Dan A. Brown and Associates
Consulting Geotechnical Engineers
300 Woodland Rd. (423)942-8681
Sequatchie, TN 37374 fax:(423)942-8687

Load Testing of Drilled Shaft Foundations in Limestone, Nashville, TN

Dan Brown, P.E., Ph.D.

Introduction

Drilled shafts constructed to bear on or within rock provide an extremely reliable foundation system as a result of the ability of the geotechnical design engineer to observe and verify both the bearing stratum and the structural integrity of each drilled shaft foundation. Individual drilled shafts in rock are capable of supporting extremely high design loads, approaching the structural capacity of the reinforced column itself.

Because of the large load capacity of these foundations, it is relatively the difficult and expensive to conduct full scale load tests. As a result, the bearing capacity of drilled shafts in rock has traditionally been assessed very conservatively. In Nashville and similar areas, rock-bearing shafts are traditionally designed on the basis of end bearing alone with an allowable base resistance of around 80 to 100 ksf on rock that is verified by probe holes to be free of soil seams within two diameters below the base.

As a part of an ongoing research project to improve design methods and cost-efficiency of rock-supported drilled shafts in the Southeastern U.S., two drilled shaft load tests have been performed at a limestone site near Nashville, TN. This report summarizes the results of the site investigation and test results, with some interpretation of the test results for the purpose of developing improved design methods.

Objective and Benefits

The objectives of this project are to conduct a carefully performed and well documented load test program with reliable measurements and a very thorough site investigation. The tests are intended to measure the performance of drilled shafts in rock that is representative of the lower bound conditions that might be expected for foundations of this type. The test data are intended to provide the basis for improvements in the design methodology used for drilled shafts in Nashville and similar major drilled shaft markets in the southeastern U.S., particularly with respect to foundations on rock. Besides Nashville, areas with hard limestone bearing strata include Birmingham, Knoxville, Chattanooga, and Huntsville among others. The testing program is also intended to serve as a test case for further research with rock-bearing drilled shafts in other types of geologic conditions.

Methodology and Site Geologic Conditions

Three candidate sites were investigated in order to locate a test site with rock conditions known to be representative of the least favorable rock that might be considered for drilled shafts with high load capacity in a hard limestone geology. The site selected was the least favorable of the three, and was located at the equipment yard of Long Foundations in Hermitage, TN on the east side of Nashville (see Figure 1). According to USGS geologic maps, this site is underlain by Carters Limestone of the Stones River Group, a fine-grained, yellowish-brown limestone with thin beds of bentonite clay. This formation is typical of the Central Basin limestones in the Nashville area. Two photos of the rock from the coring tool used to excavated the rock socket of test shaft 1 are provided in Figure 2.

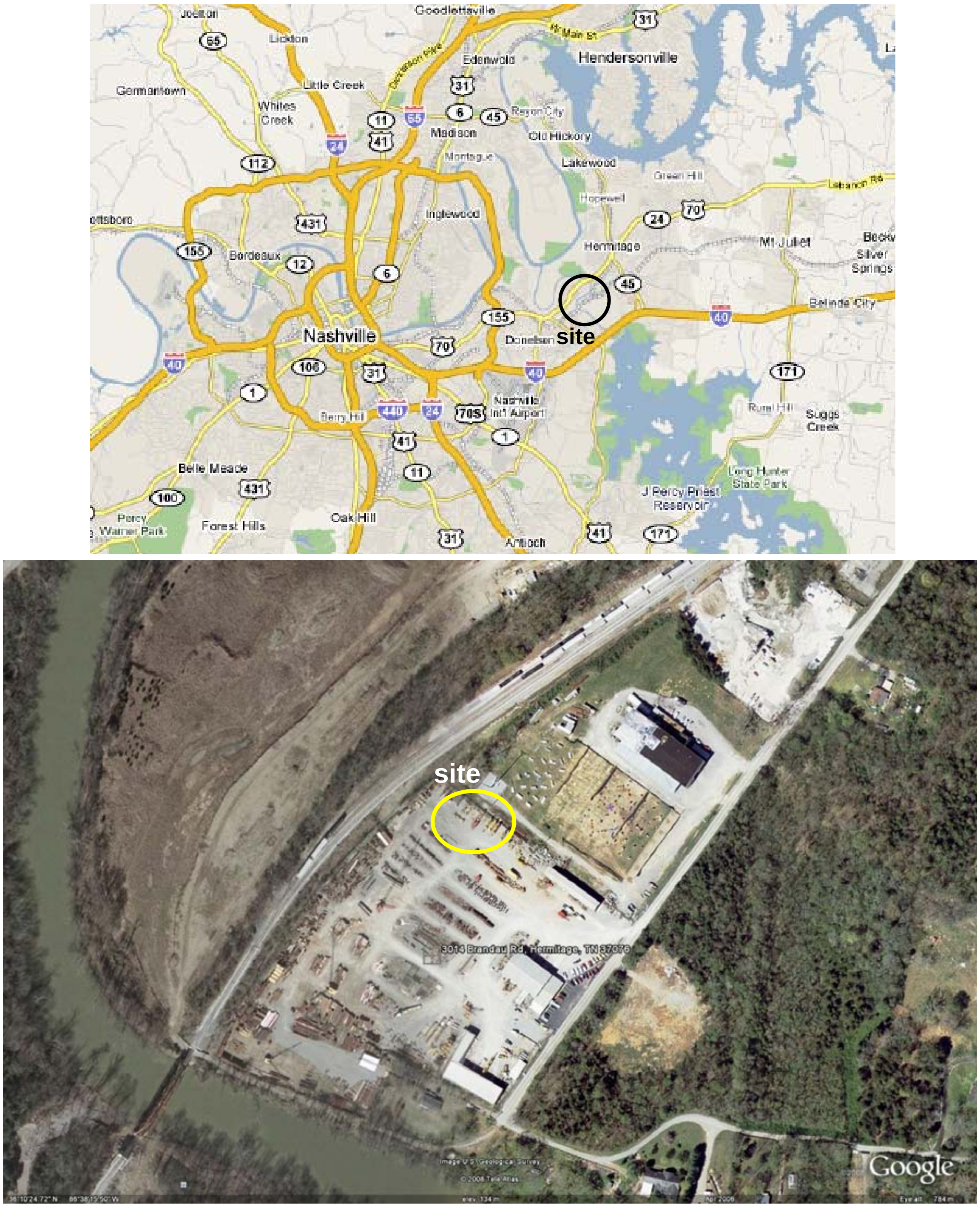


Figure 1 Nashville Test Site

Figure 2 Rock from Coring Tool Used to Excavate Socket for Test Shaft 1

The testing plan includes two Osterberg-cell load tests at the site designed to measure both the maximum base resistance and side resistance within the limestone. In order to accomplish both measurements, the plan was to conduct one test and use the measured resistance from the first to resize the 2nd test and obtain measurements that were not achieved in the 1st test.

The plan for the first test is illustrated below on Figure 3. Note that the plan includes a 54" casing to rock, a 48" socket, and a 36" diameter "bearing seat" for the O-cell. This plan provides for the base resistance to act against a 36" diameter area and the side shear reaction to act against a 48" diameter socket. A larger unit end bearing pressure is thus mobilized by utilizing a larger diameter socket for side shear reaction. Because the first test yielded in side resistance and not in end bearing, the second test utilized a similar sized socket but with a 26" O-cell in order to use the available socket resistance against a smaller base area and achieve higher unit pressures. In addition, the second test was filled with concrete to near the ground surface in order to increase the side resistance to the maximum extent possible.

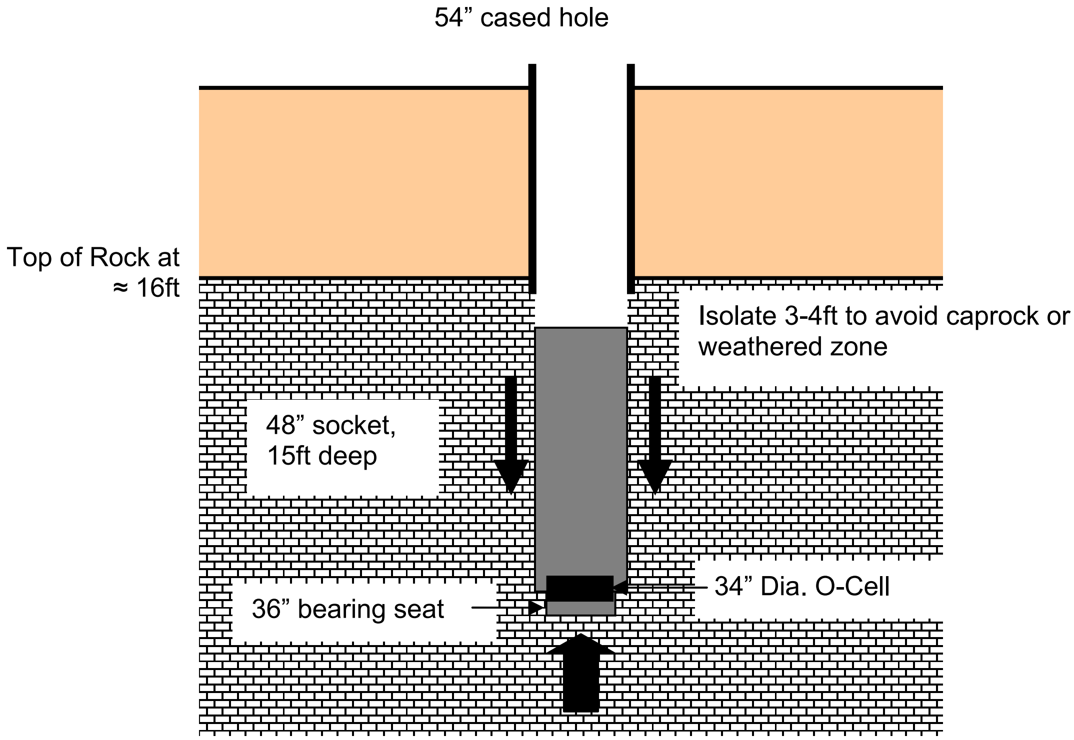


Figure 3 Schematic of Proposed Test No. 1, Nashville Site

Geotechnical Conditions

An initial boring (1) was made at the location of test shaft 1, and an additional three borings were made in the immediate vicinity of each of the two test shafts as illustrated in Figure 4. The two shafts were approximately 30 feet apart, with the borings approximately 8ft from the center of the test shafts. The detailed logs of the borings are provided in Appendix A. Schematic diagrams of the recovery, RQD, and rock strength measurements from the cores are presented in Figures 5 - 7.

The data from the borings suggest that the rock for 3 diameters below the base of test shaft 2 was somewhat more sound with average %recovery and RQD of 97% and 60% vs average values of 82% and 46% for test shaft 1. Compressive strength data were quite variable, typically ranging from 5,000psi to over 20,000psi.

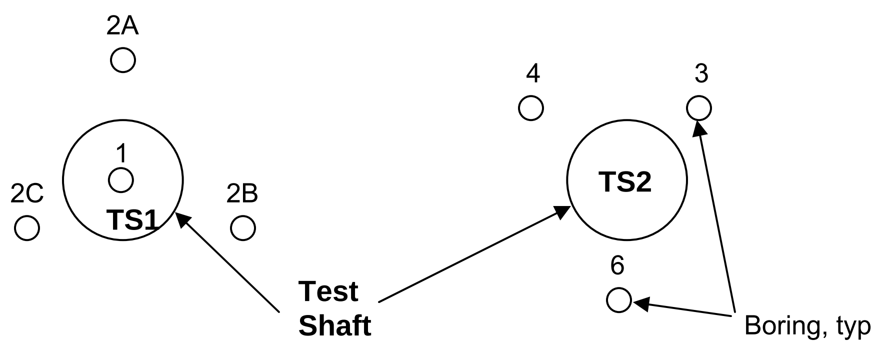


Figure 4 Test Shaft and Boring Layout (no scale)

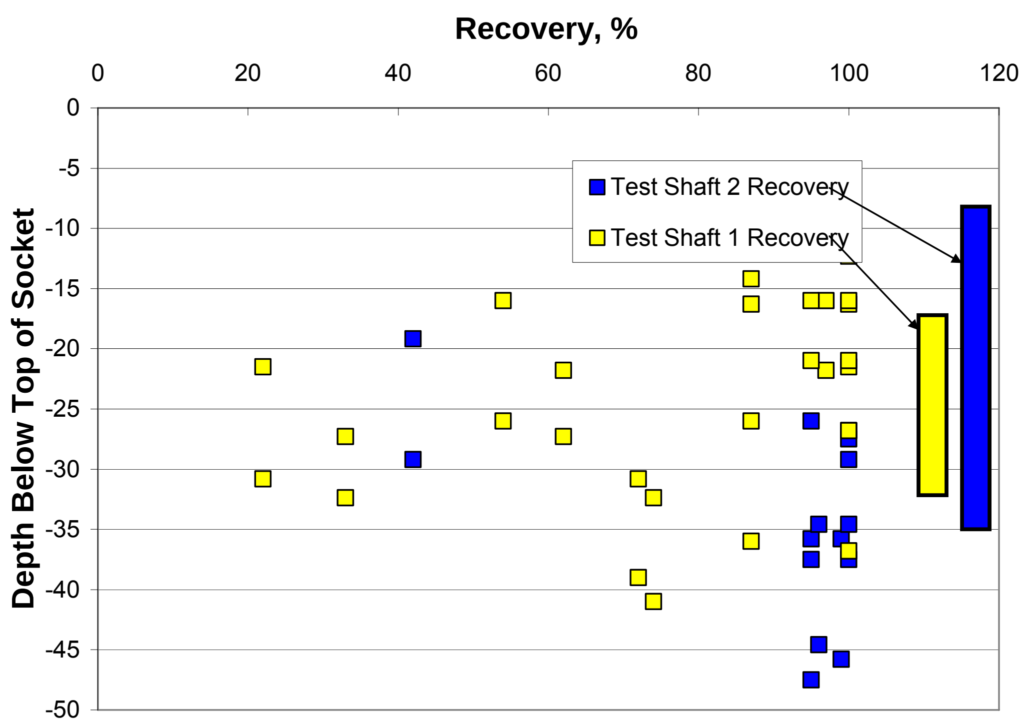


Figure 5 %Recovery from Rock Cores

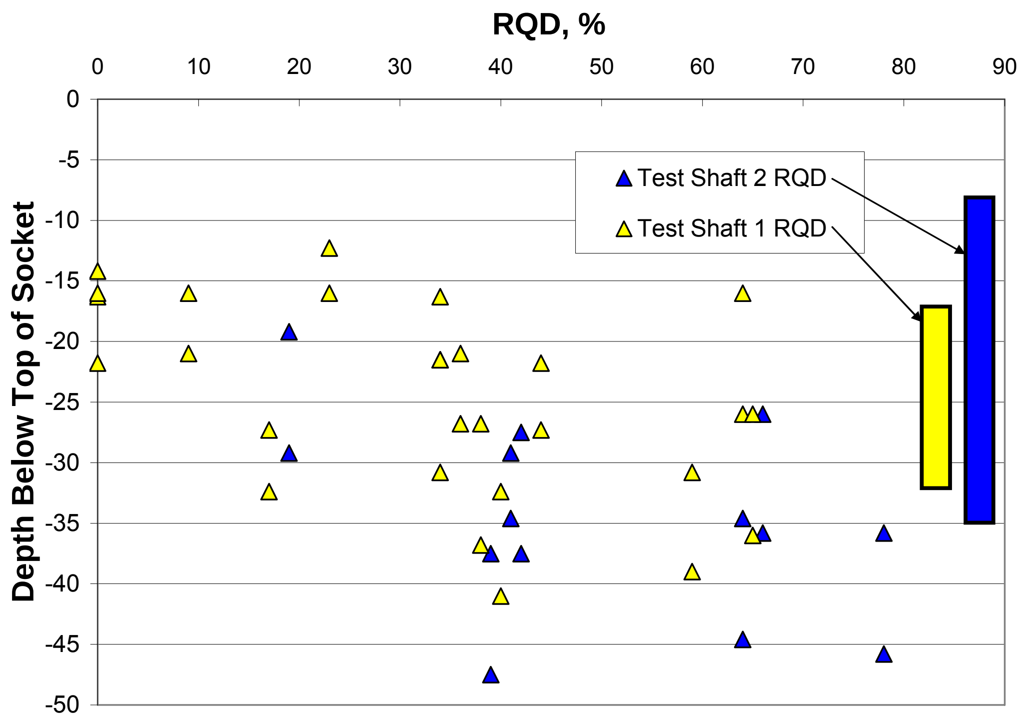


Figure 6 %RQD from Rock Cores

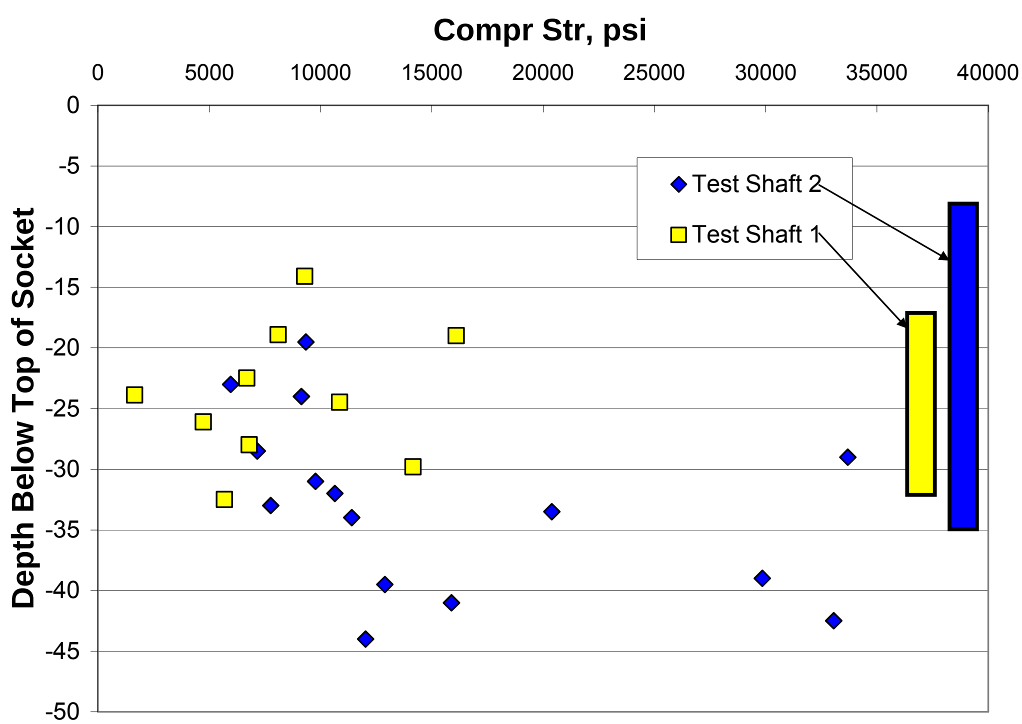


Figure 7 Compressive Strength Data from Rock Core Samples

Construction of the Test Shafts

Both shafts were constructed in the dry by first drilling to rock, then setting a 54 inch diameter temporary casing into the top of rock, and then excavating the 48 inch diameter socket into the rock using rock tools. The drilling was performed by Long Foundation Company using a Watson crawler-mounted drill rig as shown in Figure 8. An auger was used to excavate the overburden and set the casing, and a coring tool was used to excavate the rock socket and produced the cores shown previously in Figure 2. The bottom cleanout of the shaft was made first using a rock auger, with final cleanout using an earth auger. No hand cleaning of the shaft base was performed; although hand cleaning is common in this area, one objective of this study was to evaluate the effect of a less stringent cleanliness requirement. Inspection logs of the installation were made by Professional Service Industries, Inc. (PSI) and are provided in Appendix B of this report.

Figure 8 Drill Rig Set Up on Test Shaft 2

After completion of the excavation, an inspection probe hole was drilled in the base of each test shaft with an air-operated percussion tool for inspection of the rock below the base of the shaft. The log of the probe holes are included with the inspection reports in Appendix B of this report. In addition to the inspection reported by PSI, at least 6 other inspectors and engineers from local practicing geotechnical firms and TDOT examined the test hole in Test Shaft 1. The results of the PSI inspection report on the probe holes are summarized below.

Test Shaft 1: 51” test hole
3” soil seam at 19 inches
½” rock
¾” soil seam
18 inches weathered rock with voids and shale

Test Shaft 2: 72” test hole
3/8” soil seam at 36 inches

The consensus of the inspectors was that under normal circumstances the contractor would have been required to extend this shaft by at least another two feet in order to penetrate below the 3” soil seam. Because one objective of this study was to evaluate relatively less favorable rock conditions, the shaft was not extended. Several inspectors also noted that the cleaning of the base was not sufficient due to scattered rock debris and cuttings that had not been removed by the auger. No seepage water was noted in either shaft.

Test shaft 1 was completed on Sept. 17, 2008 by first placing about 3 inches of concrete into the base of the shaft, then installing the O-cell assembly and reinforcement, and then placing concrete by free fall technique within the shaft to a level approximately 3 feet below the top of rock. The O-cell for test shaft 1 was a 34 inch diameter cell mounted on a 36 inch diameter by 2 inch thick bottom plate. The cell assembly was similar (although slightly different in diameter) to the assembly for test shaft 2 which is visible in the foreground of Figure 8 and shown in close-up below in Figure 9. Six #10 bars provided the longitudinal reinforcing and carrier frame for the O-cell assembly.

Nine (9) cubic yards of concrete was reportedly placed to complete the 16 ft long socket. At 48 inches diameter, this socket has a theoretical volume of 7.5 cubic yards, thus about 20% over-consumption of concrete was apparent for this shaft.

The concrete mix was designed to produce a 5000 psi compressive strength after 2 days of curing, and was delivered to the site at a slump of 8 inches. Two compression tests performed at 7 days on the concrete for test shaft 1 indicated compressive strengths of 5660 and 5770 psi. The load test on this shaft was performed on Sept. 26 when concrete was 9 days old.

Test shaft 2 was completed on October 2 in a similar manner to test shaft 1 except for the following notable differences. The O-cell assembly utilized a 26 inch diameter cell mounted on a 28 inch diameter by 1 inch thick bottom plate, so as to exert end bearing pressure onto a smaller effective area at the base of the shaft. Five #9 bars were used for longitudinal reinforcement. In order to increase the amount of side resistance for reaction against the base during the O-cell test, this shaft was to be filled with concrete to near the ground surface, with the temporary casing removed during concrete placement.

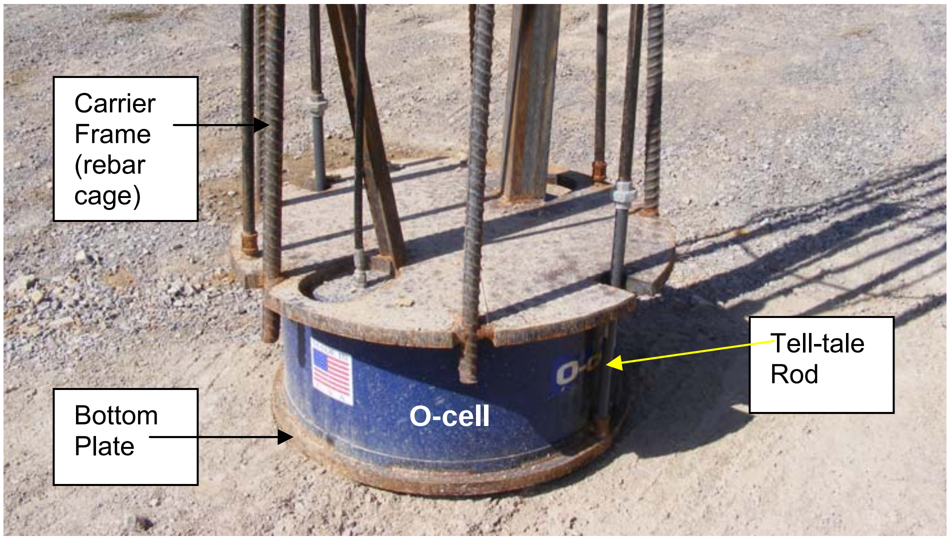


Figure 9 Close-up of O-cell Assembly (Test Shaft 2)

Nine (9) cubic yards of concrete from the first load were placed and the level of concrete was observed to fill the 17 ft length of socket and extend one foot into the 54 inch casing. The theoretical volume of concrete to achieve that elevation within the shaft was 8.5 cubic yards, thus an over-consumption of only about 5% was observed from the first load of concrete. However, an additional 11 cubic yards was placed within the casing and the level of concrete only increased by an additional 5 feet; the theoretical volume for this incremental increase in concrete elevation was only 3 cubic yards. Since the casing was still in place at the time, approximately 8 cubic yards of concrete was lost into a void somewhere below the bottom of the casing.

A review of the three borings around test shaft 2 suggests an explanation for the lost concrete noted above. These 3 borings noted top of rock (auger refusal) at depths ranging from 19.2 feet to 27.5 feet, whereas the temporary casing was installed to a depth of 20 feet. The top of sound rock was therefore quite irregular in this location, and it is likely that the concrete blew out into a void near the top of rock or bottom of casing once a few feet of head inside the casing produced sufficient pressure.

The concrete mix was similar to that used for test shaft 1. At the time of the load test on Oct. 14, 2008, a 12-day break on one cylinder indicated a compressive strength of 5900psi.

Load Test Results

Load tests of test shafts 1 and 2 were conducted by Loadtest, Inc. under direction by the writer, with tests performed on Sept. 17, 2008 and Oct. 14, 2008, respectively. The first test was organized as a part of the local monthly ASCE lunchtime meeting and thus was witnessed by around 60 attendees (see photos in Figure 10). Detailed results of both load tests are presented in Appendix C and summarized below.

Figure 10 Photos from Load Test of Test Shaft 1

The final configuration of the two test shafts including the location of strain gauges are illustrated below in Figure 11.

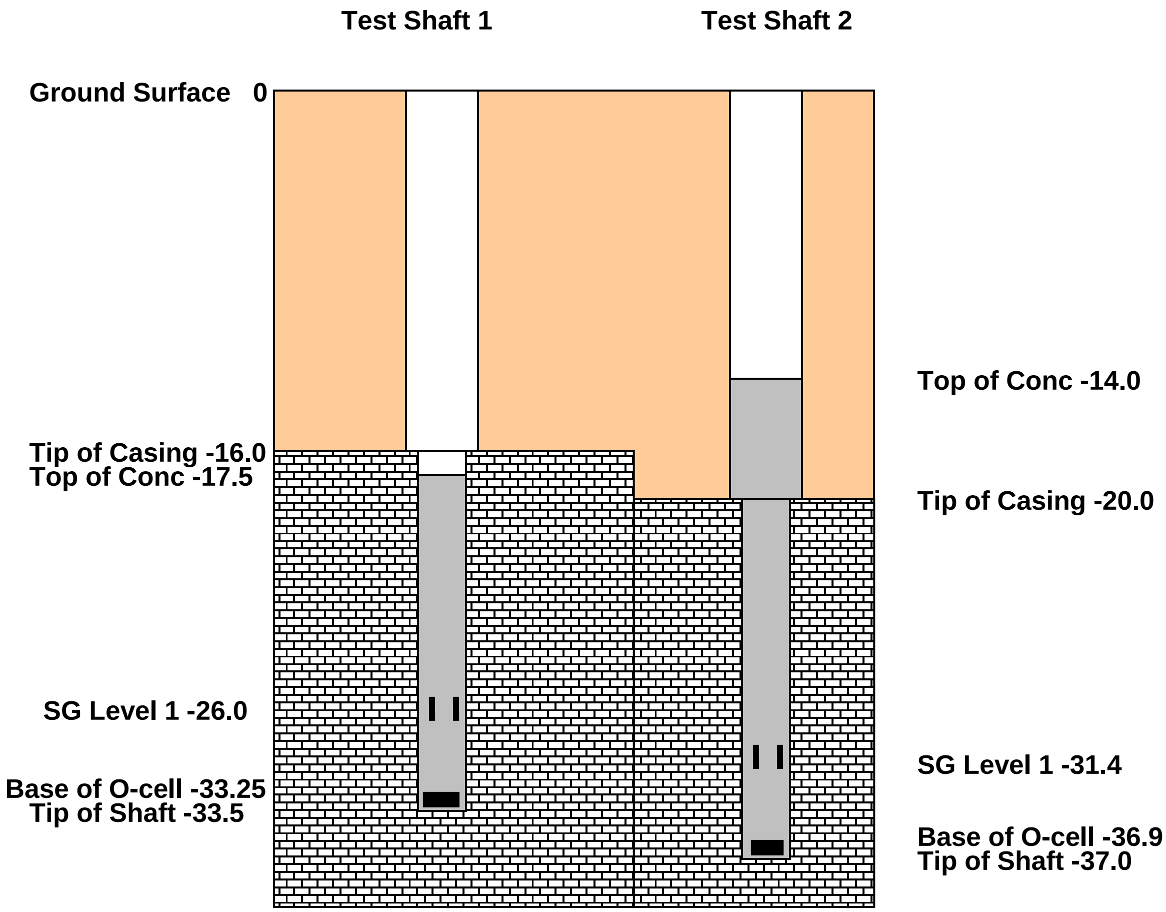


Figure 11 Schematic Diagram of Test Shafts 1 & 2

The overall side resistance in the rock was most reliably determined from the results of test shaft 1, because this test was conducted to fully mobilize the shaft resistance and was not complicated by the large concrete over-run below the casing as occurred on test shaft 2. A graphical presentation of the average unit side resistance vs displacement for the socket of test shaft 1 is illustrated on Figure 12, with data plotted based on the nominal shaft diameter of 48 inches and on a shaft diameter adjusted for over-break based on the concrete volume.

The strain data suggest that larger side resistance was mobilized in the lower portion of the socket. However, the actual distribution is subject to interpretation based on the strain gauges; there can be some uncertainty in the actual distribution of resistance compared to a top-down loading due to uncertainty in the actual modulus and area of the shaft at the exact location of the gauges and due to the upward directed loading. The interpretations of distribution of side resistance performed by Loadtest, Inc. based on the strain gauge data are included in Appendix C.

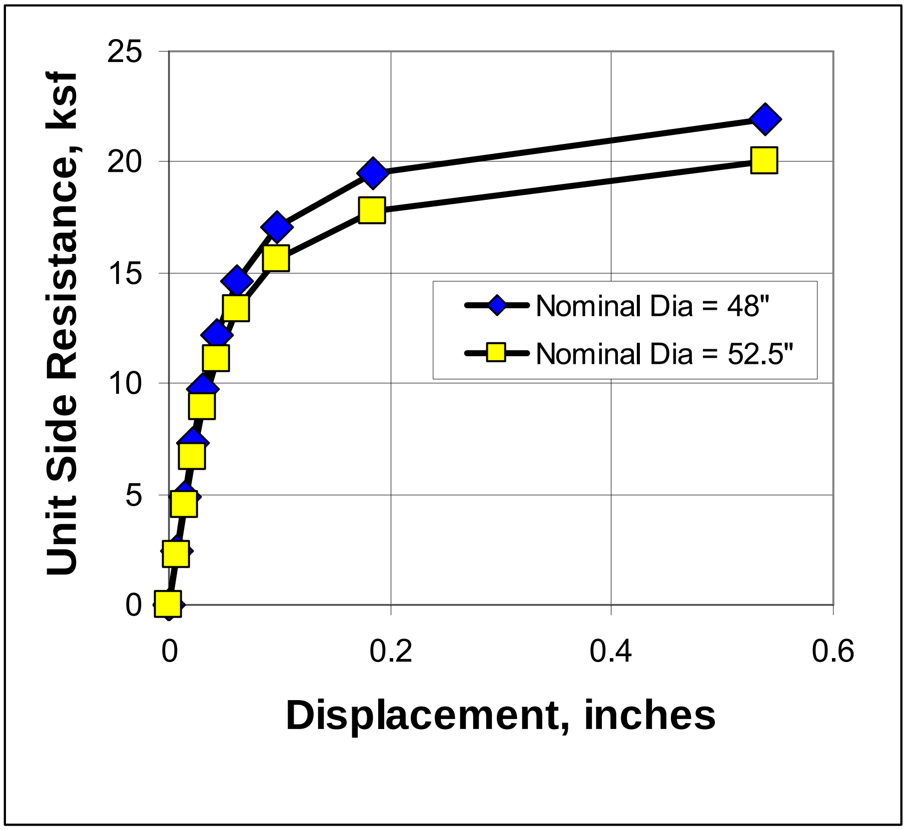


Figure 12 Average Unit Side Resistance, Test Shaft 1

The side resistance data suggest that the side resistance is mobilized at a relatively small displacement of around 0.2 inches or less, and that the maximum average side shear in the socket at test shaft 1 was around 20 ksf.

The measured unit base resistance from the two test shafts is provided on Figure 13. These data are based on the projected area from the base plate plus a distribution of 2(vert):1(horiz) downward through the few inches of concrete below the base plate. For test shaft 1, there was estimated to be 3 inches of concrete below the 36 inch diameter plate, and thus the effective area projected onto the rock was estimated to be 39 inches diameter. For test shaft 2, there was estimated to be 1.2 inches of concrete below the 28 inch diameter plate, and thus the effective area projected onto the rock was estimated to be 29.2 inches diameter.

In order to compare measured base resistance for similar size area, the base resistance is plotted vs displacement normalized by base diameter on Figure 14.

Note that the permanent displacement after removal of loading of test shaft 1 was approximately 0.15 inches and was measured 75 minutes after removal of load. The permanent set of approximately 0.1 inches was measured 8 minutes after removal of load on test shaft 2.

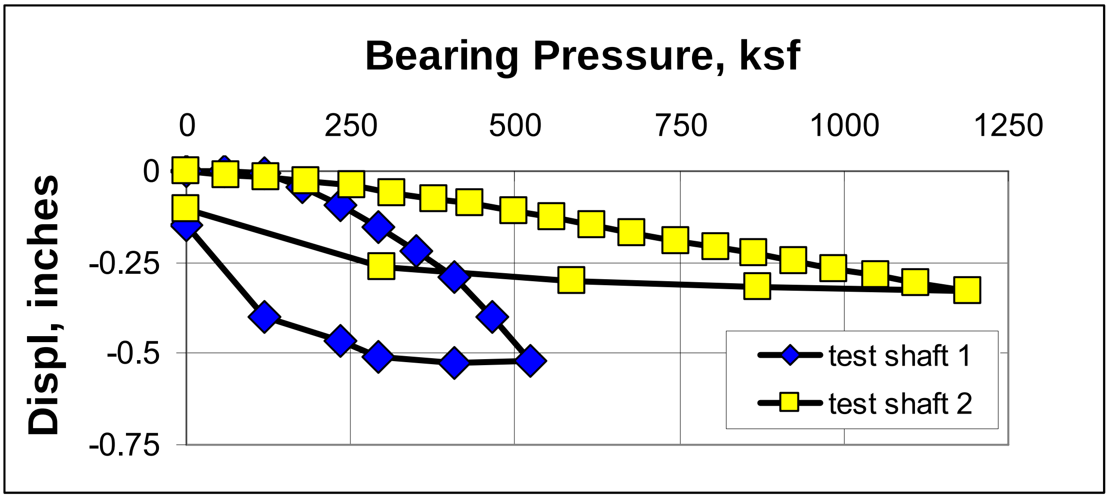


Figure 13 Base Resistance vs Displacement

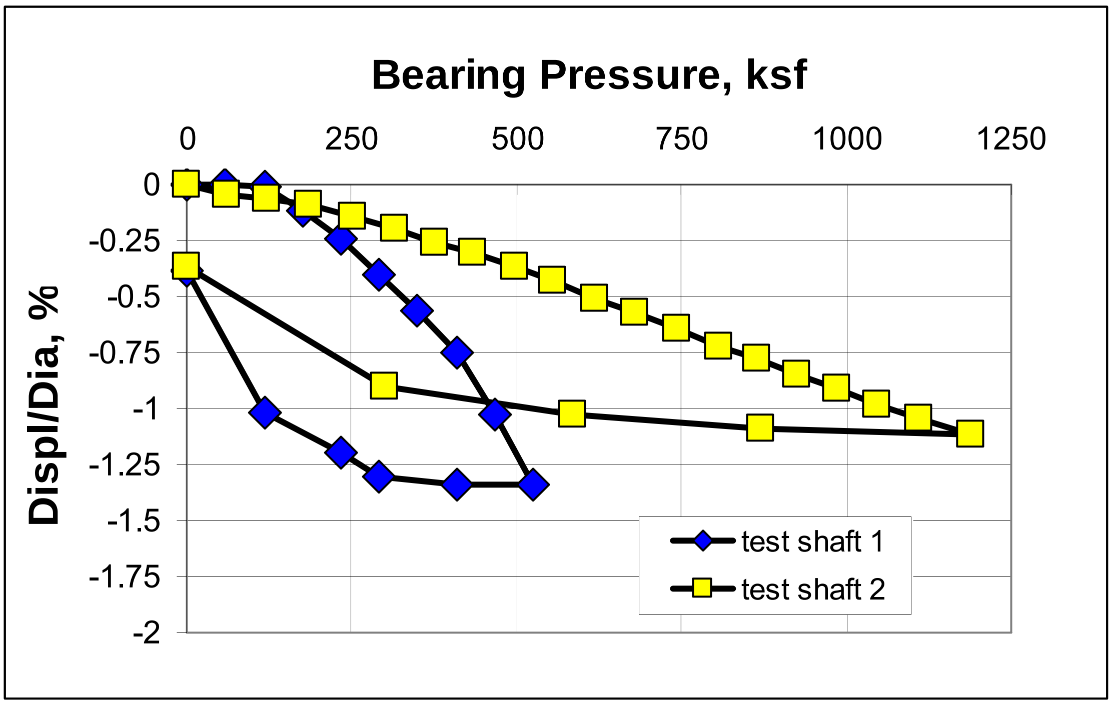


Figure 14 Base Resistance vs Displacement/Base Diameter

Analyses of Test Results

Side Resistance

The side resistance of test shaft 1 may be evaluated relative to other guidelines for side resistance of rock sockets. Typical guidelines for side resistance in rock involve some correlation with compressive strength data. The average side resistance for the socket of test shaft 1 was approximately 20ksf at a displacement of less that ½ inch. An evaluation of the 9 available compression tests from cores within the rock socket of test shaft one reveals a range of values from 1,660psi to 16,110psi and a mean of 8,300psi. Eliminating the highest and lowest values provides a range of values from 4,750psi to 14,170psi with a mean of 8,150psi. Core recovery ranged from 74% to 100% and RQD ranged from 9% to 65%.

A typical expression used for unit side resistance, f_s is one originally proposed by Rowe and Armitage[1] and subsequently modified by Kulhawy and Phoon[2] as follows:

$$f_s = C \cdot p_a \cdot \sqrt{\frac{q_u}{(p_a)}} \qquad (1)$$

where q_u is unconfined compressive strength, p_a is atmospheric pressure, and C is an empirical constant ranging from 0.65 to as high as 3. Back-analysis of the test results using f_s of 20ksf and q_u of 8300psi suggests that an average C-coefficient for this limestone would be only **0.4**, a relatively low value compared to other rock formations.

A possible explanation of the relatively low empirical constant may be that the clay-filled seams tended to contaminate the surface of the limestone so that the relatively high strength of the rock is not mobilized in side shear. It is also the case that the low RQD suggests that a large portion of the rock within the socket may not have been represented by the high strength of the relatively few portions of the core which are available for testing.

Base Resistance

The base resistance of the two shafts was mobilized up to relative displacements of just over 1% of the diameter of the loaded area, but did not mobilize the geotechnical limit of the formation in terms of bearing capacity. For evaluation of the load vs deformation characteristics of the base resistance, it is appropriate to consider the settlement, ρ_s of a rigid circular loaded area bearing on the surface of an elastic half space, which may be expressed as follows:

$$\rho_s = 0.79 \cdot \frac{q\left(1-\nu^2\right)}{E} \qquad (2)$$

where q is the bearing pressure, v is Poisson's ratio, and E is the elastic modulus of the rock mass. For a typical value of Poisson's ratio of 0.25, and values of ρ_s equal to 0.5% to 1% of the diameter of the base, the effective elastic modulus of the rock mass can be back-calculated from the load test data to derive the values shown on Figure 15.

The lower back-calculated value for test shaft 1 is undoubtedly related to the fact that approximately 4 inches of soil was present at a depth of about 19 to 23 inches below the base of the 39 inch diameter loaded area. Normalized by the base diameter, B, this represents a soil seam of thickness equal to 10% of the base diameter and located at a distance of approximately ½ B.

---

[1] Rowe, R.K. and H.H. Armitage, (1987). "A Design Method for Drilled Piers in Soft Rock," *Canadian Geotechnical Journal*, Vol. 24, pp. 126-142.
[2] Kulhawy, F.H. and K.K. Phoon, (1993). "Drilled Shaft Side Resistance in Clay Soil to Rock," *GSP38*, ASCE pp. 172-183.

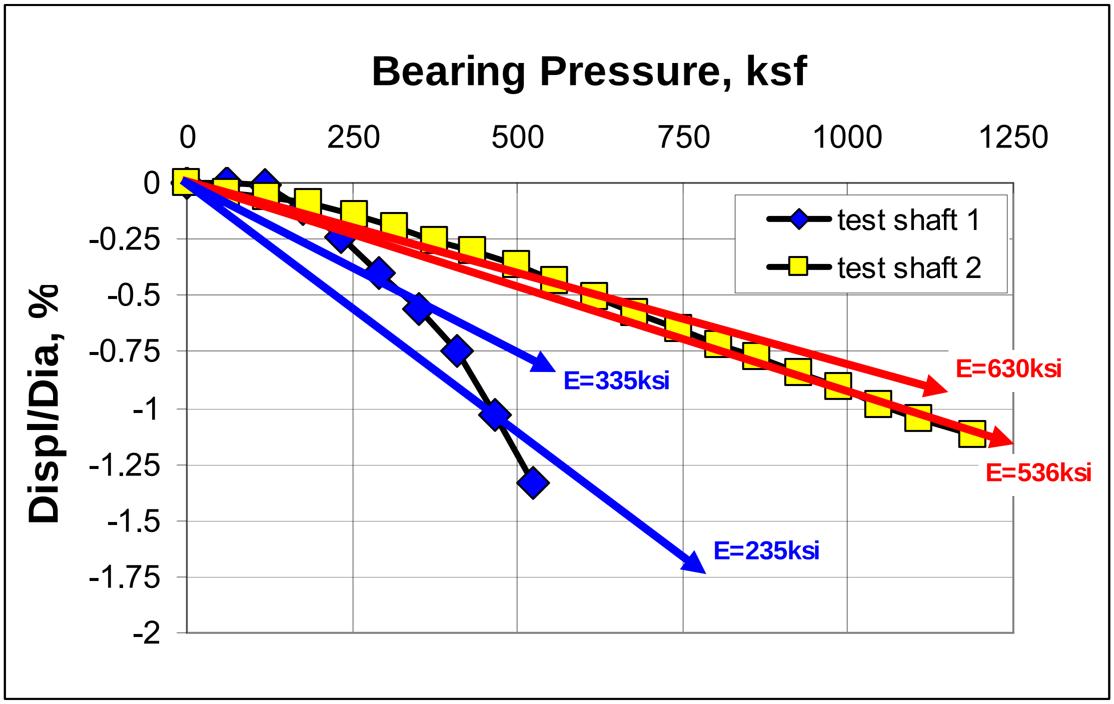


Figure 15 Back-Calculated Modulus for Base Resistance at Displacements of 0.5% and 1% Base Diameter

Preliminary Implications for Design

Based on the typical local practice, the rock conditions at test shaft 1 would not have been considered acceptable and typical design would have required the shaft excavation to continue to achieve the more favorable conditions typified by test shaft 2. It is appropriate to consider the implications for design of both conditions, hereafter referenced as follows:

- “Sound Rock” is typified by the conditions similar to test shaft 2 with only one or two small seams less than ½ inch thick
- “Fair Rock” is typified by the conditions similar to test shaft 1 with soil-filled seams up to 10% of the base diameter, B, at depths greater than ½ B.

<u>Sound Rock</u>

For a serviceability condition of a typical 4 to 6 foot diameter shaft, a displacement equal to 0.5% of the shaft diameter would result in settlements of ¼” to 3/8”. At these settlements and based on an elastic modulus of the rock in the range of 500 to 600 ksi, a service load base pressure of around 500ksf (or 250 tons per square foot) could be utilized. This value appears consistent with recent tests and values used for high rise structures in Chicago founded on limestone, several of which have been designed for service load bearing pressures of 250 to

300 tons per square foot[3]. Measurements of post-construction settlements on the recently completed Trump Tower and other similar structures have confirmed that the use of these values produces settlements consistent with predictions.

At the values indicated above, a factor of safety of 2.5 would require that the rock provide an ultimate bearing capacity of at least 1250ksf (625 tons per square foot). The load test of shaft 2 in the "Sound Rock" conditions was observed to mobilize a bearing pressure of 1250ksf at a displacement slightly over 1% of the shaft diameter without any signs of bearing failure in the rock. It may be noted that this bearing pressure is approximately 8600psi and exceeds the compressive stress that likely could be placed on the column from a structural strength limit standpoint.

It is also concluded that such high bearing pressures may be constrained by structural strength limitations at service loads such that higher than normal concrete strength may be required to fully utilize these bearing pressures. There would be little reason to include side resistance in the design of a rock-bearing shaft on Sound Rock, since little additional resistance would likely be realized and structural considerations will likely govern in any event.

For design of shafts at bearing pressures approaching the values noted above, it is expected that the following geotechnical and inspection requirements must be met:

- A thorough geotechnical site investigation is required with rock coring and compressive strength testing of the rock bearing formation.
- Rock compressive strengths in the bearing formation should be in the 10,000 psi range or higher and % recovery should typically exceed 90%.
- The site investigation should reveal that no significant solution cavities exist within the bearing formation below the anticipate bearing elevation.
- The shafts must be completed in the dry, with down-hole inspection.
- A down-hole probe to a depth of at least 2 shaft base diameters would be conducted and inspected by a qualified geotechnical engineer on each shaft.
- No more than two significant seams within the rock within two base diameters and none greater than ½ inch in thickness.

The design of drilled shaft foundations in the Nashville area using the above recommendations would represent a significant increase in bearing pressures over historical practice in the area. For the immediate future, it is recommended that large projects with designs based on these significantly higher values include a field load test for confirmation of design values.

<u>Fair Rock</u>

For a serviceability condition of a typical 4 to 6 foot diameter shaft, a displacement equal to 0.5% of the shaft diameter would result in settlements of ¼" to 3/8". At these settlements and based on an elastic modulus of the rock in the range of 200 to 300 ksi, a service load base

[3] Walton, W., (2008). "Caisson Load and Osterberg Testing in Chicago," presentation made at the ADSC Drilled Shaft Seminar, Atlanta, Nov. 19, 2008.

pressure of around 200ksf (or 100 tons per square foot) could be utilized. At this value, a factor of safety of 2.5 would require that the rock provide an ultimate bearing capacity of at least 500ksf (250 tons per square foot). The load test of shaft 1 in the “Fair Rock” conditions was observed to mobilize a bearing pressure of 500ksf at a displacement slightly over 1% of the shaft diameter without any signs of bearing failure in the rock.

For design of shafts at bearing pressures associated with the “Fair Rock” conditions described above, it is expected that the following geotechnical and inspection requirements must be met:

- A thorough geotechnical site investigation is required with rock coring and compressive strength testing of the rock bearing formation.
- Rock compressive strengths in the bearing formation should be in the 5,000 psi range or higher and % recovery should typically exceed 70%.
- The site investigation should reveal that no significant solution cavities exist within the bearing formation below the anticipate bearing elevation.
- Inspection of the shaft excavation and rock materials brought from the hole with the drilling tools should confirm that the general character of the bearing stratum is consistent with the borings and with the design conditions.

Side Resistance

It may be prudent to consider the addition of side resistance to the end bearing used in the design in “Fair Rock” conditions, particularly where 10 or more feet of socket length is required to achieve the required base resistance consistent with this condition. Note that the conditions through which the two rock sockets were constructed did not consist of rock that would qualify for the “Fair Rock” condition noted for base resistance above. The rock through which the side resistance was measured was characterized by relatively low % recovery and RQD, many seams, and highly variable compressive strengths.

For side resistance, the resistance is mobilized at small displacements and the maximum value used in design is based upon a geotechnical strength condition. For design based on the conditions measured at the Nashville site, the recommended approach is to compute the nominal (limit) side resistance using the equation cited previously:

$$f_s = C \cdot p_a \cdot \sqrt{\frac{q_u}{(p_a)}} \qquad (1)$$

where q_u is unconfined compressive strength, p_a is atmospheric pressure, and C is an empirical constant taken to be equal to **0.4**, for limestone similar to the Nashville test site. The recovery from cores in the rock at test shaft 1 averaged 85% and ranged from 20% to 100% with RQD averaging 38% and ranging from 0 to 65%.

For service load conditions, the allowable side resistance may be computed using the nominal side resistance computed above divided by a factor of safety of 2.5. The allowable unit side resistance times the surface area of the rock socket may be added to the allowable base resistance to size the shaft for service loads.

It may be noted that the design based on allowable side and base resistance values will result in a greater proportion of the service load supported in side resistance because this resistance is mobilized at smaller displacements than the base. However, since the side resistance was observed to be ductile up to displacements in excess of ½ inch, the overall factor of safety will not be significantly affected by issues of strain compatibility.

Cost Implications of Improved Design in Rock

Numerous drilled shaft designs have been completed over the years using base resistance alone and an allowable (service load) design of 100ksf or less. It is reasonable to consider several hypothetical example cases to evaluate the potential cost benefit of improved design. Based on typical current practice in the area, in-place costs of drilled shaft foundations including excavation, concrete, and typical reinforcement is estimated at approximately $400 per cubic yard in earth, $1700 per cubic yard in rock.

Example 1 - Heavy Building

Hypothetical example 1 includes a heavy building structure with 50 drilled shafts to support service loads of 3400 kips per shaft. The site is underlain by approximately 20 feet of overburden soils followed by 8 feet of weathered rock, 8 feet of rock meeting the characteristics described previously for “Fair Rock” and underlain by rock meeting the requirements for “Strong Rock”. Four designs are to be evaluated for cost implications:

A. Previous practice, based on rock excavation to “Strong Rock” and end bearing alone at an allowable base resistance of 100ksf.
B. “Strong Rock” base resistance as outlined in this report.
C. “Fair Rock” base resistance as outlined in this report.
D. “Fair Rock” base resistance plus side resistance as outlined in this report.

In each of the new designs (B, C, D) a load test is included for confirmation of the new design values. Design A (previous practice) does not include costs for a load test shaft.

For design A, the drilled shafts would be 7ft diameter at the base, and probably excavated using an 8ft diameter casing through 20ft of soil overburden followed by 7ft diameter rock socket extending 16ft into the rock. Total costs would be:

- $15,000 per shaft for earth
- $39,000 per shaft for rock
- 50 shafts @ $54k/shaft = **$2,700,000.**

For design B, the drilled shafts could be 3ft diameter, although the structural bearing stresses at service loads would be around 3300psi and high strength concrete might be required. With design of the shafts for a 3.5ft diameter base, stresses in the lower portion of the shaft would be less than 2500psi and a maximum bearing stress on “Strong Rock” would be approximately 350ksf. The 3.5ft diameter by 16ft long socket would likely include a 4ft diameter shaft through the overburden soils. Total costs would be:

- $3,750 per shaft for earth
- $9,700 per shaft for rock
- One load test shaft at a total cost of $75,000.
- 50 shafts @ $13,500 + $75k load test = **$750,000**.

For design C, the drilled shafts could be founded on the “Fair Rock” with a socket extending 8 feet below top of rock. These shafts could be 5ft diameter, with a service load bearing pressure of 175ksf. The 5ft diameter by 8ft long socket would likely include a 5.5ft diameter shaft through the overburden soils. Total costs would be:

- $7,000 per shaft for earth
- $10,000 per shaft for rock
- One load test shaft at a total cost of $75,000
- 50 shafts @ $17,000/shaft + $75k load test = **$925,000**.

For design D, the drilled shafts would be founded as for case C, but the side resistance of the socket is included. With a maximum side resistance of 20ksf as measured in test shaft 1 and a factor of safety of 2.5, an allowable unit side resistance of 8ksf would be realized. As a result, a 4.5ft diameter by 8ft long socket could mobilize 900 kips of resistance against service loads resulting in a service load demand to the base of 2500 kips and a bearing pressure of 160ksf on the 4.5ft diameter base. The 4.5ft diameter by 8ft long socket would likely include a 5ft diameter shaft through the overburden soils. Total costs would be:

- $6,000 per shaft for earth
- $8,000 per shaft for rock
- One load test shaft at a total cost of $75,000.
- 50 shafts @ $14,000/shaft + $75k load test = **$775,000**.

In summary, the estimated foundation costs for the four designs are:

A. Previous practice, **$2,700,000**.
B. “Strong Rock” base resistance, **$750,000**.
C. “Fair Rock” base resistance, **$925,000**.
D. “Fair Rock” base plus side resistance, **$775,000**.

It appears that costs are essentially similar for B and D. Either represent a potential savings of nearly $2million on the project compared to previous practice.

<u>Example 2 - Large Structure with Less Concentrated Loads</u>

Hypothetical example 2 includes a large building structure with 150 drilled shafts to support service loads of 1700 kips per shaft. The site is underlain by the same conditions as example 1, approximately 20 feet of overburden soils followed by 8 feet of weathered rock, 8 feet of rock meeting the characteristics described previously for “Fair Rock” and underlain by rock meeting the requirements for “Strong Rock”. Four designs are to be evaluated for cost implications:

A. Previous practice, based on rock excavation to “Strong Rock” and end bearing alone at an allowable base resistance of 100ksf.

B. “Strong Rock” base resistance as outlined in this report.

C. “Fair Rock” base resistance as outlined in this report.

D. “Fair Rock” base resistance plus side resistance as outlined in this report.

In each of the new designs (B, C, D) a load test is included for confirmation of the new design values. Design A (previous practice) does not include costs for a load test shaft.

For design A, the drilled shafts would be 5ft diameter at the base, and probably excavated using an 5.5ft diameter casing through 20ft of soil overburden followed by 5ft diameter rock socket extending 16ft into the rock. Total costs would be:

- $7,000 per shaft for earth
- $20,000 per shaft for rock
- 150 shafts @ $27k/shaft = **$4,050,000.**

For design B, the drilled shafts could be 3ft diameter, which is the practical minimum for downhole inspection. With design of the shafts for a 3ft diameter base, stresses in the lower portion of the shaft would be less than 1700psi and a maximum bearing stress on “Strong Rock” would be approximately 240ksf. The 3ft diameter by 16ft long socket would likely include a 3.5ft diameter shaft through the overburden soils. Total costs would be:

- $2,900 per shaft for earth
- $7,100 per shaft for rock
- One load test shaft at a total cost of $75,000.
- 150 shafts @ $10,000 + $75k load test = **$1,575,000**.

For design C, the drilled shafts could be founded on the “Fair Rock” with a socket extending 8 feet below top of rock. These shafts could be 3.5ft diameter, with a service load bearing pressure of 180ksf. The 3.5ft diameter by 8ft long socket would likely include a 4ft diameter shaft through the overburden soils. Total costs would be:

- $3,800 per shaft for earth
- $4,900 per shaft for rock
- One load test shaft at a total cost of $75,000
- 150 shafts @ $8,700/shaft + $75k load test = **$1,380,000**.

For design D, the drilled shafts would be founded as for case C, but the side resistance of the socket is included. With a maximum side resistance of 20ksf as measured in test shaft 1 and a factor of safety of 2.5, an allowable unit side resistance of 8ksf would be realized. As a result, a 3ft diameter by 8ft long socket could mobilize 600 kips of resistance against service loads resulting in a service load demand to the base of 1100 kips and a bearing pressure of

160ksf on the 3ft diameter base. The 3ft diameter by 8ft long socket would likely include a 3.5ft diameter shaft through the overburden soils. Total costs would be:

- $2,900 per shaft for earth
- $3,600 per shaft for rock
- One load test shaft at a total cost of $75,000.
- 150 shafts @ $6,500/shaft + $75k load test = **$1,050,000**.

In summary, the estimated foundation costs for the four designs are:

A. Previous practice, **$4,050,000**.
B. "Strong Rock" base resistance, **$1,575,000**.
C. "Fair Rock" base resistance, **$1,380,000**.
D. "Fair Rock" base plus side resistance, **$1,050,000**.

It appears that costs clearly favor approach D. The benefits of extremely high base resistance are not realized at the lesser load demands per shaft on this site. The key to savings is the reduced rock excavation and increased productivity associated with the shorter socket length because of the less stringent acceptance criterion. Even with including the cost of a load test, this approach represents a potential savings of $3million on the project at a cost approximately ¼ that of previous practice.

<u>Example 3 - Medium Structure with Moderate Loads</u>

Hypothetical example 3 includes a building structure with 40 drilled shafts to support service loads of 1000 kips per shaft. The site is underlain by the similar conditions as previous examples except the depth of weathered rock is less; the site has approximately 20 feet of overburden soils followed by 5 feet of weathered rock, 5 feet of rock meeting the characteristics described previously for "Fair Rock" and underlain by rock meeting the requirements for "Strong Rock". Four designs are to be evaluated for cost implications:

A. Previous practice, based on rock excavation to "Strong Rock" and end bearing alone at an allowable base resistance of 100ksf.
B. "Strong Rock" base resistance as outlined in this report.
C. "Fair Rock" base resistance as outlined in this report.
D. "Fair Rock" base resistance plus side resistance as outlined in this report.

In each of the new designs (B, C, D) a load test is included for confirmation of the new design values. Design A (previous practice) does not include costs for a load test shaft.

For design A, the drilled shafts would be 4ft diameter at the base, and probably excavated using an 4.5ft diameter casing through 20ft of soil overburden followed by 4ft diameter rock socket extending 10ft into the rock. Total costs would be:

- $4,700 per shaft for earth
- $8,000 per shaft for rock
- 40 shafts @ $12,700/shaft = **$508,000.**

For design B, the drilled shafts could be 3ft diameter, which is the practical minimum for downhole inspection. With design of the shafts for a 3ft diameter base, stresses in the lower portion of the shaft would be less than 1000psi and a maximum bearing stress on “Strong Rock” would be approximately 150ksf. The 3ft diameter by 10ft long socket would likely include a 3.5ft diameter shaft through the overburden soils. Total costs would be:

- $2,900 per shaft for earth
- $4,500 per shaft for rock
- One load test shaft at a total cost of $75,000.
- 40 shafts @ $7,400 + $75k load test = **$371,000**.

For design C, the drilled shafts could be founded on the “Fair Rock” with a socket extending 5 feet below top of rock. These shafts could be 3ft diameter, with a service load bearing pressure of 150ksf, same as design B. The 3ft diameter by 8ft long socket would likely include a 3.5ft diameter shaft through the overburden soils. Total costs would be:

- $2,900 per shaft for earth
- $2,300 per shaft for rock
- One load test shaft at a total cost of $75,000
- 40 shafts @ $5,200/shaft + $75k load test = **$283,000**.

For design D, the drilled shafts would be founded as for case C, but the side resistance of the socket is included. With a maximum side resistance of 20ksf as measured in test shaft 1 and a factor of safety of 2.5, an allowable unit side resistance of 8ksf would be realized. As a result, a 2.5ft diameter by 5ft long socket could mobilize 300 kips of resistance against service loads resulting in a service load demand to the base of 700 kips and a bearing pressure of 150ksf on the 2.5ft diameter base. The 2.5ft diameter by 5ft long socket would likely include a 3ft diameter shaft through the overburden soils. Total costs would be:

- $2,100 per shaft for earth
- $1,600 per shaft for rock
- One load test shaft at a total cost of $75,000.
- 40 shafts @ $3,700/shaft + $75k load test = **$223,000**.

In summary, the estimated foundation costs for the four designs are:

A. Previous practice, **$508,000**.
B. “Strong Rock” base resistance, **$371,000**.
C. “Fair Rock” base resistance, **$283,000**.
D. “Fair Rock” base plus side resistance, **$223,000**.

It appears that costs clearly favor approach D. Even with including the cost of a load test on this relatively small project, this approach represents a potential savings of over $250k on the project at a cost approximately ½ that of previous practice.

Summary and Conclusions

To be finalized after Nashville meeting.

Appendix A

Site Investigation and Borings

August 15, 2008

Mr. Bruce Long
Long Foundation Drilling
P.O. Box 226
3014 Brandau Road
Hermitage, Tennessee 37076

Re: Drilling Results
Long Foundation Yard
Hermitage, Tennessee

Dear Mr. Long:

Professional Service Industries, Inc.(PSI), previously performed two soil and rock test borings at the above mentioned site to determine rock quality information at the site. Based on the information obtained, additional borings in these areas were requested. Six additional borings, three at each site, were performed at the site to further evaluate the area.

Site One, borings B-2A, B-2B and B-2C, encountered auger refusal at depths of about 12 to 16 feet below existing grade. Rock recovery percentages ranged from 22 to 100 percent and RQD values ranged from 0 to 59 percent. Site Two, borings B-3, B-4 and B-6, encountered auger refusal at depths of about 20 to 28 feet below existing grade. Rock recovery percentages ranged from about 42 to 100 percent and RQD values ranged from 19 to 78 percent.

Rock compression tests were also performed on sections of the retrieved rock cores. The table below lists the locations and compressive results of each sample.

Rock Compressive Strength Results		
Boring	Core Run	Compressive Strength (psi)
B-2A	2	8,100
B-2A	3	4,750
B-2B	2	10,870
B-2B	3	14,170
B-2C	1	9,300
B-2C	3	1,660
B-3	1	33700
B-3	1	20400
B-3	2	29850
B-3	2	33050
B-4	1	9783
B-4	1	11405
B-4	2	15885
B-4	2	12026
B-6	1	9142
B-6	2	10653
B-6	3	12896

Long Foundation Drilling
8/15/08

Rock photos, boring location plan and boring logs are attached.

We appreciate the opportunity to be of service to you. If you have any questions pertaining to this letter, or if we may be of further service, please contact our office.

Respectfully submitted,

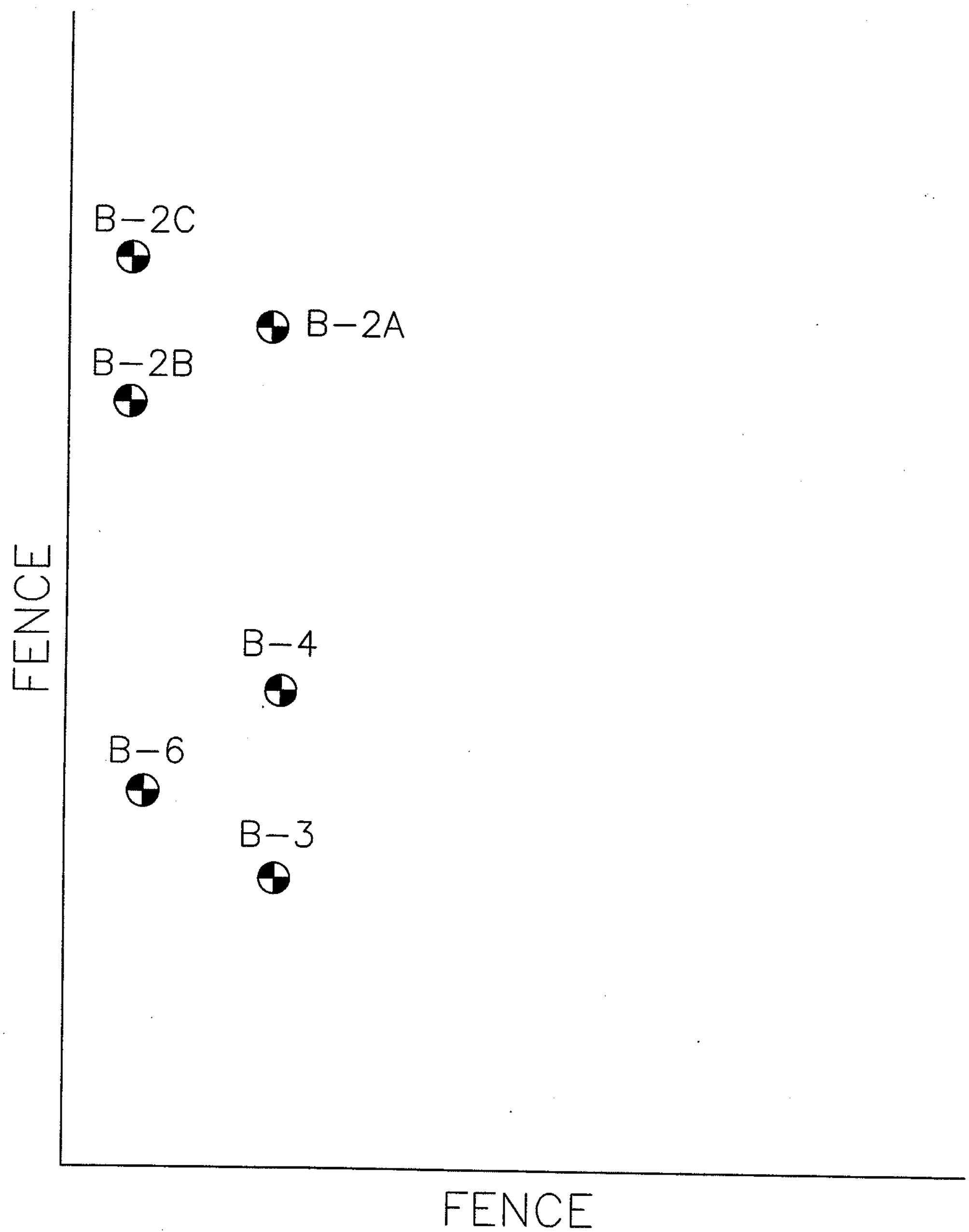
PROFESSIONAL SERVICE INDUSTRIES, INC.

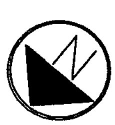
Micah T. McNeer
Department Manager
Geotechnical Services

Stephen R. Bryant
Vice President

Wayne F. Harnack, P.E.
Senior Vice President

MTM/SRB/WFH/tb





APPROXIMATE BORING LOCATION

BORING LOCATION PLAN

LONG PROJECT

HERMITAGE, TN

psi *Information To Build On*

DRAWN WD	SCALE NOT TO SCALE	PROJ. NO.
CHECKED MM	DATE AUGUST 2008	PLATE 1

GENERAL NOTES

FINE AND COARSE GRAINED SOIL PROPERTIES

PARTICLE SIZE

BOULDERS:	GREATER THAN 300 mm
COBBLES:	75 mm to 300 mm
GRAVEL:	4.74 mm to 75 mm
COARSE SAND:	2 mm to 4.75 mm
MEDIUM SAND:	0.425 mm to 2 mm
FINE SAND:	0.075 mm to 0.425 mm
SILTS & CLAYS:	LESS THAN 0.075 mm

COARSE GRAINED SOILS
(SANDS & GRAVELS)

N-VALUE	RELATIVE DENSITY
0-4	VERY LOOSE
5-10	LOOSE
11-30	MEDIUM DENSE
31-50	DENSE
OVER 50	VERY DENSE

FINE GRAINED SOILS
(SILTS & CLAYS)

N-VALUE	CONSISTENCY	Qu, PSF
0-2	VERY SOFT	0 - 500
3-4	SOFT	500 - 1000
5-8	FIRM	1000 - 2000
9-15	STIFF	2000 - 4000
16-30	VERY STIFF	4000 - 8000
OVER 31	HARD	8000+

STANDARD PENETRATION TEST (ASTM D1586)

THE STANDARD PENETRATION TEST AS DEFINED BY ASTM D1586 IS A METHOD TO OBTAIN A DISTURBED SOIL SAMPLE FOR EXAMINATION AND TESTING AND TO OBTAIN RELATIVE DENSITY AND CONSISTENCY INFORMATION. THE 1.4 INCH I.D./2.0 INCH O.D. SAMPLER IS DRIVEN 3-SIX INCH INCREMENTS WITH A 140 LB. HAMMER FALLING 30 INCHES. THE BLOW COUNTS REQUIRED TO DRIVE THE SAMPLER THE FINAL 2 INCREMENTS ARE ADDED TOGETHER AND DESIGNATE THE N-VALUE. AT TIMES, THE SAMPLER CAN NOT BE DRIVEN THE FULL 18 INCHES. THE FOLLOWING PRESENTS OUR INTERPRETATION OF THE STANDARD PENETRATION TEST WITH VARIATIONS.

BLOWS/FOOT (N-VALUE)	DESCRIPTION
25	25 BLOWS DROVE SAMPLER 12" AFTER INITIAL 6" SEATING
75/10"	75 BLOWS DROVE SAMPLER 10" AFTER INITIAL 6" SEATING
50/PR	SAMPLER ENCOUNTERED PENETRATION REFUSAL AFTER 50 BLOWS WITH NO PENETRATION
50/2"	50 BLOWS DROVE SAMPLER 2" AFTER NO INITIAL 6" SEATING

KEY TO MATERIAL CLASSIFICATION

	TOPSOIL
	SOIL FILL MATERIAL
CL	LEAN CLAY
CH	FAT CLAY
ML	LOW PLASTIC SILT
MH	HIGH PLASTIC SILT
SP	POORLY GRADED SAND
SC	CLAYEY SAND
SM	SILTY SAND

LIMESTONE BEDROCK

CRUSHED LIMESTONE

SANDSTONE

SILTSTONE

SHALE

GRAVEL

SHOTROCK FILL

ASPHALT

CONCRETE

SOIL PROPERTY SYMBOLS

N:	STANDARD PENETRATION, BPF
M:	MOISTURE CONTENT, %
LL:	LIQUID LIMIT, %
PI:	PLASTICITY INDEX, %
Qp:	POCKET PENETROMETER VALUE, TSF
Qu:	UNCONFINED COMPRESSIVE STRENGTH, TSF
DUW:	DRY UNIT WEIGHT, PCF

SAMPLING SYMBOLS

UNDISTURBED SAMPLE

SPLIT SPOON SAMPLE

ROCK CORE SAMPLE

AUGER OR BAG SAMPLE

WATER LEVEL AFTER DRILLING

WATER LEVEL AFTER 24 HRS

ROCK PROPERTIES

ROCK QUALITY DESIGNATION (RQD)

PERCENT RQD	QUALITY
90 to 100	EXCELLENT
75 to 90	GOOD
50 to 75	FAIR
25 to 50	POOR
0 to 25	VERY POOR

ROCK HARDNESS

VERY SOFT:	ROCK DISINTEGRATES OR EASILY COMPRESSES TO TOUCH; CAN BE HARD TO VERY HARD SOIL.
SOFT:	ROCK IS COHERANT BUT BREAKS EASILY TO THUMB PRESSURE AT SHARP EDGES AND CRUMBLES WITH FIRM HAND PRESSURE.
MODERATELY HARD:	SMALL PIECES CAN BE BROKEN OFF ALONG SHARP EDGES BY CONSIDERABLE HARD THUMB PRESSURE; CAN BE BROKEN BY LIGHT HAMMER BLOWS.
HARD:	ROCK CANNOT BE BROKEN BY THUMB PRESSURE, BUT CAN BE BROKEN BY MODERATE HAMMER BLOWS.
VERY HARD:	ROCK CAN BE BROKEN BY HEAVY HAMMER BLOWS.

BORING LOG

psi Information To Build On

Project: Long Project	PSI No.:	Date: 7/2/08
	Location: Nashville, TN	

Boring No.: B-2A	Total Depth 39.2'	Elev:	Water at Completion of Drilling: Not Encountered

Boring Method: Hollow Stem Auger	Drill Type: CME-550	Driller: LS

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) ▲ 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200
			Soil Overburden								

BORING LOG

Information To Build On

Project: **Long Project**		PSI No.:	Date: **7/2/08**
		Location: **Nashville, TN**	
Boring No.: **B-2A**	Total Depth **39.2'**	Elev:	Water at Completion of Drilling: **Not Encountered**
Boring Method: **Hollow Stem Auger**	Drill Type: **CME-550**	Driller: **LS**	

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200
	14.2		Light Gray to Gray, Fine to Medium Grained LIMESTONE, weathered, very highly fractured. REC = 54% ; RQD =0% 6 inch void 1.5 inch void 1.5 inch void								
	16.3		Light Gray to Gray, Fine to Medium Grained LIMESTONE with clay seams, weathered, moderately fractured. REC = 87% ; RQD = 34% Clay Seam/Crack Clay Seam/Crack Clay Seam/Crack Clay Seam/Crack Clay Seam/Crack 1.5 inch void								

BORING LOG

Information To Build On

Project: **Long Project**		PSI No.:	Date: **7/2/08**
		Location: **Nashville, TN**	
Boring No.: **B-2A**	Total Depth **39.2'**	Elev:	Water at Completion of Drilling: **Not Encountered**
Boring Method: **Hollow Stem Auger**	Drill Type: **CME-550**	Driller: **LS**	

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
	21.5		Light Gray to Gray, Fine to Medium Grained LIMESTONE with clay seams, weathered, moderately fractured. REC = 87% ; RQD = 34%								
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								

BORING LOG

psi *Information To Build On*

Project: Long Project	PSI No.:	Date: 7/2/08
	Location: Nashville, TN	
Boring No.: B-2A	Total Depth 39.2'	Elev:	Water at Completion of Drilling: Not Encountered
Boring Method: Hollow Stem Auger	Drill Type: CME-550	Driller: LS

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) ▲ 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200
	30.8		Light Gray to Gray, Fine to Medium Grained LIMESTONE with clay seams, weathered, moderately fractured.								
			REC = 100% ; RQD = 59%								
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
			1 inch void								
			1 inch void								
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
	39.0		End of Coring 39.0 Feet								

BORING LOG

Information To Build On

Project: **Long Project**		PSI No.:	Date: **7/2/08**
		Location: **Nashville, TN**	
Boring No.: **B-2B**	Total Depth **41.0'**	Elev:	Water at Completion of Drilling: **Not Encountered**
Boring Method: **Hollow Stem Auger**	Drill Type: **CME-550**	Driller: **LS**	

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200
			Soil Overburden								

NV1 LONG PROJECT.GPJ 8/15/08

BORING LOG

Information To Build On

Project: **Long Project**		PSI No.:	Date: **7/2/08**
		Location: **Nashville, TN**	
Boring No.: **B-2B**	Total Depth **41.0'**	Elev:	Water at Completion of Drilling: **Not Encountered**
Boring Method: **Hollow Stem Auger**	Drill Type: **CME-550**	Driller: **LS**	

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200
	16.0		Light Gray to Gray, Fine to Medium Grained LIMESTONE with clay seams, weathered, very highly fractured. REC=22%, RQD=0% 1 inch void Clay Seam/Crack 32.4 inch void (17.0 to 19.7 feet)								

BORING LOG

Information To Build On

Project: Long Project	PSI No.:	Date: 7/2/08
	Location: Nashville, TN	

Boring No.: B-2B	Total Depth 41.0'	Elev:	Water at Completion of Drilling: Not Encountered
Boring Method: Hollow Stem Auger	Drill Type: CME-550	Driller: LS	

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200
			2.5 inch void 12 inch void								
	21.8		Light Gray to Gray, Fine to Medium Grained LIMESTONE with clay seams, weathered, moderately fractured. REC=72%, RQD=44% Clay Seam/Crack 6 inch clay seam 1 inch void Clay Seam/Crack Clay Seam/Crack Clay Seam/Crack Clay Seam/Crack Clay Seam/Crack								
	27.3		Light Gray to Gray, Fine to Medium Grained LIMESTONE with clay seams, weathered, very highly fractured. REC=97%, RQD=17% Clay Seam/Crack Clay Seam/Crack								

BORING LOG

psi Information To Build On

Project: Long Project	PSI No.:	Date: 7/2/08
	Location: Nashville, TN	
Boring No.: B-2B	Total Depth 41.0'	Elev:
Water at Completion of Drilling: Not Encountered		
Boring Method: Hollow Stem Auger	Drill Type: CME-550	Driller: LS

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
	32.4		Light Gray to Gray, Fine to Medium Grained LIMESTONE with clay seams, weathered, highly fractured. REC=62%, RQD=40%								
			Clay Seam/Crack								
			1 inch void								
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								

BORING LOG

Information To Build On

Project: Long Project	PSI No.:	Date: 7/2/08
	Location: Nashville, TN	

Boring No.: B-2B	Total Depth 41.0'	Elev:	Water at Completion of Drilling: Not Encountered
Boring Method: Hollow Stem Auger	Drill Type: CME-550	Driller: LS	

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) ▲ 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200
			Clay Seam/Crack								
			1 inch void								
	41.0										
			End of Coring 41.0 Feet								

BORING LOG

Information To Build On

Project: Long Project	PSI No.:	Date: 7/2/08
	Location: Nashville, TN	

Boring No.: B-2C	Total Depth 37.2'	Elev:	Water at Completion of Drilling: Not Encountered
Boring Method: Hollow Stem Auger	Drill Type: CME-550	Driller: LS	

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200
			Soil Overburden								

NV1 LONG PROJECT.GPJ 8/15/08

BORING LOG

Information To Build On

Project: Long Project		PSI No.:	Date: 7/2/08
		Location: Nashville, TN	
Boring No.: B-2C	Total Depth 37.2'	Elev:	Water at Completion of Drilling: Not Encountered
Boring Method: Hollow Stem Auger	Drill Type: CME-550	Driller: LS	

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200
	12.3		Light Gray to Gray, Fine to Medium Grained LIMESTONE with clay seams, weathered, highly fractured. REC=33%, RQD=23% 30 inch clay seam (13.5 to 16.0 feet)								
	16.0		Light Gray to Gray, Fine to Medium Grained LIMESTONE with clay seams, weathered, very highly fractured. REC=74%, RQD=9% Clay Seam/Crack 3 inch void Clay Seam/Crack Clay Seam/Crack Clay Seam/Crack								

BORING LOG

Information To Build On

Project: Long Project		PSI No.:	Date: 7/2/08
		Location: Nashville, TN	
Boring No.: B-2C	Total Depth 37.2'	Elev:	Water at Completion of Drilling: Not Encountered
Boring Method: Hollow Stem Auger	Drill Type: CME-550	Driller: LS	

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200
			Clay Seam/Crack								
	21.0		Clay Seam/Crack								
			Light Gray to Gray, Fine to Medium Grained LIMESTONE with clay seams, weathered, highly fractured. REC=100%, RQD=36%								
			1 inch void								
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
	26.8										
			Light Gray to Gray, Fine to Medium Grained LIMESTONE with clay seams, weathered, highly fractured. REC=95%, RQD=38%								
			1 inch void								

BORING LOG

Information To Build On

Project: **Long Project**		PSI No.:	Date: **7/2/08**
		Location: **Nashville, TN**	
Boring No.: **B-2C**	Total Depth **37.2'**	Elev:	Water at Completion of Drilling: **Not Encountered**
Boring Method: **Hollow Stem Auger**	Drill Type: **CME-550**	Driller: **LS**	

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) ▲ 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
	37.0		End of Coring 37.0 Feet								

BORING LOG

Information To Build On

Project: **Long Project**		PSI No.:	Date: **7/23/08**
		Location: **Nashville, TN**	
Boring No.: **B-3**	Total Depth **45.9'**	Elev:	Water at Completion of Drilling: **Not Encountered**
Boring Method: **Hollow Stem Auger**	Drill Type: **CME-550**	Driller: **JH**	

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) ▲ 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200
			Soil Overburden								

BORING LOG

Information To Build On

Project: Long Project	PSI No.:	Date: 7/23/08
	Location: Nashville, TN	

Boring No.: B-3	Total Depth 45.9'	Elev:	Water at Completion of Drilling: Not Encountered
Boring Method: Hollow Stem Auger	Drill Type: CME-550	Driller: JH	

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) ▲ 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200

NV1 LONG PROJECT.GPJ 8/15/08

BORING LOG

Information To Build On

Project: Long Project	PSI No.:	Date: 7/23/08
	Location: Nashville, TN	

Boring No.: B-3	Total Depth 45.9'	Elev:	Water at Completion of Drilling: Not Encountered
Boring Method: Hollow Stem Auger	Drill Type: CME-550	Driller: JH	

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) ▲ 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200
	26.0		Auger Refusal 26.0 Feet; Begin Coring								
			Light Gray to Gray, Fine to Medium Grained LIMESTONE with clay seam and shale partings, slightly fractured. REC=95%; RQD=66% Clay Seam/Crack Clay Seam/Crack								

BORING LOG

Information To Build On

Project: Long Project	PSI No.:	Date: 7/23/08
	Location: Nashville, TN	

Boring No.: B-3	Total Depth 45.9'	Elev:	Water at Completion of Drilling: Not Encountered
Boring Method: Hollow Stem Auger	Drill Type: CME-550	Driller: JH	

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) ▲ 10 20 30 40 50 60 70 80 90	%M	LL	PI	Qp	Qu	% Pass #200
			Clay Seam/Crack Clay Seam/Crack Clay Seam/Crack								
			Clay Seam/Crack								
	35.8		Clay Seam/Crack								
			Light Gray to Gray, Fine to Medium Grained LIMESTONE with clay seam and shale partings, slightly fractured. REC=99%; RQD=78%								
			Clay Seam/Crack Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								

BORING LOG

psi *Information To Build On*

Project: **Long Project**	PSI No.:	Date: **7/23/08**
	Location: **Nashville, TN**	

Boring No.: **B-3**	Total Depth **45.9'**	Elev:	Water at Completion of Drilling: **Not Encountered**
Boring Method: **Hollow Stem Auger**	Drill Type: **CME-550**	Driller: **JH**	

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200
			Clay Seam/Crack Clay Seam/Crack								
	45.8		Coring Terminated at 45.8 Feet Water Level After Coring at 23.0 Feet								

NV1 LONG PROJECT.GPJ 8/15/08

BORING LOG

Information To Build On

Project: Long Project	PSI No.:	Date: 7/24/08
	Location: Nashville, TN	

Boring No.: B-4	Total Depth 47.5'	Elev:	Water at Completion of Drilling: Not Encountered
Boring Method: Hollow Stem Auger	Drill Type: CME-550	Driller: JH	

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) ▲ 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200
			Soil Overburden								

NV1 LONG PROJECT.GPJ 8/15/08

BORING LOG

Information To Build On

Project: Long Project		PSI No.:	Date: 7/24/08
		Location: Nashville, TN	
Boring No.: B-4	Total Depth 47.5'	Elev:	Water at Completion of Drilling: Not Encountered
Boring Method: Hollow Stem Auger	Drill Type: CME-550	Driller: JH	

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) ▲ 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200

BORING LOG

Information To Build On

Project: Long Project	PSI No.:	Date: 7/24/08
	Location: Nashville, TN	

Boring No.: B-4	Total Depth 47.5'	Elev:	Water at Completion of Drilling: Not Encountered
Boring Method: Hollow Stem Auger	Drill Type: CME-550	Driller: JH	

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200
	27.5		Auger Refusal 27.5 Feet; Begin Coring								
			Light Gray to Gray, Fine to Medium Grained LIMESTONE with clay seams, ly fractured. REC=100%, RQD=42% Clay Seam/Crack Clay Seam/Crack								

BORING LOG

psi Information To Build On

Project: **Long Project**		PSI No.:	Date: **7/24/08**
		Location: **Nashville, TN**	
Boring No.: **B-4**	Total Depth **47.5'**	Elev:	Water at Completion of Drilling: **Not Encountered**
Boring Method: **Hollow Stem Auger**	Drill Type: **CME-550**	Driller: **JH**	

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
			Clay Seam/Crack								
	37.5		Light Gray to Gray, Fine to Medium Grained LIMESTONE with clay seams, ly fractured. REC=95%, RQD=39%								

BORING LOG

Information To Build On

Project: Long Project		PSI No.:	Date: 7/24/08
		Location: Nashville, TN	
Boring No.: B-4	Total Depth 47.5'	Elev:	Water at Completion of Drilling: Not Encountered
Boring Method: Hollow Stem Auger	Drill Type: CME-550		Driller: JH

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) ▲ 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200
			Clay Seam/Crack								
	47.5										
			Coring Terminated at 47.5 Feet								
			Water Level After Coring at 33.3 Feet								

BORING LOG

Information To Build On

Project: Long Project		PSI No.:	Date: 8/1/08
		Location: Nashville, TN	
Boring No.: B-6	Total Depth 44.6'	Elev:	Water at Completion of Drilling: Not Encountered
Boring Method: Hollow Stem Auger	Drill Type: CME -55	Driller: JH	

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) ▲ 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200
			Soil Overburden								

NV1 LONG PROJECT.GPJ 8/15/08

BORING LOG

psi Information To Build On

Project: Long Project	PSI No.:	Date: 8/1/08
	Location: Nashville, TN	

Boring No.: B-6	Total Depth 44.6'	Elev:	Water at Completion of Drilling: Not Encountered
Boring Method: Hollow Stem Auger	Drill Type: CME -55	Driller: JH	

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200
	19.2		Auger Refusal 19.2 Feet; Begin Coring:								
			Light Gray to Gray, Fine to Medium Grained LIMESTONE with clay seams								

BORING LOG

PSI Information To Build On

Project: Long Project		PSI No.:	Date: 8/1/08
		Location: Nashville, TN	
Boring No.: B-6	Total Depth 44.6'	Elev:	Water at Completion of Drilling: Not Encountered
Boring Method: Hollow Stem Auger	Drill Type: CME -55	Driller: JH	

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200
			and shale partings, weathered, very highly fractured. VOIDS between 20.0' to 21.3' and 23.0' to 26.8' REC=42%; RQD=19%								
	29.2		Light Gray to Gray, Fine to Medium Grained LIMESTONE with clay seams and shale partings, weathered, moderately fractured.								

BORING LOG

Information To Build On

Project: **Long Project**		PSI No.:	Date: **8/1/08**
		Location: **Nashville, TN**	
Boring No.: **B-6**	Total Depth **44.6'**	Elev:	Water at Completion of Drilling: **Not Encountered**
Boring Method: **Hollow Stem Auger**	Drill Type: **CME -55**	Driller: **JH**	

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) ▲ 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200
			REC=100%; RQD=41%								
	34.6		Light Gray to Gray, Fine to Medium Grained LIMESTONE with clay seams and shale partings, weathered, moderately fractured. REC=96%; RQD=64%								

BORING LOG

psi *Information To Build On*

Project: Long Project	PSI No.:	Date: 8/1/08
	Location: Nashville, TN	

Boring No.: B-6	Total Depth 44.6'	Elev:	Water at Completion of Drilling: Not Encountered
Boring Method: Hollow Stem Auger	Drill Type: CME -55	Driller: JH	

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) ▲ 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	Qu	% Pass #200
	44.6										
			Coring Terminated at 44.6 Feet								

NV1 LONG PROJECT.GPJ 8/15/08


LONG
B-2A@14.2'-39.2'


LONG
B-2B@21.6'-41.0'
#2B
#2B
#2B

psi


LONG
B-3@26.0'-45.7'


LONG
B-4@27.5'-47.5'


LONG
B-6@ 19.2'- 44.6'

psi Information To Build On
Engineering • Consulting • Testing

June 2, 2008

Mr. Bruce Long
Long Foundation Drilling Co.
P.O. Box 266
3014 Brandau Road
Hermitage, Tennessee 37076

Dear Mr. Long:

As requested, Professional Service Industries, Inc., performed two borings at the Long Foundation Drilling equipment yard in Hermitage, Tennessee. The first boring, B-1, was located in the rear of the yard. Auger refusal in this boring was encountered at about 16 feet below the ground surface. Two, 10 foot rock core runs were then performed. Recovery percentage for each run was 100% and RQD values were 64% and 65%. The second boring, B-2, was performed along the northern property line. Auger refusal in this boring was encountered at about 16½ feet below the ground surface. Two, 10 foot rock core runs were also performed at this location. Recovery percentages were 93% and 97% and RQD values were 51% and 46%.

Respectfully submitted,

PROFESSIONAL SERVICE INDUSTRIES, INC.

Micah T. McNeer
Department Manager
Geotechnical Services

Wayne F. Harnack, P.E.
Senior Vice President

GENERAL NOTES

FINE AND COARSE GRAINED SOIL PROPERTIES

PARTICLE SIZE

BOULDERS:	GREATER THAN 300 mm
COBBLES:	75 mm to 300 mm
GRAVEL:	4.74 mm to 75 mm
COARSE SAND:	2 mm to 4.75 mm
MEDIUM SAND:	0.425 mm to 2 mm
FINE SAND:	0.075 mm to 0.425 mm
SILTS & CLAYS:	LESS THAN 0.075 mm

COARSE GRAINED SOILS
(SANDS & GRAVELS)

N-VALUE	RELATIVE DENSITY
0-4	VERY LOOSE
5-10	LOOSE
11-30	MEDIUM DENSE
31-50	DENSE
OVER 50	VERY DENSE

FINE GRAINED SOILS
(SILTS & CLAYS)

N-VALUE	CONSISTENCY	Qu, PSF
0-2	VERY SOFT	0 - 500
3-4	SOFT	500 - 1000
5-8	FIRM	1000 - 2000
9-15	STIFF	2000 - 4000
16-30	VERY STIFF	4000 - 8000
OVER 31	HARD	8000 +

STANDARD PENETRATION TEST (ASTM D1586)

THE STANDARD PENETRATION TEST AS DEFINED BY ASTM D1586 IS A METHOD TO OBTAIN A DISTURBED SOIL SAMPLE FOR EXAMINATION AND TESTING AND TO OBTAIN RELATIVE DENSITY AND CONSISTENCY INFORMATION. THE 1.4 INCH I.D./2.0 INCH O.D. SAMPLER IS DRIVEN 3-SIX INCH INCREMENTS WITH A 140 LB. HAMMER FALLING 30 INCHES. THE BLOW COUNTS REQUIRED TO DRIVE THE SAMPLER THE FINAL 2 INCREMENTS ARE ADDED TOGETHER AND DESIGNATE THE N-VALUE. AT TIMES, THE SAMPLER CAN NOT BE DRIVEN THE FULL 18 INCHES. THE FOLLOWING PRESENTS OUR INTERPRETATION OF THE STANDARD PENETRATION TEST WITH VARIATIONS.

BLOWS/FOOT (N-VALUE)	DESCRIPTION
25	25 BLOWS DROVE SAMPLER 12" AFTER INITIAL 6" SEATING
75/10"	75 BLOWS DROVE SAMPLER 10" AFTER INITIAL 6" SEATING
50/PR	SAMPLER ENCOUNTERED PENETRATION REFUSAL AFTER 50 BLOWS WITH NO PENETRATION
50/2"	50 BLOWS DROVE SAMPLER 2" AFTER NO INITIAL 6" SEATING

KEY TO MATERIAL CLASSIFICATION

TOPSOIL	LIMESTONE BEDROCK
SOIL FILL MATERIAL	CRUSHED LIMESTONE
CL LEAN CLAY	SANDSTONE
CH FAT CLAY	SILTSTONE
ML LOW PLASTIC SILT	SHALE
MH HIGH PLASTIC SILT	GRAVEL
SP POORLY GRADED SAND	SHOTROCK FILL
SC CLAYEY SAND	ASPHALT
SM SILTY SAND	CONCRETE

SOIL PROPERTY SYMBOLS

N: STANDARD PENETRATION, BPF
M: MOISTURE CONTENT, %
LL: LIQUID LIMIT, %
PI: PLASTICITY INDEX, %
Qp: POCKET PENETROMETER VALUE, TSF
Qu: UNCONFINED COMPRESSIVE STRENGTH, TSF
DUW: DRY UNIT WEIGHT, PCF

SAMPLING SYMBOLS

UNDISTURBED SAMPLE
SPLIT SPOON SAMPLE
ROCK CORE SAMPLE
AUGER OR BAG SAMPLE
WATER LEVEL AFTER DRILLING
WATER LEVEL AFTER 24 HRS

ROCK PROPERTIES

ROCK QUALITY DESIGNATION (RQD)

PERCENT RQD	QUALITY
90 to 100	EXCELLENT
75 to 90	GOOD
50 to 75	FAIR
25 to 50	POOR
0 to 25	VERY POOR

ROCK HARDNESS

VERY SOFT:	ROCK DISINTEGRATES OR EASILY COMPRESSES TO TOUCH; CAN BE HARD TO VERY HARD SOIL.
SOFT:	ROCK IS COHERANT BUT BREAKS EASILY TO THUMB PRESSURE AT SHARP EDGES AND CRUMBLES WITH FIRM HAND PRESSURE.
MODERATELY HARD:	SMALL PIECES CAN BE BROKEN OFF ALONG SHARP EDGES BY CONSIDERABLE HARD THUMB PRESSURE; CAN BE BROKEN BY LIGHT HAMMER BLOWS.
HARD:	ROCK CANNOT BE BROKEN BY THUMB PRESSURE, BUT CAN BE BROKEN BY MODERATE HAMMER BLOWS.
VERY HARD:	ROCK CAN BE BROKEN BY HEAVY HAMMER BLOWS.

psi Information To Build On

BORING LOG

psi Information To Build On

Project: Long Project	PSI No.:	Date: 5/29/08
	Location: Nashville, TN	

Boring No.: B-1	Total Depth 36.0'	Elev:	Water at Completion of Drilling: After Coring 3 Feet
Boring Method: Hollow Stem Auger	Drill Type: CME-55		Driller: JH

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	CBR	PID
	0.5		6" CRUSHED LIMESTONE								
			Brown CLAY with chert and silt. (DRILLER DESCRIPTION)								
	16.0		Auger Refusal 16.0 Feet; Begin Coring. Light Gray to Gray, Fine to Medium Grained LIMESTONE with clay seams and shale partings, slightly fractured. REC=100%; RQD=64%								
	26.0		Light Gray to Gray, Fine to Medium Grained LIMESTONE with clay seams and shale partings, slightly fractured. REC=100%; RQD=65%								
	36.0		Coring Terminated 36.0 Feet Water Level After Coring 3.0 Feet								

BORING LOG

Information To Build On

Project: **Long Project**		PSI No.:	Date: **5/29/08**
		Location: **Nashville, TN**	
Boring No.: **B-2**	Total Depth **36.5'**	Elev:	Water at Completion of Drilling: **Not Encountered**
Boring Method: **Hollow Stem Auger**	Drill Type: **CME-55**	Driller: **JH**	

Elevation (MSL)	Depth (feet)	Sample	DESCRIPTION OF MATERIALS	N	N VALUE (bpf) 10 20 30 40 50 60 70 80 90	% M	LL	PI	Qp	CBR	PID
	0.7		8" CRUSHED LIMESTONE								
			Brown CLAY with chert and silt. (DRILLER DESCRIPTION)								
	16.5		Auger Refusal 16.5 Feet; Begin Coring. Light Gray to Gray, Fine to Medium Grained LIMESTONE with clay seams, moderately fractured. REC=93%; RQD=51%								
	26.5		Very Light Gray to Gray, Fine to Medium Grained LIMESTONE with clay seams and shale partings, moderately fractured. REC=97%; RQD=46%								
	36.5		Coring Terminated 36.5 Feet Water Lost During Coring								

NV1 LONG CORE.GPJ 6/3/08

1


LONG
FOUNDATION
B2@16.5'-36.5'

Appendix B

Inspection Records of Drilled Shaft Construction

REPORT OF CONCRETE COMPRESSION TEST

TESTED FOR: LONG FOUNDATION

PROJECT: LONG FOUNDATION

DATE: SEPTEMBER 24, 2008

OUR REPORT NO.:

FIELD DATA:

LOCATION OF PLACEMENT TEST CAISSON #1

DATE PLACED	9/17/08
TIME	4:36 p.m.
SLUMP, IN.	8
AIR CONTENT %	5.5
AIR TEMPERATURE, °F	82
CONCRETE TEMPERATURE, °F	77
DATE RECEIVED IN LAB	9/18/08
FIELD DATA SUBMITTED BY	PSI/C. O'NEILL
MIX DATA SUBMITTED BY	

SUPPLIER	METRO
DELIVERY TICKET NO./TRUCK NO.	10053
MIX NUMBER AND PROPORTIONS	5,000 2 DAY
CEMENT	
WATER	
FINE AGGREGATE	
COARSE AGGREGATE	
ADMIXTURE	

NOTE: APPLICABLE ASTM STANDARDS, UNLESS OTHERWISE INDICATED: SLUMP: C143; AIR CONTENT: C231 (EXCLUDING SEC.6); TEMPERATURE: C1064; CYLINDERS: C31 (EXCLUDING SEC. 10.1.2); SAMPLING: C172

COMPRESSION TEST RESULTS

ASTM C39; C1231

LABORATORY NUMBER	SPECIMEN IDENTIFICATION OR SET NO.	TEST AGE (DAYS)	DATE OF TEST	TOTAL LOAD (LBS.)	CYLINDER DIAMETER (IN.)	CYLINDER AREA (SQ. IN.)	COMPRESSIVE STRENGTH (PSI)	TYPE OF BREAK
1130	1A	7	9/24/08	71525	4.01		5660	TYPE 2
1130	1B	28	10/15/08	99556	4.01		7880	TYPE 2
1130	1C	28	10/15/08	98469	4.01		7800	TYPE 2
1130	1D	9	9/26/08	72456	4.01		5770	TYPE 5
SPECIFICATIONS		28					5000	

REMARKS:

X Cylinders made by PSI representative

X Cylinders picked up by PSI representative.

X Test results comply with applicable specifications.

_____ Cylinders made by Architect's or Contractor's representative

_____ Cylinders delivered to PSI laboratory.

_____ Test results do not comply with Applicable specifications.

BATCHED: 3:31, EMPTY 4:45, TRUCK NO.241
DENSITY UNIT WT.=145.6pcf

Respectfully Submitted,
Professional Service Industries, Inc.

THESE TEST RESULTS APPLY ONLY TO THE SPECIFIC SAMPLES TESTED AND MAY NOT BE INDICATIVE OF THE ENTIRE CONCRETE PLACEMENT.

REPORT OF FIELD INSPECTION OF CONCRETE

TESTED FOR: LONG FOUNDATION

PROJECT: LONG FOUNDATION

DATE: SEPTEMBER 17, 2008

OUR REPORT NO.:

FIELD DATA: Concrete was a 5000 psi mix delivered my MRM, mix number 5000 2 Day.

SET NO.	NO. OF SPECIMENS MADE	CONCRETE SUPPLIER TICKET NUMBER	TIME TRUCK DISPATCHED	TIME TRUCK UNLOADED	CUBIC YARDS OF CONCRETE	SLUMP, in.	AIR CONTENT, %	TEMPERATURE, ^{0}F	
								AIR	CONCRETE
1	4	10053	3:31pm	4:45pm	9	8	5.5	82	77

LOCATION:

1	Unit wt.=145.6PCF

NOTE: APPLICABLE ASTM STANDARDS, UNLESS OTHERWISE INDICATED: MAKING SPECIMENS: C31-00 (EXC. SEC. 9.1.2); SLUMP: C143-00; AIR CONTENT: C231-97 (EXC. SEC. 6); TEMPERATURE: C1064-99; SAMPLING: C172-99

REMARKS: Observed the placement of 9 cubic yards of concrete.

Respectfully submitted,
Professional Service Industries, Inc.

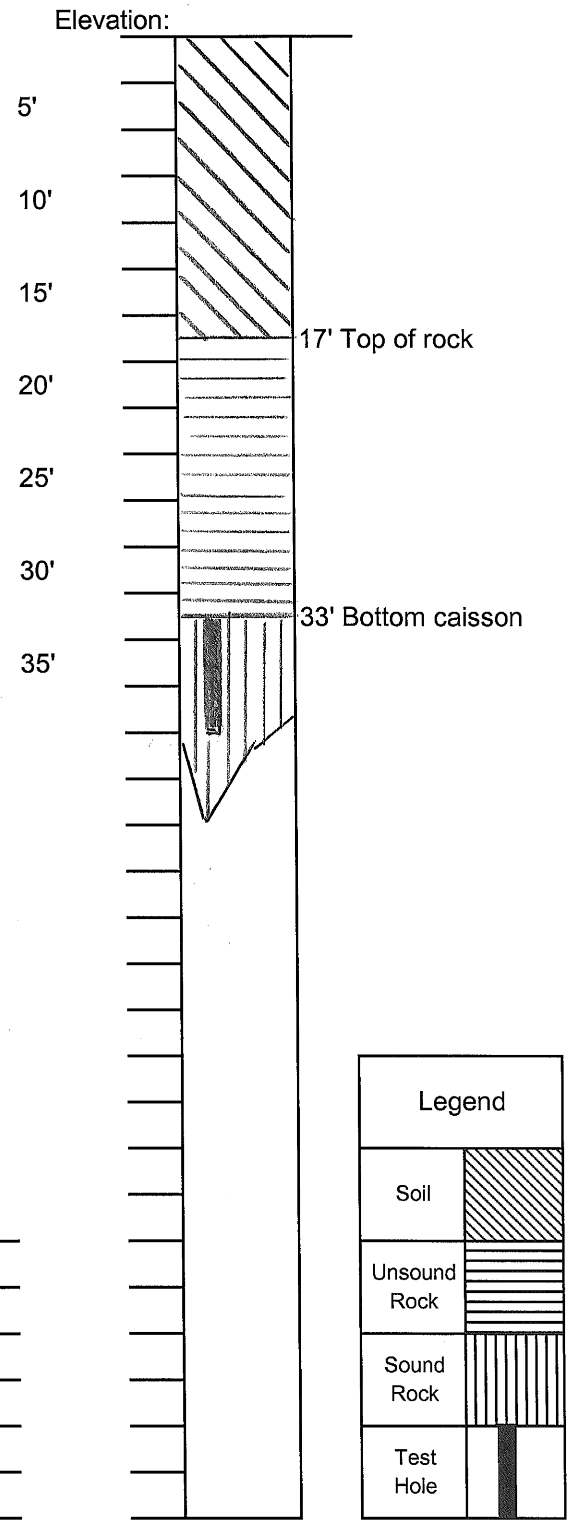
CAISSON FIELD DATA REPORT

LONG FOUNDATION

PSI Report No.: Load cell in bottom of caisson

Date: 9/17/2008

Caisson Number	
Caisson Location	
Caisson Diameter, in	48"
Socket Depth Required, ft	
Ground Elevation	
Plumbness Checked (see notes)	
Caisson Start Date/Time	
Caisson Drilling Complete Date/Time	
Caisson Length (Top of Concrete to Bottom)	
Top of Rock (Elevation)	Minus 17 feet
Bottom of Caisson (Elevation)	Minus 33 feet
Test Holes (number/length)	1 at 51"
Rock depth removed	16 feet
Test Hole Accepted (date/time)	
Loose Material at Bottom (?)	Yes
Water Condition at Bottom (depth/flow rate)	None
Reinforcing steel, vertical (size/spacing)	6 #9
Reinforcing steel, bands (size/spacing)	#4 at 12" O.C.
Reinforcing steel clearance from sides	
Reinforcing steel clearance from bottom	
Concrete volume - theoretical	
Concrete volume - actual	
Top of Concrete elevation	
Concrete placement start (date/time)	9/17/08 - 4:27pm
Concrete placement finish (date/time)	9/17/08 - 4:45pm



REMARKS

3 inch soil seam at 19 inches

1/2 inch rock

3/4 inch soil seam

18 inch weathered rock with voids and shale

51 inch deep test hole

Note: *Plumbness check done by contractor; observed by PSI. Caissons were constructed using steel casing.*

Surveyed locations and elevations were provided to PSI by others.

Professional Service Industries, Inc.

REPORT OF CONCRETE COMPRESSION TEST

TESTED FOR: LONG FOUNDATION

PROJECT: LONG FOUNDATION

DATE: OCTOBER 9, 2008

OUR REPORT NO.:

FIELD DATA:

LOCATION OF PLACEMENT Test Shaft #2

DATE PLACED	10/2/08	SUPPLIER	METRO
TIME	1:21 p.m.	DELIVERY TICKET NO./TRUCK NO.	11202
SLUMP, IN.	6.5"	MIX NUMBER AND PROPORTIONS	5,000 2 DAY PT AE
AIR CONTENT %	8.0	CEMENT	
AIR TEMPERATURE, °F	72	WATER	
CONCRETE TEMPERATURE, °F	77	FINE AGGREGATE	
DATE RECEIVED IN LAB	10/3/08	COARSE AGGREGATE	
FIELD DATA SUBMITTED BY	PSI/C. O'NEILL	ADMIXTURE	PLASTICIZER
MIX DATA SUBMITTED BY			

NOTE: APPLICABLE ASTM STANDARDS, UNLESS OTHERWISE INDICATED: SLUMP: C143; AIR CONTENT: C231 (EXCLUDING SEC.6); TEMPERATURE: C1064; CYLINDERS: C31 (EXCLUDING SEC. 10.1.2); SAMPLING: C172

COMPRESSION TEST RESULTS

ASTM C39; C1231

LABORATORY NUMBER	SPECIMEN IDENTIFICATION OR SET NO.	TEST AGE (DAYS)	DATE OF TEST	TOTAL LOAD (LBS.)	CYLINDER DIAMETER (IN.)	CYLINDER AREA (SQ. IN.)	COMPRESSIVE STRENGTH (PSI)	TYPE OF BREAK
1371	1A	7	10/09/08	62743	4.00		4990	TYPE 2
1371	1B	28	10/30/08	85761	4.01		6790	TYPE 5
1371	1C	28	10/30/08	81428	4.01		6450	TYPE 2
1371	1D	12	10/14/08	74188	4.00		5900	TYPE 2
SPECIFICATIONS		28					5000	

REMARKS:

X Cylinders made by PSI representative

X Cylinders picked up by PSI representative.

X Test results comply with applicable specifications.

_____ Cylinders made by Architect's or Contractor's representative

_____ Cylinders delivered to PSI laboratory.

_____ Test results do not comply with Applicable specifications.

BATCHED: 12:14, EMPTY: 1:17, TRUCK NO.201
DENSITY UNIT WT.=140.0pcf

Respectfully Submitted,
Professional Service Industries, Inc.

REPORT OF FIELD INSPECTION OF CONCRETE

TESTED FOR: LONG FOUNDATION PROJECT: LONG FOUNDATION

DATE: OCTOBER 2, 2008 OUR REPORT NO.:

FIELD DATA: Concrete was a 5000 psi mi delivered by MRM, mix number 5000 2 Day PT.

SET NO.	NO. OF SPECIMENS MADE	CONCRETE SUPPLIER TICKET NUMBER	TIME TRUCK DISPATCHED	TIME TRUCK UNLOADED	CUBIC YARDS OF CONCRETE	SLUMP, in.	AIR CONTENT, %	TEMPERATURE, °F	
								AIR	CONCRETE
1	4	11202	12:14pm	1:17pm	9	6.5	8.0	72	77

LOCATION:

1	Sampled at shaft #2, unit wt.=140.0pcf

NOTE: APPLICABLE ASTM STANDARDS, UNLESS OTHERWISE INDICATED: MAKING SPECIMENS: C31-00 (EXC. SEC. 9.1.2); SLUMP: C143-00; AIR CONTENT: C231-97 (EXC. SEC. 6); TEMPERATURE: C1064-99; SAMPLING: C172-99

REMARKS: Observed the placement of 20 cubic yards of concrete.

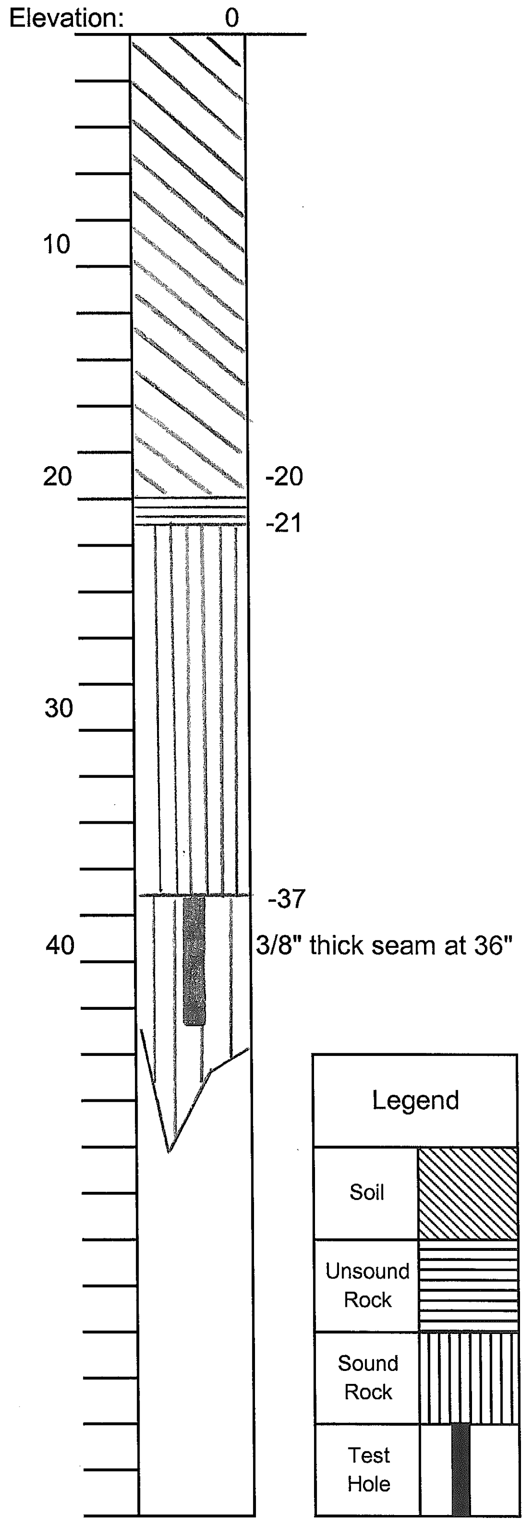
Respectfully submitted,
Professional Service Industries, Inc.

CAISSON FIELD DATA REPORT

LONG FOUNDATION

PSI Report No.: ____________________ Date: 10/2/2008

Caisson Number	Test Shaft
Caisson Location	#2
Caisson Diameter, in	48"
Socket Depth Required, ft	
Ground Elevation	
Plumbness Checked (see notes)	
Caisson Start Date/Time	
Caisson Drilling Complete Date/Time	
Caisson Length (Top of Concrete to Bottom)	
Top of Rock (Elevation)	Minus 20 feet
Bottom of Caisson (Elevation)	Minus 37 feet
Test Holes (number/length)	1 - 6 feet
Rock depth removed	17 feet
Test Hole Accepted (date/time)	10/2/2008
Loose Material at Bottom (?)	No
Water Condition at Bottom (depth/flow rate)	Dry
Reinforcing steel, vertical (size/spacing)	5 #9
Reinforcing steel, bands (size/spacing)	#3 at 24"
Reinforcing steel clearance from sides	3"
Reinforcing steel clearance from bottom	
Concrete volume - theoretical	
Concrete volume - actual	
Top of Concrete elevation	
Concrete placement start (date/time)	10/2/2008
Concrete placement finish (date/time)	



REMARKS

Note: *Plumbness check done by contractor; observed by PSI. Caissons were constructed using steel casing.*

Surveyed locations and elevations were provided to PSI by others.

Professional Service Industries, Inc.

Appendix C

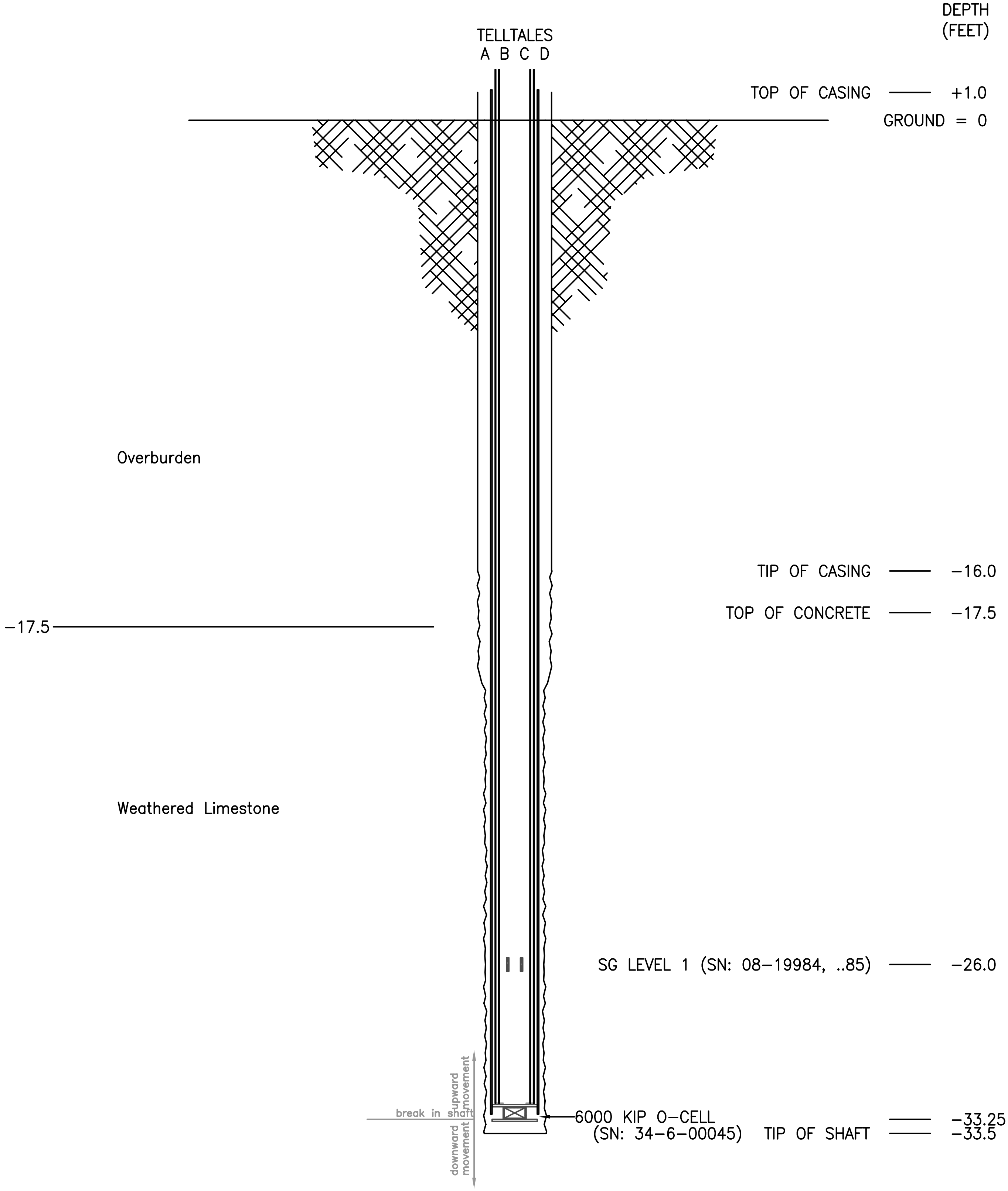
Load Test Reports

LOADTEST

TABLE A:
SUMMARY OF DIMENSIONS, ELEVATIONS & SHAFT PROPERTIES

Shaft:			
Nominal shaft diameter (EL -17.5 ft to -33.5 ft)	=	48 in	1219 mm
O-cell: 34-6-00045	=	34 in	860 mm
Length of side shear above break at base of O-cell	=	15.8 ft	4.80 m
Length of side shear below break at base of O-cell	=	0.3 ft	0.08 m
Shaft side shear area above O-cell base	=	197.9 ft²	18.4 m²
Shaft side shear area below O-cell base	=	3.1 ft²	0.3 m²
Shaft base area (assumed to be 36" + 2:1 load distribution over 3" below the O-cell)	=	8.3 ft²	0.8 m²
Bouyant weight of pile above base of O-cell	=	31 kips	0.14 MN
Estimated shaft stiffness, AE (EL -17.5 ft to -33.5 ft)	=	8,020,000 kips	35,700 MN
Elevation of ground surface (assumed)	=	+0.0 ft	+0.00 m
Elevation of top of shaft concrete	=	-17.5 ft	-5.33 m
Elevation of base of O-cell (The break between upward and downward movement.)	=	-33.2 ft	-10.13 m
Elevation of shaft tip	=	-33.5 ft	-10.21 m
Elevation of water table	=	NOT ENCOUNTERED	
Casings:			
Elevation of top of inner temporary casing (54.0 in O.D.)	=	+1.0 ft	+0.30 m
Elevation of bottom of inner temporary casing (54.0 in O.D.)	=	-16.0 ft	-4.88 m
Compression Sections:			
Elevation of top of compression section used for upper shaft compression	=	-17.5 ft	-5.33 m
Elevation of bottom of compression section used for upper shaft compression	=	-32.1 ft	-9.78 m
Strain Gages:			
Elevation of strain gage Level 1	=	-26.0 ft	-7.94 m
Miscellaneous:			
Top plate diameter (2-inch thickness)	=	33.0 in	838 mm
Bottom plate diameter (2-inch thickness)	=	36.0 in	914 mm
ReBar size (6 No.)	=	# 10	M 32
Spiral size (13 inch spacing)	=	# 5	M 16
ReBar cage diameter	=	36 in	914 mm
Unconfined compressive concrete strength	=	5771 psi	39.8 MPa
Bottom Plate Telltales with radius	=	16.5 in	419 mm

NOTE: NOMINAL SHAFT 48"ø
CASING 54"ø



NOTE: SOIL BASED ON BORING # B−1

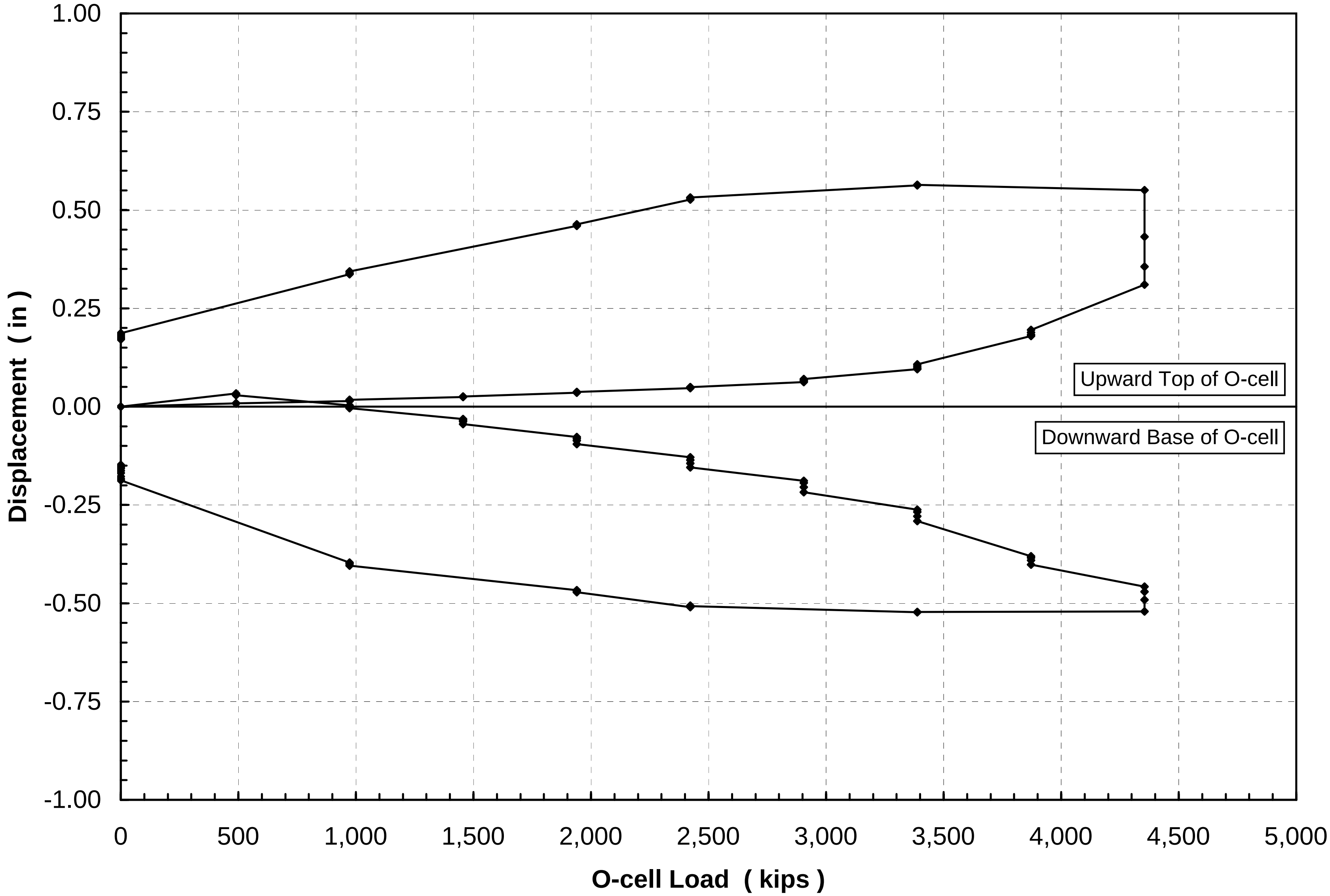
LOADTEST
2631−D NW 41st St.
Gainesville, FL 32606
Phone 800−368−1138
FAX 352−378−3934

SCHEMATIC SECTION OF TEST SHAFT
ADSC RESEARCH − NASHVILLE, TN

DRAWN BY: THE	DATE: 09/02/08	CHECKED BY:	LT−9507
REVISED BY: THE	DATE: 09/30/08	SCALE: NTS	FIGURE A

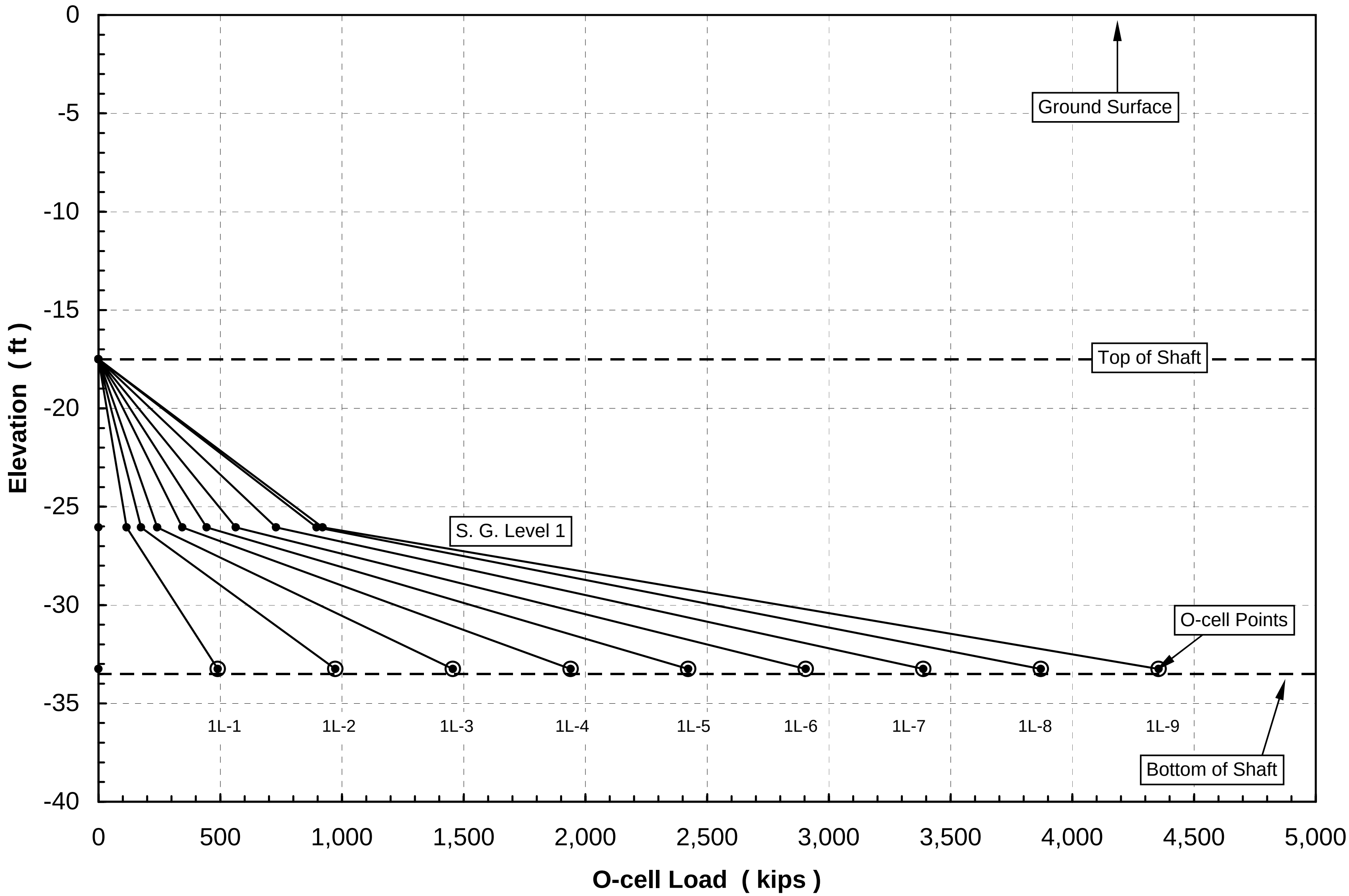
Osterberg Cell Load-Displacement

TS-1 - ADSC Research Project - Nashville, TN



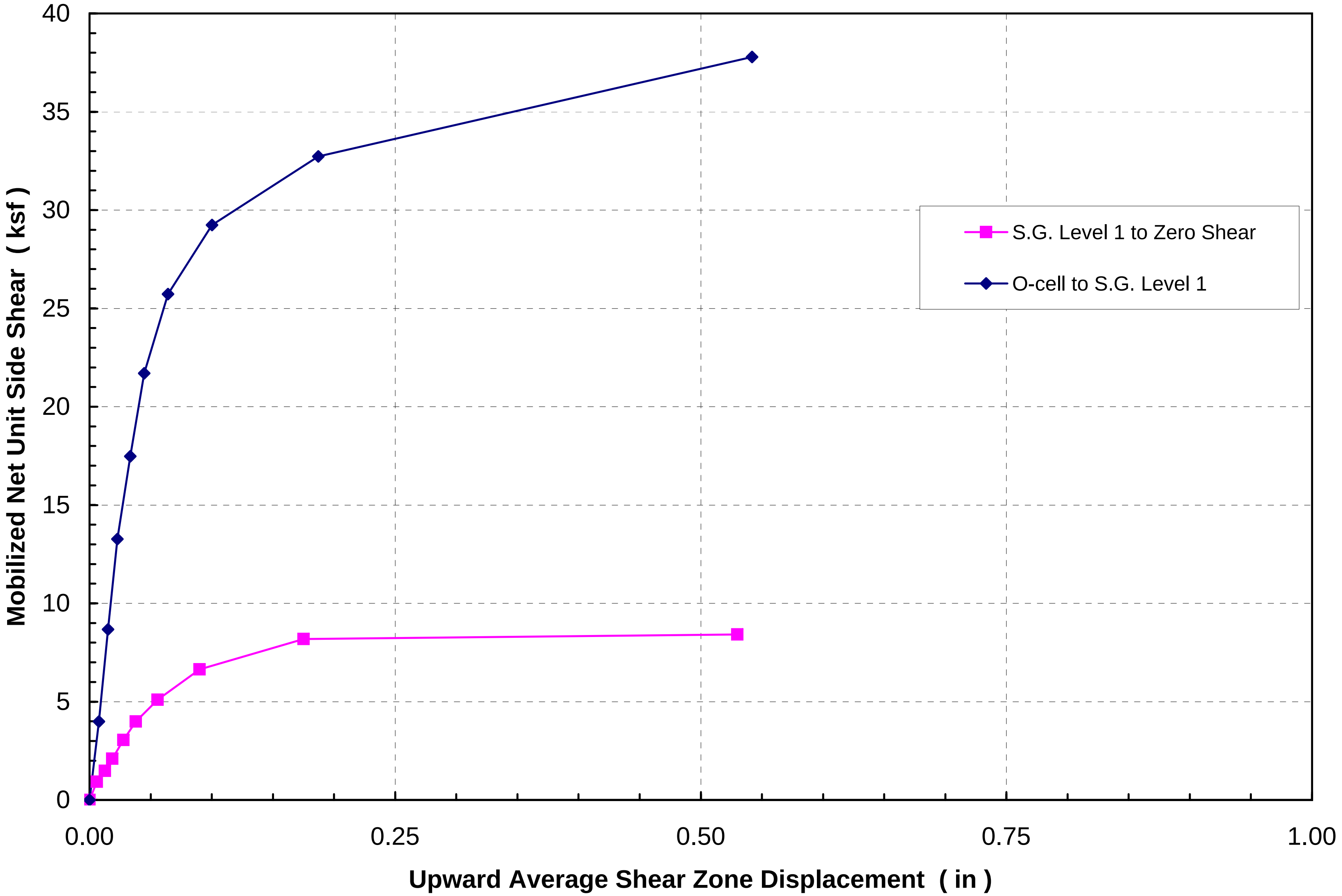
Strain Gage Load Distribution

TS-1 - ADSC Research Project - Nashville, TN



Mobilized Net Unit Side Shear

TS-1 - ADSC Research Project - Nashville, TN

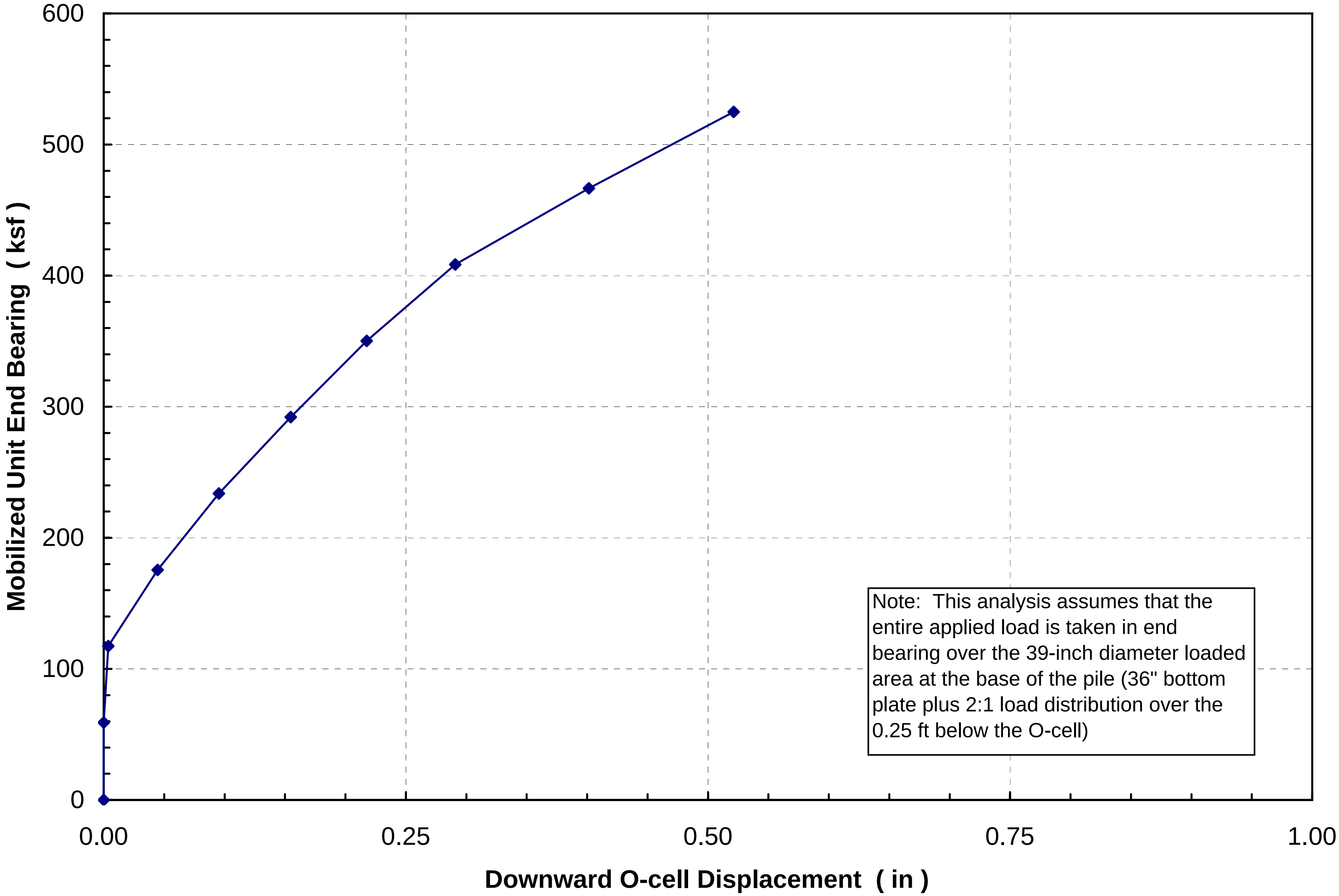


LOADTEST, Inc. Project No. LT-9507

Figure 3 of 5

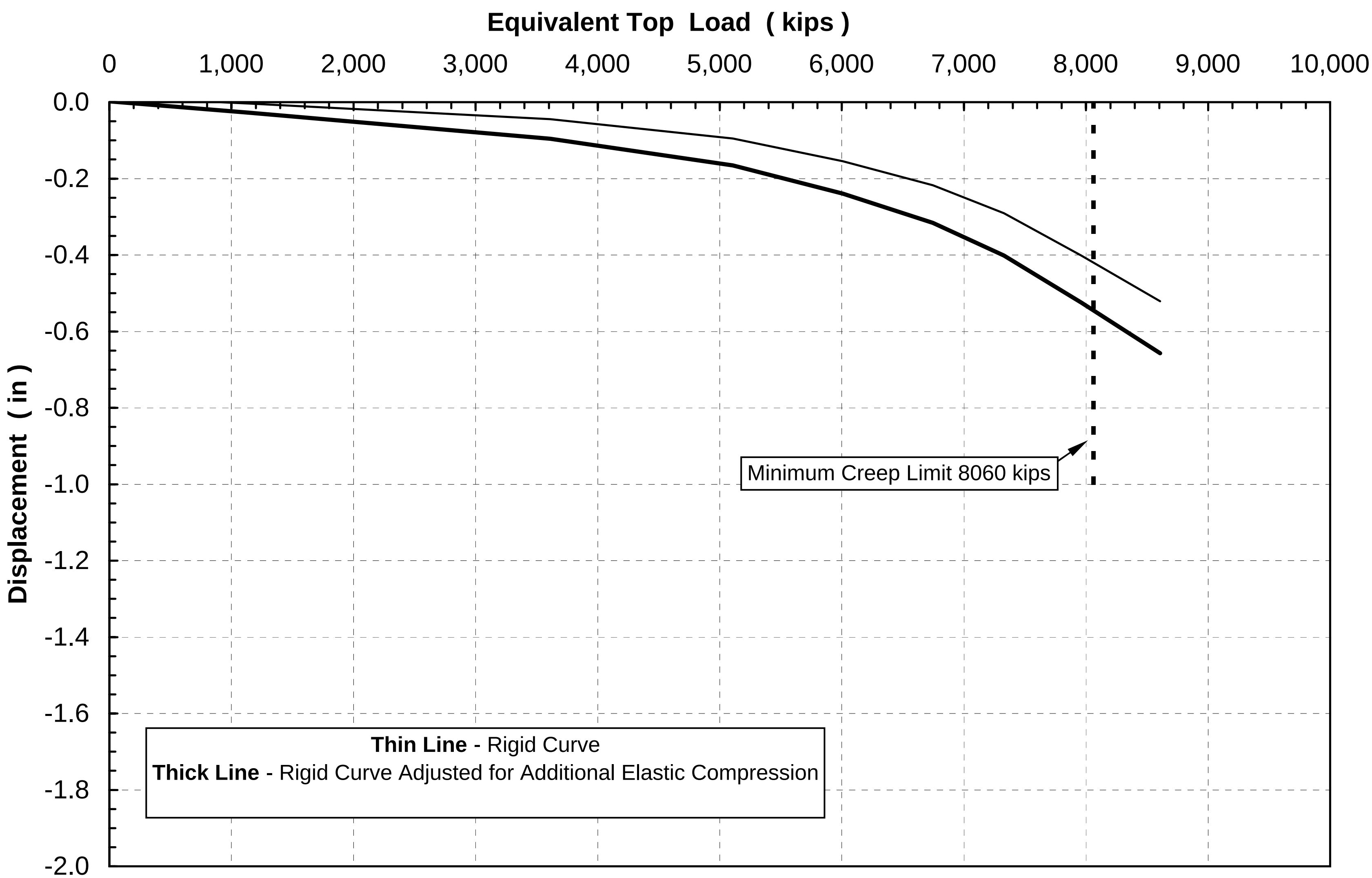
Mobilized Unit End Bearing

TS-1 - ADSC Research Project - Nashville, TN



Equivalent Top Load-Displacement

TS-1 - ADSC Research Project - Nashville, TN



Upward Top of Shaft Movement Telltales
TS-1 - ADSC Research Project - Nashville, TN

Load Test Increment	Hold Time (minutes)	Time (h:m:s)	O-cell Pressure (psi)	O-cell Load (kips)	Top of Shaft A (in)	Top of Shaft B (in)	Top of Shaft Avg (in)	Top Plate Telltales A (in)	Top Plate Telltales B (in)	Top Plate Telltales Average (in)	Bottom Plate Telltales A - (04) - 9336 (in)	Bottom Plate Telltales B - (06) - 14175 (in)	Bottom Plate Telltales Average (in)
1 L - 0	-	10:19:00	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1 L - 1	1	11:05:30	800	490	0.005	0.006	0.005	0.003	0.002	0.003	0.060	-0.116	-0.028
1 L - 1	2	11:06:30	800	490	0.005	0.006	0.005	0.003	0.002	0.003	0.061	-0.115	-0.027
1 L - 1	4	11:08:30	800	490	0.005	0.006	0.005	0.003	0.003	0.003	0.063	-0.114	-0.025
1 L - 1	8	11:12:30	800	490	0.005	0.006	0.005	0.003	0.003	0.003	0.065	-0.112	-0.023
1 L - 2	1	11:14:30	1,600	973	0.009	0.010	0.010	0.005	0.004	0.005	0.101	-0.089	0.006
1 L - 2	2	11:15:30	1,600	973	0.010	0.010	0.010	0.005	0.005	0.005	0.104	-0.087	0.008
1 L - 2	4	11:17:30	1,600	973	0.010	0.010	0.010	0.005	0.005	0.005	0.108	-0.084	0.012
1 L - 2	8	11:21:30	1,600	973	0.012	0.012	0.012	0.006	0.005	0.005	0.112	-0.081	0.016
1 L - 3	1	11:23:30	2,400	1,456	0.016	0.018	0.017	0.008	0.006	0.007	0.151	-0.054	0.049
1 L - 3	2	11:24:30	2,400	1,456	0.017	0.017	0.017	0.009	0.007	0.008	0.155	-0.051	0.052
1 L - 3	4	11:26:30	2,400	1,456	0.017	0.018	0.017	0.009	0.007	0.008	0.159	-0.048	0.056
1 L - 3	8	11:30:30	2,400	1,456	0.017	0.018	0.018	0.009	0.007	0.008	0.166	-0.042	0.062
1 L - 4	1	11:33:30	3,200	1,939	0.024	0.025	0.025	0.012	0.010	0.011	0.213	-0.009	0.102
1 L - 4	2	11:34:30	3,200	1,939	0.025	0.026	0.025	0.012	0.010	0.011	0.218	-0.006	0.106
1 L - 4	4	11:36:30	3,200	1,939	0.025	0.026	0.026	0.012	0.010	0.011	0.225	0.000	0.112
1 L - 4	8	11:40:30	3,200	1,939	0.026	0.026	0.026	0.012	0.011	0.011	0.235	0.008	0.121
1 L - 5	1	11:43:00	4,000	2,422	0.033	0.034	0.034	0.013	0.013	0.013	0.283	0.041	0.162
1 L - 5	2	11:44:00	4,000	2,422	0.034	0.035	0.035	0.013	0.013	0.013	0.294	0.047	0.170
1 L - 5	4	11:46:00	4,000	2,422	0.035	0.036	0.036	0.014	0.013	0.014	0.306	0.054	0.180
1 L - 5	8	11:50:00	4,000	2,422	0.036	0.036	0.036	0.014	0.014	0.014	0.319	0.063	0.191
1 L - 6	1	11:52:30	4,800	2,905	0.046	0.047	0.047	0.016	0.016	0.016	0.372	0.099	0.235
1 L - 6	2	11:53:30	4,800	2,905	0.049	0.049	0.049	0.016	0.017	0.016	0.381	0.105	0.243
1 L - 6	4	11:55:30	4,800	2,905	0.050	0.051	0.050	0.016	0.017	0.017	0.396	0.114	0.255
1 L - 6	8	11:59:30	4,800	2,905	0.053	0.054	0.053	0.017	0.017	0.017	0.414	0.128	0.271
1 L - 7	1	12:02:30	5,600	3,388	0.075	0.076	0.076	0.019	0.020	0.020	0.493	0.183	0.338
1 L - 7	2	12:03:30	5,600	3,388	0.079	0.079	0.079	0.019	0.021	0.020	0.504	0.190	0.347
1 L - 7	4	12:05:30	5,600	3,388	0.082	0.083	0.083	0.020	0.021	0.020	0.520	0.202	0.361
1 L - 7	8	12:09:30	5,600	3,388	0.087	0.087	0.087	0.020	0.021	0.020	0.540	0.216	0.378
1 L - 8	1	12:24:00	6,400	3,871	0.156	0.156	0.156	0.022	0.025	0.024	0.721	0.352	0.537
1 L - 8	2	12:25:00	6,400	3,871	0.159	0.160	0.159	0.022	0.025	0.024	0.729	0.358	0.543
1 L - 8	4	12:27:00	6,400	3,871	0.165	0.165	0.165	0.023	0.025	0.024	0.743	0.368	0.556
1 L - 8	8	12:31:00	6,400	3,871	0.171	0.172	0.172	0.023	0.025	0.024	0.763	0.383	0.573
1 L - 9	1	12:34:00	7,200	4,354	0.285	0.285	0.285	0.022	0.028	0.025	0.945	0.541	0.743
1 L - 9	2	12:35:00	7,200	4,354	0.332	0.332	0.332	0.021	0.028	0.025	1.006	0.600	0.803
1 L - 9	4	12:37:00	7,200	4,354	0.408	0.408	0.408	0.020	0.028	0.024	1.104	0.695	0.900
1 L - 9	8	12:41:00	7,200	4,354	0.526	0.527	0.527	0.019	0.029	0.024	1.255	0.841	1.048
1 U - 1	1	12:49:30	5,600	3,388	0.543	0.543	0.543	0.016	0.026	0.021	1.274	0.857	1.065
1 U - 1	2	12:50:30	5,600	3,388	0.542	0.543	0.543	0.016	0.026	0.021	1.274	0.856	1.065
1 U - 1	4	12:52:30	5,600	3,388	0.541	0.542	0.541	0.016	0.026	0.021	1.273	0.856	1.064
1 U - 2	1	12:54:30	4,000	2,422	0.514	0.515	0.515	0.013	0.021	0.017	1.230	0.815	1.022
1 U - 2	2	12:55:30	4,000	2,422	0.514	0.514	0.514	0.013	0.021	0.017	1.227	0.813	1.020
1 U - 2	4	12:57:30	4,000	2,422	0.509	0.510	0.510	0.013	0.021	0.017	1.227	0.812	1.020
1 U - 3	1	12:59:30	3,200	1,939	0.452	0.452	0.452	0.010	0.015	0.012	1.126	0.720	0.923
1 U - 3	2	13:00:30	3,200	1,939	0.450	0.450	0.450	0.010	0.015	0.012	1.120	0.717	0.918
1 U - 3	4	13:02:30	3,200	1,939	0.448	0.448	0.448	0.010	0.014	0.012	1.117	0.713	0.915
1 U - 4	1	13:05:00	1,600	973	0.335	0.336	0.336	0.007	0.009	0.008	0.931	0.549	0.740
1 U - 4	2	13:06:00	1,600	973	0.331	0.332	0.332	0.007	0.009	0.008	0.919	0.543	0.731
1 U - 4	4	13:08:00	1,600	973	0.329	0.329	0.329	0.007	0.009	0.008	0.914	0.537	0.725
1 U - 5	1	13:11:00	0	0	0.182	0.182	0.182	0.004	0.005	0.005	0.508	0.231	0.369
1 U - 5	2	13:12:00	0	0	0.179	0.179	0.179	0.004	0.005	0.005	0.501	0.224	0.363
1 U - 5	4	13:14:00	0	0	0.176	0.176	0.176	0.004	0.005	0.005	0.491	0.216	0.354
1 U - 5	8	13:18:00	0	0	0.173	0.173	0.173	0.004	0.005	0.005	0.476	0.208	0.342
1 U - 5	16	13:26:00	0	0	0.170	0.170	0.170	0.004	0.005	0.005	0.466	0.199	0.333
1 U - 5	30	13:40:00	0	0	0.168	0.168	0.168	0.005	0.006	0.005	0.457	0.193	0.325
1 U - 5	45	13:55:00	0	0	0.167	0.167	0.167	0.005	0.006	0.005	0.453	0.189	0.321
1 U - 5	60	14:10:00	0	0	0.167	0.166	0.167	0.004	0.006	0.005	0.449	0.186	0.317
1 U - 5	75	14:25:00	0	0	0.166	0.166	0.166	0.004	0.005	0.005	0.445	0.184	0.315

* Positive values indicate upward reference beam movement.

** Average top of shaft includes reference beam correction.

Upward and Downward O-cell Plate Movement and Creep (calculated)
TS-1 - ADSC Research Project - Nashville, TN

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)	Bot. Plate Movement** (in)	Creep Up Per Hold (in)	Creep Dn Per Hold (in)
1 L - 0	-	10:19:00	0	0	0.000	0.000	0.000	0.000		
1 L - 1	1	11:05:30	800	490	0.005	0.003	0.008	0.033		
1 L - 1	2	11:06:30	800	490	0.005	0.003	0.008	0.032	0.000	0.001
1 L - 1	4	11:08:30	800	490	0.005	0.003	0.008	0.031	0.000	0.002
1 L - 1	8	11:12:30	800	490	0.005	0.003	0.009	0.029	0.000	0.002
1 L - 2	1	11:14:30	1,600	973	0.010	0.005	0.014	0.003		
1 L - 2	2	11:15:30	1,600	973	0.010	0.005	0.015	0.002	0.001	0.002
1 L - 2	4	11:17:30	1,600	973	0.010	0.005	0.015	-0.003	0.000	0.004
1 L - 2	8	11:21:30	1,600	973	0.012	0.005	0.017	-0.004	0.002	0.001
1 L - 3	1	11:23:30	2,400	1,456	0.017	0.007	0.024	-0.032		
1 L - 3	2	11:24:30	2,400	1,456	0.017	0.008	0.025	-0.035	0.001	0.003
1 L - 3	4	11:26:30	2,400	1,456	0.017	0.008	0.025	-0.038	0.000	0.003
1 L - 3	8	11:30:30	2,400	1,456	0.018	0.008	0.026	-0.045	0.001	0.006
1 L - 4	1	11:33:30	3,200	1,939	0.025	0.011	0.036	-0.077		
1 L - 4	2	11:34:30	3,200	1,939	0.025	0.011	0.036	-0.081	0.000	0.004
1 L - 4	4	11:36:30	3,200	1,939	0.026	0.011	0.037	-0.087	0.001	0.005
1 L - 4	8	11:40:30	3,200	1,939	0.026	0.011	0.037	-0.095	0.001	0.009
1 L - 5	1	11:43:00	4,000	2,422	0.034	0.013	0.047	-0.129		
1 L - 5	2	11:44:00	4,000	2,422	0.035	0.013	0.048	-0.136	0.001	0.007
1 L - 5	4	11:46:00	4,000	2,422	0.036	0.014	0.049	-0.144	0.001	0.008
1 L - 5	8	11:50:00	4,000	2,422	0.036	0.014	0.050	-0.155	0.000	0.011
1 L - 6	1	11:52:30	4,800	2,905	0.047	0.016	0.063	-0.188		
1 L - 6	2	11:53:30	4,800	2,905	0.049	0.016	0.065	-0.194	0.003	0.005
1 L - 6	4	11:55:30	4,800	2,905	0.050	0.017	0.067	-0.205	0.002	0.011
1 L - 6	8	11:59:30	4,800	2,905	0.053	0.017	0.070	-0.218	0.003	0.013
1 L - 7	1	12:02:30	5,600	3,388	0.076	0.020	0.095	-0.262		
1 L - 7	2	12:03:30	5,600	3,388	0.079	0.020	0.099	-0.268	0.003	0.006
1 L - 7	4	12:05:30	5,600	3,388	0.083	0.020	0.103	-0.279	0.004	0.011
1 L - 7	8	12:09:30	5,600	3,388	0.087	0.020	0.107	-0.291	0.004	0.012
1 L - 8	1	12:24:00	6,400	3,871	0.156	0.024	0.180	-0.381		
1 L - 8	2	12:25:00	6,400	3,871	0.159	0.024	0.183	-0.384		
1 L - 8	4	12:27:00	6,400	3,871	0.165	0.024	0.188	-0.391	0.006	0.007
1 L - 8	8	12:31:00	6,400	3,871	0.172	0.024	0.195	-0.401	0.007	0.011
1 L - 9	1	12:34:00	7,200	4,354	0.285	0.025	0.310	-0.458		
1 L - 9	2	12:35:00	7,200	4,354	0.332	0.025	0.356	-0.471	0.046	0.013
1 L - 9	4	12:37:00	7,200	4,354	0.408	0.024	0.432	-0.492	0.076	0.021
1 L - 9	8	12:41:00	7,200	4,354	0.527	0.024	0.550	-0.521	0.118	0.030
1 U - 1	1	12:49:30	5,600	3,388	0.543	0.021	0.564	-0.522		
1 U - 1	2	12:50:30	5,600	3,388	0.543	0.021	0.564	-0.523		
1 U - 1	4	12:52:30	5,600	3,388	0.541	0.021	0.563	-0.523		
1 U - 2	1	12:54:30	4,000	2,422	0.515	0.017	0.532	-0.507		
1 U - 2	2	12:55:30	4,000	2,422	0.514	0.017	0.531	-0.506		
1 U - 2	4	12:57:30	4,000	2,422	0.510	0.017	0.526	-0.510		
1 U - 3	1	12:59:30	3,200	1,939	0.452	0.012	0.464	-0.472		
1 U - 3	2	13:00:30	3,200	1,939	0.450	0.012	0.462	-0.469		
1 U - 3	4	13:02:30	3,200	1,939	0.448	0.012	0.460	-0.467		
1 U - 4	1	13:05:00	1,600	973	0.336	0.008	0.344	-0.404		
1 U - 4	2	13:06:00	1,600	973	0.332	0.008	0.340	-0.400		
1 U - 4	4	13:08:00	1,600	973	0.329	0.008	0.337	-0.397		
1 U - 5	1	13:11:00	0	0	0.182	0.005	0.186	-0.188		
1 U - 5	2	13:12:00	0	0	0.179	0.005	0.184	-0.183		
1 U - 5	4	13:14:00	0	0	0.176	0.005	0.181	-0.177		
1 U - 5	8	13:18:00	0	0	0.173	0.005	0.178	-0.169		
1 U - 5	16	13:26:00	0	0	0.170	0.005	0.175	-0.163		
1 U - 5	30	13:40:00	0	0	0.168	0.005	0.173	-0.157		
1 U - 5	45	13:55:00	0	0	0.167	0.005	0.172	-0.154		
1 U - 5	60	14:10:00	0	0	0.167	0.005	0.171	-0.151		
1 U - 5	75	14:25:00	0	0	0.166	0.005	0.171	-0.148		

* Elastic compression above the O-cell.

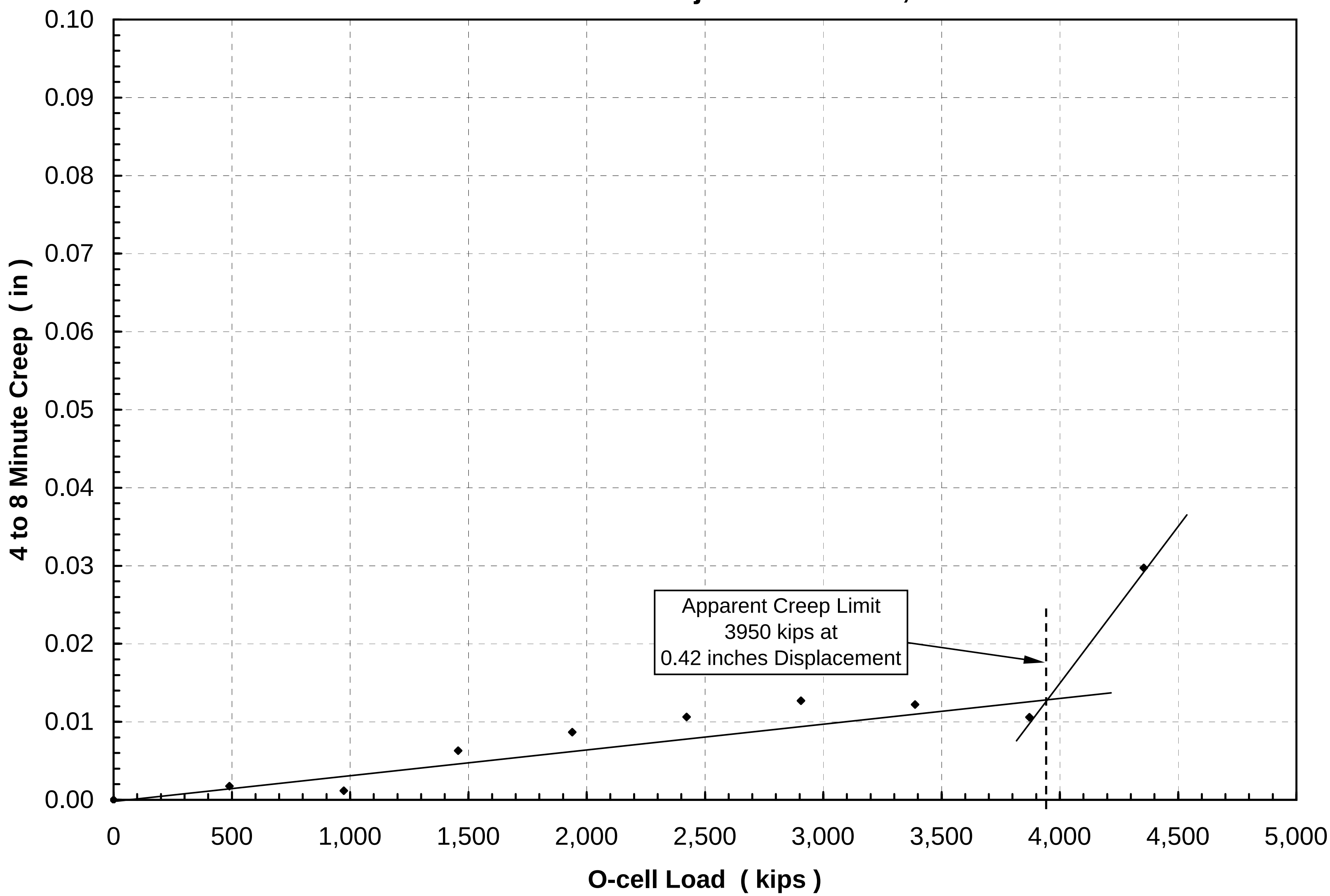
**Top of shaft minus Bottom Plate Telltale

Strain Gage Readings and Loads at Level 1
TS-1 - ADSC Research Project - Nashville, TN

Load	Hold	Time	O-cell		Level 1		
Test Increment	Time (minutes)	(h:m:s)	Pressure (psi)	Load (kips)	A - (08) - 19984 (με)	B - (08) - 19985 (με)	Av. Load (kips)
1 L - 0	-	10:19:00	0	0	0.0	0.0	0
1 L - 1	1	11:05:30	800	490	17.0	10.1	108
1 L - 1	2	11:06:30	800	490	17.1	10.3	110
1 L - 1	4	11:08:30	800	490	17.4	10.9	114
1 L - 1	8	11:12:30	800	490	17.7	11.1	115
1 L - 2	1	11:14:30	1,600	973	27.9	14.2	169
1 L - 2	2	11:15:30	1,600	973	28.4	14.5	172
1 L - 2	4	11:17:30	1,600	973	28.5	14.6	173
1 L - 2	8	11:21:30	1,600	973	28.8	14.8	175
1 L - 3	1	11:23:30	2,400	1,456	38.6	19.3	232
1 L - 3	2	11:24:30	2,400	1,456	38.9	19.5	234
1 L - 3	4	11:26:30	2,400	1,456	39.4	19.9	238
1 L - 3	8	11:30:30	2,400	1,456	39.9	20.4	242
1 L - 4	1	11:33:30	3,200	1,939	52.6	30.2	332
1 L - 4	2	11:34:30	3,200	1,939	53.0	30.8	336
1 L - 4	4	11:36:30	3,200	1,939	53.6	31.2	340
1 L - 4	8	11:40:30	3,200	1,939	54.2	31.8	345
1 L - 5	1	11:43:00	4,000	2,422	65.1	41.6	428
1 L - 5	2	11:44:00	4,000	2,422	65.7	42.1	432
1 L - 5	4	11:46:00	4,000	2,422	66.3	42.8	438
1 L - 5	8	11:50:00	4,000	2,422	67.0	43.9	445
1 L - 6	1	11:52:30	4,800	2,905	77.7	54.5	530
1 L - 6	2	11:53:30	4,800	2,905	78.3	55.8	538
1 L - 6	4	11:55:30	4,800	2,905	79.6	57.2	549
1 L - 6	8	11:59:30	4,800	2,905	81.0	59.7	564
1 L - 7	1	12:02:30	5,600	3,388	96.1	77.0	694
1 L - 7	2	12:03:30	5,600	3,388	97.0	78.1	702
1 L - 7	4	12:05:30	5,600	3,388	98.7	80.0	717
1 L - 7	8	12:09:30	5,600	3,388	99.9	82.0	729
1 L - 8	1	12:24:00	6,400	3,871	118.1	101.6	881
1 L - 8	2	12:25:00	6,400	3,871	118.2	101.8	882
1 L - 8	4	12:27:00	6,400	3,871	118.5	102.9	888
1 L - 8	8	12:31:00	6,400	3,871	119.1	104.4	896
1 L - 9	1	12:34:00	7,200	4,354	119.3	123.2	972
1 L - 9	2	12:35:00	7,200	4,354	112.4	124.1	948
1 L - 9	4	12:37:00	7,200	4,354	107.0	126.1	935
1 L - 9	8	12:41:00	7,200	4,354	99.1	130.7	921
1 U - 1	1	12:49:30	5,600	3,388	83.4	122.2	824
1 U - 1	2	12:50:30	5,600	3,388	83.3	122.3	825
1 U - 1	4	12:52:30	5,600	3,388	83.2	122.3	824
1 U - 2	1	12:54:30	4,000	2,422	64.9	103.3	674
1 U - 2	2	12:55:30	4,000	2,422	65.2	103.6	677
1 U - 2	4	12:57:30	4,000	2,422	64.6	103.1	672
1 U - 3	1	12:59:30	3,200	1,939	47.3	76.0	494
1 U - 3	2	13:00:30	3,200	1,939	46.8	75.2	489
1 U - 3	4	13:02:30	3,200	1,939	46.3	74.6	485
1 U - 4	1	13:05:00	1,600	973	27.5	46.8	298
1 U - 4	2	13:06:00	1,600	973	27.2	46.0	293
1 U - 4	4	13:08:00	1,600	973	26.7	45.4	289
1 U - 5	1	13:11:00	0	0	21.7	20.3	168
1 U - 5	2	13:12:00	0	0	21.7	20.1	168
1 U - 5	4	13:14:00	0	0	21.7	19.6	166
1 U - 5	8	13:18:00	0	0	21.7	19.0	163
1 U - 5	16	13:26:00	0	0	21.5	18.9	162
1 U - 5	30	13:40:00	0	0	21.1	18.5	159
1 U - 5	45	13:55:00	0	0	20.9	18.5	158
1 U - 5	60	14:10:00	0	0	20.9	18.5	158
1 U - 5	75	14:25:00	0	0	20.7	18.4	157

End Bearing Creep Limit

TS-1 - ADSC Research Project - Nashville, TN



Upper Side Shear Creep Limit

TS-1 - ADSC Research Project - Nashville, TN

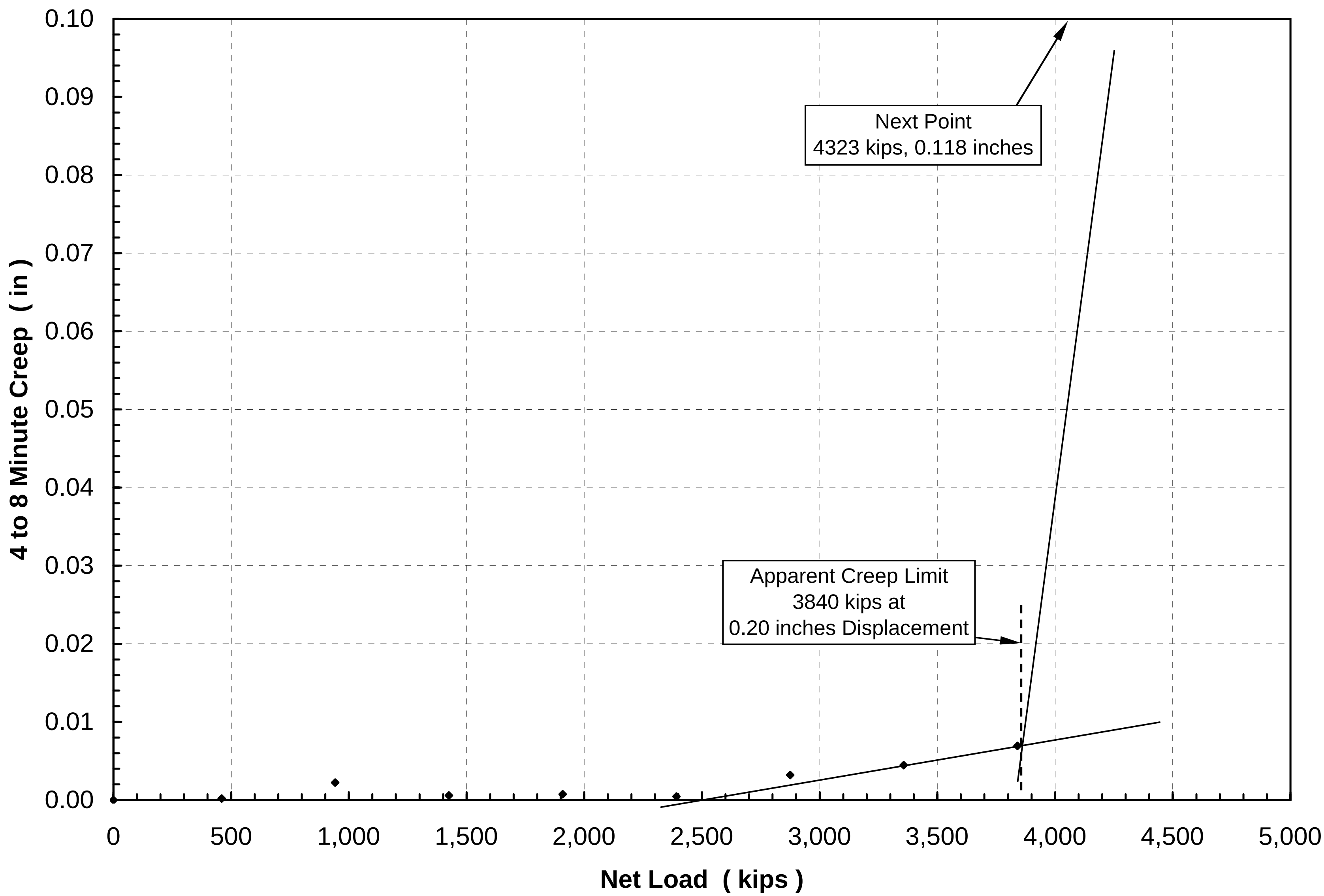
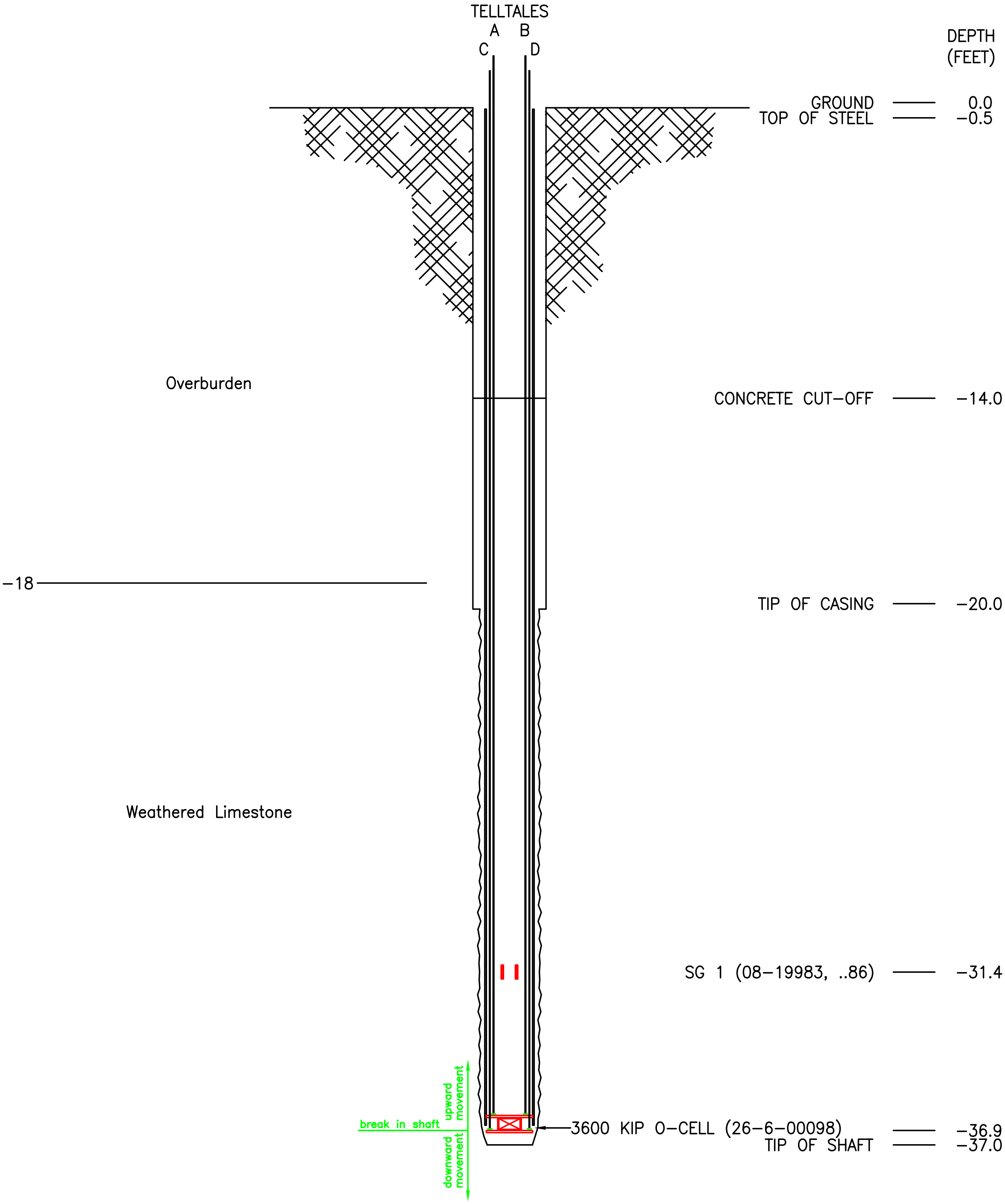


TABLE A:
SUMMARY OF DIMENSIONS, DEPTHS & SHAFT PROPERTIES

Shaft:			
Nominal shaft diameter (EL -14.0 ft to -20.0 ft)	=	54 in	1372 mm
Nominal shaft diameter (EL -20.0 ft to -37.0 ft)	=	48 in	1219 mm
O-cell: 26-6-00098	=	26 in	660 mm
Length of side shear above break at base of O-cell	=	22.9 ft	6.98 m
Length of side shear below break at base of O-cell	=	0.10 ft	0.030 m
Shaft side shear area above O-cell base	=	297 ft^2	27.6 m^2
Shaft base area (assumed to be 28" + 2:1 load distribution over 0.1' below the O-cell)	=	4.7 ft^2	0.43 m^2
Bouyant weight of pile above base of O-cell	=	47 kips	0.21 MN
Estimated shaft stiffness, AE (EL -14.0 ft to -20.0 ft)	=	10,200,000 kips	45,100 MN
Estimated shaft stiffness, AE (EL -20.0 ft to -37.0 ft)	=	8,050,000 kips	35,800 MN
Depth of ground surface	=	+0.0 ft	+0.00 m
Depth of top of shaft concrete	=	-14.0 ft	-4.27 m
Depth of base of O-cell (The break between upward and downward movement.)	=	-36.9 ft	-11.25 m
Depth of shaft tip	=	-37.0 ft	-11.28 m
Depth of water table	=	NOT ENCOUNTERED	
Casings:			
Depth of top of outer temporary casing (54.0 in O.D.)	=	+0.0 ft	+0.00 m
Depth of bottom of outer temporary casing (54.0 in O.D.)	=	-20.0 ft	-6.10 m
Compression Sections:			
Depth of top of compression section used for upper shaft compression	=	-14.0 ft	+0.00 m
Depth of bottom of compression section used for upper shaft compression	=	-36.0 ft	-10.97 m
Strain Gages:			
Depth of strain gage Level 1	=	-30.6 ft	-9.45 m
Miscellaneous:			
Top plate diameter (1-inch thickness)	=	33.0 in	838 mm
Bottom plate diameter (1-inch thickness)	=	28.0 in	711 mm
ReBar size (5 No.)	=	# 9	M 29
Spiral size (24 inch spacing)	=	# 3	M 10
ReBar cage diameter	=	30 in	762 mm
Unconfined compressive concrete strength	=	5900 psi	40.7 MPa

NOTE: NOMINAL SHAFT 54"ø
NOMINAL ROCK SOCKET 48"ø
BOTTOM PLATE 28"ø

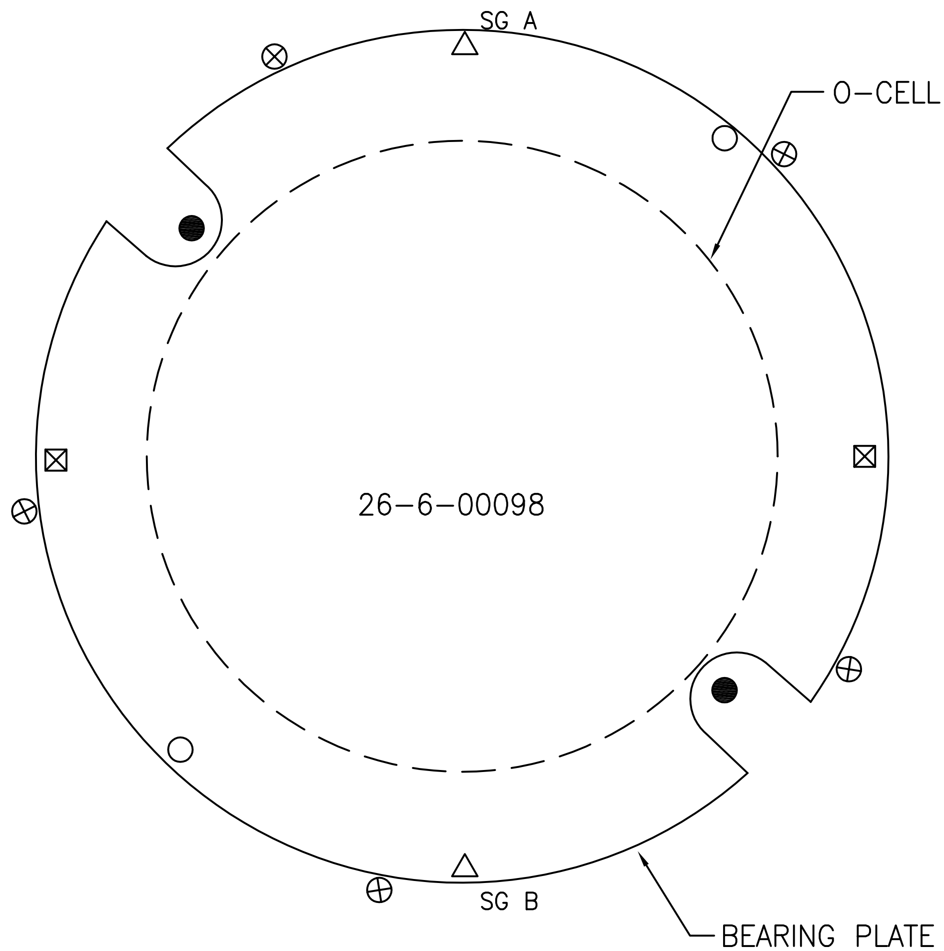


NOTE: SOIL BASED ON BORING # B−2

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

SCHEMATIC SECTION OF TEST SHAFT
ADSC RESEARCH − NASHVILLE, TN

DRAWN BY: THE	DATE: 09/02/08	CHECKED BY:	LT−9507−2
REVISED BY: NKY	DATE: 10/15/08	SCALE: NTS	FIGURE A



LEGEND:

STRAIN GAGE △
BOTTOM PLATE TELLTALE ●
TOP PLATE TELLTALE ○
HYDRAULIC HOSE ⊠
REBAR ⊗

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

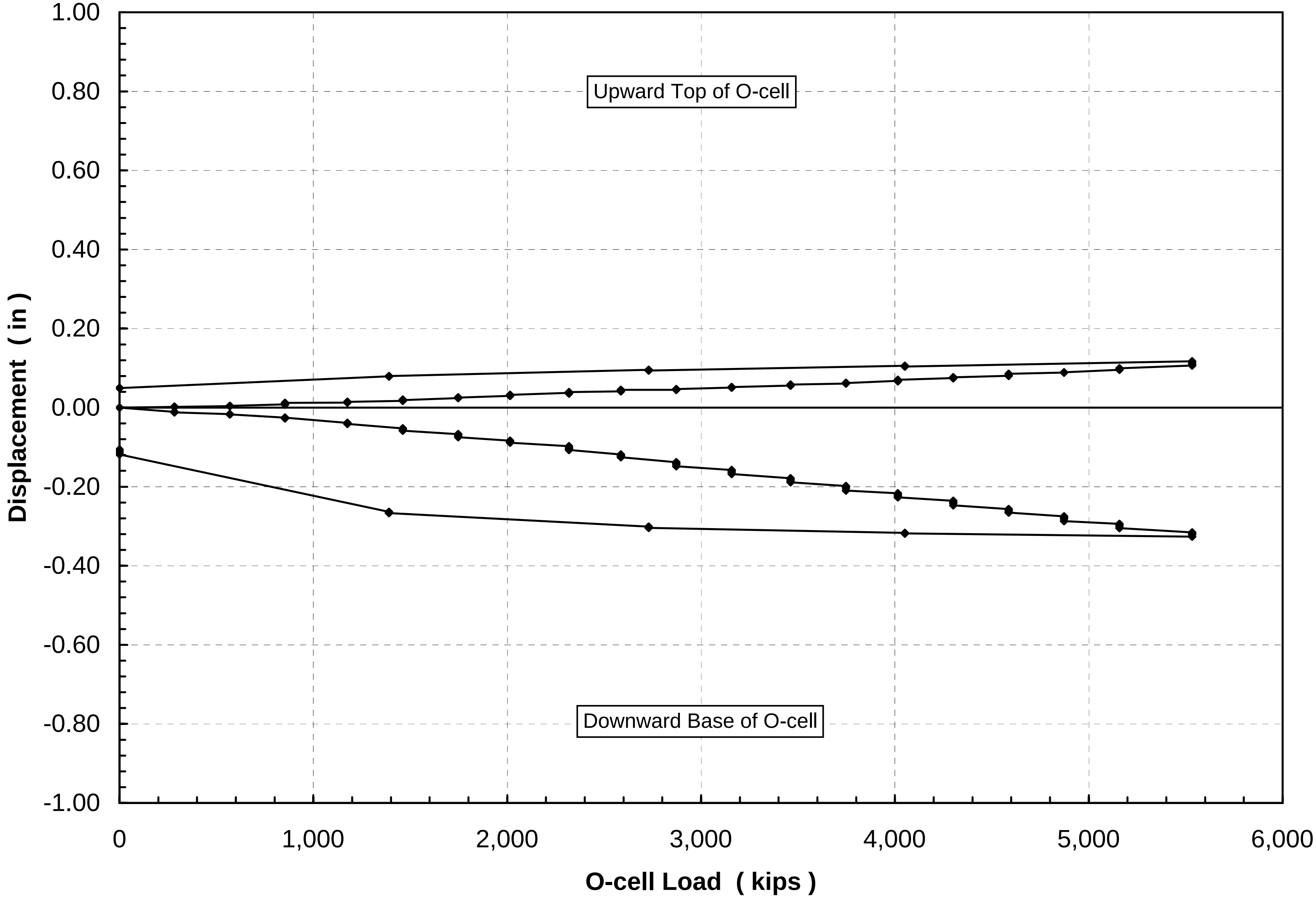
INSTRUMENTATION LAYOUT

ADSC RESEARCH - NASHVILLE, TN

DWN BY: NKY	DATE: 10/16/08	CHECKED BY:	LT-9507-2
REVISED BY:	DATE:	SCALE: NTS	**FIGURE B**

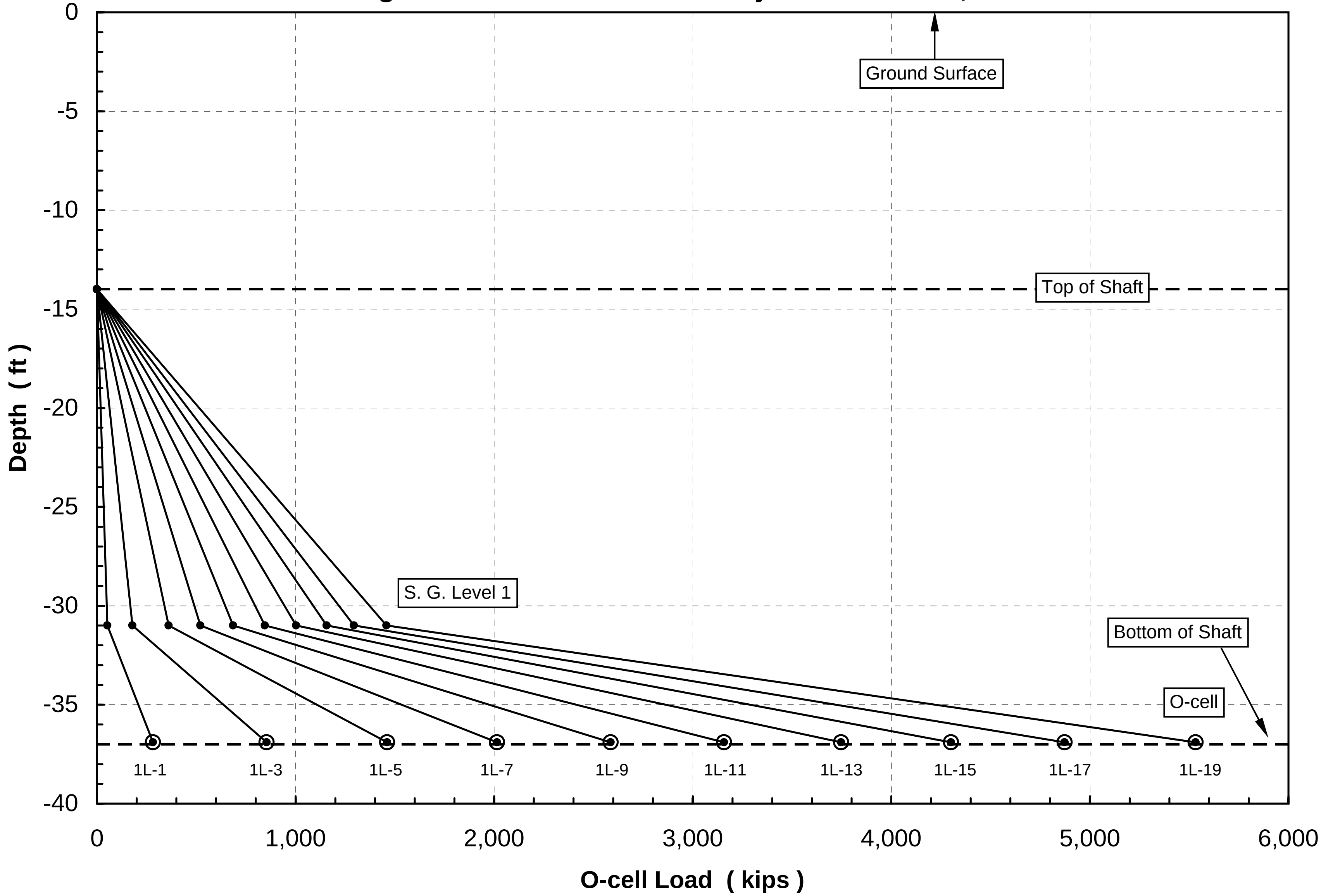
Osterberg Cell Load-Movement

TS-2 - Long Foundation Research Project - Nashville, TN



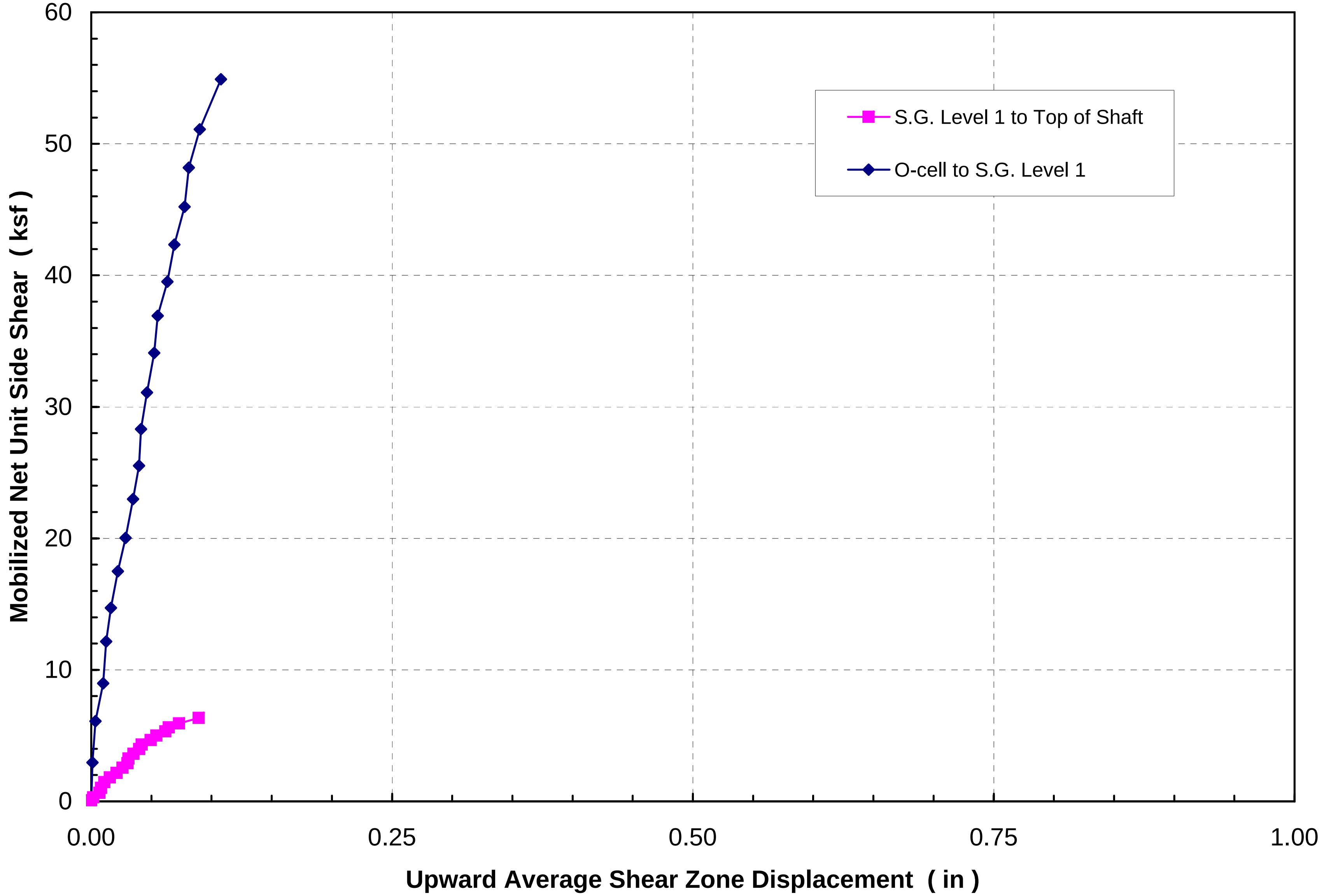
Strain Gage Load Distribution

TS-2 - Long Foundation Research Project - Nashville, TN



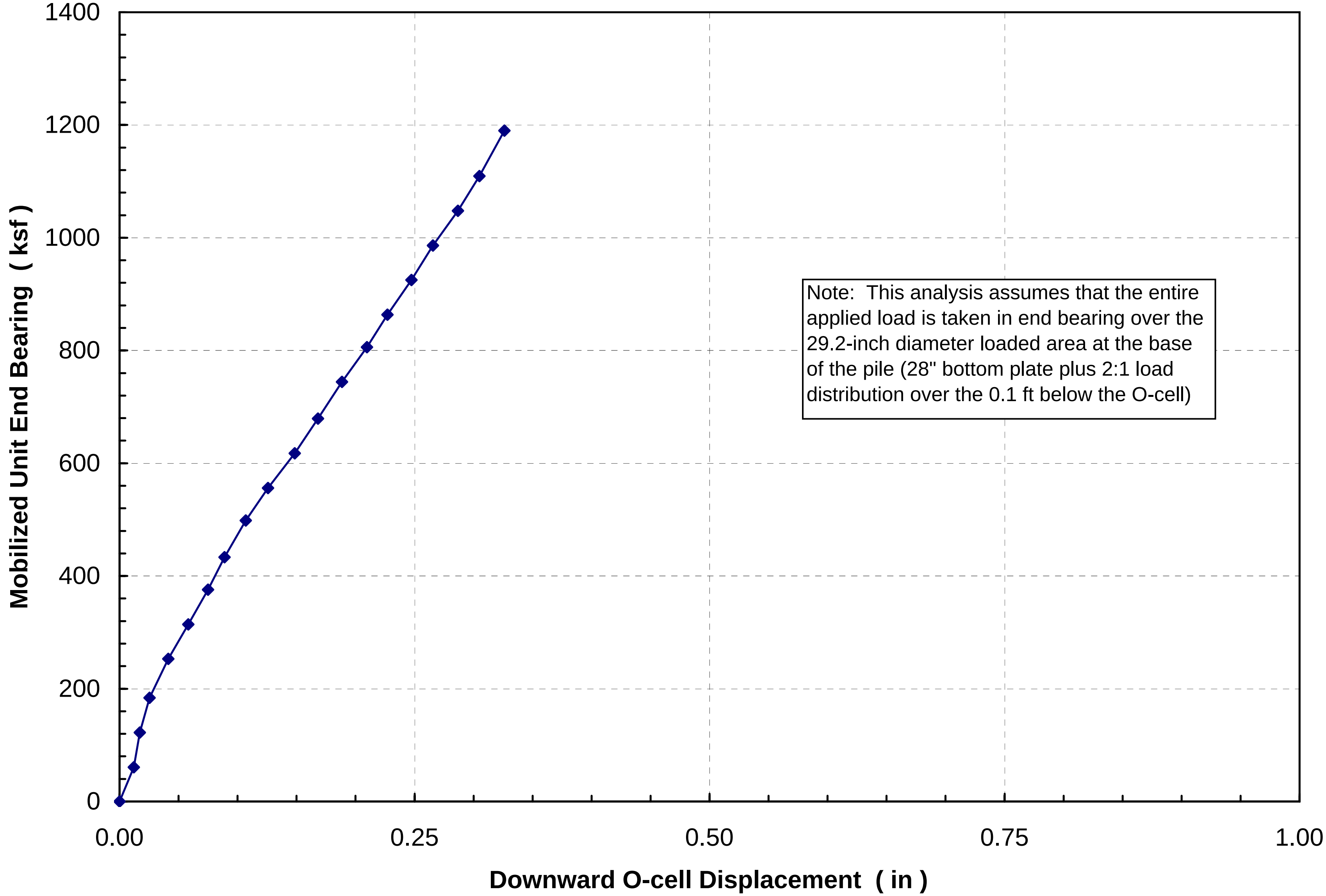
Mobilized Net Unit Side Shear

TS-2 - Long Foundation Research Project - Nashville, TN



Mobilized Unit End Bearing

TS-2 - Long Foundation Research Project - Nashville, TN



Upward Top of Shaft Movement and Shaft Compression
TS-2 - Long Foundation Research Project - Nashville, TN

Load	Hold	Time	O-cell		Top of Shaft			Telltales			Bottom Plate Telltales		
Test	Time		Pressure	Load	Leica A	Leica B	Average	A - 05-19538	B - 07-28201	Average	A - 04-9336	B - 06-14175	Average
Increment	(minutes)	(h:m:s)	(psi)	(kips)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)	(in)
1 L - 0	-	11:34:30	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1 L - 1	1	11:55:30	750	283	0.000	0.000	0.000	0.002	0.002	0.002	0.010	0.012	0.011
1 L - 1	2	11:56:30	750	283	0.000	-0.001	0.000	0.002	0.002	0.002	0.010	0.012	0.011
1 L - 1	4	11:58:30	750	283	0.001	0.000	0.000	0.002	0.002	0.002	0.010	0.012	0.011
1 L - 1	8	12:02:30	750	283	0.000	-0.001	0.000	0.002	0.002	0.002	0.011	0.012	0.012
1 L - 2	1	12:05:00	1,550	568	0.001	0.000	0.000	0.004	0.003	0.003	0.017	0.017	0.017
1 L - 2	2	12:06:00	1,550	568	0.001	0.000	0.000	0.004	0.003	0.003	0.017	0.017	0.017
1 L - 2	4	12:08:00	1,550	568	0.001	0.001	0.001	0.004	0.004	0.004	0.018	0.018	0.018
1 L - 2	8	12:12:00	1,550	568	0.001	0.001	0.001	0.004	0.003	0.004	0.018	0.018	0.018
1 L - 3	1	12:14:00	2,350	854	0.004	0.001	0.002	0.006	0.005	0.006	0.028	0.028	0.028
1 L - 3	2	12:15:00	2,350	854	0.002	0.002	0.002	0.006	0.005	0.006	0.029	0.028	0.029
1 L - 3	4	12:17:00	2,350	854	0.003	0.003	0.003	0.006	0.006	0.006	0.030	0.030	0.030
1 L - 3	8	12:21:00	2,350	854	0.006	0.005	0.005	0.006	0.006	0.006	0.031	0.031	0.031
1 L - 4	1	12:22:30	3,250	1,176	0.005	0.004	0.004	0.008	0.008	0.008	0.043	0.044	0.043
1 L - 4	2	12:23:30	3,250	1,176	0.007	0.005	0.006	0.009	0.008	0.008	0.045	0.045	0.045
1 L - 4	4	12:25:30	3,250	1,176	0.006	0.006	0.006	0.009	0.008	0.008	0.046	0.046	0.046
1 L - 4	8	12:29:30	3,250	1,176	0.008	0.005	0.006	0.008	0.008	0.008	0.047	0.048	0.048
1 L - 5	1	12:31:30	4,050	1,461	0.008	0.006	0.007	0.010	0.010	0.010	0.060	0.060	0.060
1 L - 5	2	12:32:30	4,050	1,461	0.009	0.009	0.009	0.011	0.010	0.010	0.062	0.062	0.062
1 L - 5	4	12:34:30	4,050	1,461	0.010	0.009	0.010	0.011	0.010	0.011	0.064	0.064	0.064
1 L - 5	8	12:38:30	4,050	1,461	0.009	0.008	0.008	0.011	0.011	0.011	0.066	0.067	0.067
1 L - 6	1	12:40:30	4,850	1,747	0.012	0.011	0.011	0.013	0.012	0.012	0.080	0.078	0.079
1 L - 6	2	12:41:30	4,850	1,747	0.014	0.013	0.013	0.013	0.012	0.012	0.082	0.080	0.081
1 L - 6	4	12:43:30	4,850	1,747	0.014	0.012	0.013	0.013	0.012	0.012	0.084	0.083	0.084
1 L - 6	8	12:47:30	4,850	1,747	0.013	0.012	0.013	0.013	0.013	0.013	0.088	0.087	0.087
1 L - 7	1	12:50:00	5,600	2,015	0.017	0.014	0.015	0.015	0.014	0.014	0.100	0.098	0.099
1 L - 7	2	12:51:00	5,600	2,015	0.016	0.014	0.015	0.015	0.014	0.014	0.103	0.100	0.101
1 L - 7	4	12:53:00	5,600	2,015	0.017	0.017	0.017	0.015	0.015	0.015	0.106	0.103	0.105
1 L - 7	8	12:57:00	5,600	2,015	0.018	0.017	0.017	0.015	0.014	0.015	0.108	0.105	0.106
1 L - 8	1	12:59:00	6,450	2,319	0.021	0.021	0.021	0.017	0.016	0.016	0.120	0.117	0.118
1 L - 8	2	13:00:00	6,450	2,319	0.019	0.019	0.019	0.017	0.016	0.017	0.122	0.120	0.121
1 L - 8	4	13:02:00	6,450	2,319	0.022	0.021	0.021	0.017	0.016	0.017	0.126	0.123	0.125
1 L - 8	8	13:06:00	6,450	2,319	0.022	0.022	0.022	0.018	0.016	0.017	0.130	0.128	0.129
1 L - 9	1	13:07:30	7,200	2,587	0.022	0.022	0.022	0.019	0.019	0.019	0.142	0.139	0.140
1 L - 9	2	13:08:30	7,200	2,587	0.023	0.023	0.023	0.019	0.018	0.019	0.145	0.141	0.143
1 L - 9	4	13:10:30	7,200	2,587	0.023	0.024	0.024	0.020	0.018	0.019	0.148	0.145	0.146
1 L - 9	8	13:14:30	7,200	2,587	0.025	0.026	0.025	0.020	0.019	0.019	0.153	0.149	0.151
1 L - 10	1	13:16:00	8,000	2,872	0.025	0.024	0.024	0.021	0.020	0.020	0.165	0.160	0.163
1 L - 10	2	13:17:00	8,000	2,872	0.024	0.025	0.024	0.021	0.020	0.021	0.168	0.163	0.165
1 L - 10	4	13:19:00	8,000	2,872	0.026	0.026	0.026	0.021	0.020	0.021	0.172	0.166	0.169
1 L - 10	8	13:23:00	8,000	2,872	0.026	0.026	0.026	0.021	0.020	0.021	0.178	0.171	0.174
1 L - 11	1	13:25:00	8,800	3,158	0.028	0.029	0.028	0.023	0.021	0.022	0.191	0.182	0.186
1 L - 11	2	13:26:00	8,800	3,158	0.028	0.029	0.028	0.023	0.022	0.022	0.193	0.184	0.188
1 L - 11	4	13:28:00	8,800	3,158	0.029	0.030	0.029	0.023	0.022	0.022	0.198	0.188	0.193
1 L - 11	8	13:32:00	8,800	3,158	0.030	0.029	0.029	0.024	0.022	0.023	0.203	0.192	0.198
1 L - 12	1	13:34:30	9,650	3,462	0.032	0.031	0.032	0.025	0.023	0.024	0.216	0.204	0.210
1 L - 12	2	13:35:30	9,650	3,462	0.031	0.032	0.031	0.025	0.023	0.024	0.219	0.207	0.213
1 L - 12	4	13:37:30	9,650	3,462	0.032	0.031	0.032	0.025	0.023	0.024	0.223	0.211	0.217
1 L - 12	8	13:41:30	9,650	3,462	0.034	0.034	0.034	0.026	0.024	0.025	0.229	0.216	0.223
1 L - 13	1	13:43:00	10,450	3,747	0.035	0.035	0.035	0.027	0.025	0.026	0.240	0.226	0.233
1 L - 13	2	13:44:00	10,450	3,747	0.037	0.035	0.036	0.027	0.025	0.026	0.243	0.229	0.236
1 L - 13	4	13:46:00	10,450	3,747	0.037	0.036	0.036	0.027	0.025	0.026	0.247	0.233	0.240
1 L - 13	8	13:50:00	10,450	3,747	0.035	0.036	0.035	0.028	0.025	0.026	0.252	0.238	0.245
1 L - 14	1	13:52:00	11,200	4,015	0.039	0.041	0.040	0.029	0.026	0.028	0.264	0.249	0.257
1 L - 14	2	13:53:00	11,200	4,015	0.039	0.038	0.039	0.029	0.026	0.028	0.267	0.252	0.259
1 L - 14	4	13:55:00	11,200	4,015	0.040	0.040	0.040	0.029	0.027	0.028	0.271	0.256	0.264
1 L - 14	8	13:59:00	11,200	4,015	0.042	0.043	0.042	0.029	0.027	0.028	0.277	0.262	0.269
1 L - 15	1	14:01:00	12,000	4,301	0.046	0.045	0.045	0.031	0.028	0.029	0.289	0.274	0.281
1 L - 15	2	14:02:00	12,000	4,301	0.045	0.044	0.045	0.031	0.028	0.029	0.292	0.277	0.285
1 L - 15	4	14:04:00	12,000	4,301	0.047	0.047	0.047	0.031	0.028	0.030	0.296	0.281	0.289
1 L - 15	8	14:08:00	12,000	4,301	0.048	0.046	0.047	0.031	0.028	0.030	0.302	0.287	0.294
1 L - 16	1	14:10:00	12,800	4,587	0.050	0.049	0.049	0.033	0.030	0.031	0.315	0.298	0.306
1 L - 16	2	14:11:00	12,800	4,587	0.050	0.049	0.049	0.033	0.030	0.031	0.318	0.301	0.310
1 L - 16	4	14:13:00	12,800	4,587	0.050	0.050	0.050	0.033	0.030	0.031	0.322	0.305	0.313
1 L - 16	8	14:17:00	12,800	4,587	0.054	0.054	0.054	0.033	0.030	0.032	0.328	0.311	0.320
1 L - 17	1	14:18:30	13,600	4,873	0.056	0.055	0.055	0.034	0.032	0.033	0.340	0.321	0.330
1 L - 17	2	14:19:30	13,600	4,873	0.056	0.055	0.055	0.035	0.032	0.033	0.343	0.324	0.333
1 L - 17	4	14:21:30	13,600	4,873	0.056	0.056	0.056	0.035	0.031	0.033	0.347	0.328	0.338
1 L - 17	8	14:25:30	13,600	4,873	0.055	0.058	0.056	0.035	0.032	0.033	0.353	0.334	0.343
1 L - 18	1	14:27:30	14,400	5,158	0.062	0.061	0.061	0.036	0.033	0.034	0.365	0.345	0.355
1 L - 18	2	14:28:30	14,400	5,158	0.062	0.062	0.062	0.036	0.033	0.035	0.368	0.348	0.358
1 L - 18	4	14:30:30	14,400	5,158	0.064	0.062	0.063	0.036	0.033	0.035	0.373	0.353	0.363
1 L - 18	8	14:34:30	14,400	5,158	0.064	0.065	0.064	0.036	0.033	0.035	0.380	0.359	0.370
1 L - 19	1	14:36:30	15,450	5,533	0.071	0.069	0.070	0.038	0.035	0.036	0.396	0.375	0.385
1 L - 19	2	14:37:30	15,450	5,533	0.072	0.072	0.072	0.038	0.035	0.037	0.401	0.380	0.390
1 L - 19	4	14:39:30	15,450	5,533	0.075	0.076	0.075	0.038	0.035	0.037	0.408	0.386	0.397
1 L - 19	8	14:43:30	15,450	5,533	0.080	0.081	0.080	0.038	0.035	0.037	0.418	0.396	0.407

Upward Top of Shaft Movement and Shaft Compression
TS-2 - Long Foundation Research Project - Nashville, TN

Load Test Increment	Hold Time (minutes)	Time (h:m:s)	O-cell Pressure (psi)	O-cell Load (kips)	Top of Shaft Leica A (in)	Top of Shaft Leica B (in)	Top of Shaft Average (in)	Telltales A - 05-19538 (in)	Telltales B - 07-28201 (in)	Telltales Average (in)	Bottom Plate Telltales A - 04-9336 (in)	Bottom Plate Telltales B - 06-14175 (in)	Bottom Plate Telltales Average (in)
1 U - 1	1	14:46:00	11,300	4,051	0.072	0.073	0.072	0.033	0.030	0.032	0.401	0.380	0.391
1 U - 1	2	14:47:00	11,300	4,051	0.073	0.071	0.072	0.034	0.030	0.032	0.401	0.380	0.391
1 U - 1	4	14:49:00	11,300	4,051	0.074	0.074	0.074	0.034	0.030	0.032	0.401	0.381	0.391
1 U - 2	1	14:51:30	7,600	2,729	0.065	0.067	0.066	0.029	0.026	0.028	0.379	0.362	0.370
1 U - 2	2	14:52:30	7,600	2,729	0.067	0.068	0.067	0.029	0.026	0.028	0.378	0.361	0.369
1 U - 2	4	14:54:30	7,600	2,729	0.068	0.068	0.068	0.029	0.026	0.027	0.377	0.360	0.369
1 U - 3	1	14:57:30	3,850	1,390	0.058	0.059	0.058	0.023	0.020	0.021	0.332	0.318	0.325
1 U - 3	2	14:58:30	3,850	1,390	0.057	0.057	0.057	0.023	0.020	0.021	0.329	0.316	0.323
1 U - 3	4	15:00:30	3,850	1,390	0.057	0.058	0.057	0.023	0.020	0.021	0.327	0.315	0.321
1 U - 4	1	15:02:30	0	0	0.038	0.038	0.038	0.013	0.010	0.012	0.159	0.154	0.156
1 U - 4	2	15:03:30	0	0	0.039	0.038	0.039	0.013	0.010	0.012	0.155	0.149	0.152
1 U - 4	4	15:05:30	0	0	0.038	0.038	0.038	0.013	0.010	0.011	0.151	0.146	0.148
1 U - 4	8	15:09:30	0	0	0.038	0.038	0.038	0.013	0.009	0.011	0.146	0.141	0.144

Upward and Downward O-cell Plate Movement and Creep (calculated)
TS-2 - Long Foundation Research Project - Nashville, TN

Load Test Increment	Hold Time (minutes)	Time (h:m:s)	O-cell		Top of Shaft (in)	Elastic Comp. (in)	Top Plate Movement (in)	Bot. Plate Movement * (in)	Creep Up Per Hold (in)	Creep Dn Per Hold (in)
			Pressure (psi)	Load (kips)						
1 L - 0	-	11:34:30	0	0	0.000	0.000	0.000	0.000		
1 L - 1	1	11:55:30	750	283	0.000	0.002	0.002	-0.011		
1 L - 1	2	11:56:30	750	283	0.000	0.002	0.001	-0.011	-0.001	0.000
1 L - 1	4	11:58:30	750	283	0.000	0.002	0.002	-0.011	0.001	-0.001
1 L - 1	8	12:02:30	750	283	0.000	0.002	0.002	-0.012	-0.001	0.001
1 L - 2	1	12:05:00	1,550	568	0.000	0.003	0.004	-0.016		
1 L - 2	2	12:06:00	1,550	568	0.000	0.003	0.004	-0.017	0.000	0.000
1 L - 2	4	12:08:00	1,550	568	0.001	0.004	0.005	-0.017	0.001	0.000
1 L - 2	8	12:12:00	1,550	568	0.001	0.004	0.005	-0.017	0.000	0.000
1 L - 3	1	12:14:00	2,350	854	0.002	0.006	0.008	-0.026		
1 L - 3	2	12:15:00	2,350	854	0.002	0.006	0.008	-0.027	0.000	0.001
1 L - 3	4	12:17:00	2,350	854	0.003	0.006	0.009	-0.027	0.001	0.000
1 L - 3	8	12:21:00	2,350	854	0.005	0.006	0.012	-0.025	0.003	-0.002
1 L - 4	1	12:22:30	3,250	1,176	0.004	0.008	0.013	-0.039		
1 L - 4	2	12:23:30	3,250	1,176	0.006	0.008	0.014	-0.039	0.002	0.000
1 L - 4	4	12:25:30	3,250	1,176	0.006	0.008	0.014	-0.040	0.000	0.001
1 L - 4	8	12:29:30	3,250	1,176	0.006	0.008	0.015	-0.041	0.000	0.001
1 L - 5	1	12:31:30	4,050	1,461	0.007	0.010	0.017	-0.053		
1 L - 5	2	12:32:30	4,050	1,461	0.009	0.010	0.019	-0.053	0.002	0.000
1 L - 5	4	12:34:30	4,050	1,461	0.010	0.011	0.020	-0.054	0.001	0.002
1 L - 5	8	12:38:30	4,050	1,461	0.008	0.011	0.019	-0.058	-0.001	0.004
1 L - 6	1	12:40:30	4,850	1,747	0.011	0.012	0.024	-0.067		
1 L - 6	2	12:41:30	4,850	1,747	0.013	0.012	0.026	-0.067	0.002	0.000
1 L - 6	4	12:43:30	4,850	1,747	0.013	0.012	0.025	-0.071	0.000	0.003
1 L - 6	8	12:47:30	4,850	1,747	0.013	0.013	0.025	-0.075	0.000	0.004
1 L - 7	1	12:50:00	5,600	2,015	0.015	0.014	0.030	-0.083		
1 L - 7	2	12:51:00	5,600	2,015	0.015	0.014	0.029	-0.086	0.000	0.003
1 L - 7	4	12:53:00	5,600	2,015	0.017	0.015	0.032	-0.088	0.002	0.001
1 L - 7	8	12:57:00	5,600	2,015	0.017	0.015	0.032	-0.089	0.000	0.001
1 L - 8	1	12:59:00	6,450	2,319	0.021	0.016	0.037	-0.097		
1 L - 8	2	13:00:00	6,450	2,319	0.019	0.017	0.036	-0.102	-0.002	0.005
1 L - 8	4	13:02:00	6,450	2,319	0.021	0.017	0.038	-0.103	0.003	0.001
1 L - 8	8	13:06:00	6,450	2,319	0.022	0.017	0.039	-0.107	0.001	0.004
1 L - 9	1	13:07:30	7,200	2,587	0.022	0.019	0.041	-0.118		
1 L - 9	2	13:08:30	7,200	2,587	0.023	0.019	0.042	-0.120	0.001	0.002
1 L - 9	4	13:10:30	7,200	2,587	0.024	0.019	0.043	-0.123	0.001	0.003
1 L - 9	8	13:14:30	7,200	2,587	0.025	0.019	0.045	-0.126	0.002	0.003
1 L - 10	1	13:16:00	8,000	2,872	0.024	0.020	0.045	-0.138		
1 L - 10	2	13:17:00	8,000	2,872	0.024	0.021	0.045	-0.141	0.000	0.002
1 L - 10	4	13:19:00	8,000	2,872	0.026	0.021	0.047	-0.143	0.002	0.002
1 L - 10	8	13:23:00	8,000	2,872	0.026	0.021	0.047	-0.148	0.000	0.005
1 L - 11	1	13:25:00	8,800	3,158	0.028	0.022	0.051	-0.158		
1 L - 11	2	13:26:00	8,800	3,158	0.028	0.022	0.051	-0.160	0.000	0.002
1 L - 11	4	13:28:00	8,800	3,158	0.029	0.022	0.052	-0.163	0.001	0.003
1 L - 11	8	13:32:00	8,800	3,158	0.029	0.023	0.052	-0.168	0.000	0.005
1 L - 12	1	13:34:30	9,650	3,462	0.032	0.024	0.056	-0.179		
1 L - 12	2	13:35:30	9,650	3,462	0.031	0.024	0.056	-0.181	0.000	0.003
1 L - 12	4	13:37:30	9,650	3,462	0.032	0.024	0.056	-0.186	0.000	0.004
1 L - 12	8	13:41:30	9,650	3,462	0.034	0.025	0.059	-0.189	0.003	0.003
1 L - 13	1	13:43:00	10,450	3,747	0.035	0.026	0.061	-0.198		
1 L - 13	2	13:44:00	10,450	3,747	0.036	0.026	0.062	-0.200	0.001	0.002
1 L - 13	4	13:46:00	10,450	3,747	0.036	0.026	0.063	-0.203	0.001	0.004
1 L - 13	8	13:50:00	10,450	3,747	0.035	0.026	0.062	-0.210	-0.001	0.006
1 L - 14	1	13:52:00	11,200	4,015	0.040	0.028	0.068	-0.217		
1 L - 14	2	13:53:00	11,200	4,015	0.039	0.028	0.066	-0.221	-0.002	0.004
1 L - 14	4	13:55:00	11,200	4,015	0.040	0.028	0.068	-0.224	0.002	0.003
1 L - 14	8	13:59:00	11,200	4,015	0.042	0.028	0.071	-0.227	0.003	0.003
1 L - 15	1	14:01:00	12,000	4,301	0.045	0.029	0.075	-0.236		
1 L - 15	2	14:02:00	12,000	4,301	0.045	0.029	0.074	-0.240	-0.001	0.004
1 L - 15	4	14:04:00	12,000	4,301	0.047	0.030	0.077	-0.242	0.003	0.002
1 L - 15	8	14:08:00	12,000	4,301	0.047	0.030	0.077	-0.247	0.000	0.006
1 L - 16	1	14:10:00	12,800	4,587	0.049	0.031	0.081	-0.257		
1 L - 16	2	14:11:00	12,800	4,587	0.049	0.031	0.081	-0.260	0.000	0.003
1 L - 16	4	14:13:00	12,800	4,587	0.050	0.031	0.081	-0.263	0.001	0.003
1 L - 16	8	14:17:00	12,800	4,587	0.054	0.032	0.086	-0.266	0.004	0.002
1 L - 17	1	14:18:30	13,600	4,873	0.055	0.033	0.089	-0.275		
1 L - 17	2	14:19:30	13,600	4,873	0.055	0.033	0.089	-0.278	0.000	0.003
1 L - 17	4	14:21:30	13,600	4,873	0.056	0.033	0.089	-0.282	0.000	0.004
1 L - 17	8	14:25:30	13,600	4,873	0.056	0.033	0.090	-0.287	0.001	0.005
1 L - 18	1	14:27:30	14,400	5,158	0.061	0.034	0.096	-0.294		
1 L - 18	2	14:28:30	14,400	5,158	0.062	0.035	0.097	-0.296	0.001	0.003
1 L - 18	4	14:30:30	14,400	5,158	0.063	0.035	0.098	-0.300	0.001	0.004
1 L - 18	8	14:34:30	14,400	5,158	0.064	0.035	0.099	-0.305	0.002	0.005
1 L - 19	1	14:36:30	15,450	5,533	0.070	0.036	0.106	-0.315		
1 L - 19	2	14:37:30	15,450	5,533	0.072	0.037	0.109	-0.318	0.002	0.003
1 L - 19	4	14:39:30	15,450	5,533	0.075	0.037	0.112	-0.321	0.004	0.003
1 L - 19	8	14:43:30	15,450	5,533	0.080	0.037	0.117	-0.326	0.005	0.005

Upward and Downward O-cell Plate Movement and Creep (calculated)
TS-2 - Long Foundation Research Project - Nashville, TN

Load Test Increment	Hold Time (minutes)	Time (h:m:s)	O-cell Pressure (psi)	O-cell Load (kips)	Top of Shaft (in)	Elastic Comp. (in)	Top Plate Movement (in)	Bot. Plate Movement * (in)	Creep Up Per Hold (in)	Creep Dn Per Hold (in)
1 U - 1	1	14:46:00	11,300	4,051	0.072	0.032	0.104	-0.318		
1 U - 1	2	14:47:00	11,300	4,051	0.072	0.032	0.104	-0.319		
1 U - 1	4	14:49:00	11,300	4,051	0.074	0.032	0.106	-0.317		
1 U - 2	1	14:51:30	7,600	2,729	0.066	0.028	0.094	-0.304		
1 U - 2	2	14:52:30	7,600	2,729	0.067	0.028	0.095	-0.302		
1 U - 2	4	14:54:30	7,600	2,729	0.068	0.027	0.095	-0.301		
1 U - 3	1	14:57:30	3,850	1,390	0.058	0.021	0.080	-0.267		
1 U - 3	2	14:58:30	3,850	1,390	0.057	0.021	0.078	-0.266		
1 U - 3	4	15:00:30	3,850	1,390	0.057	0.021	0.079	-0.264		
1 U - 4	1	15:02:30	0	0	0.038	0.012	0.050	-0.118		
1 U - 4	2	15:03:30	0	0	0.039	0.012	0.050	-0.114		
1 U - 4	4	15:05:30	0	0	0.038	0.011	0.049	-0.110		
1 U - 4	8	15:09:30	0	0	0.038	0.011	0.049	-0.106		

* Top of Shaft minus Bottom Plate Telltale.

Strain Gage Readings and Loads at Level 1
TS-2 - Long Foundation Research Project - Nashville, TN

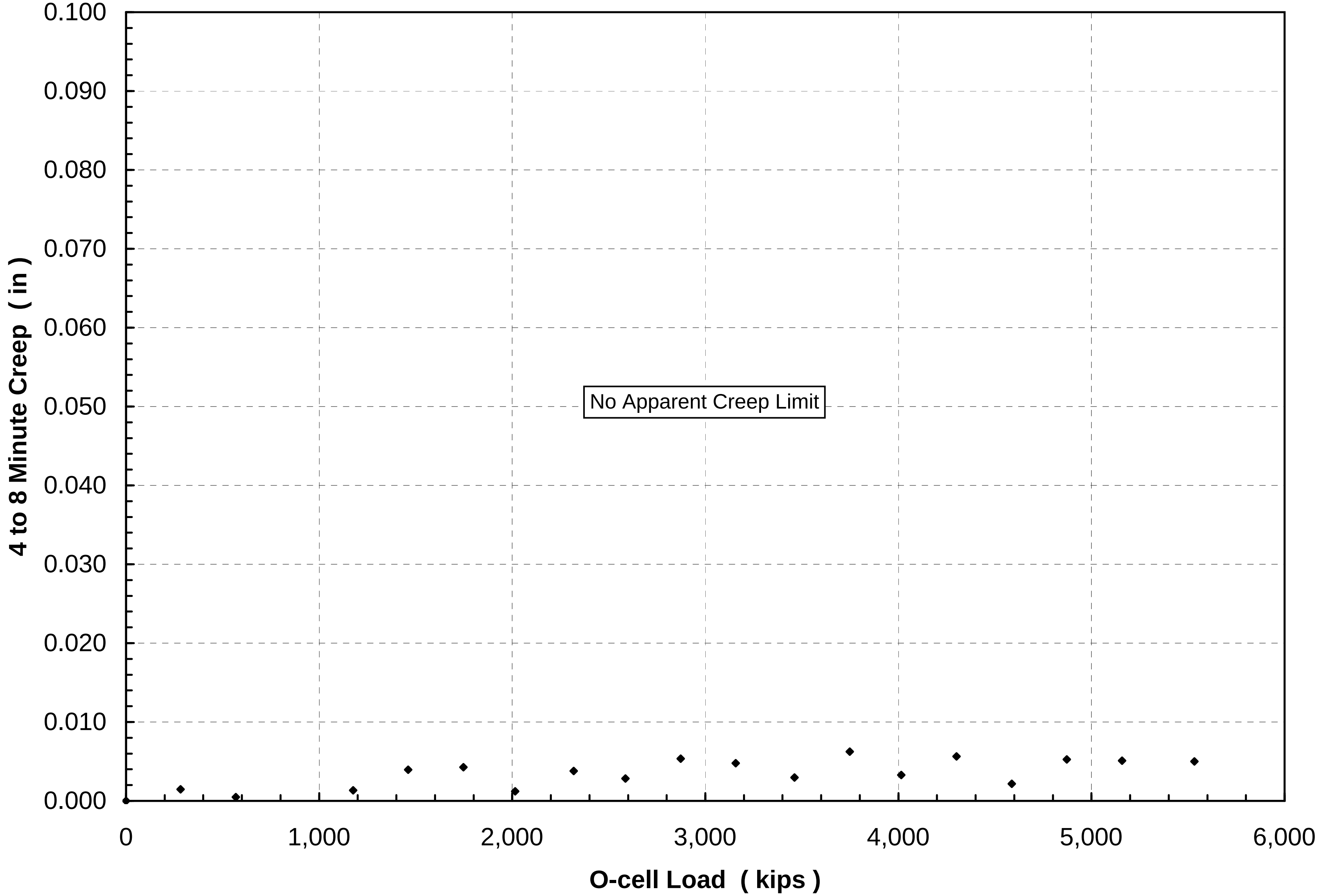
Load Test Increment	Hold Time (minutes)	Time (h:m:s)	O-cell Pressure (psi)	O-cell Load (kips)	Level 1 A - 08-19983 (με)	Level 1 B - 08-19986 (με)	Level 1 Av. Load (kips)
1 L - 0	-	11:34:30	0	0	0.0	0.0	0
1 L - 1	1	11:55:30	750	283	6.9	6.6	54
1 L - 1	2	11:56:30	750	283	6.8	6.5	53
1 L - 1	4	11:58:30	750	283	6.7	6.6	53
1 L - 1	8	12:02:30	750	283	6.7	6.4	52
1 L - 2	1	12:05:00	1,550	568	13.0	12.6	103
1 L - 2	2	12:06:00	1,550	568	13.1	12.7	104
1 L - 2	4	12:08:00	1,550	568	13.3	12.6	104
1 L - 2	8	12:12:00	1,550	568	13.4	12.6	105
1 L - 3	1	12:14:00	2,350	854	21.9	21.3	174
1 L - 3	2	12:15:00	2,350	854	22.0	21.4	175
1 L - 3	4	12:17:00	2,350	854	22.2	21.7	177
1 L - 3	8	12:21:00	2,350	854	22.3	21.9	178
1 L - 4	1	12:22:30	3,250	1,176	31.2	31.7	253
1 L - 4	2	12:23:30	3,250	1,176	31.5	31.9	255
1 L - 4	4	12:25:30	3,250	1,176	31.9	32.3	258
1 L - 4	8	12:29:30	3,250	1,176	32.3	32.9	263
1 L - 5	1	12:31:30	4,050	1,461	41.4	41.9	336
1 L - 5	2	12:32:30	4,050	1,461	42.2	42.7	342
1 L - 5	4	12:34:30	4,050	1,461	43.4	44.4	353
1 L - 5	8	12:38:30	4,050	1,461	44.2	45.2	360
1 L - 6	1	12:40:30	4,850	1,747	52.9	53.9	430
1 L - 6	2	12:41:30	4,850	1,747	53.3	54.3	433
1 L - 6	4	12:43:30	4,850	1,747	53.5	54.7	435
1 L - 6	8	12:47:30	4,850	1,747	54.2	55.0	439
1 L - 7	1	12:50:00	5,600	2,015	62.7	63.3	507
1 L - 7	2	12:51:00	5,600	2,015	63.0	63.6	510
1 L - 7	4	12:53:00	5,600	2,015	63.4	64.2	514
1 L - 7	8	12:57:00	5,600	2,015	64.1	64.7	518
1 L - 8	1	12:59:00	6,450	2,319	73.4	73.3	590
1 L - 8	2	13:00:00	6,450	2,319	73.8	73.8	594
1 L - 8	4	13:02:00	6,450	2,319	74.3	74.2	598
1 L - 8	8	13:06:00	6,450	2,319	75.0	74.9	603
1 L - 9	1	13:07:30	7,200	2,587	83.7	83.0	671
1 L - 9	2	13:08:30	7,200	2,587	84.1	83.4	674
1 L - 9	4	13:10:30	7,200	2,587	84.5	83.9	678
1 L - 9	8	13:14:30	7,200	2,587	85.2	84.5	683
1 L - 10	1	13:16:00	8,000	2,872	93.8	92.5	750
1 L - 10	2	13:17:00	8,000	2,872	94.2	92.8	753
1 L - 10	4	13:19:00	8,000	2,872	94.7	93.5	757
1 L - 10	8	13:23:00	8,000	2,872	95.4	94.1	763
1 L - 11	1	13:25:00	8,800	3,158	103.9	101.9	829
1 L - 11	2	13:26:00	8,800	3,158	104.4	102.4	833
1 L - 11	4	13:28:00	8,800	3,158	104.9	102.9	837
1 L - 11	8	13:32:00	8,800	3,158	105.6	103.4	841
1 L - 12	1	13:34:30	9,650	3,462	114.2	111.3	908
1 L - 12	2	13:35:30	9,650	3,462	114.7	111.8	911
1 L - 12	4	13:37:30	9,650	3,462	115.3	112.4	916
1 L - 12	8	13:41:30	9,650	3,462	116.1	113.1	923
1 L - 13	1	13:43:00	10,450	3,747	124.2	120.6	985
1 L - 13	2	13:44:00	10,450	3,747	124.6	120.8	988
1 L - 13	4	13:46:00	10,450	3,747	125.3	121.6	994
1 L - 13	8	13:50:00	10,450	3,747	126.0	122.1	999
1 L - 14	1	13:52:00	11,200	4,015	134.0	129.6	1061
1 L - 14	2	13:53:00	11,200	4,015	134.4	129.9	1064
1 L - 14	4	13:55:00	11,200	4,015	135.0	130.4	1068
1 L - 14	8	13:59:00	11,200	4,015	135.7	131.1	1074
1 L - 15	1	14:01:00	12,000	4,301	143.9	138.5	1137
1 L - 15	2	14:02:00	12,000	4,301	144.4	139.0	1140
1 L - 15	4	14:04:00	12,000	4,301	144.9	139.5	1145
1 L - 15	8	14:08:00	12,000	4,301	145.8	140.2	1151
1 L - 16	1	14:10:00	12,800	4,587	153.4	147.3	1210
1 L - 16	2	14:11:00	12,800	4,587	153.9	147.7	1214
1 L - 16	4	14:13:00	12,800	4,587	154.4	148.2	1218
1 L - 16	8	14:17:00	12,800	4,587	155.3	148.8	1224
1 L - 17	1	14:18:30	13,600	4,873	162.7	155.5	1281
1 L - 17	2	14:19:30	13,600	4,873	162.9	155.8	1283
1 L - 17	4	14:21:30	13,600	4,873	163.3	156.2	1286
1 L - 17	8	14:25:30	13,600	4,873	163.6	156.6	1289
1 L - 18	1	14:27:30	14,400	5,158	171.0	163.7	1347
1 L - 18	2	14:28:30	14,400	5,158	171.4	163.8	1349
1 L - 18	4	14:30:30	14,400	5,158	171.9	164.2	1353
1 L - 18	8	14:34:30	14,400	5,158	172.5	164.9	1358
1 L - 19	1	14:36:30	15,450	5,533	181.9	174.3	1434
1 L - 19	2	14:37:30	15,450	5,533	182.6	174.9	1439
1 L - 19	4	14:39:30	15,450	5,533	183.3	175.9	1445
1 L - 19	8	14:43:30	15,450	5,533	184.0	176.8	1452

Strain Gage Readings and Loads at Level 1
TS-2 - Long Foundation Research Project - Nashville, TN

Load Test Increment	Hold Time (minutes)	Time (h:m:s)	O-cell Pressure (psi)	O-cell Load (kips)	Level 1 A - 08-19983 (με)	Level 1 B - 08-19986 (με)	Level 1 Av. Load (kips)
1 U - 1	1	14:46:00	11,300	4,051	158.3	151.7	1248
1 U - 1	2	14:47:00	11,300	4,051	160.6	154.0	1266
1 U - 1	4	14:49:00	11,300	4,051	160.8	154.1	1267
1 U - 2	1	14:51:30	7,600	2,729	140.2	133.7	1102
1 U - 2	2	14:52:30	7,600	2,729	140.1	134.0	1104
1 U - 2	4	14:54:30	7,600	2,729	140.2	134.0	1104
1 U - 3	1	14:57:30	3,850	1,390	110.9	104.0	865
1 U - 3	2	14:58:30	3,850	1,390	111.0	104.1	866
1 U - 3	4	15:00:30	3,850	1,390	111.0	104.1	866
1 U - 4	1	15:02:30	0	0	56.3	52.5	438
1 U - 4	2	15:03:30	0	0	55.9	52.3	435
1 U - 4	4	15:05:30	0	0	55.5	52.1	433
1 U - 4	8	15:09:30	0	0	54.7	51.7	429

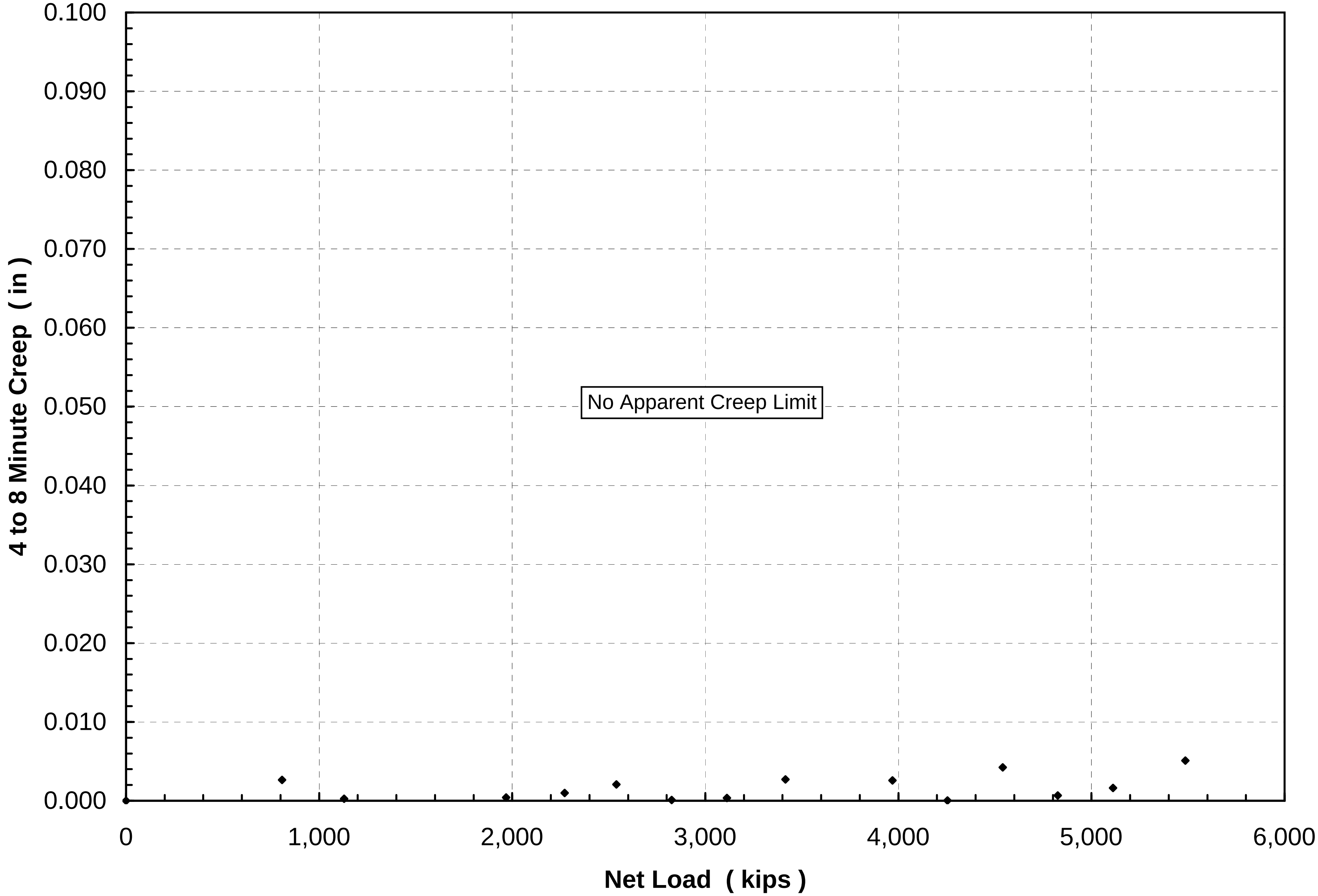
End Bearing Creep Limit

TS-2 - Long Foundation Research Project - Nashville, TN



Side Shear Creep Limit

TS-2 - Long Foundation Research Project - Nashville, TN



Appendix D, Figure 2