Applied Foundation Testing

October 9, 2008

Final Report of
Drilled Shaft Post Grouting
Drilled Shaft Load Test Program
I-80 Bridge Project (Broadway Bridge Viaduct)
Council Bluffs,
Pottawattamie County, Iowa
NHS-080-1(318)0-11-78
AFT Project No.: 108026

For:
Mike Kemery
Longfellow Drilling
1209 County Highway J23
Clearfield, Iowa 50840
Ph: 641 336 2297
Fax: 641 336 2387

Authored By:

Michael K. Muchard, P.E.
Principal Geotechnical Engineer

INTRODUCTION

This report is provided to summarize the procedures and results of the drilled shaft post grouting performed as part of the subject drilled shaft load test project. Objectives of the load test program included evaluation of conventional drilled shafts and post grouted drilled shafts for use in the future design and construction of the Broadway Bridge Viaduct in Council Bluffs, Iowa. The test site was located adjacent to the future bridge at the intersection of 12th Street and West Broadway. Please refer to the contract documents for a site plan of the actual location of the test site. The project entailed construction of three strain instrumented test drilled shafts. Two shafts included sleeve port and plate base grouting apparatus and were post grouted. The third shaft was un-grouted and served as a control shaft for comparison of the un-grouted end bearing. All shafts were 60 inches in diameter and had lengths of approximately 55 and 65 feet. The control shaft was 55 feet. Post grouted shafts were 55 feet and 65 feet. The testing sequence included performing SPT borings at each test shaft location prior to construction, performing integrity testing using the crosshole sonic logging method on the test shafts prior to post grouting. Post grouting was then performed. All embedded strain gages were monitored during the post grouting process as well. Finally, Statnamic load testing was performed on all three shafts in accordance with ASTM D7383. Each test method performed is documented in separate reports. This report only contains the post grouting of the drilled shafts.

The load test program performed herein was a design phase program for the future Broadway Bridge project. As an innovative contractural means to more cost effectively obtain load test data, the testing was included in the construction contract for the nearby I-80 Bridge over the Missouri River project, which also utilized drilled shafts. The I-80 Bridge general contractor was Jensen Construction Company. Longfellow Drilling was the drilled shaft contractor and managed all load test program activities including: site preparation, shaft installation and all required support to carry out the testing. Applied Foundation Testing was contracted through Longfellow Drilling on behalf of the Iowa DOT to perform the instrumentation, CSL, post grouting, Statnamic load testing and associated engineering reports. Construction inspection and oversight was provided by Iowa DOT and FHWA representatives. The Geotechnical engineer of record was CH2MHILL. Additional soil borings at each test shaft location along with concrete QC testing for the test program was performed by Geotechnical Services, Inc.

GENERALIZED SOIL CONDITIONS

A geotechnical investigation was initially performed by CH2MHILL. As part of the load test contract, SPT borings were required at each of the three test shaft locations. These borings were performed by Geotechnical Services, Inc. and are attached with this report. We have provided a brief description of the soils conditions for general use while reviewing this report. For detailed information on the soil conditions, please refer to the attached borings.

The borings were drilled to a depth of 70 feet below the ground surface at each specific test shaft location. The ground surface elevation at the site was between +988.5 and +990.5 feet. In general, the upper 20 feet in all three borings consisted of soft to stiff silty clay (CL) and (CL-CH). SPT N values in this upper silty clay ranged from 3 to 14. The water table was around 16 to 17 feet in depth below ground surface. The upper silty clays were underlain by fine sand and silty fine sand (SP-SM) to depths of 55 to 60 feet. SPT N values in the sands ranged from 6 to 42. the fine silty sands gave way to a more coarse grained sand which extended to the boring bottom of 70 feet. In the TS-1 boring a soft clay layer was encountered between the bottom of the fine sand at 55 feet and the coarse sand at 60 feet.

TS-1 which was the 65 foot post grouted shaft was tipped in the coarse sand while TS-2 (55 ft post grouted shaft) and TS-3 (ungrouted) were tipped in the fine grained sandy soils. These medium dense granular soils were very conducive to improvement by base grouting. It is important to note that the two post grouted shafts, TS-1 and TS-2 were tipped in very similar density sands with SPT N values of 11 and 12, respectively. The un-grouted control shaft, TS-3, was tipped in a more competent sand with an SPT N of 24. This is an important consideration when evaluating the improvement from grouting.

POST GROUTED SHAFT BACKGROUND

The end bearing component of drilled shafts is not fully utilized in most design methods due to the large displacement required to mobilize ultimate capacity. Consequently, a large portion of the ultimate capacity necessarily goes unused. In an effort to regain some of this unusable capacity, mechanistic procedures to integrate its contribution have been developed using pressure grouting beneath the shaft tip (also called post grouting or base grouting). Pressure grouting the tips of drilled shafts has been successfully used worldwide to precompress soft debris or loose soil relaxed by excavation (Bolognesi and Moretto, 1973; Stoker, 1983; Bruce, 1986; Fleming, 1993. In the year 2002, a process was patented in the United States and is commercially known as SynchroPile©. The post-grouting process entails: (1) installation of a grout distribution system during conventional cage preparation that provides grout tube-access to the bottom of the shaft reinforcement cage, and (2) after the shaft concrete has cured, injection of high pressure grout beneath the tip of the shaft which both densifies the in-situ soil and compresses any debris left by the drilling process. By essentially preloading the soil beneath the tip, higher end bearing capacities can be realized within the service displacement limits. There are a number of grout distribution systems in use. A sleeve port with plate above was used at this project. This system is sometimes referred to as a tube-a-manchette. Sleeve port systems use a rubber tube over a perforated pipe section.

The overall capacity of the shaft is still derived from both side shear and end bearing where the available side shear is calculated using one or a combination of various design methods. Further, the calculation of the available side shear is an important step in determining the pressure to which the grout can be pumped.

The design approach for post grouted drilled shaft tips in sand makes use of common parameters used for a conventional (un-grouted) drilled shaft design. This methodology includes the following seven steps:

1. Determine the ungrouted end bearing capacity in units of stress.
2. Determine the permissible displacement as a percentage of shaft diameter (we understand 1" maximum was used for this project).
3. Evaluate the ultimate side shear resistance for the desired shaft length and diameter (in units of force).
4. Establish a maximum grout pressure that can be resisted by the side shear (ultimate side shear divided by the tip cross sectional area).
5. Calculate the Grout Pressure Index, GPI, defined as the ratio of grout pressure to the ungrouted end bearing capacity (Step 3 / Step 1).
6. Using design curves from Chart 1, determine the Tip Capacity Multiplier, TCM, using the GPI calculated in Step 5. Calculate the grouted end bearing capacity (effective ultimate) by multiplying the TCM by the ungrouted end bearing (TCM * Step 1).

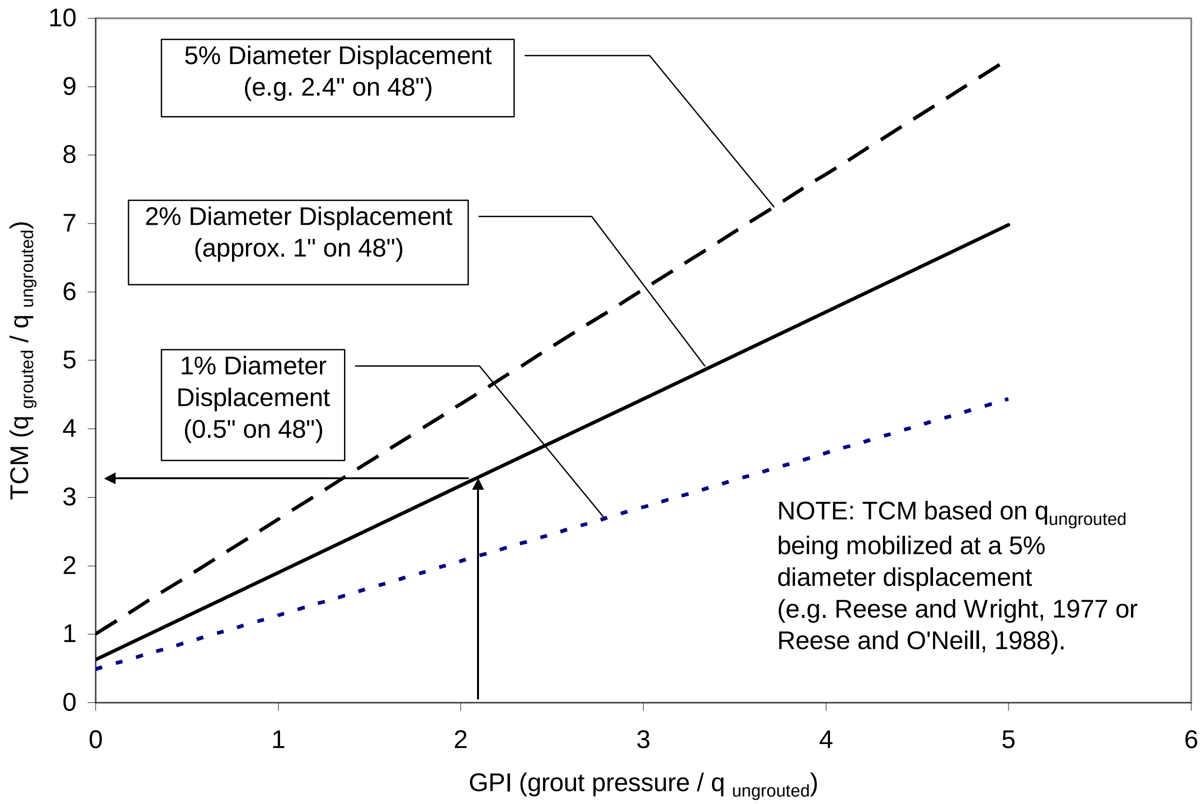


Chart 1.

The ungrouted capacity (GPI = 0) is represented by these curves at the y-intercept where TCM = 1 for a 5% displacement (no improvement). The 1% and 2% intercepts reduce the end bearing according to the normal behavior of partially mobilized end bearing. Interestingly, the grouted end bearing capacity is strongly dependent on available side shear capacity (grout pressure) as well as the permissible displacement. However, it is relatively independent of the ungrouted end bearing capacity when in sandy soils. As such, the end bearing in loose sand deposits can be greatly improved in both stiffness and ultimate capacity given sufficient side shear against which to develop grout pressure. In dense sands and clays significant improvement in stiffness can be realized with more modest effects on ultimate capacity.

Post grouting shaft tips in other formations such as clays, silts, and rock can be advantageous for the same reasons as in sand. However, the degree of improvement may be more modest. In clays and plastic silts, the TCM can be assumed to be 1.0 although AFT has seen it as high as 1.5 if sufficient side shear can be developed. In non plastic silts, the TCM can be assumed to be 1.0 for initial designs but a verification load test program is recommend as much higher values may be reasonable. In rock, post grouted shafts have the potential to engage both the side shear and end bearing simultaneously. In all soil types the achieved grout pressure can be used as a lower bound for usable end bearing and the attainable grout pressure is always dependent on the available side shear against which to react. In contrast, sufficient side shear capacity does not assure that grout pressure can be developed without excessive volumes of grout. In all cases, post grouting shaft tips provides a capacity verification for every shaft grouted.

FOUNDATION DESCRIPTION AND CONSTRUCTION

The three test shafts designated as TS-1, TS-2 and TS-3 were all 60 inch in diameter. TS-1 had a plan length of 65 feet and included a sleeve port and plate type post grout apparatus at its base. TS-2 had a plan length of 55 feet and included a sleeve port with plate above type post grout apparatus at its base. This system is sometimes referred to as a tube-a-manchette. Sleeve port systems use a rubber tube over a perforated pipe section. TS-3 had a plan length of 55 feet and was a conventional drilled shaft with NO grouting apparatus. TS-3 served as a control shaft to judge the improvement from post grouting. It is noted that the ungrouted test shaft was tipped in a little more dense sand than the grouted shafts. The test shafts were designed and constructed with planned ultimate capacities such that they could be reached within the constrains of the 2000 ton Statnamic device.

Table 1. Summary of Test Shafts.

Shaft Number	Shaft Diameter (inches)	Shaft Length (feet)	Shaft Type
TS-1	60	66.3	Post Grouted
TS-2	60	55.4	Post Grouted
TS-3	60	55.9	Non-Grouted

Shaft reinforcement was the same for all three test shafts and consisted of 23 - #10 longitudinal bars with #5 shear hoops on 12 inch centers. A 3 inch clear spacing governed the steel hoop diameter. Sisterbar strain gages were installed at four vertical levels in all three test shafts as shown in the schematic drawings in Appendix B. A description of the strain gages is provided under separate cover in the Report of Statnamic Load Testing dated October 9, 2008.

Shaft construction was performed using the “wet method”. The general procedure included placing a short upper permanent casing 4 to 5 feet in length to both stabilize the near surface soils and provide a clean and level surface for load testing. A dedicated track mount drill rig used various drilling tools, auger and cleanout bucket to excavate the soils. Water and polymer slurry admixture drilling fluid was introduced early on used to stabilize the walls of the excavation. Once the required depths were attained, the shaft bottoms were mechanically cleaned using a standard clean-out bucket and inspected for cleanliness by sounding with a weighted tape. The upper 4 to 5 feet of each shaft was constructed 66 inches in diameter using a permanent casing that extended approximately one foot above grade. The nominal shaft diameter for the remaining deoth was 60 inches. A tremie was used to place the concrete via a pump truck. The tremie was maintained 10 to 15 feet below the rising concrete head at all times. Concrete quality assurance testing was performed by Geotechncial Services, Inc. Drilled shaft construction was completed between August 20 and August 22, 2008. For more information on the shaft construction please see the drilled shaft construction records included in Appendix B.

For the purpose of analysis of the grouting measurements, nominal shaft diameters and lengths provided in Table 1 were used in our calculations. The concrete compressive strengths used in our calculations were 4,820 psi for TS-1 and 5,020 psi for TS-2. It is noted that these strengths were based on tests performed on the same day post grouting occurred.

POST GROUTING TEST SHAFTS

Post grouting of both test shafts TS-1 and TS-2 were performed on August 28, 2008. TS-2 was grouted first followed by TS-1 The grout plant used was a model IC 310 E manufactured by H A NY of Switzerland. The plant was made of three components including a colloidal mixer, agitated holding tank, and a hydraulic actuated piston type pump capable of 1,500 psi grouting pressure. It is noted that maximum target grout pressures were limited to approximately 600 psi since that was the rating of the PVC grout tubing. The grout was Type I GU (General Use) Portland cement. The design water/cement ratio was 0.5 however it was lowered slightly during the grouting of TS-2 to reduce volume take. During grouting, the grout pressure, volume, shaft displacement, and embedded strain gages were monitored with a data acquisition system. To accurately measure upward shaft displacement, an independent reference beam was set up over the test shaft to attach the LVDT's. Back up displacement measurements were made by AFT with a surveyors level. Grout pressure was measured with an electronic pressure transducer and with a Bourdon oil filled dial gage. Grout volume measurements were made manually by recording the levels in the holding tank. Every 1 inch drop in the holding tank level is equivalent to 5 liters (0.177 cu ft) of grout placed.

The general procedure consisted of first flushing the grout lines with fresh water until clear water return was observed. This was done shortly after the completion of the shaft construction and again just prior to post grouting. Each base grout apparatus included two separate U-Tubes both systems were flushed. Grouting began on one of the U-Tube systems with the other being filled with water and closed off. When grout return was observed from the opposing tube, the return line valve was closed and pressurization started. The grout was injected at low flow rates to build pressure slowly. Once the design pressure was achieved on TS-2, the opposing ball valve was left in the closed position for a period of approximately 5 minutes then opened to ambient atmospheric pressure. At the completion of TS-1, the ball valve was immediately opened and the grout was allowed to backflow out of the shaft and bleed off to atmospheric pressure.

This general procedure was used for both shafts. A detailed description of the grouting measurements for each shaft is given below.

TS-1 Post Grout Data

As shown in Figure 1, the maximum grout pressure achieved was 660 psi measured at the pump with the pressure transducer. Also shown in Figure 1 is the concurrent shaft top displacement. The maximum shaft top displacement was 0.083 inches measured with the LVDT's. At the completion of the grouting process, a permanent upward movement of 0.063 inches was measured. A total volume of 19.2 cubic feet of grout was placed which is shown concurrently with the grout pressure in Figure 2. This volume roughly equates to a grout cylinder beneath the shaft base of equal diameter to the shaft and 1 foot in height. A summary of the measurements during grouting are shown in Table 2. To mention once again, the pressure was not locked-in upon completion of the grouting of this shaft and grout was observed to backflow out of the tubes as the shaft rebouded. The valve remained open during the grout curing process.

A comparison of the redundant pressure and displacement measurements presented in Figures 3 and 4 suggest good agreement and reliability. This is an important aspect of the test program since only manual measurements will be obtained in a production setting.

Table 2. Summary of Test Shaft Post Grouting Measurements

Shaft Number	Maximum Grout Pressure (psi)	Maximum Grout Volume (cubic feet)	Maximum Upward Displacement (inches)	Permanent Upward Displacement (inches)
TS-1	660	19.2	0.083	0.063

The strain gages within the shaft were also monitored during the grouting to provide more insight as to the shaft behavior during grouting. The bottom level of strain gages was approximately 2.5 feet above the base grout plate. Data from this level can be used to evaluate the bi-directional force applied at the shaft base as a result of the grouting procedure. The data from each of the four gages as well as the average at this level are given in Figure 5. These measurements suggest fairly significant eccentricities near the shaft bottom. Averaging of these gages produces a nice consistent curve which is also shown in Figure 5. It is particularly interesting that at about 45 minutes into the grouting, the eccentricities get very erratic and demonstrate complex bending patterns. Referring back to Figure 2 (grout pressure and volume) a drop in grout pressure and an increase in volume occurs at this same time. We believe this is due to the grout migrating a short distance up and around the sides of the shaft. Thereby, some side loading is induced near the shaft bottom. This behavior was not demonstrated in any of the other gage levels higher in the shaft.

Force calculated from the bottom level of strain gages provides a quantification of the shaft skin friction and end bearing to the degree of the applied grout pressure (only partially mobilized). This is graphically displayed in Figure 6 where the force at the shaft base plotted versus upward shaft displacement. The upward shaft displacement shown in this figure is sum of the measured shaft top movement and the theoretical elastic shortening thus is more representative of the actual shaft base upward movement. The upward acting force in Figure 6 has not been reduced to account for the buoyant weight of the drilled shaft which is approximately 135 kips. Therefore, the verified upward side shear resistance was 627 kips. An equal and opposite force of 762 kips shown in Figure 6 acted downward in end bearing. Therefore, the total verified capacity was approximately 1,389 kips during the grouting. The upward side shear resistance is below ultimate due to the small upward displacement and that the curve in Figure 6 is still in the linear range. It can not be determined whether the end bearing was full or partially mobilized from the grouting data.

The average forces at each gage level in the shaft were also calculated. These calculated forces are shown in Figure 7 versus shaft top displacement. Mobilized side shear load distribution can be estimated from these data. Note that these forces have not been reduced to account for the buoyant weight of the drilled shaft. In addition, the upward displacement was not corrected to account for theoretical elastic shortening. A summary of the estimated load distribution during grouting is provided in Table 3.

Table 3. Summary of Load Distribution During Post Grouting

Shaft Zone	Maximum Mobilized Resistance (kips)	Maximum Mobilized Unit Strength Shear (ksf)
989.31ft to 969.04 ft (Segment 1)	92	0.29
969.04 ft to 957.29 ft (Segment 2)	212	1.15
957.29 ft to 926.29 ft (Segment 3)	323	0.66
Total Verified Side Shear	627	0.63
Verified End Bearing	762	38.8
Total Verified Capacity	1,389 kips	

*All data shown in table has been corrected for the buoyant weight of the drilled shaft.

We have also performed an evaluation of the force acting at the shaft base calculated based on the strain gages and calculated using the pressure acting on the surface area of the shaft tip. These calculations are graphically displayed in Figure 8. This analysis indicates that the grout did not act on the full surface area of the shaft base at any point during the grouting. It does suggest that early on, the grout acted on the full surface area of the grout plate. As the grouting duration increased, the plate area affected by the grout was reduced. Near the end of grouting, it is estimated that the grout acted on approximately 60 percent of the surface area of the plate. This is typical for the Tube-a-Manchette system. As previously mentioned, it is also implied by the measurements that the grout did migrate up the walls of the shaft to some relatively minor degree. In any event, the grouting measurements suggest significant improvement in end bearing capacity.

TS-2 Post Grout Data

The maximum grout pressure achieved was 660 psi As shown in Figure 9, measured at the pump with the electronic pressure transducer. Also shown in Figure 9 is the concurrent shaft top displacement. The maximum shaft top displacement was 0.071 inches measured with the LVDT's. At the completion of the grouting process, a permanent upward movement of 0.060 inches was measured. A total volume of 22.9 cubic feet of grout was placed which is shown concurrently with the grout pressure in Figure 10. This volume roughly equates to a grout cylinder beneath the shaft base of equal diameter to the shaft and 1 foot in height. A summary of the measurements during grouting are shown in Table 4. It is important to note, the pressure was partially locked-in upon completion of the grouting of this shaft. The ball valve was locked off immediately after grout completion but was un-locked after approximately 5 minutes. Grout was not observed to backflow out of the tube upon un-locking the ball valve but the grout was cured with the valve open.

A comparison of the redundant pressure and displacement measurements presented in Figures 11 and 12 also suggest good agreement and reliability.

Table 4. Summary of Test Shaft Post Grouting Measurements

Shaft Number	Maximum Grout Pressure (psi)	Maximum Grout Volume (cubic feet)	Maximum Upward Displacement (inches)	Permanent Upward Displacement (inches)
TS-2	660	22.9	0.071	0.060

The strain gages within this shaft were monitored as well during grouting. The bottom level of strain gages was approximately 2.0 feet above the base grout plate. The data from each of the four gages as well as the average at this level are given in Figure 13. These measurements suggest fairly significant eccentricities near the shaft bottom. Averaging of these gages produces a nice consistent curve which is also shown in Figure 13. Similar to the other post grouted shaft, the strain gages captured eccentricities and similar bending patterns near the later portion of the grouting process. Referring back to Figure 10 (grout pressure and volume) a drop in grout pressure and an increase in volume is linked to this behavior. We believe this is due to the grout migrating a short distance up and around the sides of the shaft. Thereby, some side loading is induced near the shaft bottom. This behavior was not demonstrated in any of the other gage levels higher in the shaft.

Force calculated from the bottom level of strain gages provides a quantification of the shaft skin friction and end bearing to the degree of the applied grout pressure (only partially mobilized). This is graphically displayed in Figure 14 where the force at the shaft base is plotted versus upward shaft displacement. The upward shaft displacement shown in this figure is sum of the measured shaft top movement and the theoretical elastic shortening thus is more representative of the actual shaft base upward movement. The upward acting force in Figure 14 has not been reduced to account for the buoyant weight of the drilled shaft which is approximately 112 kips. Therefore, the verified upward side shear resistance was 610 kips. An equal and opposite force of 722 kips shown in Figure 14 acted downward in end bearing. Therefore, the total verified capacity was approximately 1,332 kips during the grouting. The upward side shear resistance is below ultimate due to the small upward displacement and that the curve in Figure 14 is still in the linear range. It can not be determined whether the end bearing was full or partially mobilized from the grouting data.

The average forces at each gage level in the shaft were also calculated. These calculated forces are shown in Figure 15 versus shaft top displacement. Mobilized side shear load distribution can be estimated from these data. Note that these forces have not been reduced to account for the buoyant weight of the drilled shaft. In addition, the upward displacement was not corrected to account for theoretical elastic shortening. A summary of the estimated load distribution during grouting is provided in Table 5.

Table 5. Summary of Load Distribution During Post Grouting

Shaft Zone	Maximum Mobilized Resistance (kips)	Maximum Mobilized Unit Strength Shear (ksf)
988.84ft to 966.97 ft (Segment 1)	133	0.39
966.97 ft to 954.47 ft (Segment 2)	153	0.78
954.47 ft to 935.22 ft (Segment 3)	324	1.07
Total Verified Side Shear	610	0.73
Verified End Bearing	722	36.8
Total Verified Capacity	1,332 kips	

*All data shown in table has been corrected for the buoyant weight of the drilled shaft.

We have also performed an evaluation of the force acting at the shaft base calculated based on the strain gages and calculated using the pressure acting on the surface area of the shaft tip. These calculations are graphically displayed in Figure 16. This analysis indicates that the grout did not act on the full surface area of the shaft base at any point during the grouting. It does suggest that early on, the grout acted on a greater surface area than later in the grouting process. Near the end of grouting, it is estimated that the grout acted on approximately 50 percent of the surface area of the plate. This is typical for the Tube-a-Manchette system. As previously mentioned, it is also implied by the measurements that the grout did migrate up the walls of the shaft to some relatively minor degree. In any event, the grouting measurements suggest significant improvement in end bearing capacity.

PRELIMINARY PRODUCTION SHAFT POST GROUTING CRITERIA RECOMMENDATIONS

Based on our analysis of the post grouting data and Statnamic load test results, we have developed a preliminary production grouting criteria, which is presented herein. We also recommend that this preliminary criteria be verified and refined if necessary during the method shaft installation for the future project.

Discontinue grouting when one of the following criteria is met:

Pressure - The minimum design pressure of 600 psi is achieved while pumping a minimum net volume of approximately 3 cubic feet into the shaft. That is assuming a 60 inch diameter drilled shaft. This should be reduced for smaller diameter shafts. Should the grout pressure not be achieved while the shaft has not exceeded the upward displacement criterion, one or all of the following approaches shall be taken: (1) the water cement ratio can be reduced systematically by an interval of 0.05 and grouting resumed until the design pressure can be achieved. The practical lower limit for w/c ratios of grout is 0.4. If the pressure is slowly building, grouting may continue until the design pressure is met. If the design pressure still not been attained after large volumes (approx. 30 cubic feet) have been placed, and the shaft is within the displacement criterion, the grout lines shall be fully flushed with clear water and the shaft shall be re-grouted in stages.

Displacement - An upward surveyed displacement exceeds 0.25 inches. If the design pressure has not been attained within this displacement, the grout lines shall be fully flushed with clear water and the Engineer shall be contacted for direction.

Volume - A minimum net volume of approximately 3 cubic feet must be pumped into the shaft by the time the design pressure is achieved. That is assuming a 60 inch diameter drilled shaft. This should be reduced for smaller diameter shafts. This will assure that an artificial pressure is not induced by access line blockage.

A minimum of four separate measurements of grout pressure, grout volume, and shaft top upward displacement and time of grouting shall be recorded that represent the range of grout pressure delivered to the shaft tip. This information shall be documented on the Post Grout Field Record and submitted to the Engineer for each shaft.

SUMMARY

A drilled shaft load test program was performed to accomplish several goals, one of which was to evaluate use of post grouted drilled shafts for the future Broadway Bridge Viaduct in Council Bluffs, Iowa. The project entailed construction of three strain instrumented test drilled shafts. Two shafts included sleeve port with plate above type base grouting apparatus and were post grouted. The third shaft was un-grouted and served as a control shaft for comparison of the un-grouted end bearing. All shafts were 60 inches in diameter and had lengths of approximately 55 and 65 feet. The control shaft designated as TS-3 was 55 feet. Post grouted shaft TS-2 was 55 feet and Post grouted shaft TS-1 was 65 feet. The testing sequence included performing SPT borings at each test shaft location prior to construction, and integrity testing using the crosshole sonic logging method on the shafts prior to post grouting. Post grouting was then performed. All embedded strain gages were monitored during the post grouting process as well. Finally, Statnamic load testing was performed on all three shafts in accordance with ASTM D7383. Each test method performed is documented in separate reports. This report only contains the post grouting of the drilled shafts.

The post grouting was successfully carried out and the results analyzed. Both shafts behaved very consistently during grouting. A maximum grout pressure of 660 psi was achieved in both cases with similar upward displacements and similar volumes of grout placed. TS-1, the longer shaft at 65 feet, actually displaced upward slightly more than TS-2 which was only 55 feet. TS-1 had a maximum upward displacement of 0.083 inch while TS-2 displaced upward 0.071 inch, overall minimal amounts in either case. Similar volumes were placed with 19.2 and 22.9 cubic feet for TS-1 and TS-2, respectively. Strain data suggests verified end bearing ranged from approximately 762 kips to 722 kips for TS-1 and TS-2 during grouting. Overall verified capacity estimates for the respective shafts were 1,389 kips and 1,332 kips. In both cases the overall verified capacity estimates, during grouting, were well below ultimate since the upward side shear was not fully mobilized. It is noted that the reader consult the Report of Statnamic Load Testing Dated October 9, 2008, which compliments this report, prior to making final engineering conclusions as to the effectiveness of the post grouting.

As part of the evaluation of the post grouting, preliminary production shaft post grouting criteria recommendations were also provided for use in the future bridge project specifications. This preliminary criteria should be verified and refined if necessary during a method shaft installation in the future construction of the bridge.

CLOSURE

It has been a pleasure working with you and we appreciate all your support in the field to successfully complete the post grouting. If you have any questions relating to this information please contact us at your convenience.

LIMITATIONS

This report presents test measurements made by AFT. Interpretations were made based upon the measurements made by AFT with the latest techniques available and currently accepted standards of care recognized by Geotechnical Engineering professionals. AFT is an independent agency and is not the Geotechnical Engineer of Record. The Geotechnical Engineer of Record should ultimately make final recommendations for foundation design and construction.

Rebar cages with drill rig and existing Broadway Bridge Viaduct in background.

Shaft excavation

Grout distribution system at shaft bottom.

Finishing shaft top.

Grout hose attached.

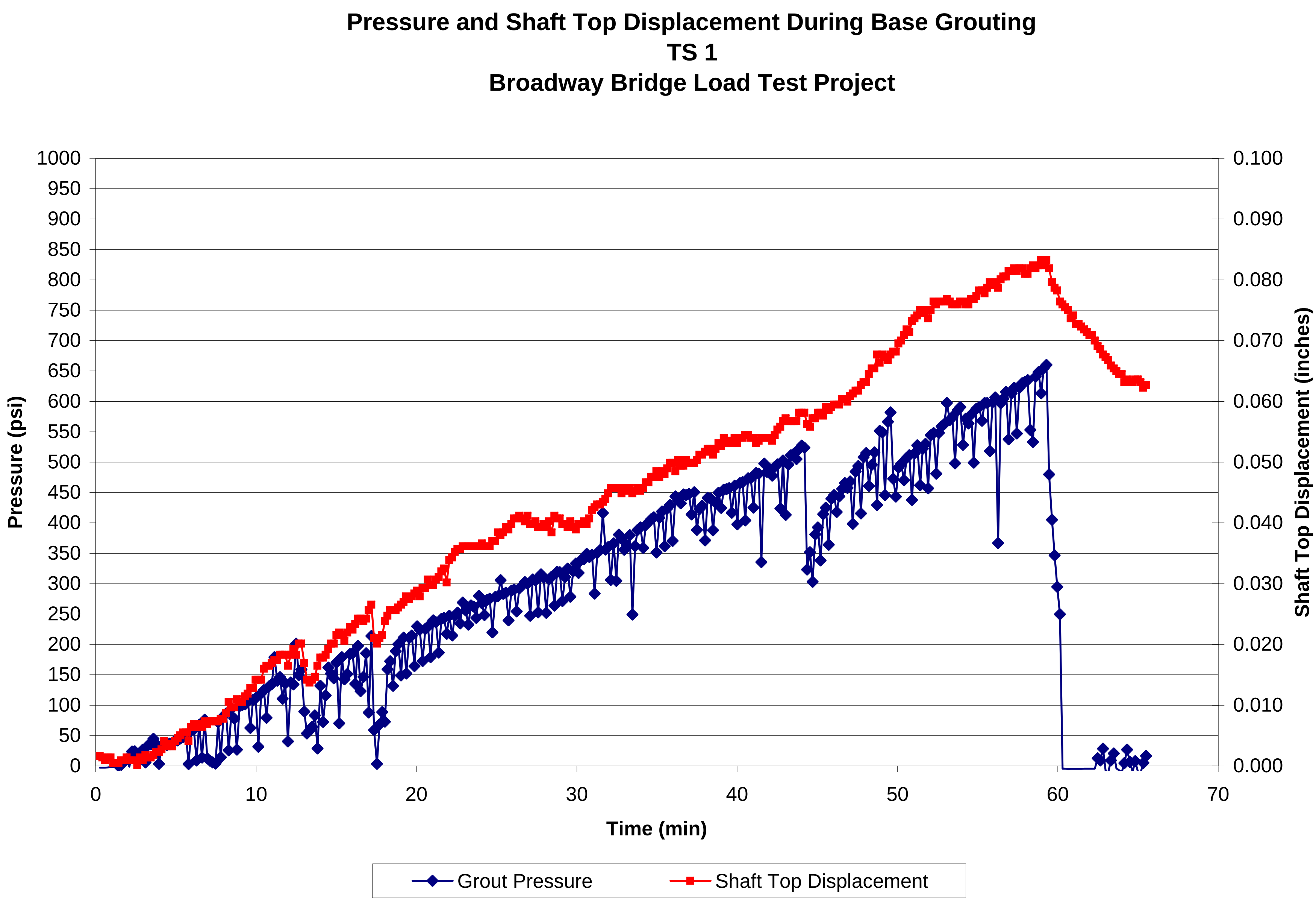
LVDT's attached to reference beam.

Back up survey readings.

Grout pressure measurement bourdon gage and electronic pressure transducer.

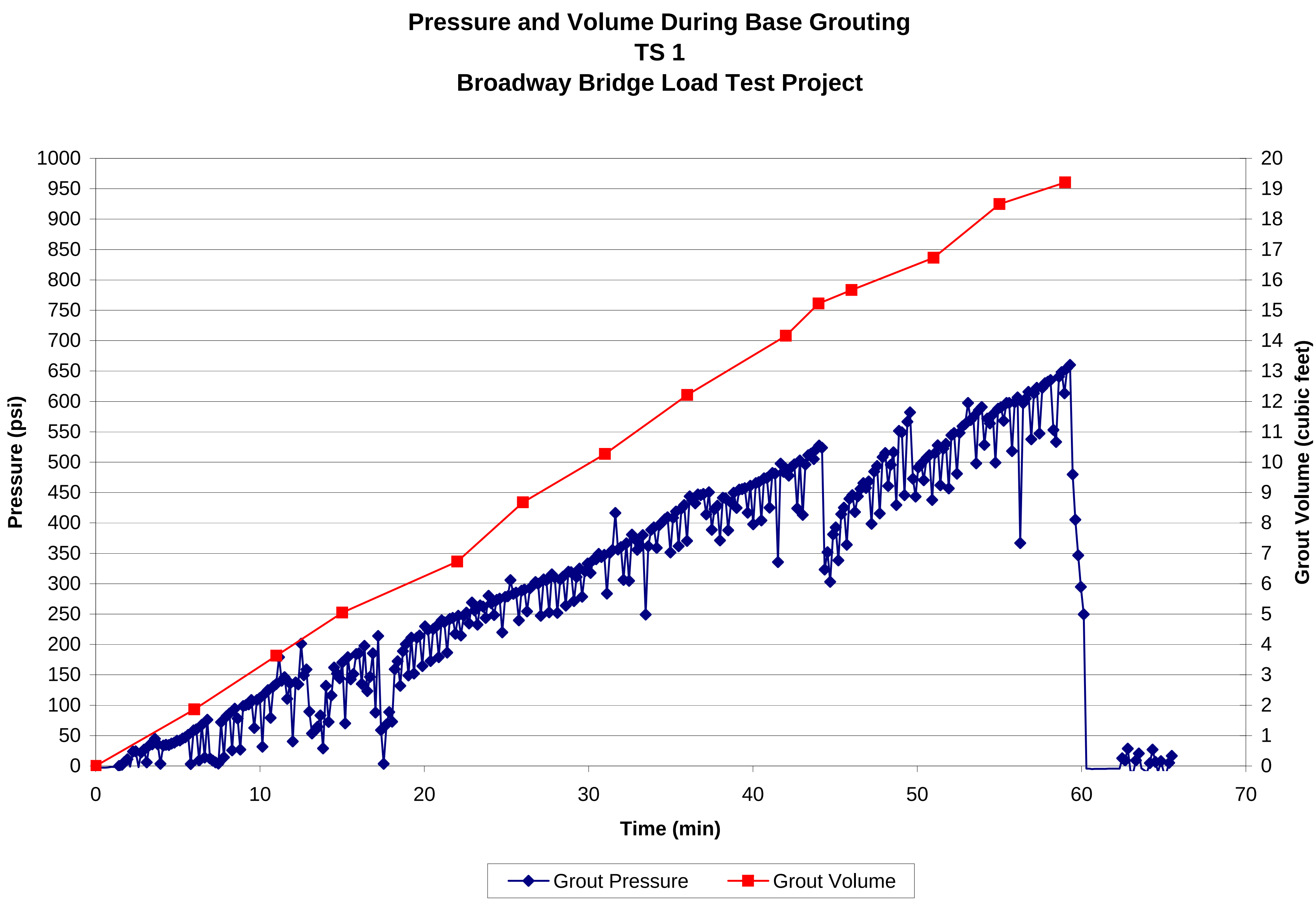
Data acquisition system used to monitor test shaft grouting operation.

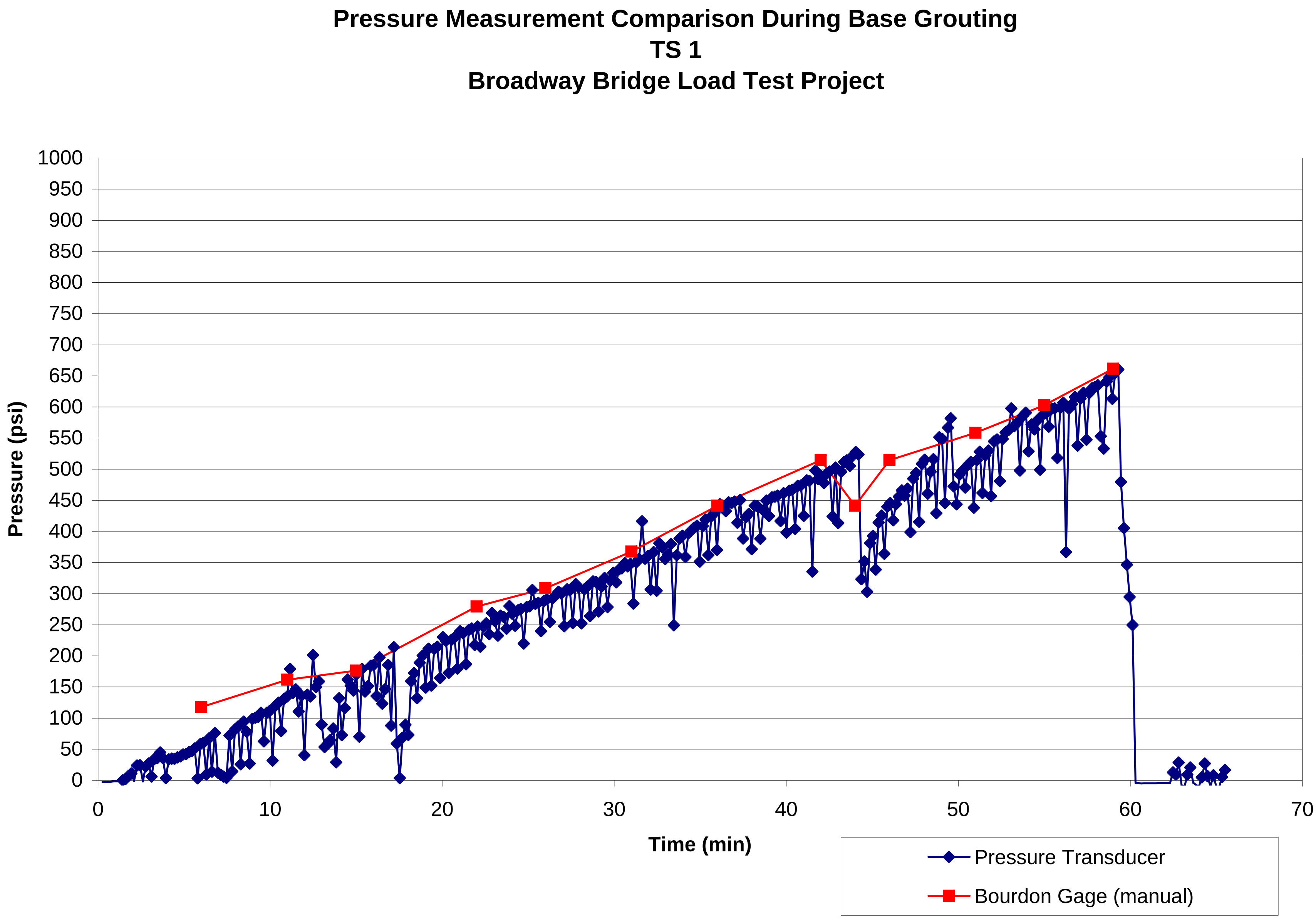
Appendix A



Pressure and Shaft Top Displacement During Base Grouting
TS 1
Broadway Bridge Load Test Project
Pressure (psi)
Shaft Top Displacement (inches)
Time (min)
1000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
0.100
0.090
0.080
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
0
10
20
30
40
50
60
70
Grout Pressure
Shaft Top Displacement

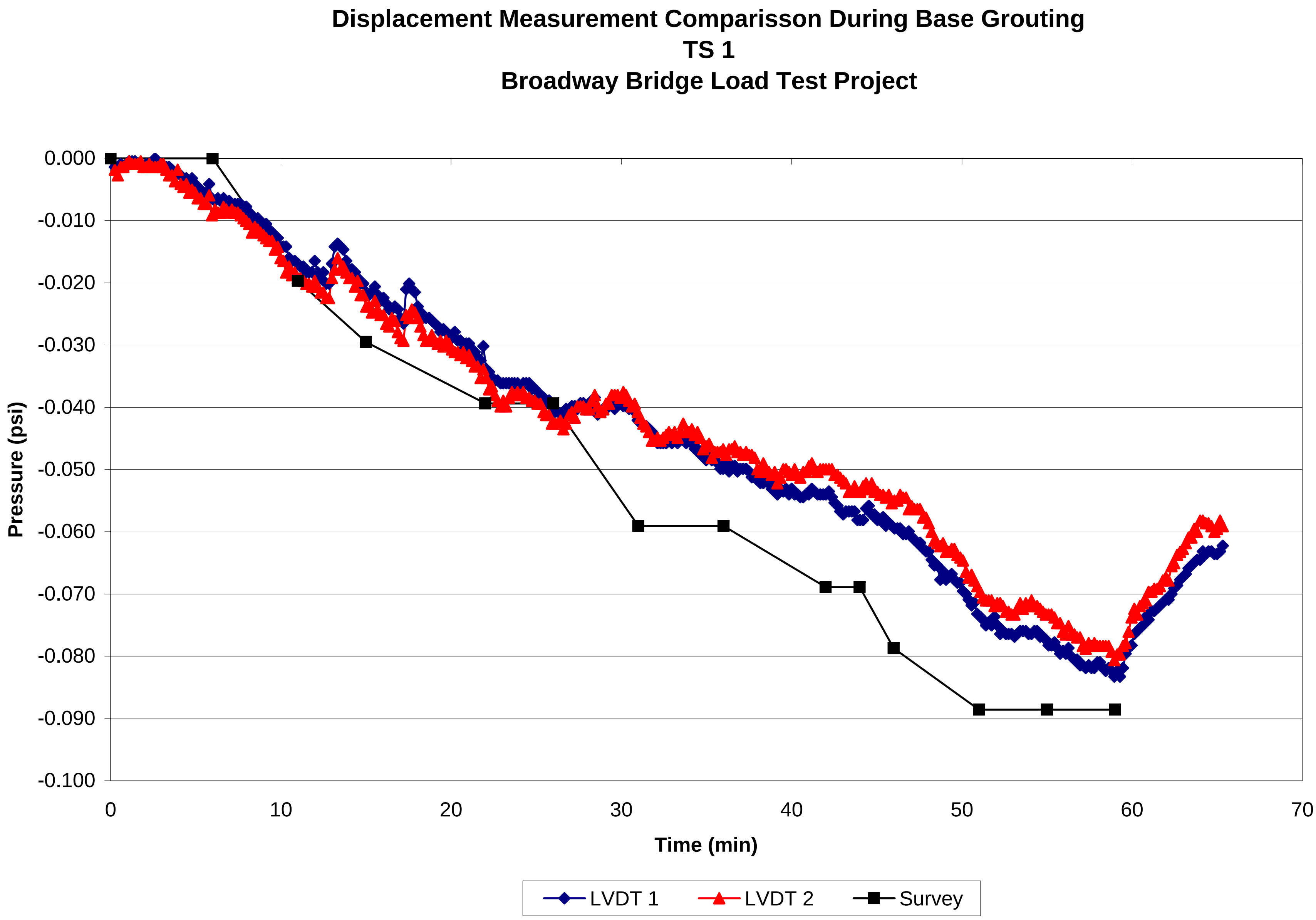
Figure 1


Pressure and Volume During Base Grouting
TS 1
Broadway Bridge Load Test Project
Pressure (psi)
Grout Volume (cubic feet)
Time (min)
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
0
10
20
30
40
50
60
70
Grout Pressure
Grout Volume



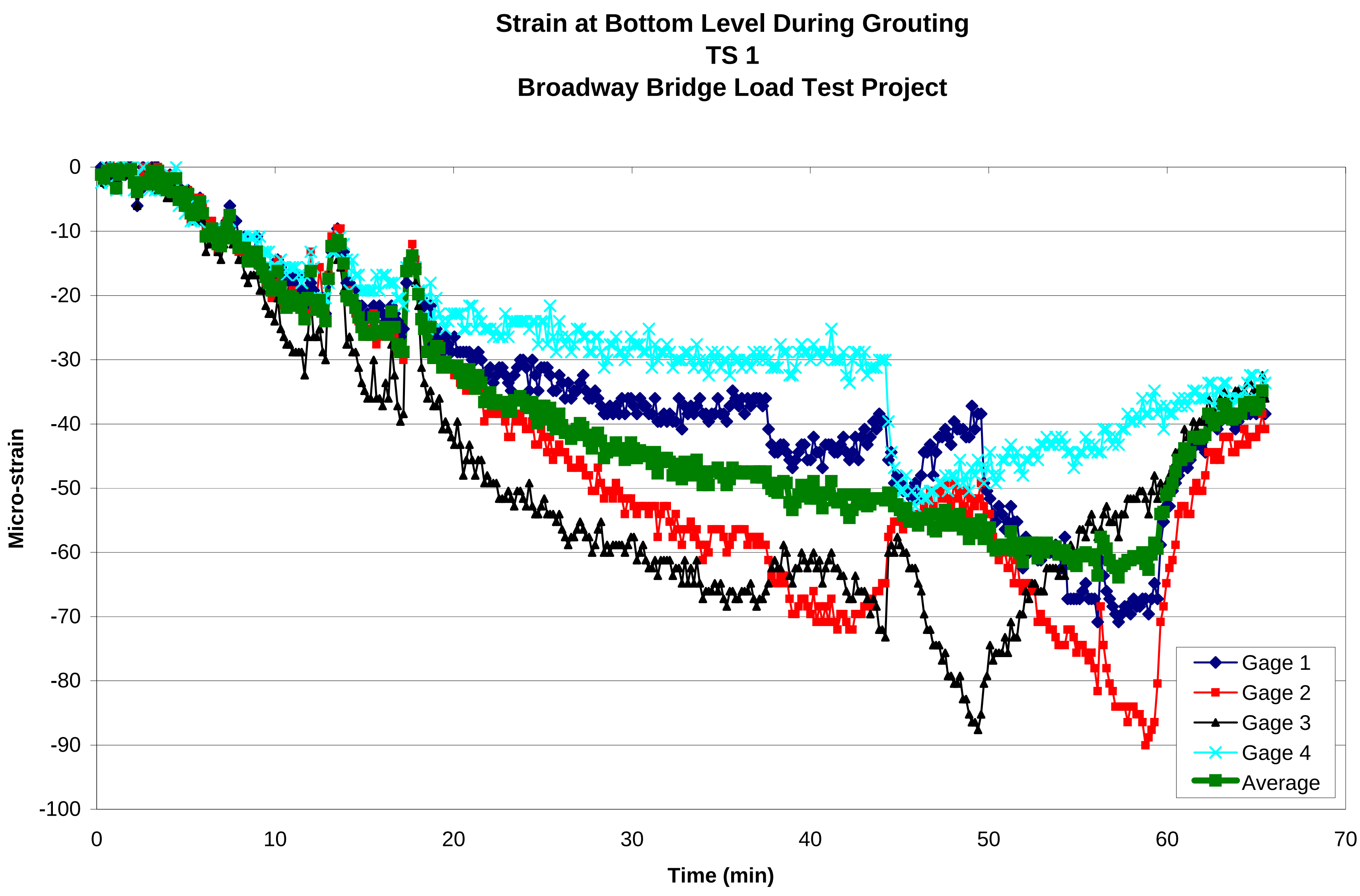
Applied Foundation Testing

Figure 3



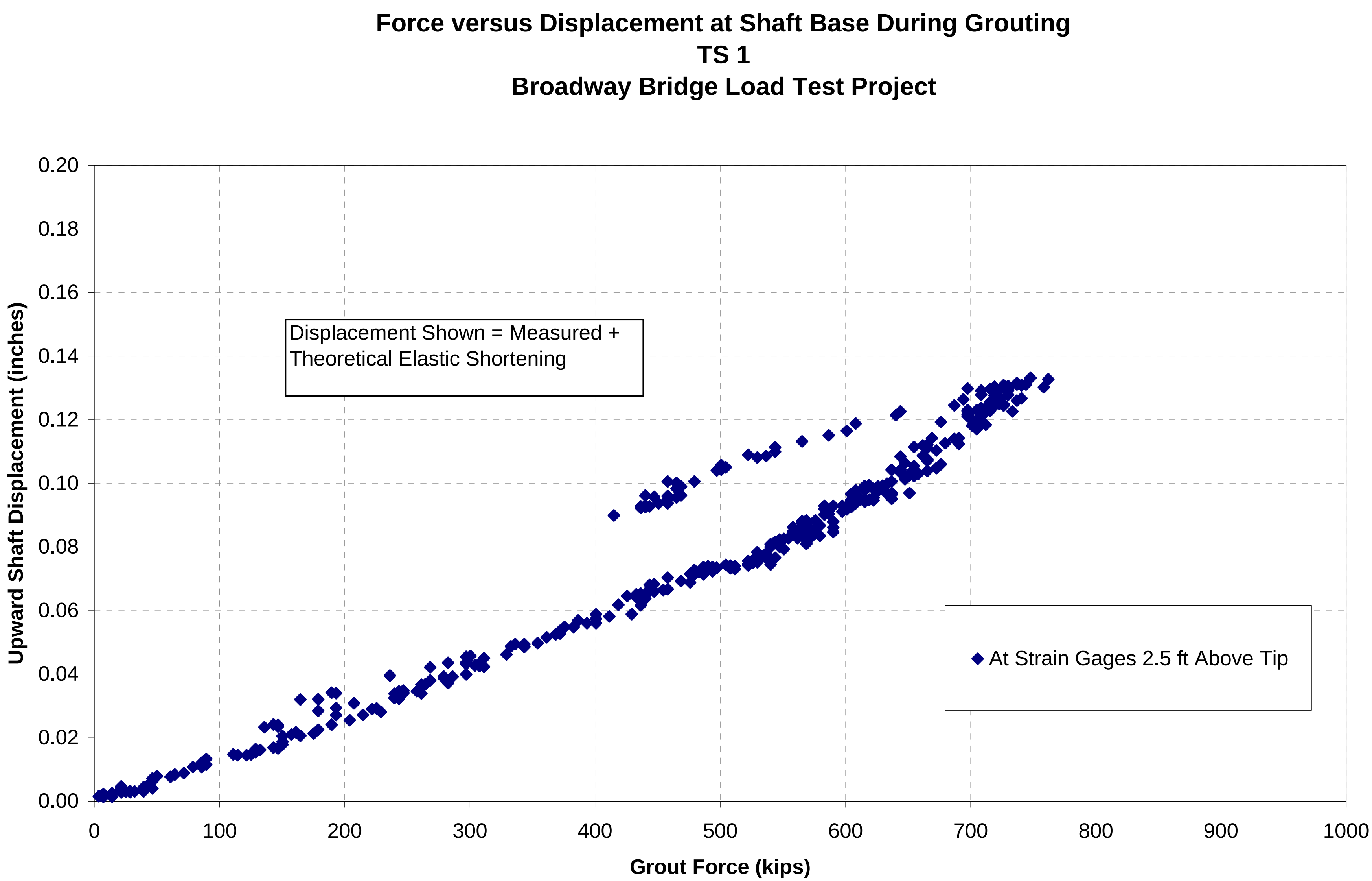
Displacement Measurement Comparisson During Base Grouting
TS 1
Broadway Bridge Load Test Project
0.000
-0.010
-0.020
-0.030
-0.040
-0.050
-0.060
-0.070
-0.080
-0.090
-0.100
Pressure (psi)
0
10
20
30
40
50
60
70
Time (min)
LVDT 1
LVDT 2
Survey

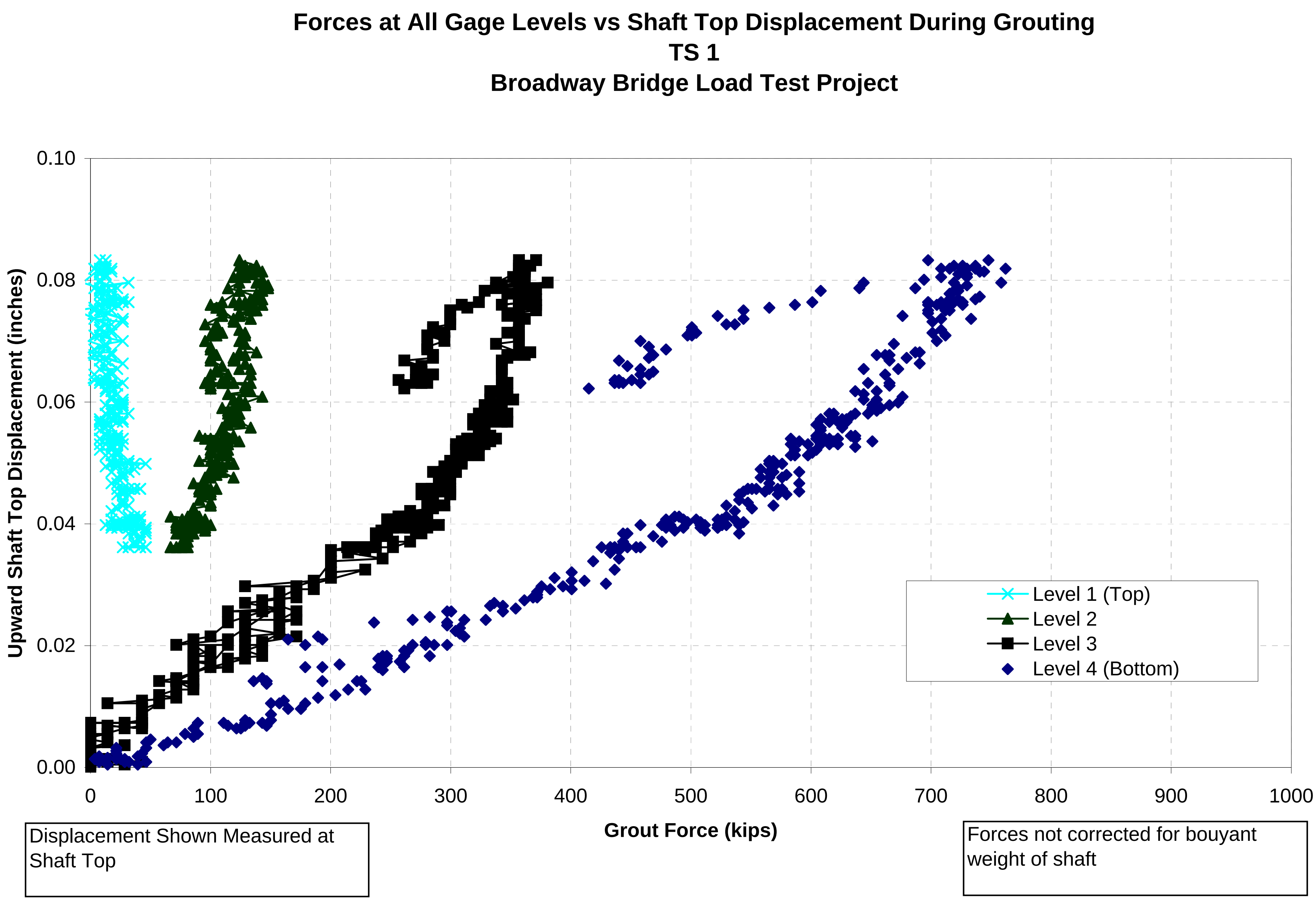
Figure 4



Strain at Bottom Level During Grouting
TS 1
Broadway Bridge Load Test Project
Micro-strain
Time (min)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
0
10
20
30
40
50
60
70
Gage 1
Gage 2
Gage 3
Gage 4
Average

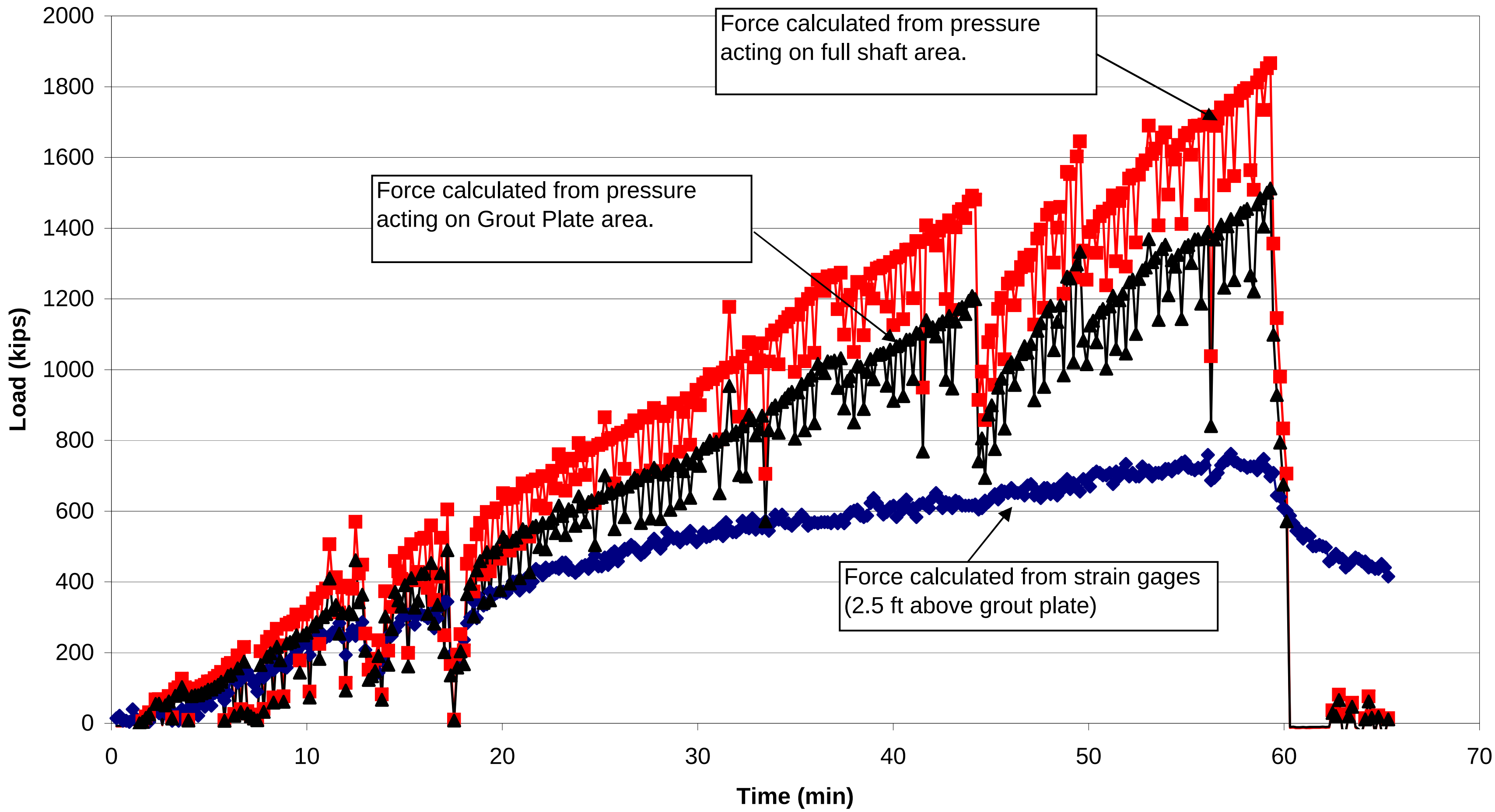
Figure 5

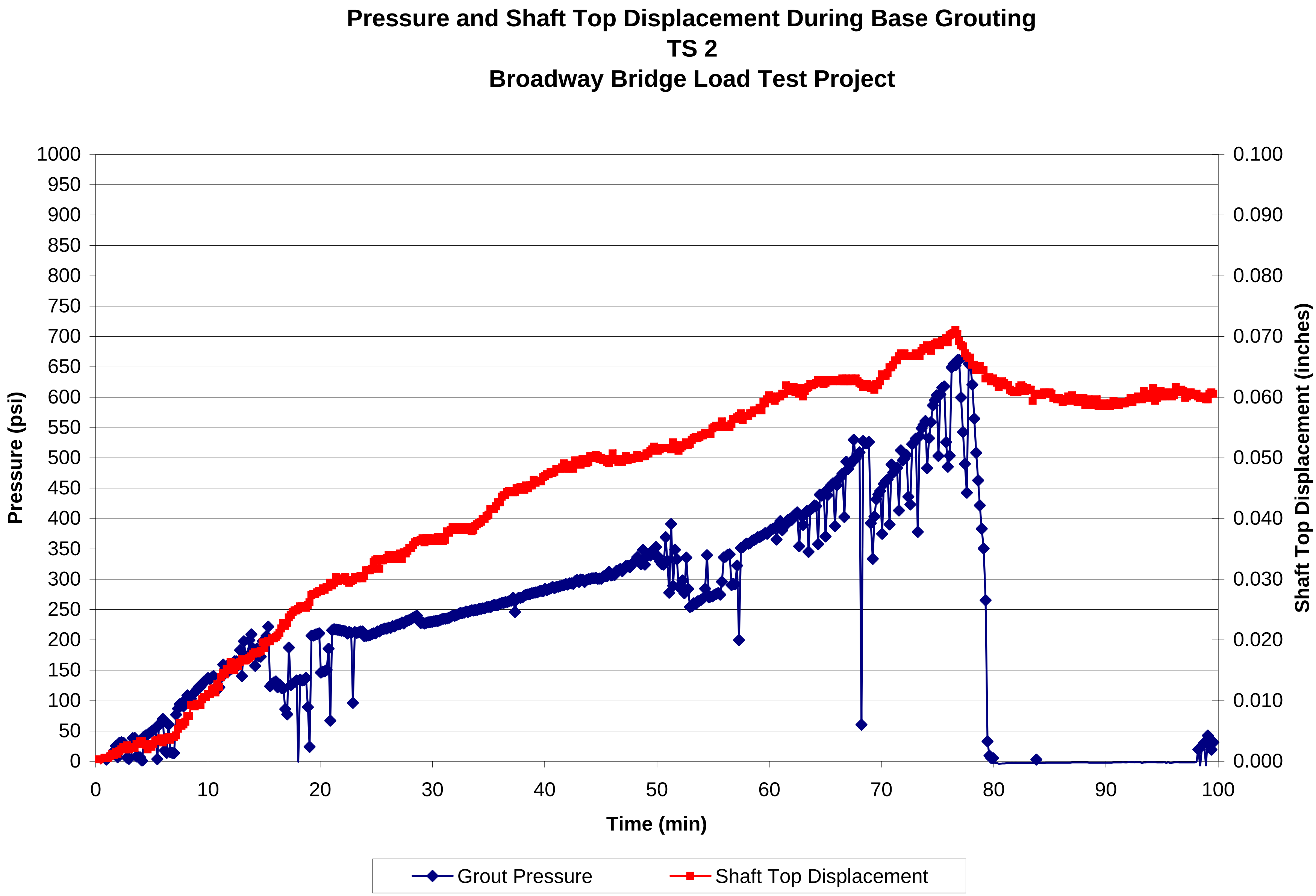

Force versus Displacement at Shaft Base During Grouting
TS 1
Broadway Bridge Load Test Project
Displacement Shown = Measured + Theoretical Elastic Shortening
At Strain Gages 2.5 ft Above Tip
Upward Shaft Displacement (inches)
Grout Force (kips)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0
100
200
300
400
500
600
700
800
900
1000



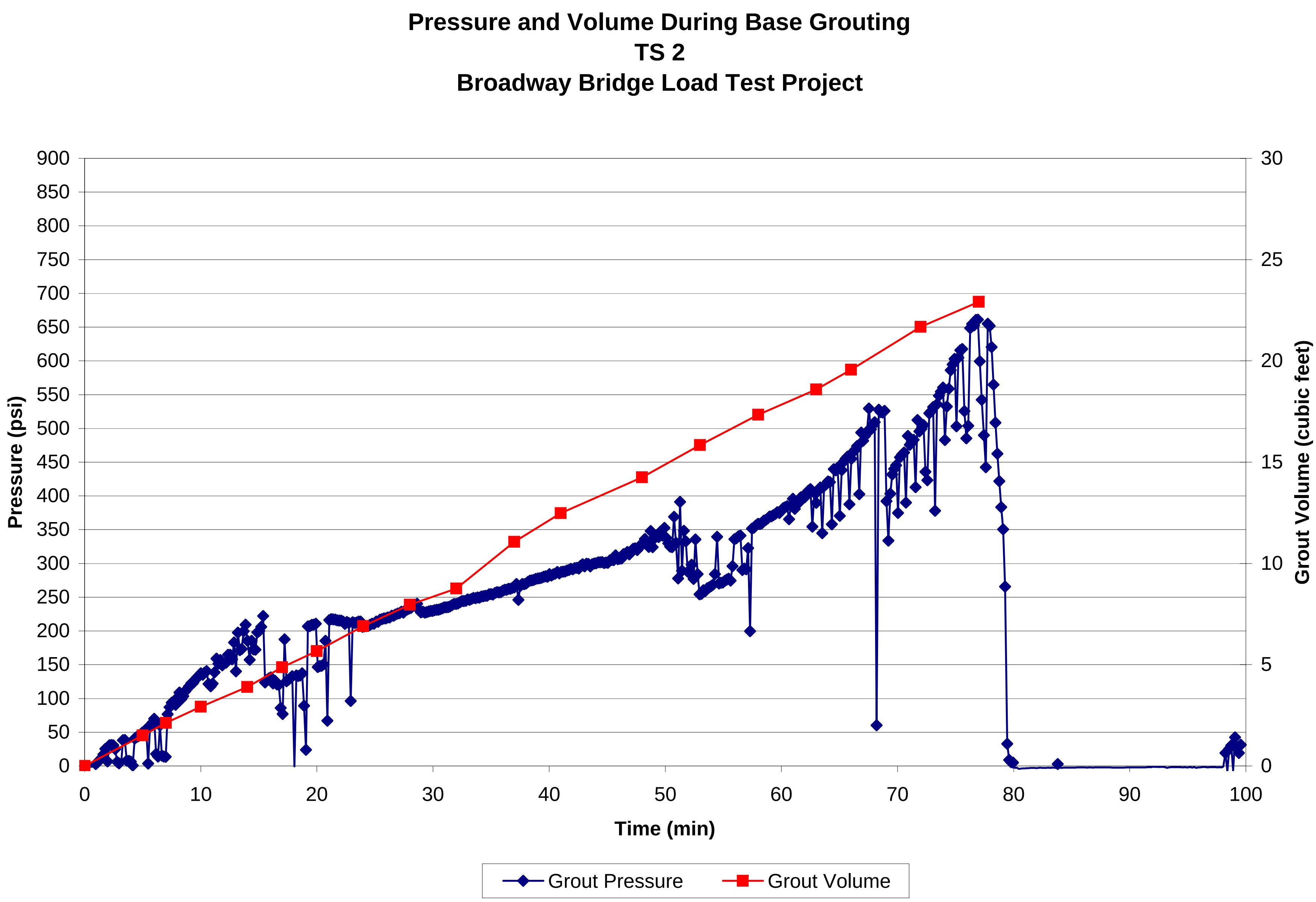
Forces at All Gage Levels vs Shaft Top Displacement During Grouting
TS 1
Broadway Bridge Load Test Project
Upward Shaft Top Displacement (inches)
0.10
0.08
0.06
0.04
0.02
0.00
0
100
200
300
400
500
600
700
800
900
1000
Grout Force (kips)
Level 1 (Top)
Level 2
Level 3
Level 4 (Bottom)
Displacement Shown Measured at Shaft Top
Forces not corrected for bouyant weight of shaft

Comparison of Calculated Forces at Shaft Base During Grouting
TS 1
Broadway Bridge Load Test Project





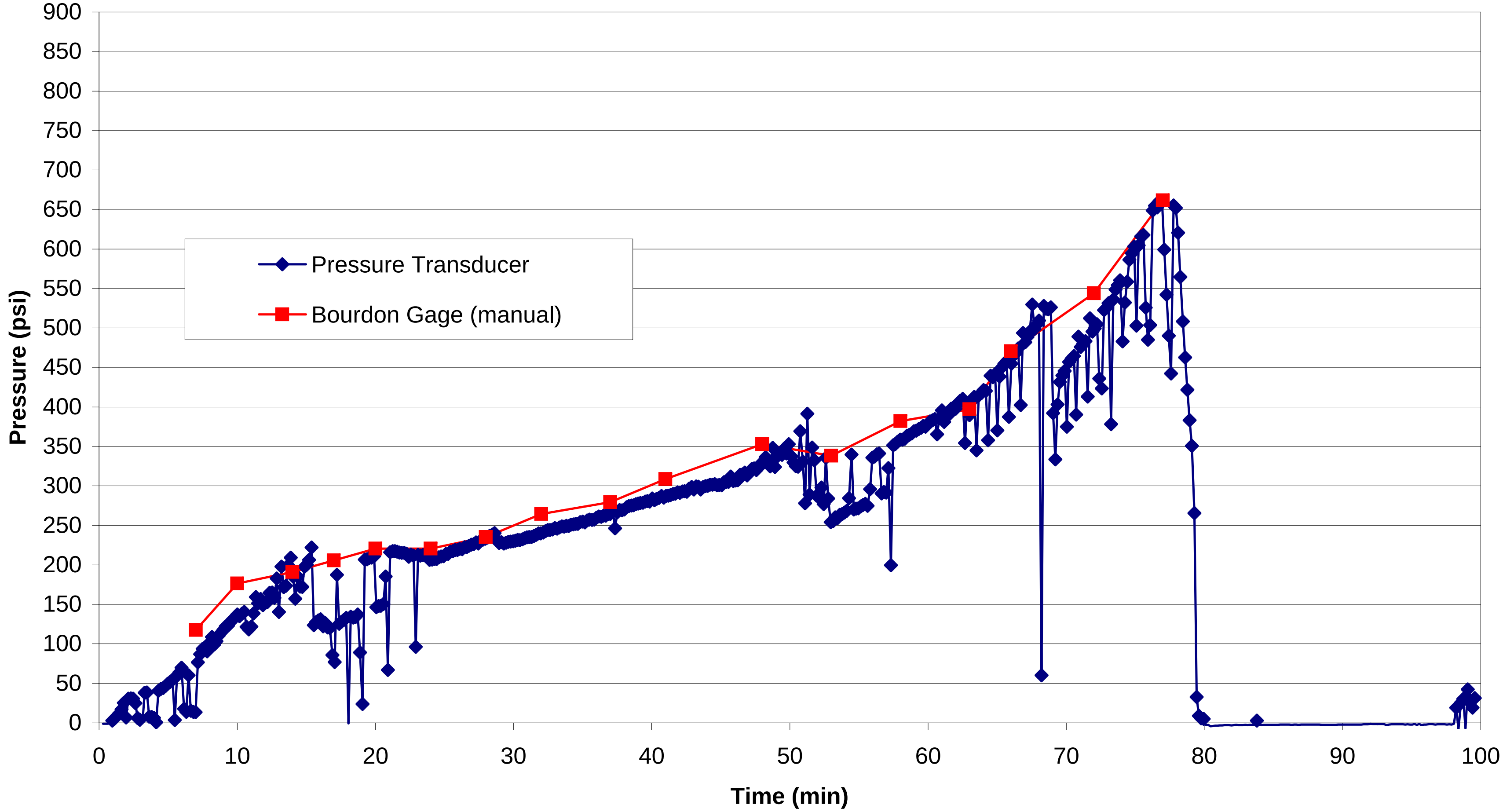
Pressure and Shaft Top Displacement During Base Grouting
TS 2
Broadway Bridge Load Test Project
Pressure (psi)
Shaft Top Displacement (inches)
Time (min)
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
0.000
0.010
0.020
0.030
0.040
0.050
0.060
0.070
0.080
0.090
0.100
0
10
20
30
40
50
60
70
80
90
100
Grout Pressure
Shaft Top Displacement

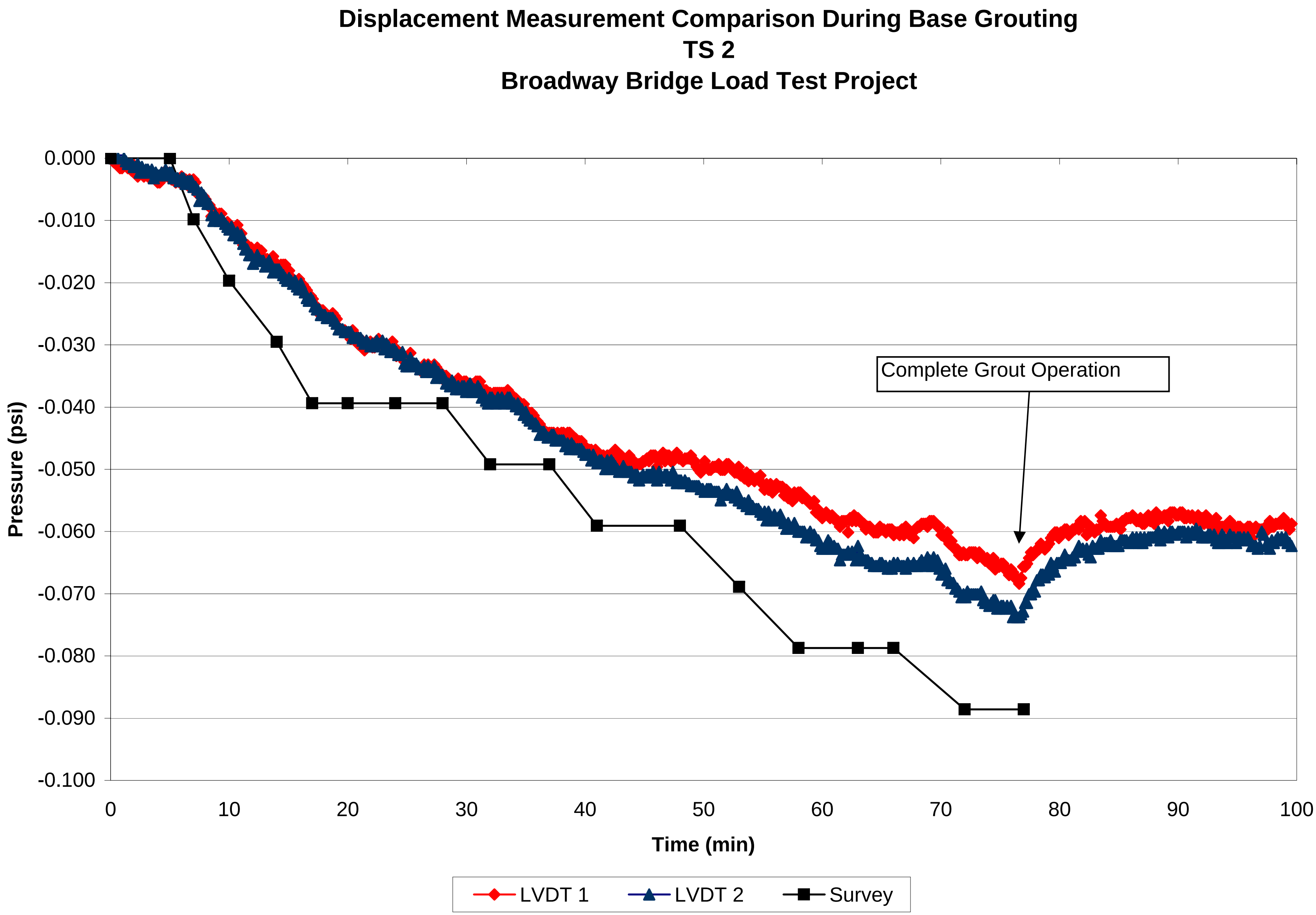


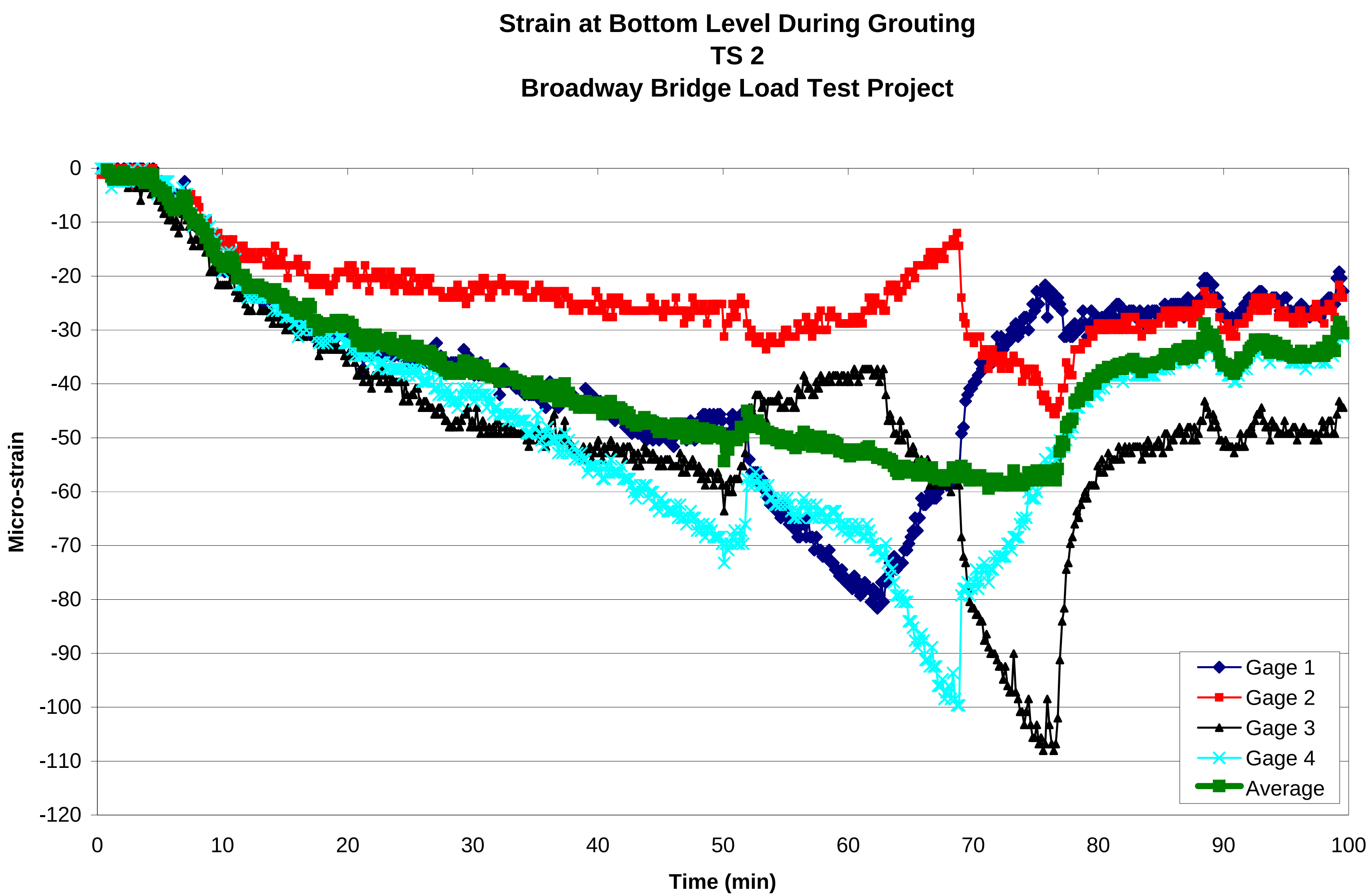
Pressure and Volume During Base Grouting
TS 2
Broadway Bridge Load Test Project
Pressure (psi)
Grout Volume (cubic feet)
Time (min)
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
0
5
10
15
20
25
30
0
10
20
30
40
50
60
70
80
90
100
Grout Pressure
Grout Volume

Figure 10

Pressure Measurement Comparison During Base Grouting
TS 2
Broadway Bridge Load Test Project

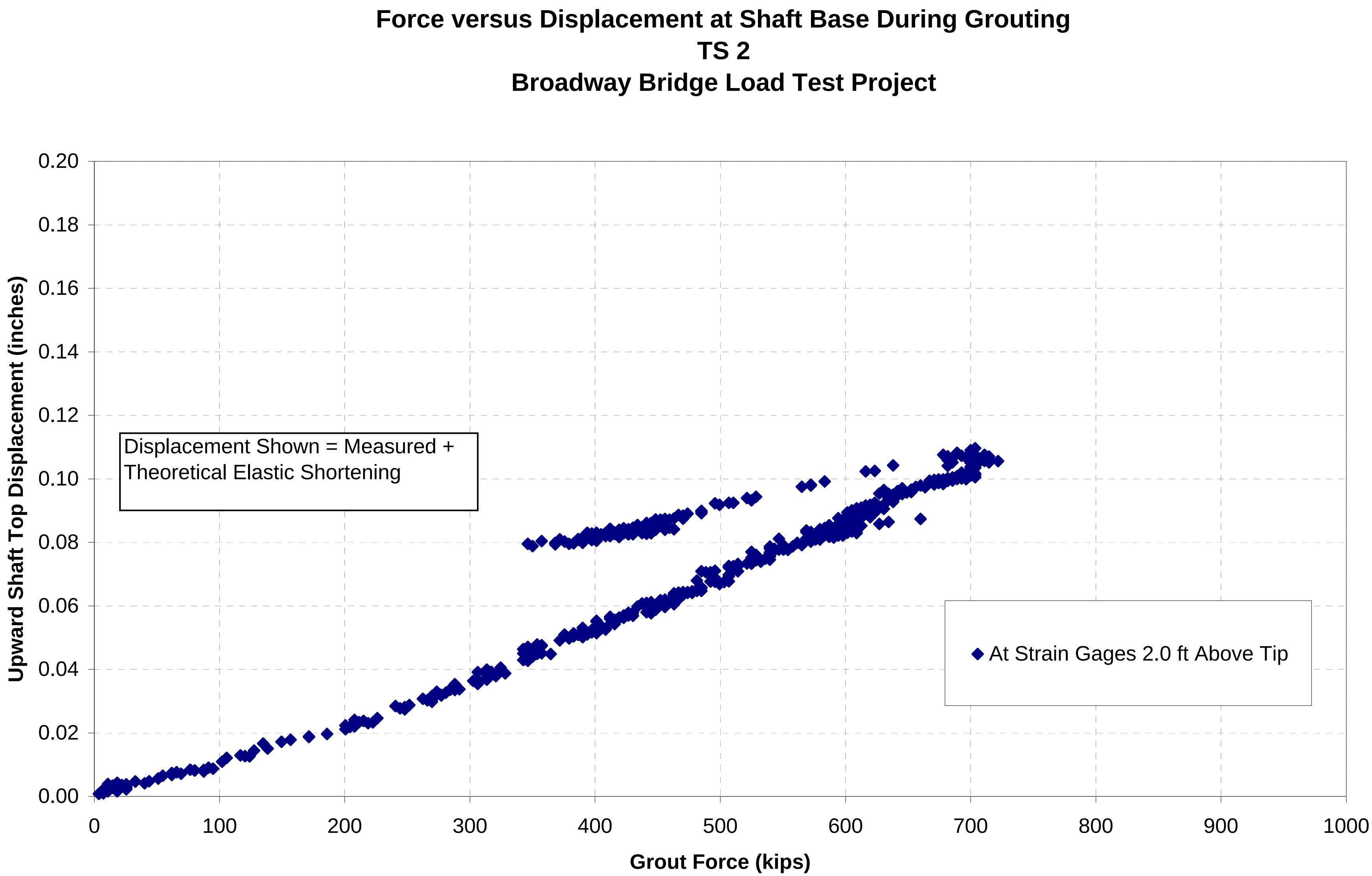



Displacement Measurement Comparison During Base Grouting
TS 2
Broadway Bridge Load Test Project
Pressure (psi)
0.000
-0.010
-0.020
-0.030
-0.040
-0.050
-0.060
-0.070
-0.080
-0.090
-0.100
0
10
20
30
40
50
60
70
80
90
100
Time (min)
Complete Grout Operation
LVDT 1
LVDT 2
Survey



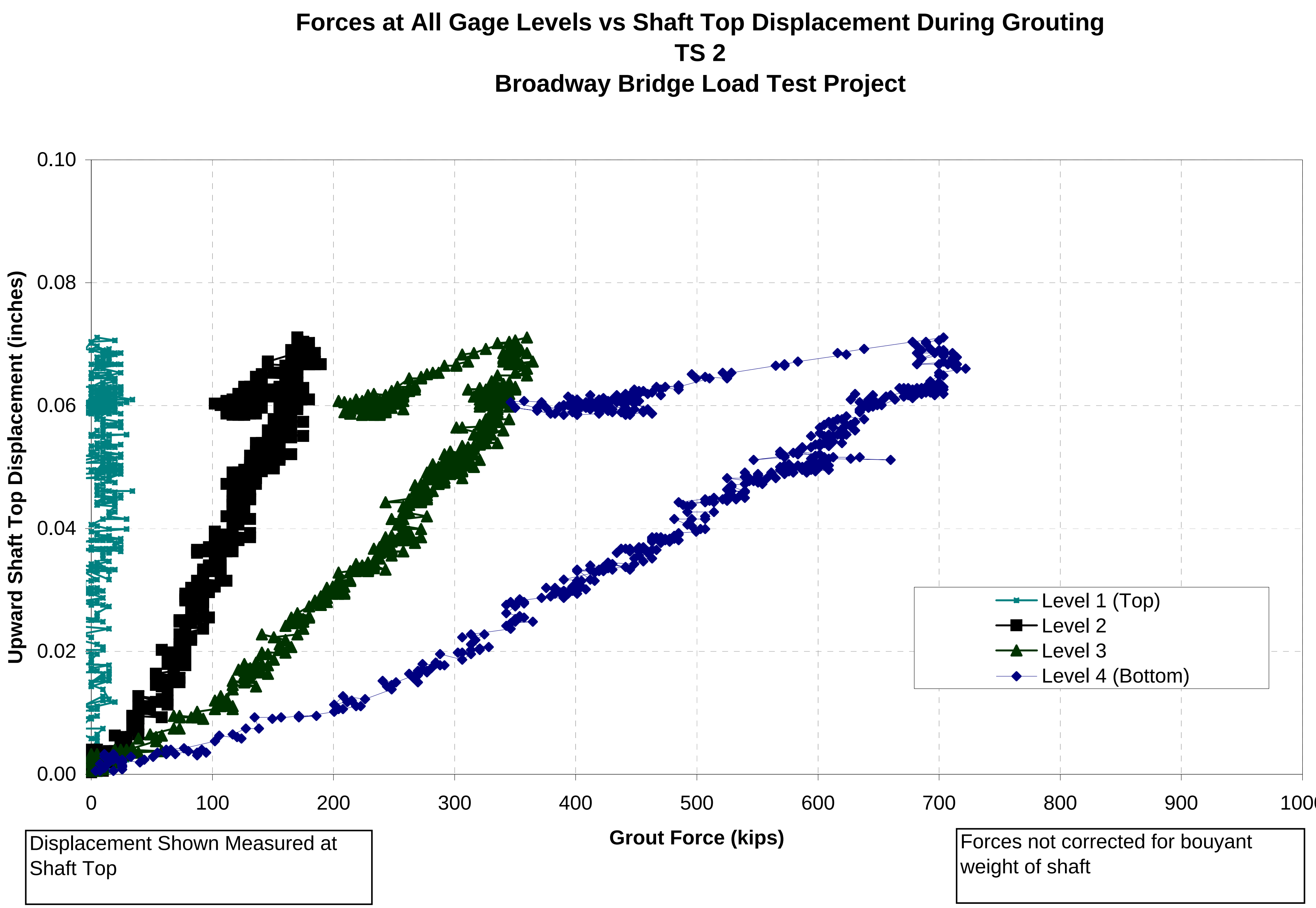
Strain at Bottom Level During Grouting
TS 2
Broadway Bridge Load Test Project
Micro-strain
Time (min)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
0
10
20
30
40
50
60
70
80
90
100
Gage 1
Gage 2
Gage 3
Gage 4
Average

Figure 13



Force versus Displacement at Shaft Base During Grouting
TS 2
Broadway Bridge Load Test Project
Upward Shaft Top Displacement (inches)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0
100
200
300
400
500
600
700
800
900
1000
Grout Force (kips)
Displacement Shown = Measured + Theoretical Elastic Shortening
At Strain Gages 2.0 ft Above Tip

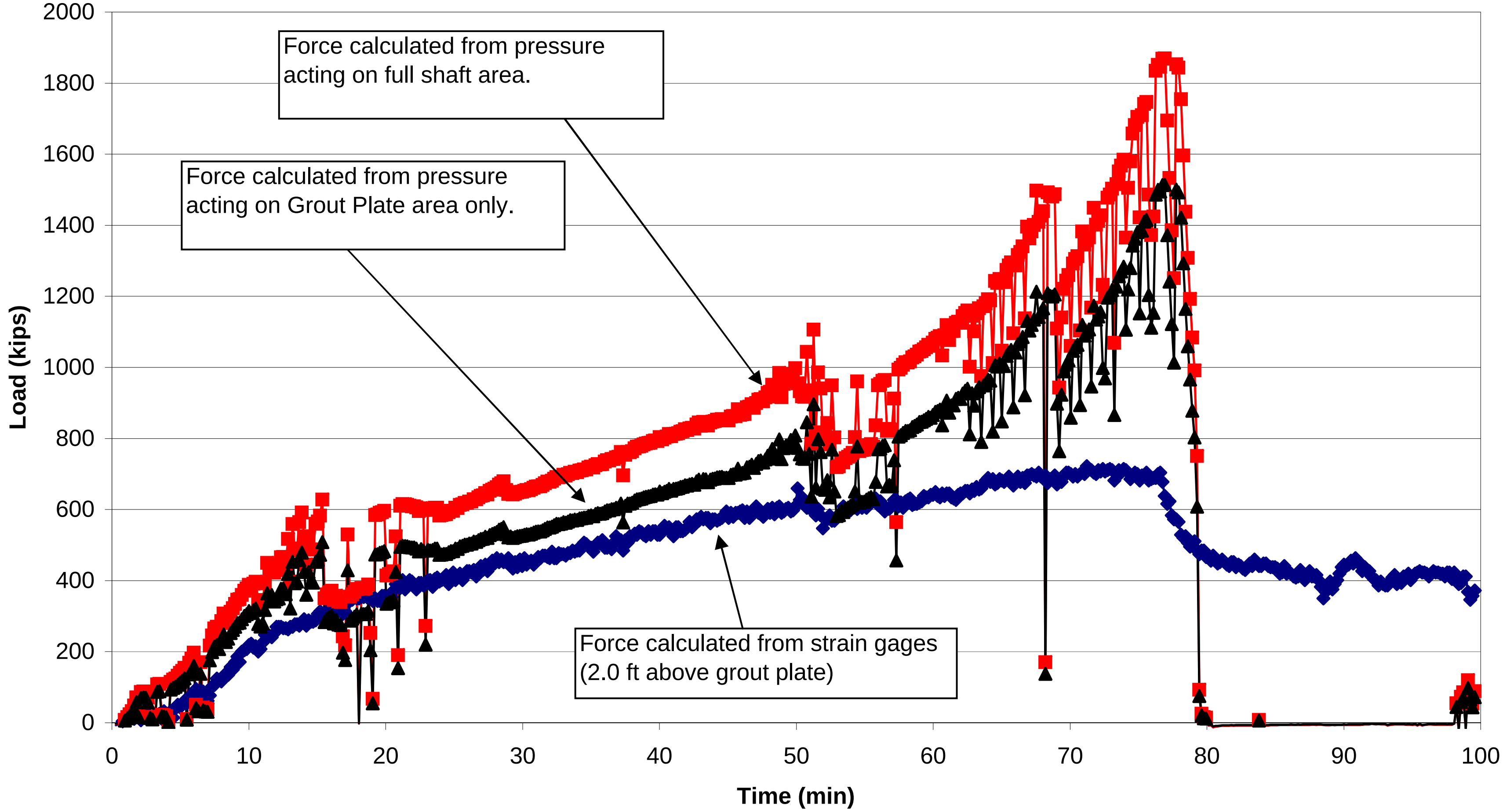
Figure 14



Forces at All Gage Levels vs Shaft Top Displacement During Grouting
TS 2
Broadway Bridge Load Test Project
Upward Shaft Top Displacement (inches)
0.10
0.08
0.06
0.04
0.02
0.00
0
100
200
300
400
500
600
700
800
900
1000
Grout Force (kips)
Level 1 (Top)
Level 2
Level 3
Level 4 (Bottom)
Displacement Shown Measured at Shaft Top
Forces not corrected for bouyant weight of shaft

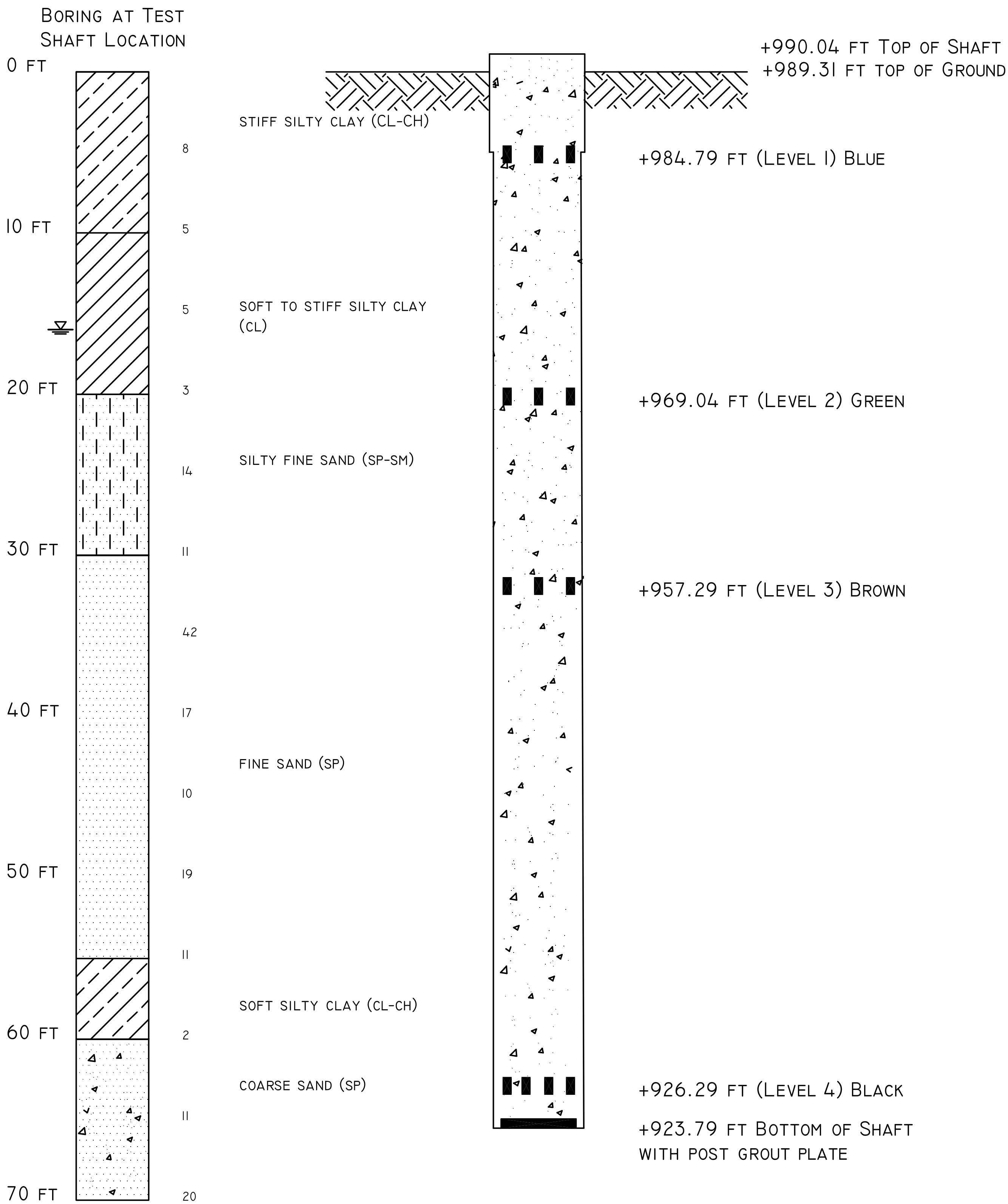
Figure 15

Comparison of Calculated Forces at Shaft Base During Grouting
TS 2
Broadway Bridge Load Test Project



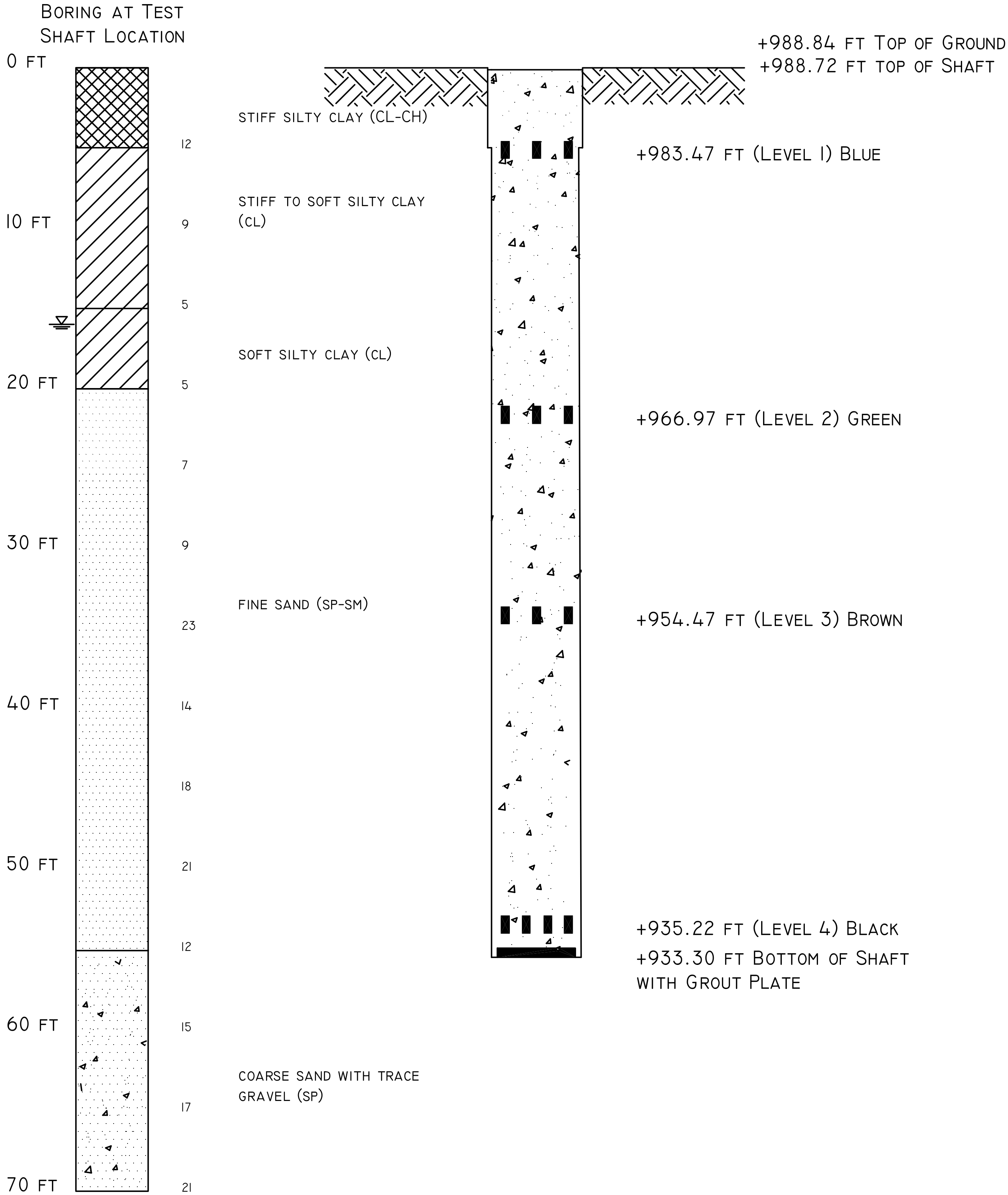
Appendix B

Iowa DOT Project TS-1
Schematic Drawing
Axial Statnamic Load Test



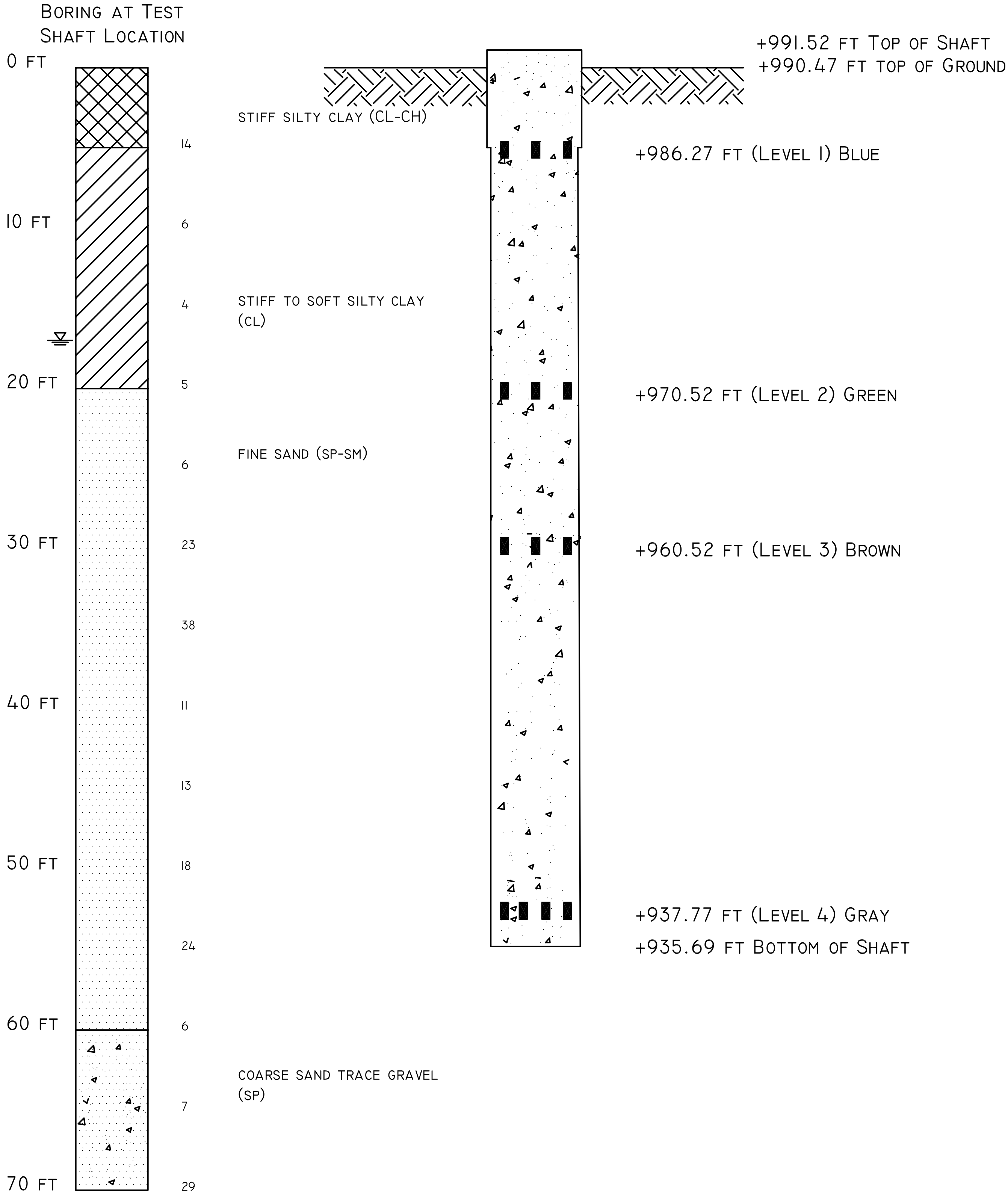
Applied Foundation Testing, Inc.	Iowa DOT TS-1 Council Bluffs, Iowa

Iowa DOT Project TS-2
Schematic Drawing
Axial Statnamic Load Test



Applied Foundation Testing, Inc.	Iowa DOT TS-2 Council Bluffs, Iowa

Iowa DOT Project TS-3
Schematic Drawing
Axial Statnamic Load Test



	Applied Foundation Testing, Inc.	Iowa DOT TS-3 Council Bluffs, Iowa

Drilled Shaft Post Grout Field Record	
Project Name: Broadway Bridge Load Test Project	
	Shaft Designation: TS-1 (Test Shaft)
Contractor: Longfellow Drilling	Post Grout Date: 8/29/08
Post Grouting By: Applied Foundation Testing, Inc.	AFT Grout Technician: Jason Frederic
	AFT Data Acquisition Engineer: Mike Muchard, P.E.
Post Grouting Information	
Grout Plant Type: HANY IC 310	Grout Type: Type I Portland Cement
Pump Type: Single Stage Piston	Starting Water / Cement Ratio: 0.5 (+/- 0.05)
Mixer Type: Colloidal Mixing w/Agitator Holding	Yield: 36 Liters per bag (1.256 ft^3) @ 0.5 w/c ratio
Post Grouting Criteria	
Maximum Permissible Displacement: 0.25 inch	Maximum Required Grout Pressure: 600 psi (41 bar)
Grout Volume Reset Value: Field Determined	
Post Grouting Data / Comments	
starting w/c ratio = 0.5	

	Grout Pressure		Upward Shaft Displacement		Grout Volume Tank Reading				Notes
Time	bar	psi	mm	inches	Inches				
12:47			131.0		10.0				Start pumping grout
12:53	8	118	131.00		20.5	to	8.00		Grout return - lock opposing valve
12:58	11	162	131.50		18.0	to	6.50		
1:02	12	176	131.75		14.5				
1:09	19	279	132.00		24.0	to	11.00		
1:13	21	309	132.00		22.0	to	10.00		
1:18	25	368	132.50		19.0	to	7.00		
1:23	30	441	132.50		18.0	to	6.00		
1:29	35	515	132.75		17.0	to	6.00		
1:31	30	441	132.75		12.0				
1:33	35	515	133.00		14.5				
1:38	38	559	133.25		20.5	to	9.00		
1:42	41	603	133.25		19.0	to	7.00		
1:46	45	662	133.25		11.0				Complete - DID NOT LOCK IN
									PRESSURE
	bar	psi	mm	inches	L		ft^3		
Maximums	**45**	**662**	**2.25**	**0.089**	**542.5**		**19.2**		

Conversions : Grout plant holding tank volume calibration = 1 inch in tank = .177 cubic feet grout
(1 cubic meter = 1.307 cubic yards = 35.3 cubic feet) (1 Bar = 100 kPa = 14.7 psi)
(28.32 Liters = 1 cubic foot) (3.785 Liters = 1 Gallon) (25.4 mm = 1 inch) (1 kg = 2.21 lbs)

Drilled Shaft Post Grout Field Record

Project Name: Broadway Bridge Load Test Project	
	Shaft Designation: TS-2 (Test Shaft)
Contractor: Longfellow Drilling	Post Grout Date: 8/29/08
Post Grouting By: Applied Foundation Testing, Inc.	AFT Grout Technician: Jason Frederic
	AFT Data Acquisition Engineer: Mike Muchard, P.E.

Post Grouting Information

Grout Plant Type: HANY IC 310	Grout Type: Type I Portland Cement
Pump Type: Single Stage Piston	Starting Water / Cement Ratio: 0.5 (+/- 0.05)
Mixer Type: Colloidal Mixing w/Agitator Holding	Yield: 36 Liters per bag (1.256 ft^3) @ 0.5 w/c ratio

Post Grouting Criteria

Maximum Permissible Displacement: 0.25 inch	Maximum Required Grout Pressure: 600 psi (41 bar)
Grout Volume Reset Value: Field Determined	

Post Grouting Data / Comments

starting w/c ratio = 0.5

Time	Grout Pressure		Upward Shaft Displacement		Grout Volume Tank Reading			Notes
	bar	psi	mm	inches	Inches			
9:48			45.0		10.5			Start pumping grout
9:53					19.0	to	7.50	Grout return - lock opposing valve
9:55	8	118	45.25		11.0			
9:58	12	176	45.50		15.5			
10:02	13	191	45.75		21.0	to	9.00	
10:05	14	206	46.00		14.5			
10:08	15	221	46.00		19.0	to	6.00	
10:12	15	221	46.00		13.0			
10:16	16	235	46.00		19.0	to	6.00	
10:20	18	265	46.25		10.5			
10:25	19	279	46.25		23.5	to	11.00	
10:29	21	309	46.50		19.0	to	6.00	Reduce w/c ratio to 0.48
10:36	24	353	46.50		16.0			
10:41	23	338	46.75		25.0	to	13.50	
10:46	26	382	47.00		22.0	to	9.50	
10:51	27	397	47.00		16.5			
10:54	32	470	47.00		22.0	to	11.00	Reduce w/c ratio to 0.45
11:00	37	544	47.25		23.0	to	11.00	
11:05	45	662	47.25		18.0			Complete - lock off ball valve
	bar	psi	mm	inches	L		ft^3	
Maximums	**45**	**662**	**2.25**	**0.089**	**647.5**		**22.9**	

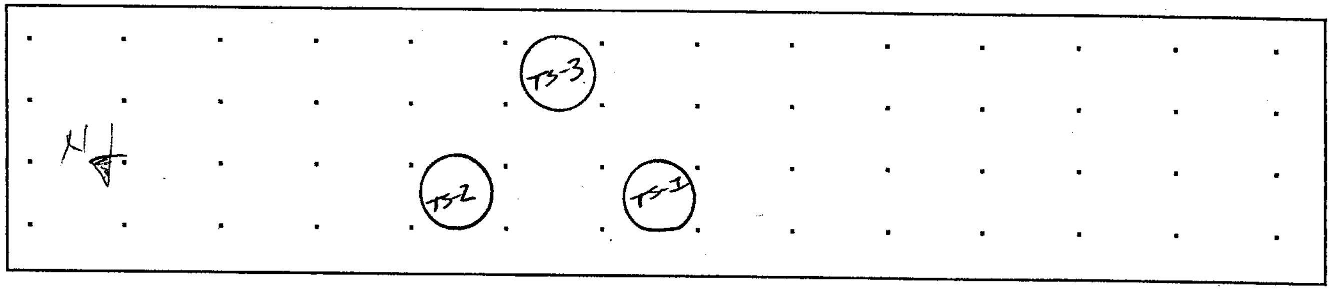
Conversions : Grout plant holding tank volume calibration = 1 inch in tank = .177 cubic feet grout

(1 cubic meter = 1.307 cubic yards = 35.3 cubic feet) (1 Bar = 100 kPa = 14.7 psi)

(28.32 Liters = 1 cubic foot) (3.785 Liters = 1 Gallon) (25.4 mm = 1 inch) (1 kg = 2.21 lbs)

DRILLED SHAFT FIELD REPORT

County POTTAWATTAMIE
Project # NHS-080-1(318)0--11-78
Design #
Prime Contractor JENSEN
Drilled Shaft Contractor LONGFELLOW

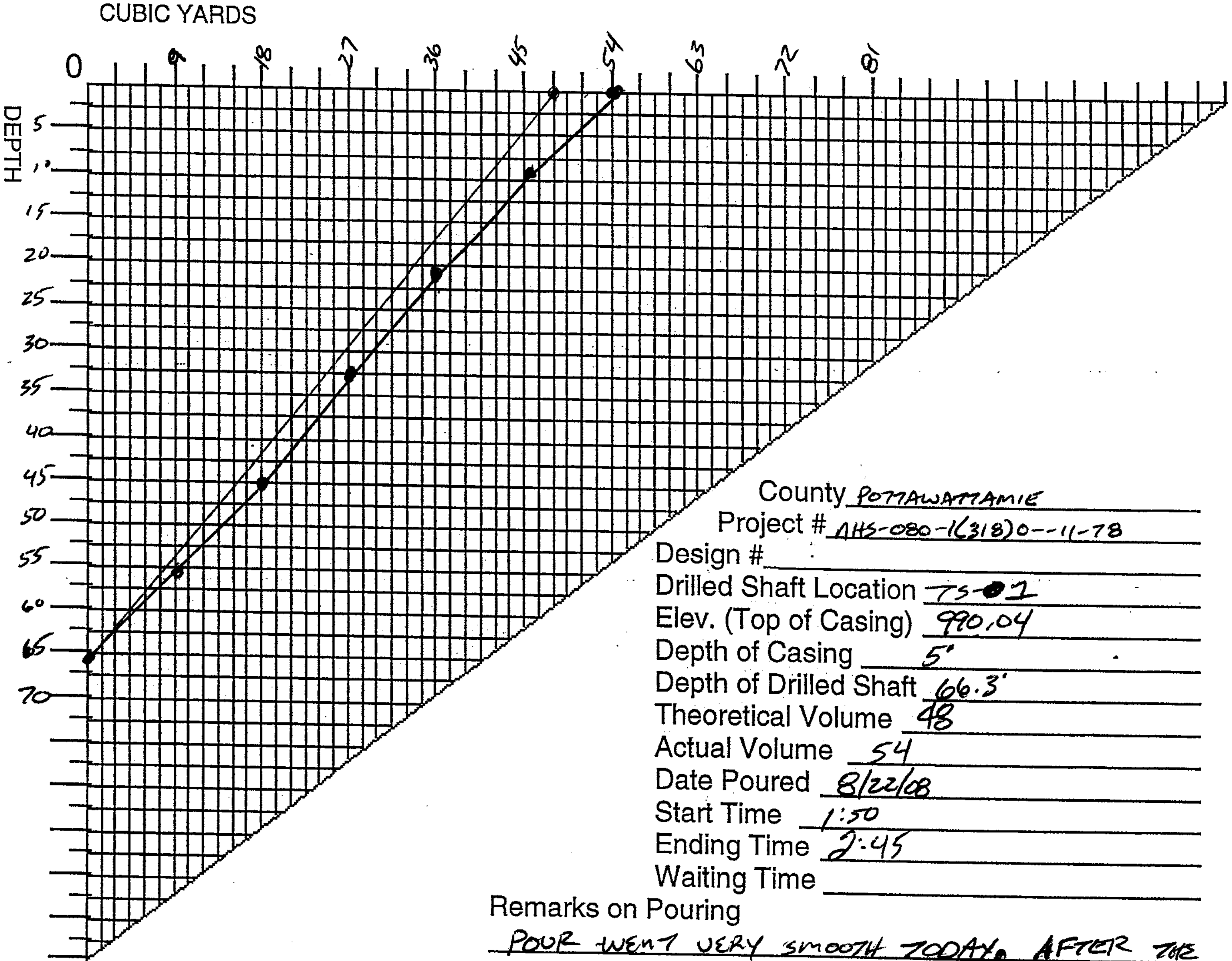


	Drilled Shaft Location	TS-3	TS-2	TS-1					
	Pouring Date	8/20/08	8/21/08	8/22/08					
DESIGN	Shaft Diameter	60"	60"	60"					
DESIGN	Casing Diameter	— 60"	— 60"	— 60"					
DESIGN	(Socket/Bell) Diameter	—	—	—					
DESIGN	Top Elevation	991.47	989.84	990.31					
DESIGN	Bottom Elevation	933.00	933.00	923.00					
AS BUILT	Cap Diameter								
AS BUILT	Shaft Diameter	60"	60"	60"					
AS BUILT	Casing Diameter	66"	66"	66"					
AS BUILT	Casing Length	5'	~~3~~ 4'	5'					
AS BUILT	(Socket/Bell) Diameter	60"	60"	60"					
AS BUILT	Top Elevation	55.9 991.52	55.4 988.72	990.04 66.3					
AS BUILT	Bottom Elevation	935.62	933.32	923.74					
AS BUILT	(Sand/Rock) Elevation	—	—	—					
AS BUILT	(Sand/Rock) Elevation	—	—	—					
AS BUILT	Bottom Casing Elev.	986.52	984.72	985.04					

PREPARED BY JASON KOHL APPROVED BY

DRILLED SHAFT CONCRETE REPORT

DEPTH	CYDS
66.3	0
56	4 1/4
45	18 1/4
32.5	27 1/2
21	36 3/4
9	46
0	54



County POTTAWATTAMIE
Project # NHS-080-1(318)0--11-78
Design # ____
Drilled Shaft Location TS-1
Elev. (Top of Casing) 990.04
Depth of Casing 5'
Depth of Drilled Shaft 66.3'
Theoretical Volume 48
Actual Volume 54
Date Poured 8/22/08
Start Time 1:50
Ending Time 2:45
Waiting Time ____

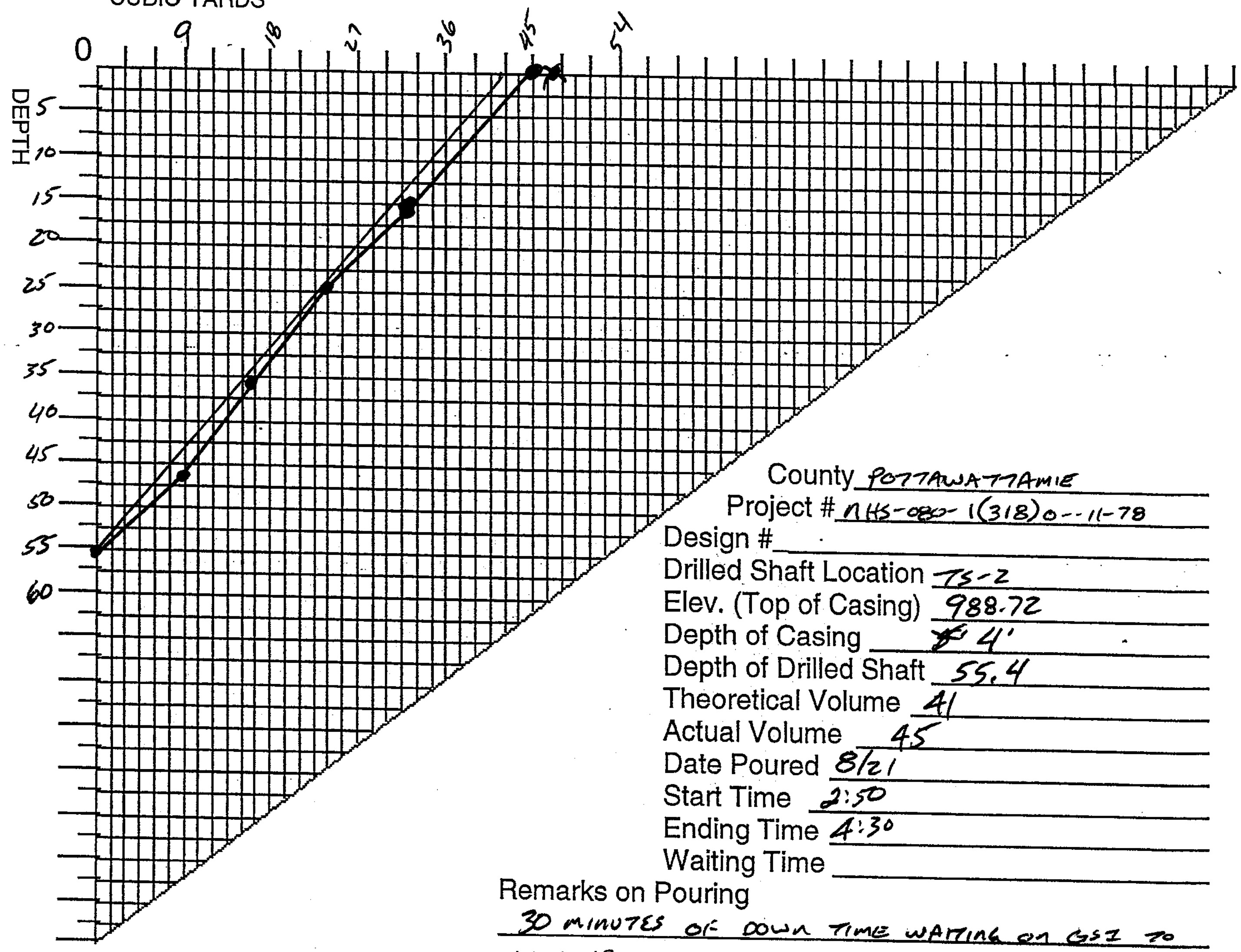
Remarks on Pouring

POUR WENT VERY SMOOTH TODAY. AFTER THE CONCRETE WAS PLACED JOHN w/ AFT DIRECTED LONGFELLOW TO CLEAN AND PRESSURIZE THE GROUT TUBES WHEN THE WATER ~~CLEARED~~ CLEARED UP. HAVING PRESSURE ON THE TUBES CAUSED WATER TO SEEP UP THRU THE SHAFT. WATER WAS IMMEDIATELY SHUT OFF WHEN THIS WAS NOTICED.

Prepared by JASON KOHL
Checked by ____

DRILLED SHAFT CONCRETE REPORT

DEPTH	CYDS
55.4	0
46.5	8
35	16
24	24
16	32
~~40~~	40
0	45



County POTTAWATTAMIE

Project # NHS-080-1(318)0--11-78

Design # ____

Drilled Shaft Location TS-2

Elev. (Top of Casing) 988.72

Depth of Casing 4'

Depth of Drilled Shaft 55.4

Theoretical Volume 41

Actual Volume 45

Date Poured 8/21

Start Time 2:50

Ending Time 4:30

Waiting Time ____

Remarks on Pouring

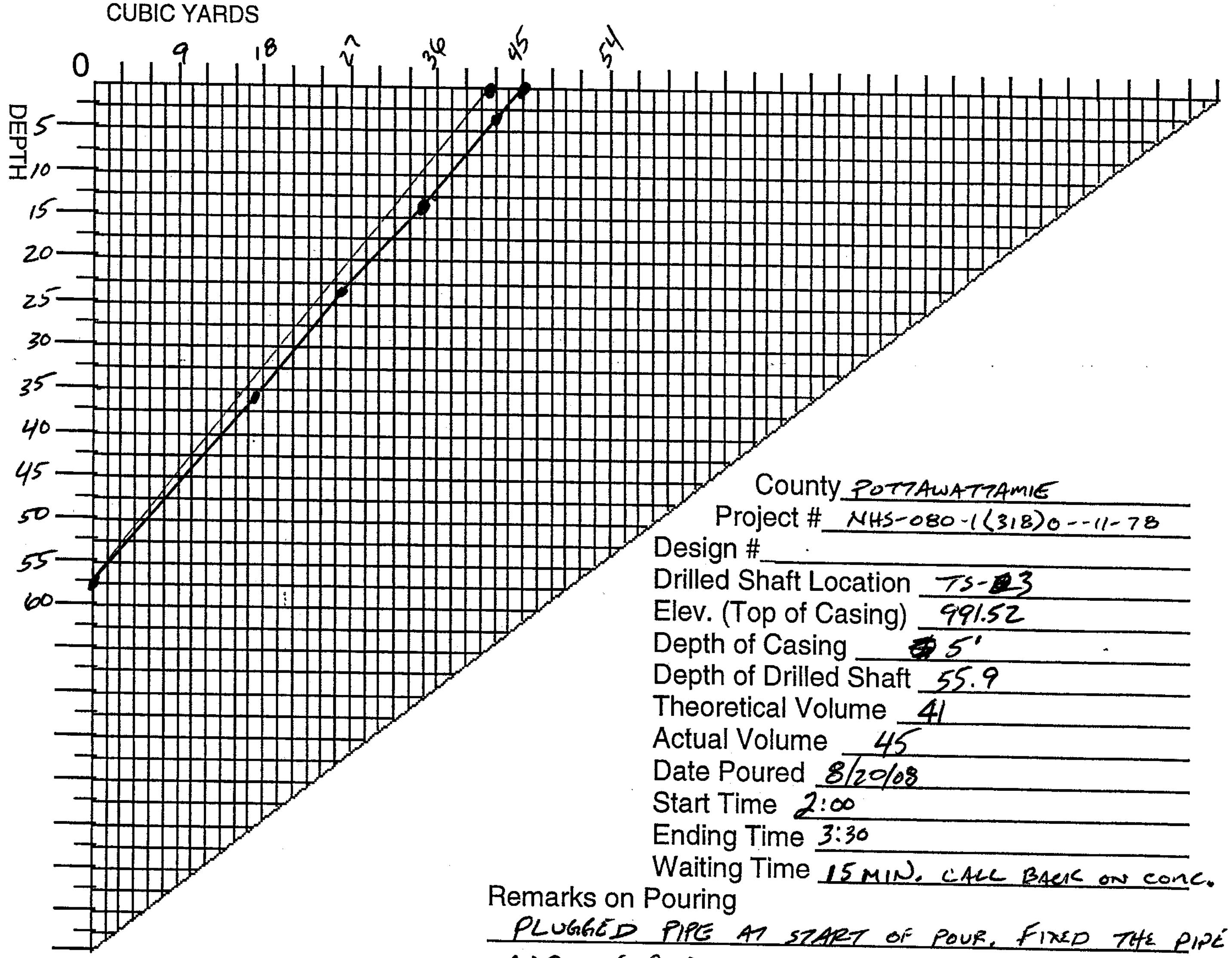
30 MINUTES OF DOWN TIME WAITING ON GSI TO SHOW UP ON SITE TO TAKE TEST CYLINDERS. 10MIN. DOWN TO TAKE STRAPS OFF OF CAGE. AT THE START OF THE POUR THEY SHUT THE PUMP TRUCK OFF WHEN THEY NOTICED THE SLURRY PUMP WASN'T RUNNING. THERE WAS ONLY A SMALL AMOUNT OF CONCRETE IN THE HOLE AT THAT TIME, AND THE PUMP PIPE COULDN'T HAVE HAD MUCH EMBEDMENT IN THE CONC.

Prepared by JASON KOHL

Checked by ____

DRILLED SHAFT CONCRETE REPORT

DEPTH	CYDS
55.9	0
	9
36	17.5
23.5	26.0
13	34.5
3.3	43.0
0	45 ~~44.5~~



County POTTAWATTAMIE

Project # NHS-080-1(318)0--11-78

Design #

Drilled Shaft Location TS-~~B~~3

Elev. (Top of Casing) 991.52

Depth of Casing ~~8~~ 5'

Depth of Drilled Shaft 55.9

Theoretical Volume 41

Actual Volume 45

Date Poured 8/20/08

Start Time 2:00

Ending Time 3:30

Waiting Time 15 MIN. CALL BACK ON CONC.

Remarks on Pouring

PLUGGED PIPE AT START OF POUR. FIXED THE PIPE AND THE POUR WENT VERY SMOOTH

Prepared by JASON KOHL

Checked by

BORING LOG No. TS 1

BORING NO.	LOCATION OF BORING	ELEVATION	DATUM	DRILLER	LOGGER
TS 1	TS1 Stake	987.65	IDOT Plan Sheet	DAH	JLW

WATER LEVEL OBSERVATIONS				TYPE OF SURFACE	DRILL RIG
WHILE DRILLING	END OF DRILLING	24 HOURS AFTER DRILLING		Grass and Weeds	B-57
				DRILLING METHOD	TOTAL DEPTH
20	16			3 1/4" Hollow Stem Auger with Drilling Mud	70'

DEP. FT.	SAMPLE DATA: SAMPLE NO. & TYPE	"N" BLOWS (FT)	% REC.	SOIL DESCRIPTION: COLOR, MOISTURE, CONSISTENCY / GEOLOGIC DESCRIPTION & OTHER REMARKS	USCS CLASS.	LABORATORY DATA: % MC	DRY DENS. pcf	Qu psf	DEP. FT.
				Gray brown, Moist, STIFF SILTY CLAY					
5	S-1	8	90		CL-CH	29.2			5
10	S-2	5	90	ALLUVIUM 10.0'		13.1			10
				Light gray, Very moist, SOFT to STIFF SILTY CLAY					
15	S-3	5	95		CL	32.3			15
20	S-4	3	85	ALLUVIUM 20.0'		29.9			20
				Gray brown, Wet, SILTY FINE SAND					
25	S-5	14	85		SP-SM	24.0			25
30	S-6	11	90	ALLUVIUM 30.0'		23.3			30
				Gray, Wet, FINE SAND					
35	S-7	42	90			22.1			35
	S-8	17	85			24.7			

GSI Geotechnical Services, Inc.
2853 99th Street, Des Moines, IA 50322
(515) 270-6542 FAX (515) 270-1911

PROJECT: Drilled Shaft Load Tests
LOCATION: 12th Street & Broadway, Council Bluffs, IA
JOB NO.: 086103
DATE: 6-23-08

BORING LOG No. TS 1

BORING NO.	LOCATION OF BORING	ELEVATION	DATUM	DRILLER	LOGGER
TS 1	TS1 Stake	987.65	IDOT Plan Sheet	DAH	JLW

WATER LEVEL OBSERVATIONS				TYPE OF SURFACE	DRILL RIG
WHILE DRILLING	END OF DRILLING	24 HOURS AFTER DRILLING		Grass and Weeds	B-57
				DRILLING METHOD	TOTAL DEPTH
20	16			3 1/4" Hollow Stem Auger with Drilling Mud	70'

DEP. FT.	SAMPLE NO. & TYPE	"N" BLOWS (FT)	% REC.	SOIL DESCRIPTION: COLOR, MOISTURE, CONSISTENCY / GEOLOGIC DESCRIPTION & OTHER REMARKS	USCS CLASS.	% MC	DRY DENS. pcf	Qu psf	DEP. FT.
					SP				
45	S-9	10	90			28.4			45
50	S-10	19	85			29.5			50
55	S-11	11	88	ALLUVIUM 55.0'		26.2			55
				Light gray, Very moist, SOFT SILTY CLAY	CL-CH				
60	S-12	2	90	ALLUVIUM 60.0'		52.9			60
				Dark gray, Wet, COARSE SAND					
65	S-13	11	85		SP				65
70	S-14	20	90	ALLUVIUM 70.0'		14.9			70
				Bottom of Boring @ 70'					
75									75

GSI Geotechnical Services, Inc.
2853 99th Street, Des Moines, IA 50322
(515) 270-6542 FAX (515) 270-1911

PROJECT: Drilled Shaft Load Tests
LOCATION: 12th Street & Broadway, Council Bluffs, IA
JOB NO.: 086103
DATE: 6-23-08

BORING LOG No. TS 2

BORING NO.	LOCATION OF BORING	ELEVATION	DATUM	DRILLER	LOGGER
TS 2	TS2 Stake	987.42	IDOT Plan Sheet	DAH	JLW

WATER LEVEL OBSERVATIONS				TYPE OF SURFACE	DRILL RIG
WHILE DRILLING	END OF DRILLING	24 HOURS AFTER DRILLING		Grass and Weeds	B-57
				DRILLING METHOD	**TOTAL DEPTH**
20	16			3 1/4" Hollow Stem Auger with Drilling Mud	70'

DEP. FT.	SAMPLE NO. & TYPE	"N" BLOWS (FT)	% REC.	SOIL DESCRIPTION: COLOR, MOISTURE, CONSISTENCY / GEOLOGIC DESCRIPTION & OTHER REMARKS	USCS CLASS.	% MC	DRY DENS. pcf	Qu psf	DEP FT.
				Dark brown and gray mixed, Moist, STIFF SILTY CLAY traces of brick and crushed rock	CL-CH				
5	S-1	12	90	FILL 5.0'		22.3			5
				Dark brown to gray, Very moist STIFF to SOFT SILTY CLAY	CL				
10	S-2	9	95			34.8			10
15	S-3	5	90	ALLUVIUM 15.0'		27.8			15
				Gray to light gray, Very moist, SOFT SILTY CLAY trace sand	CL				
20	S-4	5	90	ALLUVIUM 20.0'		35.1			20
				Gray brown to gray, Wet, FINE SAND					
25	S-5	7	85			22.3			25
30	S-6	9	95			24.4			30
35	S-7	23	90			25.4			35
					SP-SM				
	S-8	14	90			24.9			

GSI Geotechnical Services, Inc.
2853 99th Street, Des Moines, IA 50322
(515) 270-6542 FAX (515) 270-1911

PROJECT: Drilled Shaft Load Tests
LOCATION: 12th Street & Broadway, Council Bluffs, IA
JOB NO.: 086103
DATE: 6-24-08

BORING LOG No. TS 2

BORING NO.	LOCATION OF BORING	ELEVATION	DATUM	DRILLER	LOGGER
TS 2	TS2 Stake	987.42	IDOT Plan Sheet	DAH	JLW

WATER LEVEL OBSERVATIONS				TYPE OF SURFACE	DRILL RIG
WHILE DRILLING	END OF DRILLING	24 HOURS AFTER DRILLING		Grass and Weeds	B-57
				DRILLING METHOD	TOTAL DEPTH
20	18			3 1/4" Hollow Stem Auger with Drilling Mud	70'

DEP. FT.	SAMPLE DATA: SAMPLE NO. & TYPE	"N" BLOWS (FT)	% REC.	SOIL DESCRIPTION: COLOR, MOISTURE, CONSISTENCY / GEOLOGIC DESCRIPTION & OTHER REMARKS	USCS CLASS.	LABORATORY DATA: % MC	DRY DENS. pcf	Qu psf	DEP. FT.
45	S-9	18	90			26.0			45
50	S-10	21	95			20.9			50
55	S-11	12	85	ALLUVIUM 55.0'		24.5			55
				Dark gray, Wet, COARSE SAND trace gravel					
60	S-12	15	85			25.9			60
					SP				
65	S-13	17	85			19.9			65
70	S-14	21	80	ALLUVIUM 70.0'		20.8			70
				Bottom of Boring @ 70'					
75									75

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PROJECT: Drilled Shaft Load Tests
LOCATION: 12th Street & Broadway, Council Bluffs, IA
JOB NO.: 086103
DATE: 6-24-08

BORING LOG No. TS 3

BORING NO.	LOCATION OF BORING	ELEVATION	DATUM	DRILLER	LOGGER
TS 3	TS2 Stake	987.84	IDOT Plan Sheet	DAH	JLW

WATER LEVEL OBSERVATIONS					
WHILE DRILLING	END OF DRILLING	24 HOURS AFTER DRILLING		TYPE OF SURFACE: Grass and Weeds	DRILL RIG: B-57
20	17			DRILLING METHOD: 3 1/4" Hollow Stem Auger with Drilling Mud	TOTAL DEPTH: 80'

DEP. FT.	SAMPLE NO. & TYPE	"N" BLOWS (FT)	% REC.	SOIL DESCRIPTION: COLOR, MOISTURE, CONSISTENCY / GEOLOGIC DESCRIPTION & OTHER REMARKS	USCS CLASS.	% MC	DRY DENS. pcf	Qu psf	DEP. FT.
				Dark brown and gray mixed, Moist, STIFF SILTY CLAY traces of brick and crushed rock	CL-CH				
	S-1	14	85	FILL 5.0'		18.5			
5.5				Gray brown to gray, Very moist STIFF to SOFT SILTY CLAY					5.5
	S-2	6	90			26.7			
11					CL				11
	S-3	4	85			34.7			
16.5									16.5
	S-4	5	85	ALLUVIUM 20.0'		38.5			
				Gray brown to gray, Wet, FINE SAND					
22									22
	S-5	6	90			24.4			
27.5									27.5
	S-6	23	95			24.0			
33									33
	S-7	38	85			25.7			
38.5									38.5
	S-8	11	90		SP-SM	29.1			
				ALLUVIUM					

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PROJECT: Drilled Shaft Load Tests
LOCATION: 12th Street & Broadway, Council Bluffs, IA
JOB NO.: 086103
DATE: 6-24-08

BORING LOG No. TS 3

BORING NO.	LOCATION OF BORING	ELEVATION	DATUM	DRILLER	LOGGER
TS 3	TS2 Stake	987.84	IDOT Plan Sheet	DAH	JLW

WATER LEVEL OBSERVATIONS				TYPE OF SURFACE	DRILL RIG
WHILE DRILLING	END OF DRILLING	24 HOURS AFTER DRILLING		Grass and Weeds	B-57
				DRILLING METHOD	TOTAL DEPTH
20	17			3 1/4" Hollow Stem Auger with Drilling Mud	80'

DEP. FT.	SAMPLE NO. & TYPE	"N" BLOWS (FT)	% REC.	SOIL DESCRIPTION: COLOR, MOISTURE, CONSISTENCY / GEOLOGIC DESCRIPTION & OTHER REMARKS	USCS CLASS.	% MC	DRY DENS. pcf	Qu psf	DEP. FT.
	S-9	13	90	Gray brown to gray, Wet, FINE SAND		30.1			
49.5	S-10	18	90			26.7			49.5
55	S-11	24	90			29.6			55
	S-12	6	85	ALLUVIUM		33.8			
60.5				60.0' Dark gray, Wet, COARSE SAND trace gravel					60.5
	S-13	7	85			21.2			
66									66
	S-14	29	85		SP	13.3			
71.5									71.5
	S-15	10	85			20.6			
77									77
	S-16	14	85	ALLUVIUM		16.6			
				80.0' Bottom of Boring @ 80'					
82.5									82.5

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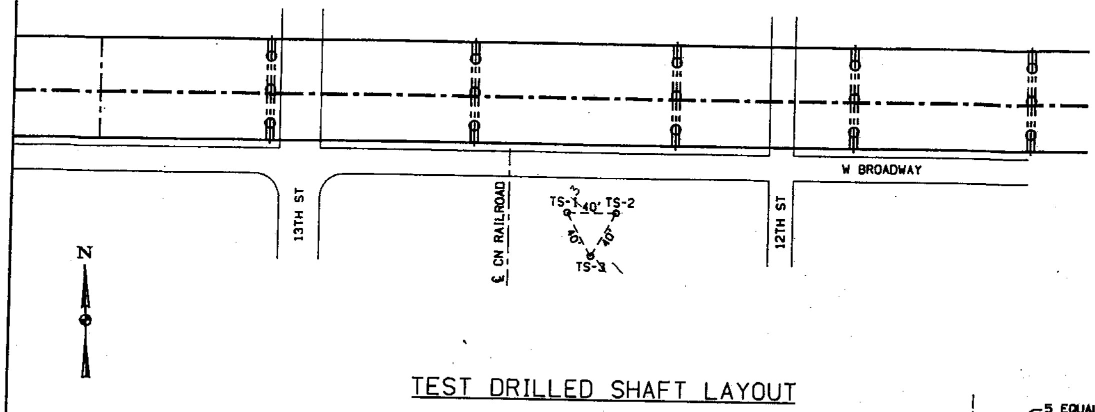
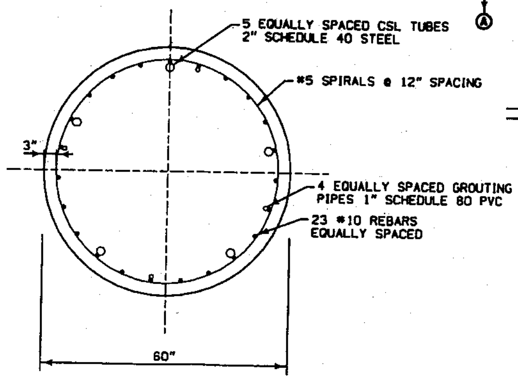
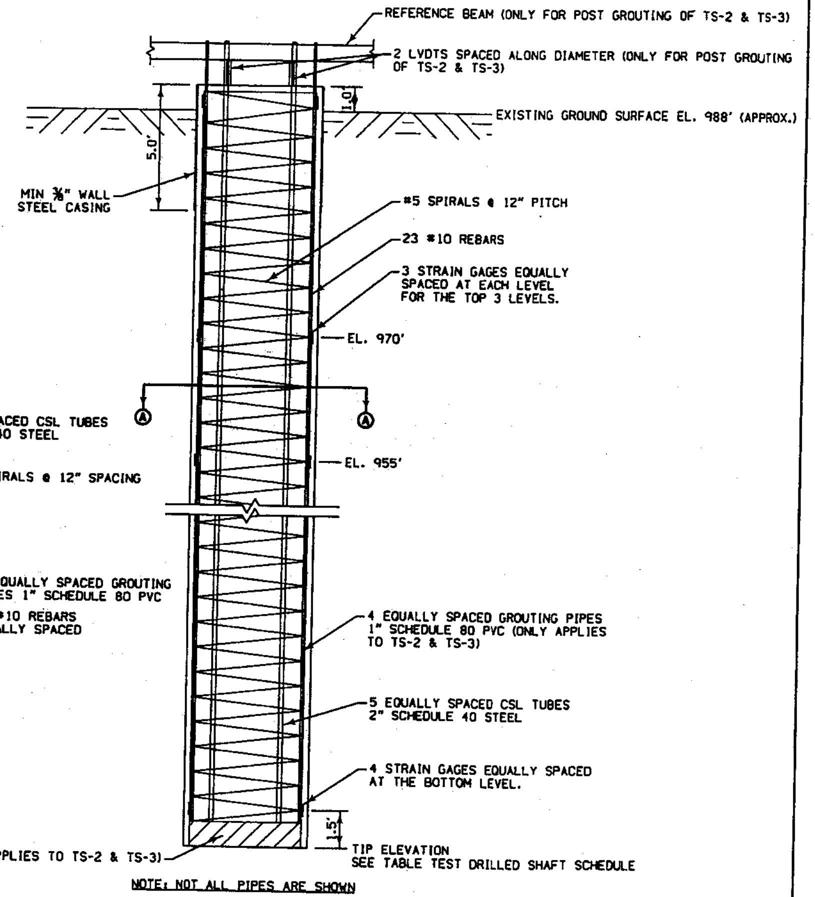


TEST DRILLED SHAFT LAYOUT



SECTION A



NOTE: NOT ALL PIPES ARE SHOWN

TEST DRILLED SHAFT DETAIL (NTS)

TEST DRILLED SHAFT SCHEDULE

TEST SHAFT NO.	DIA. (FT)	TIP ELEVATION (FT) (APPROX.)	POST GROUTING	NORTHING	EASTING	SURFACE ELEVATION (FT)
TS-1	5	933	NO	468477.17	991002.80	987.65
TS-2	5	933	END GROUTING	468475.75	991042.78	987.42
TS-3	5	923	END GROUTING	468441.84	991021.56	987.84

990.47

CONSTRUCTION SEQUENCE:

1.
THE CONTRACTOR SHALL PHYSICALLY LOCATE ALL UNDERGROUND UTILITIES INCLUDING FIBER OPTIC LINES PRIOR TO STARTING WORK. IF THERE IS A CONFLICT BETWEEN A TEST DRILLED SHAFT LOCATION AND AN EXISTING UTILITY (IES), RELOCATE THE TEST SHAFT AS DIRECTED BY THE ENGINEER. THE MINIMUM CENTER TO CENTER DISTANCE BETWEEN TEST SHAFTS SHALL BE 40 FEET. THE CONTRACTOR SHALL CONDUCT THE WORK IN SUCH A MANNER TO ENSURE THAT UTILITIES WILL NOT REQUIRE RELOCATION OR WILL NOT BE DISTURBED .

2.
CONFIRMATION BORINGS SHALL BE COMPLETED AT THE TEST SHAFT LOCATIONS TO A DEPTH 15 FEET BELOW THE TIP OF THE THREE TEST SHAFTS PRIOR TO TEST SHAFT INSTALLATION. THE DRILLED SHAFT TIP ELEVATION MAY BE ADJUSTED BY ENGINEER BASED ON THE CONFIRMATION BORING LOGS.

3.
INSTALL DRILLED SHAFT WITH INSTRUMENTATIONS AND GROUT CELL UNDER THE INSTRUCTIONS OF POST GROUTING SPECIALTY CONTRACTOR AND STATNAMIC LOAD TEST SPECIALTY CONTRACTOR. THE TEST DRILLED SHAFT SHALL BE INSTALLED ACCORDING TO THE IOWA DOT SPECIAL PROVISION FOR TEST DRILLED SHAFT.

4.
PERFORM CROSSHOLE SONIC LOGGING (CSL) TESTS ON ALL THREE TEST SHAFTS PRIOR TO POST PRESSURE GROUTING.

5.
PERFORM POST GROUTING OF TEST DRILLED SHAFTS TS-2 AND TS-3. POST GROUTING SHALL BE PERFORMED BY THE SPECIFIED POST GROUTING SPECIALTY CONTRACTOR.

6.
PREPARE THE DRILLED SHAFT TOP SURFACE AS REQUIRED FOR STATNAMIC LOAD TEST AND PERFORM STATNAMIC LOAD TEST. STATNAMIC LOAD TEST SHALL BE PERFORMED BY THE SPECIFIED STATNAMIC LOAD TEST CONTRACTOR.

LAP LENGTH TABLE

BAR	REQUIRED LAP LENGTH
#5	2'-6"
#10	4'-10"

* The contractor may substitute mechanical rebar splicers for lap splices. No additional compensation resulting from this substitution will be provided. Mechanical splicers shall be in accordance with IM 451, Appendix E.

DESIGN FOR
DRILLED SHAFT LOAD TEST

TEST DRILLED SHAFT
SEPTEMBER 2007
POTTAWATTAMIE COUNTY

IOWA DEPARTMENT OF TRANSPORTATION - HIGHWAY DIVISION
DESIGN SHEET NO. 2 OF 2 FILE NO. 30168 DESIGN NO. 808

DESIGN TEAM IOWA DOT\CH2M HILL

POTTAWATTAMIE COUNTY	PROJECT NUMBER	NHS-80-K318)0--11-78	SHEET NUMBER DSLT.02

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ESTIMATED QUANTITIES

ITEM NO.	ITEM CODE	ITEM	UNIT	TOTAL	AS BUILT QUANTITY
1	2404-7775000	REINFORCING STEEL	LB	22,000	
2	2533-4980005	MOBILIZATION	LS	1	
3	2599-9999005	POST PRESSURE GROUTING	EACH	2	
4	2599-9999005	STATNAMIC LOAD TEST	EACH	3	
5	2599-9999009	TEST DRILLED SHAFT	LF	178	

ITEM NO. ESTIMATE REFERENCE INFORMATION

2. INCLUDES THE COST ASSOCIATED WITH THE MOBILIZATION AND DEMOBILIZATION OF ANY EQUIPMENTS NECESSARY FOR INSTALLING THE TEST DRILLED SHAFTS.

3. INCLUDES THE COST OF ALL LABOR, MATERIALS, AND EQUIPMENT ASSOCIATED WITH POST GROUTING AND FINAL REPORTS IN ACCORDANCE WITH SPECIAL PROVISION, POST PRESSURE GROUTING. INCLUDES THE COST OF MOBILIZATION AND DEMOBILIZATION OF EQUIPMENTS FOR POST PRESSURE GROUTING.

4. INCLUDES THE COST OF ALL LABOR, MATERIALS, AND EQUIPMENT ASSOCIATED WITH THE INSTRUMENTATION OF THE TEST DRILLED SHAFTS AND PERFORMING AND REPORTING THE STATNAMIC LOAD TEST IN ACCORDANCE WITH SPECIAL PROVISION, STATNAMIC LOAD TEST. INCLUDES THE COST OF MOBILIZATION AND DEMOBILIZATION OF EQUIPMENTS FOR STATNAMIC LOAD TEST.

5. INCLUDES ALL LABOR, MATERIALS, AND EQUIPMENT NECESSARY TO INSTALL DRILLED SHAFTS IN ACCORDANCE WITH SPECIAL PROVISION, TEST DRILLED SHAFT AND SUPPLEMENTAL SPECIFICATION 01032, CONCRETE DRILLED SHAFT. INCLUDES THE COST OF ALL LABOR, MATERIALS, AND EQUIPMENT TO RESTORE LOAD TEST SITE TO ITS ORIGINAL CONDITION.

SPECIFICATIONS:

CONSTRUCTION: IOWA DEPARTMENT OF TRANSPORTATION STANDARD SPECIFICATIONS FOR HIGHWAY AND BRIDGE CONSTRUCTION, SERIES OF 2001, PLUS APPLICABLE SUPPLEMENTAL SPECIFICATIONS AND SPECIAL PROVISIONS FOR, TEST DRILLED SHAFT, POST PRESSURE GROUTING AND STATNAMIC LOAD TEST.

DESIGN STRESSES:

DESIGN STRESSES FOR THE FOLLOWING MATERIALS ARE IN ACCORDANCE WITH AASHTO STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGE, 17TH EDITION, 2002.

CONCRETE, FC' = 4000 PSI.

REINFORCING STEEL, ASTM A615 GRADE 60.

STEEL CASING, ASTM A252, GRADE 2.

GEOTECHNICAL DESIGN

LICENSED PROFESSIONAL ENGINEER
Emad Farouz
15897
IOWA

I hereby certify that this engineering document was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Iowa.

Emad Farouz 10/29/07
Signature Date

Emad Farouz
Printed or Typed Name

My license renewal date is December 31, 20 08.

Pages or sheets covered by this seal: DSLT.01-DSLT.02

DESIGN FOR
DRILLED SHAFT LOAD TEST

QUANTITIES

SEPTEMBER 2007

POTTAWATTAMIE COUNTY

IOWA DEPARTMENT OF TRANSPORTATION - HIGHWAY DIVISION

DESIGN SHEET NO. 1 OF 2 FILE NO. 30168 DESIGN NO. 808

DESIGN TEAM IOWA DOT\CH2M HILL | POTTAWATTAMIE COUNTY | PROJECT NUMBER NHS-80-1(318)0--11-78 | SHEET NUMBER DSLT.01

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