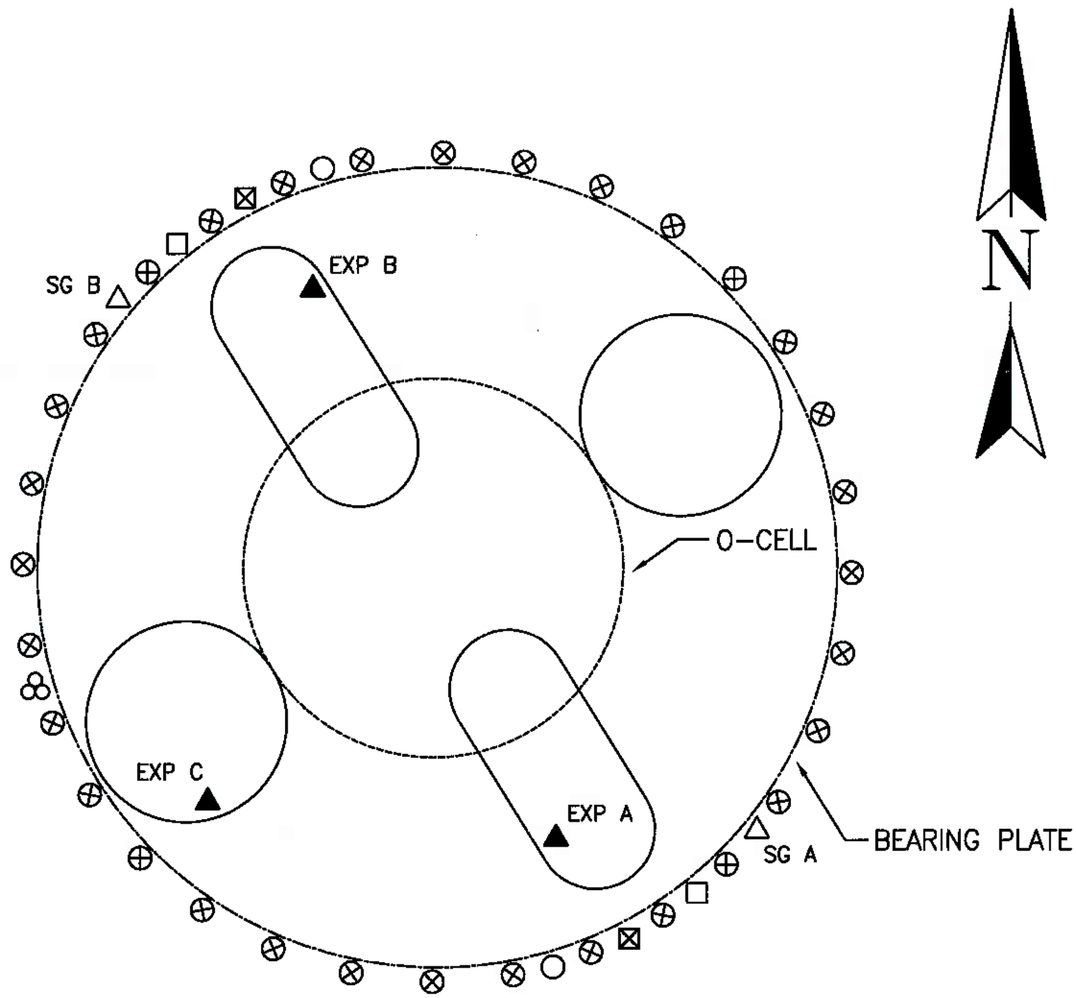
SCHEMATIC SECTION OF TEST SHAFT

IL 5 / IL 84 Interchange – Rock Island County, IL

DRAWN BY: SCB	DATE: 10/5/07	CHECKED BY: WGR	LT-9405
REVISED BY: MDA	DATE: 04/24/08	SCALE: NTS	FIGURE A



LEGEND:

STRAIN GAGE	△
LVWDT	▲
TELLTALE	○
VENT PIPE	□
HYDRAULIC HOSES	⊠
REBAR	⊗
CABLE BUNDLE	

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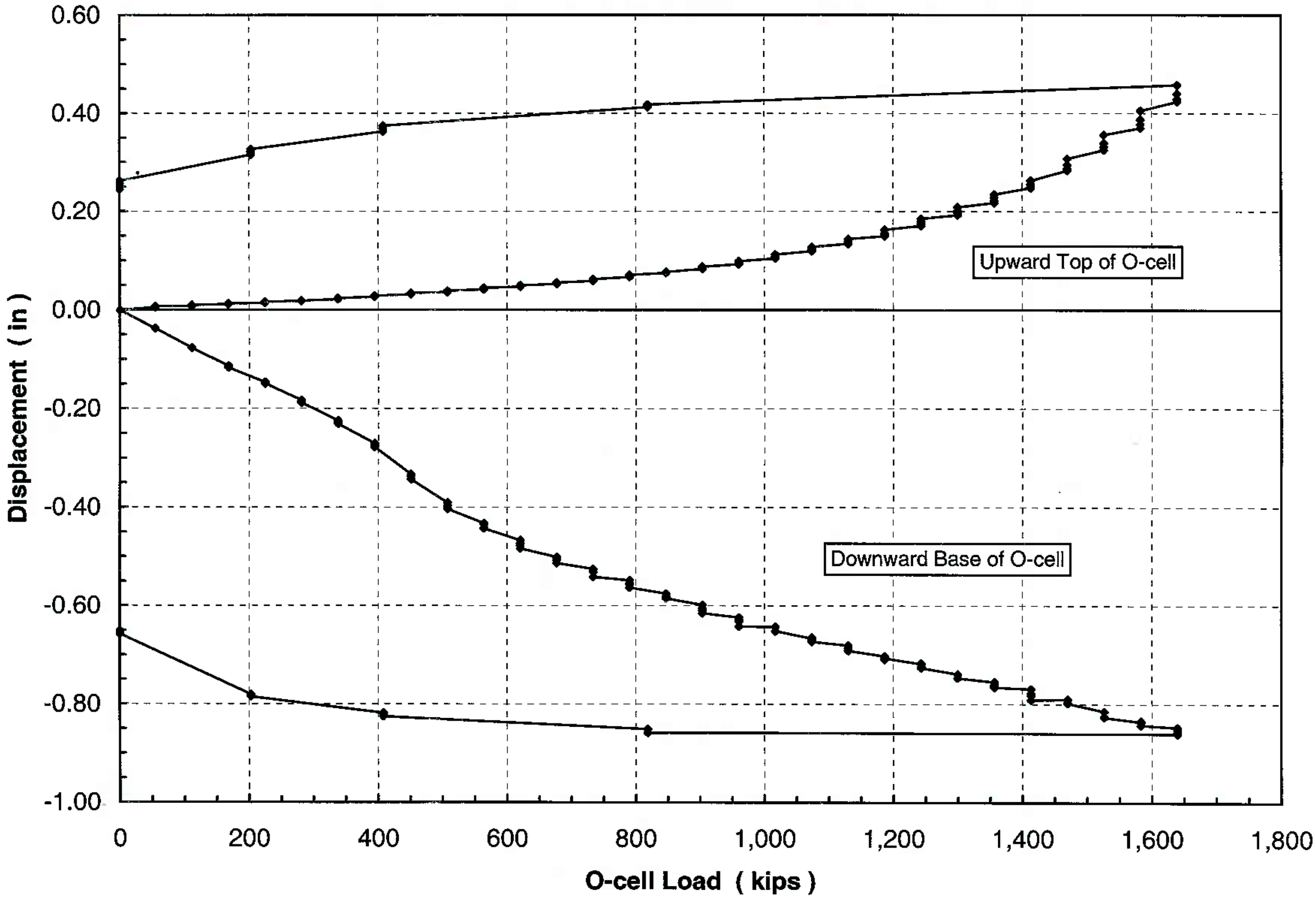
INSTRUMENTATION LAYOUT
IL 5 / IL 84 Interchange – Rock Island County, IL

DWN BY: AMK	DATE: 04/18/08	CHECKED BY:	LT-9405
REVISED BY: MDA	DATE: 04/24/08	SCALE: NTS	FIGURE B

LOADTEST

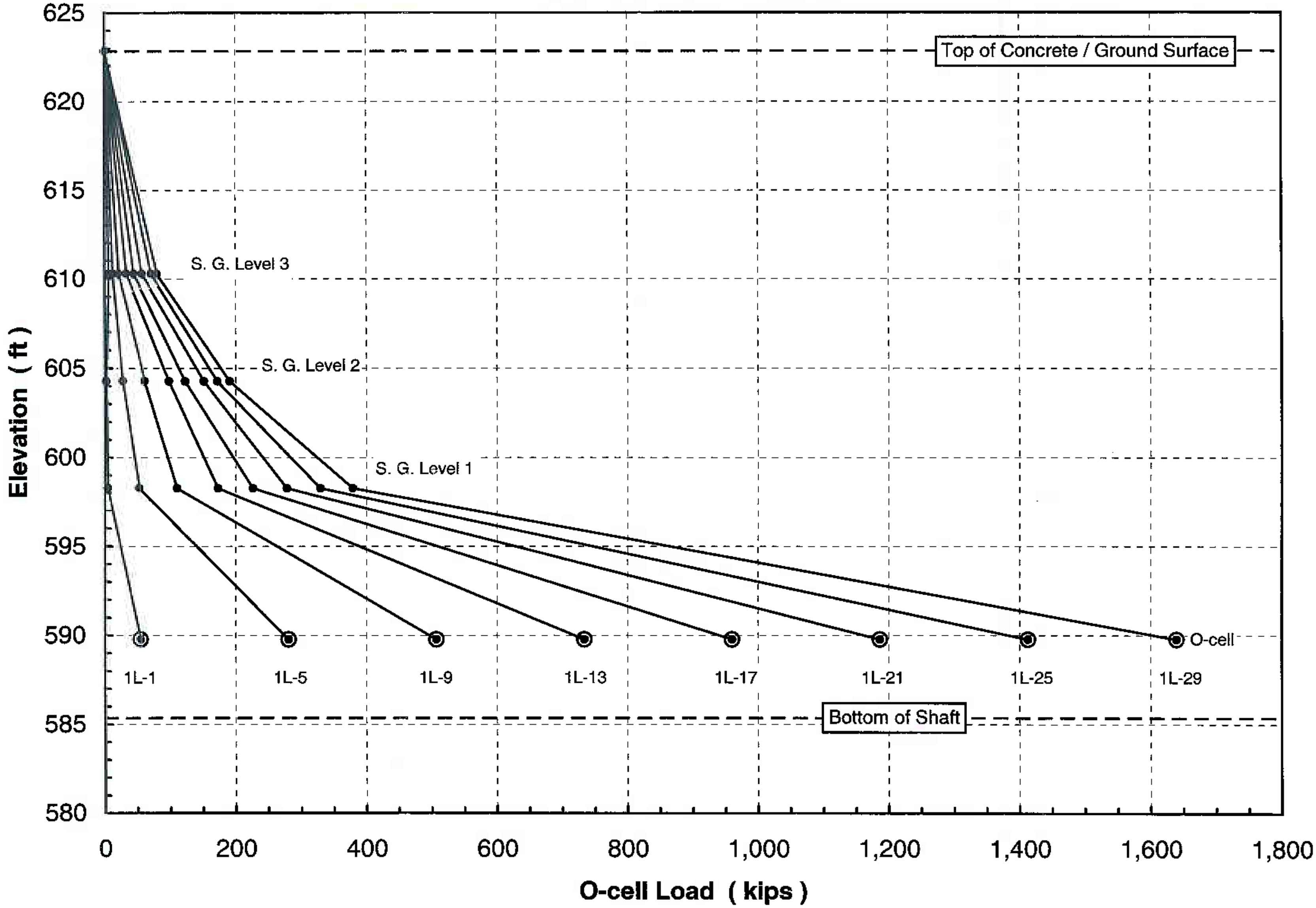
Osterberg Cell Load-Movement

Test Shaft #1 - IL 5 / IL 84 Interchange - Rock Island Co., IL



Strain Gage Load Distribution

Test Shaft #1 - IL 5 / IL 84 Interchange - Rock Island Co., IL



LOADTEST, Inc. Project No. LT-9405

Figure 2 of 5

Mobilized Net Unit Side Shear

Test Shaft #1 - IL 5 / IL 84 Interchange - Rock Island Co., IL

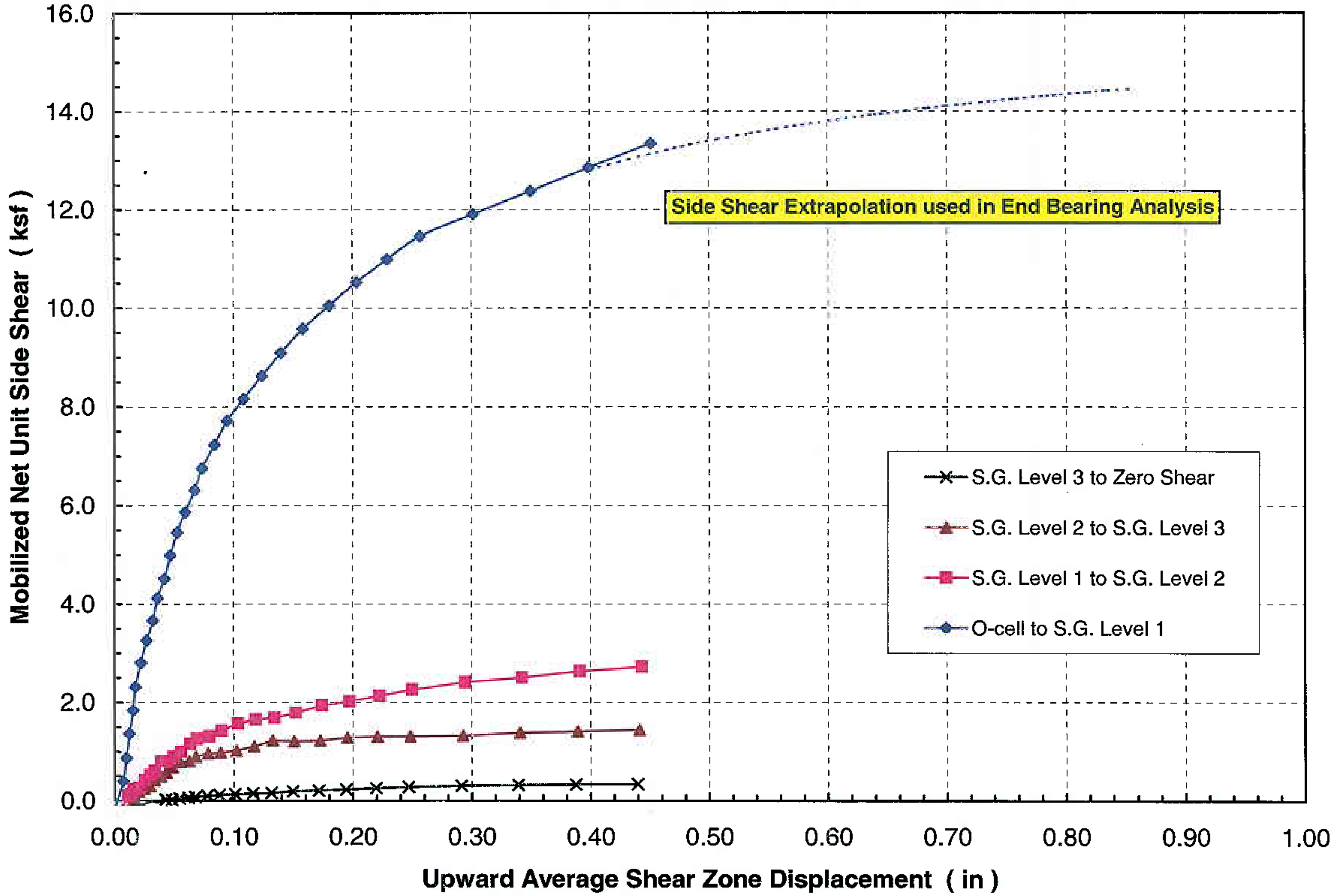


Figure 3 of 5

Mobilized Unit End Bearing

Test Shaft #1 - IL 5 / IL 84 Interchange - Rock Island Co., IL

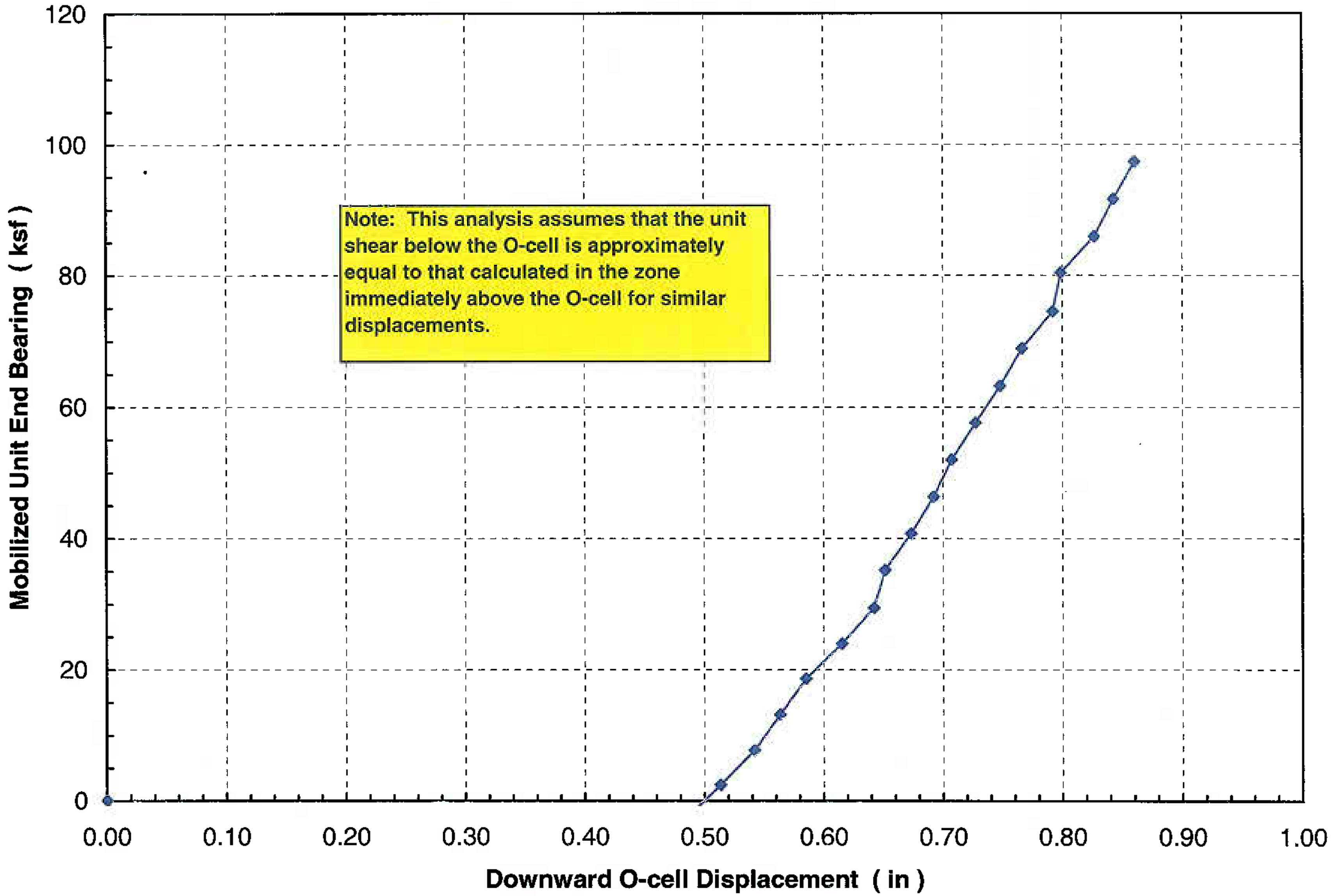
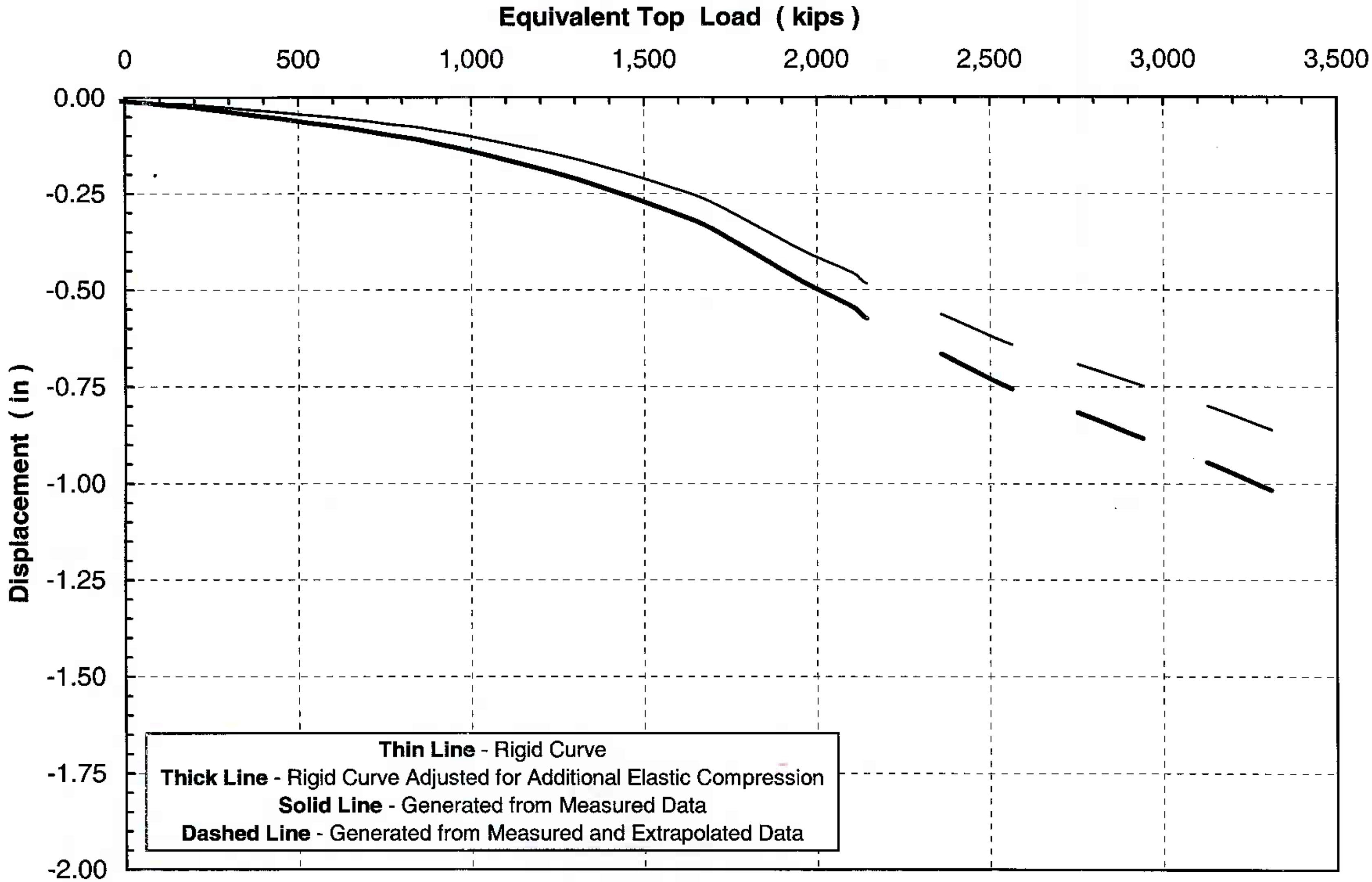


Figure 4 of 5

Equivalent Top Load Load-Movement

Test Shaft #1 - IL 5 / IL 84 Interchange - Rock Island Co., IL



APPENDIX A

FIELD DATA & DATA REDUCTION

Upward Top of Shaft Movement and Shaft Compression
Test Shaft #1 - IL 5 / IL 84 Interchange - Rock Island Co., IL

Load Test Increment	Hold Time (minutes)	Time (h:m:s)	O-cell		Top of Shaft			Telltales		
			Pressure (psi)	Load (kips)	A (in)	B (in)	Average (in)	A (in)	B (in)	Average (in)
1 L - 0	-	10:37:00	0	0	0.000	0.000	0.000	0.000	0.000	0.000
1 L - 1	1	11:05:30	400	55	0.004	0.006	0.005	0.001	0.001	0.001
1 L - 1	2	11:06:30	400	55	0.004	0.008	0.006	0.001	0.001	0.001
1 L - 1	4	11:08:30	400	55	0.004	0.007	0.006	0.001	0.001	0.001
1 L - 1	8	11:12:30	400	55	0.004	0.009	0.007	0.001	0.001	0.001
1 L - 2	1	11:15:00	800	111	0.005	0.008	0.007	0.001	0.001	0.001
1 L - 2	2	11:16:00	800	111	0.006	0.010	0.008	0.001	0.001	0.001
1 L - 2	4	11:18:00	800	111	0.006	0.012	0.009	0.001	0.001	0.001
1 L - 2	8	11:22:00	800	111	0.006	0.012	0.009	0.001	0.001	0.001
1 L - 3	1	11:24:00	1,200	168	0.007	0.013	0.010	0.001	0.001	0.001
1 L - 3	2	11:25:00	1,200	168	0.008	0.014	0.011	0.001	0.001	0.001
1 L - 3	4	11:27:00	1,200	168	0.008	0.014	0.011	0.001	0.001	0.001
1 L - 3	8	11:31:00	1,200	168	0.008	0.015	0.012	0.001	0.001	0.001
1 L - 4	1	11:33:30	1,600	224	0.009	0.016	0.013	0.002	0.001	0.002
1 L - 4	2	11:34:30	1,600	224	0.009	0.017	0.013	0.002	0.001	0.002
1 L - 4	4	11:36:30	1,600	224	0.009	0.017	0.013	0.002	0.001	0.002
1 L - 4	8	11:40:30	1,600	224	0.010	0.019	0.015	0.002	0.002	0.002
1 L - 5	1	11:43:30	2,000	281	0.011	0.021	0.016	0.002	0.002	0.002
1 L - 5	2	11:44:30	2,000	281	0.011	0.021	0.016	0.002	0.002	0.002
1 L - 5	4	11:46:30	2,000	281	0.012	0.021	0.017	0.002	0.002	0.002
1 L - 5	8	11:50:30	2,000	281	0.011	0.021	0.016	0.002	0.002	0.002
1 L - 6	1	11:52:30	2,400	338	0.013	0.025	0.019	0.003	0.002	0.003
1 L - 6	2	11:53:30	2,400	338	0.013	0.026	0.019	0.003	0.002	0.003
1 L - 6	4	11:55:30	2,400	338	0.013	0.025	0.019	0.003	0.003	0.003
1 L - 6	8	11:59:30	2,400	338	0.013	0.028	0.021	0.003	0.003	0.003
1 L - 7	1	12:02:30	2,800	394	0.015	0.031	0.023	0.003	0.003	0.003
1 L - 7	2	12:03:30	2,800	394	0.016	0.032	0.024	0.003	0.003	0.003
1 L - 7	4	12:05:30	2,800	394	0.016	0.032	0.024	0.003	0.003	0.003
1 L - 7	8	12:09:30	2,800	394	0.016	0.034	0.025	0.003	0.003	0.003
1 L - 8	1	12:12:30	3,200	451	0.018	0.037	0.028	0.004	0.004	0.004
1 L - 8	2	12:13:30	3,200	451	0.018	0.038	0.028	0.004	0.004	0.004
1 L - 8	4	12:15:30	3,200	451	0.018	0.038	0.028	0.004	0.004	0.004
1 L - 8	8	12:19:30	3,200	451	0.019	0.041	0.030	0.004	0.004	0.004
1 L - 9	1	12:21:30	3,600	507	0.021	0.042	0.032	0.005	0.004	0.004
1 L - 9	2	12:22:30	3,600	507	0.021	0.043	0.032	0.005	0.004	0.005
1 L - 9	4	12:24:30	3,600	507	0.021	0.043	0.032	0.005	0.005	0.005
1 L - 9	8	12:28:30	3,600	507	0.022	0.045	0.034	0.005	0.005	0.005
1 L - 10	1	12:30:30	4,000	564	0.024	0.048	0.036	0.005	0.005	0.005
1 L - 10	2	12:31:30	4,000	564	0.024	0.049	0.036	0.005	0.005	0.005
1 L - 10	4	12:33:30	4,000	564	0.025	0.049	0.037	0.005	0.005	0.005
1 L - 10	8	12:37:30	4,000	564	0.027	0.051	0.039	0.005	0.005	0.005
1 L - 11	1	12:39:30	4,400	621	0.028	0.054	0.041	0.006	0.006	0.006
1 L - 11	2	12:40:30	4,400	621	0.028	0.055	0.042	0.006	0.006	0.006
1 L - 11	4	12:42:30	4,400	621	0.029	0.056	0.043	0.006	0.006	0.006
1 L - 11	8	12:46:30	4,400	621	0.029	0.058	0.043	0.006	0.006	0.006
1 L - 12	1	12:48:00	4,800	677	0.032	0.060	0.046	0.007	0.006	0.006
1 L - 12	2	12:49:00	4,800	677	0.032	0.061	0.047	0.007	0.006	0.006
1 L - 12	4	12:51:00	4,800	677	0.033	0.062	0.048	0.007	0.006	0.007
1 L - 12	8	12:55:00	4,800	677	0.033	0.064	0.049	0.007	0.007	0.007
1 L - 13	1	12:57:00	5,200	734	0.036	0.067	0.052	0.007	0.007	0.007
1 L - 13	2	12:58:00	5,200	734	0.037	0.069	0.053	0.007	0.007	0.007
1 L - 13	4	13:00:00	5,200	734	0.038	0.070	0.054	0.007	0.007	0.007
1 L - 13	8	13:04:00	5,200	734	0.039	0.071	0.055	0.007	0.007	0.007
1 L - 14	1	13:06:00	5,600	790	0.042	0.076	0.059	0.008	0.008	0.008
1 L - 14	2	13:07:00	5,600	790	0.043	0.077	0.060	0.008	0.008	0.008
1 L - 14	4	13:09:00	5,600	790	0.044	0.078	0.061	0.008	0.008	0.008
1 L - 14	8	13:13:00	5,600	790	0.045	0.080	0.063	0.008	0.008	0.008
1 L - 15	1	13:15:00	6,000	847	0.049	0.084	0.067	0.008	0.009	0.009
1 L - 15	2	13:16:00	6,000	847	0.050	0.084	0.067	0.008	0.009	0.009
1 L - 15	4	13:18:00	6,000	847	0.051	0.084	0.067	0.008	0.009	0.009
1 L - 15	8	13:22:00	6,000	847	0.052	0.084	0.068	0.008	0.009	0.009
1 L - 16	1	13:24:00	6,400	904	0.057	0.090	0.074	0.009	0.010	0.010
1 L - 16	2	13:25:00	6,400	904	0.058	0.090	0.074	0.009	0.010	0.010
1 L - 16	4	13:27:00	6,400	904	0.059	0.093	0.076	0.009	0.010	0.010
1 L - 16	8	13:31:00	6,400	904	0.061	0.095	0.078	0.009	0.010	0.010

Upward Top of Shaft Movement and Shaft Compression
Test Shaft #1 - IL 5 / IL 84 Interchange - Rock Island Co., IL

Load Test Increment	Hold Time (minutes)	Time (h:m:s)	O-cell Pressure (psi)	O-cell Load (kips)	Top of Shaft A (in)	Top of Shaft B (in)	Top of Shaft Average (in)	Telltales A (in)	Telltales B (in)	Telltales Average (in)
1 L - 17	1	13:32:30	6,800	960	0.065	0.100	0.083	0.009	0.011	0.010
1 L - 17	2	13:33:30	6,800	960	0.066	0.101	0.084	0.009	0.011	0.010
1 L - 17	4	13:35:30	6,800	960	0.069	0.104	0.086	0.009	0.011	0.010
1 L - 17	8	13:39:30	6,800	960	0.070	0.107	0.088	0.009	0.011	0.010
1 L - 18	1	13:41:30	7,200	1,017	0.075	0.112	0.094	0.010	0.012	0.011
1 L - 18	2	13:42:30	7,200	1,017	0.077	0.116	0.096	0.010	0.012	0.011
1 L - 18	4	13:44:30	7,200	1,017	0.079	0.117	0.098	0.010	0.012	0.011
1 L - 18	8	13:48:30	7,200	1,017	0.081	0.122	0.102	0.010	0.012	0.011
1 L - 19	1	13:50:30	7,600	1,073	0.087	0.128	0.108	0.010	0.013	0.012
1 L - 19	2	13:51:30	7,600	1,073	0.091	0.129	0.110	0.010	0.013	0.012
1 L - 19	4	13:53:30	7,600	1,073	0.093	0.131	0.112	0.010	0.013	0.012
1 L - 19	8	13:57:30	7,600	1,073	0.096	0.136	0.116	0.010	0.014	0.012
1 L - 20	1	13:59:30	8,000	1,130	0.102	0.142	0.122	0.011	0.014	0.013
1 L - 20	2	14:00:30	8,000	1,130	0.104	0.144	0.124	0.011	0.014	0.013
1 L - 20	4	14:02:30	8,000	1,130	0.108	0.146	0.127	0.011	0.015	0.013
1 L - 20	8	14:06:30	8,000	1,130	0.112	0.151	0.132	0.011	0.015	0.013
1 L - 21	1	14:08:00	8,400	1,187	0.117	0.156	0.137	0.011	0.015	0.013
1 L - 21	2	14:09:00	8,400	1,187	0.118	0.158	0.138	0.011	0.015	0.013
1 L - 21	4	14:11:00	8,400	1,187	0.122	0.162	0.142	0.011	0.016	0.013
1 L - 21	8	14:15:00	8,400	1,187	0.128	0.171	0.150	0.011	0.016	0.013
1 L - 22	1	14:16:30	8,800	1,243	0.135	0.178	0.157	0.011	0.016	0.014
1 L - 22	2	14:17:30	8,800	1,243	0.139	0.183	0.161	0.011	0.016	0.014
1 L - 22	4	14:19:30	8,800	1,243	0.143	0.188	0.166	0.012	0.017	0.014
1 L - 22	8	14:23:30	8,800	1,243	0.149	0.193	0.171	0.012	0.017	0.014
1 L - 23	1	14:25:30	9,200	1,300	0.156	0.199	0.178	0.012	0.017	0.015
1 L - 23	2	14:26:30	9,200	1,300	0.159	0.205	0.182	0.012	0.018	0.015
1 L - 23	4	14:28:30	9,200	1,300	0.164	0.209	0.187	0.012	0.018	0.015
1 L - 23	8	14:32:30	9,200	1,300	0.171	0.217	0.194	0.012	0.018	0.015
1 L - 24	1	14:34:00	9,600	1,356	0.179	0.225	0.202	0.012	0.019	0.015
1 L - 24	2	14:35:00	9,600	1,356	0.183	0.230	0.207	0.012	0.019	0.015
1 L - 24	4	14:37:00	9,600	1,356	0.189	0.237	0.213	0.012	0.019	0.015
1 L - 24	8	14:41:00	9,600	1,356	0.196	0.242	0.219	0.012	0.019	0.016
1 L - 25	1	14:42:30	10,000	1,413	0.207	0.257	0.232	0.012	0.020	0.016
1 L - 25	2	14:43:30	10,000	1,413	0.209	0.257	0.233	0.012	0.020	0.016
1 L - 25	4	14:45:30	10,000	1,413	0.215	0.264	0.239	0.012	0.020	0.016
1 L - 25	8	14:49:30	10,000	1,413	0.224	0.269	0.246	0.012	0.020	0.016
1 L - 26	1	14:51:30	10,400	1,470	0.239	0.294	0.267	0.013	0.021	0.017
1 L - 26	2	14:52:30	10,400	1,470	0.243	0.298	0.271	0.013	0.021	0.017
1 L - 26	4	14:54:30	10,400	1,470	0.250	0.306	0.278	0.013	0.021	0.017
1 L - 26	8	14:58:30	10,400	1,470	0.263	0.318	0.291	0.013	0.021	0.017
1 L - 27	1	15:00:30	10,800	1,526	0.279	0.336	0.308	0.013	0.022	0.018
1 L - 27	2	15:01:30	10,800	1,526	0.285	0.343	0.314	0.013	0.022	0.018
1 L - 27	4	15:03:30	10,800	1,526	0.294	0.349	0.322	0.013	0.022	0.018
1 L - 27	8	15:07:30	10,800	1,526	0.309	0.368	0.339	0.013	0.023	0.018
1 L - 28	1	15:09:00	11,200	1,583	0.324	0.379	0.352	0.013	0.023	0.018
1 L - 28	2	15:10:00	11,200	1,583	0.329	0.390	0.360	0.013	0.023	0.018
1 L - 28	4	15:12:00	11,200	1,583	0.339	0.399	0.369	0.013	0.023	0.018
1 L - 28	8	15:16:00	11,200	1,583	0.356	0.418	0.387	0.013	0.023	0.018
1 L - 29	1	15:18:00	11,600	1,639	0.374	0.436	0.405	0.014	0.024	0.019
1 L - 29	2	15:19:00	11,600	1,639	0.381	0.439	0.410	0.014	0.024	0.019
1 L - 29	4	15:21:00	11,600	1,639	0.392	0.450	0.421	0.014	0.024	0.019
1 L - 29	8	15:25:00	11,600	1,639	0.409	0.469	0.439	0.014	0.024	0.019
1 U - 1	1	15:27:00	5,800	819	0.375	0.433	0.404	0.007	0.021	0.014
1 U - 1	2	15:28:00	5,800	819	0.371	0.432	0.402	0.007	0.021	0.014
1 U - 1	4	15:30:00	5,800	819	0.369	0.429	0.399	0.006	0.020	0.013
1 U - 2	1	15:31:30	2,900	408	0.334	0.394	0.364	0.003	0.018	0.010
1 U - 2	2	15:32:30	2,900	408	0.328	0.390	0.359	0.003	0.017	0.010
1 U - 2	4	15:34:30	2,900	408	0.322	0.384	0.353	0.003	0.017	0.010
1 U - 3	1	15:36:30	1,450	203	0.287	0.349	0.318	0.001	0.016	0.009
1 U - 3	2	15:37:30	1,450	203	0.282	0.343	0.313	0.001	0.016	0.008
1 U - 3	4	15:39:30	1,450	203	0.276	0.338	0.307	0.001	0.016	0.008
1 U - 4	1	15:41:30	0	0	0.223	0.287	0.255	0.001	0.012	0.007
1 U - 4	2	15:42:30	0	0	0.218	0.282	0.250	0.001	0.012	0.007
1 U - 4	4	15:44:30	0	0	0.212	0.277	0.245	0.001	0.012	0.006
1 U - 4	8	15:48:30	0	0	0.206	0.272	0.239	0.000	0.012	0.006

O-cell Expansion

Test Shaft #1 - IL 5 / IL 84 Interchange - Rock Island Co., IL

Load Test Increment	Hold Time (minutes)	Time (h:m:s)	O-cell Pressure (psi)	O-cell Load (kips)	O-cell Expansion A - 08-5252 (in)	B - 08-5296 (in)	C - 08-5297 * (in)	Average (in)
1 L - 0	-	10:37:00	0	0	0.000	0.000	0.000	0.000
1 L - 1	1	11:05:30	400	55	0.035	0.052	0.018	0.043
1 L - 1	2	11:06:30	400	55	0.035	0.052	0.018	0.043
1 L - 1	4	11:08:30	400	55	0.035	0.052	0.018	0.044
1 L - 1	8	11:12:30	400	55	0.036	0.053	0.019	0.044
1 L - 2	1	11:15:00	800	111	0.075	0.094	0.040	0.084
1 L - 2	2	11:16:00	800	111	0.076	0.095	0.041	0.086
1 L - 2	4	11:18:00	800	111	0.077	0.096	0.042	0.087
1 L - 2	8	11:22:00	800	111	0.078	0.097	0.043	0.088
1 L - 3	1	11:24:00	1,200	168	0.115	0.135	0.066	0.125
1 L - 3	2	11:25:00	1,200	168	0.117	0.137	0.067	0.127
1 L - 3	4	11:27:00	1,200	168	0.119	0.138	0.068	0.129
1 L - 3	8	11:31:00	1,200	168	0.120	0.140	0.070	0.130
1 L - 4	1	11:33:30	1,600	224	0.151	0.171	0.091	0.161
1 L - 4	2	11:34:30	1,600	224	0.152	0.172	0.092	0.162
1 L - 4	4	11:36:30	1,600	224	0.154	0.174	0.094	0.164
1 L - 4	8	11:40:30	1,600	224	0.156	0.175	0.095	0.165
1 L - 5	1	11:43:30	2,000	281	0.191	0.211	0.121	0.201
1 L - 5	2	11:44:30	2,000	281	0.194	0.213	0.123	0.203
1 L - 5	4	11:46:30	2,000	281	0.195	0.215	0.124	0.205
1 L - 5	8	11:50:30	2,000	281	0.197	0.217	0.126	0.207
1 L - 6	1	11:52:30	2,400	338	0.236	0.256	0.151	0.246
1 L - 6	2	11:53:30	2,400	338	0.239	0.259	0.152	0.249
1 L - 6	4	11:55:30	2,400	338	0.241	0.261	0.153	0.251
1 L - 6	8	11:59:30	2,400	338	0.244	0.264	0.155	0.254
1 L - 7	1	12:02:30	2,800	394	0.287	0.307	0.178	0.297
1 L - 7	2	12:03:30	2,800	394	0.289	0.310	0.178	0.300
1 L - 7	4	12:05:30	2,800	394	0.292	0.313	0.179	0.303
1 L - 7	8	12:09:30	2,800	394	0.296	0.317	0.180	0.306
1 L - 8	1	12:12:30	3,200	451	0.358	0.371	0.213	0.364
1 L - 8	2	12:13:30	3,200	451	0.363	0.375	0.214	0.369
1 L - 8	4	12:15:30	3,200	451	0.368	0.381	0.218	0.375
1 L - 8	8	12:19:30	3,200	451	0.373	0.383	0.218	0.378
1 L - 9	1	12:21:30	3,600	507	0.424	0.429	0.242	0.427
1 L - 9	2	12:22:30	3,600	507	0.430	0.436	0.243	0.433
1 L - 9	4	12:24:30	3,600	507	0.434	0.443	0.248	0.439
1 L - 9	8	12:28:30	3,600	507	0.438	0.446	0.248	0.442
1 L - 10	1	12:30:30	4,000	564	0.474	0.474	0.272	0.474
1 L - 10	2	12:31:30	4,000	564	0.478	0.476	0.272	0.477
1 L - 10	4	12:33:30	4,000	564	0.483	0.485	0.275	0.484
1 L - 10	8	12:37:30	4,000	564	0.490	0.485	0.283	0.488
1 L - 11	1	12:39:30	4,400	621	0.516	0.512	0.293	0.514
1 L - 11	2	12:40:30	4,400	621	0.521	0.522	0.295	0.521
1 L - 11	4	12:42:30	4,400	621	0.527	0.528	0.302	0.527
1 L - 11	8	12:46:30	4,400	621	0.533	0.534	0.303	0.534
1 L - 12	1	12:48:00	4,800	677	0.552	0.555	0.312	0.554
1 L - 12	2	12:49:00	4,800	677	0.556	0.555	0.315	0.556
1 L - 12	4	12:51:00	4,800	677	0.563	0.559	0.319	0.561
1 L - 12	8	12:55:00	4,800	677	0.566	0.571	0.322	0.569
1 L - 13	1	12:57:00	5,200	734	0.583	0.585	0.328	0.584
1 L - 13	2	12:58:00	5,200	734	0.589	0.585	0.328	0.587
1 L - 13	4	13:00:00	5,200	734	0.595	0.591	0.333	0.593
1 L - 13	8	13:04:00	5,200	734	0.602	0.607	0.337	0.604
1 L - 14	1	13:06:00	5,600	790	0.616	0.615	0.347	0.616
1 L - 14	2	13:07:00	5,600	790	0.621	0.623	0.349	0.622
1 L - 14	4	13:09:00	5,600	790	0.628	0.623	0.350	0.626
1 L - 14	8	13:13:00	5,600	790	0.632	0.635	0.357	0.634
1 L - 15	1	13:15:00	6,000	847	0.650	0.651	0.362	0.651
1 L - 15	2	13:16:00	6,000	847	0.654	0.660	0.364	0.657
1 L - 15	4	13:18:00	6,000	847	0.658	0.660	0.366	0.659
1 L - 15	8	13:22:00	6,000	847	0.664	0.660	0.366	0.662
1 L - 16	1	13:24:00	6,400	904	0.683	0.681	0.375	0.682
1 L - 16	2	13:25:00	6,400	904	0.691	0.687	0.377	0.689
1 L - 16	4	13:27:00	6,400	904	0.696	0.694	0.383	0.695
1 L - 16	8	13:31:00	6,400	904	0.703	0.703	0.394	0.703

O-cell Expansion
Test Shaft #1 - IL 5 / IL 84 Interchange - Rock Island Co., IL

Load Test Increment	Hold Time (minutes)	Time (h:m:s)	O-cell Pressure (psi)	O-cell Load (kips)	O-cell Expansion A - 08-5252 (in)	O-cell Expansion B - 08-5296 (in)	O-cell Expansion C - 08-5297 * (in)	O-cell Expansion Average (in)
1 L - 17	1	13:32:30	6,800	960	0.716	0.717	0.399	0.717
1 L - 17	2	13:33:30	6,800	960	0.721	0.724	0.402	0.722
1 L - 17	4	13:35:30	6,800	960	0.725	0.734	0.405	0.729
1 L - 17	8	13:39:30	6,800	960	0.745	0.736	0.409	0.741
1 L - 18	1	13:41:30	7,200	1,017	0.746	0.749	0.415	0.748
1 L - 18	2	13:42:30	7,200	1,017	0.747	0.754	0.421	0.750
1 L - 18	4	13:44:30	7,200	1,017	0.755	0.767	0.429	0.761
1 L - 18	8	13:48:30	7,200	1,017	0.761	0.767	0.430	0.764
1 L - 19	1	13:50:30	7,600	1,073	0.781	0.790	0.442	0.786
1 L - 19	2	13:51:30	7,600	1,073	0.782	0.790	0.445	0.786
1 L - 19	4	13:53:30	7,600	1,073	0.789	0.799	0.448	0.794
1 L - 19	8	13:57:30	7,600	1,073	0.796	0.806	0.456	0.801
1 L - 20	1	13:59:30	8,000	1,130	0.813	0.817	0.470	0.815
1 L - 20	2	14:00:30	8,000	1,130	0.819	0.828	0.470	0.823
1 L - 20	4	14:02:30	8,000	1,130	0.824	0.828	0.473	0.826
1 L - 20	8	14:06:30	8,000	1,130	0.834	0.838	0.481	0.836
1 L - 21	1	14:08:00	8,400	1,187	0.849	0.856	0.492	0.852
1 L - 21	2	14:09:00	8,400	1,187	0.852	0.865	0.495	0.858
1 L - 21	4	14:11:00	8,400	1,187	0.860	0.869	0.502	0.865
1 L - 21	8	14:15:00	8,400	1,187	0.869	0.871	0.505	0.870
1 L - 22	1	14:16:30	8,800	1,243	0.885	0.893	0.518	0.889
1 L - 22	2	14:17:30	8,800	1,243	0.891	0.893	0.522	0.892
1 L - 22	4	14:19:30	8,800	1,243	0.897	0.909	0.529	0.903
1 L - 22	8	14:23:30	8,800	1,243	0.908	0.916	0.541	0.912
1 L - 23	1	14:25:30	9,200	1,300	0.927	0.936	0.553	0.932
1 L - 23	2	14:26:30	9,200	1,300	0.932	0.942	0.555	0.937
1 L - 23	4	14:28:30	9,200	1,300	0.940	0.957	0.561	0.948
1 L - 23	8	14:32:30	9,200	1,300	0.951	0.962	0.569	0.956
1 L - 24	1	14:34:00	9,600	1,356	0.969	0.976	0.583	0.972
1 L - 24	2	14:35:00	9,600	1,356	0.973	0.995	0.586	0.984
1 L - 24	4	14:37:00	9,600	1,356	0.982	0.995	0.592	0.989
1 L - 24	8	14:41:00	9,600	1,356	0.994	1.006	0.603	1.000
1 L - 25	1	14:42:30	10,000	1,413	1.011	1.024	0.619	1.017
1 L - 25	2	14:43:30	10,000	1,413	1.017	1.037	0.624	1.027
1 L - 25	4	14:45:30	10,000	1,413	1.025	1.051	0.634	1.038
1 L - 25	8	14:49:30	10,000	1,413	1.040	1.068	0.645	1.054
1 L - 26	1	14:51:30	10,400	1,470	1.063	1.084	0.661	1.073
1 L - 26	2	14:52:30	10,400	1,470	1.066	1.090	0.670	1.078
1 L - 26	4	14:54:30	10,400	1,470	1.079	1.104	0.682	1.092
1 L - 26	8	14:58:30	10,400	1,470	1.091	1.120	0.694	1.106
1 L - 27	1	15:00:30	10,800	1,526	1.130	1.149	0.714	1.140
1 L - 27	2	15:01:30	10,800	1,526	1.135	1.157	0.721	1.146
1 L - 27	4	15:03:30	10,800	1,526	1.152	1.176	0.732	1.164
1 L - 27	8	15:07:30	10,800	1,526	1.174	1.192	0.751	1.183
1 L - 28	1	15:09:00	11,200	1,583	1.195	1.216	0.769	1.205
1 L - 28	2	15:10:00	11,200	1,583	1.198	1.224	0.776	1.211
1 L - 28	4	15:12:00	11,200	1,583	1.211	1.237	0.792	1.224
1 L - 28	8	15:16:00	11,200	1,583	1.231	1.264	0.806	1.248
1 L - 29	1	15:18:00	11,600	1,639	1.256	1.265	0.826	1.271
1 L - 29	2	15:19:00	11,600	1,639	1.265	1.295	0.836	1.280
1 L - 29	4	15:21:00	11,600	1,639	1.279	1.314	0.848	1.296
1 L - 29	8	15:25:00	11,600	1,639	1.297	1.339	0.869	1.318
1 U - 1	1	15:27:00	5,800	819	1.243	1.308	0.823	1.276
1 U - 1	2	15:28:00	5,800	819	1.240	1.308	0.820	1.274
1 U - 1	4	15:30:00	5,800	819	1.225	1.301	0.813	1.263
1 U - 2	1	15:31:30	2,900	408	1.162	1.237	0.767	1.200
1 U - 2	2	15:32:30	2,900	408	1.153	1.226	0.760	1.190
1 U - 2	4	15:34:30	2,900	408	1.146	1.216	0.752	1.181
1 U - 3	1	15:36:30	1,450	203	1.083	1.141	0.706	1.112
1 U - 3	2	15:37:30	1,450	203	1.076	1.133	0.697	1.105
1 U - 3	4	15:39:30	1,450	203	1.067	1.126	0.688	1.096
1 U - 4	1	15:41:30	0	0	0.895	0.943	0.584	0.919
1 U - 4	2	15:42:30	0	0	0.888	0.938	0.577	0.913
1 U - 4	4	15:44:30	0	0	0.880	0.928	0.570	0.904
1 U - 4	8	15:48:30	0	0	0.872	0.922	0.562	0.897

* LVWDT C is not included in the average due to its orientation.
LVWDTs A and B are oriented 180° opposed.

Upward and Downward O-cell Plate Movement and Creep (calculated)
Test Shaft #1 - IL 5 / IL 84 Interchange - Rock Island Co., IL

Load Test Increment	Hold Time (minutes)	Time (h:m:s)	O-cell Pressure (psi)	O-cell Load (kips)	Top of Shaft (in)	Total Comp. * (in)	Top Plate Movement (in)	O-cell Expansion (in)	Bot. Plate Movement (in)	Creep Up Per Hold (in)	Creep Dn Per Hold (in)
1 L - 0	-	10:37:00	0	0	0.000	0.000	0.000	0.000	0.000		
1 L - 1	1	11:05:30	400	55	0.005	0.001	0.006	0.043	-0.038		
1 L - 1	2	11:06:30	400	55	0.006	0.001	0.007	0.043	-0.037	0.001	-0.001
1 L - 1	4	11:08:30	400	55	0.006	0.001	0.006	0.044	-0.038	0.000	0.001
1 L - 1	8	11:12:30	400	55	0.007	0.001	0.007	0.044	-0.037	0.001	-0.001
1 L - 2	1	11:15:00	800	111	0.007	0.001	0.007	0.084	-0.077		
1 L - 2	2	11:16:00	800	111	0.008	0.001	0.009	0.086	-0.077	0.001	0.000
1 L - 2	4	11:18:00	800	111	0.009	0.001	0.010	0.087	-0.077	0.001	0.000
1 L - 2	8	11:22:00	800	111	0.009	0.001	0.010	0.088	-0.078	0.000	0.001
1 L - 3	1	11:24:00	1,200	168	0.010	0.001	0.011	0.125	-0.114		
1 L - 3	2	11:25:00	1,200	168	0.011	0.001	0.012	0.127	-0.115	0.001	0.001
1 L - 3	4	11:27:00	1,200	168	0.011	0.001	0.012	0.129	-0.116	0.000	0.002
1 L - 3	8	11:31:00	1,200	168	0.012	0.001	0.013	0.130	-0.117	0.001	0.001
1 L - 4	1	11:33:30	1,600	224	0.013	0.002	0.014	0.161	-0.147		
1 L - 4	2	11:34:30	1,600	224	0.013	0.002	0.015	0.162	-0.148	0.001	0.001
1 L - 4	4	11:36:30	1,600	224	0.013	0.002	0.015	0.164	-0.150	0.000	0.002
1 L - 4	8	11:40:30	1,600	224	0.015	0.002	0.016	0.165	-0.149	0.002	0.000
1 L - 5	1	11:43:30	2,000	281	0.016	0.002	0.018	0.201	-0.183		
1 L - 5	2	11:44:30	2,000	281	0.016	0.002	0.018	0.203	-0.185	0.000	0.002
1 L - 5	4	11:46:30	2,000	281	0.017	0.002	0.019	0.205	-0.186	0.001	0.001
1 L - 5	8	11:50:30	2,000	281	0.016	0.002	0.018	0.207	-0.189	0.000	0.002
1 L - 6	1	11:52:30	2,400	338	0.019	0.003	0.022	0.246	-0.224		
1 L - 6	2	11:53:30	2,400	338	0.019	0.003	0.022	0.249	-0.227	0.001	0.002
1 L - 6	4	11:55:30	2,400	338	0.019	0.003	0.022	0.251	-0.230	0.000	0.003
1 L - 6	8	11:59:30	2,400	338	0.021	0.003	0.023	0.254	-0.231	0.002	0.001
1 L - 7	1	12:02:30	2,800	394	0.023	0.003	0.026	0.297	-0.271		
1 L - 7	2	12:03:30	2,800	394	0.024	0.003	0.027	0.300	-0.272	0.001	0.002
1 L - 7	4	12:05:30	2,800	394	0.024	0.003	0.027	0.303	-0.275	0.000	0.003
1 L - 7	8	12:09:30	2,800	394	0.025	0.003	0.028	0.306	-0.278	0.001	0.003
1 L - 8	1	12:12:30	3,200	451	0.028	0.004	0.031	0.364	-0.333		
1 L - 8	2	12:13:30	3,200	451	0.028	0.004	0.032	0.369	-0.337	0.001	0.004
1 L - 8	4	12:15:30	3,200	451	0.028	0.004	0.032	0.375	-0.343	0.000	0.006
1 L - 8	8	12:19:30	3,200	451	0.030	0.004	0.034	0.378	-0.344	0.002	0.001
1 L - 9	1	12:21:30	3,600	507	0.032	0.004	0.036	0.427	-0.391		
1 L - 9	2	12:22:30	3,600	507	0.032	0.005	0.037	0.433	-0.397	0.001	0.006
1 L - 9	4	12:24:30	3,600	507	0.032	0.005	0.037	0.439	-0.402	0.000	0.005
1 L - 9	8	12:28:30	3,600	507	0.034	0.005	0.038	0.442	-0.404	0.002	0.002
1 L - 10	1	12:30:30	4,000	564	0.036	0.005	0.041	0.474	-0.433		
1 L - 10	2	12:31:30	4,000	564	0.036	0.005	0.042	0.477	-0.435	0.001	0.002
1 L - 10	4	12:33:30	4,000	564	0.037	0.005	0.042	0.484	-0.442	0.001	0.007
1 L - 10	8	12:37:30	4,000	564	0.039	0.005	0.044	0.488	-0.443	0.002	0.002
1 L - 11	1	12:39:30	4,400	621	0.041	0.006	0.047	0.514	-0.467		
1 L - 11	2	12:40:30	4,400	621	0.042	0.006	0.047	0.521	-0.474	0.001	0.006
1 L - 11	4	12:42:30	4,400	621	0.043	0.006	0.048	0.527	-0.479	0.001	0.005
1 L - 11	8	12:46:30	4,400	621	0.043	0.006	0.050	0.534	-0.484	0.001	0.005
1 L - 12	1	12:48:00	4,800	677	0.046	0.006	0.052	0.554	-0.501		
1 L - 12	2	12:49:00	4,800	677	0.047	0.006	0.053	0.556	-0.503	0.001	0.002
1 L - 12	4	12:51:00	4,800	677	0.048	0.007	0.054	0.561	-0.507	0.001	0.004
1 L - 12	8	12:55:00	4,800	677	0.049	0.007	0.055	0.569	-0.513	0.001	0.007
1 L - 13	1	12:57:00	5,200	734	0.052	0.007	0.059	0.584	-0.525		
1 L - 13	2	12:58:00	5,200	734	0.053	0.007	0.060	0.587	-0.527	0.001	0.002
1 L - 13	4	13:00:00	5,200	734	0.054	0.007	0.061	0.593	-0.531	0.001	0.005
1 L - 13	8	13:04:00	5,200	734	0.055	0.007	0.062	0.604	-0.542	0.001	0.010
1 L - 14	1	13:06:00	5,600	790	0.059	0.008	0.067	0.616	-0.549		
1 L - 14	2	13:07:00	5,600	790	0.060	0.008	0.068	0.622	-0.554	0.001	0.005
1 L - 14	4	13:09:00	5,600	790	0.061	0.008	0.069	0.626	-0.557	0.001	0.003
1 L - 14	8	13:13:00	5,600	790	0.063	0.008	0.071	0.634	-0.563	0.002	0.007
1 L - 15	1	13:15:00	6,000	847	0.067	0.009	0.075	0.651	-0.576		
1 L - 15	2	13:16:00	6,000	847	0.067	0.009	0.076	0.657	-0.581	0.001	0.005
1 L - 15	4	13:18:00	6,000	847	0.067	0.009	0.076	0.659	-0.583	0.001	0.002
1 L - 15	8	13:22:00	6,000	847	0.068	0.009	0.077	0.662	-0.585	0.001	0.002
1 L - 16	1	13:24:00	6,400	904	0.074	0.010	0.083	0.682	-0.599		
1 L - 16	2	13:25:00	6,400	904	0.074	0.010	0.084	0.689	-0.605	0.001	0.007
1 L - 16	4	13:27:00	6,400	904	0.076	0.010	0.086	0.695	-0.610	0.002	0.004
1 L - 16	8	13:31:00	6,400	904	0.078	0.010	0.088	0.703	-0.615	0.002	0.006

Upward and Downward O-cell Plate Movement and Creep (calculated)
Test Shaft #1 - IL 5 / IL 84 Interchange - Rock Island Co., IL

Load Test Increment	Hold Time (minutes)	Time (h:m:s)	O-cell Pressure (psi)	O-cell Load (kips)	Top of Shaft (in)	Total Comp. * (in)	Top Plate Movement (in)	O-cell Expansion (in)	Bot. Plate Movement (in)	Creep Up Per Hold (in)	Creep Dn Per Hold (in)
1 L - 17	1	13:32:30	6,800	960	0.083	0.010	0.093	0.717	-0.624		
1 L - 17	2	13:33:30	6,800	960	0.084	0.010	0.094	0.722	-0.628	0.001	0.004
1 L - 17	4	13:35:30	6,800	960	0.086	0.010	0.097	0.729	-0.633	0.003	0.004
1 L - 17	8	13:39:30	6,800	960	0.088	0.010	0.099	0.741	-0.642	0.002	0.009
1 L - 18	1	13:41:30	7,200	1,017	0.094	0.011	0.104	0.748	-0.643		
1 L - 18	2	13:42:30	7,200	1,017	0.096	0.011	0.107	0.750	-0.643	0.003	0.000
1 L - 18	4	13:44:30	7,200	1,017	0.098	0.011	0.109	0.761	-0.652	0.002	0.009
1 L - 18	8	13:48:30	7,200	1,017	0.102	0.011	0.113	0.764	-0.651	0.004	-0.001
1 L - 19	1	13:50:30	7,600	1,073	0.108	0.012	0.119	0.786	-0.667		
1 L - 19	2	13:51:30	7,600	1,073	0.110	0.012	0.122	0.786	-0.665	0.003	-0.002
1 L - 19	4	13:53:30	7,600	1,073	0.112	0.012	0.124	0.794	-0.670	0.002	0.006
1 L - 19	8	13:57:30	7,600	1,073	0.116	0.012	0.128	0.801	-0.673	0.004	0.003
1 L - 20	1	13:59:30	8,000	1,130	0.122	0.013	0.135	0.815	-0.681		
1 L - 20	2	14:00:30	8,000	1,130	0.124	0.013	0.137	0.823	-0.687	0.002	0.006
1 L - 20	4	14:02:30	8,000	1,130	0.127	0.013	0.140	0.826	-0.686	0.003	-0.001
1 L - 20	8	14:06:30	8,000	1,130	0.132	0.013	0.144	0.836	-0.692	0.004	0.006
1 L - 21	1	14:08:00	8,400	1,187	0.137	0.013	0.150	0.852	-0.703		
1 L - 21	2	14:09:00	8,400	1,187	0.138	0.013	0.151	0.858	-0.707	0.002	0.004
1 L - 21	4	14:11:00	8,400	1,187	0.142	0.013	0.155	0.865	-0.709	0.004	0.002
1 L - 21	8	14:15:00	8,400	1,187	0.150	0.013	0.163	0.870	-0.707	0.008	-0.002
1 L - 22	1	14:16:30	8,800	1,243	0.157	0.014	0.170	0.889	-0.718		
1 L - 22	2	14:17:30	8,800	1,243	0.161	0.014	0.175	0.892	-0.717	0.005	-0.002
1 L - 22	4	14:19:30	8,800	1,243	0.166	0.014	0.180	0.903	-0.724	0.005	0.007
1 L - 22	8	14:23:30	8,800	1,243	0.171	0.014	0.185	0.912	-0.727	0.006	0.003
1 L - 23	1	14:25:30	9,200	1,300	0.178	0.015	0.192	0.932	-0.739		
1 L - 23	2	14:26:30	9,200	1,300	0.182	0.015	0.197	0.937	-0.741	0.005	0.001
1 L - 23	4	14:28:30	9,200	1,300	0.187	0.015	0.201	0.948	-0.747	0.005	0.007
1 L - 23	8	14:32:30	9,200	1,300	0.194	0.015	0.209	0.956	-0.747	0.008	0.000
1 L - 24	1	14:34:00	9,600	1,356	0.202	0.015	0.217	0.972	-0.755		
1 L - 24	2	14:35:00	9,600	1,356	0.207	0.015	0.222	0.984	-0.762	0.005	0.007
1 L - 24	4	14:37:00	9,600	1,356	0.213	0.015	0.228	0.989	-0.760	0.007	-0.002
1 L - 24	8	14:41:00	9,600	1,356	0.219	0.016	0.235	1.000	-0.766	0.006	0.005
1 L - 25	1	14:42:30	10,000	1,413	0.232	0.016	0.248	1.017	-0.769		
1 L - 25	2	14:43:30	10,000	1,413	0.233	0.016	0.249	1.027	-0.778	0.001	0.009
1 L - 25	4	14:45:30	10,000	1,413	0.239	0.016	0.256	1.038	-0.782	0.006	0.005
1 L - 25	8	14:49:30	10,000	1,413	0.246	0.016	0.263	1.054	-0.792	0.007	0.009
1 L - 26	1	14:51:30	10,400	1,470	0.267	0.017	0.283	1.073	-0.790		
1 L - 26	2	14:52:30	10,400	1,470	0.271	0.017	0.287	1.078	-0.791	0.004	0.001
1 L - 26	4	14:54:30	10,400	1,470	0.278	0.017	0.295	1.092	-0.797	0.008	0.006
1 L - 26	8	14:58:30	10,400	1,470	0.291	0.017	0.307	1.106	-0.798	0.013	0.002
1 L - 27	1	15:00:30	10,800	1,526	0.308	0.018	0.325	1.140	-0.815		
1 L - 27	2	15:01:30	10,800	1,526	0.314	0.018	0.332	1.146	-0.814	0.006	0.000
1 L - 27	4	15:03:30	10,800	1,526	0.322	0.018	0.339	1.164	-0.825	0.008	0.011
1 L - 27	8	15:07:30	10,800	1,526	0.339	0.018	0.356	1.183	-0.826	0.017	0.001
1 L - 28	1	15:09:00	11,200	1,583	0.352	0.018	0.370	1.205	-0.836		
1 L - 28	2	15:10:00	11,200	1,583	0.360	0.018	0.378	1.211	-0.834	0.008	-0.002
1 L - 28	4	15:12:00	11,200	1,583	0.369	0.018	0.387	1.224	-0.837	0.010	0.003
1 L - 28	8	15:16:00	11,200	1,583	0.387	0.018	0.405	1.248	-0.842	0.018	0.006
1 L - 29	1	15:18:00	11,600	1,639	0.405	0.019	0.424	1.271	-0.847		
1 L - 29	2	15:19:00	11,600	1,639	0.410	0.019	0.429	1.280	-0.852	0.005	0.004
1 L - 29	4	15:21:00	11,600	1,639	0.421	0.019	0.440	1.296	-0.856	0.011	0.005
1 L - 29	8	15:25:00	11,600	1,639	0.439	0.019	0.458	1.318	-0.860	0.018	0.004
1 U - 1	1	15:27:00	5,800	819	0.404	0.014	0.418	1.276	-0.858		
1 U - 1	2	15:28:00	5,800	819	0.402	0.014	0.415	1.274	-0.858		
1 U - 1	4	15:30:00	5,800	819	0.399	0.013	0.412	1.263	-0.851		
1 U - 2	1	15:31:30	2,900	408	0.364	0.010	0.374	1.200	-0.826		
1 U - 2	2	15:32:30	2,900	408	0.359	0.010	0.369	1.190	-0.821		
1 U - 2	4	15:34:30	2,900	408	0.353	0.010	0.363	1.181	-0.818		
1 U - 3	1	15:36:30	1,450	203	0.318	0.009	0.327	1.112	-0.785		
1 U - 3	2	15:37:30	1,450	203	0.313	0.008	0.321	1.105	-0.784		
1 U - 3	4	15:39:30	1,450	203	0.307	0.008	0.315	1.096	-0.781		
1 U - 4	1	15:41:30	0	0	0.255	0.007	0.262	0.919	-0.657		
1 U - 4	2	15:42:30	0	0	0.250	0.007	0.257	0.913	-0.657		
1 U - 4	4	15:44:30	0	0	0.245	0.006	0.251	0.904	-0.653		
1 U - 4	8	15:48:30	0	0	0.239	0.006	0.245	0.897	-0.652		

* Elastic compression above the O-cell.

Strain Gage Readings and Loads at Levels 1, 2 & 3
Test Shaft #1 - IL 5 / IL 84 Interchange - Rock Island Co., IL

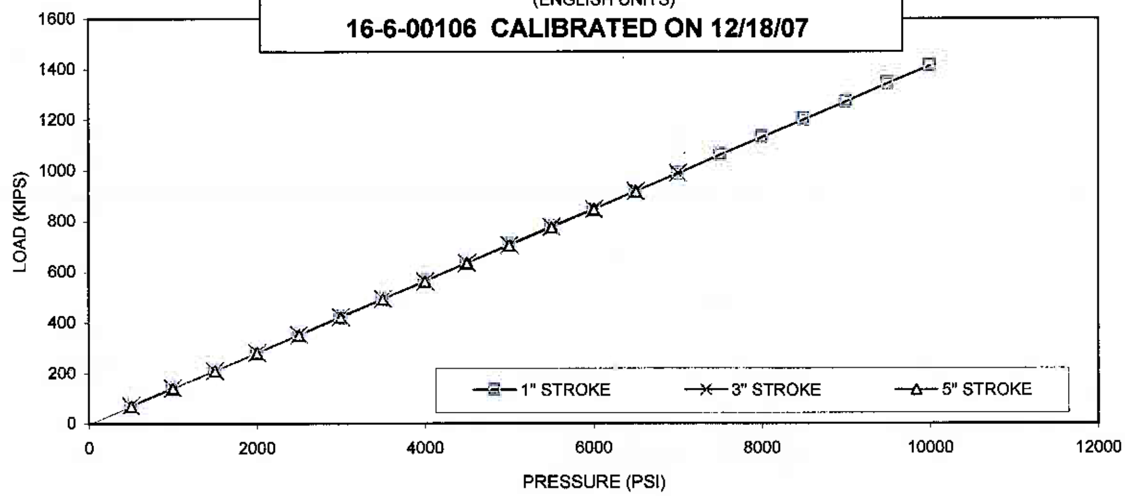
Load Test Increment	Hold Time (minutes)	Time (h:m:s)	O-cell Pressure (psi)	O-cell Load (kips)	Level 1 A - 08-6536 (με)	Level 1 B - 08-6537 (με)	Level 1 Av. Load (kips)	Level 2 A - 08-6538 (με)	Level 2 B - 08-6539 (με)	Level 2 Av. Load (kips)	Level 3 A - 08-6540 (με)	Level 3 B - 08-6541 (με)	Level 3 Av. Load (kips)
1 L - 0	-	10:37:00	0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
1 L - 1	1	11:05:30	400	55	0.8	0.2	3	0.2	1.1	4	0.2	1.0	4
1 L - 1	2	11:06:30	400	55	1.9	0.8	8	-0.3	1.2	3	0.2	0.5	3
1 L - 1	4	11:08:30	400	55	1.5	0.7	7	0.2	0.8	3	0.5	0.5	4
1 L - 1	8	11:12:30	400	55	1.6	-0.1	4	0.0	0.6	2	0.5	1.0	6
1 L - 2	1	11:15:00	800	111	3.2	1.9	15	0.9	1.8	8	0.5	0.4	3
1 L - 2	2	11:16:00	800	111	3.4	1.9	16	1.1	1.6	8	0.5	0.9	5
1 L - 2	4	11:18:00	800	111	2.8	2.2	15	0.8	1.5	7	0.4	0.4	3
1 L - 2	8	11:22:00	800	111	3.1	2.5	17	0.9	1.8	8	0.5	1.3	7
1 L - 3	1	11:24:00	1,200	168	5.1	3.9	27	1.6	2.9	14	0.7	1.6	9
1 L - 3	2	11:25:00	1,200	168	4.7	4.3	27	1.6	2.5	13	0.8	0.6	5
1 L - 3	4	11:27:00	1,200	168	5.6	4.1	30	2.3	2.9	16	0.8	0.9	6
1 L - 3	8	11:31:00	1,200	168	4.7	4.1	27	1.2	2.5	11	0.7	1.7	9
1 L - 4	1	11:33:30	1,600	224	6.6	5.6	37	2.7	3.6	19	0.9	1.2	8
1 L - 4	2	11:34:30	1,600	224	6.5	5.8	37	2.9	3.3	19	0.8	1.0	7
1 L - 4	4	11:36:30	1,600	224	6.2	6.1	37	2.5	3.3	18	0.8	1.2	8
1 L - 4	8	11:40:30	1,600	224	7.2	5.8	40	3.1	3.7	21	0.9	1.9	11
1 L - 5	1	11:43:30	2,000	281	8.8	7.5	49	4.6	4.7	28	1.3	1.4	10
1 L - 5	2	11:44:30	2,000	281	10.1	7.7	54	4.3	4.7	27	1.0	2.3	13
1 L - 5	4	11:46:30	2,000	281	9.0	7.4	50	4.7	4.7	29	1.1	2.5	14
1 L - 5	8	11:50:30	2,000	281	9.5	7.7	52	4.4	4.5	27	1.0	2.2	12
1 L - 6	1	11:52:30	2,400	338	12.1	9.4	65	6.3	5.5	36	1.6	2.7	16
1 L - 6	2	11:53:30	2,400	338	11.3	9.7	64	6.2	5.3	35	1.3	1.8	12
1 L - 6	4	11:55:30	2,400	338	10.9	9.1	61	5.8	5.7	35	1.5	2.0	13
1 L - 6	8	11:59:30	2,400	338	11.4	9.3	63	6.6	5.2	36	1.6	1.8	13
1 L - 7	1	12:02:30	2,800	394	14.9	11.3	80	6.9	6.3	40	1.8	2.4	16
1 L - 7	2	12:03:30	2,800	394	14.4	11.4	78	7.7	6.6	43	1.8	2.3	15
1 L - 7	4	12:05:30	2,800	394	14.4	11.4	79	8.1	6.1	43	1.6	2.4	15
1 L - 7	8	12:09:30	2,800	394	14.8	10.7	78	7.4	6.1	41	1.6	2.0	14
1 L - 8	1	12:12:30	3,200	451	18.0	13.5	96	9.2	7.7	51	2.1	2.9	19
1 L - 8	2	12:13:30	3,200	451	17.4	14.0	96	9.1	7.6	51	2.1	3.5	21
1 L - 8	4	12:15:30	3,200	451	16.8	13.8	93	9.3	7.8	52	2.0	3.7	22
1 L - 8	8	12:19:30	3,200	451	17.4	14.2	96	9.7	7.6	53	2.0	3.7	22
1 L - 9	1	12:21:30	3,600	507	19.7	15.9	108	11.2	8.8	61	2.4	3.8	24
1 L - 9	2	12:22:30	3,600	507	19.7	16.4	109	11.0	8.6	60	2.4	3.2	21
1 L - 9	4	12:24:30	3,600	507	20.7	16.4	113	11.4	9.3	63	2.5	2.9	21
1 L - 9	8	12:28:30	3,600	507	20.1	16.1	110	11.6	8.3	61	2.4	3.2	21
1 L - 10	1	12:30:30	4,000	564	22.3	18.3	123	12.9	9.7	69	2.8	3.3	23
1 L - 10	2	12:31:30	4,000	564	24.4	18.3	130	13.3	9.8	70	2.7	4.2	27
1 L - 10	4	12:33:30	4,000	564	23.6	18.3	128	13.4	9.9	71	2.8	3.7	25
1 L - 10	8	12:37:30	4,000	564	24.2	18.5	130	12.5	9.8	68	2.9	3.2	23
1 L - 11	1	12:39:30	4,400	621	26.6	20.0	142	16.1	11.0	83	3.2	4.5	29
1 L - 11	2	12:40:30	4,400	621	25.8	20.2	140	15.4	11.1	80	3.2	3.6	26
1 L - 11	4	12:42:30	4,400	621	25.7	20.4	140	16.1	11.1	83	3.2	3.6	26
1 L - 11	8	12:46:30	4,400	621	26.2	20.6	142	15.1	11.2	80	3.2	4.7	30
1 L - 12	1	12:48:00	4,800	677	29.9	22.2	158	16.8	12.0	87	3.4	5.1	32
1 L - 12	2	12:49:00	4,800	677	28.2	22.2	153	16.6	12.3	88	3.5	4.5	30
1 L - 12	4	12:51:00	4,800	677	28.4	22.4	154	16.7	12.5	89	3.4	4.6	31
1 L - 12	8	12:55:00	4,800	677	28.4	22.6	155	16.3	12.4	87	3.4	4.4	30
1 L - 13	1	12:57:00	5,200	734	30.7	24.3	167	18.6	13.5	98	3.9	5.0	34
1 L - 13	2	12:58:00	5,200	734	31.7	24.4	170	18.5	13.5	97	3.9	4.9	33
1 L - 13	4	13:00:00	5,200	734	32.0	24.4	172	18.0	13.5	96	3.8	4.8	33
1 L - 13	8	13:04:00	5,200	734	32.3	24.6	173	18.7	13.5	98	3.8	4.9	33
1 L - 14	1	13:06:00	5,600	790	33.8	26.6	184	19.0	14.7	103	4.1	5.1	35
1 L - 14	2	13:07:00	5,600	790	33.5	26.7	183	19.5	14.5	103	4.2	5.5	37
1 L - 14	4	13:09:00	5,600	790	34.0	26.7	185	19.6	14.9	105	4.2	5.4	37
1 L - 14	8	13:13:00	5,600	790	35.0	26.9	188	18.9	14.8	103	4.0	5.5	36
1 L - 15	1	13:15:00	6,000	847	36.8	28.6	199	19.5	15.9	108	4.3	5.6	38
1 L - 15	2	13:16:00	6,000	847	37.4	28.6	201	20.2	16.0	110	4.2	5.8	38
1 L - 15	4	13:18:00	6,000	847	37.5	28.7	201	20.9	15.9	112	4.2	5.7	38
1 L - 15	8	13:22:00	6,000	847	38.0	28.7	203	20.4	16.1	111	4.3	5.7	38
1 L - 16	1	13:24:00	6,400	904	39.5	30.6	213	21.6	16.9	117	4.7	6.2	42
1 L - 16	2	13:25:00	6,400	904	39.5	30.6	213	21.1	17.2	116	4.6	6.2	41
1 L - 16	4	13:27:00	6,400	904	38.9	30.6	211	21.2	17.2	117	4.5	6.0	40
1 L - 16	8	13:31:00	6,400	904	39.9	30.8	215	21.9	17.4	119	4.6	6.4	42

Strain Gage Readings and Loads at Levels 1, 2 & 3
Test Shaft #1 - IL 5 / IL 84 Interchange - Rock Island Co., IL

Load Test Increment	Hold Time (minutes)	Time (h:m:s)	O-cell Pressure (psi)	O-cell Load (kips)	Level 1 A - 08-6536 (με)	Level 1 B - 08-6537 (με)	Level 1 Av. Load (kips)	Level 2 A - 08-6538 (με)	Level 2 B - 08-6539 (με)	Level 2 Av. Load (kips)	Level 3 A - 08-6540 (με)	Level 3 B - 08-6541 (με)	Level 3 Av. Load (kips)
1 L - 17	1	13:32:30	6,800	960	42.5	32.6	228	22.6	18.2	124	4.8	6.8	44
1 L - 17	2	13:33:30	6,800	960	42.1	32.7	228	22.1	18.4	123	4.8	6.6	44
1 L - 17	4	13:35:30	6,800	960	41.6	32.6	226	22.4	18.5	124	4.9	6.7	44
1 L - 17	8	13:39:30	6,800	960	41.6	32.8	226	21.9	18.5	123	4.9	6.7	44
1 L - 18	1	13:41:30	7,200	1,017	44.3	34.3	239	23.0	19.5	129	5.1	7.2	47
1 L - 18	2	13:42:30	7,200	1,017	44.5	34.3	240	24.2	19.5	133	5.0	7.1	46
1 L - 18	4	13:44:30	7,200	1,017	44.3	34.5	240	24.3	19.4	133	5.1	7.4	48
1 L - 18	8	13:48:30	7,200	1,017	44.7	34.6	241	22.8	19.5	129	5.1	7.3	48
1 L - 19	1	13:50:30	7,600	1,073	46.3	36.5	252	23.4	20.6	134	5.3	7.6	49
1 L - 19	2	13:51:30	7,600	1,073	46.5	36.6	253	24.1	20.8	136	5.1	7.2	47
1 L - 19	4	13:53:30	7,600	1,073	47.2	36.7	255	24.8	20.8	138	5.2	7.5	48
1 L - 19	8	13:57:30	7,600	1,073	46.8	36.8	254	23.8	21.1	136	5.1	7.7	49
1 L - 20	1	13:59:30	8,000	1,130	48.9	38.6	266	25.2	22.0	144	5.3	7.8	50
1 L - 20	2	14:00:30	8,000	1,130	48.7	38.7	266	25.0	22.0	143	5.5	8.0	51
1 L - 20	4	14:02:30	8,000	1,130	48.9	38.7	266	25.1	22.0	143	5.5	8.0	51
1 L - 20	8	14:06:30	8,000	1,130	49.2	38.9	268	26.1	22.3	147	5.5	8.0	51
1 L - 21	1	14:08:00	8,400	1,187	51.2	40.4	278	26.0	23.2	149	5.6	8.2	53
1 L - 21	2	14:09:00	8,400	1,187	51.0	40.3	278	25.7	23.1	148	5.7	8.2	53
1 L - 21	4	14:11:00	8,400	1,187	50.9	40.5	278	25.8	23.2	149	5.7	8.4	54
1 L - 21	8	14:15:00	8,400	1,187	51.0	40.5	278	26.3	23.4	151	6.4	8.5	57
1 L - 22	1	14:16:30	8,800	1,243	53.0	42.3	290	26.7	24.4	155	6.6	8.6	58
1 L - 22	2	14:17:30	8,800	1,243	53.0	42.3	290	26.3	24.4	154	6.7	8.6	59
1 L - 22	4	14:19:30	8,800	1,243	53.2	42.3	290	26.6	24.5	155	6.7	8.8	59
1 L - 22	8	14:23:30	8,800	1,243	53.2	42.6	291	26.2	24.7	155	6.7	8.8	59
1 L - 23	1	14:25:30	9,200	1,300	55.0	44.2	302	27.2	25.7	161	7.0	9.0	61
1 L - 23	2	14:26:30	9,200	1,300	55.2	44.0	302	26.9	25.8	160	6.9	9.3	62
1 L - 23	4	14:28:30	9,200	1,300	55.2	44.4	303	25.9	25.8	157	6.9	9.3	62
1 L - 23	8	14:32:30	9,200	1,300	55.3	44.6	304	27.1	26.1	162	7.0	9.2	62
1 L - 24	1	14:34:00	9,600	1,356	56.8	46.2	313	27.7	27.0	166	7.3	9.5	64
1 L - 24	2	14:35:00	9,600	1,356	57.1	46.3	314	27.4	27.1	166	7.2	9.4	64
1 L - 24	4	14:37:00	9,600	1,356	57.3	46.4	315	27.1	27.3	165	7.4	9.7	65
1 L - 24	8	14:41:00	9,600	1,356	57.4	46.8	317	27.4	27.6	167	7.6	9.8	66
1 L - 25	1	14:42:30	10,000	1,413	59.1	48.1	326	27.8	28.4	171	7.9	10.1	69
1 L - 25	2	14:43:30	10,000	1,413	59.2	48.3	327	27.6	28.4	170	8.1	10.2	69
1 L - 25	4	14:45:30	10,000	1,413	59.2	48.4	327	27.5	28.8	171	8.0	10.2	69
1 L - 25	8	14:49:30	10,000	1,413	59.5	48.9	330	27.4	29.2	172	8.0	10.4	70
1 L - 26	1	14:51:30	10,400	1,470	61.5	50.5	341	28.2	30.0	177	8.2	10.8	72
1 L - 26	2	14:52:30	10,400	1,470	61.5	50.7	341	28.2	30.1	177	8.1	10.7	72
1 L - 26	4	14:54:30	10,400	1,470	61.5	51.0	342	27.8	30.3	177	8.4	10.9	74
1 L - 26	8	14:58:30	10,400	1,470	61.8	51.5	345	27.5	30.6	177	8.3	11.1	74
1 L - 27	1	15:00:30	10,800	1,526	64.0	52.7	355	28.2	31.8	182	8.5	11.4	76
1 L - 27	2	15:01:30	10,800	1,526	64.3	52.7	356	28.1	31.9	183	8.3	11.6	76
1 L - 27	4	15:03:30	10,800	1,526	64.4	52.9	357	27.9	32.1	183	8.2	11.6	75
1 L - 27	8	15:07:30	10,800	1,526	64.6	52.9	357	27.6	32.6	183	8.1	11.9	76
1 L - 28	1	15:09:00	11,200	1,583	66.7	54.0	367	28.0	33.4	187	8.3	12.2	78
1 L - 28	2	15:10:00	11,200	1,583	66.9	53.9	367	27.9	33.4	186	8.2	12.3	78
1 L - 28	4	15:12:00	11,200	1,583	67.0	53.9	368	27.6	33.6	186	8.0	12.4	78
1 L - 28	8	15:16:00	11,200	1,583	67.2	54.2	369	27.6	33.8	187	8.1	12.4	78
1 L - 29	1	15:18:00	11,600	1,639	69.0	55.0	377	27.7	34.5	189	8.1	12.7	79
1 L - 29	2	15:19:00	11,600	1,639	69.1	55.2	378	27.9	34.7	190	8.2	12.7	80
1 L - 29	4	15:21:00	11,600	1,639	69.2	55.1	378	27.6	34.9	190	8.2	12.7	80
1 L - 29	8	15:25:00	11,600	1,639	69.6	55.1	379	27.3	35.4	191	8.2	12.7	80
1 U - 1	1	15:27:00	5,800	819	34.8	26.1	185	11.3	21.6	100	3.5	9.1	48
1 U - 1	2	15:28:00	5,800	819	34.5	25.7	183	11.1	21.4	99	3.5	9.3	49
1 U - 1	4	15:30:00	5,800	819	33.3	25.1	178	10.6	20.6	95	3.2	9.1	47
1 U - 2	1	15:31:30	2,900	408	14.1	12.4	81	2.3	13.1	47	1.0	6.9	30
1 U - 2	2	15:32:30	2,900	408	12.1	10.9	70	1.6	12.5	43	0.8	6.7	28
1 U - 2	4	15:34:30	2,900	408	11.3	10.4	66	1.1	12.0	40	0.6	6.5	27
1 U - 3	1	15:36:30	1,450	203	1.5	6.3	24	-2.9	7.9	15	-0.6	4.9	16
1 U - 3	2	15:37:30	1,450	203	1.5	6.0	23	-3.2	7.6	13	-0.7	4.8	16
1 U - 3	4	15:39:30	1,450	203	0.9	5.5	20	-3.8	7.0	10	-0.8	4.4	14
1 U - 4	1	15:41:30	0	0	-7.0	1.2	-17	-7.5	3.1	-13	-1.8	2.9	4
1 U - 4	2	15:42:30	0	0	-7.9	0.7	-22	-7.5	2.7	-14	-1.7	2.8	4
1 U - 4	4	15:44:30	0	0	-7.7	0.7	-21	-7.5	2.8	-14	-1.8	2.7	3
1 U - 4	8	15:48:30	0	0	-8.0	-0.2	-25	-7.9	2.5	-17	-1.8	2.6	3

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	71	70	69
1000	141	140	139
1500	210	211	210
2000	281	281	279
2500	352	351	351
3000	424	423	420
3500	494	494	493
4000	565	563	563
4500	635	634	634
5000	706	705	704
5500	778	776	775
6000	847	845	845
6500	918	917	917
7000	988	988	
7500	1062		
8000	1131		
8500	1201		
9000	1272		
9500	1344		
10000	1414		

16" O-CELL, SERIAL # 16-6-00106

LOAD CONVERSION FORMULA

LOAD = PRESSURE * 0.1415 + (-2.09)
{KIPS} {PSI}

Regression Output:

Constant	-2.0872	kips
X Coefficient	0.1415	kip / psi
R Square	1.0000	
No. of Observations	47	
Degrees of Freedom	45	
Std Err of Y Est	1.12	
Std Err of X Coeff	0.0001	

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.: CIVIL INC.
* AE & FC JOB NO: SO3426	* JOB LOCATION: EAST MOLINE, IL
* CUSTOMER P.O. NO.: LT-9405	* DATED: 04/01/08

SERVICE ENGINEER: ____________ DATE: 4-3-08

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

Vibrating Wire Displacement Transducer Calibration Report

Range: 150 mm

Calibration Date: March 20, 2008

Serial Number: 08-5252

Temperature: 24.7 °C

Calibration Instruction: CI-4400

Technician: J. Ouellette

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	2563	2563	2563	-0.20	-0.13	0.01	0.01
30.0	3510	3509	3510	30.04	0.02	29.99	0.00
60.0	4451	4452	4452	60.13	0.09	59.96	-0.03
90.0	5394	5392	5393	90.20	0.14	90.04	0.03
120.0	6327	6327	6327	120.04	0.03	120.00	0.00
150.0	7258	7258	7258	149.78	-0.15	149.99	-0.01

(mm) Linear Gage Factor (G): 0.03194 (mm/ digit) **Regression Zero: 2569**

Polynomial Gage Factors: A: 7.08247E-08 B: 0.03125 C: -80.546

(inches) Linear Gage Factor (G): 0.001258 (inches/ digit)

Polynomial Gage Factors: A: 2.78837E-09 B: 0.001230 C: -3.1711

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 : 4957 Temp(T_0): 25.5 °C Date: April 07, 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: 08-5896

Calibration Date: March 31, 2008

Temperature: 24.7 °C

Calibration Instruction: CI-4400

Technician: J. Ouellette

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	2621	2618	2620	-0.01	-0.01	-0.02	-0.01
30.0	3562	3561	3562	30.04	0.03	30.04	0.03
60.0	4500	4499	4500	59.97	-0.02	59.98	-0.02
90.0	5441	5440	5441	90.00	0.00	90.00	0.00
120.0	6380	6381	6381	119.99	-0.01	119.99	-0.01
150.0	7322	7321	7322	150.01	0.01	150.01	0.01

(mm) Linear Gage Factor (G): 0.03191 (mm/ digit) **Regression Zero: 2620**

Polynomial Gage Factors: A: -1.9258E-09 B: 0.03193 C: -83.637

(inches) Linear Gage Factor (G): 0.001256 (inches/ digit)

Polynomial Gage Factors: A: -7.582E-11 B: 0.001257 C: -3.2928

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 : 5001 Temp(T_0): 24.9 °C Date: April 07, 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: 08-5897

Calibration Date: March 31, 2008

Temperature: 24.7 °C

Calibration Instruction: CI-4400

Technician: J. Ouellette

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	2582	2581	2582	0.36	0.24	-0.05	-0.03
30.0	3500	3499	3500	29.97	-0.02	30.05	0.03
60.0	4422	4422	4422	59.73	-0.18	60.06	0.04
90.0	5349	5349	5349	89.64	-0.24	89.97	-0.02
120.0	6285	6284	6285	119.82	-0.12	119.91	-0.06
150.0	7236	7233	7235	150.46	0.31	150.06	0.04

(mm) Linear Gage Factor (G): 0.03226 (mm/ digit) **Regression Zero: 2570**

Polynomial Gage Factors: A: -1.4125E-07 B: 0.03365 C: -85.963

(inches) Linear Gage Factor (G): 0.001270 (inches/ digit)

Polynomial Gage Factors: A: -5.5609E-09 B: 0.001325 C: -3.3844

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 : 4931 Temp(T_0): 25.1 °C Date: April 07, 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

Serial Number: 08-6536

Prestress: 35,000 psi

Temperature: 23.6 °C

Calibration Instruction: CI-VW Rebar

Date of Calibration: March 28, 2008

Cable Length: 40 ft.

Factory Zero Reading: 7117

Regression Zero: 7122

Technician: J. Ouellette

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7185	7186	7186		
1,500	7840	7841	7841	655	-0.45
3,000	8577	8575	8576	736	-0.32
4,500	9316	9318	9317	741	0.00
6,000	10056	10056	10056	739	0.25
100	7186				

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

Serial Number: 08-6537

Prestress: 35,000 psi

Temperature: 23.7 °C

Calibration Instruction: CI-VW Rebar

Date of Calibration: March 28, 2008

Cable Length: 40 ft.

Factory Zero Reading: 6814

Regression Zero: 6830

Technician: J. Ouellette

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	6885	6885	6885		
1,500	7537	7537	7537	652	-0.12
3,000	8245	8246	8246	709	-0.18
4,500	8956	8958	8957	712	-0.14
6,000	9679	9679	9679	722	0.27
100	6885				

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: 08-6538

Prestress: 35,000 psi

Temperature: 23.5 °C

Calibration Instruction: CI-VW Rebar

Date of Calibration: March 28, 2008

Cable Length: 40 ft.

Factory Zero Reading: 7147

Regression Zero: 7150

Technician: J. Ouellette

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7213	7213	7213		
1,500	7883	7881	7882	669	-0.41
3,000	8629	8629	8629	747	-0.31
4,500	9384	9386	9385	756	0.09
6,000	10132	10131	10132	747	0.18
100	7213				

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

Gage Factor: 0.342 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: 08-6539

Prestress: 35,000 psi

Temperature: 23.7 °C

Calibration Instruction: CI-VW Rebar

Date of Calibration: March 28, 2008

Cable Length: 40 ft.

Factory Zero Reading: 6794

Regression Zero: 6809

Technician: J. Ouellette

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	6873	6873	6873		
1,500	7501	7503	7502	629	-0.41
3,000	8206	8207	8207	705	-0.41
4,500	8921	8920	8921	714	-0.08
6,000	9639	9638	9639	718	0.40
100	6873				

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

Gage Factor: 0.356 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: 08-6540

Prestress: 35,000 psi

Temperature: 23.8 °C

Calibration Instruction: CI-VW Rebar

Date of Calibration: March 28, 2008

Cable Length: 40 ft.

Factory Zero Reading: 6975

Regression Zero: 6968

Technician: J. Ouellette

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7026	7026	7026		
1,500	7682	7684	7683	657	-0.23
3,000	8405	8402	8404	721	-0.27
4,500	9132	9132	9132	729	-0.03
6,000	9861	9861	9861	729	0.23
100	7026				

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 28, 2008

Serial Number: 08-6541

Cable Length: 40 ft.

Prestress: 35,000 psi

Factory Zero Reading: 6971

Temperature: 23.5 °C

Regression Zero: 6985

Calibration Instruction: CI-VW Rebar

Technician: J. Ouellette

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7047	7047	7047		
1,500	7684	7681	7683	636	-0.36
3,000	8394	8392	8393	711	-0.27
4,500	9104	9102	9103	710	-0.19
6,000	9828	9827	9828	725	0.41
100	7047				

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

Gage Factor: 0.355 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

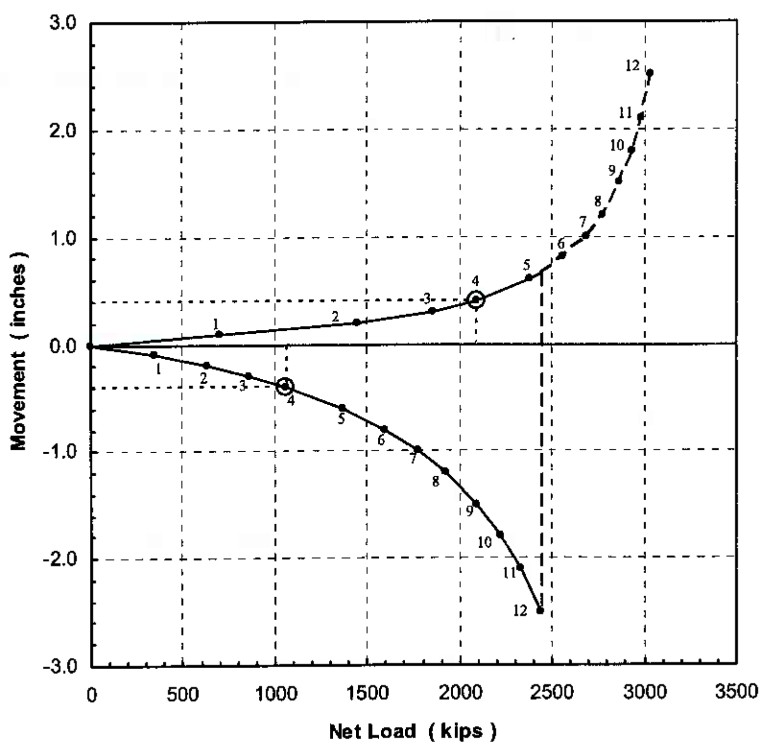
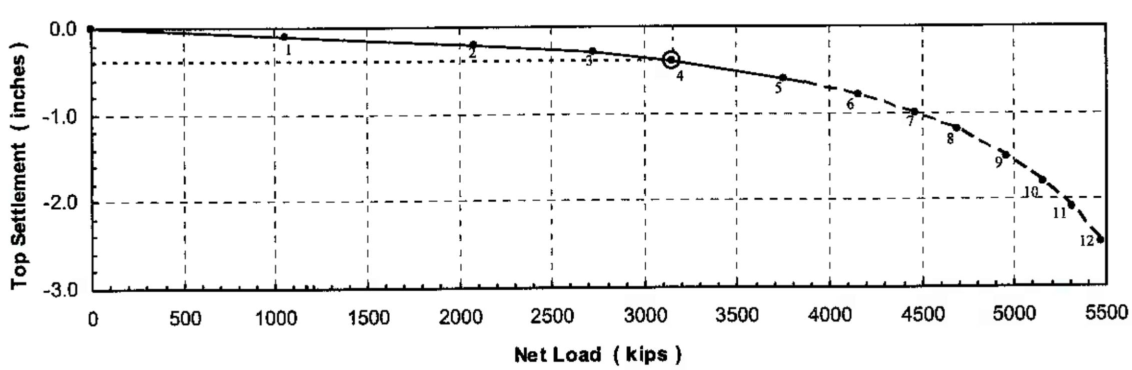
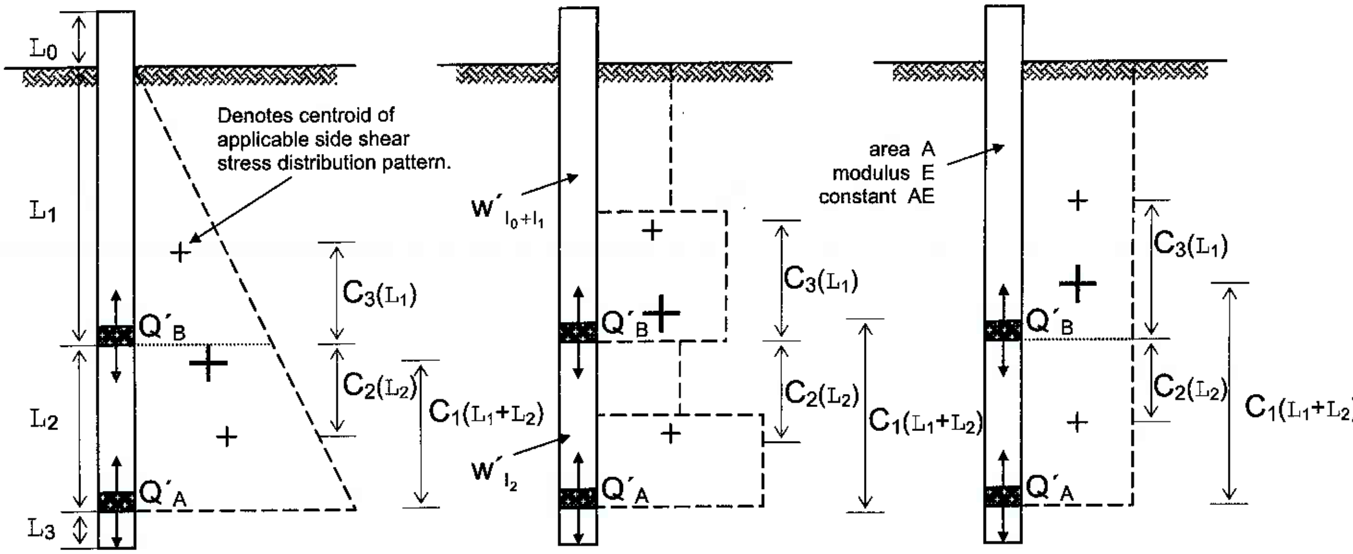


Figure B



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

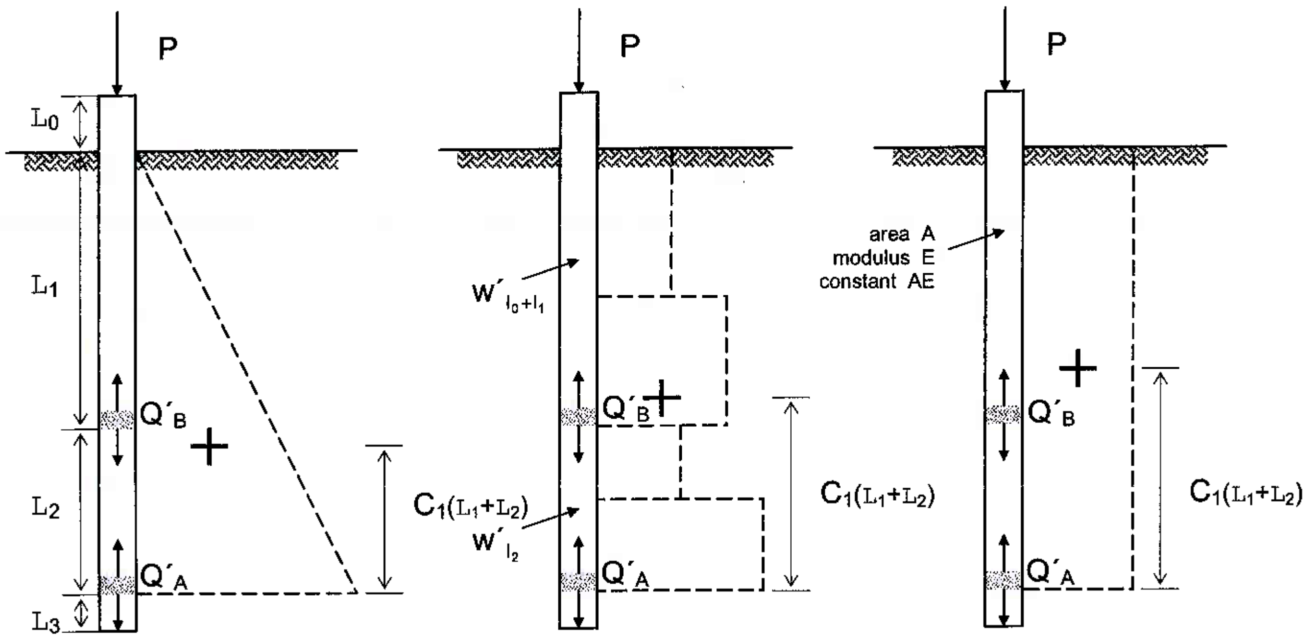
$C_3 = \frac{1}{3}$	Centroid Factor $= C_3$	$C_3 = \frac{1}{2}$
$\delta_{\uparrow l_1} = \frac{1}{3}\frac{Q'_{\uparrow B} l_1}{AE}$	$\delta_{\uparrow l_1} = C_3\frac{Q'_{\uparrow B} l_1}{AE}$	$\delta_{\uparrow l_1} = \frac{1}{3}\frac{Q'_{\uparrow B} l_1}{AE}$
$C_2 = \frac{1}{3}\left(\frac{3l_1+2l_2}{2l_1+l_2}\right)$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

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

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

$\delta_{\downarrow l_0} = \frac{Pl_0}{AE}$	$\delta_{\downarrow l_0} = \frac{Pl_0}{AE}$	$\delta_{\downarrow l_0} = \frac{Pl_0}{AE}$
$C_1 = \frac{1}{3}$	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:

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

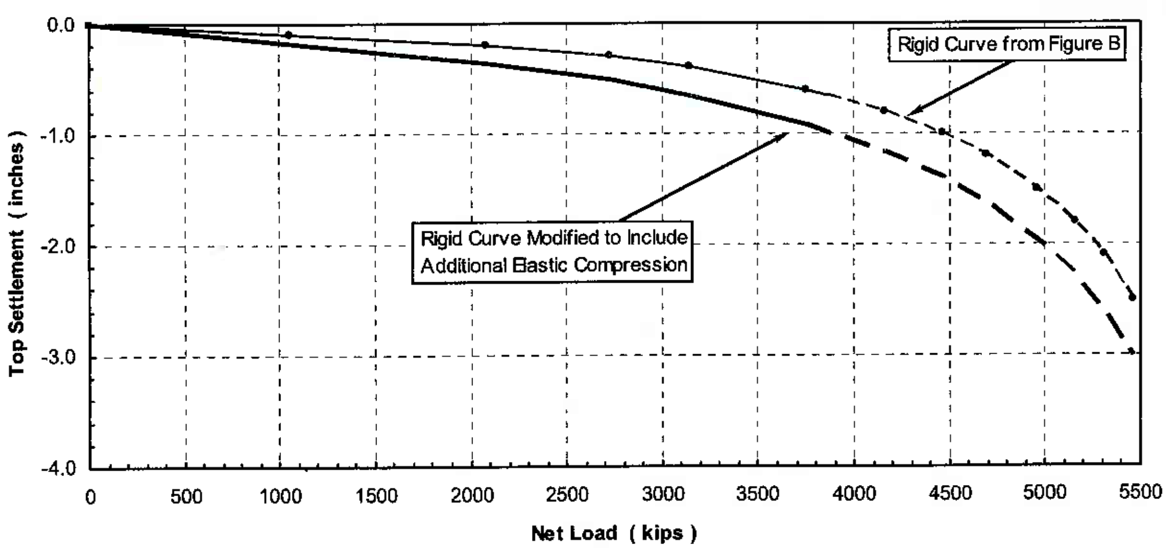
Component loads Q selected at the same (±) Δ_{OLT}.

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

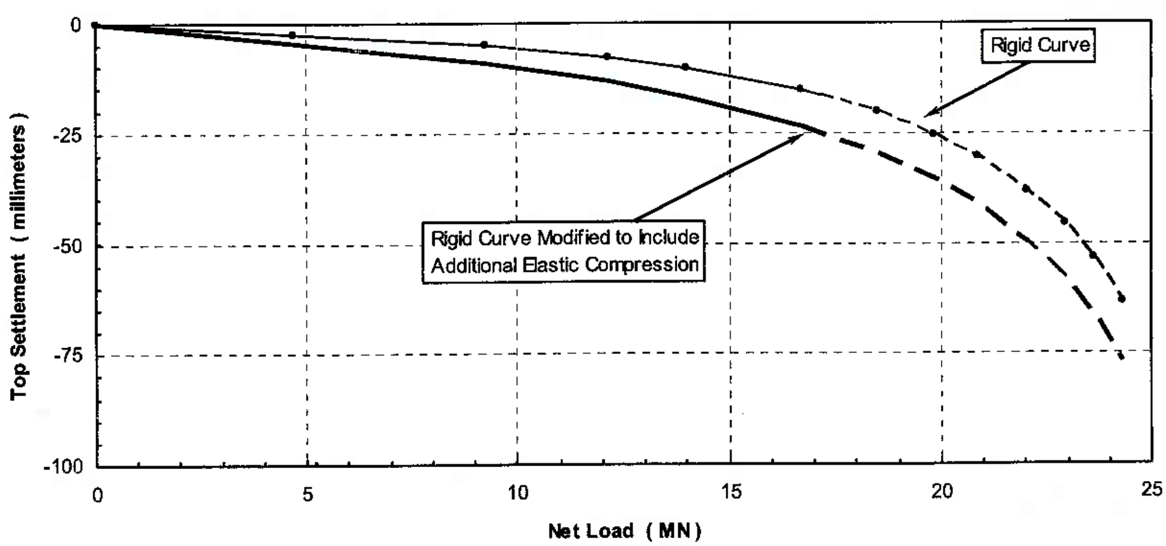


Example Calculation for the Additional Elastic Compression Correction For Single Level Test (SI Units)

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



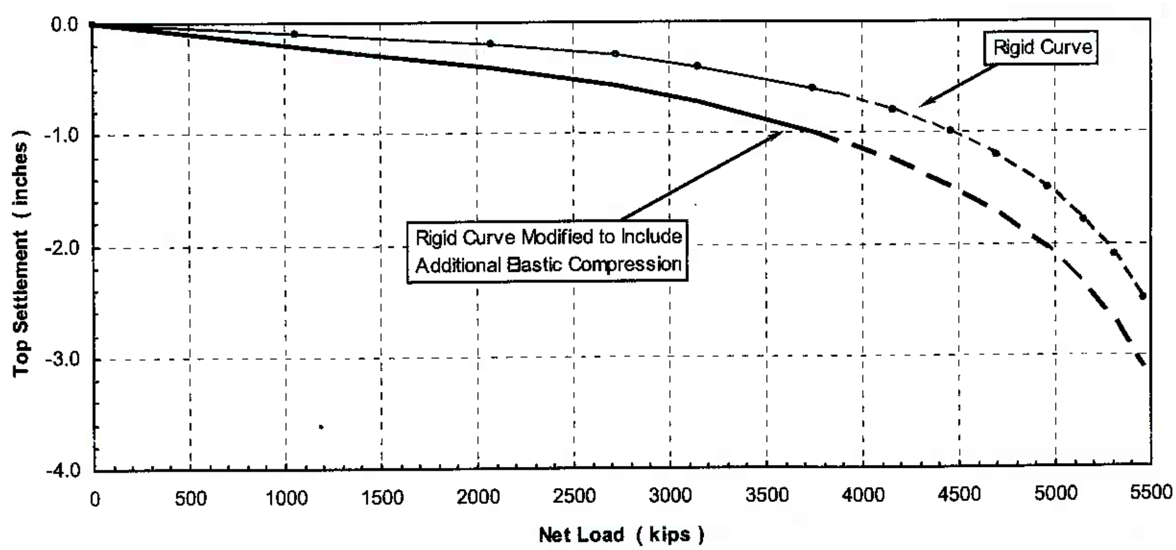
Example Calculation for the Additional Elastic Compression Correction For Multi Level Test (English Units)

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

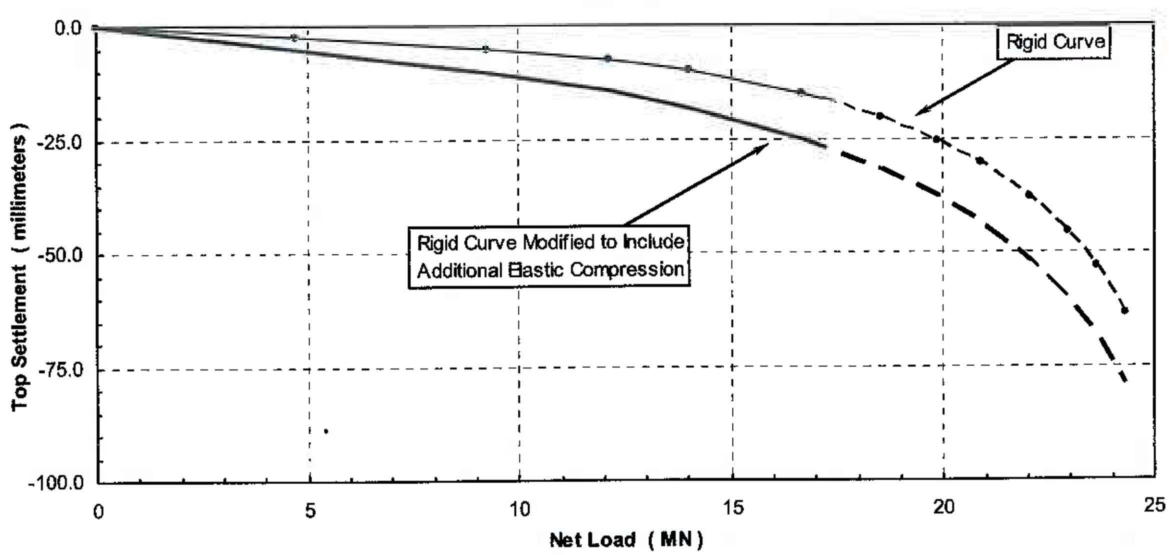


Example Calculation for the Additional Elastic Compression Correction For Multi Level Test (SI Units)

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

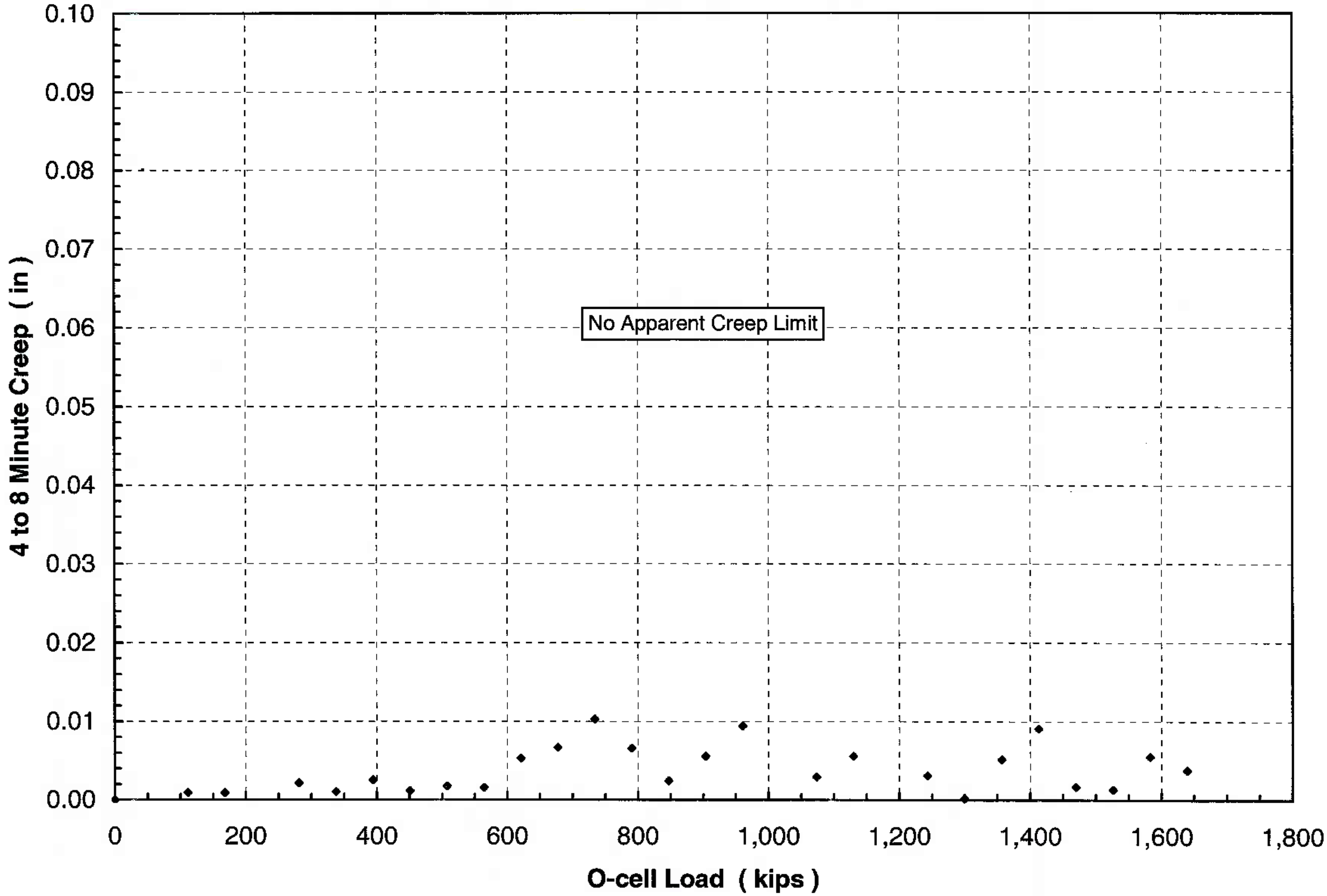


APPENDIX D

O-CELL METHOD FOR DETERMINING CREEP LIMIT LOADING

Combined EB and Lower SS Creep Limit

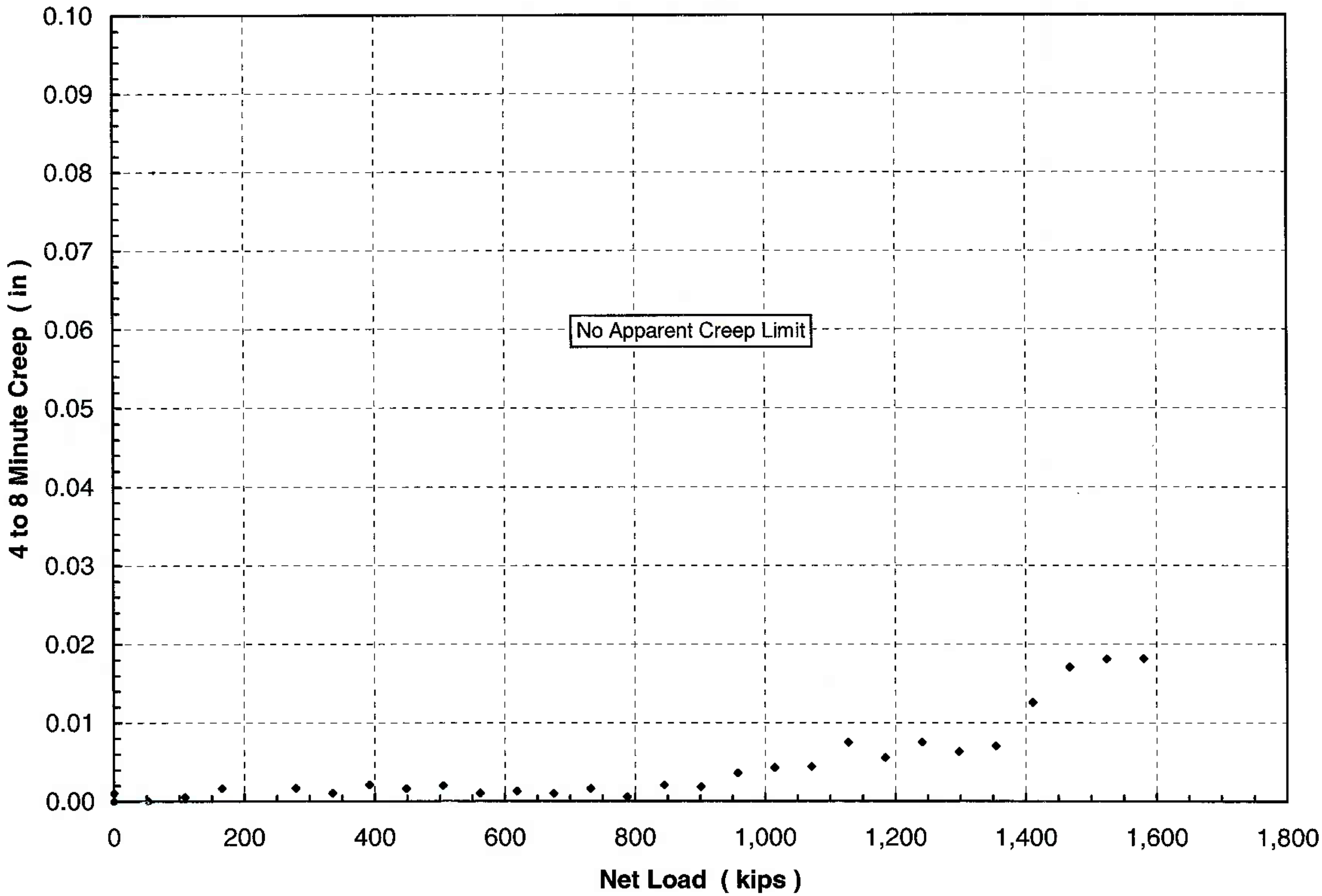
Test Shaft #1 - IL 5 / IL 84 Interchange - Rock Island Co., IL



Appendix D, Figure 1

Upper Side Shear Creep Limit

Test Shaft #1 - IL 5 / IL 84 Interchange - Rock Island Co., IL



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.

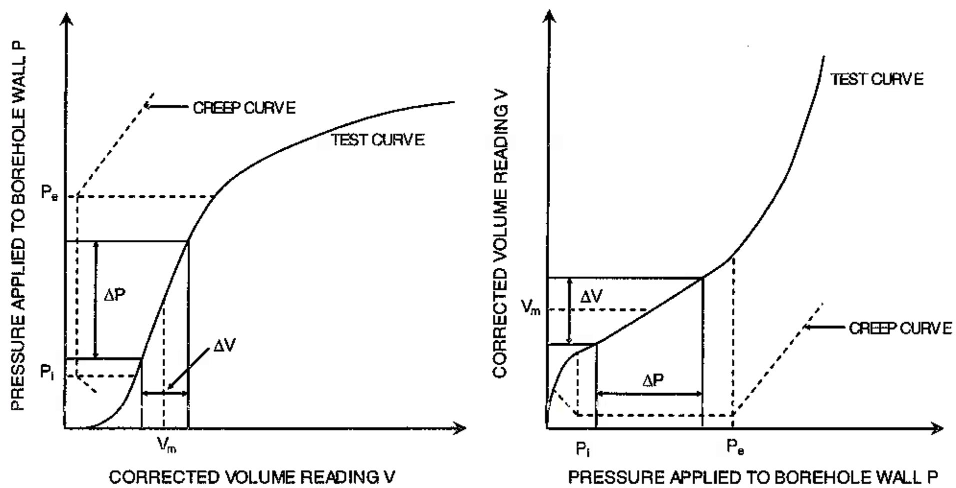


FIG. 8 Pressuremeter Test Curves for Procedure A

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.

APPENDIX E

SOIL BORING LOGS

Illinois Department of Transportation
Division of Highways
IDOT

SOIL BORING LOG

Date 7/8/05

ROUTE FAP 308 DESCRIPTION P92-082-03 John Deere Road over IL 84, 3.25 m. W. of I-80 LOGGED BY W. Garza

SECTION 5 HB LOCATION Hampton Twp. - 32NE, SEC. , TWP. 18N, RNG. 1E

COUNTY Rock Island DRILLING METHOD Hollow Stem Auger HAMMER TYPE B-53 Diedrich Automatic

STRUCT. NO. ______
Station ______

BORING NO. B-3
Station 24+62
Offset 57.00ft Rt
Ground Surface Elev. 617.0 ft

Surface Water Elev. ______ ft
Stream Bed Elev. ______ ft

Groundwater Elev.:
First Encounter ______ ft
Upon Completion ______ ft
After ____ Hrs. ______ ft

Description	Elev.	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
VERY SOFT brown dry SANDY LOAM				0.0	
	614.50				
MEDIUM dark gray SHALEY CLAY			3 4 7		
	613.00				
		-5			
VERY DENSE dark gray SHALE			8 12 61		
	609.50				
Borehole continued with rock coring.					
		-10			
		-15			
		-20			

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

Illinois Department of Transportation
Division of Highways
IDOT

ROCK CORE LOG

Date 10/24/06

ROUTE FAP 308 DESCRIPTION P92-082-03 John Deere Road over IL 84 LOGGED BY W. Garza

SECTION 5 HB LOCATION Hampton Twp. - 32 NE, SEC. , TWP. 18N, RNG. 1E

COUNTY Rock Island CORING METHOD

STRUCT. NO.
Station

CORING BARREL TYPE & SIZE

Core Diameter 1.5 in
Top of Rock Elev. 600.00 ft
Begin Core Elev. 600.00 ft

BORING NO. B-1b
Station 25+00
Offset 50.00ft Rt CL
Ground Surface Elev. 618.0 ft

Description	DEPTH (ft)	CORE (#)	RECOVERY (%)	R.Q.D. (%)	CORE TIME (min/ft)	STRENGTH (tsf)
Shale: Black and laminated, Qu by pocket penetrometer: 1.2 to 2.2 t.s.f. to 597.0; 4.5+ t.s.f. to 595.0	-20 595.00	1	100	0	4	
Shale: As above, Qu by pocket penetrometer: 1.7 t.s.f. to 594.0; 4.5+ t.s.f. to 592.0 Sandstone: Gray, fine to medium grained, tenacious, extending from 592.0 to end of core.	-25 590.00	2	100	0	1.6	
Sandstone: As above Qu by compressive strength: 587.3 to 586.8	-30 585.00	3	100	35	0.4	25.2
Sandstone: As above Qu by compressive strength: 582.1 to 581.6 (Sample was cracked and patched with capping compound.)	-35 580.00	4	100	52	1.2	36.8

Color pictures of the cores
Cores will be stored for examination until
The "Strength" column represents the uniaxial compressive strength of the core sample (ASTM D-2938)

Illinois Department of Transportation
Division of Highways
IDOT

ROCK CORE LOG

Date 10/24/06

ROUTE FAP 308 DESCRIPTION P92-082-03 John Deere Road over IL 84 LOGGED BY W. Garza

SECTION 5 HB LOCATION Hampton Twp. - 32 NE, SEC. , TWP. 18N, RNG. 1E

COUNTY Rock Island CORING METHOD

STRUCT. NO.
Station

CORING BARREL TYPE & SIZE

Core Diameter 1.5 in
Top of Rock Elev. 600.00 ft
Begin Core Elev. 600.00 ft

BORING NO. B-1b
Station 25+00
Offset 50.00ft Rt CL
Ground Surface Elev. 618.0 ft

Description	DEPTH (ft)	CORE (#)	RECOVERY (%)	R.Q.D. (%)	CORE TIME (min/ft)	STRENGTH (tsf)
Sandstone: As above to 577.0 Shale: 577.0 to 575.0, gray-brown, Qu by pocket penetrometer: 4.5+ t.s.f. to end of core. Qu by compressive strength: 577.5 to 577.0 575.00	-40	5	100	67	2	194.5
Shale: Light gray-brown, Qu by pocket penetrometer: 4.5+ t.s.f. throughout. Qu by compressive strength: 571.7 to 571.3 570.00	-45	6	100	45	2.8	512.8
Shale: Black, laminated, Qu by pocket penetrometer: 4.5+ t.s.f. throughout. 565.00	-50	7	100	65	3.4	
End of Boring	-55					

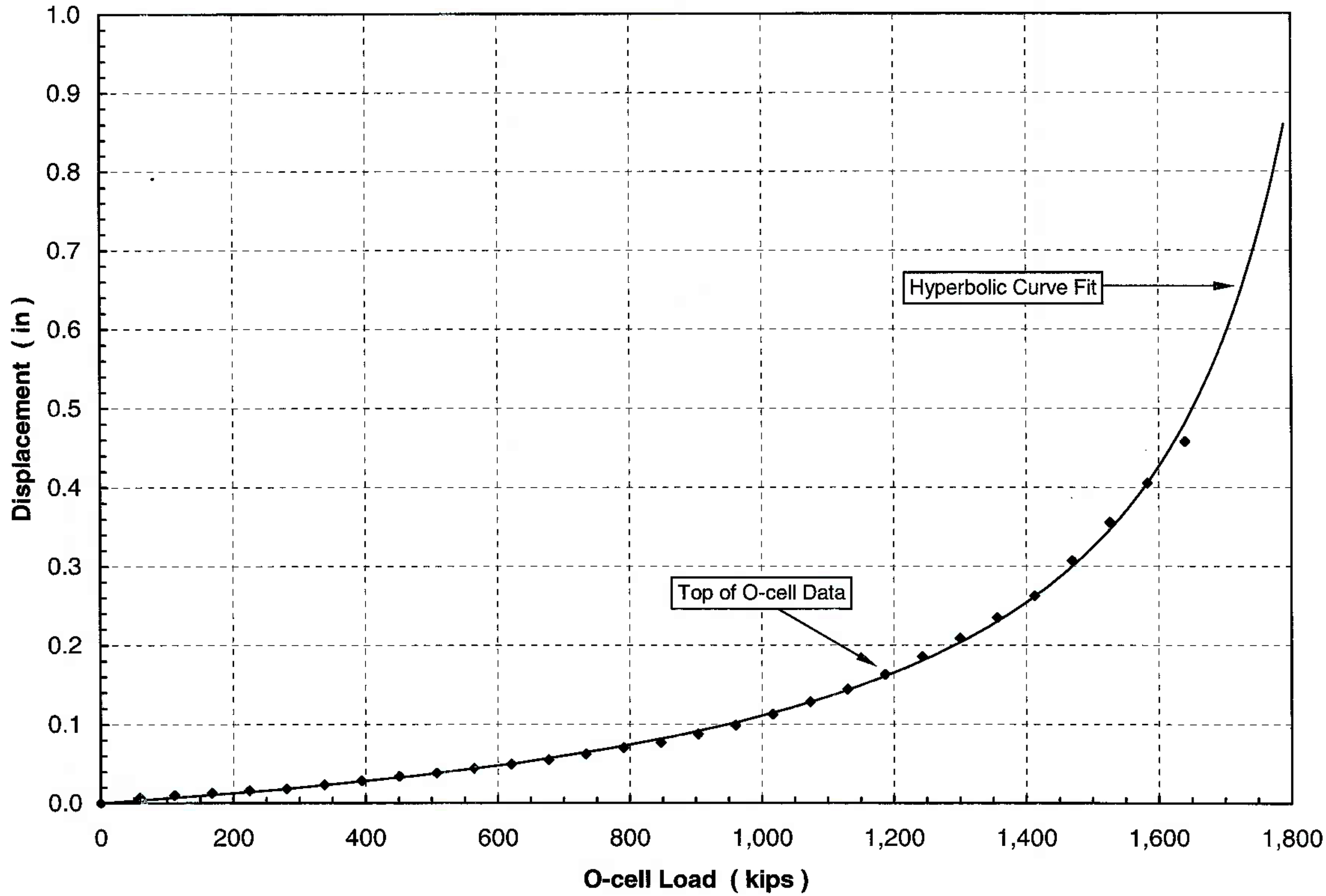
Color pictures of the cores
Cores will be stored for examination until
The "Strength" column represents the uniaxial compressive strength of the core sample (ASTM D-2938)

APPENDIX F

HYPERBOLIC CURVE FITTING

Hyperbolic Fit and Extrapolation

Test Shaft #1 - IL 5 / IL 84 Interchange - Rock Island Co., IL

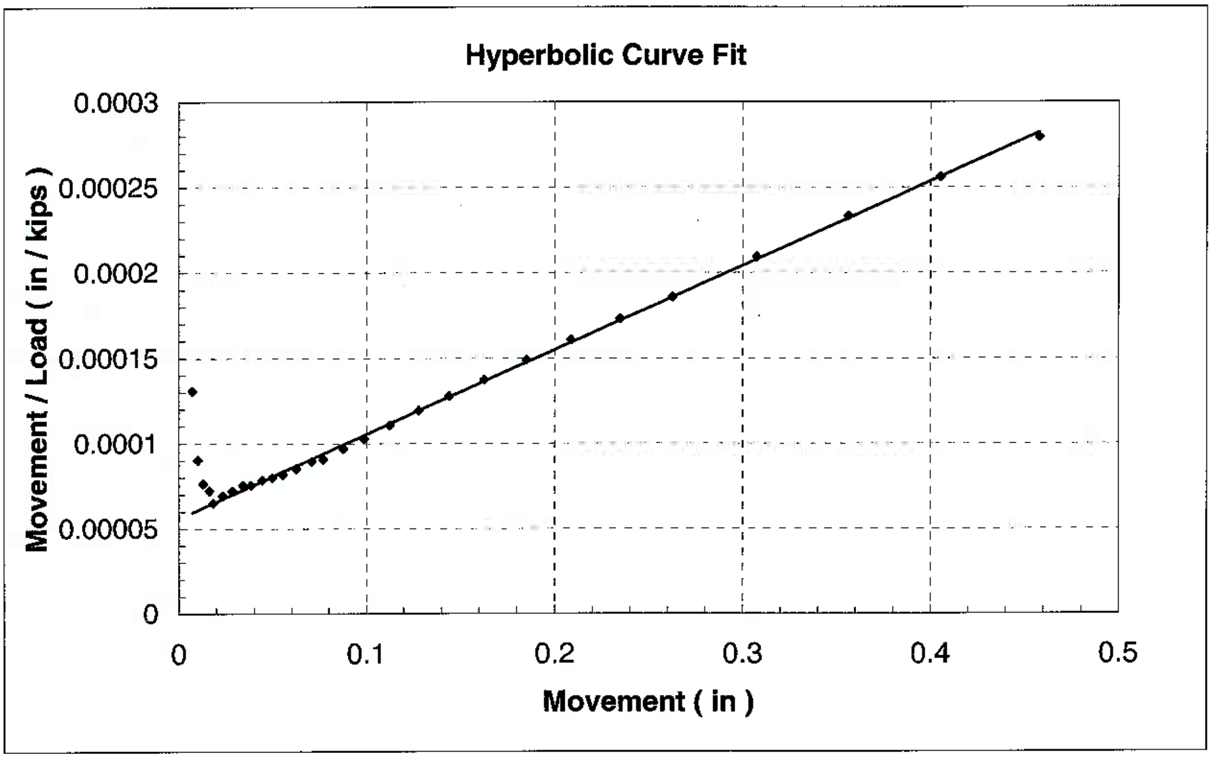


Appendix F, Figure 1

Table F-1: Hyperbolic Curve Fit of Upward Top of O-cell Movement

Net Load (kips)	Gross Load (kips)	Up* (in)	Y_u* (in/kip)	$Y_{u\ calc}$ (in/kip)	Gross $Load_{calc}$ (kips)
0	0	0.000	-	-	-
0	55	0.007	0.000131	0.000060	120
52	111	0.010	0.000090	0.000061	165
109	168	0.013	0.000076	0.000062	206
166	224	0.016	0.000072	0.000064	254
222	281	**0.018**	**0.000065**	0.000065	281
279	338	**0.023**	**0.000069**	0.000068	346
335	394	**0.028**	**0.000072**	0.000070	406
392	451	**0.034**	**0.000075**	0.000073	467
449	507	**0.038**	**0.000076**	0.000075	512
505	564	**0.044**	**0.000078**	0.000078	569
562	621	**0.050**	**0.000080**	0.000080	616
618	677	**0.055**	**0.000082**	0.000083	664
675	734	**0.062**	**0.000085**	0.000087	719
732	790	**0.071**	**0.000089**	0.000091	777
788	847	**0.077**	**0.000091**	0.000094	818
845	904	**0.088**	**0.000097**	0.000099	883
901	960	**0.099**	**0.000103**	0.000105	942
958	1017	**0.113**	**0.000111**	0.000112	1009
1015	1073	**0.128**	**0.000119**	0.000119	1074
1071	1130	**0.144**	**0.000128**	0.000127	1134
1128	1187	**0.163**	**0.000137**	0.000136	1194
1184	1243	**0.185**	**0.000149**	0.000147	1256
1241	1300	**0.209**	**0.000161**	0.000159	1312
1298	1356	**0.235**	**0.000173**	0.000172	1365
1354	1413	**0.263**	**0.000186**	0.000186	1414
1411	1470	**0.307**	**0.000209**	0.000208	1480
1467	1526	**0.356**	**0.000233**	0.000232	1536
1524	1583	**0.405**	**0.000256**	0.000256	1582
1581	1639	**0.458**	**0.000279**	0.000282	1623

* Values in **bold** are used in the curve fit.



SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.999667711
R Square	0.999335533
Adjusted R Squ	0.999306643
Standard Error	1.64482E-06
Observations	25

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	9.35842E-08	9.35842E-08	34591.20558	4.7308E-38
Residual	23	6.2225E-11	2.70543E-12		
Total	24	9.36464E-08			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	5.59838E-05	5.08722E-07	110.0479213	8.14231E-33	5.49314E-05	5.70362E-05	5.49314E-05	5.70362E-05
X Variable 1	0.000493836	2.65521E-06	185.9871113	4.7308E-38	0.000488343	0.000499328	0.000488343	0.000499328

APPENDIX G

POST TEST GROUTING PROCEDURE

POST-TEST GROUTING PROCEDURES FOR PRODUCTION DRILLED SHAFTS TESTED WITH AN OSTERBERG CELL

During the O-cell test the shaft breaks on a horizontal plane, separating the upper section above the O-cell (upper side-shear) from the lower section below the O-cell (combined end bearing and lower side shear). This creates an annular space, the size of which depends on the shaft/O-cell geometry and the expansion of the O-cell.

When a production shaft has been tested, the engineer may want to include the end bearing component from the lower section in order to obtain sufficient capacity of the production shaft. In such cases the contractor will be required to grout the O-cell and the annular space around the O-cell in order to allow load transfer to the lower side shear and end bearing.

POST-TEST GROUTING OF OSTERBERG CELLS

a) The grout shall consist of Portland cement and water only, **NO SAND**. The grout shall be fluid and pumpable. An initial mix consisting of 6 to 7 gallons of water per 95-lb bag of cement is recommended. Adjust water to obtain desired consistency.
b) The mixing shall be thorough to ensure that there are no lumps of dry cement. Pass the grout through a window screen mesh before pumping.
c) Connect the grout pump outlet to one hydraulic line of the O-cell. Open the other line and establish a flow of water through the system.
d) Pump the grout through the O-cell hydraulic line while collecting the effluent from the bleed line. Monitor characteristics of effluent material and when it becomes equivalent to the grout being pumped, stop pumping.
e) Take three samples of the grout for compression testing @ 28 days, if required.

Recommended pre-mixed amount of grout for grouting of O-cell:				
O-cell Diameter (Inches)	13	21	26	34
Grout Volume (Cubic Feet)	4	7	9	13

POST-TEST GROUTING OF ANNULAR SPACE AROUND OSTERBERG CELLS

a) Prepare a fluid grout mix consisting of Portland cement and water only, **NO SAND**. The mixing procedures should be as outlined for grouting the O-cells. The quantity of grout should be at least three (3) times the theoretical volume required to fill the annular space and grout pipes.
b) Pump water and establish a flow through each of the PVC grout pipes (two or three per shaft).
c) Pump the fluid grout through one of the PVC pipes until the grout is observed flowing from the second grout pipe or until 1.5 times the theoretical volume has been pumped.
d) If no return of grout is observed from the second grout pipe, transfer the pump to the second pipe and pump grout through it until 1.5 times the theoretical volume has been pumped.
e) If higher strength grout is deemed necessary, immediately proceed with pumping the higher strength grout (which may be a sand mix). The pumping procedures for this grout will be the same as described above for the initial cement-water grout. **The entire grouting operation must be completed before the set time for the initial grout has elapsed.**
f) Take three (3) samples of each type of grout for compression testing @ 28 days.

Recommended pre-mix amount of grout for grouting of annular space:								
Shaft Diameter (Feet)	2	3	4	5	6	7	8	9
Grout Volume (Cubic Feet)	25	30	40	50	65	80	100	125