REPORT ON DRILLED PILE
LOAD TESTING (OSTERBERG METHOD)

TP-2 - Crosstown Commons Project
Minneapolis, MN (LT-9193-2)

Prepared for: American Engineering Testing Co.
550 Cleveland Ave., North
St. Paul, MN 55114

Attention: Mr. Gregory Reuter

PROJECT NUMBER: LT-9193-2, March 26, 2008

	Telephone:	Fax:
Head Office:		
2631-D NW 41st Street, Gainesville FL 32606	352-378-3717 800-368-1138	352-378-3934
Regional Offices:		
785 The Kingsway, Peterborough, Ontario, Canada K9J 6W7	705-749-0076	705-743-6854
5740 Executive Drive, Suite 108, Baltimore, MD 21228	410-788-4180 800-436-2355	410-788-4182

E-mail: Info@loadtest.com Internet: www.loadtest.com

LOADTEST

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

March 26, 2008

American Engineering Testing Co.
550 Cleveland Ave., North
St. Paul, MN 55114

Attention: Mr. Gregory Reuter

Load Test Report: TP-2 - Crosstown Commons Project
Location: Minneapolis, MN (LT-9193-2)

Dear Mr. Reuter,

The enclosed report contains the data and analysis summary for the O-cell test performed on TP-2 - Crosstown Commons Project, on March 18, 2008. For your convenience, we have included an executive summary of the test results in addition to our standard detailed data report. Preliminary results were issued on March 21, 2008.

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,

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

EXECUTIVE SUMMARY

On March 18, 2008, we tested a nominal 72-inch (1,829-mm) diameter production test pile constructed by Atlas Foundation Co. Mr. William G. Ryan of LOADTEST, Inc. carried out the test. Atlas Foundation Co. excavated the 61.0-foot (18.59-meter) deep pile under natural ground water seepage and performed final cleanout and concreting on February 6, 2008. Sub-surface conditions at the test pile location consist primarily of alternating layers of saturated sand and moist loamy sand, with intermittent pockets of sand with pebbles and gravel. Representatives of the Minnesota Department of Transportation observed construction and testing of the pile.

The maximum bi-directional load applied to the pile was 1,374 kips (6.11 MN). At the maximum load, the displacements above and below the O-cell were 0.302 inches (7.67 mm) and 0.588 inches (14.93 mm), respectively. Unit shear data calculated from strain gages indicated a maximum net unit side shear of 5.4 ksf (260 kPa) between the O-cell and strain gage level 2. We also calculated a maximum applied end bearing pressure of 37.7 ksf (1,807 kPa).

Using the procedures described in the report text and in Appendix C, we constructed an equivalent top load curve for the test pile. For a top loading of 2,000 kips (8.9 MN), the adjusted test data indicate this pile would settle approximately 0.30 inches (7.7 mm) of which 0.05 inches (1.3 mm) is estimated elastic compression.

Q_{drive} = 971 Tons

LIMITATIONS OF EXECUTIVE SUMMARY

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

TABLE OF CONTENTS

@ drive = 971 Tons.

SITE CONDITIONS AND PILE CONSTRUCTION

Site Sub-surface Conditions: The sub-surface stratigraphy at the general location of the test pile is reported to consist of alternating layers of saturated sand and moist loamy sand with intermittent pockets of sand with pebbles and gravel. The generalized subsurface profile is included in Figure A and a boring log indicating conditions near the pile is presented in Appendix E. More detailed geologic information can be obtained from the Minnesota Department of Transportation.

Test Pile Construction: Atlas Foundation Co. finished excavation of the production test pile on February 6, 2008 and performed the final cleanout and concreting on February 6, 2008. Plan was 764.0', so 10' ~~higher~~ shorter than plan.

We understand that the 72-inch (1,829-mm) test pile was excavated to a tip elevation of 774.0 feet (235.92 meters), under natural ground water seepage. The pile was started by pre-drilling, then advancing an 87-inch (2,210-mm) O.D. surface casing. A 75-inch (1,905-mm) O.D. inner casing was then inserted as the drilling progressed. A 72-inch auger and clean-out bucket was used for drilling and cleaning the pile. After cleaning the base, the reinforcing cage with attached O-cell assembly was inserted into the excavation and temporarily supported at the surface. Concrete was then delivered by pump through a tremie pipe into the base of the pile until the top of the concrete reached an elevation of 829.3 feet (252.76 meters). The contractor removed both the 75-inch (1,905-mm) O.D. casing and the 87-inch (2,210-mm) O.D. casing that same day. No unusual problems occurred during construction of the pile. Table B contains a summary of dimensions, elevations and shaft properties used in the data evaluations.

OSTERBERG CELL TESTING

Pile Instrumentation: Test pile instrumentation and assembly was carried out under the direction of Aaron King of LOADTEST, Inc. between February 4, 2008 and February 6, 2008. The loading assembly consisted of one 21-inch (530-mm) O-cell located 3.0 feet (0.91 meters) above the tip of pile. Calibrations of the O-cell and instrumentation used for this test are included in Appendix B.

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

Strain gages were used to assess the side shear load transfer of the pile above the Osterberg cell assembly. Five levels of two sister bar vibrating wire strain gages (Geokon Model 4911 Series) were installed, diametrically opposed, in the pile above the base of the O-cell assembly. Details concerning the strain gage placement appear in Table B and Figures A & B. The strain gages were positioned as recommended by LOADTEST, Inc. and the Minnesota Department of Transportation.

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

Test Arrangement: Throughout the load test, key elements of pile response were monitored using the equipment and instruments described herein. Pile compression was measured using ¼-inch telltales installed in the ½-inch steel pipes (described under Pile Instrumentation) and monitored by LVWDTs (Geokon Model 4450 Series). Two automated digital survey levels (Leica NA 3003) were used to monitor the top of pile movement from a distance of 25.4 feet (7.74 meters) (Appendix A, Page 1).

A Bourdon pressure gage and a vibrating wire pressure transducer were used to measure the pressure applied to the O-cell at each load interval. We used the 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 gage 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. The same 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 loading the O-cell in order to break the tack welds that hold it closed (for handling and for placement in the pile) and to form the fracture plane in the concrete surrounding the base of the O-cell. After the break occurs, we immediately release the pressure and then begin the loading procedure. Zero readings for all instrumentation are taken prior to the preliminary weld-breaking load-unload cycle, which in this case involved a maximum applied load of 1,525 kips (6.8 MN) to the O-cell.

The Osterberg cell load test was conducted as follows: We loaded the 21-inch (530-mm) diameter O-cell, with its base located 3.0 feet (0.91 meters) above the base of pile to assess the combined end bearing and lower side shear below the O-cell and the side shear above. We loaded the O-cell in 9 increments to a bi-directional gross

O-cell load of 1,374 kips (6.11 MN). The loading was halted after load interval 1L-9 because the side shear above the O-cell was beginning to displace and the integrity of the pile needed to be maintained for production use. The O-cell was then unloaded in five decrements and the test was concluded.

We applied the load increments using the Quick Load Test Method for Individual Piles (ASTM D1143 *Standard Test Method for Piles Under Static Axial Load*), holding each successive load increment constant for eight minutes by manually adjusting the O-cell pressure. The data logger automatically recorded the instrument readings every 30 seconds, but herein we report only the 1, 2, 4 and 8-minute readings (where applicable) during each increment of maintained load.

TEST RESULTS AND ANALYSES

General: The loads applied by the O-cell act in two opposing directions, resisted by the capacity of the pile above and below. Theoretically, the O-cell does not impose an additional upward load until its expansion force exceeds the buoyant weight of the pile above the O-cell. Therefore, *net load*, which is defined as gross O-cell load minus the buoyant weight of the pile 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 pile of 150 kips (0.67 MN) above the O-cell.

Upper Side Shear Resistance: The maximum upward applied *net load* to the upper side shear was 1,224 kips (5.45 MN) which occurred at load interval 1L-9. At this loading, the upward movement of the O-cell top was 0.302 inches (7.67 mm).

In order to assess the side shear resistance of the test pile, loads are calculated based on the strain gage data (Appendix A, Pages 4, 5, and 6) and estimates of pile stiffness (AE) which are presented below. We used the ACI formula ($E_c=57000\sqrt{f'_c}$) to calculate an elastic modulus for the concrete, where an average of f'_c was calculated to be 5,900 psi (40.68 MPa). This, combined with the area of reinforcing steel and nominal pile diameter, provided an average pile stiffness (AE) of 27,000,000 kips (120,000 MN) in the outer casing section (zero shear to elevation +822.8'), 20,300,000 kips (90,500 MN) in the inner casing section (elevation +822.8' to +813.8'), 19,200,000 kips (85,300 MN) below the casings and above the O-cell base (elevation +813.8' to +777.0') and 17,600,000 kips (78,500 MN) below the O-cell to the tip of pile (elevation +777.0' to +774.0'). Net unit shear curves are presented in Figure 3. Net unit shear values for loading increment 1L-9 follow in Table A:

TABLE A: Average Mobilized Net Unit Side Shear Values for 1L-9

Load Transfer Zone	Displacement [1]	Net Unit Side Shear [2, 3]
Strain Gage Level 5 to Zero Shear Elevation	↑ 0.297"	Negligible
Strain Gage Level 4 to Strain Gage Level 5	↑ 0.297"	0.1 ksf (6 kPa)
Strain Gage Level 3 to Strain Gage Level 4	↑ 0.298"	Negligible
Strain Gage Level 2 to Strain Gage Level 3	↑ 0.298"	3.8 ksf (184 kPa)
O-cell to Strain Gage Level 2 [4]	↑ 0.300"	5.4 ksf (260 kPa)

[1] Average displacement of load transfer zone.
[2] For upward-loaded shear, the buoyant weight of pile in each zone has been subtracted from the load shed in the respective zone above the O-cell.
[3] Net unit shear values derived from the strain gages above the O-cell assembly may not be ultimate values. See Figure 3 for mobilized net unit shear vs. average shear zone displacement plots.
[4] Level 1 strain gage data yielded higher loads than applied by the O-cell and are not included in the analysis.

Combined End Bearing And Lower Side Shear Resistance: The maximum O-cell load applied to the combined end bearing and lower side shear was 1,374 kips (6.11 MN) which occurred at load interval 1L-9 (Appendix A, Page 3, Figure 1). At this loading, the average downward movement of the O-cell base was 0.588 inches (14.93 mm). The load taken in shear by the 3.0 feet (0.91 meters) pile section below the O-cell is calculated to be 307 kips (1.37 MN) assuming an estimated unit side shear value of 5.4 ksf (260 kPa) and a nominal 72-inch (1,829-mm) pile diameter. The applied load to end bearing is then 1,067 kips (4.75 MN) and the unit end bearing at the base of the pile is calculated to be 37.7 ksf (1,807 kPa) at the above noted displacement. A unit end bearing curve is presented in Figure 4.

Equivalent Top Load: Figure 5 presents the equivalent top-loaded load-settlement curves. The lighter curve, described in Procedure Part I of Appendix C, was generated by using the measured upward top of O-cell and downward base of O-cell data. 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.

For an equivalent top loading of 2,000 kips (8.9 MN), the adjusted test data indicate this pile would settle approximately 0.30 inches (7.7 mm) of which 0.05 inches (1.3 mm) is estimated elastic compression.

Note that, as explained previously, the equivalent top load curve applies to incremental loading durations of eight minutes. Creep effects will reduce the ultimate resistance of both components and increase 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.

Creep Limit: See Appendix D for our O-cell method for determining creep limit. The combined end bearing and lower side shear creep data (Appendix A, Page 3) indicate that a creep limit of 1,220 kips (5.4 MN) was reached at a movement of 0.42 inches (10.6 mm) (Appendix D, Figure 1). The upper side shear creep data (Appendix A, Page 3) indicate that a creep limit of 825 kips (3.67 MN) was reached at a movement of 0.08 inches (2.03 mm) (Appendix D, Figure 2). One interpretation of the data presented herein is that significant creep for this pile will not begin until a top loading exceeds 2,319 kips (10.3 MN) by some unknown amount. The engineer should come to his own conclusions with regard to the suitability of the creep limit analysis to address long term creep which may be an important design consideration.

Pile Compression Comparison: The measured maximum pile compression, averaged from two telltales, is 0.005 inches (0.13 mm) at 1L-9 (Appendix A, Page 3). Using an average pile stiffness of 26,000,000 kips (120,000 MN) and the load distribution in Figure 2 at 1L-9, we calculated an elastic compression of 0.004 inches (0.11 mm) over the length of the compression telltales.

POST-TEST O-CELL GROUTING

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

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 pile and foundation engineering industry.

Please note that some of the information contained in this report is based on data (i.e. pile 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 pile 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 pile construction. Since construction technique can play a significant role in determining the load bearing capacity of a drilled pile, the engineer should pay close attention to the drilled pile 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

Steven A. Evans, B.S.C.E.
Project Engineer

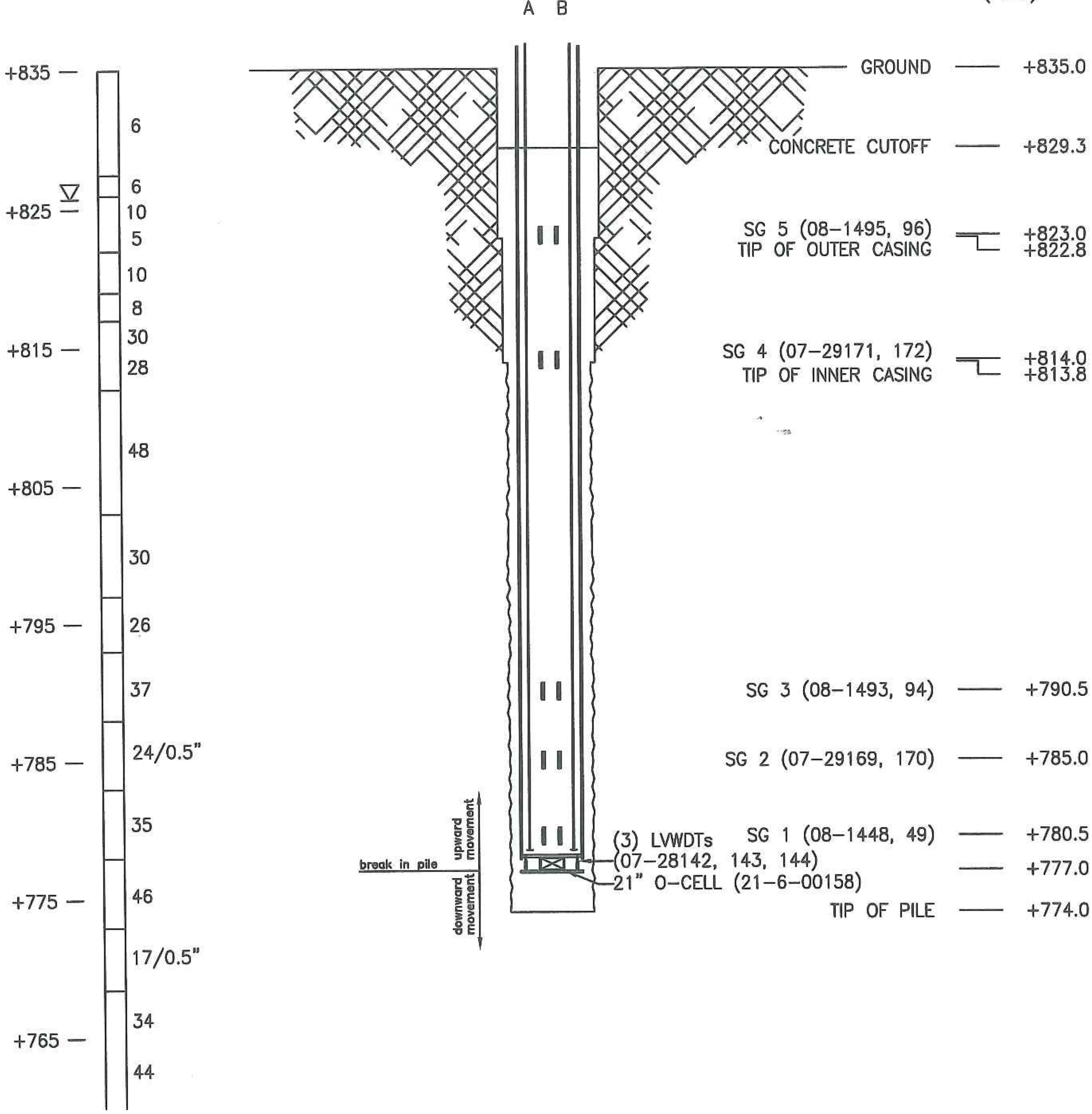
Reviewed for LOADTEST, Inc. by

D. Tilson
for Robert C. Simpson

TABLE B:
SUMMARY OF DIMENSIONS, ELEVATIONS & SHAFT PROPERTIES

Shaft:			
Nominal shaft diameter (EL +829.3 ft to +822.8 ft)	=	87 in	2210 mm
Nominal shaft diameter (EL +822.8 ft to +813.8 ft)	=	75 in	1905 mm
Nominal shaft diameter (EL +813.8 ft to +777.0 ft)	=	72 in	1829 mm
O-cell: 21-6-000158	=	21 in	530 mm
Bouyant weight of pile above base of O-cell	=	150 kips	0.67 MN
Estimated shaft stiffness, AE (EL +829.3 ft to +822.8 ft)	=	27,000,000 kips	120,000 MN
Estimated shaft stiffness, AE (EL +822.8 ft to +813.8 ft)	=	20,300,000 kips	90,500 MN
Estimated shaft stiffness, AE (EL +813.8 ft to +777.0 ft)	=	19,200,000 kips	85,300 MN
Estimated shaft stiffness, AE (EL +777.0 ft to +774.0 ft)	=	17,600,000 kips	78,500 MN
Elevation of ground surface	=	+835.0 ft	+254.51 m
Elevation of top of shaft concrete	=	+829.3 ft	+252.76 m
Elevation of water table	=	+825.5 ft	+251.61 m
Elevation of base of O-cell (The break between upward and downward movement.)	=	+777.0 ft	+236.83 m
Elevation of shaft tip	=	+774.0 ft	+235.92 m
Casings:			
Elevation of top of outer temporary casing (87.0 in O.D.)	=	+834.8 ft	+254.43 m
Elevation of top of inner temporary casing (75.0 in O.D.)	=	+826.8 ft	+251.99 m
Elevation of bottom of outer temporary casing (87.0 in O.D.)	=	+822.8 ft	+250.77 m
Elevation of bottom of inner temporary casing (75.0 in O.D.)	=	+813.8 ft	+248.03 m
Compression Sections:			
Elevation of top of compression section used for upper shaft compression	=	+829.3 ft	+252.76 m
Elevation of bottom of compression section used for upper shaft compression	=	+778.1 ft	+237.17 m
Strain Gages:			
Elevation of strain gage Level 5	=	+823.0 ft	+250.85 m
Elevation of strain gage Level 4	=	+814.0 ft	+248.11 m
Elevation of strain gage Level 3	=	+790.0 ft	+240.79 m
Elevation of strain gage Level 2	=	+785.0 ft	+239.27 m
Elevation of strain gage Level 1	=	+780.5 ft	+237.90 m
Miscellaneous:			
Top plate diameter (2-inch thickness)	=	56.25 in	1429 mm
Bottom plate diameter (2-inch thickness)	=	59.00 in	1499 mm
ReBar size (32 No.)	=	# 10	M 32
Spiral size (12 inch spacing)	=	# 4	M 13
ReBar cage diameter	=	60 in	1524 mm
Unconfined compressive concrete strength	=	5900 psi	40.7 MPa

NOTE:
- NOMINAL PILE 72"ø
- NOMINAL TEMPORARY OUTER CASING 87"ø
- NOMINAL TEMPORARY INNER CASING 75"ø
- WATER EL = +825.5'



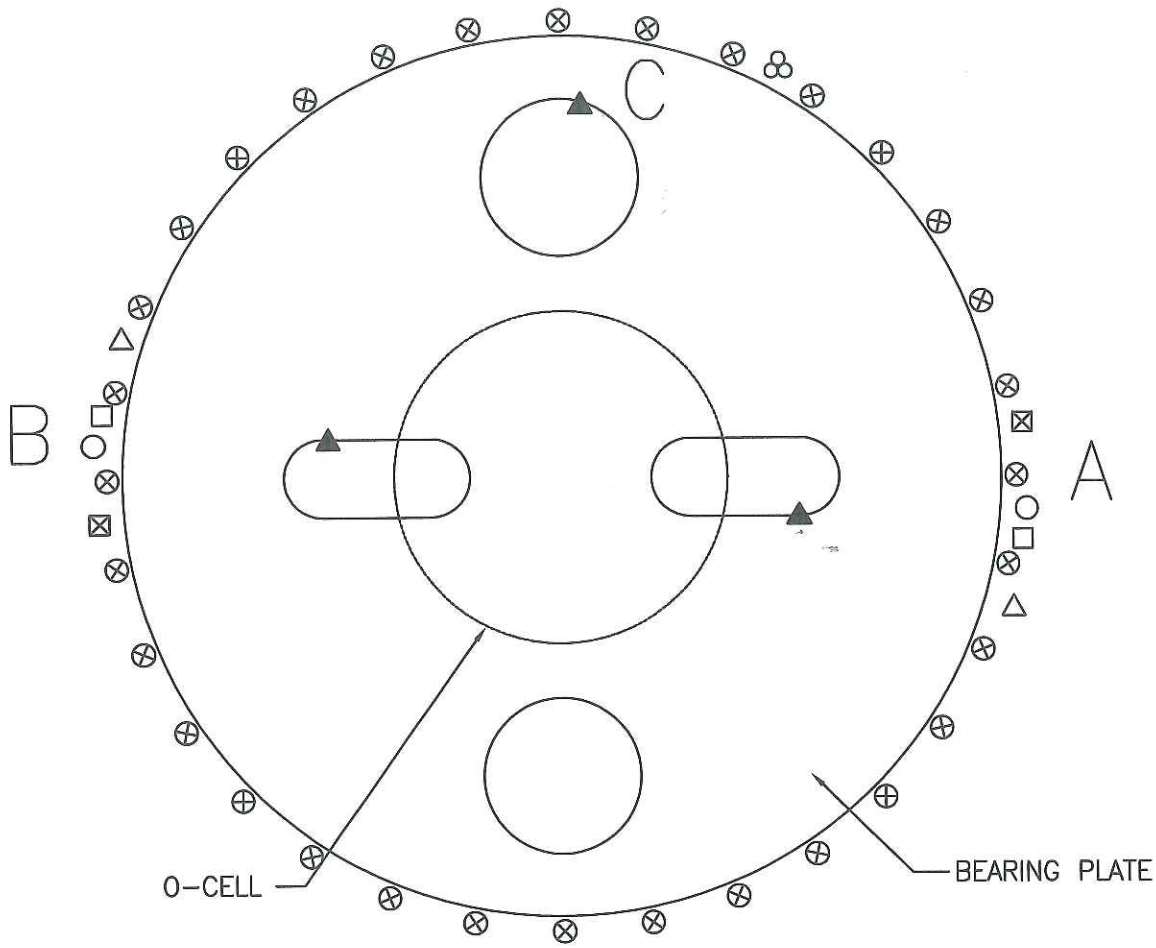
- NOTE: SOIL PROPERTIES BASED ON MnDOT BORING NO. T02 (2782-27405)

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

SCHEMATIC SECTION OF TEST PILE

CROSSTOWN COMMONS PROJECT - MINNEAPOLIS, MN

DRAWN BY: SAE	DATE: 03/24/08	CHECKED BY:	LT-9193-2
REVISED BY:	DATE:	SCALE: NTS	FIGURE A



LEGEND:

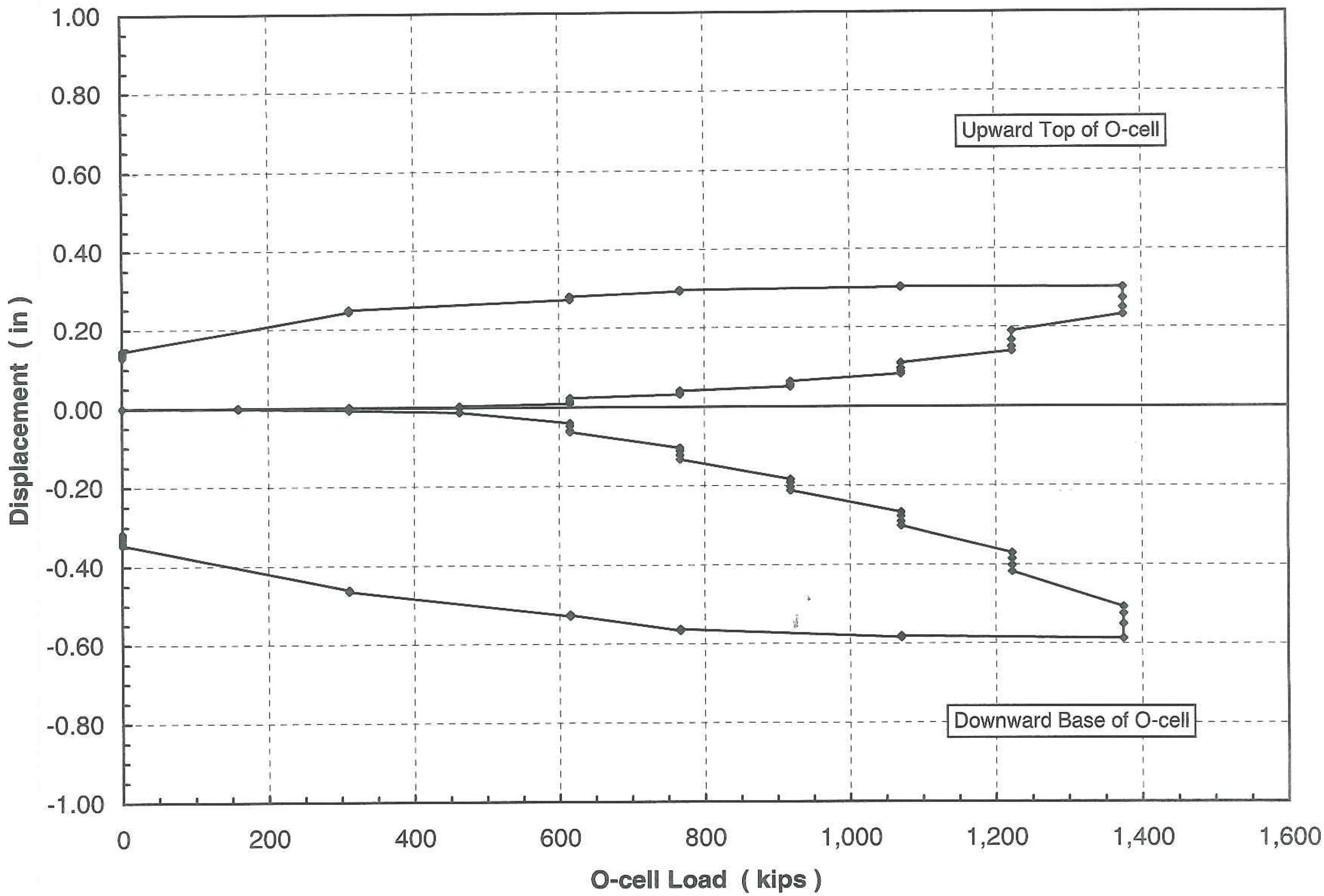
STRAIN GAGE	△
LVWDT	▲
TELLTALE	○
VENT PIPE	□
HYDRAULIC HOSES	⊠
REBAR	⊗
CABLE BUNDLE	ஃ

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

INSTRUMENTATION LAYOUT CROSSTOWN COMMONS PROJECT – MINNEAPOLIS, MN			
DWN BY: SAE	DATE: 03/25/08	CHECKED BY:	LT-9193-2
REVISED BY:	DATE:	SCALE: NTS	FIGURE B

Osterberg Cell Load-Movement

TS-2 - Crosstown Commons Project - Minneapolis, MN



LOADTEST, Inc. Project No. LT-9193-2

Figure 1 of 5

Strain Gage Load Distribution

TS-2 - Crosstown Commons Project - Minneapolis, MN

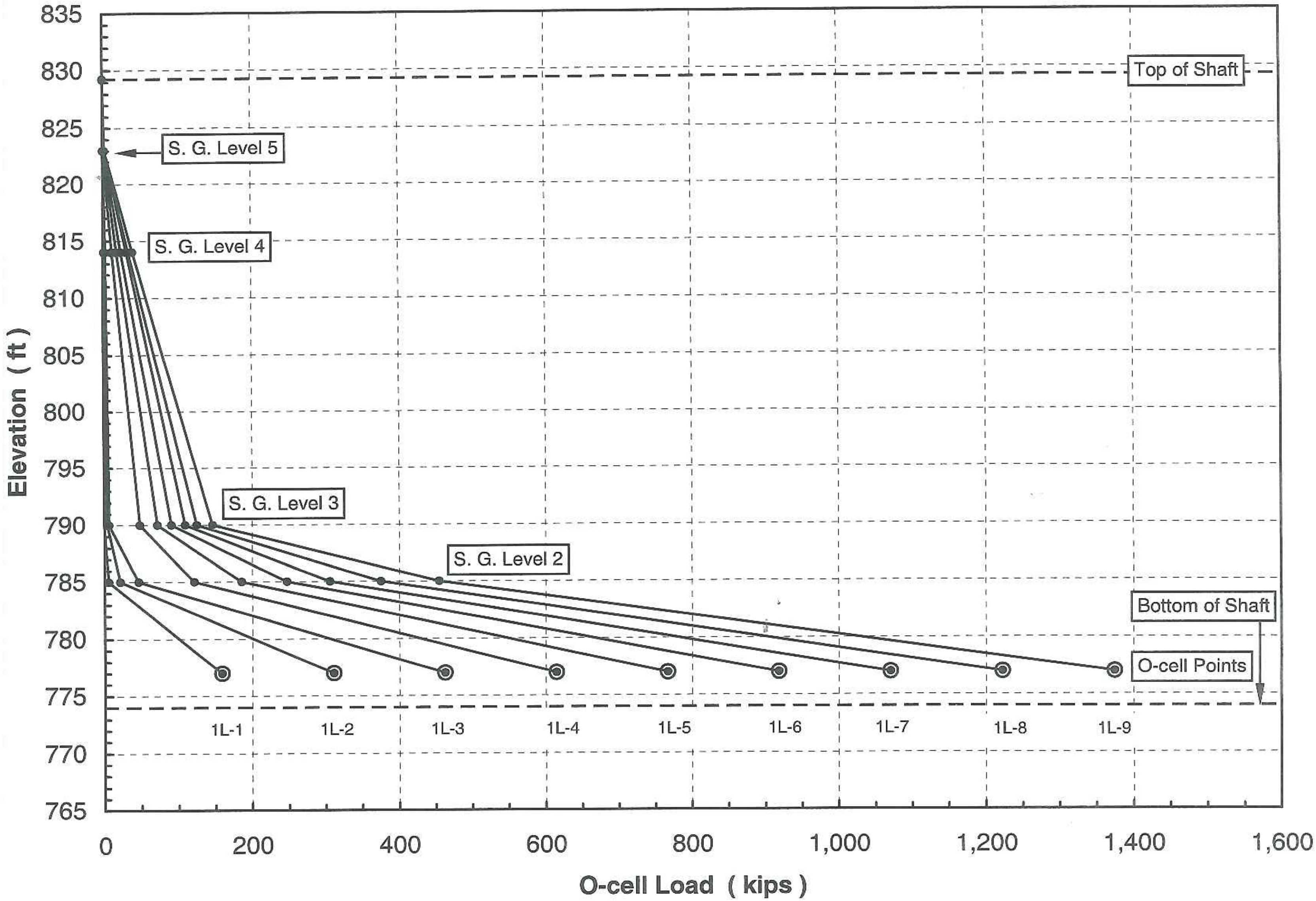
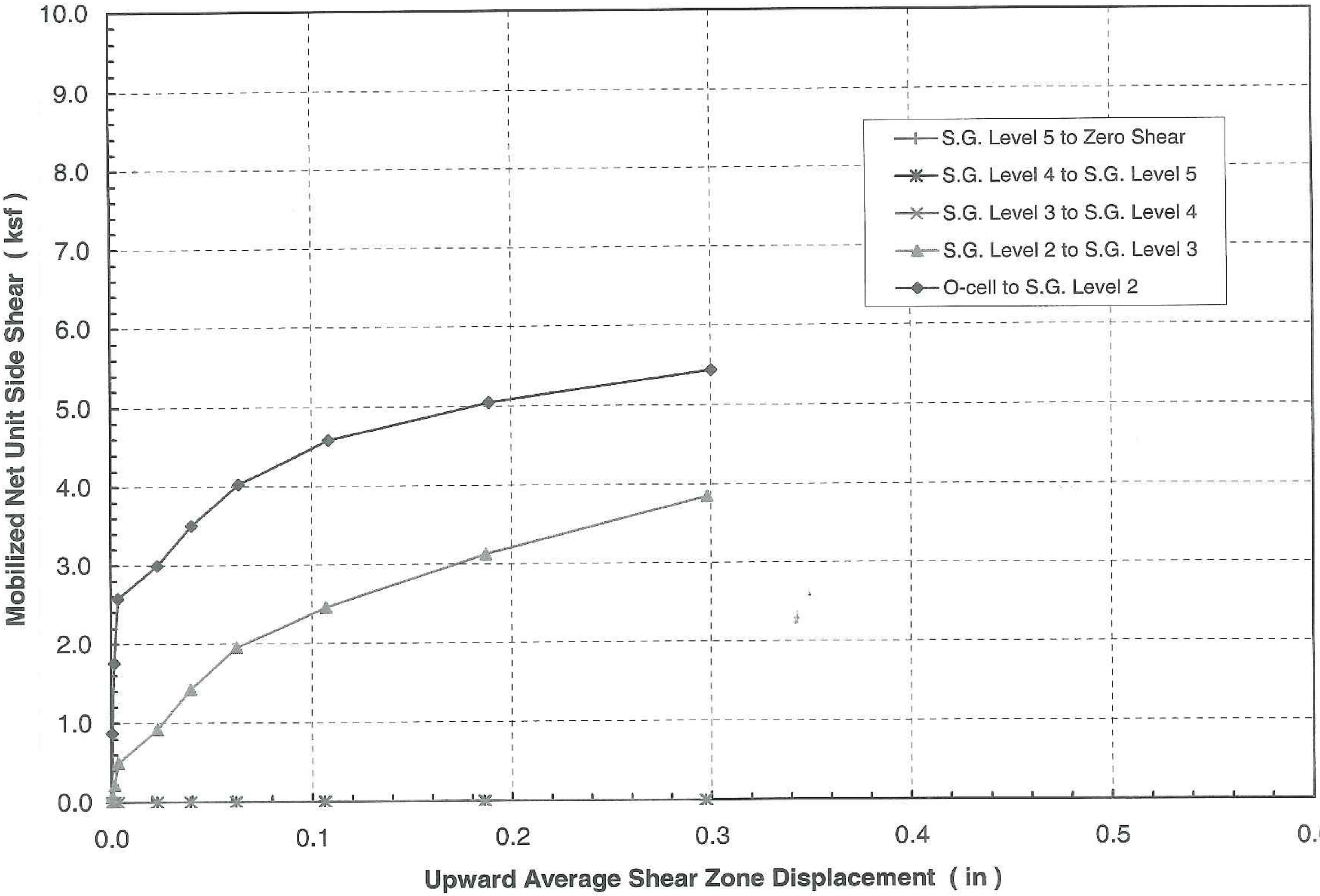


Figure 2 of 5

Mobilized Net Unit Side Shear

TS-2 - Crosstown Commons Project - Minneapolis, MN

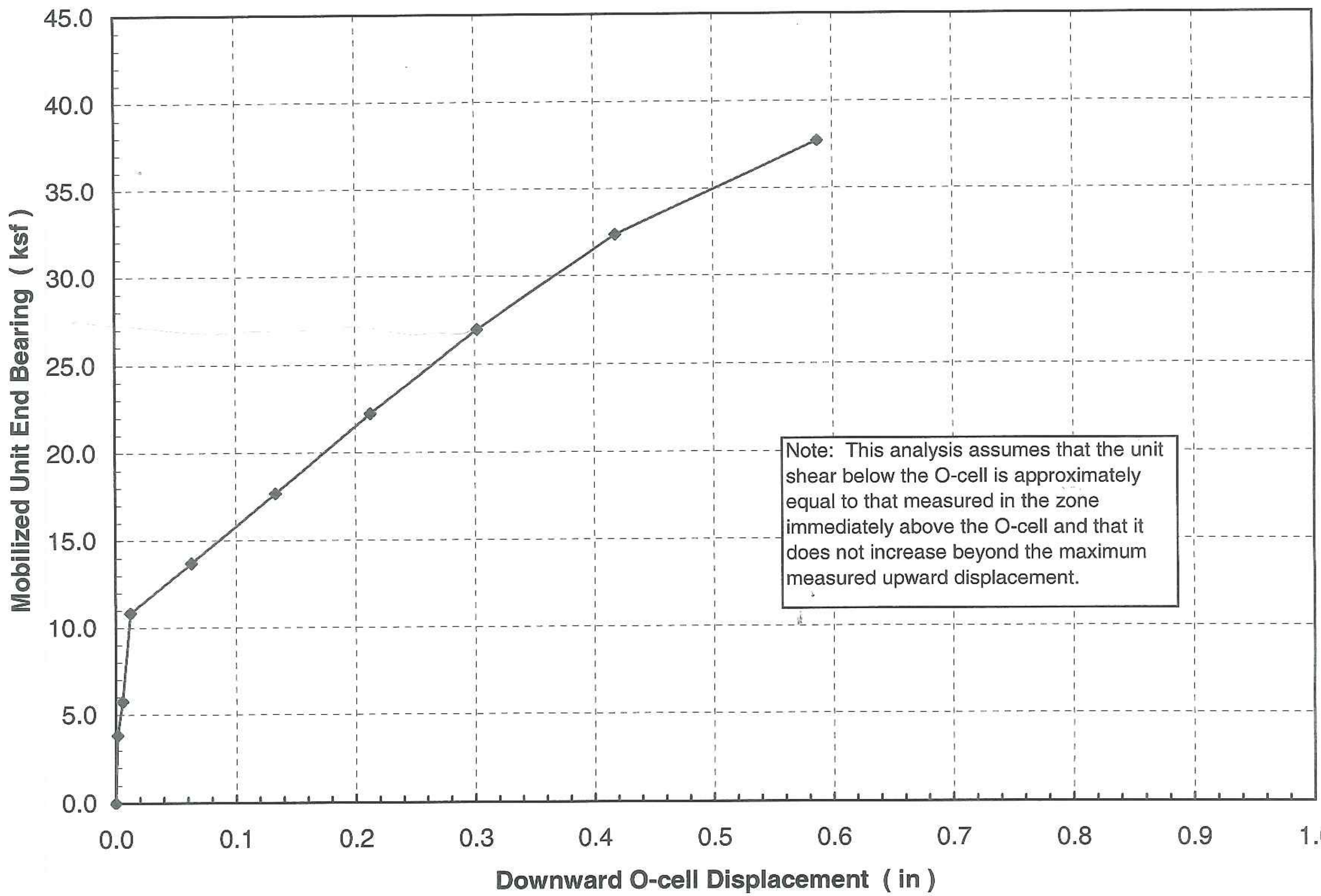


LOADTEST, Inc. Project No. LT-9193-2

Figure 3 of 5

Mobilized Unit End Bearing

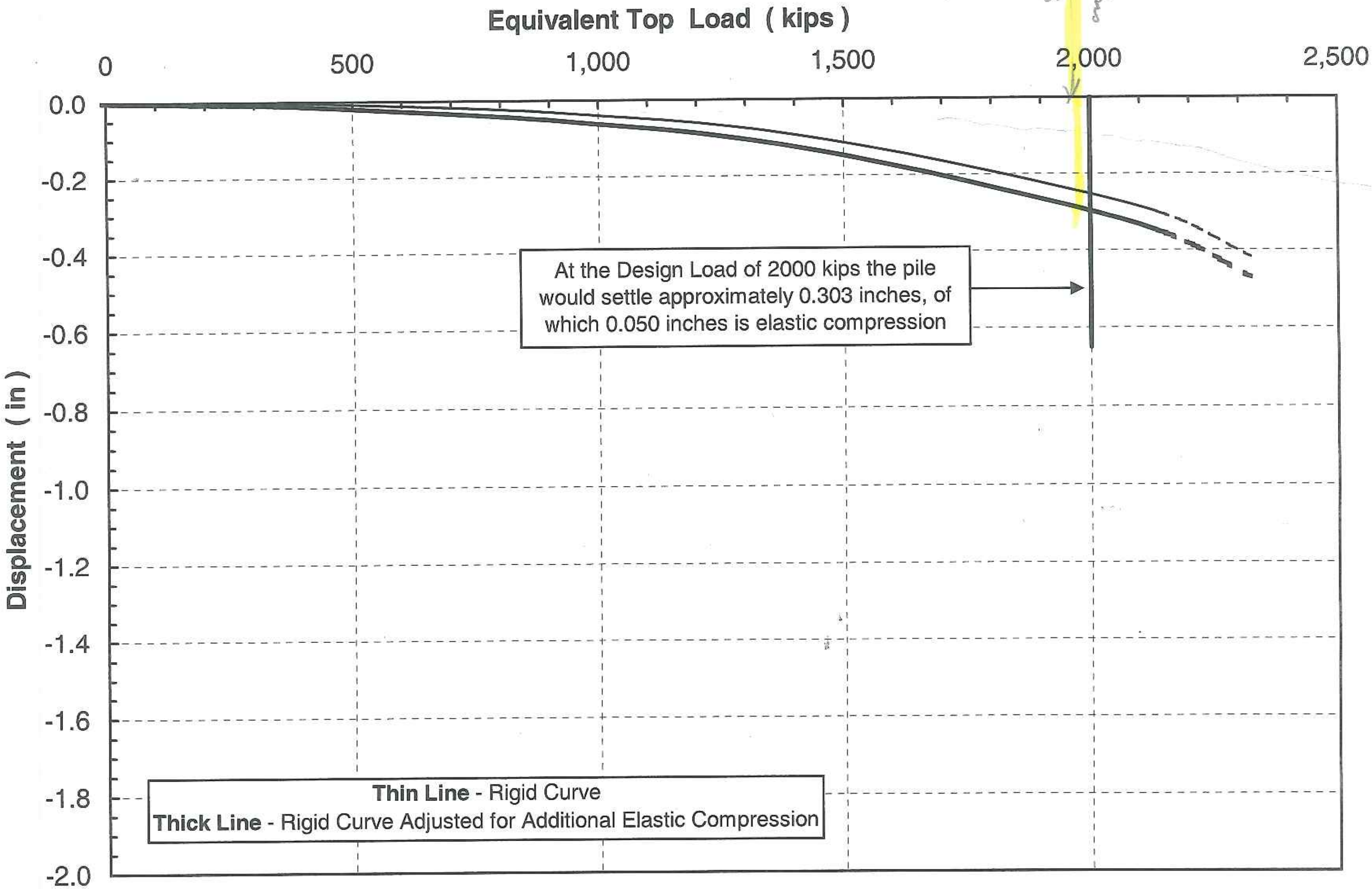
TS-2 - Crosstown Commons Project - Minneapolis, MN



Equivalent Top Load Load-Movement

TS-2 - Crosstown Commons Project - Minneapolis, MN

Design 971 Tons = 1950 Kips



APPENDIX A

FIELD DATA AND DATA REDUCTION

Upward Top of Shaft Movement and Shaft Compression
TP-2 - Crosstown Commons Project - Minneapolis, MN

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 Avg ** (in)	Telltales A (in)	Telltales B (in)	Telltales Average (in)
1 L - 0	-	10:27:00	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1 L - 1	1	10:30:00	600	159	0.000	0.000	0.001	0.001	0.000	0.000	0.000
1 L - 1	2	10:31:00	600	159	0.000	0.001	0.002	0.001	0.000	0.000	0.000
1 L - 1	4	10:33:00	600	159	0.000	0.001	0.001	0.001	0.000	0.000	0.000
1 L - 1	8	10:37:00	600	159	0.000	0.001	0.000	0.001	0.000	0.000	0.000
1 L - 2	1	10:38:30	1,200	311	0.000	0.002	0.001	0.002	0.000	0.000	0.000
1 L - 2	2	10:39:30	1,200	311	0.000	0.002	0.002	0.002	0.000	0.000	0.000
1 L - 2	4	10:41:30	1,200	311	0.000	0.002	0.002	0.002	0.000	0.000	0.000
1 L - 2	8	10:45:30	1,200	311	0.000	0.002	0.001	0.002	0.000	0.000	0.000
1 L - 3	1	10:47:00	1,800	463	0.000	0.002	0.001	0.001	0.000	0.000	0.000
1 L - 3	2	10:48:00	1,800	463	0.000	0.002	0.002	0.002	0.000	0.000	0.000
1 L - 3	4	10:50:00	1,800	463	0.000	0.003	0.004	0.003	0.000	0.000	0.000
1 L - 3	8	10:54:00	1,800	463	0.000	0.004	0.004	0.004	0.000	0.000	0.000
1 L - 4	1	10:56:00	2,400	615	0.000	0.009	0.010	0.010	0.000	0.000	0.000
1 L - 4	2	10:57:00	2,400	615	0.000	0.011	0.012	0.012	0.000	0.000	0.000
1 L - 4	4	10:59:00	2,400	615	0.000	0.015	0.017	0.016	0.000	0.000	0.000
1 L - 4	8	11:03:00	2,400	615	0.000	0.024	0.022	0.023	0.001	0.001	0.001
1 L - 5	1	11:05:00	3,000	767	0.000	0.032	0.030	0.031	0.001	0.001	0.001
1 L - 5	2	11:06:00	3,000	767	0.000	0.033	0.031	0.032	0.001	0.001	0.001
1 L - 5	4	11:08:00	3,000	767	0.000	0.035	0.033	0.034	0.001	0.002	0.001
1 L - 5	8	11:12:00	3,000	767	0.000	0.040	0.039	0.039	0.001	0.002	0.001
1 L - 6	1	11:14:00	3,600	919	0.000	0.049	0.049	0.049	0.001	0.003	0.002
1 L - 6	2	11:15:00	3,600	919	0.000	0.051	0.052	0.052	0.001	0.003	0.002
1 L - 6	4	11:17:00	3,600	919	0.000	0.054	0.055	0.055	0.002	0.003	0.002
1 L - 6	8	11:21:00	3,600	919	0.000	0.062	0.062	0.062	0.002	0.003	0.002
1 L - 7	1	11:23:00	4,200	1,070	0.000	0.081	0.079	0.080	0.002	0.004	0.003
1 L - 7	2	11:24:00	4,200	1,070	0.000	0.086	0.085	0.085	0.002	0.004	0.003
1 L - 7	4	11:26:00	4,200	1,070	0.000	0.093	0.092	0.093	0.002	0.004	0.003
1 L - 7	8	11:30:00	4,200	1,070	0.000	0.106	0.106	0.106	0.002	0.004	0.003
1 L - 8	1	11:32:00	4,800	1,222	0.000	0.135	0.134	0.134	0.002	0.006	0.004
1 L - 8	2	11:33:00	4,800	1,222	0.000	0.144	0.145	0.145	0.002	0.006	0.004
1 L - 8	4	11:35:00	4,800	1,222	0.000	0.163	0.161	0.162	0.002	0.006	0.004
1 L - 8	8	11:39:00	4,800	1,222	0.000	0.187	0.185	0.186	0.002	0.006	0.004
1 L - 9	1	11:41:00	5,400	1,374	0.000	0.229	0.225	0.227	0.003	0.007	0.005
1 L - 9	2	11:42:00	5,400	1,374	0.000	0.247	0.242	0.244	0.003	0.007	0.005
1 L - 9	4	11:44:00	5,400	1,374	0.000	0.269	0.267	0.268	0.003	0.007	0.005
1 L - 9	8	11:48:00	5,400	1,374	0.000	0.299	0.295	0.297	0.003	0.007	0.005
1 U - 1	1	11:50:00	4,200	1,070	0.000	0.301	0.296	0.299	0.003	0.007	0.005
1 U - 1	2	11:51:00	4,200	1,070	0.000	0.302	0.297	0.299	0.003	0.007	0.005
1 U - 1	4	11:53:00	4,200	1,070	0.000	0.298	0.295	0.297	0.003	0.007	0.005
1 U - 2	1	11:55:00	3,000	767	0.000	0.291	0.291	0.291	0.003	0.007	0.005
1 U - 2	2	11:56:00	3,000	767	0.000	0.291	0.291	0.291	0.003	0.007	0.005
1 U - 2	4	11:58:00	3,000	767	0.000	0.286	0.288	0.287	0.003	0.007	0.005
1 U - 3	1	12:00:00	2,400	615	0.000	0.275	0.275	0.275	0.003	0.007	0.005
1 U - 3	2	12:01:00	2,400	615	0.000	0.274	0.274	0.274	0.003	0.007	0.005
1 U - 3	4	12:03:00	2,400	615	0.000	0.267	0.266	0.267	0.003	0.007	0.005
1 U - 4	1	12:05:30	1,200	311	0.000	0.244	0.243	0.243	0.003	0.007	0.005
1 U - 4	2	12:06:30	1,200	311	0.000	0.243	0.241	0.242	0.003	0.007	0.005
1 U - 4	4	12:08:30	1,200	311	0.000	0.240	0.238	0.239	0.003	0.006	0.004
1 U - 5	1	12:12:30	0	0	0.000	0.139	0.140	0.139	0.003	0.005	0.004
1 U - 5	2	12:13:30	0	0	0.000	0.136	0.135	0.136	0.003	0.005	0.004
1 U - 5	4	12:15:30	0	0	0.000	0.132	0.132	0.132	0.003	0.005	0.004
1 U - 5	8	12:19:30	0	0	0.000	0.128	0.127	0.128	0.003	0.005	0.004
1 U - 5	15	12:26:30	0	0	0.000	0.125	0.124	0.124	0.003	0.005	0.004

O-cell Expansion
TP-2 - Crosstown Commons Project - Minneapolis, MN

Load Test Increment	Hold Time (minutes)	Time (h:m:s)	O-cell Pressure (psi)	O-cell Load (kips)	O-cell Expansion A - 07-28142 (in)	B - 07-28143 (in)	C - 07-28144 * (in)	Average (in)
1 L - 0	-	10:27:00	0	0	0.000	0.000	0.000	0.000
1 L - 1	1	10:30:00	600	159	0.001	0.002	0.001	0.002
1 L - 1	2	10:31:00	600	159	0.001	0.002	0.002	0.002
1 L - 1	4	10:33:00	600	159	0.001	0.002	0.001	0.002
1 L - 1	8	10:37:00	600	159	0.002	0.002	0.001	0.002
1 L - 2	1	10:38:30	1,200	311	0.004	0.008	0.006	0.006
1 L - 2	2	10:39:30	1,200	311	0.005	0.009	0.006	0.007
1 L - 2	4	10:41:30	1,200	311	0.005	0.009	0.006	0.007
1 L - 2	8	10:45:30	1,200	311	0.005	0.009	0.007	0.007
1 L - 3	1	10:47:00	1,800	463	0.009	0.018	0.014	0.014
1 L - 3	2	10:48:00	1,800	463	0.010	0.019	0.014	0.014
1 L - 3	4	10:50:00	1,800	463	0.010	0.020	0.015	0.015
1 L - 3	8	10:54:00	1,800	463	0.011	0.021	0.016	0.016
1 L - 4	1	10:56:00	2,400	615	0.042	0.057	0.049	0.050
1 L - 4	2	10:57:00	2,400	615	0.049	0.068	0.059	0.059
1 L - 4	4	10:59:00	2,400	615	0.064	0.086	0.075	0.075
1 L - 4	8	11:03:00	2,400	615	0.075	0.097	0.085	0.086
1 L - 5	1	11:05:00	3,000	767	0.120	0.151	0.133	0.136
1 L - 5	2	11:06:00	3,000	767	0.128	0.160	0.141	0.144
1 L - 5	4	11:08:00	3,000	767	0.143	0.174	0.153	0.158
1 L - 5	8	11:12:00	3,000	767	0.158	0.190	0.168	0.174
1 L - 6	1	11:14:00	3,600	919	0.214	0.257	0.227	0.235
1 L - 6	2	11:15:00	3,600	919	0.224	0.269	0.238	0.246
1 L - 6	4	11:17:00	3,600	919	0.237	0.283	0.252	0.260
1 L - 6	8	11:21:00	3,600	919	0.252	0.301	0.268	0.277
1 L - 7	1	11:23:00	4,200	1,070	0.319	0.381	0.347	0.350
1 L - 7	2	11:24:00	4,200	1,070	0.333	0.398	0.363	0.366
1 L - 7	4	11:26:00	4,200	1,070	0.353	0.421	0.384	0.387
1 L - 7	8	11:30:00	4,200	1,070	0.376	0.447	0.407	0.411
1 L - 8	1	11:32:00	4,800	1,222	0.464	0.554	0.502	0.509
1 L - 8	2	11:33:00	4,800	1,222	0.487	0.581	0.526	0.534
1 L - 8	4	11:35:00	4,800	1,222	0.519	0.618	0.558	0.568
1 L - 8	8	11:39:00	4,800	1,222	0.556	0.660	0.595	0.608
1 L - 9	1	11:41:00	5,400	1,374	0.674	0.803	0.720	0.738
1 L - 9	2	11:42:00	5,400	1,374	0.706	0.841	0.754	0.773
1 L - 9	4	11:44:00	5,400	1,374	0.754	0.894	0.805	0.824
1 L - 9	8	11:48:00	5,400	1,374	0.816	0.963	0.867	0.889
1 U - 1	1	11:50:00	4,200	1,070	0.811	0.959	0.869	0.885
1 U - 1	2	11:51:00	4,200	1,070	0.811	0.959	0.869	0.885
1 U - 1	4	11:53:00	4,200	1,070	0.812	0.960	0.869	0.886
1 U - 2	1	11:55:00	3,000	767	0.787	0.931	0.843	0.859
1 U - 2	2	11:56:00	3,000	767	0.787	0.931	0.843	0.859
1 U - 2	4	11:58:00	3,000	767	0.787	0.931	0.843	0.859
1 U - 3	1	12:00:00	2,400	615	0.740	0.874	0.790	0.807
1 U - 3	2	12:01:00	2,400	615	0.736	0.870	0.786	0.803
1 U - 3	4	12:03:00	2,400	615	0.734	0.868	0.784	0.801
1 U - 4	1	12:05:30	1,200	311	0.654	0.771	0.693	0.713
1 U - 4	2	12:06:30	1,200	311	0.651	0.769	0.690	0.710
1 U - 4	4	12:08:30	1,200	311	0.646	0.762	0.685	0.704
1 U - 5	1	12:12:30	0	0	0.446	0.533	0.471	0.489
1 U - 5	2	12:13:30	0	0	0.436	0.522	0.461	0.479
1 U - 5	4	12:15:30	0	0	0.424	0.510	0.448	0.467
1 U - 5	8	12:19:30	0	0	0.413	0.498	0.436	0.455
1 U - 5	15	12:26:30	0	0	0.404	0.488	0.427	0.446

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

Upward and Downward O-cell Plate Movement and Creep (calculated)
TP-2 - Crosstown Commons Project - Minneapolis, MN

Load Test Increment	Hold Time (minutes)	Time (h:m:s)	O-cell Pressure (psi)	O-cell Load (kips)	Top of Shaft (in)	Total Comp. * (in)	Top Plate Movement (in)	O-cell Expansion (in)	Bot. Plate Movement (in)	Creep Up Per Hold (in)	Creep Dn Per Hold (in)
1 L - 0	-	10:27:00	0	0	0.000	0.000	0.000	0.000	0.000		
1 L - 1	1	10:30:00	600	159	0.001	0.000	0.001	0.002	-0.001		
1 L - 1	2	10:31:00	600	159	0.001	0.000	0.001	0.002	0.000	0.001	-0.001
1 L - 1	4	10:33:00	600	159	0.001	0.000	0.001	0.002	-0.001	0.000	0.000
1 L - 1	8	10:37:00	600	159	0.001	0.000	0.001	0.002	-0.001	-0.001	0.001
1 L - 2	1	10:38:30	1,200	311	0.002	0.000	0.002	0.006	-0.005		
1 L - 2	2	10:39:30	1,200	311	0.002	0.000	0.002	0.007	-0.005	0.000	0.000
1 L - 2	4	10:41:30	1,200	311	0.002	0.000	0.002	0.007	-0.005	0.000	0.000
1 L - 2	8	10:45:30	1,200	311	0.002	0.000	0.002	0.007	-0.006	0.000	0.001
1 L - 3	1	10:47:00	1,800	463	0.001	0.000	0.001	0.014	-0.012		
1 L - 3	2	10:48:00	1,800	463	0.002	0.000	0.002	0.014	-0.012	0.001	0.000
1 L - 3	4	10:50:00	1,800	463	0.003	0.000	0.004	0.015	-0.012	0.001	-0.001
1 L - 3	8	10:54:00	1,800	463	0.004	0.000	0.004	0.016	-0.012	0.000	0.001
1 L - 4	1	10:56:00	2,400	615	0.010	0.000	0.010	0.050	-0.040		
1 L - 4	2	10:57:00	2,400	615	0.012	0.000	0.012	0.059	-0.047	0.002	0.007
1 L - 4	4	10:59:00	2,400	615	0.016	0.000	0.016	0.075	-0.059	0.005	0.012
1 L - 4	8	11:03:00	2,400	615	0.023	0.001	0.023	0.086	-0.063	0.007	0.004
1 L - 5	1	11:05:00	3,000	767	0.031	0.001	0.032	0.136	-0.104		
1 L - 5	2	11:06:00	3,000	767	0.032	0.001	0.033	0.144	-0.111	0.001	0.007
1 L - 5	4	11:08:00	3,000	767	0.034	0.001	0.036	0.158	-0.123	0.002	0.011
1 L - 5	8	11:12:00	3,000	767	0.039	0.001	0.041	0.174	-0.133	0.005	0.010
1 L - 6	1	11:14:00	3,600	919	0.049	0.002	0.051	0.235	-0.184		
1 L - 6	2	11:15:00	3,600	919	0.052	0.002	0.054	0.246	-0.193	0.003	0.009
1 L - 6	4	11:17:00	3,600	919	0.055	0.002	0.057	0.260	-0.203	0.004	0.011
1 L - 6	8	11:21:00	3,600	919	0.062	0.002	0.064	0.277	-0.213	0.007	0.009
1 L - 7	1	11:23:00	4,200	1,070	0.080	0.003	0.083	0.350	-0.267		
1 L - 7	2	11:24:00	4,200	1,070	0.085	0.003	0.088	0.366	-0.277	0.006	0.010
1 L - 7	4	11:26:00	4,200	1,070	0.093	0.003	0.096	0.387	-0.291	0.007	0.014
1 L - 7	8	11:30:00	4,200	1,070	0.106	0.003	0.109	0.411	-0.302	0.014	0.011
1 L - 8	1	11:32:00	4,800	1,222	0.134	0.004	0.138	0.509	-0.371		
1 L - 8	2	11:33:00	4,800	1,222	0.145	0.004	0.149	0.534	-0.385	0.010	0.014
1 L - 8	4	11:35:00	4,800	1,222	0.162	0.004	0.166	0.568	-0.402	0.017	0.017
1 L - 8	8	11:39:00	4,800	1,222	0.186	0.004	0.190	0.608	-0.418	0.024	0.016
1 L - 9	1	11:41:00	5,400	1,374	0.227	0.005	0.232	0.738	-0.507		
1 L - 9	2	11:42:00	5,400	1,374	0.244	0.005	0.249	0.773	-0.524	0.018	0.017
1 L - 9	4	11:44:00	5,400	1,374	0.268	0.005	0.273	0.824	-0.551	0.024	0.027
1 L - 9	8	11:48:00	5,400	1,374	0.297	0.005	0.302	0.889	-0.588	0.029	0.037
1 U - 1	1	11:50:00	4,200	1,070	0.299	0.005	0.304	0.885	-0.582		
1 U - 1	2	11:51:00	4,200	1,070	0.299	0.005	0.304	0.885	-0.581		
1 U - 1	4	11:53:00	4,200	1,070	0.297	0.005	0.302	0.886	-0.584		
1 U - 2	1	11:55:00	3,000	767	0.291	0.005	0.296	0.859	-0.563		
1 U - 2	2	11:56:00	3,000	767	0.291	0.005	0.296	0.859	-0.563		
1 U - 2	4	11:58:00	3,000	767	0.287	0.005	0.292	0.859	-0.567		
1 U - 3	1	12:00:00	2,400	615	0.275	0.005	0.280	0.807	-0.527		
1 U - 3	2	12:01:00	2,400	615	0.274	0.005	0.279	0.803	-0.525		
1 U - 3	4	12:03:00	2,400	615	0.267	0.005	0.272	0.801	-0.529		
1 U - 4	1	12:05:30	1,200	311	0.243	0.005	0.248	0.713	-0.464		
1 U - 4	2	12:06:30	1,200	311	0.242	0.005	0.247	0.710	-0.463		
1 U - 4	4	12:08:30	1,200	311	0.239	0.004	0.244	0.704	-0.460		
1 U - 5	1	12:12:30	0	0	0.139	0.004	0.144	0.489	-0.346		
1 U - 5	2	12:13:30	0	0	0.136	0.004	0.140	0.479	-0.340		
1 U - 5	4	12:15:30	0	0	0.132	0.004	0.136	0.467	-0.331		
1 U - 5	8	12:19:30	0	0	0.128	0.004	0.132	0.455	-0.323		
1 U - 5	15	12:26:30	0	0	0.124	0.004	0.129	0.446	-0.318		

Strain Gage Readings and Loads at Levels 1 and 2
TP-2 - Crosstown Commons Project - Minneapolis, MN

Load Test Increment	Hold Time (minutes)	Time (h:m:s)	O-cell Pressure (psi)	O-cell Load (kips)	Level 1 A - 08-1448 ($\mu\varepsilon$)	Level 1 B - 08-1449 ($\mu\varepsilon$)	Level 1 Av. Load (kips)	Level 2 A - 07-29169 ($\mu\varepsilon$)	Level 2 B - 07-29170 ($\mu\varepsilon$)	Level 2 Av. Load (kips)
1 L - 0	-	10:27:00	0	0	0.0	0.0	0	0.0	0.0	0
1 L - 1	1	10:30:00	600	159	-1.0	-1.2	-21	-0.1	0.8	6
1 L - 1	2	10:31:00	600	159	-0.9	-1.2	-19	-0.1	0.7	6
1 L - 1	4	10:33:00	600	159	-1.1	-1.5	-24	-0.3	0.8	5
1 L - 1	8	10:37:00	600	159	-1.2	-1.3	-23	-0.2	0.8	6
1 L - 2	1	10:38:30	1,200	311	-3.6	1.2	-23	-1.3	3.9	24
1 L - 2	2	10:39:30	1,200	311	-3.7	1.4	-22	-1.4	4.2	26
1 L - 2	4	10:41:30	1,200	311	-3.7	1.6	-20	-1.5	4.0	23
1 L - 2	8	10:45:30	1,200	311	-3.9	1.8	-20	-1.5	4.2	25
1 L - 3	1	10:47:00	1,800	463	-7.1	5.0	-19	-2.8	8.6	55
1 L - 3	2	10:48:00	1,800	463	-7.1	5.6	-14	-3.2	8.8	52
1 L - 3	4	10:50:00	1,800	463	-7.4	5.9	-14	-3.0	9.0	57
1 L - 3	8	10:54:00	1,800	463	-7.5	6.1	-13	-3.4	9.2	54
1 L - 4	1	10:56:00	2,400	615	-2.0	4.0	19	1.6	10.4	113
1 L - 4	2	10:57:00	2,400	615	-1.0	5.5	42	1.9	11.2	123
1 L - 4	4	10:59:00	2,400	615	0.6	6.6	68	2.8	11.6	136
1 L - 4	8	11:03:00	2,400	615	1.6	6.9	80	3.1	12.0	142
1 L - 5	1	11:05:00	3,000	767	4.3	10.4	138	4.9	16.1	197
1 L - 5	2	11:06:00	3,000	767	4.9	10.8	147	5.0	16.4	201
1 L - 5	4	11:08:00	3,000	767	5.7	11.4	160	5.7	16.8	212
1 L - 5	8	11:12:00	3,000	767	6.1	12.1	171	5.7	17.5	218
1 L - 6	1	11:14:00	3,600	919	7.7	15.9	222	6.9	22.3	274
1 L - 6	2	11:15:00	3,600	919	8.0	16.3	228	7.1	22.8	282
1 L - 6	4	11:17:00	3,600	919	8.4	16.8	237	7.1	23.2	285
1 L - 6	8	11:21:00	3,600	919	8.7	17.3	244	7.3	23.6	290
1 L - 7	1	11:23:00	4,200	1,070	10.2	20.4	288	8.6	28.0	343
1 L - 7	2	11:24:00	4,200	1,070	10.5	20.8	294	8.8	28.2	347
1 L - 7	4	11:26:00	4,200	1,070	10.8	21.1	300	8.9	28.5	352
1 L - 7	8	11:30:00	4,200	1,070	11.0	22.1	310	9.1	29.1	359
1 L - 8	1	11:32:00	4,800	1,222	12.0	27.4	371	9.9	34.9	421
1 L - 8	2	11:33:00	4,800	1,222	12.3	28.0	379	10.4	35.4	430
1 L - 8	4	11:35:00	4,800	1,222	12.5	28.7	387	10.5	36.0	437
1 L - 8	8	11:39:00	4,800	1,222	12.8	29.4	397	10.7	36.2	441
1 L - 9	1	11:41:00	5,400	1,374	13.9	33.9	449	12.3	41.7	507
1 L - 9	2	11:42:00	5,400	1,374	14.2	34.6	458	12.6	42.0	514
1 L - 9	4	11:44:00	5,400	1,374	14.5	35.7	472	13.1	42.6	523
1 L - 9	8	11:48:00	5,400	1,374	14.9	37.1	488	13.4	43.4	534
1 U - 1	1	11:50:00	4,200	1,070	11.7	37.3	461	11.0	42.1	499
1 U - 1	2	11:51:00	4,200	1,070	11.8	37.0	458	11.0	41.8	495
1 U - 1	4	11:53:00	4,200	1,070	11.6	36.6	453	10.8	41.4	491
1 U - 2	1	11:55:00	3,000	767	7.9	31.6	372	7.7	35.9	410
1 U - 2	2	11:56:00	3,000	767	7.9	31.8	374	7.8	36.1	412
1 U - 2	4	11:58:00	3,000	767	8.1	31.8	374	7.8	36.1	413
1 U - 3	1	12:00:00	2,400	615	3.7	23.3	254	4.1	27.5	297
1 U - 3	2	12:01:00	2,400	615	3.4	23.1	249	3.8	27.1	290
1 U - 3	4	12:03:00	2,400	615	3.2	23.0	246	3.5	27.0	287
1 U - 4	1	12:05:30	1,200	311	-1.5	13.0	107	-0.6	18.2	165
1 U - 4	2	12:06:30	1,200	311	-1.4	12.8	107	-0.5	18.3	168
1 U - 4	4	12:08:30	1,200	311	-1.9	12.1	96	-0.9	17.8	159
1 U - 5	1	12:12:30	0	0	-4.5	-3.4	-74	-3.2	3.1	-1
1 U - 5	2	12:13:30	0	0	-4.6	-3.8	-79	-3.0	2.8	-1
1 U - 5	4	12:15:30	0	0	-4.7	-4.3	-84	-3.0	2.4	-6
1 U - 5	8	12:19:30	0	0	-4.8	-5.0	-92	-3.1	2.0	-11
1 U - 5	15	12:26:30	0	0	-4.9	-5.1	-94	-3.1	1.6	-13

Strain Gage Readings and Loads at Levels 3 and 4
TP-2 - Crosstown Commons Project - Minneapolis, MN

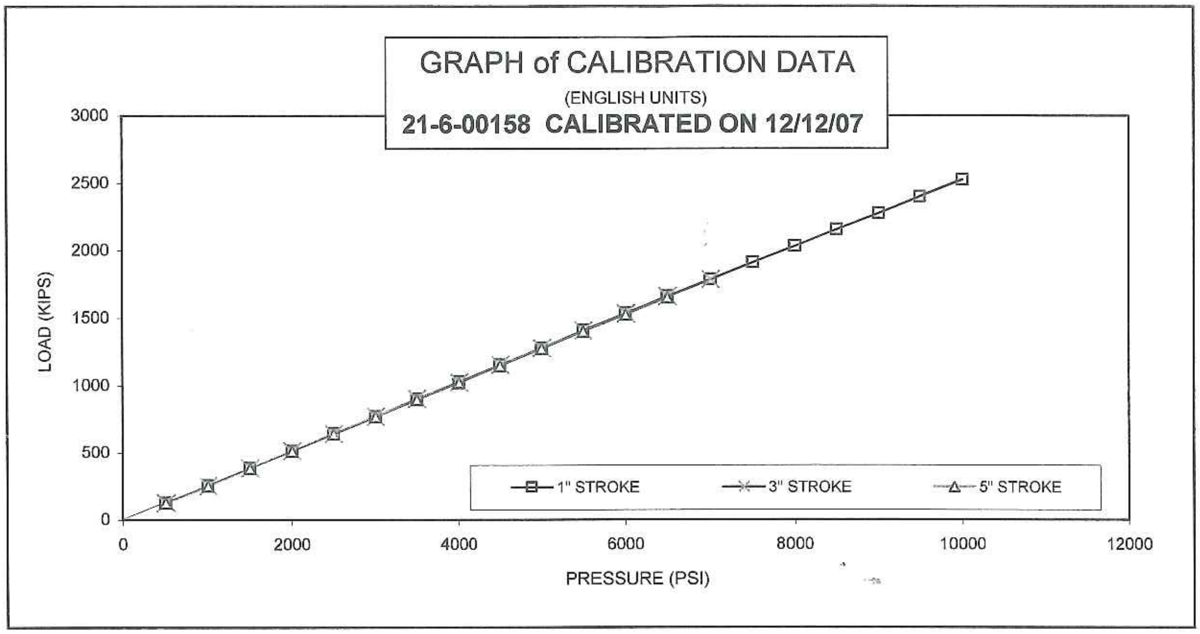
Load Test Increment	Hold Time (minutes)	Time (h:m:s)	O-cell Pressure (psi)	O-cell Load (kips)	Level 3 A - 08-1493 (με)	Level 3 B - 08-1494 (με)	Level 3 Av. Load (kips)	Level 4 A - 07-29171 (με)	Level 4 B - 07-29172 (με)	Level 4 Av. Load (kips)
1 L - 0	-	10:27:00	0	0	0.0	0.0	0	0.0	0.0	0
1 L - 1	1	10:30:00	600	159	0.6	0.0	6	0.2	-0.1	1
1 L - 1	2	10:31:00	600	159	0.0	-0.1	-1	0.1	-0.1	0
1 L - 1	4	10:33:00	600	159	0.3	0.0	3	0.1	-0.2	-1
1 L - 1	8	10:37:00	600	159	0.0	-0.1	-1	0.1	-0.2	-1
1 L - 2	1	10:38:30	1,200	311	0.1	0.2	3	0.2	-0.3	-1
1 L - 2	2	10:39:30	1,200	311	0.2	0.1	3	0.2	-0.2	0
1 L - 2	4	10:41:30	1,200	311	0.1	0.3	4	0.3	-0.1	2
1 L - 2	8	10:45:30	1,200	311	0.1	0.3	4	0.2	-0.1	1
1 L - 3	1	10:47:00	1,800	463	-0.2	0.9	7	0.3	-0.2	1
1 L - 3	2	10:48:00	1,800	463	-0.2	1.1	8	0.5	-0.1	4
1 L - 3	4	10:50:00	1,800	463	-0.2	1.0	8	0.3	0.1	4
1 L - 3	8	10:54:00	1,800	463	-0.2	0.9	7	0.4	-0.1	3
1 L - 4	1	10:56:00	2,400	615	1.4	2.5	36	0.8	0.3	11
1 L - 4	2	10:57:00	2,400	615	1.6	2.8	41	0.8	0.6	15
1 L - 4	4	10:59:00	2,400	615	2.0	2.9	46	0.8	0.5	14
1 L - 4	8	11:03:00	2,400	615	2.5	3.4	56	0.8	0.6	14
1 L - 5	1	11:05:00	3,000	767	3.3	4.6	74	1.2	0.7	19
1 L - 5	2	11:06:00	3,000	767	3.3	4.7	75	1.2	0.9	21
1 L - 5	4	11:08:00	3,000	767	3.4	4.7	76	1.2	0.9	21
1 L - 5	8	11:12:00	3,000	767	4.0	4.9	84	1.3	0.9	22
1 L - 6	1	11:14:00	3,600	919	4.1	5.9	94	1.6	1.2	29
1 L - 6	2	11:15:00	3,600	919	4.4	6.3	101	1.6	1.2	28
1 L - 6	4	11:17:00	3,600	919	4.8	6.4	106	1.6	1.2	28
1 L - 6	8	11:21:00	3,600	919	4.8	6.5	106	1.6	1.3	30
1 L - 7	1	11:23:00	4,200	1,070	5.8	7.2	122	2.0	1.5	36
1 L - 7	2	11:24:00	4,200	1,070	6.1	7.3	125	2.2	1.5	38
1 L - 7	4	11:26:00	4,200	1,070	5.9	7.4	125	2.1	1.6	38
1 L - 7	8	11:30:00	4,200	1,070	6.1	7.5	128	2.2	1.6	39
1 L - 8	1	11:32:00	4,800	1,222	6.5	8.3	140	2.7	1.6	44
1 L - 8	2	11:33:00	4,800	1,222	7.0	8.5	146	2.8	1.7	45
1 L - 8	4	11:35:00	4,800	1,222	7.2	8.4	146	2.9	1.4	44
1 L - 8	8	11:39:00	4,800	1,222	7.5	8.1	146	2.8	1.4	42
1 L - 9	1	11:41:00	5,400	1,374	8.6	8.8	163	3.4	1.5	50
1 L - 9	2	11:42:00	5,400	1,374	8.9	8.8	166	3.5	1.4	49
1 L - 9	4	11:44:00	5,400	1,374	9.4	8.8	171	3.5	1.5	50
1 L - 9	8	11:48:00	5,400	1,374	9.7	8.5	171	3.5	1.4	50
1 U - 1	1	11:50:00	4,200	1,070	9.1	8.2	163	3.2	1.5	48
1 U - 1	2	11:51:00	4,200	1,070	8.9	8.3	162	3.1	1.2	43
1 U - 1	4	11:53:00	4,200	1,070	8.7	8.3	160	3.0	1.2	43
1 U - 2	1	11:55:00	3,000	767	7.4	6.9	135	2.5	0.7	32
1 U - 2	2	11:56:00	3,000	767	7.3	7.0	134	2.5	0.9	34
1 U - 2	4	11:58:00	3,000	767	7.2	7.0	134	2.5	0.8	33
1 U - 3	1	12:00:00	2,400	615	5.4	4.9	96	1.9	0.3	23
1 U - 3	2	12:01:00	2,400	615	5.4	4.7	95	1.9	0.2	22
1 U - 3	4	12:03:00	2,400	615	5.4	4.8	95	1.8	0.2	21
1 U - 4	1	12:05:30	1,200	311	3.0	3.2	58	1.3	-0.4	9
1 U - 4	2	12:06:30	1,200	311	3.0	3.1	57	1.3	-0.4	9
1 U - 4	4	12:08:30	1,200	311	2.8	3.0	55	1.3	-0.4	9
1 U - 5	1	12:12:30	0	0	-1.9	1.0	-8	-0.2	-0.4	-6
1 U - 5	2	12:13:30	0	0	-1.6	1.1	-5	-0.4	-0.5	-9
1 U - 5	4	12:15:30	0	0	-1.9	1.1	-8	-0.3	-0.5	-8
1 U - 5	8	12:19:30	0	0	-2.0	0.9	-10	-0.4	-0.6	-10
1 U - 5	15	12:26:30	0	0	-1.9	1.1	-8	-0.3	-0.6	-9

Strain Gage Readings and Loads at Levels 5
TP-2 - Crosstown Commons Project - Minneapolis, MN

Load Test Increment	Hold Time (minutes)	Time (h:m:s)	O-cell Pressure (psi)	O-cell Load (kips)	Level 5 A - 08-1495 (με)	Level 5 B - 08-1496 (με)	Level 5 Av. Load (kips)
1 L - 0	-	10:27:00	0	0	0.0	0.0	0
1 L - 1	1	10:30:00	600	159	-0.1	-0.3	-5
1 L - 1	2	10:31:00	600	159	-0.1	-0.2	-5
1 L - 1	4	10:33:00	600	159	0.4	-0.1	4
1 L - 1	8	10:37:00	600	159	-0.1	-0.1	-3
1 L - 2	1	10:38:30	1,200	311	0.1	0.0	1
1 L - 2	2	10:39:30	1,200	311	-0.1	-0.2	-4
1 L - 2	4	10:41:30	1,200	311	0.0	-0.1	-1
1 L - 2	8	10:45:30	1,200	311	0.0	0.1	1
1 L - 3	1	10:47:00	1,800	463	0.4	0.1	6
1 L - 3	2	10:48:00	1,800	463	0.3	0.0	4
1 L - 3	4	10:50:00	1,800	463	0.1	0.0	2
1 L - 3	8	10:54:00	1,800	463	0.3	0.0	4
1 L - 4	1	10:56:00	2,400	615	0.0	0.4	6
1 L - 4	2	10:57:00	2,400	615	-0.2	0.2	1
1 L - 4	4	10:59:00	2,400	615	0.0	0.1	2
1 L - 4	8	11:03:00	2,400	615	-0.7	0.2	-6
1 L - 5	1	11:05:00	3,000	767	-0.2	0.9	9
1 L - 5	2	11:06:00	3,000	767	0.4	0.6	13
1 L - 5	4	11:08:00	3,000	767	0.3	0.6	13
1 L - 5	8	11:12:00	3,000	767	-0.1	0.5	5
1 L - 6	1	11:14:00	3,600	919	0.0	0.7	10
1 L - 6	2	11:15:00	3,600	919	0.4	1.2	21
1 L - 6	4	11:17:00	3,600	919	0.9	1.0	26
1 L - 6	8	11:21:00	3,600	919	0.3	1.2	20
1 L - 7	1	11:23:00	4,200	1,070	0.4	1.7	28
1 L - 7	2	11:24:00	4,200	1,070	0.3	1.6	26
1 L - 7	4	11:26:00	4,200	1,070	0.8	1.8	34
1 L - 7	8	11:30:00	4,200	1,070	0.6	1.9	34
1 L - 8	1	11:32:00	4,800	1,222	0.7	2.6	45
1 L - 8	2	11:33:00	4,800	1,222	0.6	2.3	39
1 L - 8	4	11:35:00	4,800	1,222	0.0	2.7	35
1 L - 8	8	11:39:00	4,800	1,222	0.3	2.6	40
1 L - 9	1	11:41:00	5,400	1,374	0.8	2.8	49
1 L - 9	2	11:42:00	5,400	1,374	0.4	3.4	51
1 L - 9	4	11:44:00	5,400	1,374	0.4	3.0	46
1 L - 9	8	11:48:00	5,400	1,374	0.4	3.4	51
1 U - 1	1	11:50:00	4,200	1,070	0.8	3.4	57
1 U - 1	2	11:51:00	4,200	1,070	0.1	3.2	44
1 U - 1	4	11:53:00	4,200	1,070	0.6	3.2	52
1 U - 2	1	11:55:00	3,000	767	0.2	3.4	49
1 U - 2	2	11:56:00	3,000	767	0.1	3.2	43
1 U - 2	4	11:58:00	3,000	767	0.2	3.5	49
1 U - 3	1	12:00:00	2,400	615	-0.1	3.2	41
1 U - 3	2	12:01:00	2,400	615	-0.3	3.5	43
1 U - 3	4	12:03:00	2,400	615	-0.4	3.3	40
1 U - 4	1	12:05:30	1,200	311	0.1	3.3	46
1 U - 4	2	12:06:30	1,200	311	-0.5	3.2	37
1 U - 4	4	12:08:30	1,200	311	-0.1	3.1	40
1 U - 5	1	12:12:30	0	0	-0.6	2.8	30
1 U - 5	2	12:13:30	0	0	-0.2	2.8	35
1 U - 5	4	12:15:30	0	0	-0.7	2.9	29
1 U - 5	8	12:19:30	0	0	0.0	3.2	43
1 U - 5	15	12:26:30	0	0	-0.7	3.0	32

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	126	126	126
1000	254	252	252
1500	385	385	385
2000	512	511	511
2500	643	642	642
3000	769	769	768
3500	897	898	894
4000	1026	1022	1020
4500	1152	1152	1146
5000	1278	1278	1274
5500	1407	1404	1400
6000	1532	1530	1524
6500	1658	1656	1650
7000	1784	1782	
7500	1910		
8000	2033		
8500	2154		
9000	2277		
9500	2399		
10000	2525		

21" O-CELL, SERIAL # 21-6-00158

LOAD CONVERSION FORMULA

LOAD = PRESSURE * 0.2533 + (6.62)
{KIPS} {PSI}

Regression Output:

Constant	6.6193 kips
X Coefficient	0.2533 kip / psi
R Square	0.9999
No. of Observations	47
Degrees of Freedom	45
Std Err of Y Est	5.36
Std Err of X Coeff	0.0003

CALIBRATION STANDARDS:

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

* AE & FC CUSTOMER: LOADTEST Inc	* CONTRACTOR.: ATLAS FOUNDATION
* AE & FC JOB NO: SO3023	* JOB LOCATION: MAPLE GROVE, MN
* CUSTOMER P.O. NO.: LT-9193	* DATED: 12/28/07

SERVICE ENGINEER: ________ DATE: 1-3-08

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

Vibrating Wire Displacement Transducer Calibration Report

Range: 150 mm

Serial Number: 07-28142

Calibration Date: December 21, 2007

Temperature: 23.6 °C

Calibration Instruction: CI-4400

Technician: J. Ouellette

GK-401 Reading Position B

Actual Displacement (mm)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Displacement (Linear)	Error Linear (%FS)	Calculated Displacement (Polynomial)	Error Polynomial (%FS)
0.0	2585	2585	2585	0.08	0.05	0.09	0.06
30.0	3516	3516	3516	29.85	-0.10	29.85	-0.10
60.0	4460	4458	4459	60.01	0.00	60.00	0.00
90.0	5398	5396	5397	90.00	0.00	89.99	-0.01
120.0	6341	6340	6341	120.18	0.12	120.17	0.12
150.0	7269	7270	7270	149.88	-0.08	149.90	-0.07

(mm) Linear Gage Factor (G): 0.03198 (mm/ digit) **Regression Zero: 2583**

Polynomial Gage Factors: A: 5.16348E-09 B: 0.03193 C: -82.475

(inches) Linear Gage Factor (G): 0.001259 (inches/ digit)

Polynomial Gage Factors: A: 2.03287E-10 B: 0.001257 C: -3.2470

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

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

Refer to manual for temperature correction information.

Function Test at Shipment:

GK-401 Pos. B : 4938 Temp(T_0): 20.8 °C Date: January 07, 2008

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

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

Vibrating Wire Displacement Transducer Calibration Report

Range: 150 mm

Serial Number: 07-28143

Calibration Date: December 21, 2007

Temperature: 23.6 °C

Calibration Instruction: CI-4400

Technician: [signature]

GK-401 Reading Position B

Actual Displacement (mm)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Displacement (Linear)	Error Linear (%FS)	Calculated Displacement (Polynomial)	Error Polynomial (%FS)
0.0	2617	2616	2617	-0.05	-0.03	-0.04	-0.02
30.0	3553	3552	3553	30.08	0.05	30.08	0.05
60.0	4483	4482	4483	60.01	0.01	60.01	0.00
90.0	5410	5410	5410	89.87	-0.09	89.86	-0.09
120.0	6350	6350	6350	120.12	0.08	120.12	0.08
150.0	7277	7277	7277	149.96	-0.03	149.97	-0.02

(mm) Linear Gage Factor (G): 0.03219 (mm/ digit) **Regression Zero: 2618**

Polynomial Gage Factors: A: 3.2638E-09 B: 0.03215 C: -84.189

(inches) Linear Gage Factor (G): 0.001267 (inches/ digit)

Polynomial Gage Factors: A: 1.28496E-10 B: 0.001266 C: -3.3145

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

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

Refer to manual for temperature correction information.

Function Test at Shipment:

GK-401 Pos. B : 4955 Temp(T_0): 21.4 °C Date: January 07, 2008

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

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

Vibrating Wire Displacement Transducer Calibration Report

Range: 150 mm

Serial Number: 07-28144

Calibration Date: December 21, 2007

Temperature: 23.6 °C

Calibration Instruction: CI-4400

Technician: J. Ouellette

GK-401 Reading Position B

Actual Displacement (mm)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Displacement (Linear)	Error Linear (%FS)	Calculated Displacement (Polynomial)	Error Polynomial (%FS)
0.0	2646	2646	2646	-0.15	-0.10	0.03	0.02
30.0	3590	3588	3589	30.03	0.02	30.00	0.00
60.0	4526	4526	4526	60.02	0.01	59.88	-0.08
90.0	5470	5470	5470	90.23	0.16	90.10	0.07
120.0	6401	6403	6402	120.06	0.04	120.03	0.02
150.0	7331	7331	7331	149.79	-0.14	149.96	-0.02

(mm) Linear Gage Factor (G): 0.03200 (mm/ digit) **Regression Zero: 2651**

Polynomial Gage Factors: A: 5.85359E-08 B: 0.03142 C: -83.522

(inches) Linear Gage Factor (G): 0.001260 (inches/ digit)

Polynomial Gage Factors: A: 2.30456E-09 B: 0.001237 C: -3.2883

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

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

Refer to manual for temperature correction information.

Function Test at Shipment:

GK-401 Pos. B : 4999 Temp(T_0): 20.7 °C Date: January 07, 2008

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

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

Sister Bar Calibration Report

Model Number : 4911-4

Date of Calibration: January 17, 2008

Serial Number: 08-1448

Cable Length: 73 ft.

Prestress: 35,000 psi

Factory Zero Reading: 6649

Temperature: 21.9 °C

Regression Zero: 6674

Calibration Instruction: CI-VW Rebar

Technician: Erica

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	6733	6728	6731		
1,500	7392	7388	7390	660	-0.21
3,000	8112	8113	8113	723	-0.20
4,500	8843	8837	8840	728	-0.02
6,000	9570	9566	9568	728	0.18
100	6728				

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

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

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

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

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

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

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

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

Sister Bar Calibration Report

Model Number : 4911-4

Date of Calibration: January 17, 2008

Serial Number: 08-1449

Cable Length: 73 ft.

Prestress: 35,000 psi

Factory Zero Reading: 7022

Temperature: 21.7 °C

Regression Zero: 7037

Calibration Instruction: CI-VW Rebar

Technician: ERice

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7094	7093	7094		
1,500	7781	7784	7783	689	-0.22
3,000	8538	8539	8539	756	-0.08
4,500	9290	9297	9294	755	0.02
6,000	10047	10048	10048	754	0.09
100	7093				

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

Date of Calibration: December 28, 2007

Serial Number: 07-29169

Cable Length: 73 ft.

Prestress: 35,000 psi

Factory Zero Reading: 6779

Temperature: 21.0 °C

Regression Zero: 6784

Calibration Instruction: CI-VW Rebar

Technician: J. Ouellette

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	6838	6839	6839		
1,500	7497	7495	7496	658	-0.24
3,000	8219	8221	8220	724	-0.07
4,500	8944	8942	8943	723	0.06
6,000	9664	9660	9662	719	0.06
100	6839				

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

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

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

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

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

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

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

Sister Bar Calibration Report

Model Number : 4911-4

Date of Calibration: December 28, 2007

Serial Number: 07-29170

Cable Length: 73 ft.

Prestress: 35,000 psi

Factory Zero Reading: 6947

Temperature: 20.8 °C

Regression Zero: 6953

Calibration Instruction: CI-VW Rebar

Technician: J. Ouellette

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7011	7011	7011		
1,500	7686	7688	7687	676	-0.22
3,000	8430	8429	8430	743	-0.15
4,500	9176	9175	9176	746	0.03
6,000	9918	9921	9920	744	0.15
100	7011				

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: 08-1494

Prestress: 35,000 psi

Temperature: 21.8 °C

Calibration Instruction: CI-VW Rebar

Date of Calibration: January 18, 2008

Cable Length: 68 ft.

Factory Zero Reading: 7034

Regression Zero: 7043

Technician: ERice

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	7094	7096	7095		
1,500	7761	7762	7762	667	-0.09
3,000	8483	8484	8484	722	-0.05
4,500	9206	9208	9207	724	0.04
6,000	9930	9928	9929	722	0.07
100	7096				

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

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

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

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

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

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

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

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

Sister Bar Calibration Report

Model Number : 4911-4

Date of Calibration: January 18, 2008

Serial Number: 08-1493

Cable Length: 68 ft.

Prestress: 35,000 psi

Factory Zero Reading: 6648

Temperature: 21.7 °C

Regression Zero: 6657

Calibration Instruction: CI-VW Rebar

Technician: ERice

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	6715	6717	6716		
1,500	7377	7377	7377	661	-0.35
3,000	8113	8111	8112	735	-0.18
4,500	8852	8848	8850	738	0.09
6,000	9581	9581	9581	731	0.12
100	6718				

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

Gage Factor: 0.347 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: 07-29171

Prestress: 35,000 psi

Temperature: 20.8 °C

Calibration Instruction: CI-VW Rebar

Date of Calibration: December 28, 2007

Cable Length: 63 ft.

Factory Zero Reading: 6801

Regression Zero: 6809

Technician: *J. Ouellette*

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	6868	6866	6867		
1,500	7535	7538	7537	670	-0.25
3,000	8273	8273	8273	737	-0.20
4,500	9016	9013	9015	742	0.03
6,000	9753	9753	9753	739	0.15
100	6867				

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

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

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

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

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

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

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

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

Sister Bar Calibration Report

Model Number : 4911-4

Date of Calibration: December 28, 2007

Serial Number: 07-29172

Cable Length: 63 ft.

Prestress: 35,000 psi

Factory Zero Reading: 6786

Temperature: 20.8 °C

Regression Zero: 6791

Calibration Instruction: CI-VW Rebar

Technician: J. Ouellette

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	6854	6855	6855		
1,500	7532	7530	7531	677	-0.38
3,000	8289	8288	8289	758	-0.19
4,500	9048	9048	9048	760	0.08
6,000	9804	9802	9803	755	0.19
100	6855				

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

Gage Factor: 0.340 microstrain/ digit (GK-401 Pos."B")

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

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

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

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

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

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

Sister Bar Calibration Report

Model Number : 4911-4

Date of Calibration: January 18, 2008

Serial Number: 08-1496

Cable Length: 58 ft.

Prestress: 35,000 psi

Factory Zero Reading: 6887

Temperature: 21.8 °C

Regression Zero: 6897

Calibration Instruction: CI-VW Rebar

Technician: Erica

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	6947	6950	6949		
1,500	7619	7623	7621	673	-0.08
3,000	8346	8348	8347	726	-0.08
4,500	9077	9079	9078	731	0.08
6,000	9802	9803	9803	725	0.02
100	6949				

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

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

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

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

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

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

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

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

Sister Bar Calibration Report

Model Number : 4911-4

Serial Number: 08-1495

Prestress: 35,000 psi

Temperature: 22.1 °C

Calibration Instruction: CI-VW Rebar

Date of Calibration: January 18, 2008

Cable Length: 58 ft.

Factory Zero Reading: 6559

Regression Zero: 6571

Technician: Erica

Applied Load: (pounds)	Readings				Linearity % Max.Load
	Cycle #1	Cycle #2	Average	Change	
100	6626	6626	6626		
1,500	7284	7283	7284	658	-0.17
3,000	8001	8001	8001	718	-0.17
4,500	8725	8725	8725	724	0.05
6,000	9441	9448	9445	720	0.13
100	6626				

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

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

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

Note: The above calibration uses the linear regression method.

Users are advised to establish their own zero conditions.

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

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

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

APPENDIX C

CONSTRUCTION OF THE EQUIVALENT TOP-LOADED LOAD-SETTLEMENT CURVE

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

> Kishida H. et al., 1992, "Pile Loading Tests at Osaka Amenity Park Project," Paper by Mitsubishi Co., also briefly described in Schmertmann (1993, see bibliography). Compares one drilled shaft in tension and another in compression.
>
> Ogura, H. et al., 1995, "Application of Pile Toe Load Test to Cast-in-place

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

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

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

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

Limitations: The engineer using these results should judge the conservatism, or lack thereof, of the aforementioned assumptions and extrapolation(s) before utilizing the results for design purposes. For example, brittle failure behavior may produce movement curves with abrupt changes in curvature (not hyperbolic). However, we believe the hyperbolic fit method and our assumptions used usually produce reasonable equivalent top load settlement curves.

August, 2000

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

Figure A

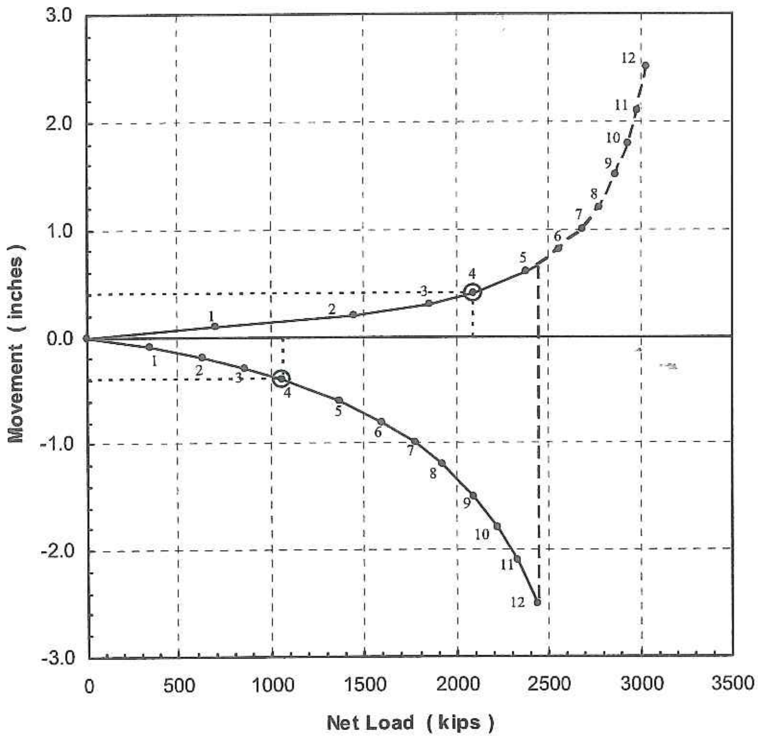
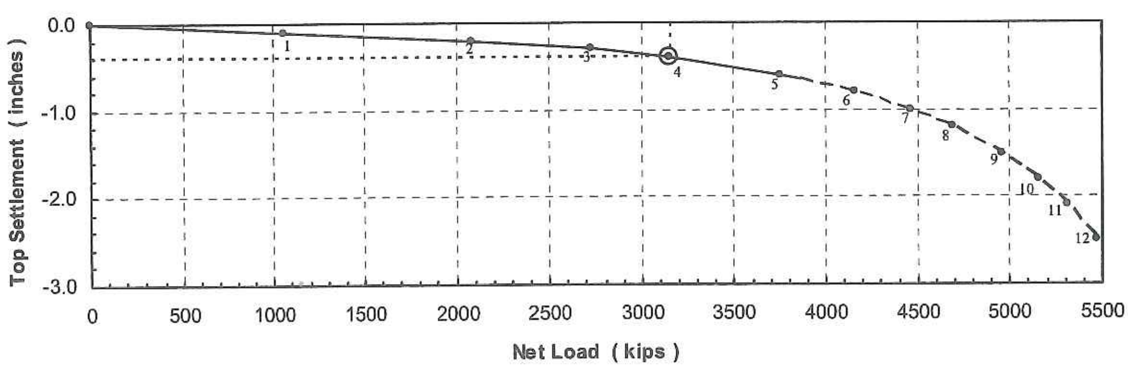
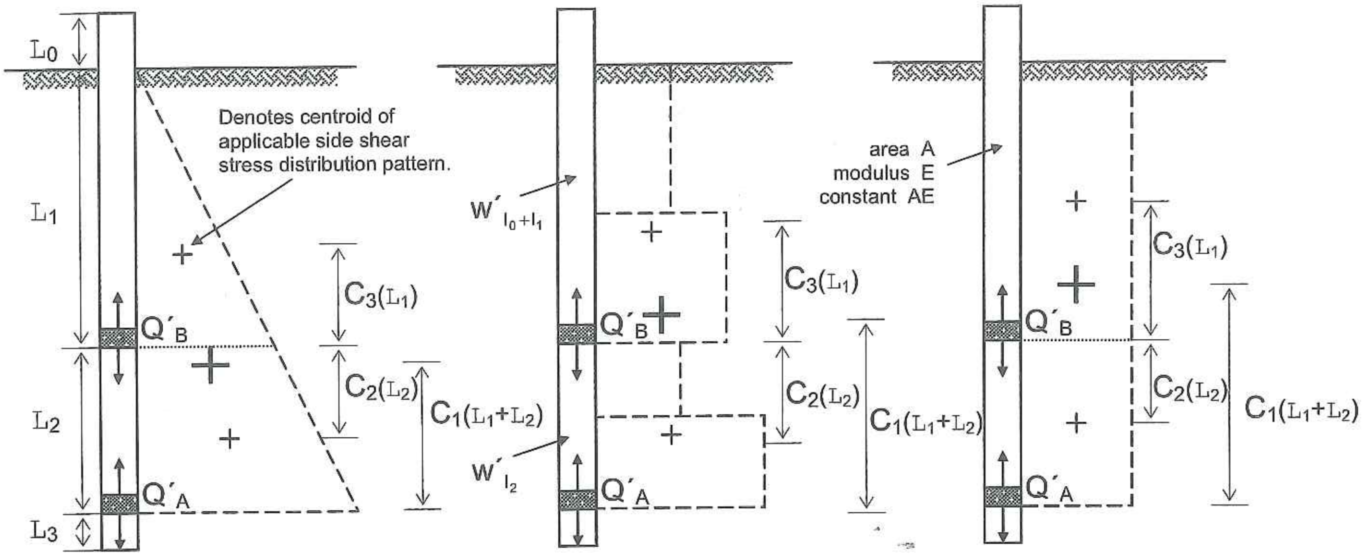


Figure B



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



1-Stage Single Level Test (Q'_A only):

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

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

3-Stage Multi Level Test (Q'_A and Q'_B): $\delta_{OLT} = \delta_{\uparrow l_1} + \delta_{\downarrow l_2}$

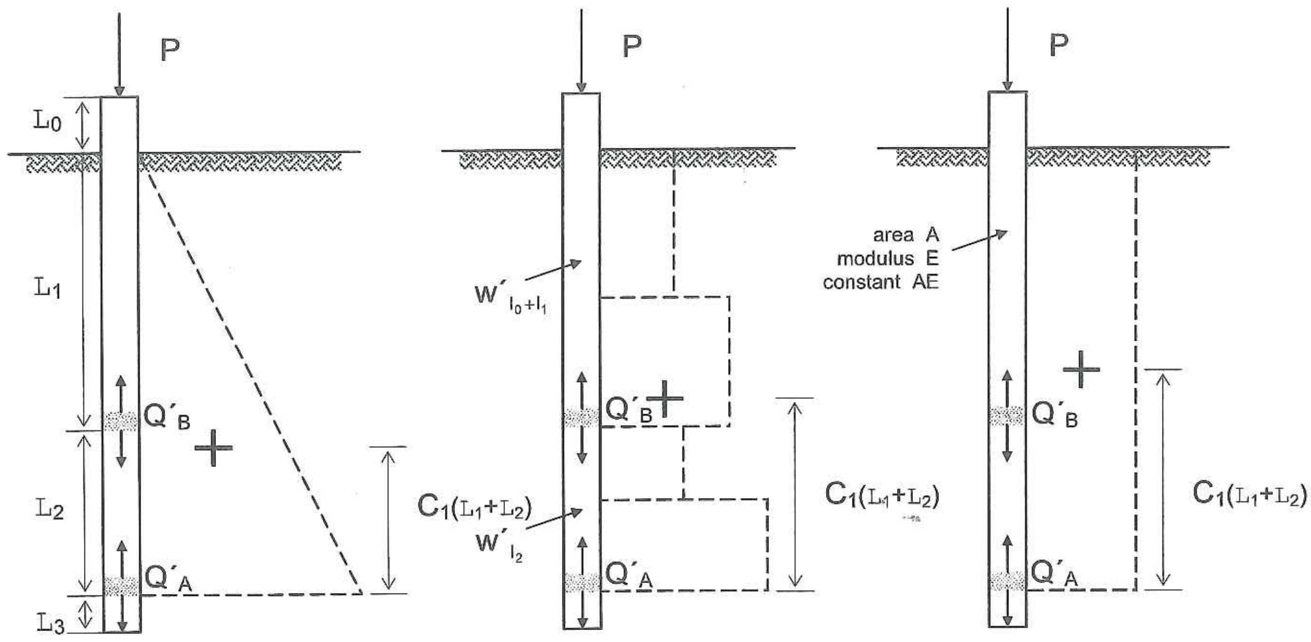
$C_3 = \dfrac{1}{3}$	Centroid Factor $= C_3$	$C_3 = \dfrac{1}{2}$
$\delta_{\uparrow l_1} = \dfrac{1}{3}\dfrac{Q'_{\uparrow B} l_1}{AE}$	$\delta_{\uparrow l_1} = C_3\dfrac{Q'_{\uparrow B} l_1}{AE}$	$\delta_{\uparrow l_1} = \dfrac{1}{3}\dfrac{Q'_{\uparrow B} l_1}{AE}$
$C_2 = \dfrac{1}{3}\left(\dfrac{3l_1+2l_2}{2l_1+l_2}\right)$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

Net Loads:

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

W' = pile weight, buoyant where below water table

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



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

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

Net and Equivalent Loads:

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

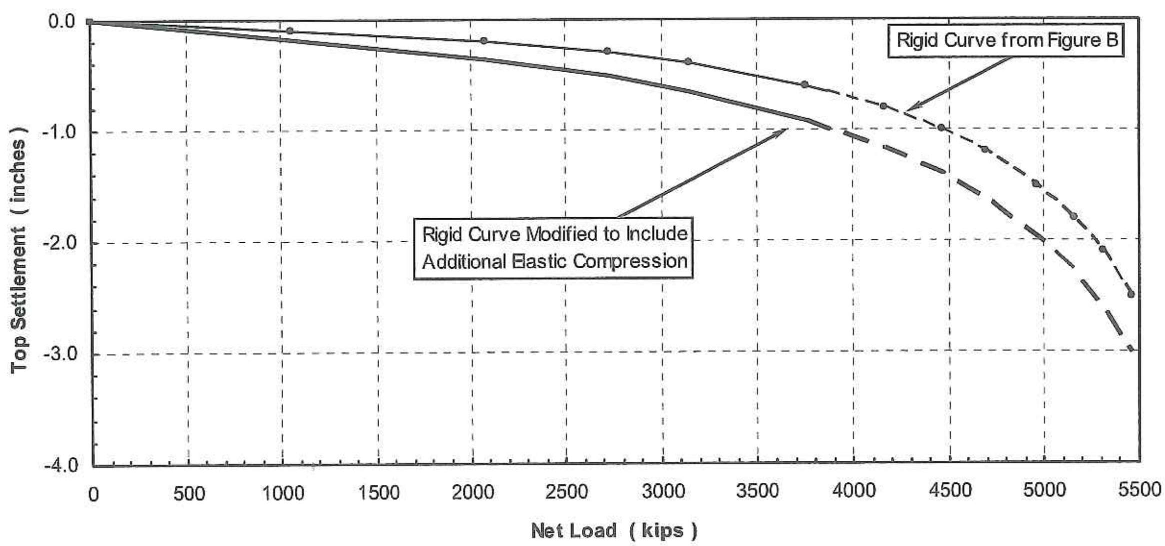
Component loads Q selected at the same (±) Δ_{OLT}.

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

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

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

Figure C



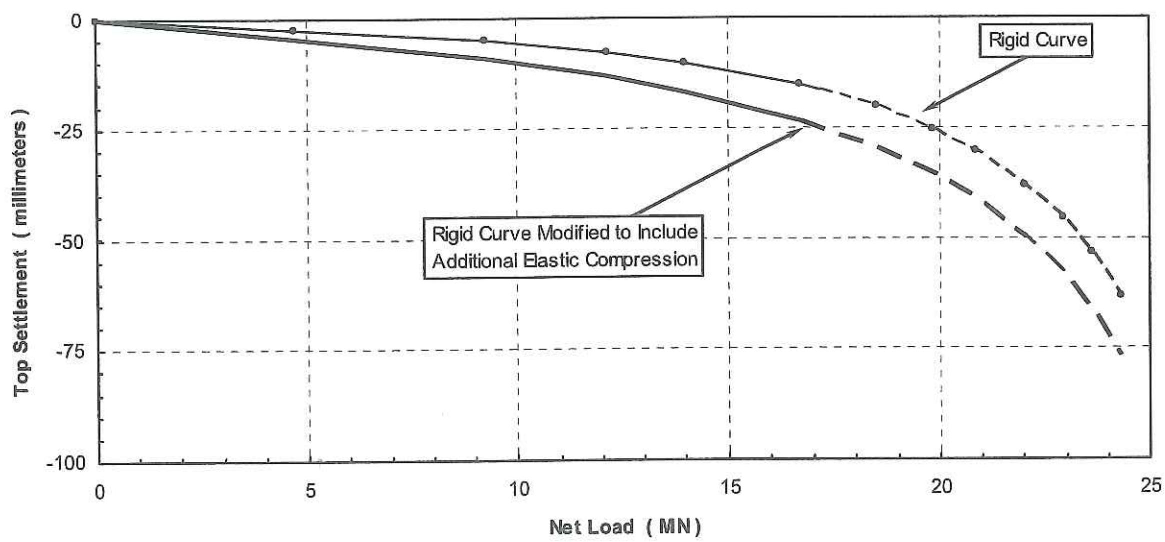
Example Calculation for the Additional Elastic Compression Correction For Single Level Test (SI Units)

Given:

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

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

Figure D

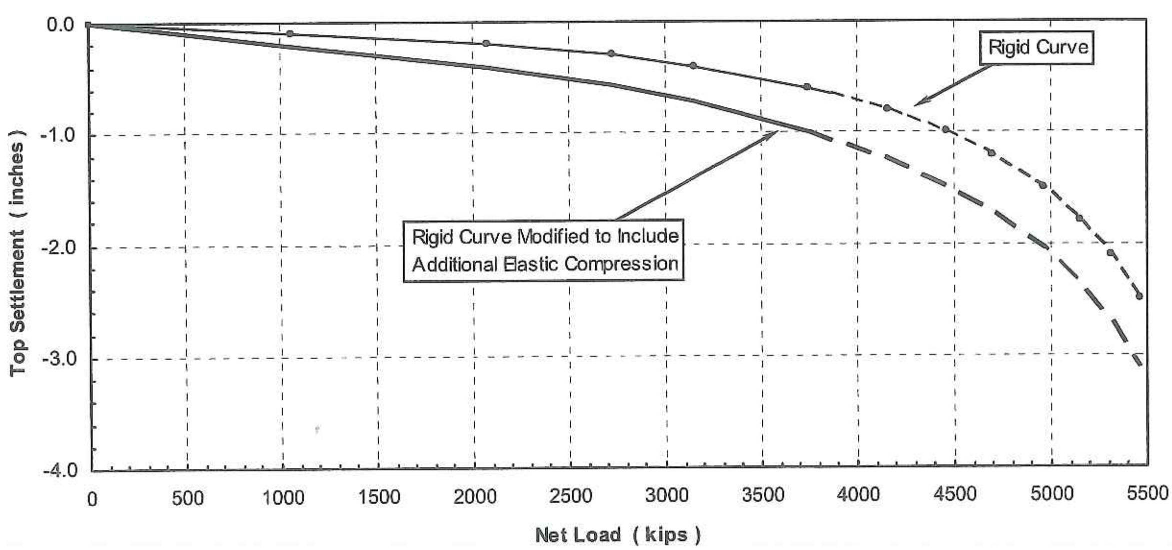


Example Calculation for the Additional Elastic Compression Correction For Multi Level Test (English Units)

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

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

Figure E

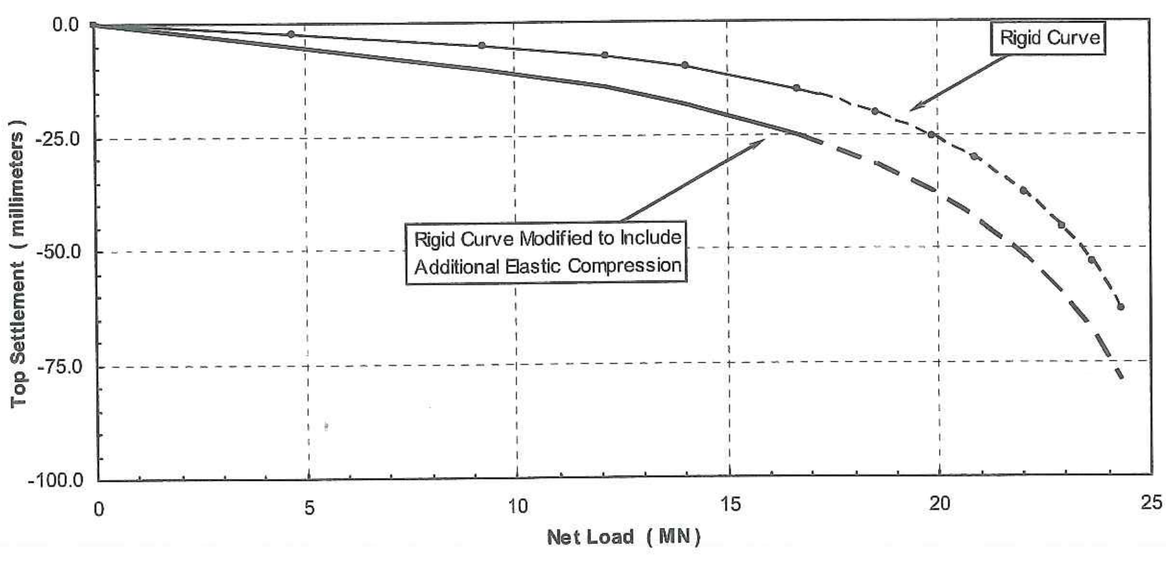


Example Calculation for the Additional Elastic Compression Correction For Multi Level Test (SI Units)

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

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

Figure F



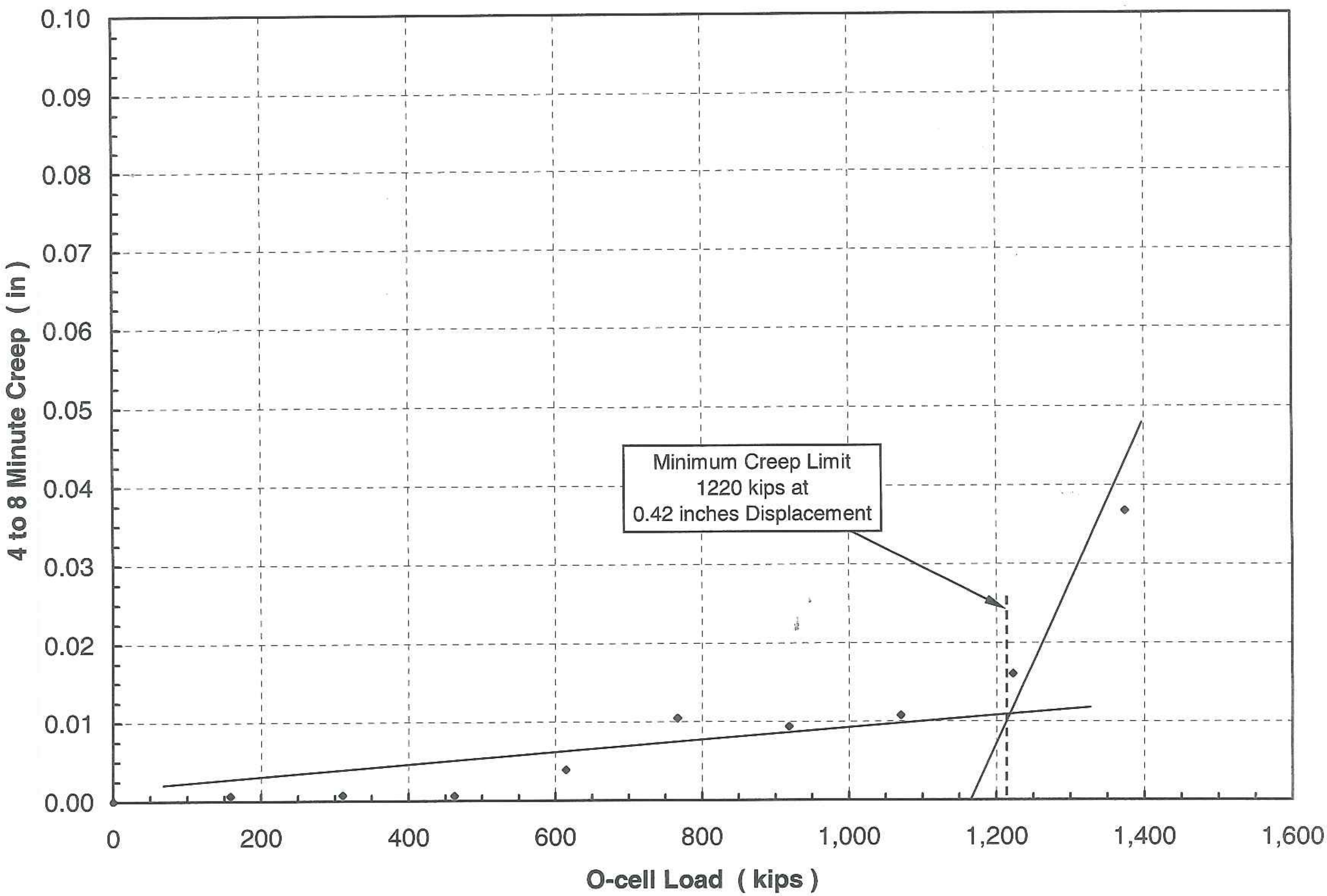
APPENDIX D

O-CELL METHOD FOR DETERMINING CREEP LIMIT LOADING

LOADTEST

Combined End Bearing and Lower Side Shear Creep Limit

TS-2 - Crosstown Commons Project - Minneapolis, MN

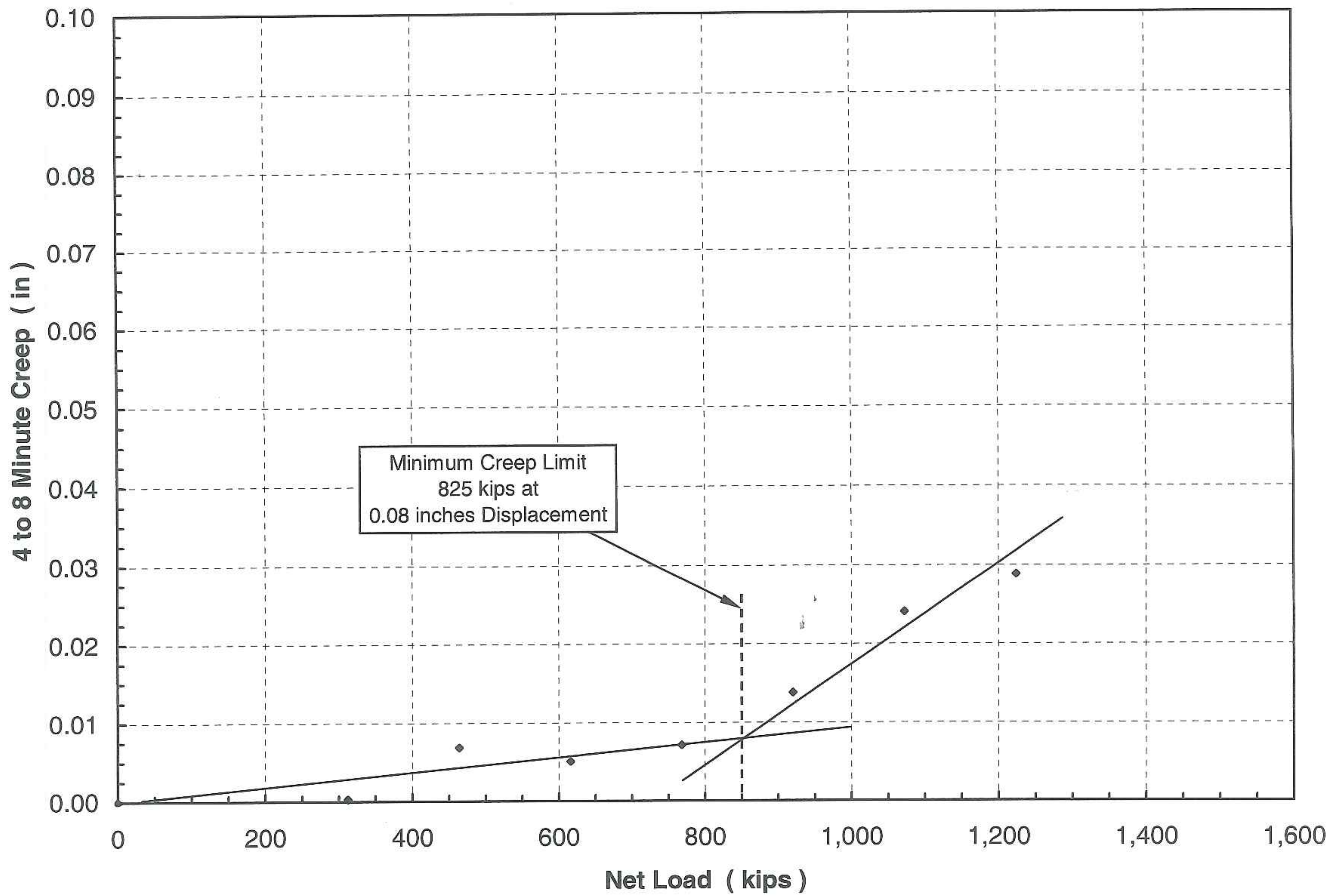


LOADTEST, Inc. Project No. LT-9193-2

Appendix D, Figure 1

Upper Side Shear Creep Limit

TS-2 - Crosstown Commons Project - Minneapolis, MN



LOADTEST, Inc. Project No. LT-9193-2

Appendix D, Figure 2

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

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

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

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

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

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

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

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

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

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

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

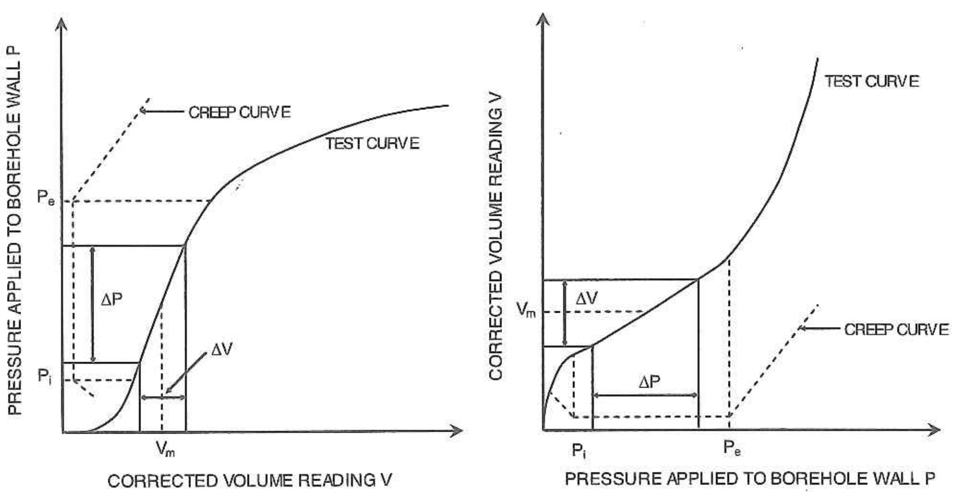


FIG. 8 Pressuremeter Test Curves for Procedure A

References

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

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

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

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

APPENDIX E

SOIL BORING LOG

PHASE II - PAGE 1

MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION
LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

UNIQUE NUMBER 69147

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
2782-27405	27405	Interstate Highway I-35W	T02	835.7 (Auto Level)

Location , , ft. LT
Hennepin Co. Coordinate: X=528031 Y=142933 (ft.)
Latitude (North)=44°54'31.72" Longitude (West)=93°16'30.53"

Drill Machine 205120 CME(LC55) Track — SHEET 1 of 4
Hammer CME Automatic Calibrated — Drilling Completed 10/3/07

Depth	Elev.	Classification	SPT N60	MC (%)	COH (psf)	γ (pcf)	Other Tests Or Remarks / Formation or Member
		Sand with Gravel, browns and damp	6	22			
7.5	828.2	slightly organic plastic Loam, black and moist	6	12			
9.0	826.7	Loamy Sand, gray-browns, moist to wet	10	17			
			5	22			
13.0	822.7	Sand with a trace of organic matter, grays and saturated	10	16			
16.0	819.7	slightly plastic Sandy Loam with pebbls, gray and wet	8	N/A			1.0' heave @ 16.0'
18.0	817.7	Sand with a thin seam of Very Fine Sand, light gray-brown and saturated	50	17			
			38	15			
23.0	812.7	Sand and Gravel, gray and saturated					
24.2	811.5	Sand with a few pockets of plastic Sandy Loam, gray-brown to	35	17			

Index Sheet Code 3.0 Continued Next Page Soil Class: DSB Rock Class: Edit Date: 11/9/07

PHASE II - PAGE 2

MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION
LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

UNIQUE NUMBER 69147

U.S. Customary Units

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS *SHEET 2 of 4*

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
2782-27405	27405	Interstate Highway I-35W	T02	835.7 *(Auto Level)*

DEPTH	Depth / Elev.	Classification	Drilling Operation	SPT N60	MC (%)	COH (psf)	γ (pcf)	Other Tests Or Remarks / Formation or Member
		brown, saturated	PD					
30		Sand with a few pockets of plastic Sandy Loam, gray-brown to brown, saturated *(continued)*	⊠	46	16			
	32.0 / 803.7		PD					
35		Sand with a little Gravel, brown and saturated	⊠	30	14			rougher drilling 34.0'-38.0'
	38.0 / 797.7		PD					
40		Sand and Gravel with a thin seam of Silt, brown and wet	⊠	26	16			
	42.0 / 793.7		PD					
45		Loamy Fine Sand with a seam of Clay Loam, light gray with gray, very moist	⊠	37	21			
	47.0 / 788.7		PD					
		Loamy Sand with a little Gravel, gray-brown and very moist		[illegible]	10			
50								

Continued Next Page

PHASE 2 - PAGE 3

MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION
LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

UNIQUE NUMBER 69147

U.S. Customary Units

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS — *SHEET 3 of 4*

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
2782-27405	27405	Interstate Highway I-35W	T02	835.7 *(Auto Level)*

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N_{60}	MC (%)	COH (psf)	γ (pcf)	Other Tests Or Remarks / Formation or Member
			Loamy Sand with a little Gravel, gray-brown and very moist *(continued)*	PD					
	52.0 / 783.7		Loamy Sand with Gravel, stone chips and pieces; browns and grays; saturated	X	39	11			
55				PD					
	57.0 / 778.7		Loamy Sand, brown and moist	X	46	10			
60			774.0	PD					BOTTOM OF DRILLED PIER (PROPOSED)
	62.0 / 773.7		plastic Sandy Loam, gray-brown and moist	X	17/.5 30/.5 50/.3	MUD			very hard drilling 64.8'-65.5'
65				PD					
	66.5 / 769.2		Clay Loam with some pebbles, gray-brown and moist	X	34	20			
	68.0 / 767.7		Sand with a stone piece, gray-brown to brown, saturated	PD					
				X	44	12			
70				PD					
				X	7 40/.2	12			
				PD					

Continued Next Page

PHASE II - PAGE 4

MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION
LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

UNIQUE NUMBER 69147

U.S. Customary Units

Mn/DOT GEOTECHNICAL SECTION - LOG & TEST RESULTS SHEET 4 of 4

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
2782-27405	27405	Interstate Highway I-35W	T02	835.7 (Auto Level)

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N_{60}	MC (%)	COH (psf)	γ (pcf)	Soil / Rock	Other Tests Or Remarks / Formation or Member
	78.9 / 756.8		Sand with a stone piece, gray-brown to brown, saturated *(continued)*	PD	50/4	18				

Bottom of Hole - 78.9'
Water measured at 9.8' while sampling and/or drilling

APPENDIX F

POST TEST GROUTING PROCEDURE

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

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

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

POST-TEST GROUTING OF OSTERBERG CELLS

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

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

POST-TEST GROUTING OF ANNULAR SPACE AROUND OSTERBERG CELLS

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

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