REPORT ON DRILLED SHAFT LOAD TESTING (OSTERBERG METHOD)

Dedicated Test Shaft - Grandview Triangle
Jackson Co., MO (LT-8843)

Prepared for: Hayes Drilling, Inc.
8845 Prospect
Kansas City, MO 64132

Attention: Mr. Luke Schuler

PROJECT NUMBER: LT-8843, June 11, 2002

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LOADTEST

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June 11, 2002

Hayes Drilling, Inc.
8845 Prospect
Kansas City, MO 64132

Attention: Mr. Luke Schuler

Load Test Report: Dedicated Test Shaft - Grandview Triangle
Location: Jackson Co., MO (LT-8843)

Dear Mr. Luke Schuler,

The enclosed report contains the data and analysis summary for the O-cell™ test performed on the dedicated test shaft for the Grandview Triangle project, on June 4, 2002. 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,

Michael D. Ahrens

Michael D. Ahrens, P.E.
LOADTEST, Inc.

EXECUTIVE SUMMARY

On June 4, 2002, we tested a nominal 72-inch dedicated test shaft constructed by Hayes Drilling, Inc. Mr. William G. Ryan and Mr. Robert C. Simpson of LOADTEST, Inc. carried out the test. Hayes Drilling, Inc. completed excavating the 49.0-ft deep shaft in the dry on May 31, 2002. Sub-surface conditions at the test shaft location consist of shale and limestone. Representatives of HNTB observed construction of the shaft.

The maximum bi-directional load applied to the shaft was 7,712 kips (34.30 MN). At the maximum load, the displacements above and below the O-cell™ were 1.409 inches (35.80 mm) and 0.223 inches (5.67 mm), respectively. Average unit shear data calculated from strain gages included a maximum calculated net unit side shear of 47.9 ksf (2,293 kPa) occurring between the O-cell™ and strain gage level 4.

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 10,926 kips (48.60 MN), the adjusted test data indicate this shaft would settle approximately 0.25 inches (6.4 mm) of which 0.15 inches (3.9 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 alternating strata of un-weathered to weathered shale and limestone. The generalized subsurface profile is included in Figure A and boring log indicating conditions near the shaft are presented in Appendix E. More detailed geologic information can be obtained from HNTB.

Test Shaft Construction: Hayes Drilling, Inc. began excavation on the dedicated test shaft, socketed in rock, on May 28, 2002 and performed the final cleanout and concreting on May 31, 2002. We understand that the nominal 72-inch (1,829-mm) test shaft was constructed to a tip elevation of +893.4 ft (+272.29 m) in the dry, however there was a small amount of seepage into the excavation. The shaft was started with an 84-in (2134-mm) O.D. casing. An auger and core-barrel were used for drilling and a bucket was used for cleaning the base of the shaft. After excavation, the water in the base of the shaft was pumped out and the excavation was logged with a sonic caliper and down-hole camera. The carrying frame with attached O-cell™ assembly was inserted into the excavation and temporarily supported from the top of the steel casing. Concrete was then delivered by pump line through a 5-inch (125-mm) O.D. pipe into the base of the shaft until the top of the concrete reached an elevation of +934.0 feet (+284.67 meters). Note that during excavation, problems were encountered in removing some of the cored limestone material, and it had to be broken up in the hole and removed with an auger. A representative of HNTB observed construction of the shaft.

OSTERBERG CELL TESTING

Shaft Instrumentation: Test shaft instrumentation and assembly was carried out under the direction of Mr. William G. Ryan of LOADTEST, Inc. on May 30 and 31, 2002. The loading assembly consisted of one 34-inch O-cell™ located 11.6 feet (3.54 meters) above the tip of shaft. Attached to the bottom of the carrying frame at the base of the shaft was a compressible end-bearing device consisting of 3 inches of styrene foam sandwiched between two ½-inch thick steel plates. The Osterberg cell was calibrated to 3,092 kips (13.75 MN) and then welded closed prior to shipping by American Equipment and Fabricating Corporation. Calibrations of O-cell™ and instrumentation used for this test are included in Appendix B.

Standard 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, Page 2). Two telltale casings were attached to the carrying frame, diametrically opposed, extending between the top of the O-cell™ assembly and the top of concrete. Compression of the pile between the O-cell™ assembly and the compressible end bearing device at the base of the shaft was measured by two Embedded Compression Telltales (ECTs), consisting of telltale rods in ½ inch steel casings, with an LVWDT attached. (Appendix A, Page 1).

Strain gages were used to assess the side shear load transfer of the shaft above and below the Osterberg cell assembly. Two levels of two sister bar vibrating wire strain gages (Geokon Model 4911 Series) were installed, diametrically opposed, in the shaft below the base of the O-cell™ assembly and four levels of two were installed in the shaft above it. Details concerning the strain gage placement appear in Table B and Figure A. The strain gages were positioned as specified by HNTB.

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™.

Test Arrangement: Throughout the load test, key elements of shaft response were monitored using the equipment and instruments described herein. Shaft compression was measured using telltales (described under Shaft Instrumentation) monitored by Linear Voltage Displacement Transducers (LVDT) (RDP Series). Two LVWDTs attached to a reference system were used to monitor the top of shaft movement (Appendix A, Page 1).

The reference system consisted of a 50-ft (15-meter) steel wide flange section supported on wood dunnage. The supports were located more than three shaft diameters from the center of the test shaft. An automated digital survey level (Leica NA 3003) was used to monitor the reference beam for movement during testing from a distance of approximately 30 feet (9.1 meters) (Appendix F). The maximum upward and downward movements observed for the reference beam were 0.022 inches (0.56 mm) and 0.020 inches (0.52 mm), respectively. The top of shaft movements have been corrected for movement of the reference system (Appendix A, Page 1).

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

Data Acquisition: All instrumentation were connected through a data logger (Data Electronics - Model 615 Datataker®), to a laptop computer, allowing data to be recorded and stored automatically at 30 second intervals and displayed in real time. A separate laptop computer synchronized to the data logging system was used to acquire the Leica NA3003 data.

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 pressure of 2,500 psi (17.24 MPa) to the O-cell™.

The Osterberg cell load test was conducted as follows: We pressurized the 34-inch (870-mm) diameter O-cell™, with its base located 11.6 feet (3.54 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 pressurized the O-cell™ in 21 loading increments to 12,610 psi (86.95 MPa) resulting in a bi-directional gross O-cell™ load of 7,712 kips (34.30 MN). The loading was halted after load interval 1L-21 because the upper side shear was displacing rapidly and a higher loading could not be achieved. Note that due to the rapid expansion of the O-cell™, it was not possible to maintain the final loading at a constant pressure. The O-cell™ was then depressurized in 5 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 four minutes by manually adjusting the O-cell™ pressure. We typically used 30 to 60 seconds to move between increments. The data logger automatically recorded the instrument readings every 30 seconds, but herein we report only the 1, 2 and 4-minute readings 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 118 kips (0.53 MN) above the O-cell™.

Upper Side Shear Resistance: The maximum upward applied *net load* to the upper side shear was 7,594 kips (33.78 MN) which occurred at the four minute reading of load interval 1L-21 (Appendix A, Page 1, Figure 1). At this loading, the upward movement of the O-cell™ top was 1.409 inches (35.80 mm).

Combined End-Bearing and Lower Side Shear Resistance: The maximum load applied below O-cell™ was 7,712 kips (34.30 MN) which occurred at load interval 1L-21 (Appendix A, Page 1, Figure 1). At this loading, the average downward movement of the O-cell™ base was 0.223 inches (5.67 mm). Due to the minimal downward displacement and the use of the compressible end-bearing device, the entire downward load is assumed to be carried by the lower side shear.

In order to assess the side shear resistance of the test shaft, loads are calculated based on the strain gage data (Appendix A, Pages 4 and 5) and estimates of shaft stiffness (AE). 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 approximately 6,000 psi (41.37 MPa) on the day of the test. This, combined with the area of reinforcing steel and average shaft diameters of 77.8 inches above the O-cell™ and 76.3 inches below, provided an average pile stiffness (AE) of 21,100,000 kips (93,853 MN) above the O-cell™, 20,300,000 kips (90,294 MN) below the O-cell™. Net unit shear values for loading increment 1L-21 follow in Table A:

TABLE A: Average Net Unit Side Shear Values for 1L-21

Load Transfer Zone	Load Direction	Net Unit Side Shear *
Top of Shaft to Strain Gage Level 6	↑	6.3 ksf (301 kPa)
Strain Gage Level 6 to Strain Gage Level 5	↑	6.2 ksf (295 kPa)
Strain Gage Level 5 to Strain Gage Level 4	↑	7.7 ksf (370 kPa)
Strain Gage Level 4 to O-cell™	↑	23.8 ksf (1138 kPa)
O-cell™ to Strain Gage Level 1	↓	47.9 ksf (2293 kPa)
Strain Gage Level 1 to Tip of Shaft	↓	12.3 ksf (590 kPa)

* 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: Level 2 and 3 strain gages data yielded unusual / unreliable data and are not included in the analysis.

Creep Limit: See Appendix D for our O-cell™ method for determining creep limit. The lower side shear creep data (Appendix A, Page 3) indicate that no apparent creep limit was reached at the maximum loading of 7,712 kips (34.30 MN) with 0.223 inches (5.67 mm) displacement (Figure 4). The upper side shear creep data (Appendix A, Page 3) indicate that a creep limit of 5,200 kips (23.13 MN) was reached at a movement of 0.217 inches (5.51 mm) (Figure 5). A top-loaded shaft will not begin significant creep until both components begin creep movement. This will occur at the maximum of the movements required to reach the creep limit for each component. We believe that significant creep for this shaft will not begin until a top loading exceeds 12,755 kips (56.73 MN) by some unknown amount.

Equivalent Top Load: Figure 2 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 lower O-cell™ data. The curve is extended out to a settlement of 0.90 inches (22.9 mm) by extrapolating the base of O-cell™ data (Appendix H). Because it is often an important component of the settlements involved, the equivalent top load curve requires an adjustment for the additional elastic compression that would occur in a top-load test. The darker curve as described in Procedure Part II of Appendix C includes this adjustment.

The test shaft was loaded to a combined upper and lower side shear load of 15,306 kips (68.08 MN). Note that none of the load was transferred to the end bearing and that the equivalent top load curve does not include end bearing. For a top loading of 10,926 kips (48.60 MN), the adjusted test data indicate this shaft would settle approximately 0.25 inches (6.4 mm) of which 0.15 inches (3.9 mm) is estimated elastic compression. For a top loading of 14,005 kips (62.29 MN) the adjusted test data indicate this shaft would settle approximately 0.50 inches (12.7 mm) of which 0.19 inches (4.9 mm) is estimated elastic compression.

Note that, as explained previously, the equivalent top load curve applies to incremental loading durations of four minutes. Creep effects will reduce the ultimate resistance of both components and increase pile 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. However, our experience suggests that such corrections are small and perhaps negligible for top loadings below the creep limit indicated in Figure 2.

Shaft Compression Comparison: The measured maximum shaft compression, averaged from two telltales, is 0.030 inches (0.76 mm) at 1L-20 (Appendix A, Page 1). Using an average shaft stiffness of 21,100,000 kips (93,853 MN) and the load distribution in Figure 3 at 1L-20, we calculated an elastic compression of 0.037 inches (0.94 mm) over the length of the compression telltales. We believe this good agreement provides evidence that the values of the estimated shaft stiffness are reasonable and that the O-cell™ loaded the shaft in accord with its calibrations. The ECTs measuring lower side shear compression did not yield reliable results.

Bottom Plate Tilt: The three LVWDTs measuring O-cell™ expansion allow us to evaluate the differential opening of the O-cell™ (Appendix A, Page 2). We calculate a maximum differential expansion of 0.06 inches (1.5 mm) (0.04°) across the nominal cross-section of the shaft at the 1L-21 maximum loading.

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

Michael D. Ahrens, P.E.
Geotechnical Engineer

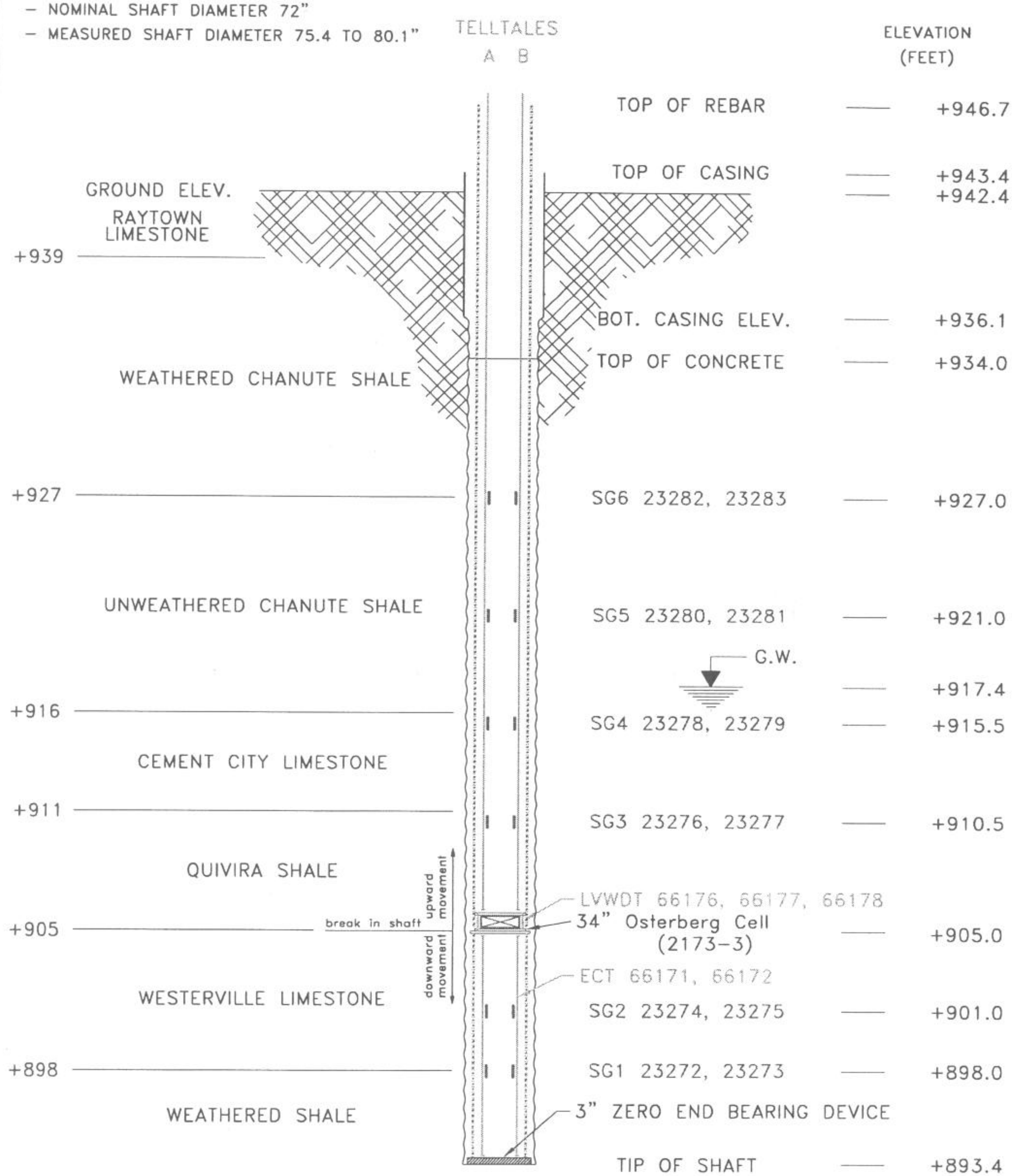
Reviewed by

Denton A. Kort, B.S.C.E.
LOADTEST, Inc.

TABLE B:
SUMMARY OF DIMENSIONS, ELEVATIONS & SHAFT PROPERTIES

Shaft:			
Average shaft diameter (EL +934.0 ft to +905.0 ft)	=	77.8 in	1976 mm
Average shaft diameter (EL +905.0 ft to +893.4 ft)	=	76.3 in	1938 mm
O-cell™: 2173-3	=	34 in	870 mm
Bouyant weight of pile above base of O-cell™	=	118 kips	0.53 MN
Estimated shaft stiffness, AE (EL +934.0 ft to +905.0 ft)	=	21,100,000 kips	93,800 MN
Estimated shaft stiffness, AE (EL +905.0 ft to +893.4 ft)	=	20,300,000 kips	90,300 MN
Elevation of top of shaft concrete	=	+934.0 ft	+284.67 m
Elevation of mud line	=	+942.4 ft	+287.23 m
Elevation of water table	=	+917.4 ft	+279.61 m
Elevation of base of O-cell™ (The break between upward and downward movement.)	=	+905.0 ft	+275.84 m
Elevation of shaft tip	=	+893.4 ft	+272.29 m
Casings:			
Elevation of top of inner temporary casing (84.0 in O.D.)	=	+943.4 ft	+287.53 m
Elevation of bottom of inner temporary casing (84.0 in O.D.)	=	+936.1 ft	+285.32 m
Compression Sections:			
Elevation of top of telltale used for upper shaft compression	=	+934.0 ft	+284.67 m
Elevation of bottom of telltale used for upper shaft compression	=	+906.3 ft	+276.23 m
Elevation of top of telltale used for lower shaft compression	=	+904.8 ft	+275.79 m
Elevation of bottom of telltale used for lower shaft compression	=	+893.6 ft	+272.36 m
Strain Gages:			
Elevation of strain gage Level 6	=	+927.0 ft	+282.54 m
Elevation of strain gage Level 5	=	+921.0 ft	+280.71 m
Elevation of strain gage Level 4	=	+915.5 ft	+279.04 m
Elevation of strain gage Level 3	=	+910.5 ft	+277.51 m
Elevation of strain gage Level 2	=	+901.0 ft	+274.62 m
Elevation of strain gage Level 1	=	+898.0 ft	+273.70 m
Miscellaneous:			
Top plate diameter (2 in thickness)	=	66 in	1676 mm
Bottom plate diameter (2 in thickness)	=	66 in	1676 mm
Frame cross sectional area (2 No. C4x7.25)	=	4.26 in²	2748 mm²
Spiral size (±60 in spacing)	=	# 5	M 16
ReBar cage diameter	=	66 in	1676 mm
Unconfined compressive concrete strength	=	6,000 psi	41.4 MPa
O-cell™ LVWDTs @ 0°, 180° and 270° with radius	=	20 in	500 mm

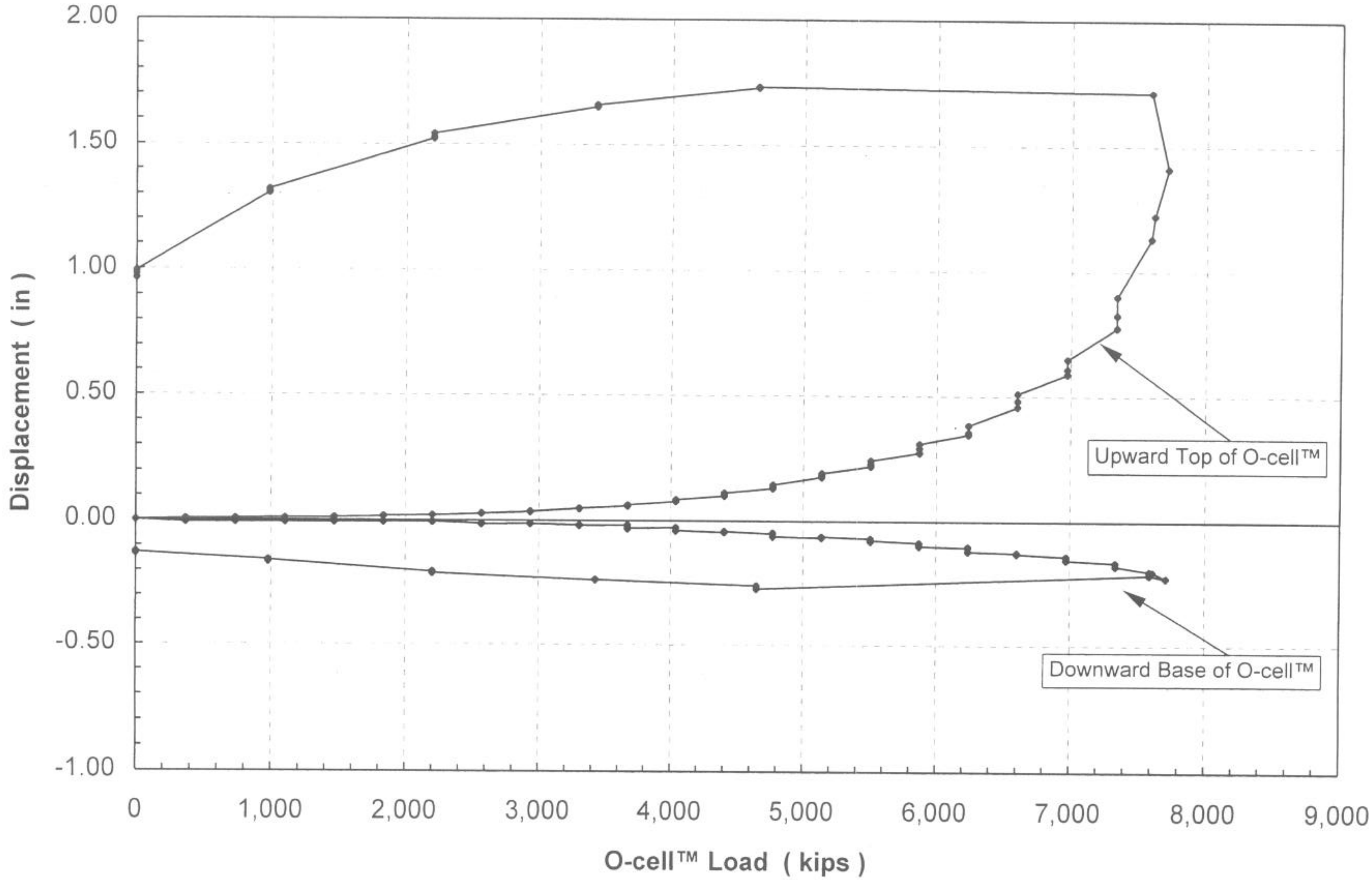
NOTE:
- NOMINAL SHAFT DIAMETER 72"
- MEASURED SHAFT DIAMETER 75.4 TO 80.1"



LOADTEST INC.	2631-D NW 41st St. Gainesville, FL 32606 Phone 800-368-1138 FAX (352) 378-3934	SCHEMATIC SECTION OF TEST SHAFT	LT-8843 Grandview Triangle Jackson County, MO FIGURE A

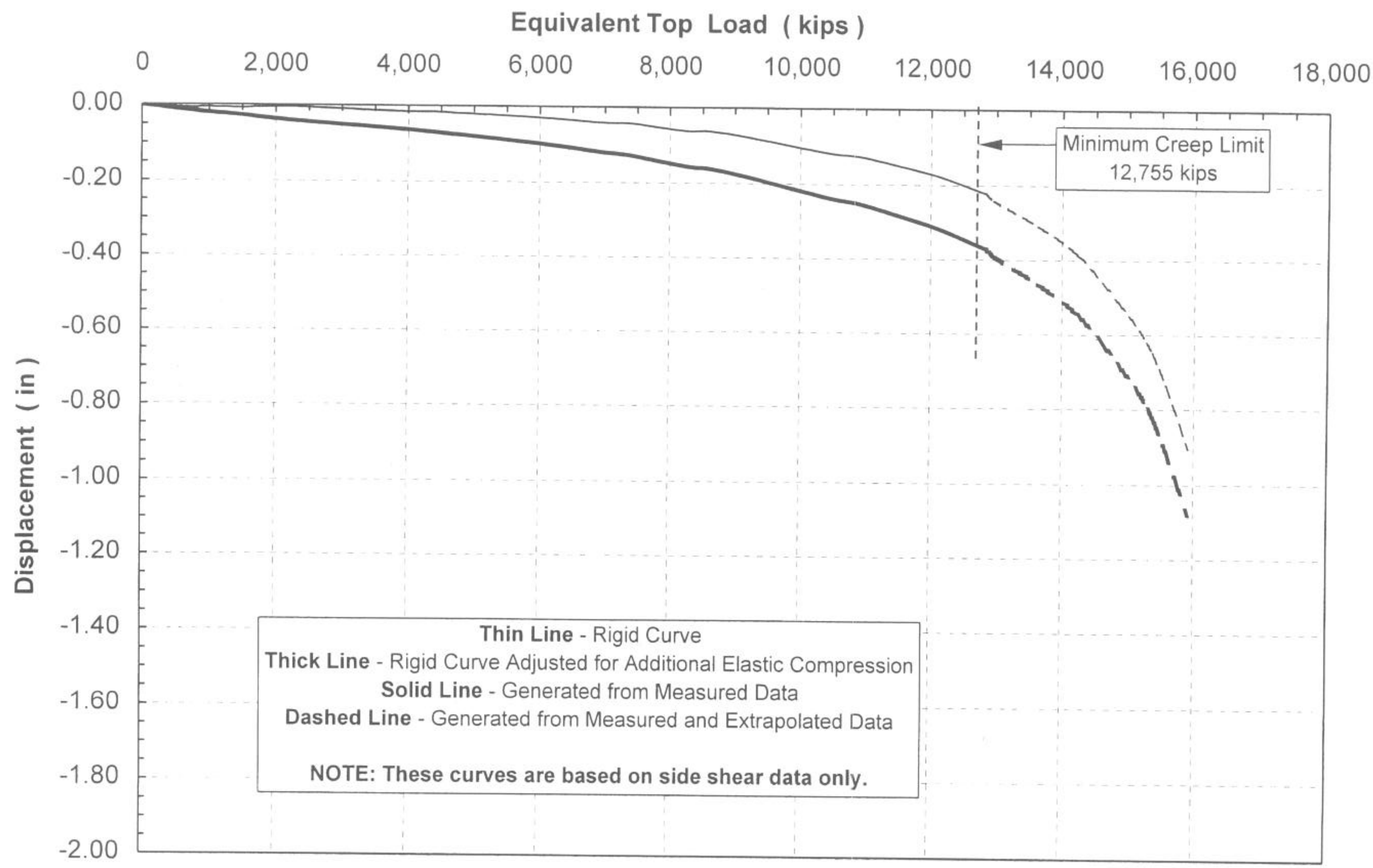
Osterberg Cell Load-Movement Curves

Dedicated Test Shaft - Grandview Triangle - Jackson Co., MO



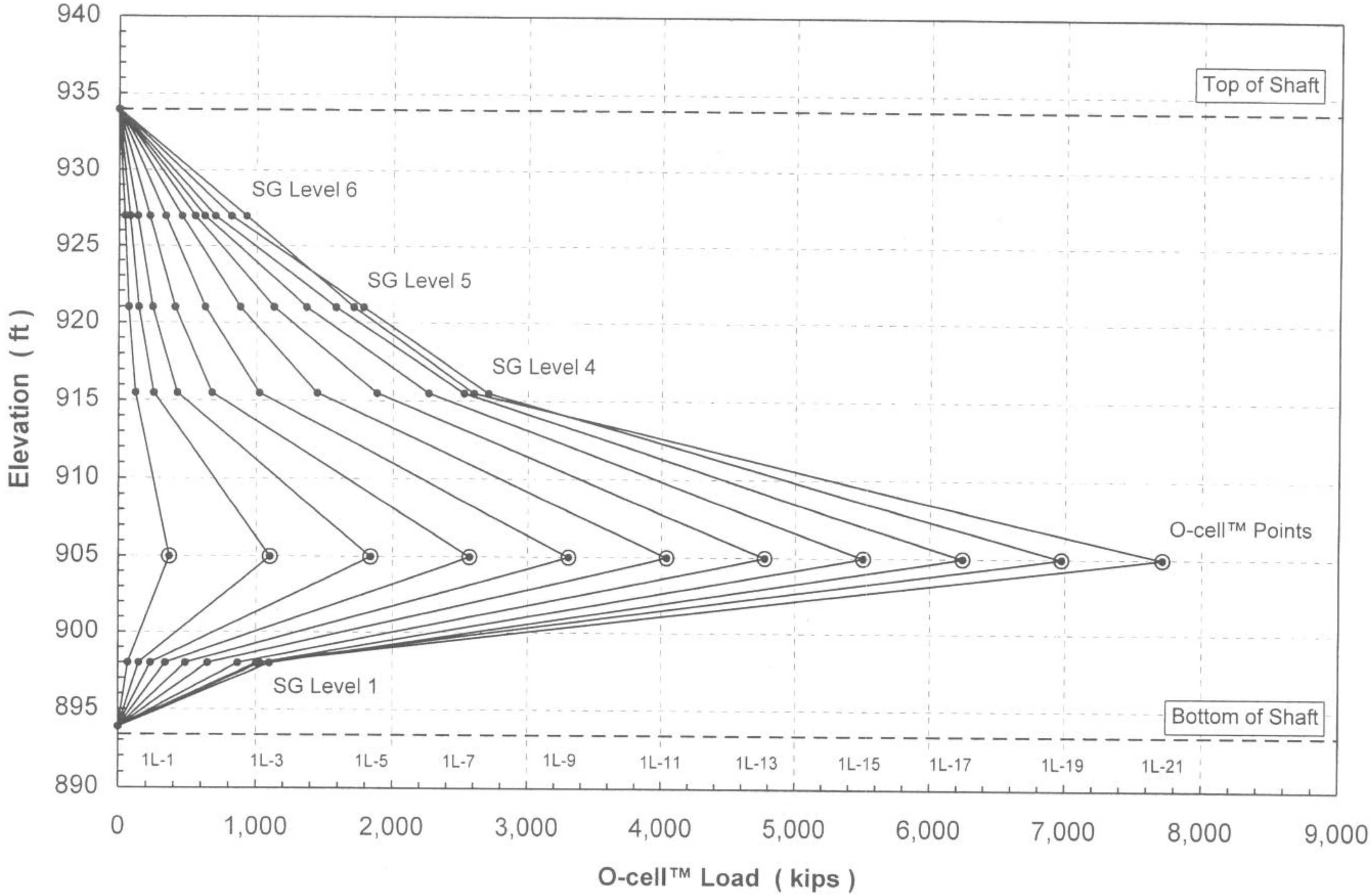
Equivalent Top Load Load-Movement Curve

Dedicated Test Shaft - Grandview Triangle - Jackson Co., MO



Strain Gage Load Distribution Curves

Dedicated Test Shaft - Grandview Triangle - Jackson Co., MO

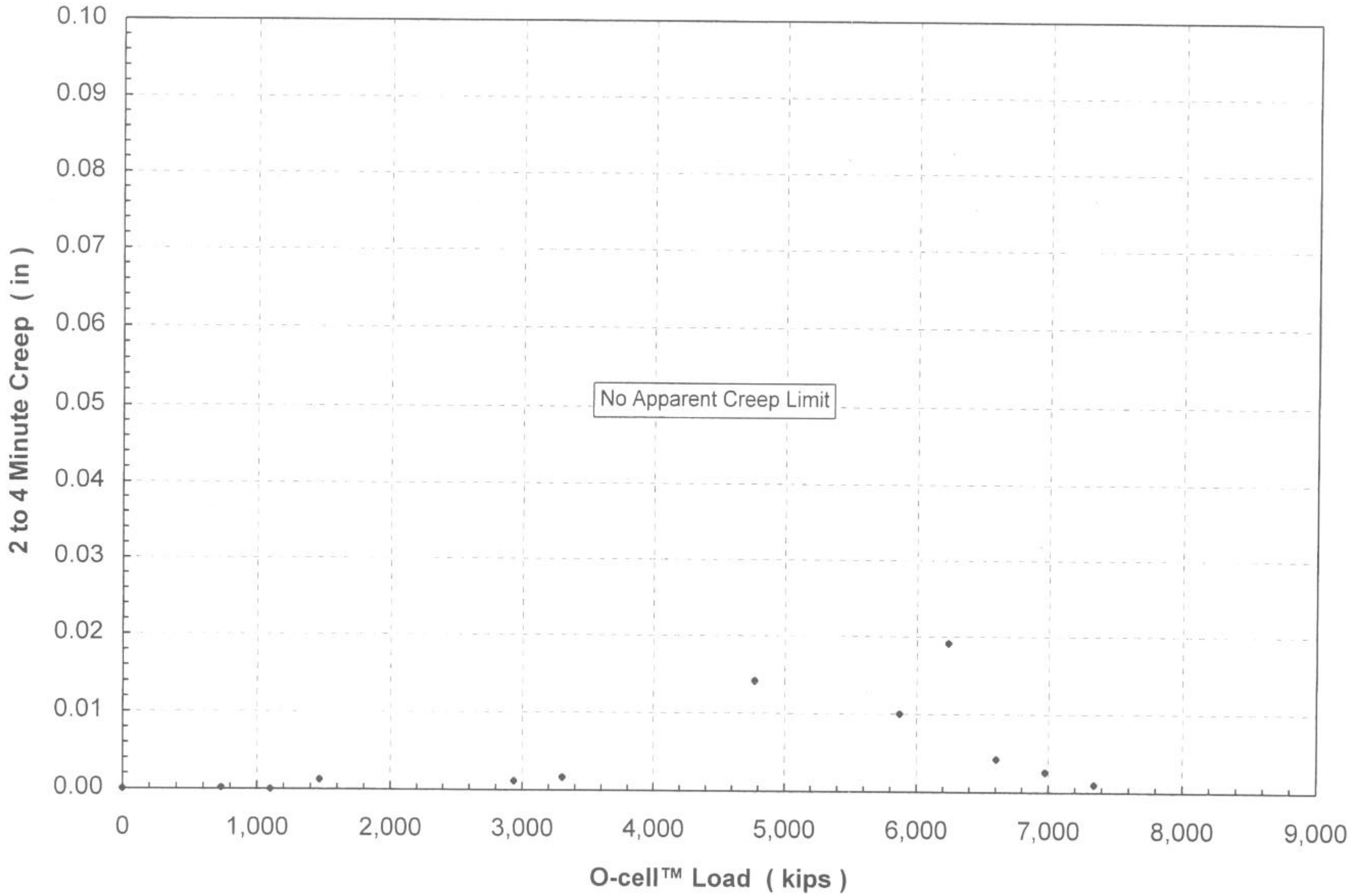


LOADTEST, Inc. Project No. LT-8843

Figure 3 of 5

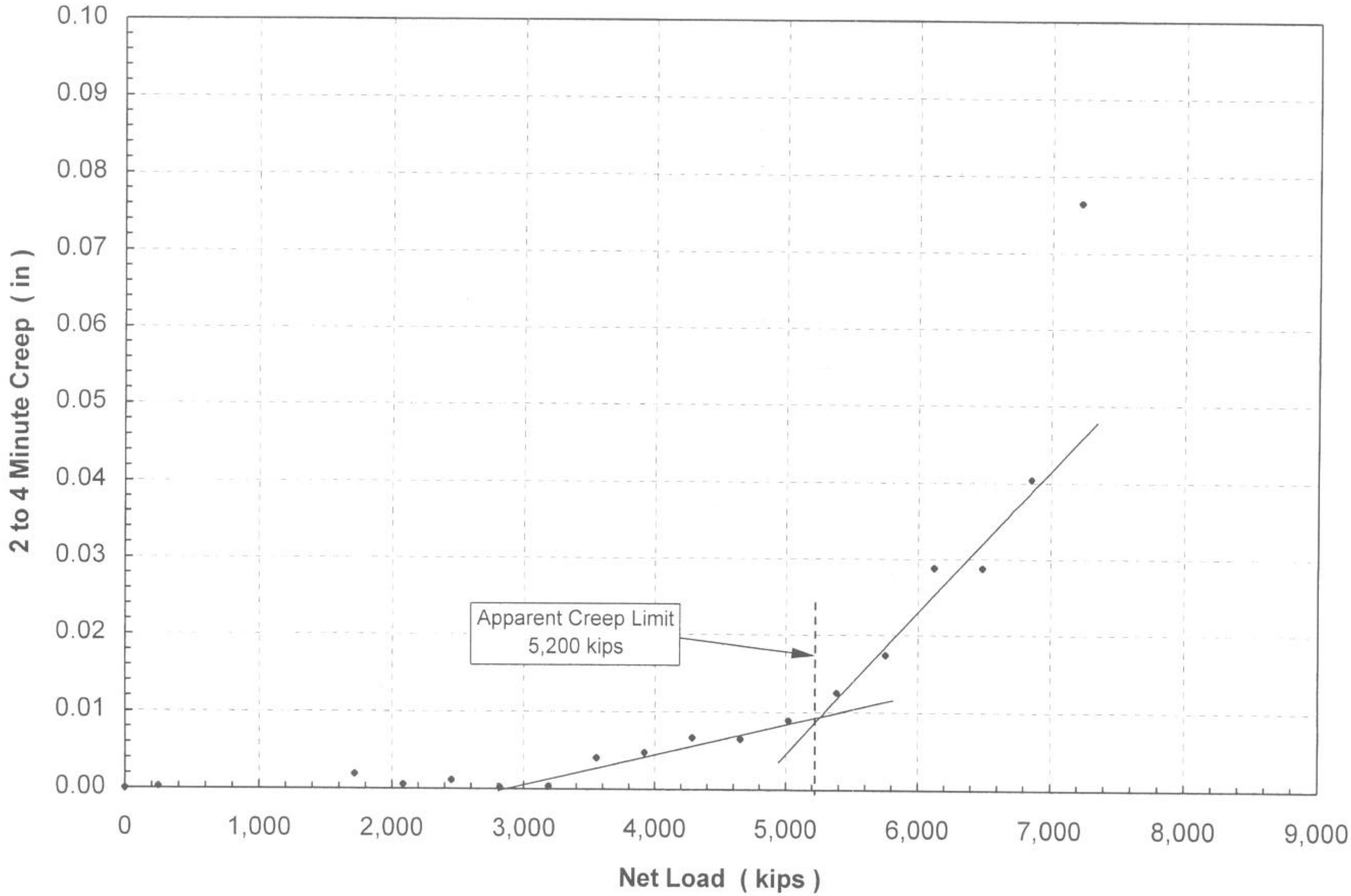
Lower Side Shear Creep Limit

Dedicated Test Shaft - Grandview Triangle - Jackson Co., MO



Upper Side Shear Creep Limit

Dedicated Test Shaft - Grandview Triangle - Jackson Co., MO



APPENDIX A

FIELD DATA & DATA REDUCTION

Upward Top of Shaft Movement and Shaft Compression
Dedicated Test Shaft - Grandview Triangle - Jackson Co., MO

Load Test Increment	Hold Time (minutes)	Time (h:m:s)	O-cell™ Pressure (psi)	O-cell™ Load (kips)	Ref. Beam * (in)	Top of Shaft A (in)	Top of Shaft B (in)	Top of Shaft Average (in)	Telltales A (in)	Telltales B (in)	Telltales Average (in)	ECT Level 1 66171 (in)	ECT Level 1 66172 (in)	ECT Level 1 Average (in)
1L-0	-	12:16:00	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1L-1	1	12:41:00	600	367	0.010	-0.006	-0.006	0.004	0.002	0.001	0.002	0.001	0.000	0.001
1L-1	2	12:42:00	600	367	0.010	-0.007	-0.005	0.004	0.002	0.001	0.002	0.001	0.000	0.001
1L-1	4	12:44:00	600	367	0.011	-0.008	-0.007	0.004	0.003	0.002	0.002	0.001	0.000	0.001
1L-2	1	12:46:00	1,200	734	0.012	-0.007	-0.007	0.005	0.003	0.001	0.002	0.001	0.000	0.001
1L-2	2	12:47:00	1,200	734	0.013	-0.008	-0.007	0.005	0.002	0.002	0.002	0.001	0.000	0.001
1L-2	4	12:49:00	1,200	734	0.014	-0.009	-0.008	0.005	0.003	0.002	0.002	0.001	0.000	0.001
1L-3	1	12:50:00	1,800	1,101	0.015	-0.010	-0.008	0.007	0.003	0.002	0.003	0.001	0.000	0.001
1L-3	2	12:51:00	1,800	1,101	0.016	-0.010	-0.008	0.007	0.003	0.003	0.003	0.001	0.000	0.001
1L-3	4	12:53:00	1,800	1,101	0.018	-0.011	-0.010	0.007	0.003	0.003	0.003	0.001	0.000	0.001
1L-4	1	12:54:00	2,400	1,468	0.018	-0.012	-0.009	0.007	0.004	0.003	0.004	0.001	0.000	0.001
1L-4	2	12:55:00	2,400	1,468	0.019	-0.012	-0.009	0.008	0.004	0.003	0.004	0.001	0.000	0.001
1L-4	4	12:57:00	2,400	1,468	0.020	-0.013	-0.011	0.008	0.004	0.003	0.004	0.001	0.000	0.001
1L-5	1	12:58:00	3,000	1,835	0.021	-0.012	-0.010	0.010	0.006	0.005	0.005	0.001	0.001	0.001
1L-5	2	12:59:00	3,000	1,835	0.021	-0.012	-0.010	0.010	0.006	0.005	0.006	0.001	0.000	0.001
1L-5	4	13:01:00	3,000	1,835	0.023	-0.012	-0.010	0.012	0.006	0.006	0.006	0.001	0.001	0.001
1L-6	1	13:02:00	3,600	2,202	0.023	-0.009	-0.008	0.014	0.007	0.007	0.007	0.001	0.001	0.001
1L-6	2	13:03:00	3,600	2,202	0.023	-0.009	-0.007	0.015	0.006	0.007	0.006	0.002	0.001	0.001
1L-6	4	13:05:00	3,600	2,202	0.022	-0.008	-0.006	0.015	0.007	0.007	0.007	0.001	0.001	0.001
1L-7	1	13:06:00	4,200	2,569	0.022	-0.003	-0.002	0.020	0.008	0.008	0.008	0.002	0.001	0.001
1L-7	2	13:07:00	4,200	2,569	0.021	-0.003	-0.002	0.019	0.008	0.008	0.008	0.002	0.001	0.001
1L-7	4	13:09:00	4,200	2,569	0.020	-0.001	0.000	0.020	0.009	0.009	0.009	0.002	0.001	0.001
1L-8	1	13:10:00	4,800	2,936	0.020	0.002	0.005	0.024	0.010	0.010	0.010	0.002	0.001	0.002
1L-8	2	13:11:00	4,800	2,936	0.020	0.003	0.006	0.025	0.010	0.010	0.010	0.002	0.001	0.002
1L-8	4	13:13:00	4,800	2,936	0.019	0.005	0.009	0.026	0.010	0.010	0.010	0.002	0.001	0.002
1L-9	1	13:14:00	5,400	3,303	0.018	0.020	0.016	0.036	0.011	0.011	0.011	0.002	0.001	0.002
1L-9	2	13:15:00	5,400	3,303	0.017	0.021	0.017	0.036	0.012	0.012	0.012	0.002	0.001	0.002
1L-9	4	13:17:00	5,400	3,303	0.013	0.025	0.022	0.036	0.012	0.012	0.012	0.002	0.001	0.002
1L-10	1	13:18:00	6,000	3,670	0.010	0.034	0.035	0.044	0.013	0.013	0.013	0.003	0.001	0.002
1L-10	2	13:19:00	6,000	3,670	0.006	0.040	0.040	0.046	0.013	0.013	0.013	0.003	0.001	0.002
1L-10	4	13:21:00	6,000	3,670	0.003	0.048	0.047	0.050	0.013	0.013	0.013	0.003	0.001	0.002
1L-11	1	13:22:00	6,600	4,037	0.000	0.061	0.062	0.062	0.015	0.015	0.015	0.003	0.002	0.002
1L-11	2	13:23:00	6,600	4,037	-0.002	0.067	0.068	0.066	0.016	0.015	0.015	0.003	0.001	0.002
1L-11	4	13:25:00	6,600	4,037	-0.005	0.076	0.075	0.071	0.016	0.015	0.015	0.003	0.000	0.002
1L-12	1	13:26:00	7,200	4,404	-0.006	0.091	0.091	0.085	0.017	0.016	0.017	0.003	-0.002	0.001
1L-12	2	13:27:00	7,200	4,404	-0.008	0.097	0.098	0.090	0.017	0.017	0.017	0.003	-0.002	0.000
1L-12	4	13:29:00	7,200	4,404	-0.010	0.106	0.107	0.096	0.018	0.017	0.017	0.003	-0.003	0.000
1L-13	1	13:30:00	7,800	4,771	-0.011	0.123	0.125	0.113	0.020	0.019	0.019	0.001	-0.004	-0.002
1L-13	2	13:31:00	7,800	4,771	-0.012	0.133	0.132	0.121	0.020	0.019	0.019	0.000	-0.005	-0.003
1L-13	4	13:33:00	7,800	4,771	-0.013	0.141	0.140	0.127	0.020	0.019	0.019	-0.001	-0.006	-0.003
1L-14	1	13:35:00	8,400	5,137	-0.014	0.173	0.170	0.157	0.022	0.020	0.021	-0.003	-0.008	-0.006
1L-14	2	13:36:00	8,400	5,137	-0.015	0.179	0.176	0.162	0.022	0.020	0.021	-0.004	-0.009	-0.006
1L-14	4	13:38:00	8,400	5,137	-0.016	0.190	0.185	0.171	0.022	0.021	0.021	-0.005	-0.010	-0.007
1L-15	1	13:39:00	9,000	5,504	-0.017	0.214	0.213	0.197	0.023	0.022	0.023	-0.007	-0.012	-0.009
1L-15	2	13:40:00	9,000	5,504	-0.017	0.225	0.224	0.207	0.023	0.022	0.023	-0.008	-0.013	-0.010
1L-15	4	13:42:00	9,000	5,504	-0.018	0.239	0.237	0.220	0.023	0.023	0.023	-0.008	-0.014	-0.011
1L-16	1	13:43:00	9,600	5,871	-0.019	0.266	0.271	0.250	0.025	0.024	0.025	-0.010	-0.016	-0.013
1L-16	2	13:44:00	9,600	5,871	-0.019	0.288	0.285	0.267	0.025	0.025	0.025	-0.011	-0.017	-0.014
1L-16	4	13:46:00	9,600	5,871	-0.020	0.304	0.304	0.285	0.025	0.025	0.025	-0.012	-0.018	-0.015
1L-17	1	13:47:00	10,200	6,238	-0.020	0.340	0.341	0.321	0.027	0.026	0.026	-0.015	-0.020	-0.018
1L-17	2	13:48:00	10,200	6,238	-0.020	0.348	0.350	0.329	0.026	0.025	0.026	-0.015	-0.021	-0.018
1L-17	4	13:50:00	10,200	6,238	-0.020	0.378	0.378	0.358	0.026	0.025	0.026	-0.017	-0.023	-0.020
1L-18	1	13:52:00	10,800	6,605	-0.018	0.451	0.449	0.432	0.028	0.027	0.027	-0.021	-0.028	-0.025
1L-18	2	13:53:00	10,800	6,605	-0.018	0.472	0.473	0.454	0.028	0.027	0.028	-0.023	-0.029	-0.026
1L-18	4	13:55:00	10,800	6,605	-0.017	0.502	0.499	0.483	0.029	0.027	0.028	-0.024	-0.030	-0.027
1L-19	1	13:57:00	11,400	6,972	-0.015	0.575	0.579	0.561	0.029	0.028	0.028	-0.029	-0.036	-0.033
1L-19	2	13:58:00	11,400	6,972	-0.014	0.596	0.596	0.581	0.029	0.027	0.028	-0.031	-0.037	-0.034
1L-19	4	14:00:00	11,400	6,972	-0.012	0.634	0.634	0.622	0.029	0.028	0.029	-0.033	-0.038	-0.036
1L-20	1	14:02:00	12,000	7,339	-0.010	0.757	0.756	0.746	0.032	0.029	0.030	-0.038	-0.044	-0.041
1L-20	2	14:03:00	12,000	7,339	-0.009	0.807	0.806	0.797	0.032	0.029	0.030	-0.041	-0.046	-0.044
1L-20	4	14:05:00	12,000	7,339	-0.008	0.883	0.881	0.874	0.031	0.028	0.030	-0.044	-0.049	-0.046
1L-21	1	14:08:30	12,410	7,590	-0.006	1.107	1.101	1.098	0.033	0.027	0.030	-0.051	-0.057	-0.054
1L-21	2	14:09:30	12,450	7,614	-0.005	1.199	1.194	1.191	0.033	0.027	0.030	-0.053	-0.059	-0.056
1L-21	4	14:11:30	12,610	7,712	-0.002	1.386	1.378	1.380	0.034	0.025	0.029	-0.058	-0.064	-0.061
1L-21	7	14:14:30	12,410	7,590	0.002	1.686	1.676	1.683	0.034	0.023	0.028	-0.062	-0.068	-0.065
1U-1	1	14:18:00	7,600	4,648	-0.001	1.719	1.707	1.712	0.024	0.014	0.019	-0.059	-0.066	-0.062
1U-1	2	14:19:00	7,600	4,648	0.000	1.717	1.706	1.711	0.024	0.013	0.019	-0.059	-0.066	-0.062
1U-1	4	14:21:00	7,600	4,648	0.000	1.714	1.703	1.708	0.024	0.013	0.019	-0.058	-0.066	-0.062
1U-2	1	14:23:00	5,600	3,425	0.001	1.647	1.636	1.642	0.020	0.009	0.014	-0.055	-0.064	-0.060
1U-2	2	14:24:00	5,600	3,425	0.002	1.642	1.631	1.638	0.019	0.008	0.014	-0.055	-0.064	-0.059
1U-2	4	14:26:00	5,600	3,425	0.003	1.636	1.625	1.634	0.020	0.008	0.014	-0.055	-0.064	-0.059
1U-3	1	14:27:00	3,600	2,202	0.003	1.536	1.523	1.533	0.015	0.004	0.010	-0.051	-0.061	-0.056
1U-3	2	14:28:00	3,600	2,202	0.004	1.515	1.515	1.519	0.015	0.004	0.010	-0.051	-0.060	-0.056
1U-3	4	14:30:00	3,600	2,202	0.006	1.513	1.503	1.513	0.015	0.003	0.009	-0.050	-0.060	-0.055
1U-4	1	14:32:00	1,600	979	0.004	1.314	1.303	1.313	0.011	0.000	0.005	-0.044	-0.054	-0.049
1U-4	2	14:33:00	1,600	979	0.004	1.305	1.293	1.303	0.011	0.000	0.005	-0.043	-0.053	-0.048
1U-4	4	14:35:00	1,600	979	0.005	1.301	1.286	1.298	0.011	0.000	0.006	-0.043	-0.053	-0.048
1U-5	1	14:37:00	0	0	0.004	0.992	0.984	0.992	0.005	-0.004	0.001	-0.037	-0.044	-0.041
1U-5	2	14:38:00	0	0	0.004	0.979	0.971	0.979	0.006	-0.004	0.001	-0.037	-0.044	-0.041
1U-5	4	14:40:00	0	0	0.003	0.965	0.957	0.964	0.005	-0.004	0.000	-0.037	-0.044	-0.040

* Positive values indicate upward reference beam movement.

O-cell™ Expansion
Dedicated Test Shaft - Grandview Triangle - Jackson Co., MO

Load Test Increment	Hold Time (minutes)	Time (h:m:s)	O-cell™ Pressure (psi)	O-cell™ Load (kips)	O-cell™ Expansion LVWDT 66176 (in)	LVWDT 66177 (in)	LVWDT 66178 * (in)	Average (in)
1 L - 0	-	12:16:00	0	0	0.000	0.000	0.000	0.000
1 L - 1	1	12:41:00	600	367	0.020	0.006	0.004	0.013
1 L - 1	2	12:42:00	600	367	0.020	0.006	0.005	0.013
1 L - 1	4	12:44:00	600	367	0.020	0.006	0.005	0.013
1 L - 2	1	12:46:00	1,200	734	0.021	0.007	0.004	0.014
1 L - 2	2	12:47:00	1,200	734	0.021	0.007	0.005	0.014
1 L - 2	4	12:49:00	1,200	734	0.021	0.007	0.004	0.014
1 L - 3	1	12:50:00	1,800	1,101	0.023	0.011	0.006	0.017
1 L - 3	2	12:51:00	1,800	1,101	0.023	0.011	0.006	0.017
1 L - 3	4	12:53:00	1,800	1,101	0.023	0.011	0.006	0.017
1 L - 4	1	12:54:00	2,400	1,468	0.021	0.014	0.007	0.018
1 L - 4	2	12:55:00	2,400	1,468	0.022	0.014	0.008	0.018
1 L - 4	4	12:57:00	2,400	1,468	0.023	0.016	0.009	0.019
1 L - 5	1	12:58:00	3,000	1,835	0.024	0.020	0.006	0.022
1 L - 5	2	12:59:00	3,000	1,835	0.023	0.020	0.007	0.021
1 L - 5	4	13:01:00	3,000	1,835	0.023	0.022	0.008	0.022
1 L - 6	1	13:02:00	3,600	2,202	0.026	0.027	0.011	0.027
1 L - 6	2	13:03:00	3,600	2,202	0.024	0.027	0.012	0.025
1 L - 6	4	13:05:00	3,600	2,202	0.024	0.028	0.014	0.026
1 L - 7	1	13:06:00	4,200	2,569	0.046	0.034	0.018	0.040
1 L - 7	2	13:07:00	4,200	2,569	0.048	0.035	0.019	0.042
1 L - 7	4	13:09:00	4,200	2,569	0.048	0.037	0.019	0.042
1 L - 8	1	13:10:00	4,800	2,936	0.047	0.045	0.027	0.046
1 L - 8	2	13:11:00	4,800	2,936	0.048	0.047	0.029	0.047
1 L - 8	4	13:13:00	4,800	2,936	0.049	0.049	0.031	0.049
1 L - 9	1	13:14:00	5,400	3,303	0.069	0.059	0.041	0.064
1 L - 9	2	13:15:00	5,400	3,303	0.070	0.062	0.042	0.066
1 L - 9	4	13:17:00	5,400	3,303	0.070	0.065	0.044	0.068
1 L - 10	1	13:18:00	6,000	3,670	0.071	0.078	0.058	0.075
1 L - 10	2	13:19:00	6,000	3,670	0.098	0.082	0.061	0.090
1 L - 10	4	13:21:00	6,000	3,670	0.100	0.085	0.066	0.092
1 L - 11	1	13:22:00	6,600	4,037	0.101	0.106	0.083	0.103
1 L - 11	2	13:23:00	6,600	4,037	0.129	0.112	0.090	0.121
1 L - 11	4	13:25:00	6,600	4,037	0.131	0.118	0.095	0.124
1 L - 12	1	13:26:00	7,200	4,404	0.154	0.138	0.116	0.146
1 L - 12	2	13:27:00	7,200	4,404	0.155	0.146	0.123	0.150
1 L - 12	4	13:29:00	7,200	4,404	0.156	0.154	0.131	0.155
1 L - 13	1	13:30:00	7,800	4,771	0.184	0.179	0.155	0.181
1 L - 13	2	13:31:00	7,800	4,771	0.185	0.188	0.163	0.186
1 L - 13	4	13:33:00	7,800	4,771	0.217	0.198	0.170	0.207
1 L - 14	1	13:35:00	8,400	5,137	0.251	0.235	0.203	0.243
1 L - 14	2	13:36:00	8,400	5,137	0.251	0.243	0.210	0.247
1 L - 14	4	13:38:00	8,400	5,137	0.251	0.254	0.220	0.253
1 L - 15	1	13:39:00	9,000	5,504	0.288	0.288	0.255	0.288
1 L - 15	2	13:40:00	9,000	5,504	0.319	0.300	0.267	0.310
1 L - 15	4	13:42:00	9,000	5,504	0.319	0.317	0.283	0.318
1 L - 16	1	13:43:00	9,600	5,871	0.359	0.359	0.324	0.359
1 L - 16	2	13:44:00	9,600	5,871	0.384	0.376	0.340	0.380
1 L - 16	4	13:46:00	9,600	5,871	0.419	0.397	0.358	0.408
1 L - 17	1	13:47:00	10,200	6,238	0.458	0.442	0.402	0.450
1 L - 17	2	13:48:00	10,200	6,238	0.458	0.452	0.413	0.455
1 L - 17	4	13:50:00	10,200	6,238	0.520	0.486	0.441	0.503
1 L - 18	1	13:52:00	10,800	6,605	0.589	0.577	0.556	0.583
1 L - 18	2	13:53:00	10,800	6,605	0.611	0.599	0.584	0.605
1 L - 18	4	13:55:00	10,800	6,605	0.646	0.630	0.620	0.638
1 L - 19	1	13:57:00	11,400	6,972	0.741	0.714	0.711	0.727
1 L - 19	2	13:58:00	11,400	6,972	0.768	0.749	0.738	0.759
1 L - 19	4	14:00:00	11,400	6,972	0.811	0.793	0.783	0.802
1 L - 20	1	14:02:00	12,000	7,339	0.947	0.931	0.927	0.939
1 L - 20	2	14:03:00	12,000	7,339	1.012	0.993	0.984	1.003
1 L - 20	4	14:05:00	12,000	7,339	1.081	1.080	1.078	1.080
1 L - 21	1	14:08:30	12,410	7,590	1.349	1.301	1.302	1.325
1 L - 21	2	14:09:30	12,450	7,614	1.439	1.401	1.394	1.420
1 L - 21	4	14:11:30	12,610	7,712	1.657	1.608	1.591	1.633
1 L - 21	7	14:14:30	12,410	7,590	1.947	1.897	1.926	1.922
1 U - 1	1	14:18:00	7,600	4,648	2.025	1.980	1.971	2.003
1 U - 1	2	14:19:00	7,600	4,648	2.018	1.979	1.970	1.999
1 U - 1	4	14:21:00	7,600	4,648	2.018	1.953	1.969	1.985
1 U - 2	1	14:23:00	5,600	3,425	1.927	1.858	1.874	1.892
1 U - 2	2	14:24:00	5,600	3,425	1.913	1.858	1.865	1.886
1 U - 2	4	14:26:00	5,600	3,425	1.913	1.858	1.865	1.885
1 U - 3	1	14:27:00	3,600	2,202	1.771	1.734	1.730	1.752
1 U - 3	2	14:28:00	3,600	2,202	1.755	1.709	1.711	1.732
1 U - 3	4	14:30:00	3,600	2,202	1.752	1.703	1.696	1.727
1 U - 4	1	14:32:00	1,600	979	1.506	1.448	1.452	1.477
1 U - 4	2	14:33:00	1,600	979	1.505	1.442	1.452	1.473
1 U - 4	4	14:35:00	1,600	979	1.496	1.426	1.433	1.461
1 U - 5	1	14:37:00	0	0	1.144	1.098	1.095	1.121
1 U - 5	2	14:38:00	0	0	1.142	1.083	1.080	1.113
1 U - 5	4	14:40:00	0	0	1.114	1.068	1.066	1.091

* LVWDT 66178 is not included in the average due to its orientation. LVWDTs 66176 and 66177 are oriented 180° opposed.

Upward and Downward O-cell™ Plate Movement and Creep (calculated)
Dedicated Test Shaft - Grandview Triangle - Jackson Co., MO

Load Test Increment	Hold Time (minutes)	Time (h:m:s)	O-cell™ Pressure (psi)	O-cell™ Load (kips)	Top of Shaft (in)	Upper 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	-	12:16:00	0	0	0.000	0.000	0.000	0.000	0.000		
1 L - 1	1	12:41:00	600	367	0.004	0.002	0.005	0.013	-0.008		
1 L - 1	2	12:42:00	600	367	0.004	0.002	0.006	0.013	-0.007	0.000	0.000
1 L - 1	4	12:44:00	600	367	0.004	0.002	0.006	0.013	-0.007	0.000	0.000
1 L - 2	1	12:46:00	1,200	734	0.005	0.002	0.007	0.014	-0.007		
1 L - 2	2	12:47:00	1,200	734	0.005	0.002	0.007	0.014	-0.007	0.001	-0.001
1 L - 2	4	12:49:00	1,200	734	0.005	0.002	0.007	0.014	-0.007	0.000	0.000
1 L - 3	1	12:50:00	1,800	1,101	0.007	0.003	0.010	0.017	-0.007		
1 L - 3	2	12:51:00	1,800	1,101	0.007	0.003	0.010	0.017	-0.007	0.000	0.000
1 L - 3	4	12:53:00	1,800	1,101	0.007	0.003	0.010	0.017	-0.007	0.000	0.000
1 L - 4	1	12:54:00	2,400	1,468	0.007	0.004	0.011	0.018	-0.007		
1 L - 4	2	12:55:00	2,400	1,468	0.008	0.004	0.012	0.018	-0.006	0.001	-0.001
1 L - 4	4	12:57:00	2,400	1,468	0.008	0.004	0.012	0.019	-0.007	0.000	0.001
1 L - 5	1	12:58:00	3,000	1,835	0.010	0.005	0.016	0.022	-0.006		
1 L - 5	2	12:59:00	3,000	1,835	0.010	0.006	0.016	0.021	-0.005	0.000	-0.001
1 L - 5	4	13:01:00	3,000	1,835	0.012	0.006	0.018	0.022	-0.004	0.002	-0.001
1 L - 6	1	13:02:00	3,600	2,202	0.014	0.007	0.021	0.027	-0.006		
1 L - 6	2	13:03:00	3,600	2,202	0.015	0.006	0.021	0.025	-0.005	0.000	-0.001
1 L - 6	4	13:05:00	3,600	2,202	0.015	0.007	0.021	0.026	-0.004	0.001	0.000
1 L - 7	1	13:06:00	4,200	2,569	0.020	0.008	0.028	0.040	-0.012		
1 L - 7	2	13:07:00	4,200	2,569	0.019	0.008	0.027	0.042	-0.015	0.000	0.002
1 L - 7	4	13:09:00	4,200	2,569	0.020	0.009	0.028	0.042	-0.014	0.001	0.000
1 L - 8	1	13:10:00	4,800	2,936	0.024	0.010	0.034	0.046	-0.012		
1 L - 8	2	13:11:00	4,800	2,936	0.025	0.010	0.035	0.047	-0.012	0.001	0.000
1 L - 8	4	13:13:00	4,800	2,936	0.026	0.010	0.035	0.049	-0.013	0.000	0.001
1 L - 9	1	13:14:00	5,400	3,303	0.036	0.011	0.047	0.064	-0.017		
1 L - 9	2	13:15:00	5,400	3,303	0.036	0.012	0.048	0.066	-0.018	0.001	0.001
1 L - 9	4	13:17:00	5,400	3,303	0.036	0.012	0.048	0.068	-0.019	0.000	0.002
1 L - 10	1	13:18:00	6,000	3,670	0.044	0.013	0.057	0.075	-0.017		
1 L - 10	2	13:19:00	6,000	3,670	0.046	0.013	0.059	0.090	-0.031	0.001	0.014
1 L - 10	4	13:21:00	6,000	3,670	0.050	0.013	0.063	0.092	-0.030	0.004	-0.002
1 L - 11	1	13:22:00	6,600	4,037	0.062	0.015	0.077	0.103	-0.026		
1 L - 11	2	13:23:00	6,600	4,037	0.066	0.015	0.081	0.121	-0.039	0.004	0.013
1 L - 11	4	13:25:00	6,600	4,037	0.071	0.015	0.086	0.124	-0.038	0.005	-0.001
1 L - 12	1	13:26:00	7,200	4,404	0.085	0.017	0.101	0.146	-0.045		
1 L - 12	2	13:27:00	7,200	4,404	0.090	0.017	0.107	0.150	-0.043	0.005	-0.001
1 L - 12	4	13:29:00	7,200	4,404	0.096	0.017	0.114	0.155	-0.041	0.007	-0.002
1 L - 13	1	13:30:00	7,800	4,771	0.113	0.019	0.132	0.181	-0.049		
1 L - 13	2	13:31:00	7,800	4,771	0.121	0.019	0.140	0.186	-0.046	0.008	-0.003
1 L - 13	4	13:33:00	7,800	4,771	0.127	0.019	0.147	0.207	-0.060	0.006	0.014
1 L - 14	1	13:35:00	8,400	5,137	0.157	0.021	0.178	0.243	-0.065		
1 L - 14	2	13:36:00	8,400	5,137	0.162	0.021	0.183	0.247	-0.063	0.006	-0.002
1 L - 14	4	13:38:00	8,400	5,137	0.171	0.021	0.192	0.253	-0.061	0.009	-0.003
1 L - 15	1	13:39:00	9,000	5,504	0.197	0.023	0.220	0.288	-0.068		
1 L - 15	2	13:40:00	9,000	5,504	0.207	0.023	0.230	0.310	-0.080	0.010	0.012
1 L - 15	4	13:42:00	9,000	5,504	0.220	0.023	0.243	0.318	-0.075	0.013	-0.004
1 L - 16	1	13:43:00	9,600	5,871	0.250	0.025	0.274	0.359	-0.085		
1 L - 16	2	13:44:00	9,600	5,871	0.267	0.025	0.292	0.380	-0.088	0.018	0.003
1 L - 16	4	13:46:00	9,600	5,871	0.285	0.025	0.309	0.408	-0.098	0.017	0.010
1 L - 17	1	13:47:00	10,200	6,238	0.321	0.026	0.347	0.450	-0.103		
1 L - 17	2	13:48:00	10,200	6,238	0.329	0.026	0.355	0.455	-0.100	0.008	-0.003
1 L - 17	4	13:50:00	10,200	6,238	0.358	0.026	0.384	0.503	-0.119	0.029	0.019
1 L - 18	1	13:52:00	10,800	6,605	0.432	0.027	0.459	0.583	-0.124		
1 L - 18	2	13:53:00	10,800	6,605	0.454	0.028	0.482	0.605	-0.123	0.023	-0.002
1 L - 18	4	13:55:00	10,800	6,605	0.483	0.028	0.511	0.638	-0.127	0.029	0.004
1 L - 19	1	13:57:00	11,400	6,972	0.561	0.028	0.590	0.727	-0.138		
1 L - 19	2	13:58:00	11,400	6,972	0.581	0.028	0.610	0.759	-0.149	0.020	0.012
1 L - 19	4	14:00:00	11,400	6,972	0.622	0.029	0.650	0.802	-0.152	0.040	0.003
1 L - 20	1	14:02:00	12,000	7,339	0.746	0.030	0.777	0.939	-0.162		
1 L - 20	2	14:03:00	12,000	7,339	0.797	0.030	0.827	1.003	-0.176	0.050	0.013
1 L - 20	4	14:05:00	12,000	7,339	0.874	0.030	0.904	1.080	-0.177	0.076	0.001
1 L - 21	1	14:08:30	12,410	7,590	1.098	0.030	1.128	1.325	-0.197		
1 L - 21	2	14:09:30	12,450	7,614	1.191	0.030	1.221	1.420	-0.199		
1 L - 21	4	14:11:30	12,610	7,712	1.380	0.029	1.409	1.633	-0.223		
1 L - 21	7	14:14:30	12,410	7,590	1.683	0.028	1.711	1.922	-0.211		
1 U - 1	1	14:18:00	7,600	4,648	1.712	0.019	1.731	2.003	-0.272		
1 U - 1	2	14:19:00	7,600	4,648	1.711	0.019	1.730	1.999	-0.269		
1 U - 1	4	14:21:00	7,600	4,648	1.708	0.019	1.727	1.985	-0.258		
1 U - 2	1	14:23:00	5,600	3,425	1.642	0.014	1.656	1.892	-0.236		
1 U - 2	2	14:24:00	5,600	3,425	1.638	0.014	1.652	1.886	-0.234		
1 U - 2	4	14:26:00	5,600	3,425	1.634	0.014	1.648	1.885	-0.238		
1 U - 3	1	14:27:00	3,600	2,202	1.533	0.010	1.542	1.752	-0.210		
1 U - 3	2	14:28:00	3,600	2,202	1.519	0.010	1.528	1.732	-0.203		
1 U - 3	4	14:30:00	3,600	2,202	1.513	0.009	1.523	1.727	-0.205		
1 U - 4	1	14:32:00	1,600	979	1.313	0.005	1.318	1.477	-0.159		
1 U - 4	2	14:33:00	1,600	979	1.303	0.005	1.308	1.473	-0.165		
1 U - 4	4	14:35:00	1,600	979	1.298	0.006	1.303	1.461	-0.158		
1 U - 5	1	14:37:00	0	0	0.992	0.001	0.993	1.121	-0.128		
1 U - 5	2	14:38:00	0	0	0.979	0.001	0.980	1.113	-0.133		
1 U - 5	4	14:40:00	0	0	0.964	0.000	0.965	1.091	-0.126		

Strain Gage Readings and Loads at Levels 1, 2 and 3
Dedicated Test Shaft - Grandview Triangle - Jackson Co., MO

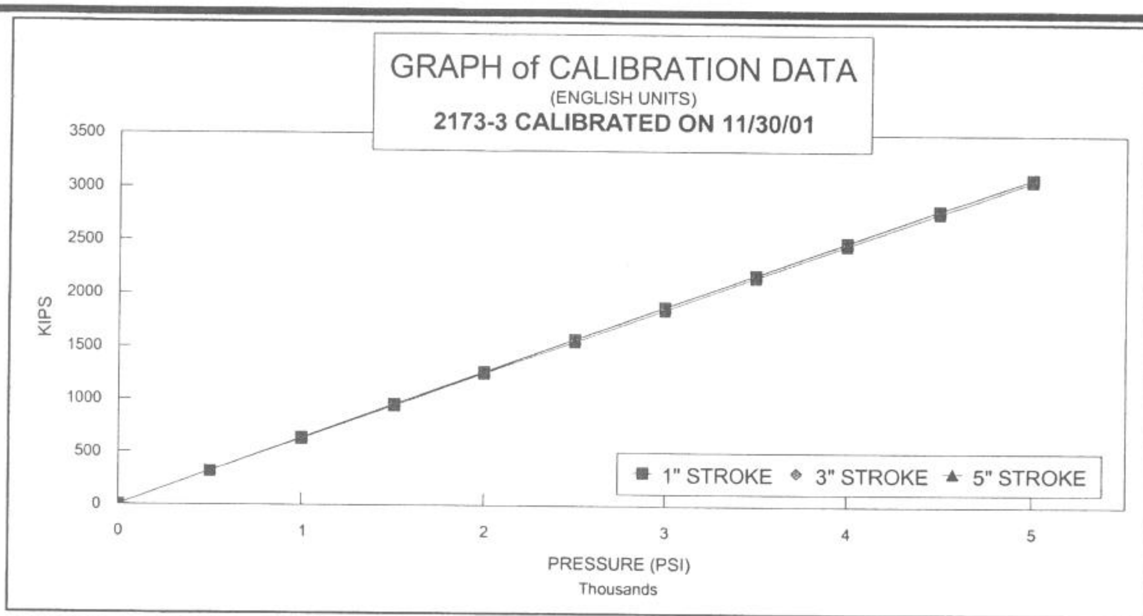
Load Test Increment	Hold Time (minutes)	Time (h:m:s)	O-cell™ Pressure (psi)	O-cell™ Load (kips)	Level 1 23272 (με)	Level 1 23273 (με)	Level 1 Av. Load (kips)	Level 2 23274 (με)	Level 2 23275 (με)	Level 2 Av. Load (kips)	Level 3 23276 (με)	Level 3 23277 (με)	Level 3 Av. Load (kips)
1 L - 0	-	12:16:00	0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
1 L - 1	1	12:41:00	600	367	2.4	4.3	71	8.7	6.7	163	11.5	20.5	325
1 L - 1	2	12:42:00	600	367	2.4	4.3	71	8.7	6.8	163	11.6	20.6	327
1 L - 1	4	12:44:00	600	367	2.4	4.3	70	8.7	6.8	163	11.6	20.8	329
1 L - 2	1	12:46:00	1,200	734	4.1	6.2	108	11.9	8.5	215	16.2	29.8	467
1 L - 2	2	12:47:00	1,200	734	4.1	6.3	110	12.1	8.6	219	16.5	30.4	476
1 L - 2	4	12:49:00	1,200	734	4.1	6.3	109	12.1	8.5	218	16.4	30.5	476
1 L - 3	1	12:50:00	1,800	1,101	5.6	8.1	145	15.3	10.2	269	21.5	40.8	633
1 L - 3	2	12:51:00	1,800	1,101	5.8	8.2	148	15.7	10.4	275	22.2	42.3	655
1 L - 3	4	12:53:00	1,800	1,101	5.7	8.2	147	15.8	10.3	275	22.2	42.4	655
1 L - 4	1	12:54:00	2,400	1,468	7.2	9.8	180	18.2	11.7	316	26.9	52.9	811
1 L - 4	2	12:55:00	2,400	1,468	7.2	9.9	180	18.4	11.7	318	27.1	53.7	819
1 L - 4	4	12:57:00	2,400	1,468	7.3	9.9	181	18.4	11.8	319	27.2	54.3	827
1 L - 5	1	12:58:00	3,000	1,835	9.1	12.3	226	20.3	13.5	356	33.3	69.0	1039
1 L - 5	2	12:59:00	3,000	1,835	9.2	12.5	229	20.5	14.0	364	33.7	70.5	1058
1 L - 5	4	13:01:00	3,000	1,835	9.3	12.8	233	20.9	14.6	374	34.5	72.7	1089
1 L - 6	1	13:02:00	3,600	2,202	11.1	15.3	278	22.6	17.5	423	40.9	83.7	1265
1 L - 6	2	13:03:00	3,600	2,202	11.0	15.3	277	22.6	17.4	423	40.9	83.9	1267
1 L - 6	4	13:05:00	3,600	2,202	11.0	15.5	280	23.0	17.9	432	41.3	85.1	1283
1 L - 7	1	13:06:00	4,200	2,569	13.4	18.3	335	24.3	20.1	468	47.8	96.8	1468
1 L - 7	2	13:07:00	4,200	2,569	13.2	18.4	334	24.5	20.2	471	48.0	96.8	1469
1 L - 7	4	13:09:00	4,200	2,569	13.6	18.7	341	25.1	20.2	477	49.9	96.8	1488
1 L - 8	1	13:10:00	4,800	2,936	16.0	21.7	398	25.4	22.3	503	56.5	106.5	1654
1 L - 8	2	13:11:00	4,800	2,936	16.2	22.1	404	25.7	22.5	509	57.4	107.2	1670
1 L - 8	4	13:13:00	4,800	2,936	16.3	22.5	410	25.8	22.7	512	58.0	107.6	1680
1 L - 9	1	13:14:00	5,400	3,303	19.0	25.6	470	25.8	24.1	527	64.2	117.1	1840
1 L - 9	2	13:15:00	5,400	3,303	19.2	26.0	477	26.0	24.3	530	64.6	117.3	1846
1 L - 9	4	13:17:00	5,400	3,303	19.5	26.5	486	25.7	24.5	530	65.1	116.9	1847
1 L - 10	1	13:18:00	6,000	3,670	22.5	29.6	549	25.4	24.8	530	71.4	126.2	2005
1 L - 10	2	13:19:00	6,000	3,670	22.7	30.0	556	25.4	24.9	530	71.4	125.9	2003
1 L - 10	4	13:21:00	6,000	3,670	23.0	30.6	566	25.2	25.2	532	72.2	125.9	2010
1 L - 11	1	13:22:00	6,600	4,037	26.1	34.2	637	22.8	22.5	478	79.7	136.8	2198
1 L - 11	2	13:23:00	6,600	4,037	26.2	34.6	642	21.8	21.5	456	79.7	135.8	2188
1 L - 11	4	13:25:00	6,600	4,037	26.3	35.1	648	20.6	21.8	447	80.4	135.2	2188
1 L - 12	1	13:26:00	7,200	4,404	29.9	38.2	719	16.5	21.5	401	86.6	143.6	2337
1 L - 12	2	13:27:00	7,200	4,404	30.5	39.2	735	15.3	21.1	385	87.4	143.7	2345
1 L - 12	4	13:29:00	7,200	4,404	31.5	40.0	754	14.6	20.8	373	88.2	143.7	2354
1 L - 13	1	13:30:00	7,800	4,771	38.9	42.0	854	19.0	18.3	393	94.9	153.1	2517
1 L - 13	2	13:31:00	7,800	4,771	39.5	41.8	858	19.2	18.0	393	94.2	152.0	2499
1 L - 13	4	13:33:00	7,800	4,771	40.1	42.0	866	18.7	18.5	392	94.3	151.9	2500
1 L - 14	1	13:35:00	8,400	5,137	46.0	44.6	956	17.1	19.8	389	100.7	159.5	2641
1 L - 14	2	13:36:00	8,400	5,137	45.6	44.8	953	16.4	20.8	392	100.3	159.0	2632
1 L - 14	4	13:38:00	8,400	5,137	45.6	45.9	966	14.5	23.4	399	101.2	159.3	2644
1 L - 15	1	13:39:00	9,000	5,504	49.7	48.6	1037	12.3	20.8	349	106.4	167.5	2780
1 L - 15	2	13:40:00	9,000	5,504	49.6	48.6	1035	11.3	17.7	306	106.3	167.2	2776
1 L - 15	4	13:42:00	9,000	5,504	49.1	48.5	1029	9.7	14.3	254	106.0	166.1	2762
1 L - 16	1	13:43:00	9,600	5,871	53.3	51.8	1109	7.5	-3.8	39	111.5	173.1	2888
1 L - 16	2	13:44:00	9,600	5,871	52.4	51.1	1092	6.8	-11.4	-49	111.5	170.9	2867
1 L - 16	4	13:46:00	9,600	5,871	51.6	50.8	1080	5.2	-20.6	-163	112.4	169.3	2859
1 L - 17	1	13:47:00	10,200	6,238	55.5	53.5	1150	3.4	-72.5	-729	119.0	173.6	2970
1 L - 17	2	13:48:00	10,200	6,238	52.4	51.4	1095	3.0	-88.4	-901	116.4	167.6	2883
1 L - 17	4	13:50:00	10,200	6,238	52.4	51.9	1100	-0.3	-150.8	-1594	120.3	165.7	2904
1 L - 18	1	13:52:00	10,800	6,605	53.0	53.0	1118	3.9	-327.7	-3416	128.8	165.2	2984
1 L - 18	2	13:53:00	10,800	6,605	50.9	51.7	1083	2.3	-361.7	-3791	127.9	163.1	2953
1 L - 18	4	13:55:00	10,800	6,605	49.0	50.3	1047	0.6	-405.0	-4266	126.8	159.4	2904
1 L - 19	1	13:57:00	11,400	6,972	50.0	49.9	1054	3.2	-583.3	-6121	128.6	156.4	2893
1 L - 19	2	13:58:00	11,400	6,972	48.7	49.0	1030	2.6	-623.3	-6548	128.0	152.7	2849
1 L - 19	4	14:00:00	11,400	6,972	46.8	48.1	1002	0.2	-672.4	-7091	125.8	148.8	2787
1 L - 20	1	14:02:00	12,000	7,339	48.5	49.0	1028	3.0	-873.5	-9184	143.4	131.0	2785
1 L - 20	2	14:03:00	12,000	7,339	47.6	47.5	1004	3.9	-938.2	-9857	145.2	122.7	2719
1 L - 20	4	14:05:00	12,000	7,339	47.3	45.7	982	5.0	-1027.4	-10786	146.2	107.6	2576
1 L - 21	1	14:08:30	12,410	7,590	50.5	45.4	1011	7.5	-1251.7	-13127	160.6	55.1	2189
1 L - 21	2	14:09:30	12,450	7,614	50.6	45.2	1011	6.4	-1305.1	-13701	161.2	25.6	1897
1 L - 21	4	14:11:30	12,610	7,712	51.3	45.0	1016	5.3	-1378.5	-14488	163.5	-29.4	1362
1 L - 21	7	14:14:30	12,410	7,590	51.2	43.2	996	4.2	-1438.4	-15131	167.7	-89.1	798
1 U - 1	1	14:18:00	7,600	4,648	35.2	19.8	580	2.5	-1338.1	-14090	130.4	-28.8	1031
1 U - 1	2	14:19:00	7,600	4,648	35.8	20.4	593	3.1	-1335.7	-14059	131.3	-26.0	1068
1 U - 1	4	14:21:00	7,600	4,648	36.4	20.6	601	3.4	-1332.6	-14023	131.6	-22.9	1103
1 U - 2	1	14:23:00	5,600	3,425	28.8	9.4	403	1.9	-1244.6	-13110	110.1	-18.2	933
1 U - 2	2	14:24:00	5,600	3,425	29.5	10.2	418	2.6	-1240.8	-13063	111.6	-15.8	973
1 U - 2	4	14:26:00	5,600	3,425	29.9	10.5	426	3.1	-1237.1	-13018	112.2	-13.6	1001
1 U - 3	1	14:27:00	3,600	2,202	22.1	1.6	250	0.3	-1111.0	-11718	89.6	3.2	942
1 U - 3	2	14:28:00	3,600	2,202	22.7	1.9	259	1.1	-1104.8	-11644	90.7	6.3	985
1 U - 3	4	14:30:00	3,600	2,202	22.8	2.2	263	1.8	-1099.2	-11577	91.1	8.6	1011
1 U - 4	1	14:32:00	1,600	979	14.3	-2.4	126	-5.8	-885.1	-9399	65.0	35.1	1016
1 U - 4	2	14:33:00	1,600	979	14.2	-2.5	123	-5.8	-880.3	-9349	64.4	35.8	1017
1 U - 4	4	14:35:00	1,600	979	14.2	-2.4	124	-5.3	-876.8	-9305	64.8	36.6	1029
1 U - 5	1	14:37:00	0	0	4.2	-3.6	6	-14.9	-693.4	-7473	31.8	22.3	548
1 U - 5	2	14:38:00	0	0	4.0	-3.6	4	-14.7	-688.6	-7419	31.4	21.9	542
1 U - 5	4	14:40:00	0	0	3.5	-3.6	-1	-14.8	-683.6	-7369	31.1	21.5	534

Strain Gage Readings and Loads at Levels 4, 5 and 6
Dedicated Test Shaft - Grandview Triangle - Jackson Co., MO

Load Test Increment	Hold Time (minutes)	Time (h:m:s)	O-cell™ Pressure (psi)	O-cell™ Load (kips)	Level 4 23278 (με)	Level 4 23279 (με)	Level 4 Av. Load (kips)	Level 5 23280 (με)	Level 5 23281 (με)	Level 5 Av. Load (kips)	Level 6 23282 (με)	Level 6 23283 (με)	Level 6 Av. Load (kips)
1L-0	-	12:16:00	0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
1L-1	1	12:41:00	600	367	6.6	5.3	120	4.1	2.9	71	2.0	2.1	42
1L-1	2	12:42:00	600	367	6.6	5.3	120	4.1	3.1	73	2.1	2.0	42
1L-1	4	12:44:00	600	367	6.6	5.3	120	4.1	2.9	71	2.0	2.0	41
1L-2	1	12:46:00	1,200	734	9.8	7.7	178	5.8	4.5	104	3.0	2.9	59
1L-2	2	12:47:00	1,200	734	10.0	7.8	181	5.9	4.4	104	3.0	2.9	60
1L-2	4	12:49:00	1,200	734	10.0	7.8	181	5.9	4.3	103	2.9	2.9	59
1L-3	1	12:50:00	1,800	1,101	13.3	10.6	242	7.7	6.0	139	3.9	3.7	77
1L-3	2	12:51:00	1,800	1,101	13.7	11.0	250	7.9	6.1	142	4.0	3.8	80
1L-3	4	12:53:00	1,800	1,101	13.8	11.1	252	8.0	6.1	144	4.0	3.9	80
1L-4	1	12:54:00	2,400	1,468	16.6	13.7	307	9.6	7.8	176	4.9	4.7	97
1L-4	2	12:55:00	2,400	1,468	16.7	13.9	311	9.7	7.8	178	4.9	4.8	99
1L-4	4	12:57:00	2,400	1,468	16.9	14.0	314	9.8	7.9	180	4.9	4.8	99
1L-5	1	12:58:00	3,000	1,835	20.9	18.6	400	12.4	10.2	229	6.4	6.1	126
1L-5	2	12:59:00	3,000	1,835	21.2	19.1	408	12.7	10.6	236	6.5	6.2	129
1L-5	4	13:01:00	3,000	1,835	21.6	20.0	422	13.1	10.9	244	6.8	6.4	134
1L-6	1	13:02:00	3,600	2,202	25.4	25.7	519	16.1	13.6	301	8.4	8.0	166
1L-6	2	13:03:00	3,600	2,202	25.4	26.0	522	16.2	13.9	306	8.4	8.1	167
1L-6	4	13:05:00	3,600	2,202	25.8	26.7	533	16.6	14.3	313	8.7	8.3	172
1L-7	1	13:06:00	4,200	2,569	30.8	33.2	649	20.2	17.6	384	10.6	10.1	210
1L-7	2	13:07:00	4,200	2,569	31.0	33.5	655	20.4	18.1	391	10.8	10.3	214
1L-7	4	13:09:00	4,200	2,569	32.3	34.3	676	21.3	18.6	405	11.2	10.6	221
1L-8	1	13:10:00	4,800	2,936	38.3	40.7	801	25.4	22.1	482	13.4	12.5	264
1L-8	2	13:11:00	4,800	2,936	39.3	41.8	823	26.2	22.8	497	13.8	12.8	270
1L-8	4	13:13:00	4,800	2,936	40.3	42.7	843	26.9	23.3	510	14.3	13.3	280
1L-9	1	13:14:00	5,400	3,303	47.0	49.4	978	31.4	27.3	596	16.7	14.8	320
1L-9	2	13:15:00	5,400	3,303	48.2	50.1	998	32.1	27.6	606	17.0	15.1	326
1L-9	4	13:17:00	5,400	3,303	49.5	51.1	1021	33.1	28.4	625	17.6	15.4	335
1L-10	1	13:18:00	6,000	3,670	56.7	58.3	1167	38.2	32.0	712	20.1	16.8	375
1L-10	2	13:19:00	6,000	3,670	57.8	59.0	1185	38.8	32.9	728	20.5	17.1	382
1L-10	4	13:21:00	6,000	3,670	59.1	60.4	1212	39.8	33.7	745	21.1	17.4	391
1L-11	1	13:22:00	6,600	4,037	68.4	69.3	1397	46.1	37.8	851	23.9	19.0	436
1L-11	2	13:23:00	6,600	4,037	69.5	70.2	1417	46.9	38.3	864	24.3	19.3	443
1L-11	4	13:25:00	6,600	4,037	70.9	71.4	1444	47.9	38.9	881	25.0	19.8	454
1L-12	1	13:26:00	7,200	4,404	78.7	79.2	1602	53.3	42.6	973	27.1	20.9	488
1L-12	2	13:27:00	7,200	4,404	80.1	80.8	1633	54.3	43.7	995	27.7	21.4	498
1L-12	4	13:29:00	7,200	4,404	81.5	82.1	1661	55.3	44.1	1008	28.1	21.8	507
1L-13	1	13:30:00	7,800	4,771	90.6	90.9	1842	60.9	48.0	1106	30.2	22.8	539
1L-13	2	13:31:00	7,800	4,771	91.5	91.3	1856	61.7	48.1	1115	30.3	23.0	541
1L-13	4	13:33:00	7,800	4,771	92.8	92.4	1880	62.4	48.6	1127	30.7	23.4	549
1L-14	1	13:35:00	8,400	5,137	101.1	102.8	2069	68.5	52.9	1232	32.8	24.2	579
1L-14	2	13:36:00	8,400	5,137	101.4	103.0	2075	68.8	53.0	1237	32.9	24.5	583
1L-14	4	13:38:00	8,400	5,137	102.0	104.7	2099	69.7	53.6	1252	33.2	24.9	589
1L-15	1	13:39:00	9,000	5,504	108.6	113.9	2259	75.2	57.7	1349	34.9	25.2	609
1L-15	2	13:40:00	9,000	5,504	108.8	114.5	2266	76.1	57.8	1359	35.0	25.5	615
1L-15	4	13:42:00	9,000	5,504	108.0	114.9	2262	76.6	58.0	1366	35.0	26.1	620
1L-16	1	13:43:00	9,600	5,871	115.1	123.9	2425	82.0	62.1	1463	36.4	26.7	641
1L-16	2	13:44:00	9,600	5,871	114.0	123.2	2408	82.0	62.1	1463	36.0	27.0	639
1L-16	4	13:46:00	9,600	5,871	114.0	123.5	2410	83.0	62.5	1477	36.2	28.2	654
1L-17	1	13:47:00	10,200	6,238	120.7	130.9	2554	88.5	65.7	1565	37.9	28.9	678
1L-17	2	13:48:00	10,200	6,238	116.7	127.0	2474	86.4	64.2	1529	37.0	29.3	673
1L-17	4	13:50:00	10,200	6,238	119.7	129.1	2526	89.1	66.5	1579	37.9	30.8	697
1L-18	1	13:52:00	10,800	6,605	126.7	134.4	2650	95.0	69.6	1671	39.6	32.1	727
1L-18	2	13:53:00	10,800	6,605	126.8	133.8	2644	96.0	69.4	1679	39.8	32.8	738
1L-18	4	13:55:00	10,800	6,605	126.1	132.7	2626	96.4	70.0	1689	39.9	33.9	749
1L-19	1	13:57:00	11,400	6,972	132.6	136.7	2733	102.0	72.7	1773	41.4	35.8	784
1L-19	2	13:58:00	11,400	6,972	131.2	135.2	2704	101.5	72.4	1765	41.3	36.7	792
1L-19	4	14:00:00	11,400	6,972	130.5	136.1	2707	101.6	73.8	1780	41.2	39.0	815
1L-20	1	14:02:00	12,000	7,339	139.8	140.7	2848	107.8	77.5	1881	42.5	42.4	862
1L-20	2	14:03:00	12,000	7,339	139.7	138.3	2822	107.6	76.8	1871	42.2	43.7	872
1L-20	4	14:05:00	12,000	7,339	138.7	133.8	2765	107.3	73.2	1833	42.3	44.9	886
1L-21	1	14:08:30	12,410	7,590	146.2	124.2	2744	111.4	66.2	1803	43.5	48.6	935
1L-21	2	14:09:30	12,450	7,614	144.8	120.9	2697	110.5	63.9	1771	43.4	49.2	941
1L-21	4	14:11:30	12,610	7,712	144.4	111.7	2599	109.8	58.5	1709	42.9	48.4	926
1L-21	7	14:14:30	12,410	7,590	145.2	97.1	2460	112.4	46.3	1611	43.9	44.0	893
1U-1	1	14:18:00	7,600	4,648	111.8	58.8	1731	85.2	23.2	1100	27.9	28.7	575
1U-1	2	14:19:00	7,600	4,648	112.4	59.4	1744	85.5	23.7	1108	28.0	28.7	576
1U-1	4	14:21:00	7,600	4,648	113.0	59.3	1749	85.6	23.7	1110	27.9	28.6	573
1U-2	1	14:23:00	5,600	3,425	96.2	37.4	1357	71.1	11.6	839	19.1	20.5	402
1U-2	2	14:24:00	5,600	3,425	96.9	38.0	1369	71.5	11.9	847	19.3	20.7	407
1U-2	4	14:26:00	5,600	3,425	97.0	38.1	1371	71.5	11.9	846	19.2	20.5	403
1U-3	1	14:27:00	3,600	2,202	79.6	20.0	1012	56.4	4.0	613	11.7	13.2	253
1U-3	2	14:28:00	3,600	2,202	79.7	20.5	1017	56.2	4.1	612	11.8	13.1	253
1U-3	4	14:30:00	3,600	2,202	79.3	20.2	1009	55.8	4.0	607	11.5	12.6	245
1U-4	1	14:32:00	1,600	979	58.4	9.5	689	40.1	0.9	417	6.2	4.9	113
1U-4	2	14:33:00	1,600	979	57.5	8.4	669	39.5	0.9	409	6.0	4.4	105
1U-4	4	14:35:00	1,600	979	57.1	7.6	657	39.1	0.5	402	6.0	4.1	103
1U-5	1	14:37:00	0	0	28.1	-1.9	266	21.3	-4.1	175	1.5	-5.1	-36
1U-5	2	14:38:00	0	0	27.7	-2.6	255	21.0	-4.4	169	1.4	-5.4	-40
1U-5	4	14:40:00	0	0	27.1	-3.7	238	20.4	-4.3	164	1.2	-5.6	-45

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	323	325	323
1000	639	636	627
1500	958	952	942
2000	1263	1253	1244
2500	1575	1564	1548
3000	1878	1864	1850
3500	2183	2167	2156
4000	2487	2471	2457
4500	2795	2777	2762
5000	3092	3078	3064

34" O-CELL, SERIAL # 2173-3

LOAD CONVERSION FORMULA

LOAD = PRESSURE * 0.6116 + (26.6)
{KIPS} {PSI}

Regression Output:

Constant	**26.599**
X Coefficient	**0.612**
R Squared	1.000
No. of Observations	30
Degrees of Freedom	28
Std Err of Y Est	11.394
Std Err of X Coef.	0.001

CALIBRATION STANDARDS:

All data presented is 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 gauges, ANSI specifications B40.1.

*AE & FC CUSTOMER: LOADTEST INC. *AE & FC JOB NO.: 3042 *CUSTOMER P.O.NO.: LT-8843	*CONTRACTOR: HAYES DRILLING, INC. *JOB LOCATION: KANSAS CITY, MO *DATED: 04/08/02

SERVICE ENGINEER: [signature] DATE: 10 April 2002

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

Vibrating Wire Displacement Transducer Calibration Report

Model Number: 4450-3-8

Range: 8"

Serial Number: 66176

Mfg. Number: 02-850

Customer: Loadtest Inc.

Temperature: 23.7 °C

Cust. I.D. #: n/a

Cal. Std. Control Numbers: 344, 373, 524, 529

Job Number: 18651

Calibration Date: March 12, 2002

Technician: CMB

Displacement (inches)	GK-401 Reading Position B Cycle 1	Cycle 2	Average	Change	% Linearity
0.000	2522	2517	2520		-0.17
1.575	3786	3789	3788	1268	0.13
3.150	5035	5034	5035	1247	0.11
4.725	6281	6280	6281	1246	0.06
6.300	7519	7518	7519	1238	-0.11
7.875	8773	8773	8773	1255	-0.02

Calibration Factor (C): 0.001261 (Inches/ Digit)

Regression Zero: 2530

Refer to manual for temperature correction information.

Function Test at Shipment (GK-401 Reading)

Position "B": 5130

or

Position "F":

Date: April 16, 2002

Temperature: 26.1 °C

Wiring Code: Red and Black: Gage White and Green: Thermistor

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

Model Number: 4450-3-8

Range: 8"

Serial Number: 66177

Mfg. Number: 02-851

Customer: Loadtest Inc.

Temperature: 23.7 °C

Cust. I.D. #: n/a

Cal. Std. Control Numbers: 344, 373, 524, 529

Job Number: 18651

Calibration Date: March 12, 2002

Technician: CMB

Displacement (inches)	GK-401 Reading Position B Cycle 1	Cycle 2	Average	Change	% Linearity
0.000	2553	2550	2552		0.03
1.575	3813	3811	3812	1261	0.10
3.150	5068	5069	5069	1257	0.10
4.725	6300	6297	6299	1230	-0.31
6.300	7559	7559	7559	1261	-0.24
7.875	8849	8851	8850	1291	0.31

Calibration Factor (C): 0.001254 (Inches/ Digit)

Regression Zero: 2550

Refer to manual for temperature correction information.

Function Test at Shipment (GK-401 Reading)

Position "B": 5170

or

Position "F":

Date: April 16, 2002

Temperature: 25.9 °C

Wiring Code: Red and Black: Gage White and Green: Thermistor

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

Model Number: 4450-3-8

Range: 8"

Serial Number: 66178

Mfg. Number: 02-853

Customer: Loadtest Inc.

Temperature: 23.7 °C

Cust. I.D. #: n/a

Cal. Std. Control Numbers: 344, 373, 524, 529

Job Number: 18651

Calibration Date: March 12, 2002

Technician: CMB

Displacement (inches)	GK-401 Reading Position B Cycle 1	Cycle 2	Average	Change	% Linearity
0.000	2532	2533	2533		-0.11
1.575	3800	3798	3799	1267	0.08
3.150	5054	5053	5054	1255	0.08
4.725	6307	6308	6308	1254	0.07
6.300	7549	7550	7550	1242	-0.13
7.875	8814	8813	8814	1264	0.02

Calibration Factor (C): 0.001255 (Inches/ Digit)

Regression Zero: 2539

Refer to manual for temperature correction information.

Function Test at Shipment (GK-401 Reading)

Position "B": 5123

or

Position "F":

Date: April 16, 2002

Temperature: 26.1 °C

Wiring Code: Red and Black: Gage White and Green: Thermistor

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

Model Number: 4450-3-1

Range: 1"

Serial Number: 66171

Mfg. Number: 02-816

Customer: Loadtest Inc.

Temperature: 23.5 °C

Cust. I.D. #: n/a

Cal. Std. Control Numbers: 216, 338, 405, 524, 529

Job Number: 18651

Calibration Date: March 25, 2002

Technician: CMB

Displacement (inches)	GK-401 Reading Position B Cycle 1	Cycle 2	Average	Change	% Linearity
0.000	2018	2015	2017		-0.21
0.200	3225	3223	3224	1208	0.07
0.400	4422	4419	4421	1197	0.16
0.600	5612	5610	5611	1191	0.15
0.800	6795	6791	6793	1182	0.00
1.000	7975	7971	7973	1180	-0.18

Calibration Factor (C): 0.0001679 (Inches/ Digit)

Regression Zero: 2029

Refer to manual for temperature correction information.

Function Test at Shipment (GK-401 Reading)

Position "B": 4967

or

Position "F":

Date: April 16, 2002

Temperature: 26.3 °C

Wiring Code: Red and Black: Gage White and Green: Thermistor

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

Model Number: 4450-3-1

Range: 1"

Serial Number: 66172

Mfg. Number: 02-817

Customer: Loadtest Inc.

Temperature: 23.5 °C

Cust. I.D. #: n/a

Cal. Std. Control Numbers: 216, 338, 405, 524, 529

Job Number: 18651

Calibration Date: March 25, 2002

Technician: CMB

Displacement (inches)	GK-401 Reading Position B Cycle 1	Cycle 2	Average	Change	% Linearity
0.000	2016	2011	2014		-0.27
0.200	3254	3250	3252	1239	0.10
0.400	4476	4472	4474	1222	0.20
0.600	5688	5686	5687	1213	0.15
0.800	6898	6893	6896	1209	0.02
1.000	8099	8096	8098	1202	-0.21

Calibration Factor (C): 0.0001645 (Inches/ Digit)

Regression Zero: 2030

Refer to manual for temperature correction information.

Function Test at Shipment (GK-401 Reading)

Position "B": 5089

or

Position "F":

Date: April 16, 2002

Temperature: 25.8 °C

Wiring Code: Red and Black: Gage White and Green: Thermistor

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: 23272

Customer: Loadtest Inc.

Job Number: 18651

Cust. I.D. #: n/a

Prestress: 35,000 psi

Temperature: 22.8 °C

Calibration Date: April 16, 2002

Cal. Std. Control Numbers: 85888-1, 398

Cable Length: 69 ft.

Factory Zero Reading: 6950

Regression Zero: 6965

Technician: CMB

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7010	7010	7010		
1,500	7701	7702	7702	692	-0.03
3,000	8447	8451	8449	748	0.31
4,500	9182	9183	9183	734	0.18
6,000	9909	9906	9908	725	-0.24
100	7010				

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

Gage Factor: 0.344 Microstrain/Digit (GK-401 Pos."B")

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

Note: The above calibration uses the linear regression method.

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

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

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

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

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

Sister Bar Calibration Report

Model Number : 4911-4

Serial Number: 23273

Customer: Loadtest Inc.

Job Number: 18651

Cust. I.D. #: n/a

Prestress: 35,000 psi

Temperature: 22.6 °C

Calibration Date: April 16, 2002

Cal. Std. Control Numbers: 85888-1, 398

Cable Length: 69 ft.

Factory Zero Reading: 7095

Regression Zero: 7104

Technician: CMB

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7159	7162	7161		
1,500	7846	7851	7849	688	-0.25
3,000	8605	8608	8607	758	-0.05
4,500	9361	9364	9363	756	0.08
6,000	10111	10115	10113	751	0.04
100	7163				

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

Gage Factor: 0.339 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: 23274

Customer: Loadtest Inc.

Job Number: 18651

Cust. I.D. #: n/a

Prestress: 35,000 psi

Temperature: 22.7 °C

Calibration Date: April 16, 2002

Cal. Std. Control Numbers: 85888-1, 398

Cable Length: 66 ft.

Factory Zero Reading: 6751

Regression Zero: 6783

Technician: CMB

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	6834	6829	6832		
1,500	7534	7526	7530	699	-0.01
3,000	8282	8281	8282	752	0.13
4,500	9031	9026	9029	747	0.12
6,000	9773	9765	9769	741	-0.11
100	6830				

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

Gage Factor: 0.341 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	Calibration Date:	April 16, 2002
Serial Number:	23275	Cal. Std. Control Numbers:	85888-1, 398
Customer:	Loadtest Inc.	Cable Length:	66 ft.
Job Number:	18651	Factory Zero Reading:	7018
Cust. I.D. #:	n/a	Regression Zero:	7035
Prestress:	35,000 psi		
Temperature:	22.7 °C	Technician:	CMB

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7091	7091	7091		
1,500	7781	7780	7781	690	-0.19
3,000	8533	8536	8535	754	-0.10
4,500	9293	9295	9294	760	0.17
6,000	10040	10041	10041	747	0.01
100	7091				

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

Gage Factor: 0.340 Microstrain/Digit (GK-401 Pos."B")

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

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

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

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

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

Sister Bar Calibration Report

Model Number : 4911-4

Serial Number: 23276

Customer: Loadtest Inc.

Job Number: 18651

Cust. I.D. #: n/a

Prestress: 35,000 psi

Temperature: 22.8 °C

Calibration Date: April 16, 2002

Cal. Std. Control Numbers: 85888-1, 398

Cable Length: 41 ft.

Factory Zero Reading: 6898

Regression Zero: 6914

Technician: CMB

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	6972	6971	6972		
1,500	7645	7643	7644	673	-0.31
3,000	8391	8393	8392	748	-0.01
4,500	9133	9133	9133	741	0.05
6,000	9872	9874	9873	740	0.08
100	6971				

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

Gage Factor: 0.344 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: 23277

Customer: Loadtest Inc.

Job Number: 18651

Cust. I.D. #: n/a

Prestress: 35,000 psi

Temperature: 22.8 °C

Calibration Date: April 16, 2002

Cal. Std. Control Numbers: 85888-1, 398

Cable Length: 41 ft.

Factory Zero Reading: 6833

Regression Zero: 6855

Technician: CMB

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	6911	6914	6913		
1,500	7600	7602	7601	689	-0.27
3,000	8359	8365	8362	761	-0.03
4,500	9116	9126	9121	759	0.13
6,000	9867	9877	9872	751	0.03
100	6916				

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

Gage Factor: 0.339 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: 23278

Customer: Loadtest Inc.

Job Number: 18651

Cust. I.D. #: n/a

Prestress: 35,000 psi

Temperature: 23.3 °C

Calibration Date: April 16, 2002

Cal. Std. Control Numbers: 85888-1, 398

Cable Length: 36 ft.

Factory Zero Reading: 6671

Regression Zero: 6703

Technician: CMB

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	6759	6755	6757		
1,500	7441	7438	7440	683	-0.16
3,000	8184	8182	8183	744	-0.09
4,500	8932	8930	8931	748	0.13
6,000	9670	9667	9669	738	0.00
100	6756				

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

Gage Factor: 0.343 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: 23279

Customer: Loadtest Inc.

Job Number: 18651

Cust. I.D. #: n/a

Prestress: 35,000 psi

Temperature: 23.5 °C

Calibration Date: April 16, 2002

Cal. Std. Control Numbers: 85888-1, 398

Cable Length: 36 ft.

Factory Zero Reading: 6844

Regression Zero: 6868

Technician: CMB

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	6918	6920	6919		
1,500	7616	7617	7617	698	-0.04
3,000	8366	8366	8366	750	-0.05
4,500	9121	9122	9122	756	0.14
6,000	9866	9865	9866	744	-0.06
100	6921				

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

Gage Factor: 0.340 Microstrain/Digit (GK-401 Pos."B")

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

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

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

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

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

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

Sister Bar Calibration Report

Model Number : 4911-4

Serial Number: 23280

Customer: Loadtest Inc.

Job Number: 18651

Cust. I.D. #: n/a

Prestress: 35,000 psi

Temperature: 23.3 °C

Calibration Date: April 16, 2002

Cal. Std. Control Numbers: 85888-1, 398

Cable Length: 31 ft.

Factory Zero Reading: 6910

Regression Zero: 6946

Technician: CMB

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7001	6998	7000		
1,500	7688	7685	7687	687	-0.15
3,000	8436	8437	8437	750	0.02
4,500	9181	9183	9182	746	0.04
6,000	9929	9924	9927	745	0.03
100	6999				

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: 23281

Customer: Loadtest Inc.

Job Number: 18651

Cust. I.D. #: n/a

Prestress: 35,000 psi

Temperature: 23.5 °C

Calibration Date: April 16, 2002

Cal. Std. Control Numbers: 85888-1, 398

Cable Length: 31 ft.

Factory Zero Reading: 7125

Regression Zero: 7134

Technician: CMB

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7185	7195	7190		
1,500	7872	7880	7876	686	-0.17
3,000	8619	8628	8624	748	-0.16
4,500	9372	9382	9377	754	0.06
6,000	10121	10129	10125	748	0.09
100	7197				

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

Gage Factor: 0.341 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

Calibration Date: April 16, 2002

Serial Number: 23282

Cal. Std. Control Numbers: 85888-1, 398

Customer: Loadtest Inc.

Cable Length: 25 ft.

Job Number: 18651

Factory Zero Reading: 6773

Cust. I.D. #: n/a

Regression Zero: 6812

Prestress: 35,000 psi

Technician: CMB

Temperature: 23.3 °C

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	6862	6859	6861		
1,500	7558	7556	7557	697	-0.06
3,000	8307	8306	8307	750	0.03
4,500	9064	9059	9062	755	0.30
6,000	9787	9798	9793	731	-0.23
100	6860				

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

Gage Factor: 0.341 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: 23283

Customer: Loadtest Inc.

Job Number: 18651

Cust. I.D. #: n/a

Prestress: 35,000 psi

Temperature: 23.5 °C

Calibration Date: April 16, 2002

Cal. Std. Control Numbers: 85888-1, 398

Cable Length: 25 ft.

Factory Zero Reading: 7031

Regression Zero: 7053

Technician: CMB

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7106	7105	7106		
1,500	7800	7798	7799	694	-0.14
3,000	8554	8553	8554	755	0.01
4,500	9310	9308	9309	756	0.19
6,000	10052	10050	10051	742	-0.08
100	7107				

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

Gage Factor: 0.340 Microstrain/Digit (GK-401 Pos."B")

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

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

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

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

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

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 the first converting gross to net loads. For our 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 $\ell_3 = 0$. 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 centriod 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 centriod 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

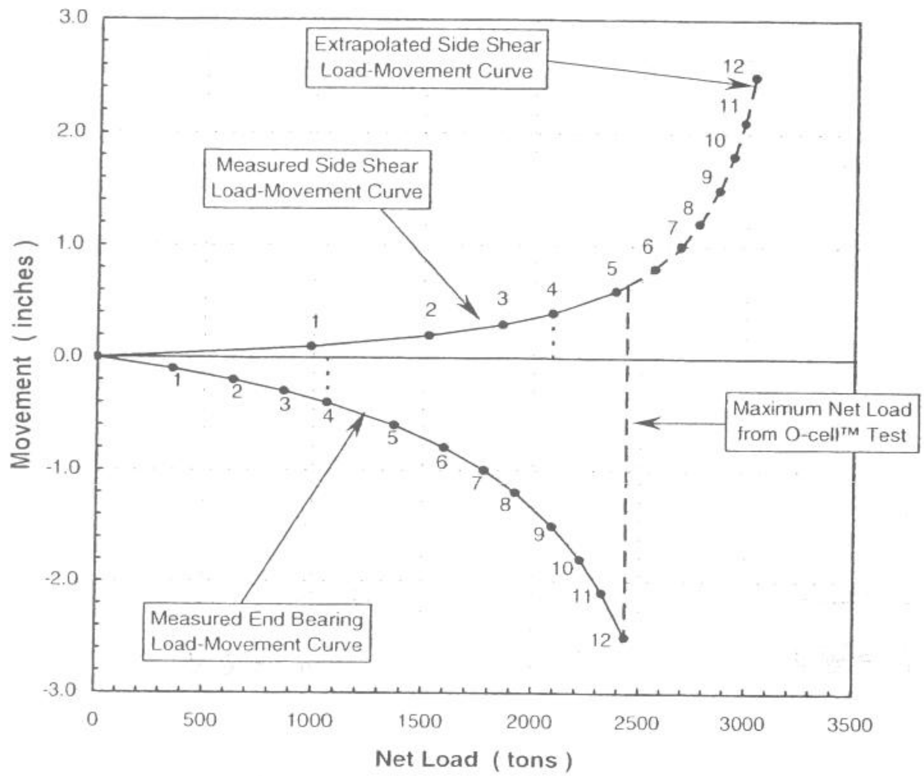
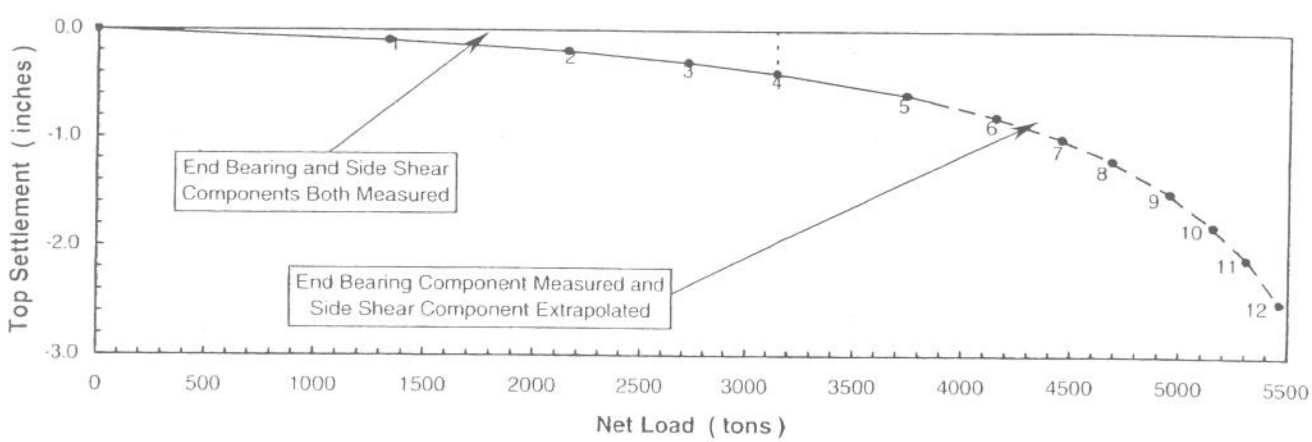
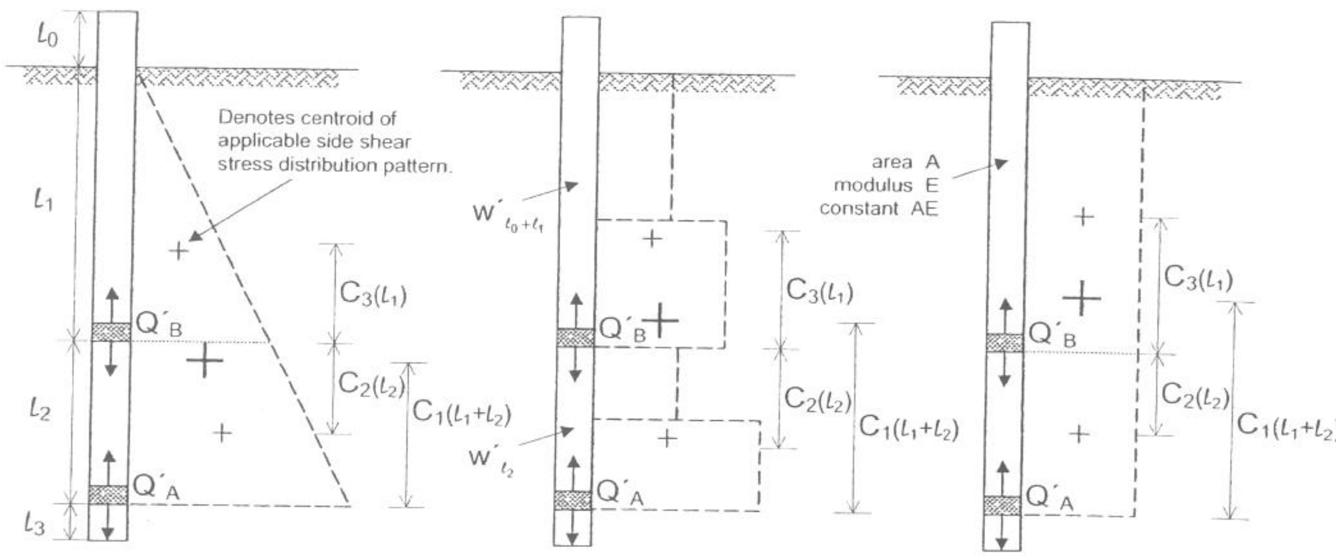


Figure B



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



1-Stage Single Level Test (Q'_A only): $\delta_{OLT} = \delta_{\uparrow(\ell_1+\ell_2)}$

$C_1 = \dfrac{1}{3}$	Centroid Factor $= C_1$	$C_1 = \dfrac{1}{2}$
$\delta_{\uparrow(\ell_1+\ell_2)} = \dfrac{1}{3}\dfrac{Q'_{\uparrow A}(\ell_1+\ell_2)}{AE}$	$\delta_{\uparrow(\ell_1+\ell_2)} = C_1\dfrac{Q'_{\uparrow A}(\ell_1+\ell_2)}{AE}$	$\delta_{\uparrow(\ell_1+\ell_2)} = \dfrac{1}{2}\dfrac{Q'_{\uparrow A}(\ell_1+\ell_2)}{AE}$

3-Stage Multi Level Test (Q'_A and Q'_B): $\delta_{OLT} = \delta_{\uparrow\ell_1} + \delta_{\downarrow\ell_2}$

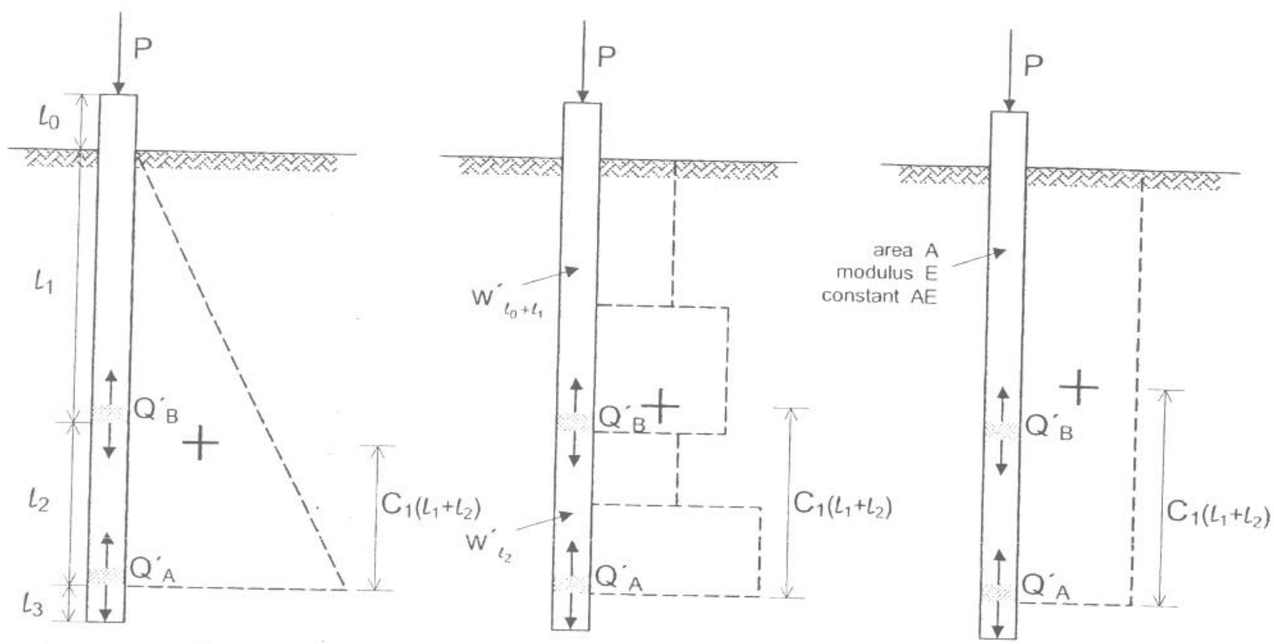
$C_3 = \dfrac{1}{3}$	Centroid Factor $= C_3$	$C_3 = \dfrac{1}{2}$
$\delta_{\uparrow\ell_1} = \dfrac{1}{3}\dfrac{Q'_{\uparrow B}\ell_1}{AE}$	$\delta_{\uparrow\ell_1} = C_3\dfrac{Q'_{\uparrow B}\ell_1}{AE}$	$\delta_{\uparrow\ell_1} = \dfrac{1}{3}\dfrac{Q'_{\uparrow B}\ell_1}{AE}$
$C_2 = \dfrac{1}{3}\left(\dfrac{3\ell_1+2\ell_2}{2\ell_1+\ell_2}\right)$	Centroid Factor $= C_2$	$C_2 = \dfrac{1}{2}$
$\delta_{\downarrow\ell_2} = \dfrac{1}{3}\left(\dfrac{3\ell_1+2\ell_2}{2\ell_1+\ell_2}\right)\dfrac{Q'_{\downarrow B}\ell_2}{AE}$	$\delta_{\downarrow\ell_2} = C_2\dfrac{Q'_{\downarrow B}\ell_2}{AE}$	$\delta_{\downarrow\ell_2} = \dfrac{1}{2}\dfrac{Q'_{\downarrow B}\ell_2}{AE}$

Net Loads:

$Q'_{\uparrow A} = Q_{\uparrow A} - w'_{\ell_0+\ell_1+\ell_2}$ $\qquad$ $Q'_{\uparrow B} = Q_{\uparrow B} - w'_{\ell_0+\ell_1}$ $\qquad$ $Q'_{\downarrow B} = Q'_{\downarrow B} + w'_{\ell_2}$

w' = pile weight, bouyant where below water table

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



Top Loaded Test: $\delta_{TLT} = \delta_{\downarrow\ell_0} + \delta_{\downarrow\ell_1+\ell_2}$

$\delta_{\downarrow\ell_0} = \dfrac{P\ell_0}{AE}$	$\delta_{\downarrow\ell_0} = \dfrac{P\ell_0}{AE}$	$\delta_{\downarrow\ell_0} = \dfrac{P\ell_0}{AE}$
$C_1 = \dfrac{1}{3}$	Centroid Factor $= C_1$	$C_1 = \dfrac{1}{2}$
$\delta_{\downarrow\ell_1+\ell_2} = \dfrac{(Q'_{\downarrow A}+2P)}{3}\dfrac{(\ell_2+\ell_2)}{AE}$	$\delta_{\downarrow\ell_1+\ell_2} = \left[(C_1)Q'_{\downarrow A}+(1-C_1)P\right]\dfrac{(\ell_1+\ell_2)}{AE}$	$\delta_{\downarrow\ell_1+\ell_2} = \dfrac{(Q'_{\downarrow A}+P)}{2}\dfrac{(\ell_1+\ell_2)}{AE}$

Net and Equivalent Loads:

$Q'_{\downarrow A} = Q_{\downarrow A} - w'_{\ell_0+\ell_1+\ell_2}$ $\qquad P_{single} = Q'_{\downarrow A} + Q'_{\uparrow A}$ $\qquad P_{multi} = Q'_{\downarrow A} + Q'_{\uparrow B} + Q'_{\downarrow B}$

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

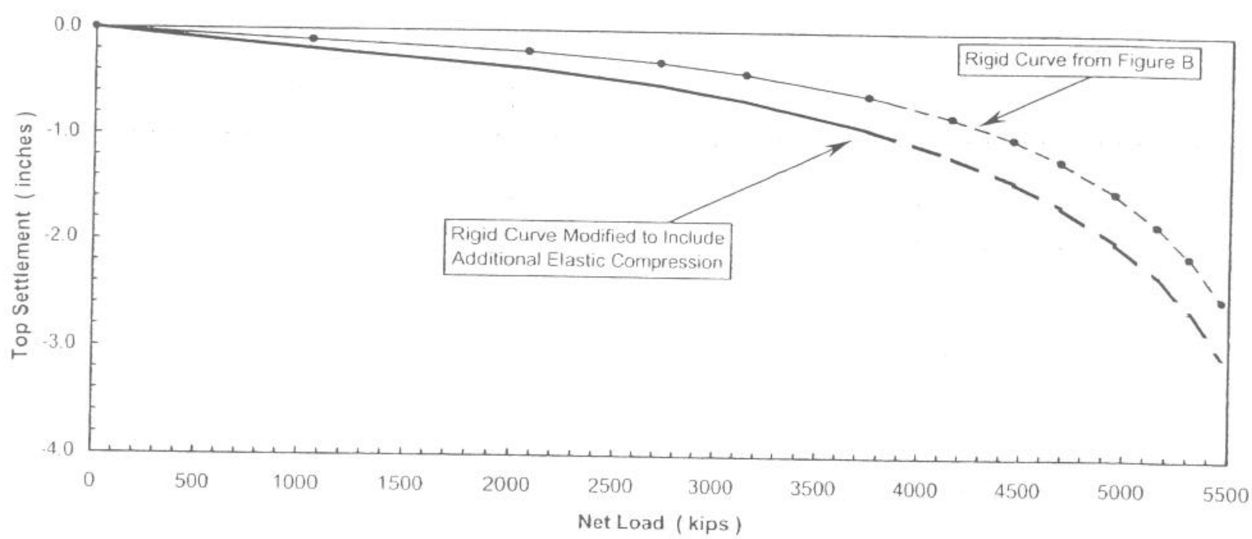
Example Calcuation for the Additional Elastic Compression Correction for Single Level Test (English Units)

Given:

$C_1 =$ 0.441
AE = 3820000 **kips** (assumed constant throughout test)
$\ell_0 =$ 5.9 **ft**
$\ell_1 =$ 48.2 **ft** (embedded length of shaft above O-cell™)
$\ell_2 =$ 0.0 **ft**
$\ell_3 =$ 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



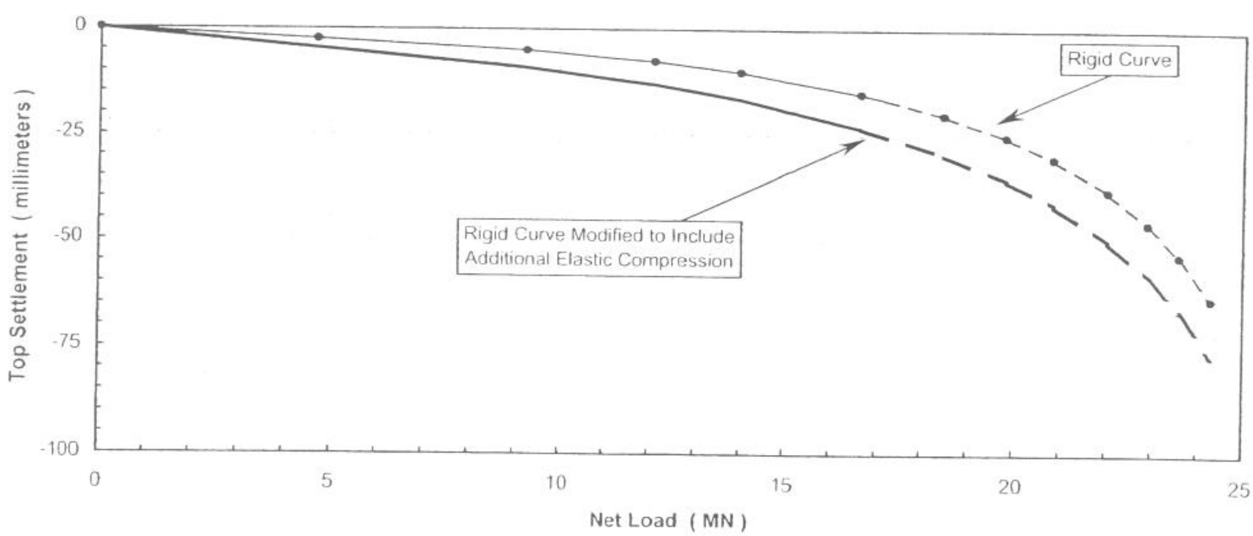
Example Calcuation for the Additional Elastic Compression Correction for Single Level Test (SI Units)

Given:

$C_1 =$ 0.441
AE = 17000 MN (assumed constant throughout test)
$\ell_0 =$ 1.80 m
$\ell_1 =$ 14.69 m (embedded length of shaft above O-cell™)
$\ell_2 =$ 0.00 m
$\ell_3 =$ 0.00 m
Shear reduction factor = 1.00 (cohesive soil)

Δ_{OLT} (mm)	$Q'_{\downarrow A}$ (MN)	$Q'_{\uparrow A}$ (MN)	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 Calcuation for the Additional Elastic Compression Correction for Multi Level Test (English Units)

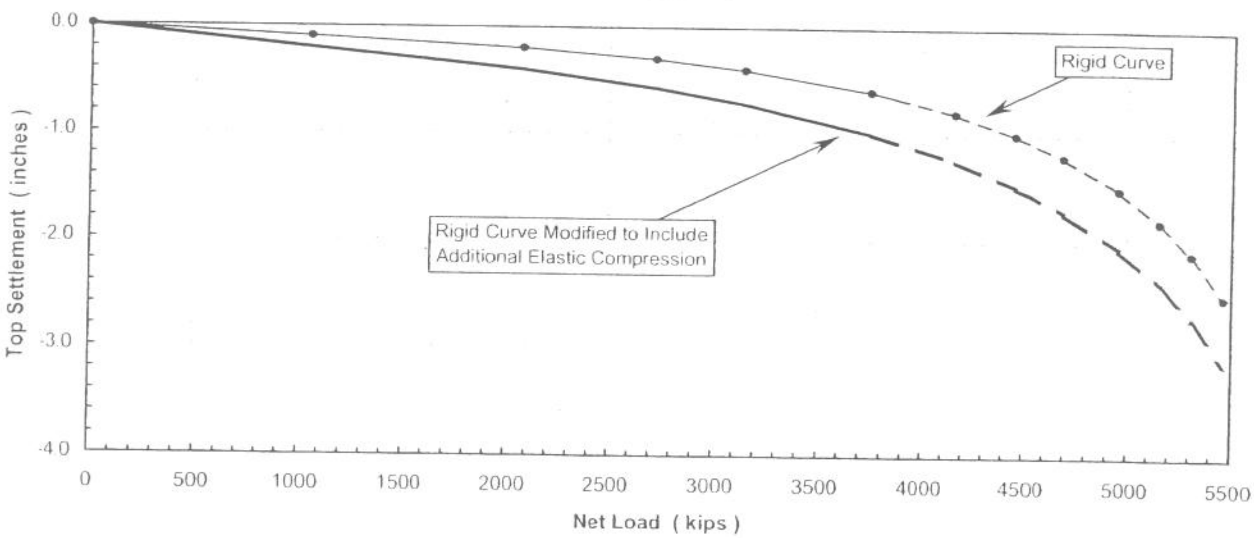
Given:

$C_1 =$ 0.441
$C_2 =$ 0.579
$C_3 =$ 0.396
AE = 3820000 **kips** (assumed constant throughout test)
$\ell_0 =$ 5.9 **ft**
$\ell_1 =$ 30.0 **ft** (embedded length of shaft above mid-cell)
$\ell_2 =$ 18.2 **ft** (embedded length of shaft between O-cells™)
$\ell_3 =$ 0.0 **ft**

Shear reduction factor = 1.00 (cohesive soil)

Δ_{OLT} (in)	$Q'_{\downarrow A}$ (kips)	$Q'_{\downarrow B}$ (kips)	$Q'_{\uparrow B}$ (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 Calcuation for the Additional Elastic Compression Correction for Multi Level Test (SI Units)

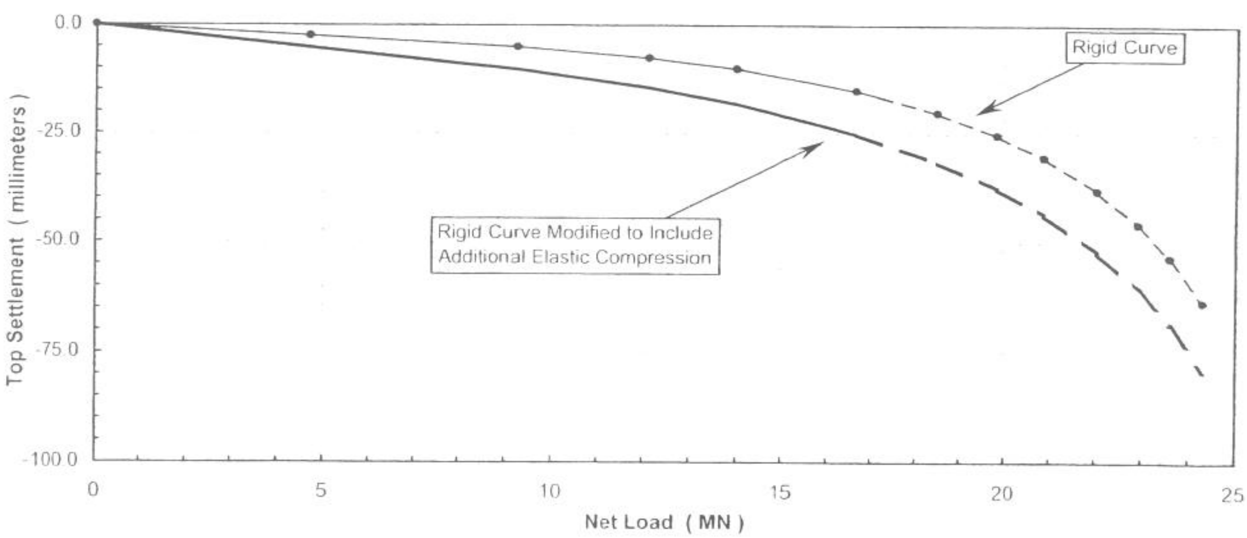
Given:

$C_1 =$ 0.441
$C_2 =$ 0.579
$C_3 =$ 0.396
AE = 17000 MN (assumed constant throughout test)
$\ell_0 =$ 1.80 m
$\ell_1 =$ 9.14 m (embedded length of shaft above mid-cell)
$\ell_2 =$ 5.55 m (embedded length of shaft between O-cells™)
$\ell_3 =$ 0.00 m

Shear reduction factor = 1.00 (cohesive soil)

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

Figure F



APPENDIX D

O-CELL™ METHOD FOR DETERMINING CREEP LIMIT LOADING

O-CELL METHOD FOR DETERMINING A CREEP LIMIT LOADING ON THE EQUIVALENT TOP-LOADED SHAFT

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, 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 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 2 to 4 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.

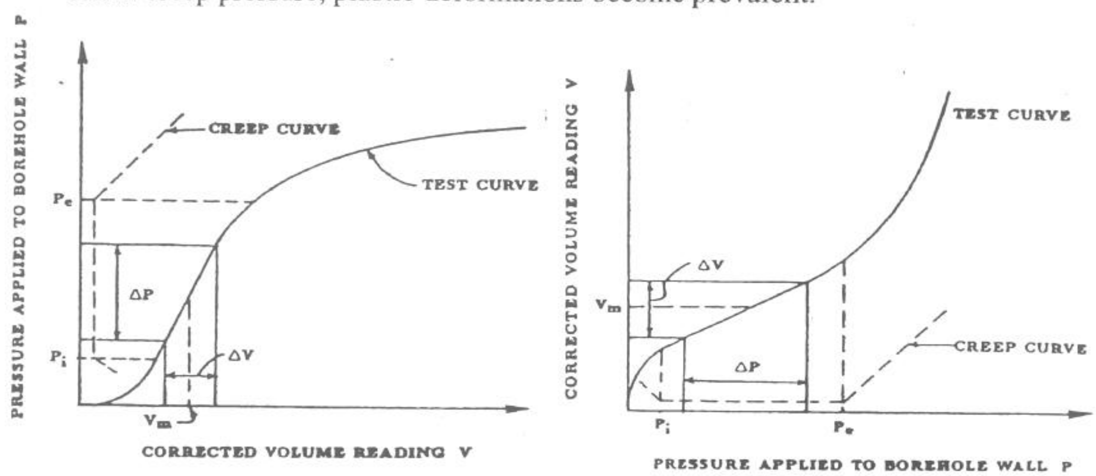


FIG. 8 Pressuremeter Test Curves for Procedure A

References

Housel, W.S. (1959), "Dynamic & Static Resistance of Coshesive Soils" 1846-1959, ASTM STP 254, pp. 22-23.

Stoll, M.U.W. (1961, Discussion, Proc. 3rd ICSMFE, Paris, Vol. III, pp. 279-281.

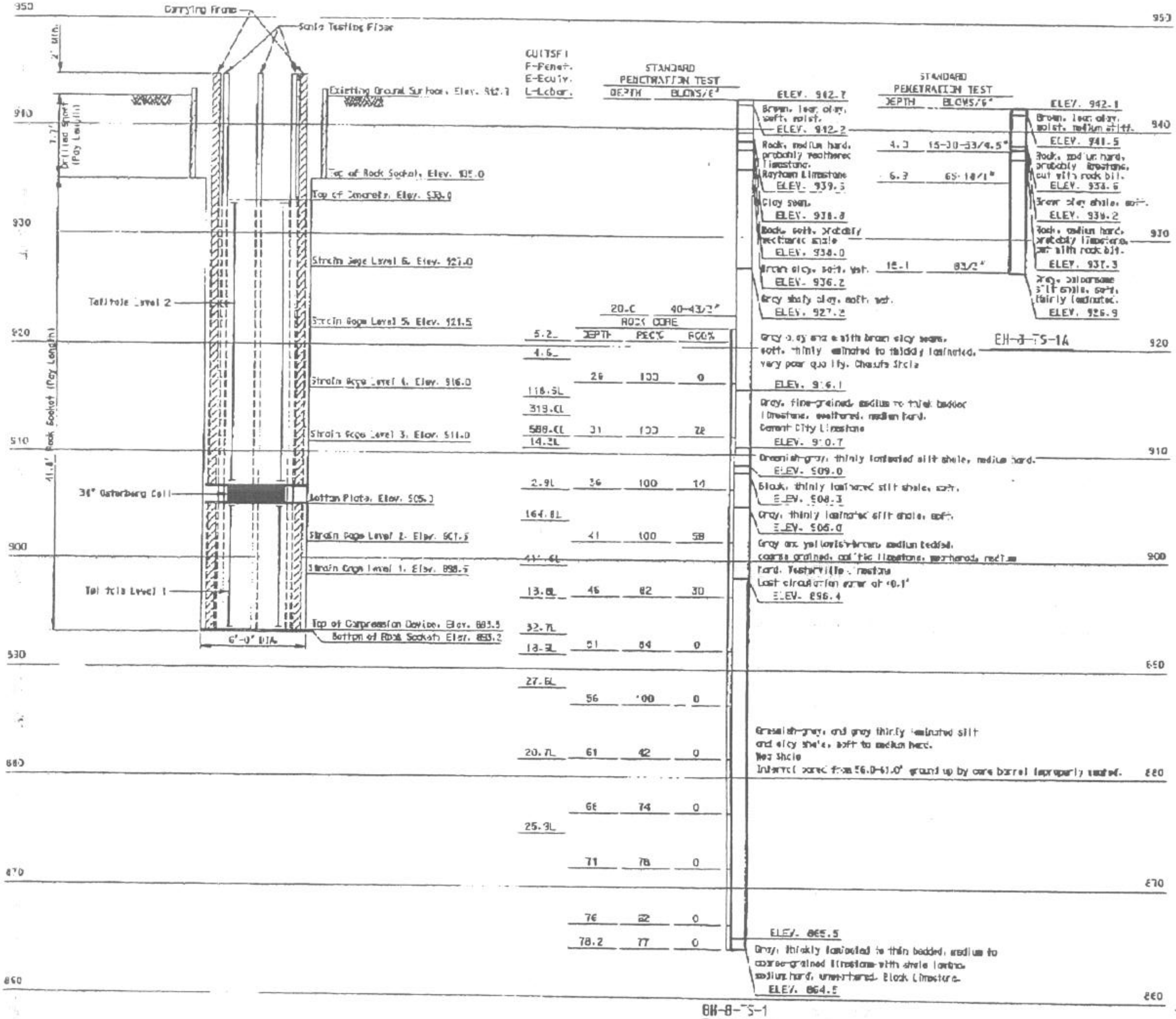
Bourges, F. and Levillian, J-P (1988), "force portante des rideaux plans metalliques charges verticalmement," Bull. No. 158, Nov.-Dec., des laboratoires des ponts et chaussees, p. 24.

Fellenius, Bengt H. (1966), Basics of Foundation Design, BiTech Publishers Ltd., p.79.

APPENDIX E

SOIL BORING LOG

State	Proj. No.	Sheet No.
MO		



Anticipated Failure Loads		
Side Shear Above Cell	Side Shear Below Cell	End Bearing
6040 Kips	5975 kips	3000 Kips

Notes:

Some details of Osterberg Load Cell construction subject to change by Loadtest Inc. with approval of the Engineer.

Strain gages and compression telltales are required to monitor performance of the load test. Strain gage levels shown are preliminary. Final strain gage locations and telltale lengths are to be determined after excavation of the test shaft by the Engineer and Loadtest, Inc.

The borings shown on this drawing were drilled by the Missouri Department of Transportation, between December 17 and December 21, 2001.

The elevation datum referred to is U.S.G.S., referenced to mean sea level.

The groundwater level shown was recorded at the time of drilling. Porosity of soil strata, weather conditions, seasonal changes, site topography, etc., may cause changes in the water level reported.

The boring information shown on this drawing is abbreviated. A complete copy of the boring log and test results is available upon request to the Project Contact.

The boring data for the locations indicated, as well as any other boring logs or other factual records of subsurface data and investigations performed by the Department for the design of the project, is available from the Project Contact upon written request as outlined in the Project Special Provisions. No greater significance or weight should be given to the boring data depicted on the plan sheets than to subsurface data available from the District or elsewhere.

The Commission does not represent or warrant that any such boring data accurately depicts the conditions to be encountered in constructing this project. A contractor assumes all risks it may encounter in basing its bid prices, time or schedule of performance on the boring data depicted here or those available from the District, or on any other documentation not expressly warranted which the contractor may obtain from the Commission.

THIS SHEET ADDED 2-5-02

TEST SHAFT LAYOUT AND SUBSURFACE INFORMATION
JACKSON COUNTY

HNTB

HNTB The HNTB Companies	Made by DJH	Date 10/6/01	Job Number 29192
	Checked by	Date	Sheet Number 1/6
Calculations For Triangle Interchange, Jackson Co. MO	Backchecked by	Date	

Estimated Subsurface Profile at 6' Ø Test Shaft, US 71 Sta. 195+08, 90' Lt.

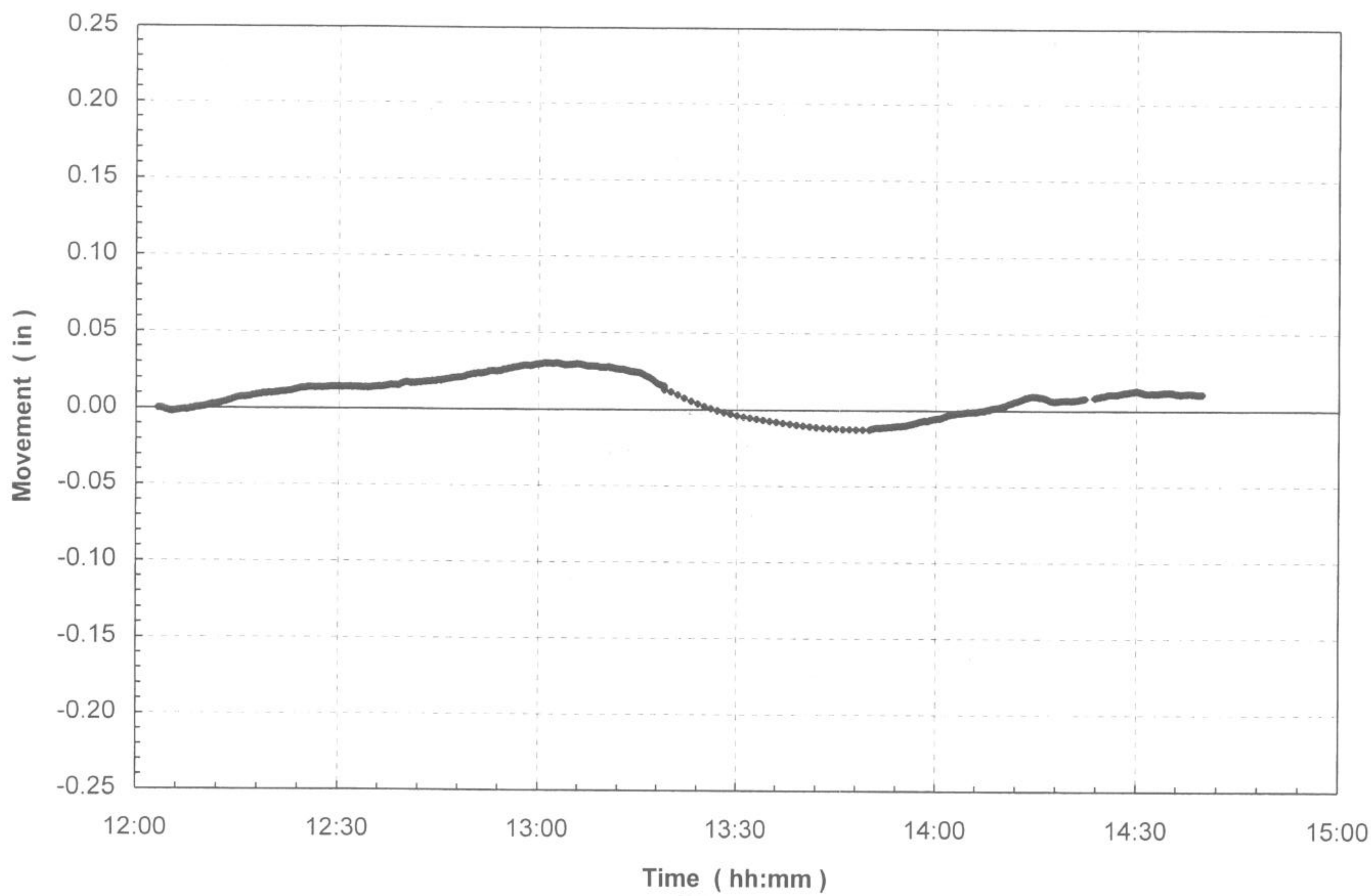
ELEV		
950		
940	RAYTOWN LIMESTONE	
930	CHANUTE SHALE – weathered	q_u median = 7.1 tsf; f_{max} smooth = 0.8 ksf; f_{max} (Osterb. Ratio) = 4.3 to 7.1 ksf
920	CHANUTE SHALE – unweathered	q_u median = 7.7 tsf; f_{max} smooth = 1.5 ksf; f_{max} (Osterb. Ratio) = 4.6 to 7.7 ksf
910	CEMENT CITY LIMESTONE	q_u median = 667 tsf = 9 ksi ∴ concrete controls; f'_c = 5 ksi ⇒ f_{max} smooth = 25.3 ksf, f_{max} (Osterb. Ratio) = 40 ksf; f'_c = 4 ksi ⇒ f_{max} smooth = 22.5 ksf
	QUIVIRA SHALE	34" Cell; q_u median = 8.0 tsf; f_{max} smooth = 2.0 ksf; f_{max} (Osterb. Ratio) = 4.8 to 8 ksf
900	WESTERVILLE LIMESTONE	q_u median = 905 tsf ∴ concrete controls, same as for Cement City
890	WEA SHALE	q_u median = 15.9 tsf; f_{max} smooth = 3.5 ksf; f_{max} (Osterb. Ratio) = 9.5 to 15.9 ksf
885		False Bottom
880		

APPENDIX F

REFERENCE BEAM MONITORING

Reference Beam Monitoring

Dedicated Test Shaft - Grandview Triangle - Jackson Co., MO

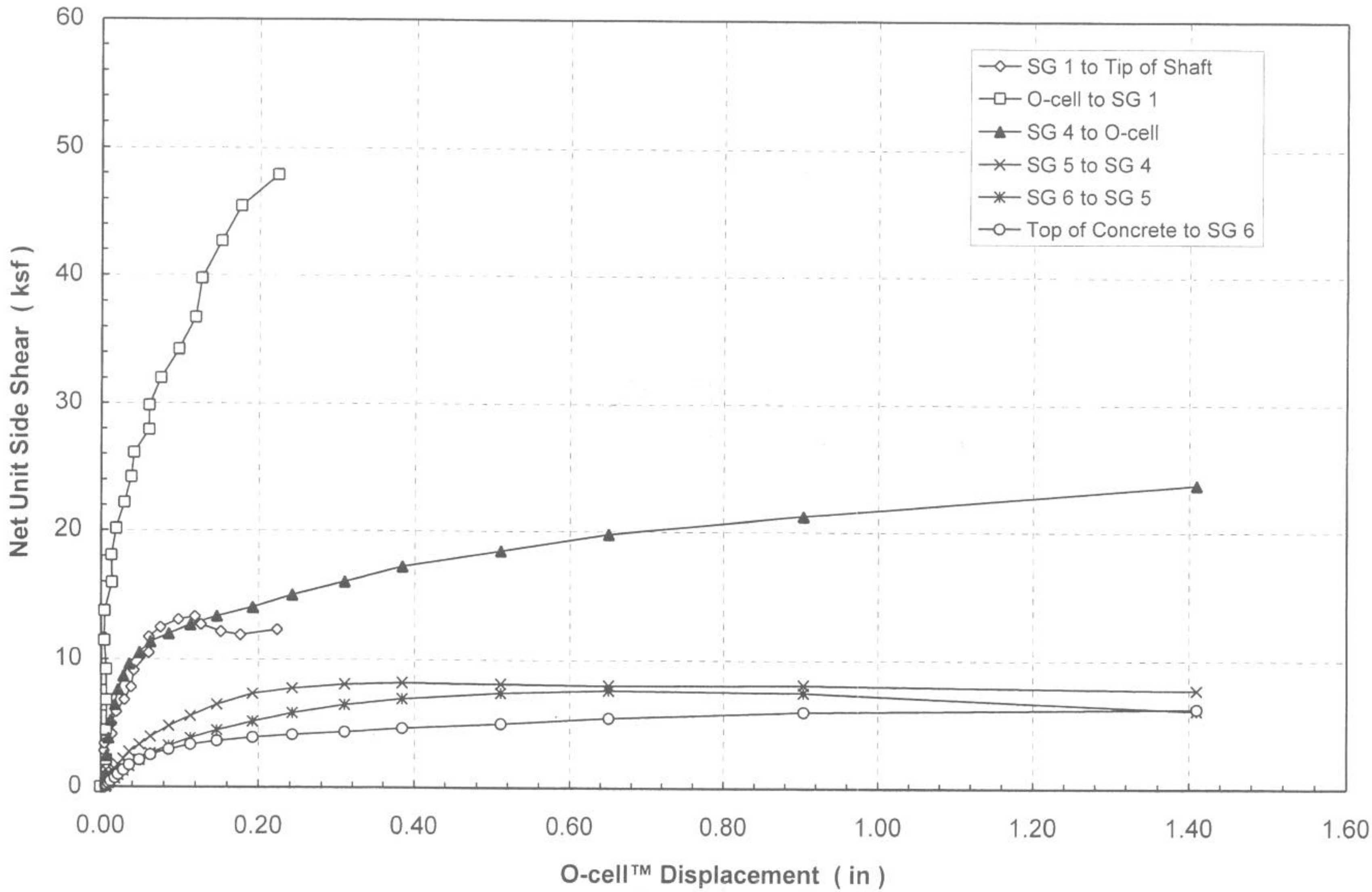


APPENDIX G

NET UNIT SHEAR CURVES

Net Unit Side Shear Curves

Dedicated Test Shaft - Grandview Triangle - Jackson Co., MO



APPENDIX H

HYPERBOLIC CURVE FITTING

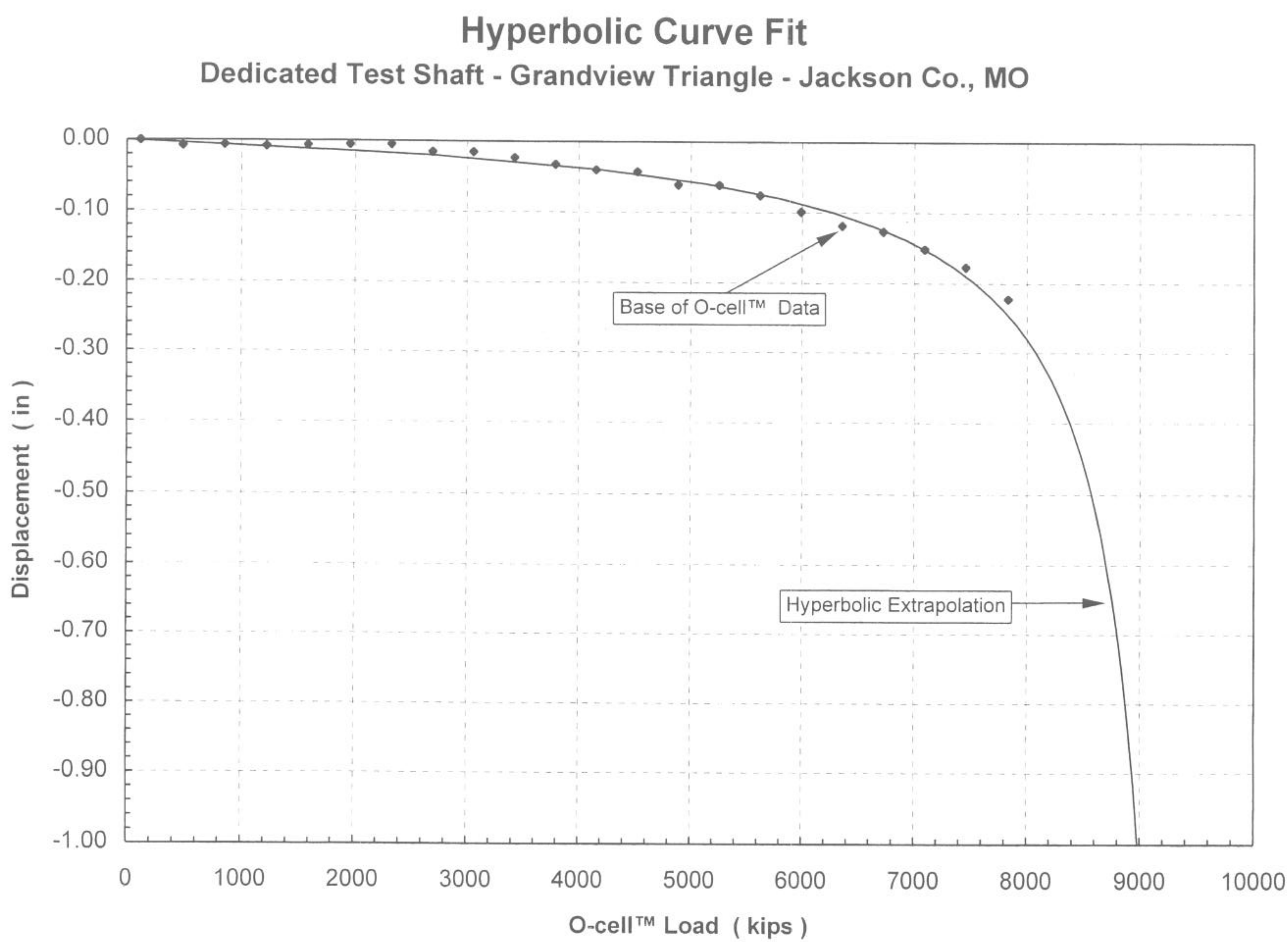
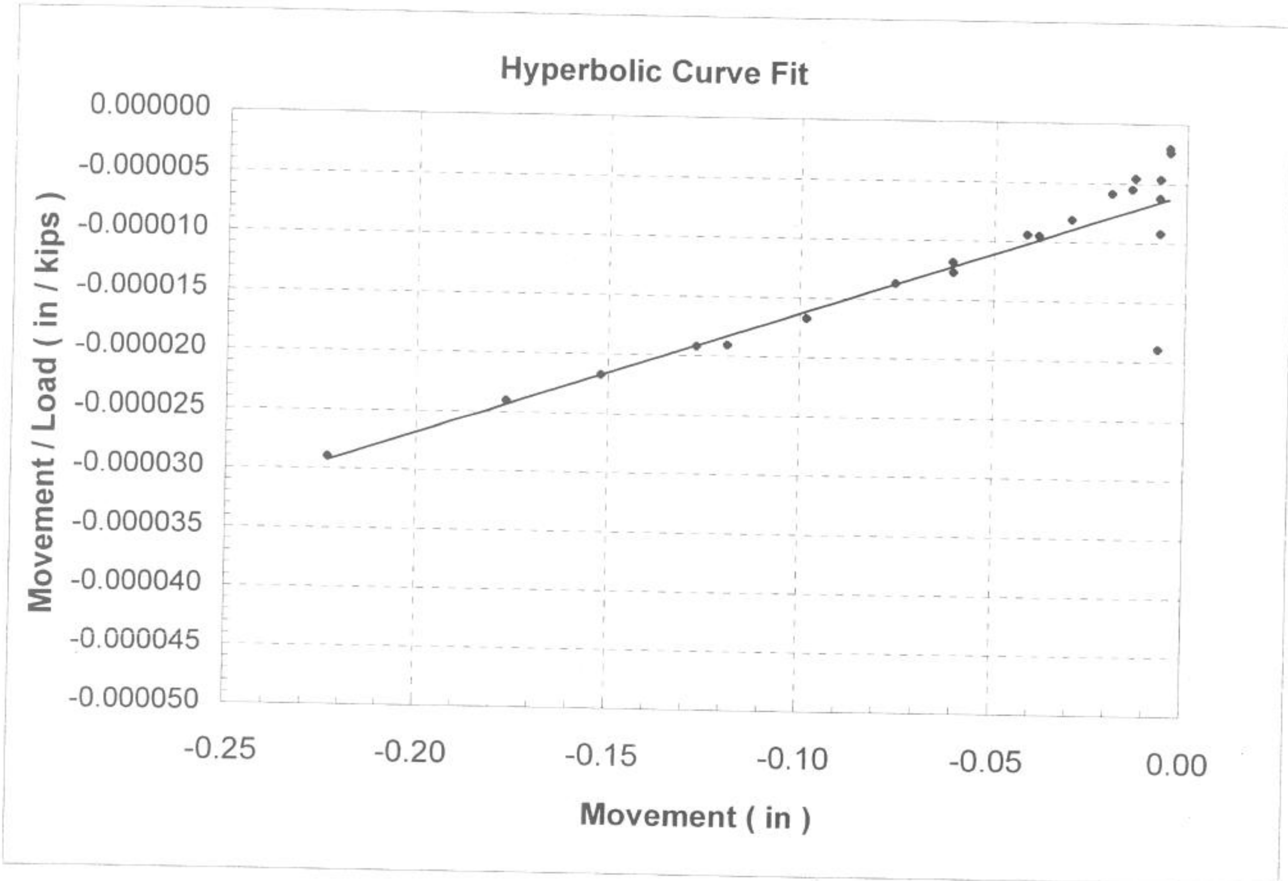

Hyperbolic Curve Fit
Dedicated Test Shaft - Grandview Triangle - Jackson Co., MO
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
Displacement (in)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
O-cell™ Load (kips)
Base of O-cell™ Data
Hyperbolic Extrapolation

Table H-1: Hyperbolic Curve Fit of Downward Base of O-cell™ Movement

Gross Load (kips)	Down* (in)	Y_d* (in/kip)	$Y_{d\ calc}$ (in/kip)	Gross Load_{calc} (kips)
0	0.0000	-	-	-
367	-0.0070	-0.000019	-0.000007	1058
734	-0.0067	-0.000009	-0.000007	1028
1101	-0.0069	-0.000006	-0.000007	1045
1468	-0.0068	-0.000005	-0.000007	1036
1835	-0.0044	-0.000002	-0.000006	699
2202	-0.0045	-0.000002	-0.000006	712
2569	-0.0141	-0.000005	-0.000007	1927
2936	-0.0134	-0.000005	-0.000007	1848
3303	-0.0194	-0.000006	-0.000008	2461
3670	**-0.0298**	**-0.000008**	-0.000009	3318
4037	**-0.0383**	**-0.000009**	-0.000010	3884
4404	**-0.0415**	**-0.000009**	-0.000010	4066
4771	**-0.0604**	**-0.000013**	-0.000012	4957
5137	**-0.0606**	**-0.000012**	-0.000012	4964
5504	**-0.0753**	**-0.000014**	-0.000014	5478
5871	**-0.0983**	**-0.000017**	-0.000016	6082
6238	**-0.1190**	**-0.000019**	-0.000018	6490
6605	**-0.1269**	**-0.000019**	-0.000019	6622
6972	**-0.1518**	**-0.000022**	-0.000022	6971
7339	**-0.1766**	**-0.000024**	-0.000024	7243
7712	**-0.2234**	**-0.000029**	-0.000029	7627

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



SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.997618397
R Square	0.995242465
Adjusted R Sq	0.994766712
Standard Erro	4.56279E-07
Observations	12

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	4.3552E-10	4.3552E-10	2091.929002	6.00998E-13
Residual	10	2.08191E-12	2.08191E-13		
Total	11	4.37602E-10			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-5.8459E-06	2.66495E-07	-21.9361895	8.68044E-10	-6.4397E-06	-5.2521E-06	-6.4397E-06	-5.2521E-06
X Variable 1	0.000104946	2.29452E-06	45.73761037	6.00998E-13	9.98335E-05	0.000110058	9.98335E-05	0.000110058