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INC.

1435 WEST 820 NORTH
PROVO, UT 84601-1343
801 374-5771 Provo
801 521-5771 SLC

LEGACY PARKWAY

STRUCTURE F-717

CENTER ST. OVER LEGACY PARKWAY

STRUCTURE D-842

CENTER ST. OVER MULTI-USE TRAIL

Salt Lake & Davis Counties, Utah

Utah Department of Transportation
SP-0067(5)0

July 2006

Geotechnical Investigation Report for Structures

200801-111 / 200801-145

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Annette Skewes
HORROCKS ENGINEERS
One West Main
PO BOX 377
AMERICAN FORK, UT 84003

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UDOT Geotechnical Engineer
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Salt Lake City, UT 84119

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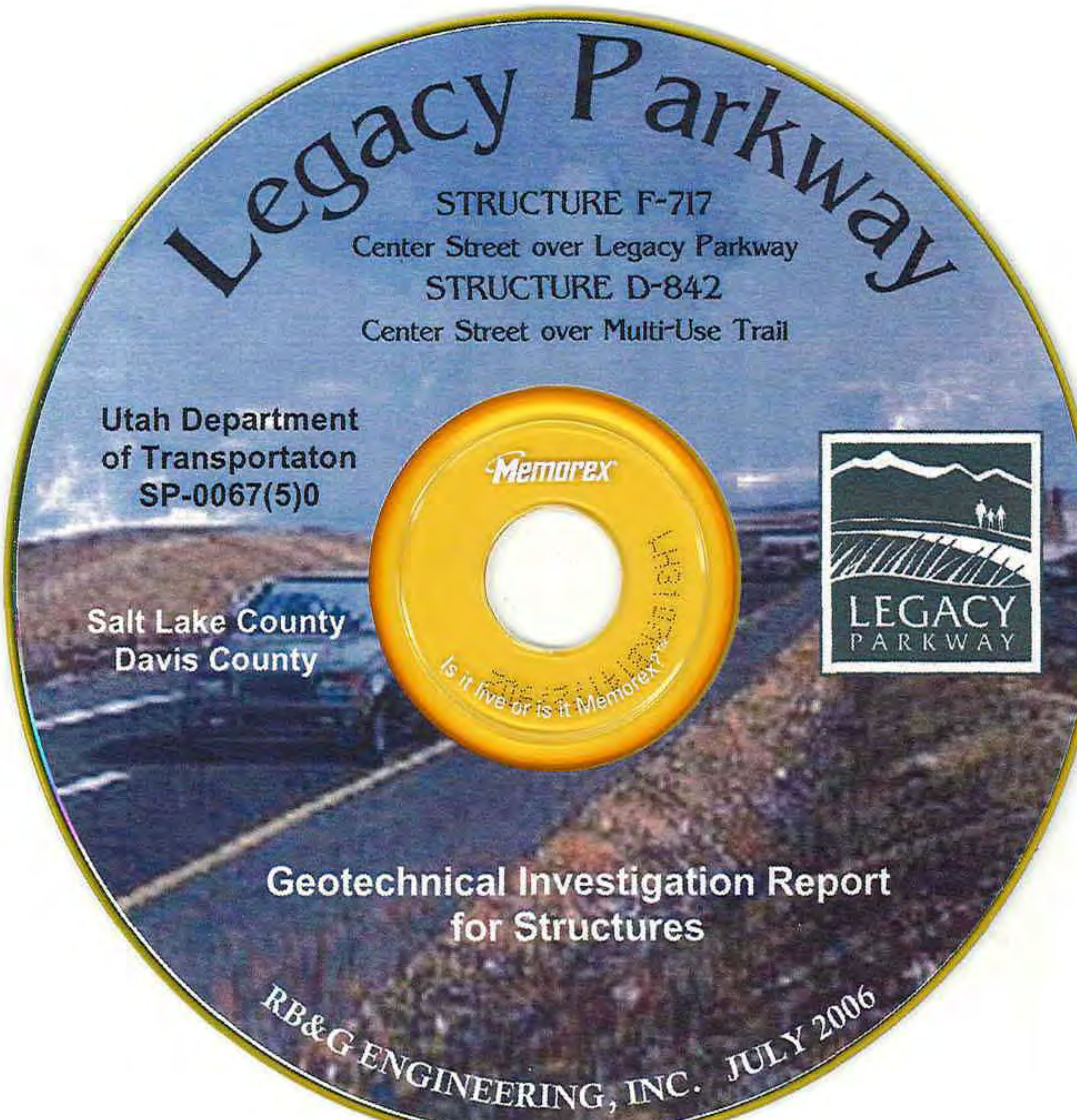
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Geotechnical Investigation Report
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RB&G ENGINEERING, INC. JULY 2006

RB&G
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INC.

July 7, 2006

Mr. Sohail Khan
Carter & Burgess
420 East South Temple Suite 342
Salt Lake City, Utah 84111-1321

Reference: Legacy Parkway Project No. SP-0067(5)0

Gentlemen:

A Geotechnical Investigation Report for Structures has been completed for Structure F-717, Center Street over Legacy Parkway, and Structure D-842, Center Street over Multi-Use Trail in Salt Lake and Davis Counties, Utah. The investigation has been conducted in accordance with a proposal submitted to your organization for the work, and the results of the study are summarized in the report transmitted herewith.

We appreciate the opportunity of providing this service for you. If there are any questions relating to the information contained herein, please call.

Sincerely,

RB&G ENGINEERING, INC.

REGISTERED PROFESSIONAL ENGINEER
NO. 162291
BRADFORD E. PRICE
7/7/06
STATE OF UTAH

Bradford E. Price, P.E.

bep/jag

1435 WEST 820 NORTH
PROVO, UT 84601-1343

PROVO 801-374-5771
SALT LAKE CITY 801-521-5771

Geotechnical Investigation Report for Structures

Legacy Parkway

Structure F-717
Center Street over Legacy Parkway

Structure D-842
Center Street over Multi-Use Trail

Salt Lake & Davis Counties, Utah

Utah Department of Transportation
SP-0067(5)0

July 2006

RB&G ENGINEERING, INC.

Professional Engineers

LEGACY PARKWAY

UTAH DEPARTMENT OF TRANSPORTATION
SP-0067(5)0

GEOTECHNICAL INVESTIGATION REPORT FOR STRUCTURES

Structure F-717 – Center Street over Legacy Parkway
Structure D-842 – Center Street over Multi-Use Trail

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UTAH DEPARTMENT OF TRANSPORTATION
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GEOTECHNICAL INVESTIGATION REPORT FOR STRUCTURES

Structure F-717 – Center Street over Legacy Parkway
Structure D-842 – Center Street over Multi-Use Trail

1.0 GENERAL

This report presents the results of geotechnical investigations and provides foundation recommendations for the following structures located within the Legacy Parkway project:

- F-717 – Center Street over Legacy Parkway
- D-842 – Center Street over Multi-use Trail

The primary purpose of this investigation is to determine the characteristics of the subsurface material throughout the project area, and to make appropriate foundation design recommendations for the proposed structures. The report is intended to aid designers in evaluating the site and subsurface conditions for foundation design and potential construction problems.

1.1 PROJECT DESCRIPTION

The Legacy Parkway will be a four-lane, limited-access, divided highway extending approximately 14 miles from Interstate 215 at 2100 North in North Salt Lake, northward to the junction of Interstate 15 and U.S. Highway 89 near Farmington (see Figure 1) . A multiple-use pedestrian, bicycle, and horse trail will parallel the Parkway.

1.1.1 General

Bridge structures do not presently exist at the Center Street Bridge site. The Center Street bridge (F-717) and multi-use trail crossing (D-842) will be located on the south side of the existing Center Street alignment in North Salt Lake.

1.1.2 Proposed Improvements

New structures will be built at locations where the Legacy Parkway roadway and trail system will cross existing streets, waterways, and other facilities. It is our understanding that the Center Street Bridge over Legacy Parkway will be a two-span structure incorporating MSE walls at each abutment, and the multi-use trail will cross beneath Center Street in a tunnel/culvert type structure. Center Street will be realigned about 150 feet south of its existing alignment in this area to cross over the proposed Parkway. Preliminary drawings of the proposed structures are included for reference in Appendix A.

1.1.3 Climatic Conditions

The climate in the project area is characterized by relatively warm summers and cold winters. The frost depth ranges between 20 to 30 inches. Winter snow often requires plowing, and de-icing salt is regularly deposited on major roadways during the winter months.

2.0 PREVIOUS REPORTS AND INVESTIGATIONS

The following geotechnical reports and investigations have been completed previously by others for this project.

2.1 PB/FAK GEOTECHNICAL INVESTIGATION REPORT

UDOT provided copies of the Geotechnical Reports prepared by Parsons Brinckerhoff Quade & Douglas (PB) for Fluor Ames Kraemer (FAK), LLC as a part of the Design-Build Legacy Parkway Project. The report includes the results of subsurface investigations performed by Kleinfelder, Inc. and provides geotechnical recommendations for the structures contemplated in the original project. It should be noted that the project was divided into 5 segments for the Design-Build Project. Segment 1 included the south interchange through Center Street. Borings were performed for the bridge originally contemplated at Center Street, and roadway borings were performed on Center Street at locations several hundred feet east and west of the bridge location.

2.2 KLEINFELDER GEOTECHNICAL INVESTIGATION

It is our understanding the Kleinfelder, Inc. conducted an investigation of the preferred Legacy Parkway alignment for UDOT and the results were submitted in a report dated June 2, 2000. Some of its findings were reproduced in the PB/FAK Design Build reports referenced in Section 2.1 above.

2.3 DAMES & MOORE PRELIMINARY GEOTECHNICAL STUDY

It is our understanding that Dames & Moore completed a geotechnical study for the proposed preliminary Legacy Parkway corridor and presented the results in a 1998 report.

3.0 EXISTING FACILITIES

Center Street is a two-lane paved road traveling in an east-west direction in this area, and the proposed Parkway will travel in a generally north-south direction, with Center Street crossing over the parkway and trail about 150 feet south of the present Center Street alignment. A building approximately 180 feet long by 115 feet wide is located on the north side of Center Street and on the east side of the proposed Legacy Parkway alignment. Various utility lines exist in the area, including overhead power lines, and buried utilities such as gas, oil, power, and communications lines.

4.0 FINDINGS

4.1 EXISTING SITE CONDITIONS

The topography is relatively flat throughout Segment 1 and generally slopes down to the west towards the Great Salt Lake. The proposed Legacy Parkway corridor begins just west of the existing I-215 / Redwood Road interchange on the south and continues northward. The southerly portion of the corridor travels along the westerly limits of North Salt Lake, Woods Cross, West Bountiful, and Centerville, about 0.5 to 2 miles west of I-15. North of Parrish Lane in Centerville, the Parkway corridor will be located less than about 0.25 miles west of I-15, with the two corridors essentially parallel continuing north to the I-15 / US-89 interchange in Farmington. The south and north interchanges are already partially constructed. A few industrial and commercial properties are located along the alignment.

4.2 SURFACE DRAINAGE

Surface drainage in the area generally follows the topography to the west and northwest towards the Great Salt Lake. In addition to the Jordan River and Oil Drain at the south interchange, some creeks, streams, and canals cross the alignment at various locations, creating the potential for flooding. Flooding and ponding on the soft surface soils can make access to bridge sites difficult.

4.3 GEOLOGY

The project is located within the Wasatch Front section of the Basin and Range physiographic region. The Wasatch Front consists of a series of down dropped valleys bounded primarily by the Wasatch Mountains on the east and the Great Salt Lake, Utah Lake and the Oquirrh Mountains on the west. The area extends from Juab County in the south up through Salt Lake, Davis, Weber and Box Elder counties to the north.

The general topography of the Wasatch Front is due, in large part, to Basin and Range extensional faulting. The Wasatch Fault is an extensional normal fault which trends northerly along the base of the Wasatch Mountains from Levan in the south, and up into Idaho to the north. Prior to extensional faulting, the region was subjected to compressional forces from the west resulting in extensive thrust faulting and mountain building. Extensional forces are still active today with various segments of the Wasatch Fault capable of generating large earthquakes with magnitudes near 7.4.

The Wasatch Mountains to the east consist predominately of Precambrian to Mesozoic, metamorphic and sedimentary bedrock. The valleys along the Wasatch Front are predominately covered with Pleistocene Lake Bonneville deposits, and younger alluvial fan and stream deposits. The Bonneville Lake Cycle began about 30,000 years ago when the climate was much cooler and wetter. The lake reached its highest elevation of about 5,100 feet, known as the Bonneville shoreline, between 16,000 to 14,500 years ago. From this shoreline, the lake eventually overtopped and breached through unconsolidated sediments near Red Rock Pass sending a catastrophic flood into the Snake River drainage system in southeastern Idaho, about 14,500 years before present. Within about a year, the lake had dropped to an elevation of about 4,740 feet, forming the Provo shoreline. Due to changing climatic conditions, the lake level gradually dropped to the historic levels of its modern day remnant, the Great Salt Lake. The last major high water shoreline of the lake was the Gilbert shoreline which reached an elevation of about 4,250 feet between 11,000 to 10,000 years ago. Historically, the Great Salt Lake has fluctuated between 4,211.9 and about 4,191 feet above sea level.

During Bonneville times thousands of feet of sediment were deposited in the valley. Deposits consist of deep-water silts and clays, shoreline sand and gravels and gravelly barrier beach and deltaic deposits. The unconsolidated to semi-consolidated valley fill deposits are thought to range from 2,000 to 5,000 feet thick (Black, and others, 2003; Currey, and others, 1984; Hintze, 1988; Stokes, 1986).

Based on surficial geologic maps of the area (Personius and Scott, 1992; Nelson and Personius, 1993), surficial geologic deposits throughout the study area consist predominately of Lake Bonneville lacustrine clay and silt, with Holocene to upper Pleistocene lateral spread deposits at some locations. Post-Bonneville lacustrine and marsh deposits are encountered along the easterly shores of the Great Salt Lake and encroach on the Parkway alignment from the west at some bridge sites. Localized upper Holocene stream alluvium associated with the Jordan River can be found along the shores of the river near the southerly terminus of the project. Bonneville lacustrine sand and gravel may be encountered near the northerly terminus, along with upper Holocene fan alluvium consisting of cobbles and gravel in a sandy matrix.

As shown on Figure 2, the Center Street site lies at the border of two mapped surficial units, with upper Holocene Jordan River stream alluvium (sand, silt, and minor clay and gravel) mapped as the predominant deposit west of the site, The surficial unit east of the site is composed of lateral-spread deposits of sand, silt, clay, and minor pebble gravel probably deposited as a result of liquefaction during a major earthquake. The deeper soils are likely lacustrine clays, silts, and sands.

4.4 GEOLOGIC HAZARDS

Geologic hazards identified within the Legacy Parkway project area include ground shaking, liquefaction-induced landslides, lateral spreading, and subsidence during a seismic event, along with shallow ground water and flooding. A more detailed discussion of seismic hazards at the Center Street site is provided in Section 5.0.

4.5 SOIL MATERIALS

Much of the Segment 1 portion of the project has been covered with a layer of compacted granular fill. Borings completed at the Center Street site generally encountered 5 to 6 feet of granular fill material, followed by interbedded layers of lean clay and loose to medium-dense sand and silt to a depth of about 60 feet. Significant deposits of medium-dense to very dense sand with silt were encountered between about 60 to 80 feet, followed by more layers of firm to stiff lean clay and medium-dense to very dense silty sand to the maximum boring depth of 128 feet. Soil conditions are described in further detail in Section 7.1.2.

4.6 HYDROGEOLOGIC CONDITIONS

Groundwater in the Salt Lake Valley occurs in late Tertiary and Quaternary alluvial and lacustrine basin-fill deposits that range from coarse gravel to clay. Four hydraulically connected aquifers have been identified in the basin sediments: 1) a deep, unconfined aquifer in gravelly deposits along the fronts of the Wasatch Range and Oquirrh Mountains; 2) a deep, confined aquifer in the center of the valley in gravel deposits beneath clay confined beds; 3) a shallow, unconfined aquifer in the center of the valley overlying the confined aquifer; and 4) local perched aquifers located primarily adjacent to mountain fronts.

The hydraulic gradient in the Parkway area generally slopes down in a westerly direction toward the Great Salt Lake. The depth to groundwater was measured at each boring location as indicated on the boring logs and was within 4.5 to 5 feet of the ground surface at the Center Street site at the time of drilling (February-March 2006). Fluctuations of a few feet can be expected due to typical seasonal variations. At some locations within Segment I, the existing ground is covered by water during at least part of the year, creating difficult access conditions. Artesian conditions were encountered in the lower confined aquifers at some locations.

4.7 POTENTIALLY HAZARDOUS MATERIALS

Potentially hazardous materials were not noted during the field investigation. All soil samples were re-examined in the laboratory and odors indicative of contamination were not noted. Potential sources of contamination include the oil drain at the southerly end of the project along with various past and present industrial sites located in the vicinity of the Parkway alignment. The apparent lack of contamination observed by field and lab personnel does not preclude the possible presence of potentially hazardous materials in the project area.

5.0 EARTHQUAKE CONSIDERATIONS

The study area is located within the seismically active Intermountain Seismic Belt which extends from Arizona to Canada. The nearest potentially active fault is the Salt Lake City Segment of the Wasatch Fault Zone (WFZ) located about 1.4 miles east of the Center Street site. The Salt Lake City segment is capable of generating a magnitude 7.2 earthquake. The Weber Segment of the WFZ is located about 2.2 miles to the northeast with the capability of a magnitude 7.4 earthquake. The West Valley Fault Zone is located about 3.4 miles to the south. It is uncertain whether the West Valley Fault Zone has a true independent seismogenic source or if it functions as an antithetic fault to the WFZ.

5.1 DESIGN CRITERIA

The site is located at latitude 40.841° North and longitude 111.943° West. USGS-NEHRP probabilistic peak ground acceleration (PGA) values are tabulated below:

Probabilistic ground motion values in %g.

	10%PE in 50 yr	2%PE in 50 yr
PGA	29.88	72.40
0.2 sec SA	69.55	169.98
1.0 sec SA	24.31	71.74

It should be noted that the USGS-NEHRP mapped values are calculated for "firm rock" sites having a shear wave velocity of 1500 feet per second in the upper 100 feet (MCEER Site Class B/C boundary), and that bedrock ground motions may amplify or attenuate as they propagate through overburden soils.

Borings and testing completed at the site of the proposed structures indicate that the clayey soils in the upper 100 feet have average undrained shear strengths of about 900 psf. Significant deposits of medium-dense to very dense sand were encountered between depths of 45 to 100 feet. Based on this information, it is recommended that MCEER Site Class D be used for seismic design.

As part of the current Legacy Parkway project, Kleinfelder developed site specific horizontal and vertical acceleration response spectra for the 1250 West bridge site and the State Street bridge site. It is our understanding that Kleinfelder will provide a separate report with conclusions and recommendations for applying the site-specific spectra at other sites on the project.

5.2 LIQUEFACTION AND LATERAL SPREAD

Liquefaction analyses were performed using the "Simplified Procedure" developed by Seed and Idriss (1971). This procedure involves determining the seismic shear stress ratio induced by an earthquake and comparing it with the seismic shear stress ratio required to cause liquefaction. Recommended refinements for the "Simplified Procedure" for SPT data presented at the 1996 NCEER workshop (Youd et al., 1997) were applied.

An evaluation of borings and testing indicates that several soil layers may liquefy during the seismic event having a 2 percent probability of exceedance in 50 years. Soil layers showing potential for liquefaction during the design event are noted on the boring logs in Appendix B. Layer thicknesses and potential liquefaction-induced settlement corresponding to volumetric strain are summarized below.

Boring No.	Thickness of Liquefiable Layers (ft)		Calculated Liquefaction Settlement (in)	
	Within Depth Investigated	Within Upper 50 Feet	Within Depth Investigated	Within Upper 50 Feet
RSB-11-607	20.0	7.5	4.0	1.5
RSB-11-608	22.2	19.5	2.3	2.1

It has been noted that some surficial soils in the area are mapped as lateral spread deposits. A review of the boring logs does not identify a continuous layer susceptible to lateral spread in the upper 30 feet of the soil profile. Evidence of a continuous layer susceptible to lateral spread was encountered between depths of about 35 to 40 feet in each of the two borings; however, empirical evidence indicates that significant lateral spread displacements usually are limited to sites where the top of the susceptible soil layer is within 10 meters (about 33 feet) of the ground surface (Bartlett and Youd, 1992). It does not appear that lateral spread mitigation will be required for the bridge structure at this site.

6.0 FIELD AND LABORATORY TEST DATA

6.1 SUBSURFACE EXPLORATION

Subsurface investigations performed at the bridge sites include borings performed by Kleinfelder in conjunction with the Design-Build project, along with supplemental borings performed in 2006 for the current project.

Boring logs for bridge subsurface investigations performed in 2006 are included in Appendix B of this report. Test holes performed by RB&G Engineering in 2006 are labeled with the prefix "RSB" (or "RSC" for CPT holes, where applicable), followed by a number identifying the bridge site, then by a hole number in the 600 series. Logs of subsurface investigations performed by Kleinfelder are also reproduced in Appendix B and are labeled with the prefix "SB" for borings and "SC" for CPT holes, followed by the Design-Build bridge number, then the boring number. It will be noted that the Center Street site is number 11, based on the Design-Build bridge number. Roadway borings performed by Kleinfelder are labeled with the prefix "RB".

For all structure borings drilled in 2006, the subsurface investigation was performed using a CME 55 rotary drill rig with a tri-cone rock bit and NW casing to advance the boring and water as the drilling fluid. Sampling was generally performed at 5-foot intervals. At some locations, sampling was performed at closer intervals to evaluate liquefaction hazard for loose cohesionless soils in the upper 30 to 40 feet. Disturbed samples were obtained by driving a 2-inch split spoon sampling tube through a distance of 18 inches using a 140-pound weight dropped from a distance of 30 inches. The drill rig used for each boring is noted on the boring log. The automatic trip hammer on the CME-55 No. 1 rig was evaluated by UDOT using Pile Driving Analyzer equipment in March 2006 and the energy ratio was determined to be about 72%. The CME-55 No. 2 rig uses a rope and cathead hammer which was determined by UDOT to have an average energy ratio of about 55%.

The number of hammer blows required to drive the sampling spoon through each 6 inches of penetration is shown on the boring logs. The sum of the last two blow counts, which represents the number of blows to drive the sampling spoon through 12 inches, is defined as the standard penetration value. The standard penetration value, corrected for overburden and hammer energy, provides a good indication of the in-place density of sandy material; however, it only provides an indication of the relative stiffness of cohesive material, since the penetration resistance of materials of this type is a function of the moisture content. Considerable care must be exercised in interpreting the standard penetration value in gravelly-type soils, particularly where the size of granular particles exceeds the inside diameter of the sampling spoon. If the spoon can be driven through the full 18 inches with a reasonable core recovery, the standard penetration value provides a good indication of the in-place density of gravelly-type material. For materials containing more than 35% gravel size particles, the density descriptions shown on the boring logs were developed based on correlations between relative density and standard penetration value for gravelly soils.

At some locations within the project it was not possible to drive the sampling spoon through the full 18 inches at some sampling depths. Where the sampling tube could not be driven through the full 18 inches, the number of blows to drive the spoon through a given depth of penetration is shown on the boring logs.

Undisturbed samples were obtained by pushing a 2.62-inch (inside diameter) thin-walled sampling tube into the subsurface material using the hydraulic pressure on the drill rig. The locations at which the undisturbed samples were obtained are shown on the boring logs.

Miniature vane shear (torvane) tests, which provide an indication of the undrained shearing strength of cohesive materials, were performed on samples of the cohesive soils during the field investigations. The results of these tests are shown on the boring logs as the torvane value in tsf.

Each sample obtained in the field was classified in the laboratory according to the Unified Soil Classification System. The symbols designating soil types according to this system are presented on the boring logs. A description of the Unified Soil Classification System is included with the logs (see Appendix B), and the meaning of the various symbols shown on the logs can be obtained from this figure. Laboratory-tested samples were also classified according to the AASHTO Classification System, and the symbols designating the soil types according to this system are also presented on the boring logs.

6.2 LABORATORY TESTING

Laboratory tests performed during this investigation to define the characteristics of the subsurface material included:

1) Mechanical Analysis
2) Density
3) Natural Moisture Content

4) Atterberg Limits
5) Unconfined Compressive Strength
6) Triaxial Shear
7) Consolidation
8) Direct Shear
9) pH, Resistivity, Sulfates, and Chlorides

Laboratory testing was performed in accordance with applicable standards published by the American Society for Testing and Materials (ASTM) and/or the American Association of State Highway and Transportation Officials (AASHTO).

The results of laboratory tests performed during this investigation are presented on the boring logs and summarized on tables located in Appendix C of this report. Plots of applicable test data are also included in Appendix C.

7.0 STRUCTURES

7.1 DESCRIPTION

7.1.1 General

It is our understanding that Structure F-717 will be a two-span concrete bridge structure with MSE walls at each abutment. The bridge is expected to be about 55 feet wide with two 93-foot long spans, for a total bridge length of about 186 feet. Structure D-842 will be a culvert/tunnel type structure approximately 28 feet wide by 60 feet long. Controlling loads for the F-717 bridge have been provided by the structural engineer and are shown on the table below. Loads for Structure D-842 have not been provided

Structure	Foundation	Strength I (kips)	Service I (kips)
F-717 Center Street over LP	Abut 1	2400	1900
	Bent 2	6120	4770
	Abut 3	2400	1900

It is our understanding that the abutment foundations for Structure F-717 are expected to consist of a single line of 10 piles, while the bent loads will be supported by three columns on separate footings, with 25 piles beneath each footing on a 5 by 5 grid. The controlling service load combination for each of the three bent pile groups is 1590 kips axial compression with a moment of 1270 kip-feet. The controlling Strength load combination for each of the bent footings is 2040 kips axial compression with a moment of 1710 kip-feet. Preliminary structure drawings indicate that large monuments to be installed at the corners and ends of abutment MSE walls will also be pile-supported, as will the culvert type multi-use trail undercrossing (D-842).

7.1.2 Subsurface Conditions

Borings completed by Kleinfelder encountered primarily clay and silt with some sand layers in the upper 41 feet. At a depth of 41 feet, Boring SB-11-259 encountered silty sand, silt, and sand with silt to a depth of about 79 feet, while Boring SB-11-262 identified fat clay between 41 and 60 feet, followed by silty sand to 90 feet. The silty sand layers were generally in a medium-dense to dense condition. Both borings then primarily encountered medium-stiff to hard silt and lean clay with a few sand layers to the bottom of the deepest boring at a depth of 166 feet. Boring RB-368, drilled on the proposed Center Street alignment about 300 feet west of Structure F-717, and Boring RB-369, drilled about 350 feet west of F-717, each extended to a depth of 76 feet and encountered similar stratigraphy to that encountered in the deeper structure borings.

CPT logs provided in the Kleinfelder reports generally characterized the subrade soils as interbedded clay, silt, and sand layers in the upper 17 to 18 meters (56 to 59 feet), followed by silty and gravelly sand layers to about 24 meters (79 feet). More clayey and silty soils were identified between about 24 to 27 meters, (79 to 89) feet, underlain by sandy/gravelly soils to about 31 meters (102 feet), then thinner layers of interbedded clay, silt, and sand to the bottoms of the soundings at a depth of about 51.5 meters (169 feet) below the ground surface, where the CPT probe encountered refusal in each hole.

Boring RSB-11-607 was drilled near the proposed west abutment (Abutment 1) of Structure F-717, while Boring RSB-11-608 was drilled at the east abutment (Abutment 3). Both borings encountered 4 to 6 feet of medium-dense granular fill, followed by firm to stiff lean clay with interbedded sand and silt layers to a depth of about 25 feet. Some softer clay samples with sand and silt layers were obtained between depths of about 25 to 60 feet, at which point the borings entered a 15 to 25-foot thick layer of medium-dense to very dense sand with silt. Below this sand layer, a layer of stiff lean clay was identified to a depth of about 94 feet, followed by medium-dense sand. Boring 608 terminated in very dense sand at 101.5 feet, while Boring 607 continued through silty sand to 112 feet, followed by firm to stiff clay with silt lenses to a final depth of 128 feet below the ground surface.

7.1.3 Groundwater Conditions

Groundwater was encountered at a depth of 5.0 feet (about elev. 4213.5 feet) in RSB-11-607, and at a depth of 4.7 feet (about elev. 4214.5 feet) in RSB-11-608. It is anticipated that up to two feet of fluctuation may occur due to seasonal variations in precipitation and climatic cycles.

7.2 RECOMMENDATIONS

7.2.1 Bridge Structures

Potential foundation types at this site include shallow foundations, such as spread footings, and deep foundations, such as drilled shafts or driven piles. Due to the magnitude of structural loads (including seismic design requirements) and generally low bearing resistance of shallow soils, deep foundations are expected to be the most efficient type for major bridge structures on the project. The depth to competent bearing layers, along with foundation settlement considerations, favors the use of driven piles rather than drilled shafts. Given the anticipated subsurface soil and groundwater conditions, driven piles can be more readily installed to greater depths than drilled shaft foundations. Recommendations for driven pile foundations are summarized below. Recommendations for shallow foundations, which may be considered for the multi-use trail underpass, are provided in Section 7.2.4.

7.2.1.1 Driven Piles

Axial compression resistance values have been estimated for 16-inch OD concrete-filled steel pipe piles. The analyses were performed using the FHWA program SPILE. Geotechnical resistance factors were selected from the 2006 Interim AASHTO LRFD Bridge Design Specifications. Estimated driving depths and factored resistance values are summarized below.

Pile Data Parameters	Location			
	F-717 Abut 1	F-717 Bent 2	F-717 Abut 3	D-842
Estimated Pile Tip Elevation (ft)	4150	4150	4150	4150
Elev. of Min. Acceptable Pile Penetration (ft)	4154	4154	4156	4155
Strength I Axial Compression Resistance (kip)	299	299	299	299
Extreme Event I Compression Resistance. (kip)	425	425	425	425
Required Driving Resistance (kip)	460	460	460	460

It will be noted that the resistance values and estimated pile tip elevations are the same for each abutment and bent. The elevations of minimum acceptable pile penetration were selected to ensure adequate embedment into the dense bearing layer shown on the test hole logs, and these elevations vary depending on location.

The estimates listed above assume that new embankments will be constructed with lightweight material and/or surcharged such that significant embankment settlement will be completed or otherwise mitigated prior to placement of structural loads on the piles.

We recommend that piles be spaced at least 3 diameters apart (center-to-center) to reduce group effects. Potential for pile group failure under axial compression loads was checked for the following proposed pile group layouts.

- Abutments with a single row of 10 piles spaced at 5.7 feet on centers
- Bent pile groups having 25 piles on a 5 x 5 grid spaced at 4.25 feet on centers

In each case, the potential for group (block) failure was found to be less critical than the axial compressive resistance of individual piles. Group resistance can therefore be determined by multiplying the single-pile resistance by the number of piles in the group for both the Strength I and Extreme Event limit states.

A preliminary pile drivability analysis has been performed using the program GRLWEAP 2005. The analysis was performed for closed-end 16-inch OD steel pipe piles having wall thicknesses of 3/8 and 1/2 inch. The analyzed driving systems were a Delmag D 25-32 diesel hammer with the manufacturer's recommended hammer cushion, and an IHC S-90 Hydrohammer, without cushioning. The results of the analyses are summarized below.

Hammer	3/8" Pipe Thickness					1/2" Pipe Thickness				
	Ultimate Capacity (kips)	Maximum Compress. Stress (ksi)	Blow Count (per foot)	Stroke (ft)	Energy (kip-ft)	Ultimate Capacity (kips)	Maximum Compress. Stress (ksi)	Blow Count (per foot)	Stroke (ft)	Energy (kip-ft)
D 25-32	400	27.8	46	8.0	34.0	400	26.2	41	7.9	31.2
	450	28.6	65	8.3	34.9	450	26.8	54	8.1	31.9
	500	29.0	104	8.4	35.2	500	27.3	74	8.3	32.4
	515	29.3	120	8.5	35.6	565	27.9	118	8.5	33.0
IHC S-90*	400	40.5	32	6.6	46.0	400	35.2	33	6.6	40.8
	450	40.6	46	6.6	46.0	450	35.2	43	6.6	40.8
	500	40.6	71	6.6	46.0	500	35.3	60	6.6	40.7
	550	40.7	122	6.6	46.0	600	35.3	124	6.6	40.4

* S-90 assumed to operate at 75% efficiency for 3/8" pipe and at 65% efficiency for 1/2" pipe thickness.

It will be observed from the table that both hammers are capable of driving piles to the required driving resistance of 460 kips without requiring more than 120 blows per foot. The calculated driving stresses are significantly greater for the IHC S-90 hammer than for the diesel hammer, due to the lack of cushioning and greater energy transfer to the pile.

Based upon the results of the WEAP analysis, pipe piles with 3/8" wall thickness can be successfully driven to the required driving resistance with either hammer system. A refined wave equation analysis should be performed for the proposed pile driving system prior to mobilizing the pile driving rig to the site.

Pile driving should be monitored to ensure that driving stresses do not exceed 0.9 times the yield strength of the steel piles. Based on the WEAP analysis, 45-ksi steel should provide sufficient drivability resistance for piles at this site. If a larger hammer such as the IHC S-90 is used, it may be necessary to cushion the pile or operate the hammer at less than the maximum efficiency to avoid excessive stresses. It should be noted that other bridge locations on the project are expected to require piles with yield strengths greater than 45 ksi, due to greater driving depth and resistance requirements.

The pile driving hammer should have a rated energy of at least 40 kip-ft. Special care should be taken to align the hammer properly with the pile head to limit the possibility of eccentric driving stresses, which can result in over-stressing of one side of the pile. Driving should be performed only with smooth, square ends of the piles (preferable the factory-cut ends) rather than rough field-cut pile ends.

7.2.1.2 Foundation Settlement

Pile resistance analyses were performed based on the neutral plane method. In this method, downdrag loads are not considered detrimental to the geotechnical pile resistance, and the resistance values above need not be reduced to account for downdrag. The effects of downdrag should, however, be accounted for in evaluations of the structural resistance of the pile section. For each of the foundation locations listed above, the axial structural resistance of the concrete-filled pipe pile section should be checked to verify that the pile section can resist the Service I Load plus a factored downdrag load of 300 kips per pile. To account for potential corrosion, we recommend that the structural capacity evaluation be performed assuming 1/16 inch of corrosion will occur on the exterior of the steel pipe.

The Extreme Event I Resistance shown above assumes that liquefiable layers will not provide resistance during seismic loading. If this value is not exceeded, it is anticipated that the principle consequences of liquefaction will be pile group settlement resulting from downdrag loads transferred from settling soil above the liquefiable layers. The pile group could potentially settle as much as the surrounding ground surface during liquefaction before the temporary downdrag loads are neutralized and the piles regain the full Extreme Event I Resistance; however, actual pile group settlement during liquefaction is expected to be somewhat less than the settlement of the surrounding ground surface. The maximum estimated ground settlement due to liquefaction at this site is about 4 inches.

Consolidation settlement of an individual bent foundation at Structure F-717 was estimated assuming a 5 x 5 grid of 25 piles spaced at 4.25 feet on centers. Assuming an axial compression service load of 1590 kips acts on the footing, the calculated consolidation settlement of the pile group is about 0.9 inches. It is therefore anticipated that pile group settlement for abutment footings will be less than 1 inch.

Settlement of abutment pile groups at Structure F-717 was estimated assuming a single row of 10 piles spaced at 5.7 feet on centers. Assuming an axial compression service load of 1900 kips acts on the footing, the calculated settlement of the pile group is less than one inch. In the analysis it was assumed that settlements caused by placement of embankment and MSE fill will be mitigated/completed prior to placement of bridge loads on the piles.

7.2.1.3 Uplift

Uplift capacities for individual piles using LRFD Procedures are 77 kips per pile for the Strength I limit state and 194 kips per pile for Extreme Event I. A resistance factor of 0.35 was used for sandy soils, and a factor of 0.25 was used for clayey soils at the Strength I limit state.

Group uplift resistance for the case of block failure was evaluated by estimating the weight of each pile group plus the shear resisting force around the perimeter of the pile group for the proposed pile groups as follows:

- Abutments with 10 piles spaced at 5.7 feet on centers
- Bent pile groups having 25 piles on a 5 x 5 grid spaced at 4.25 feet on centers

The uplift capacities listed above for individual piles were limited where necessary to ensure that the uplift resistance of individual piles will be more critical than resistance to uplift block failure of the pile group. It is therefore recommended that the uplift resistance for pile groups at these structures be assumed equal to the uplift resistance of a single pile multiplied by the number of piles in the group.

7.2.1.4 Lateral Loading

Soil parameters and other recommendations for evaluation of lateral load response using the computer programs LPILE and GROUP are included on a summary sheet in Appendix D.

7.2.1.5 Load Tests

Table 10.5.5.2.3-3 of the 2006 AASHTO LRFD Interim Specifications shows the number of dynamic pile load tests with signal matching required at each site. The number of required PDA tests depends on site variability and the number of piles to be driven. With respect to with the AASHTO table, the sites of the proposed Center Street structures can be considered to have low variability. For Structure F-717, the minimum number of tests is 4. Additional PDA testing may be necessary if pile driving conditions indicate significant variability in the soil profile at a given abutment or bent.

Pile resistance and driving criteria from PDA testing should be determined from "Beginning of Restrike" conditions. A minimum of 24 hours set-up time will likely be required after initial driving before piles demonstrate the required driving resistance, and additional time may be necessary in some instances.

7.2.1.6 Construction Considerations

Groundwater was encountered within 5 feet of the existing ground surface at the time of drilling, and dewatering will likely be required for construction of pile caps at Bent 2 and other construction activities.

It is recommended that the groundwater be lowered to a depth of 2 feet below the bottom of the excavations. It is anticipated that dewatering can best be achieved using sumps and drain trenches where clay exists at the foundation level, and that shallow wells will be most effective in dewatering foundations founded on granular layers.

Soils at the bottom of excavations may be too soft to provide an adequate working surface. Stabilization methods will depend upon conditions encountered. Moderately soft areas can be stabilized by over excavating the foundation footprint to a depth of about 1 foot, placing a geotextile fabric such as Mirafi 500X or equal and backfilling with compacted sandy gravel. Very soft areas may be stabilized by tamping cobble rock (preferably angular to subangular) into the subgrade as needed. As a minimum, it is recommended that an 8 inch layer of granular borrow be placed below the pile cap to provide a working platform.

Depending upon construction sequence and methods employed, excavation and shoring of embankment preload fill may be necessary. Maximum excavation slopes in compacted granular fill material of 1H:1V can be used for temporary cuts less than 20 feet deep. For temporary cuts between 20 and 30 feet deep, 1.5H:1V cut slopes should be used. The stability of cuts in uncompacted fill and/or natural subgrade soils should be evaluated on a case-by-case basis.

We recommend that preconstruction surveys and vibration monitoring be performed for structures and utilities located within 500 feet of the construction area.

7.2.2 Embankments

Analyses and recommendations for embankments are provided in a separate report by Kleinfelder.

7.2.3 Retaining Walls

Analyses and recommendations for retaining walls are provided in a separate report by Kleinfelder.

7.2.4 Tunnels / Culverts

The Multi-Use Trail undercrossing structure at Center Street (D-842) may be supported on pile foundations using the recommendations of Section 7.2.1 above. Alternatively, consideration may be given to supporting the structure on the clayey natural subgrade soils using the culvert floor as a mat-type foundation. Recommended subgrade parameters for this option are as follows:

Average Undrained Shear Strength: 400 psf
Nominal Bearing Resistance: 2056 psf
Coefficient of Subgrade Reaction: 30 pci

The Strength I Bearing Resistance can be estimated by multiplying the nominal resistance shown above by a resistance factor of 0.50. The bearing resistance values listed herein are applicable to structures placed on the existing subgrade soils prior to placement of roadway embankment fill around the structures. It should be noted that the placement of roadway embankment fill will consolidate subgrade soils, and the clayey and silty soils will gain strength with consolidation. If roadway embankments adjacent to the culverts are constructed in such a manner that loads from the roadway fill weight do not exceed the bearing resistance of the subgrade, bearing resistance will not be critical for the culverts. At some locations, staged construction, lightweight embankment fill, or subgrade reinforcement/modification may be necessary to provide sufficient bearing capacity for the new fill and the buried culverts.

The estimated coefficient of subgrade reaction shown above is for a 12-inch square footing area and is based on typical values for the shallow subgrade soils encountered at the site. The coefficient of subgrade reaction can be increased to 100 pci by over-excavating and placing 12 inches of compacted granular fill beneath the structure.

It is anticipated that significant consolidation settlement may occur due to placement of new roadway embankment at some locations, and that differential and total settlement considerations may control the design of the box culverts. If structures cannot be designed to tolerate the anticipated settlements, it may be advisable to preload the culvert subgrade area with temporary embankment fill, allow consolidation to occur, then excavate the temporary fill to construct the culverts.

7.2.5 Lateral Earth Pressures

Lateral earth pressures can generally be calculated using the equation

$$P = \frac{1}{2} \gamma K H^2$$

Where P = total lateral force on the wall, plf
K = earth pressure coefficient
γ = unit weight of the soil (depends on fill material)
H =height of the wall

The earth pressure coefficient used in designing the walls will depend upon whether the wall is free to move during backfilling operations, or whether the wall is restrained during backfilling. If the wall is free to move away from the soil during backfilling operations, we recommend that an active earth pressure coefficient be used in the above equation to calculate the lateral earth pressures. If the walls are restrained or braced from movement during backfilling (as is generally the case with box culverts and similar structures), we recommend that an at-rest earth pressure coefficient be used to calculate the lateral earth pressures. A passive earth pressure coefficient should be used to calculate the lateral soil resistance where the wall is being pushed toward the soil. It should be recognized that the pressures, calculated by the above equation, are earth pressures only and do not include hydrostatic pressures. Where hydrostatic pressures may exist behind a retaining structure, we recommend either the wall be designed to resist hydrostatic pressure, or that a drainage system be placed behind the wall to prevent the development of hydrostatic pressures.

Lateral earth pressure coefficients and other recommendations for computing lateral earth pressures are included in Appendix D. A general earth pressure coefficient has been provided for calculation of earth pressures where mechanical compaction equipment is expected to be operated near non-yielding walls less than about 8 feet high. This scenario is anticipated during placement of fill around culverts. The residual pressure from compaction equipment can be reduced by limiting the proximity and weight of compacting equipment near culvert walls.

Recommendations based on the Mononobe-Okabe approach for active and passive seismic lateral earth forces are included in Appendix D. For non-yielding walls, recommended equations for calculating the dynamic thrust and dynamic overturning moment are also provided.

8.0 CORROSION INVESTIGATIONS

In order to obtain an indication of the corrosive nature of the subsurface material at these sites, resistivity, pH, sulfate, and chloride tests were performed on soil samples obtained in the Test Holes. The results of these tests are tabulated below:

Test Hole	Depth (ft)	Soil Type	Resistivity ohm-cm	pH	Sulfate (ppm)	Chloride (ppm)
RSB-11-607	5-6.5	Lean Clay	9,084	8.7	1887	602
RSB-11-607	43.5-45	Lean Clay	23,360	7.7	1455	240
RSB-11-607	63.5-65	Sand w/ Silt	18,169	8.3	319	143

The 2006 Interim LRFD specifications state that resistivity less than 2,000 ohm-cm, sulfate concentration greater than 1,000 ppm, and pH less than 5.5 (8.5 in highly organic soils) are all indicative of potential pile corrosion or deterioration. Due to the high resistivity and pH, unusual potential for corrosion/deterioration of steel piles is not anticipated at this site. We recommend that Type II cement be used for concrete. For design of driven piles, it is recommended that 1/16 inch of corrosion be assumed for all surfaces in contact with soil or groundwater. This reduction has been accounted for in the pile analyses described in Section 7.2.1.1.

9.0 LIMITATIONS

The conclusions and recommendations presented in this report are based upon the results of the field and laboratory tests. It should be recognized that soil materials are inherently heterogeneous and that conditions may exist throughout this site which were not defined during this investigation. If during construction, conditions are encountered which appear to be different than those presented in this report, it is requested that we be advised in order that appropriate action may be taken.

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10.0 REFERENCES

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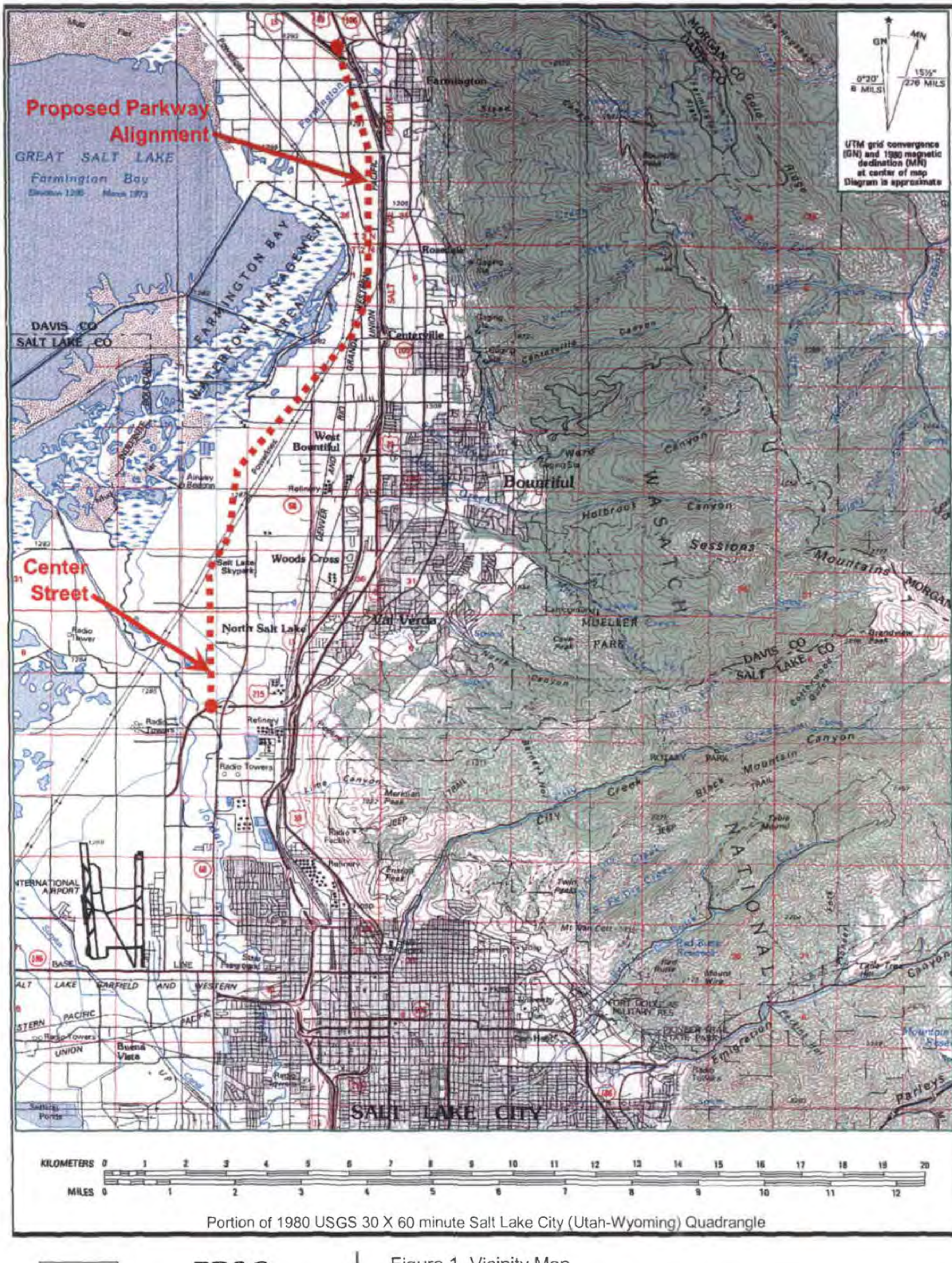
FIGURES



Portion of 1980 USGS 30 X 60 minute Salt Lake City (Utah-Wyoming) Quadrangle

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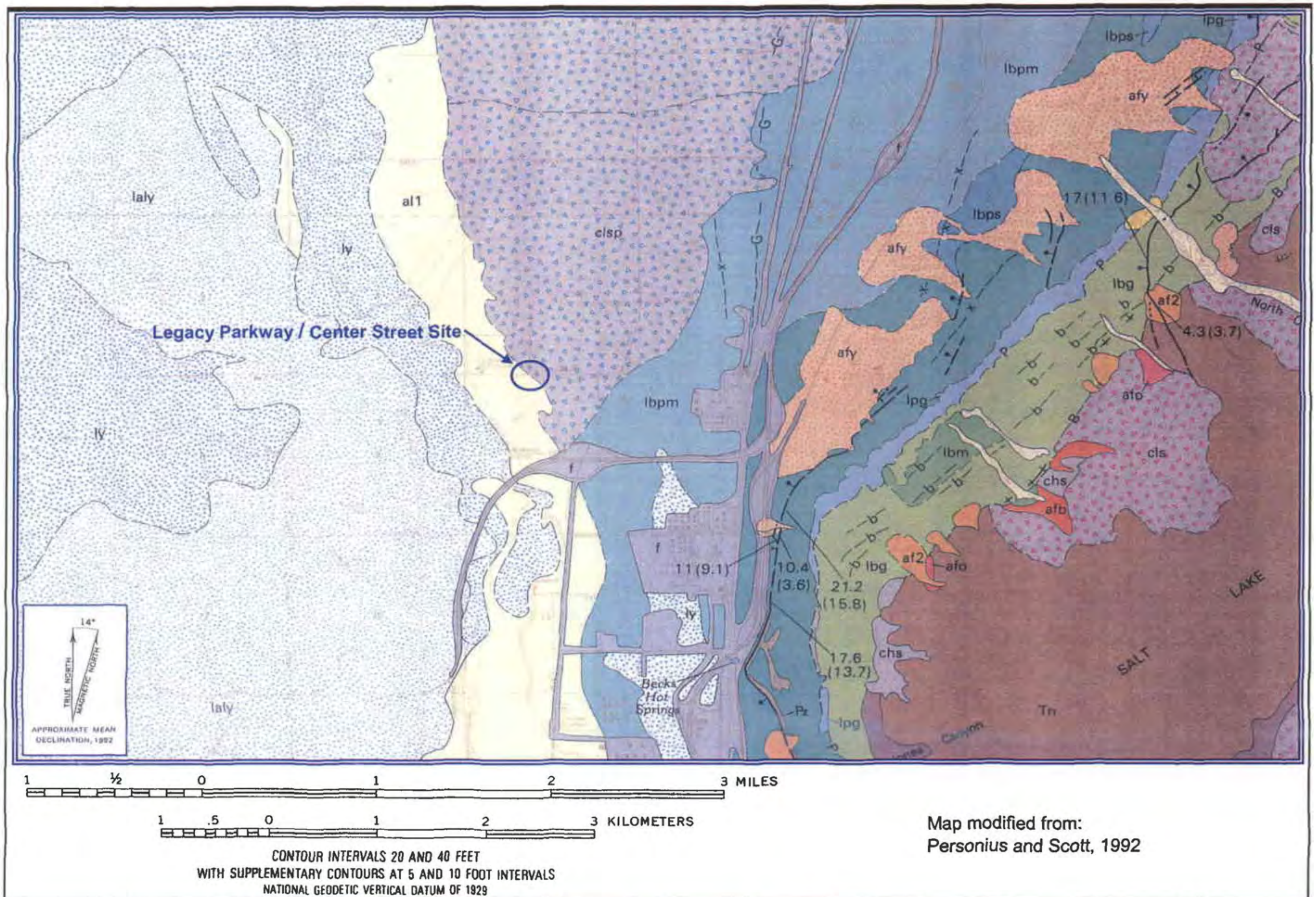
Figure 1 Vicinity Map
Proposed Legacy Parkway Alignment
Legacy Parkway
Salt Lake / Davis Counties, Utah



Map modified from:
Personius and Scott, 1992

RB&G ENGINEERING INC.
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Figure 2 Geologic Map
Center Street Structures
Legacy Parkway
Salt Lake / Davis Counties, Utah

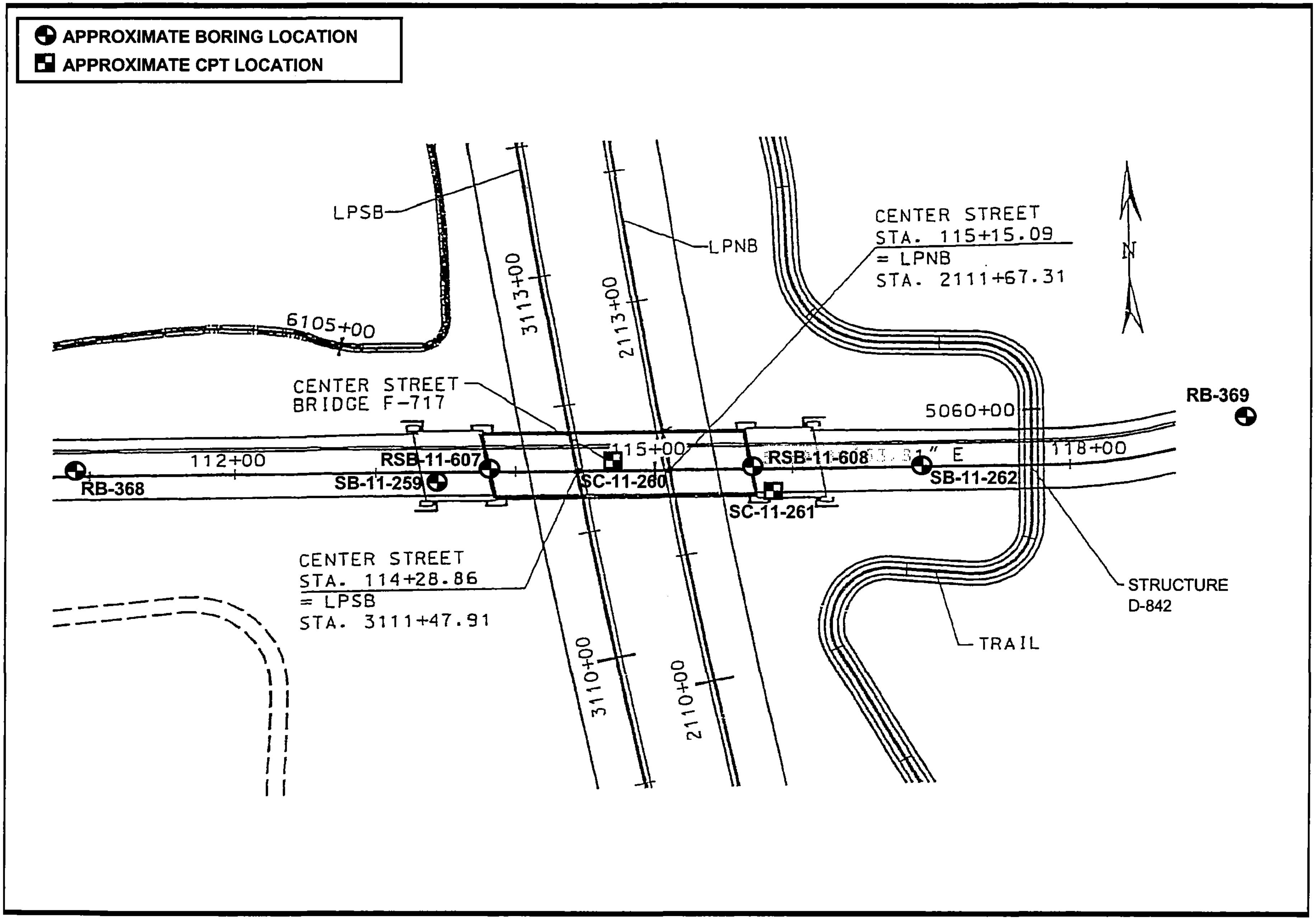

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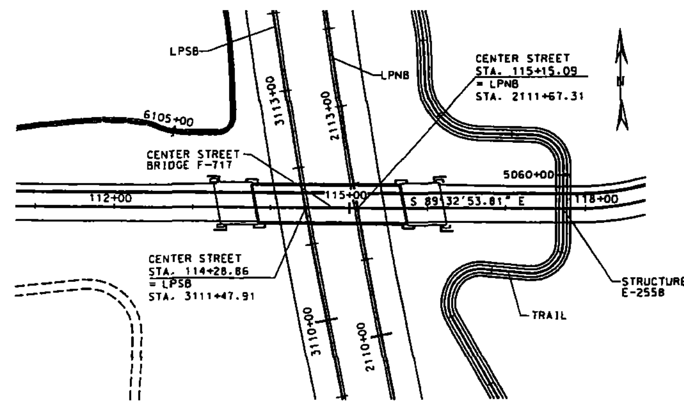
Figure 3 Site Plan and Approximate Test Hole Locations
Center Street Structures
Legacy Parkway
Salt Lake / Davis Counties, Utah

APPENDIX A
Structure Drawings

F-717

Center Street over Legacy Parkway

INDEX OF SHEETS



LOCATION PLAN

GENERAL NOTES

1. USE COATED, DEFORMED BILLET-STEEL BARS CONFORMING TO AASHTO M 284 OR M 111 AND M 31 GRADE 60 FOR ALL REINFORCING STEEL.
2. USE STRUCTURAL STEEL CONFORMING TO AASHTO M 270 GRADE 36 EXCEPT WHERE NOTED OTHERWISE.
3. CHAMFER ALL EXPOSED CONCRETE CORNERS 3/4" EXCEPT WHERE NOTED OTHERWISE.
4. PROVIDE 2" CONCRETE COVER TO REINFORCING STEEL EXCEPT WHERE NOTED OTHERWISE.
5. USE CLASS AA (AE) CAST-IN-PLACE CONCRETE EXCEPT WHERE NOTED OTHERWISE.
6. HORIZONTAL DIMESIONS ARE PLAN. VERICAL DIMENSIONS ARE PLUMB.

DESIGN DATA

HL-93 IN ACCORDANCE WITH 3rd EDITION AASHTO LRFD AND INTERIM SPECIFICATIONS THROUGH 2006.

CAST-IN-PLACE CONCRETE: f'c = 4000 PSI; Fy (REINF.) = 60,000 PSI; n = 8

PRESTRESSED CONCRETE: f'c= 7500 PSI; Fy (NONPRESTRESSED) = 60,000 PSI; n = 6
Fs (PRESTRESSED) = 270,000 PSI

STRUCTURAL STEEL: Fy = 36,000 PSI

WEARING SURFACE: 1/2 " CONCRETE; 35 PSF (FUTURE)

DESIGN SPEED: 35 mph - CENTER STREET
70 mph - LEGACY PARKWAY

SEISMIC DESIGN DATA: SEISMIC DESIGN PER MCEER/ATC 49
(2475 YR. RETURN PERIOD, 3% PE IN 75 YRS.)
Ss = MAX CONSIDERATION EQ GROUND MOTION AT 0.2 = 1.41 g
S1 = MAX CONSIDERATION EQ GROUND MOTION AT 1.0 = 0.59 g
SITE CLASS X

TRAFFIC DATA: 2008 ADT = 3,200 CENTER STREET
2020 ADT = 5,500 CENTER STREET
2020 ADT = 37300 LEGACY PARKWAY NORTHBOUND
2020 ADT = 37300 LEGACY PARKWAY SOUTHBOUND

PARAPET TEST LEVEL: TL-3

PRELIMINARY
NOT FOR CONSTRUCTION

BRIDGE LOAD RATING

	HL-93	
	RATING	LOCATION
INV.	1.12	46.53'
OPER.	1.49	83.75'

F DENOTES RATING CONTROLLED BY FLEXURE
S DENOTES RATING CONTROLLED BY SHEAR
My AT XX.XX' = XXX.X K-FT
Vy AT XX.XX' = XXX.X KIPS

QUANTITIES

ITEM	ESTIMATED	UNIT	AS CONSTRUCTED
GRANULAR BACKFILL BORROW (PLAN QUANTITY)	177.0	CU. YDS.	
PILE DRIVING EQUIPMENT	1	LUMP	
DRIVEN PILES (16 INCH)	5,264	FT.	
STRUCTURAL CONCRETE (SUBSTRUCTURE EST. LUMP QTY 433.4 CU. YDS.)	1	LUMP	
STRUCTURAL CONCRETE (SUPERSTRUCTURE EST. LUMP QTY 1970.8 CU. YDS.)	1	LUMP	
REINFORCING STEEL (EPOXY COATED)	333725.1	LBS.	
PRESTRESSED CONCRETE MEMBERS (93'-0") TYPE V	12	EACH	
STRUCTURAL STEEL (EST. LUMP QTY. XXX LBS.)	1	LUMP	
ELECTRICAL WORK - BRIDGES	1	LUMP	
PEDESTRIAN FENCE	577.1	FT.	

REVISIONS

NO. DATE BY REMARKS

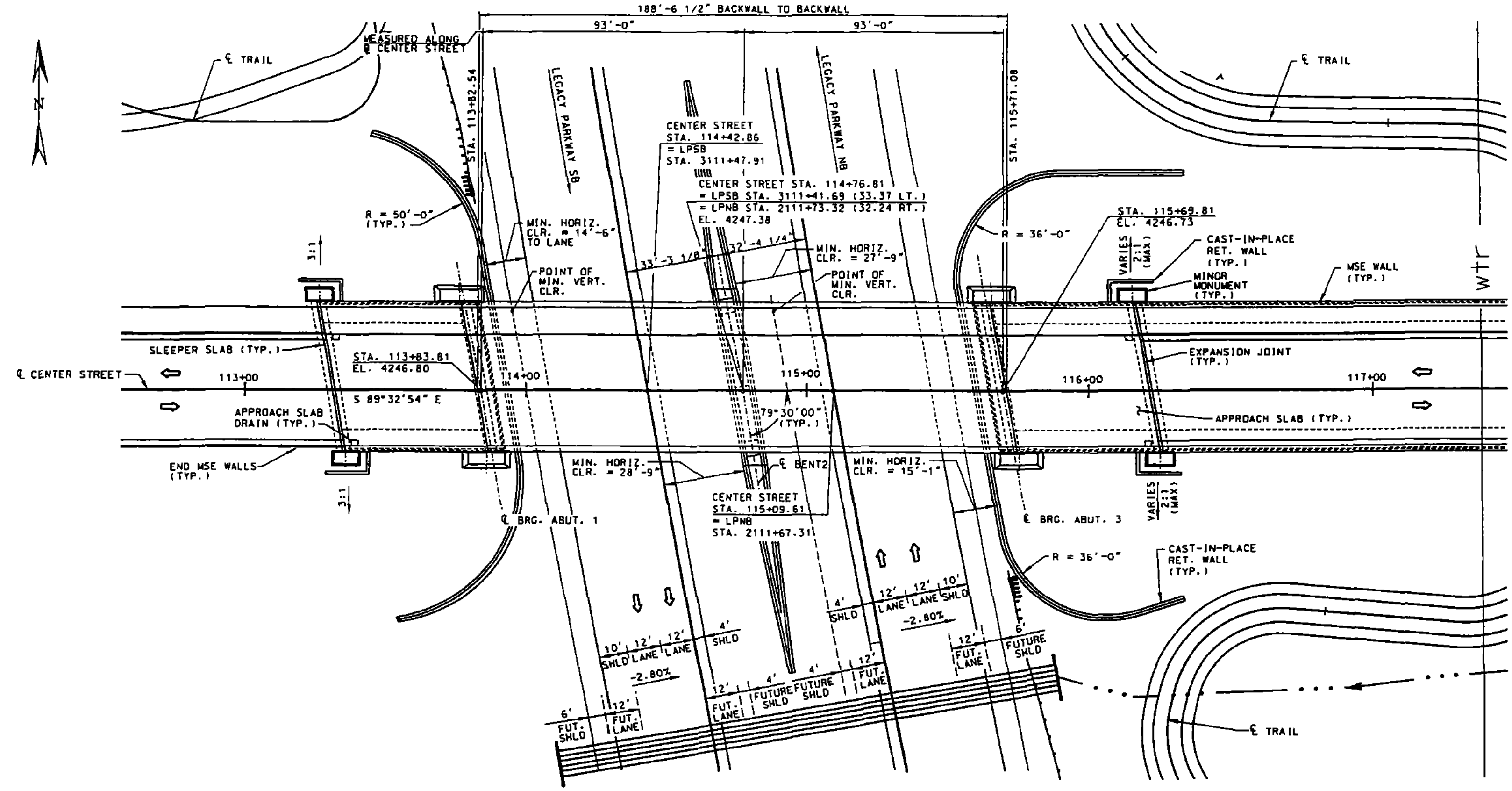
UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
STRUCTURES DIVISION

DESIGN DVP 6/06 CHECK SKD 6/06
DRAWN JBH 6/06 CHECK DVP 6/06
QUANT. DVP 6/06 CHECK SKD 6/06

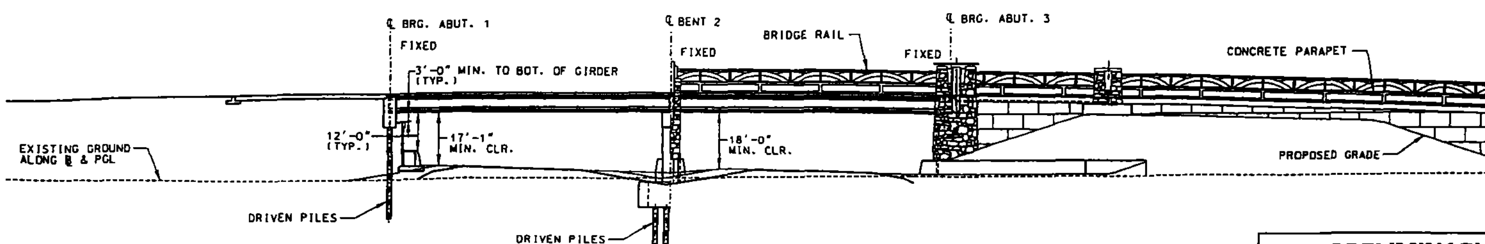
APPROVAL RECOMM. ____ DATE ____ SENIOR DESIGN ENGINEER
APPROVED ____ DATE ____ UDOT BRIDGE ENGINEER

LEGACY PARKWAY
CENTER ST OVER LEGACY PKWY
SITUATION & LAYOUT 1
PROJECT NUMBER SP-0067(5)0

SL / DAVIS
COUNTY
F-717
BRIDGE NO.
SHT. 1 OF 50



PLAN



ELEVATION

PRELIMINARY
NOT FOR CONSTRUCTION

UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
STRUCTURES DIVISION

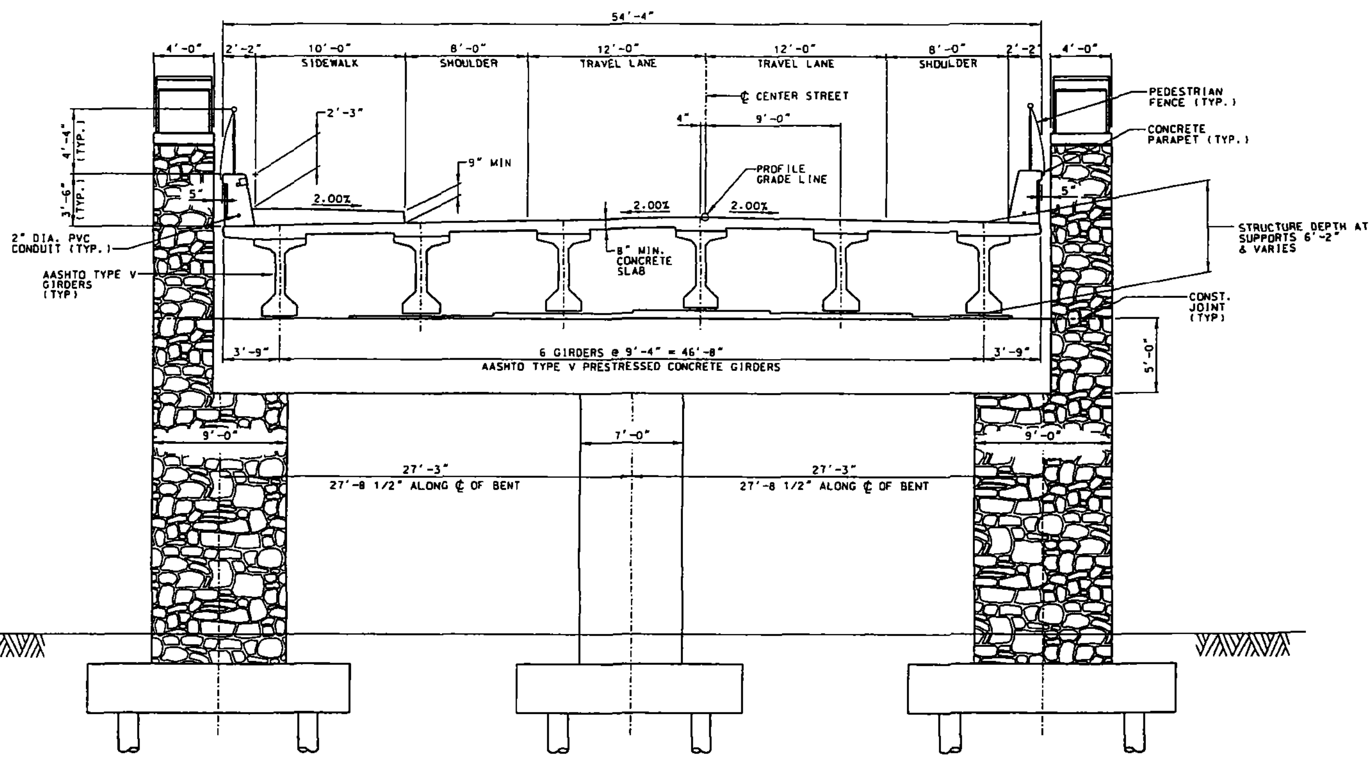
DESIGN	DVP 6/06	CHECK	SKD 6/06
DRAWN	JBH 6/06	CHECK	DVP 6/06
QUANT.	DVP 6/06	CHECK	SKD 6/06

APPROVAL RECOMM. — SENIOR BRIDGE DESIGN ENGINEER — DATE
APPROVED — UDOT BRIDGE ENGINEER — DATE

REVISIONS: NO. | DATE | BY | REMARKS

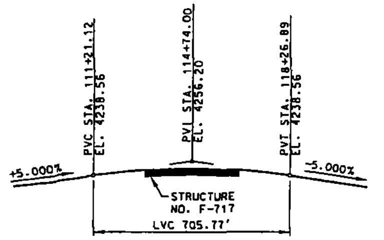
LEGACY PARKWAY
CENTER ST OVER LEGACY PKWY
SITUATION & LAYOUT 2
PROJECT NUMBER SP-0067(5)0

SL / DAVIS
COUNTY
F-717
BRIDGE NO.
SHT. 2 OF 50

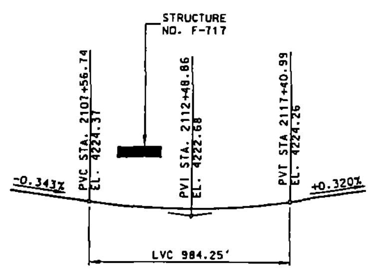


SECTION THRU STRUCTURE

LOOKING UP STATION



"C" LINE (CENTER STREET) PROFILE

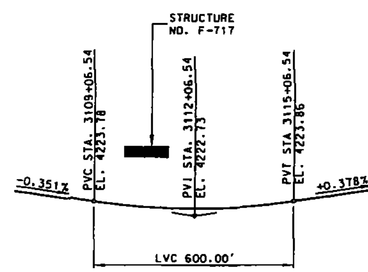


LPNB PROFILE

CURVE DATA

(1-LPNB-05)

Δ = 11°39'47" RT
R = 7183.73'
L = 1462.32'
T = 733.69'
PI STA. 2116+57.99
PC STA. 2109+24.30
PT STA. 2123+86.61



LPSB PROFILE

CURVE DATA

(1-LPSB-05)

Δ = 12°01'59" RT
R = 7250.66'
L = 1522.77'
T = 764.20'
PI STA. 3116+07.62
PC STA. 3108+43.42
PT STA. 3123+66.19

PRELIMINARY
NOT FOR CONSTRUCTION

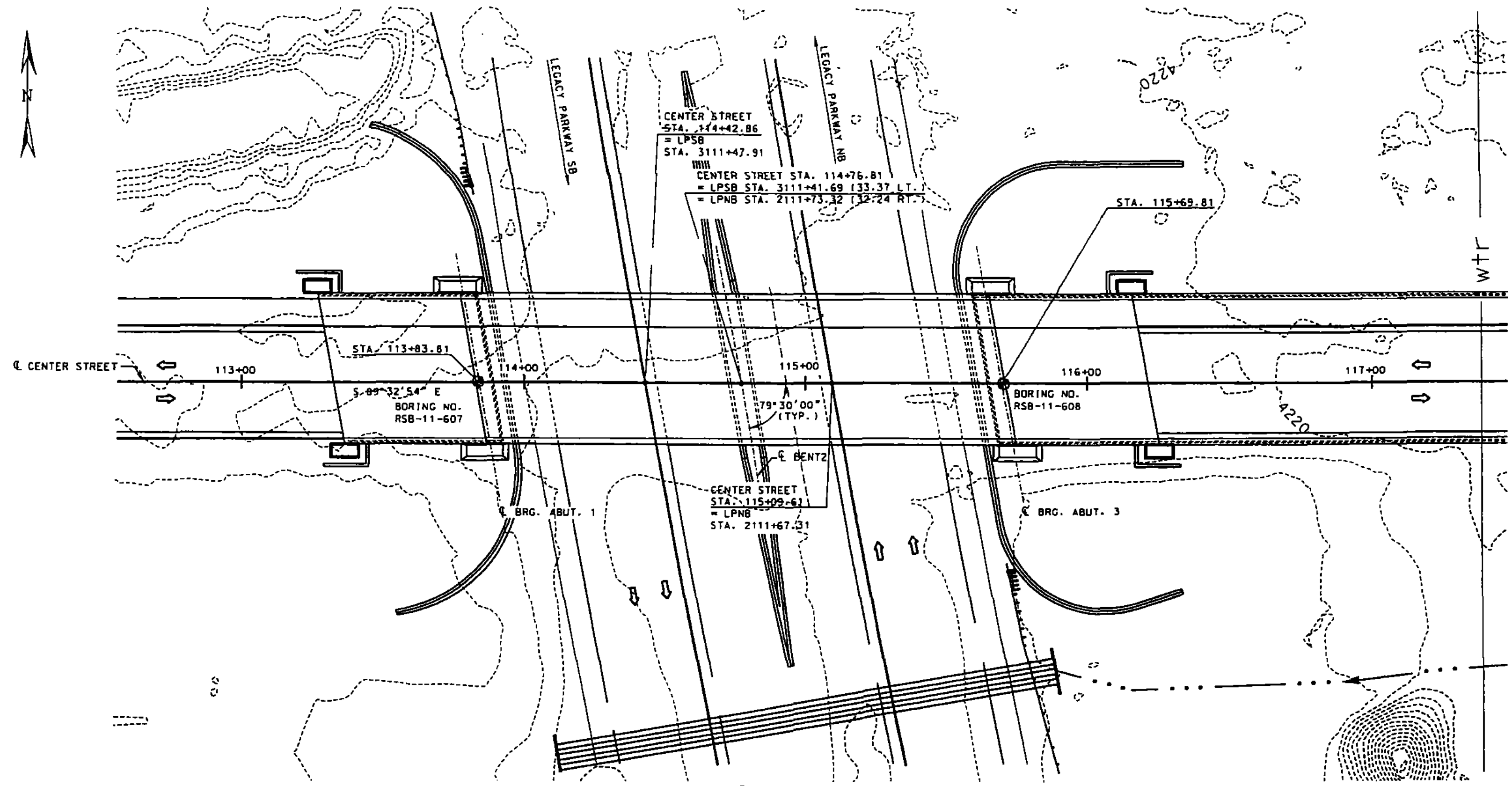
UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
STRUCTURES DIVISION

DESIGN DVP 6/06 CHECK SKD 6/06
DRAWN JBH 6/06 CHECK DVP 6/06
QUANT. DVP 6/06 CHECK SKD 6/06

REVISIONS

LEGACY PARKWAY
CENTER ST OVER LEGACY PKWY
SITUATION & LAYOUT 3
PROJECT NUMBER SP-0067(510)

SL / DAVIS
COUNTY
F-717
BRIDGE NO.
SHT. 3 OF 50



PLAN

PRELIMINARY
NOT FOR CONSTRUCTION

REVISIONS

NO.	DATE	BY	REMARKS

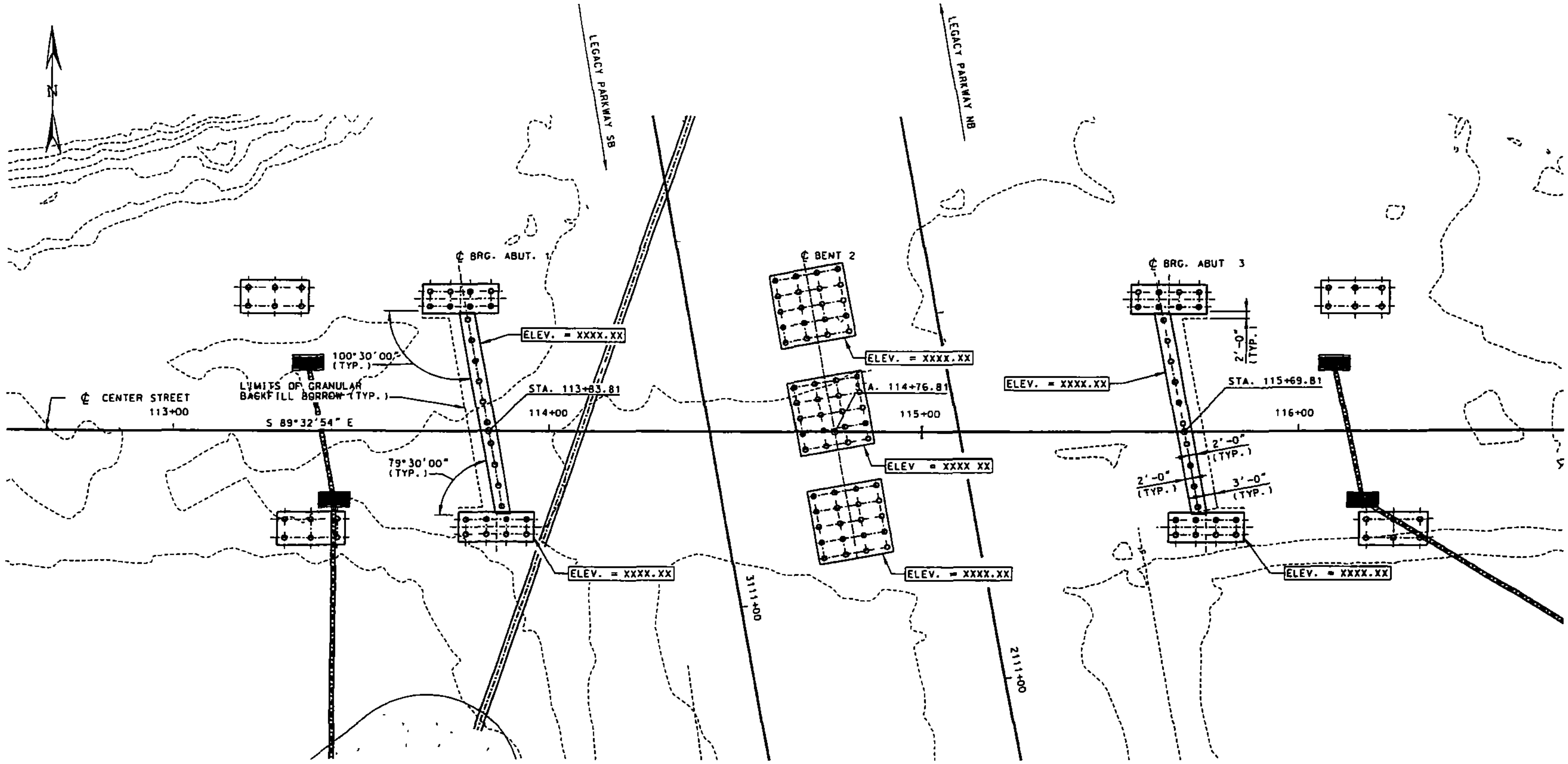
UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
STRUCTURES DIVISION

DESIGN DVP 6/06	CHECK SKD 6/06	APPROVAL RECOM.	DATE
DRAWN BAH 6/06	CHECK DVP 6/06	SENIOR DESIGN ENGINEER	
QUANT. DVP 6/06	CHECK SKD 6/06	APPROVED	DATE
		UDOT BRIDGE ENGINEER	

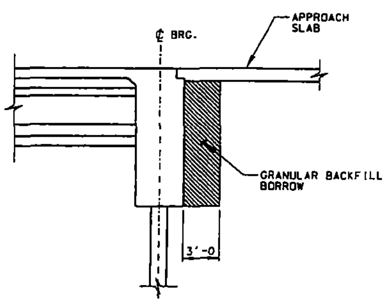
LEGACY PARKWAY
CENTER ST OVER LEGACY PKWY
BORING LOCATIONS

PROJECT NUMBER SP-0067(5)0

SL / DAVIS
COUNTY
F-717
BRIDGE NO.
SHT. 4 OF 50



PLAN



NOTE:
GRANULAR BACKFILL BORROW LIMITS EXTEND FROM BOTTOM OF ABUTMENT TO BOTTOM OF APPROACH SLAB.

GRANULAR BACKFILL BORROW PAY LIMITS

PRELIMINARY
NOT FOR CONSTRUCTION

NOTES

1. ELEVATIONS AT BOTTOM OF ABUTMENTS, MONUMENTS AND BENTS ARE SHOWN THUS: ELEV. = XXXX.XX
2. ALL PILES ARE 16 INCH DIAMETER. DRIVE IN ORIENTATION SHOWN.
3. ALL ABUTMENTS AND BENTS ARE PARALLEL TO BRG. N 10°02'44" W.

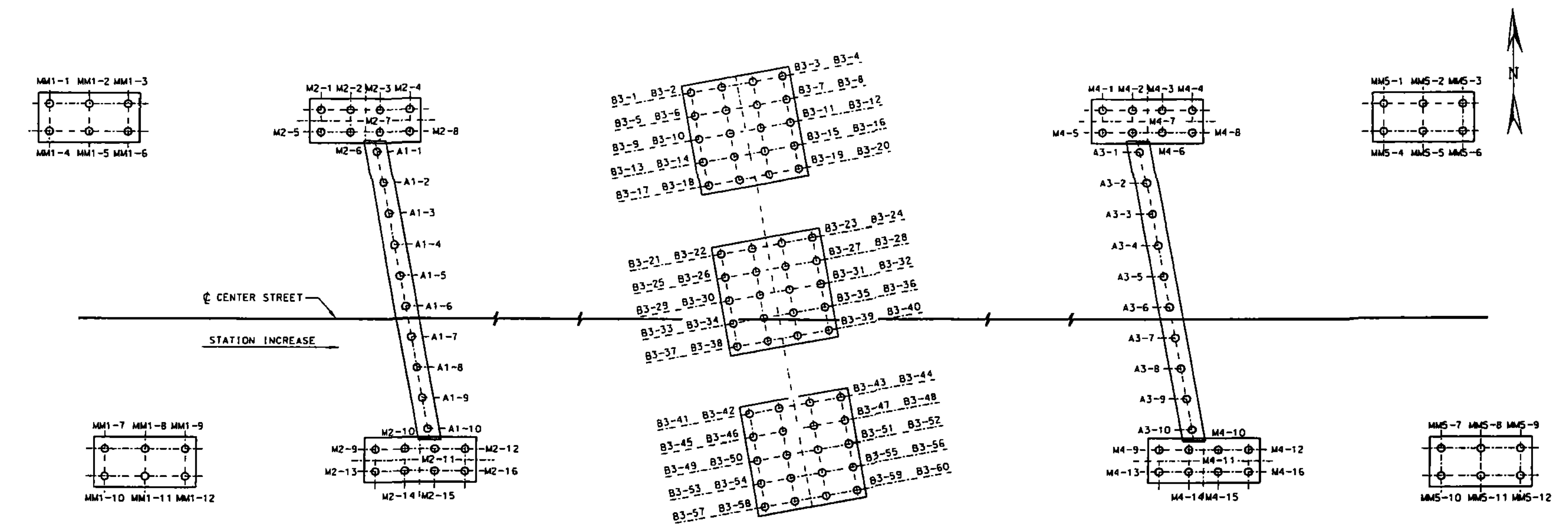
UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
STRUCTURES DIVISION

DESIGN DVP 6/06 CHECK SKD 6/06
DRAWN JLH 6/06 CHECK DVP 6/06
QUANT DVP 6/06 CHECK SKD 6/06

REVISIONS

LEGACY PARKWAY
CENTER ST OVER LEGACY PKWY
FOUNDATION PLAN
PROJECT NUMBER SP-0067(5)0

SL / DAVIS
COUNTY
F-717
BRIDGE NO.
SHT 5 OF 50



PLAN MINOR MONUMENTS ABUTMENT 1

PLAN ABUTMENT 1

PLAN BENT 1

PLAN ABUTMENT 3

PLAN MINOR MONUMENTS ABUTMENT 3

ABUTMENT 1 (MONUMENTS) AS-CONSTRUCTED PILE TIP ELEV.	
M1-1	
M1-2	
M1-3	
M1-4	
M1-5	
M1-6	
M1-7	
M1-8	

ABUTMENT 1 AS-CONSTRUCTED PILE TIP ELEV.	
A1-1	
A1-2	
A1-3	
A1-4	
A1-5	
A1-6	
A1-7	
A1-8	
A1-9	
A1-10	

BENT 2 AS-CONSTRUCTED PILE TIP ELEV.	
B2-1	
B2-2	
B2-3	
B2-4	
B2-5	
B2-6	
B2-7	
B2-8	
B2-9	
B2-10	
B2-11	
B2-12	
B2-13	
B2-14	
B2-15	
B2-16	
B2-17	
B2-18	

BENT 2 AS-CONSTRUCTED PILE TIP ELEV.	
B2-19	
B2-20	
B2-21	
B2-22	
B2-23	
B2-24	
B2-25	
B2-26	
B2-27	
B2-28	
B2-29	
B2-30	
B2-31	
B2-32	
B2-33	
B2-34	
B2-35	
B2-36	

ABUTMENT 3 AS-CONSTRUCTED PILE TIP ELEV	
A3-1	
A3-2	
A3-3	
A3-4	
A3-5	
A3-6	
A3-7	
A3-8	
A3-9	
A3-10	

ABUTMENT 1 (MONUMENTS) AS-CONSTRUCTED PILE TIP ELEV.	
M3-1	
M3-2	
M3-3	
M3-4	
M3-5	
M3-6	
M3-7	
M3-8	

PRELIMINARY
NOT FOR CONSTRUCTION

REVISIONS
NO. DATE BY REMARKS

UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
STRUCTURES DIVISION

DESIGN DVP 6/06 CHECK SKD 6/06
DRAWN JLH 6/06 CHECK DVP 6/06
QUANT. DVP 6/06 CHECK SKD 6/06

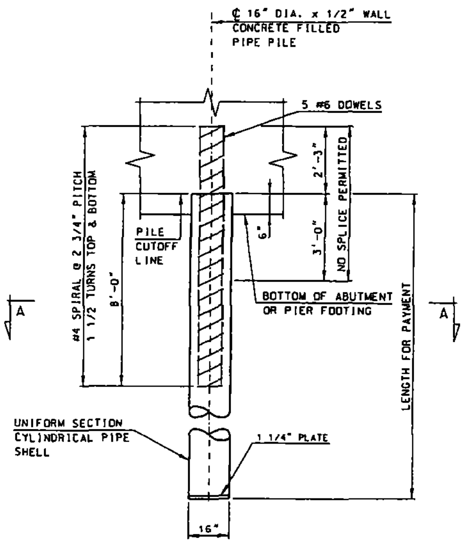
APPROVAL RECOMM. ____ SENIOR DESIGN ENGINEER ____ DATE
APPROVED ____ UDOT BRIDGE ENGINEER ____ DATE

LEGACY PARKWAY
CENTER ST OVER LEGACY PKWY
PILING PLAN

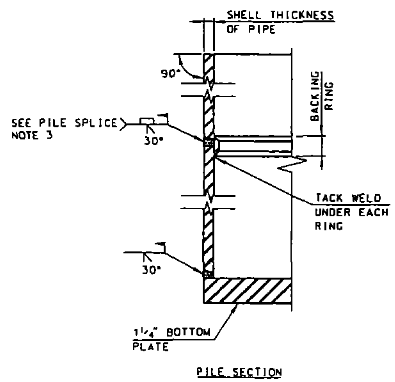
PROJECT NUMBER SP-0067(5)0

SL / DAVIS
COUNTY
F-717
BRIDGE NO.
SHT. 6 OF 50

6/2/2006 3:10:25 PM $USER$ T:\BRIDGES\SLC\LEGACY\PROJECTS\REVIEWERS\L\ORGN\F717_PILEPLN.DGN



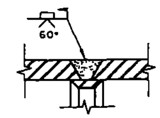
PIPE PILE DETAIL

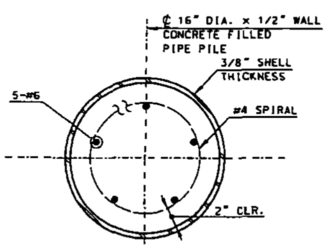


PILE SPLICE AND BOTTOM PLATE DETAILS

PILE SPLICE AND BOTTOM PLATE NOTES:

1. PROVIDE EACH BACKING RING WITH EQUALLY SPACED PINS.
2. CONFORM TO THE AASHTO/AWS BRIDGE WELDING CODE.
3. USE THE FOLLOWING WELD FOR FLAT WELD POSITION:





SECTION A-A

NOTES:

1. FILL PILE SHELLS WITH CLASS "A(AE)" CONCRETE. f'c = 3000 psi.
2 HOLD THE REINFORCING STEEL ADEQUATELY IN FINAL POSITION DURING PLACEMENT OF CONCRETE AROUND BARS.
3. PROVIDE PIPE MATERIAL CONFORMING TO ASTM A252 GRADE 3. Fy = 45 ksi.
4. NOTIFY THE DEPARTMENT AT LEAST FIVE WORKING DAYS PRIOR TO DRIVING PILES.
5. PROVIDE UNCOATED REINFORCEMENT FOR PLACEMENT INTO PILES.
6. MONITOR THE INSTALLATION OF ONE PILE AT ABUTMENT NO. 1 USING A PILE DRIVING ANALYZER (PDA).

PILE DATA

LOCATION	PILE DIAMETER (IN)	PILE SHELL THICKNESS (IN)	ESTIMATED PILE TIP ELEVATION (FT)	ELEVATION OF MIN. ACCEPTABLE PILE PENETRATION (FT)	STRENGTH I PILE LOAD (KIPS)	SERVICE I PILE RESISTANCE (KIPS)	STRENGTH I PILE RESISTANCE (KIPS)	ULTIMATE PILE RESISTANCE (KIPS)	MAXIMUM DRIVING LOAD (KIPS)	REQUIRED DRIVING RESISTANCE (KIPS)
ABUT. NO. 1	16	3/8	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
BENT NO. 2	16	3/8	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
ABUT. NO. 3	16	3/8	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX

* A FACTORED DOWNDRAG OF XXX KIPS IS NOT INCLUDED.
** A FACTORED DOWNDRAG OF XXX KIPS IS INCLUDED. THIS INCLUDES A FACTOR OF 1.3.

PRELIMINARY
NOT FOR CONSTRUCTION

UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
STRUCTURES DIVISION

DESIGN DVP 6/06 CHECK SKD 6/06
DRAWN JLH 6/06 CHECK DVP 6/06
QUANT DVP 6/06 CHECK SKD 6/06

REVISIONS

LEGACY PARKWAY
CENTER ST OVER LEGACY PKWY
DRIVEN PILE DETAILS
PROJECT NUMBER SP-0067(5)0

SL / DAVIS
COUNTY
F-717
BRIDGE NO.
SHT. 7 OF 50

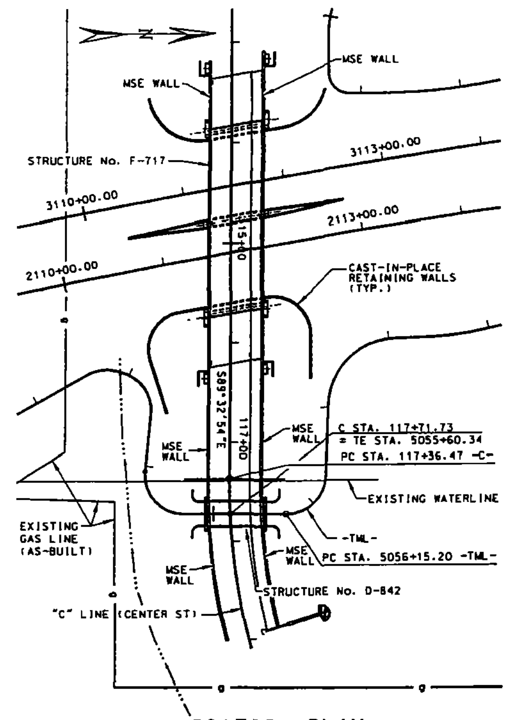
D-842

Center Street over Multi-Use Trail

INDEX OF SHEETS

QUANTITIES

ITEM	QUANT.	UNIT	AS CONST.
STRUCTURAL CONCRETE (EST. QTY. 195 CY)	1	LS	
REINFORCING STEEL (COATED)	48750	LB	
GRANULAR BACKFILL BORROW	XX	CY	
PILE DRIVING EQUIPMENT	1	LS	
DRIVEN PILES	X	FT	



LOCATION PLAN

GENERAL NOTES

1. USE COATED, DEFORMED BILLET-STEEL BARS IN ACCORDANCE WITH ASTM A615, GRADE 60. EPOXY COATED IN ACCORDANCE WITH AASHTO M 284.
2. PROVIDE STEEL FOR DRIVEN PIPE PILES CONFORMING TO ASTM A-252, GRADE 3. Fy= 45,000 PSI.
3. PROVIDE 2 INCH COVER TO REINFORCING STEEL EXCEPT WHERE NOTED OTHERWISE
4. CHAMFER EXPOSED CONCRETE CORNERS 3/4 INCH EXCEPT WHERE NOTED OTHERWISE.
5. USE CLASS AA (AE) CAST-IN-PLACE CONCRETE.
6. ALL DIMENSIONS ARE IN FEET AND INCHES. ALL STATIONS AND ELEVATIONS ARE IN FEET.
7. SEE ROADWAY PLANS FOR TRAIL DETAILS.
8. DRAWINGS ARE NOT TO SCALE. HORIZONTAL DIMENSIONS ARE PLAN DIMENSIONS AND VERTICAL DIMENSIONS ARE PLUMB.
9. PROVIDE GRANULAR BACKFILL BORROW TO MEET UDOT'S CRITERIA FOR FREE DRAINING GRANULAR BACKFILL BORROW. SPECIFICATION 02061

DESIGN DATA

HL-93 IN ACCORDANCE WITH 3rd EDITION AASHTO LRFD AND INTERIM SPECIFICATIONS THROUGH 2006.

CAST-IN-PLACE CONCRETE: f'c = 4000 PSI: Fy (REINF) = 60,000 PSI: n = 8

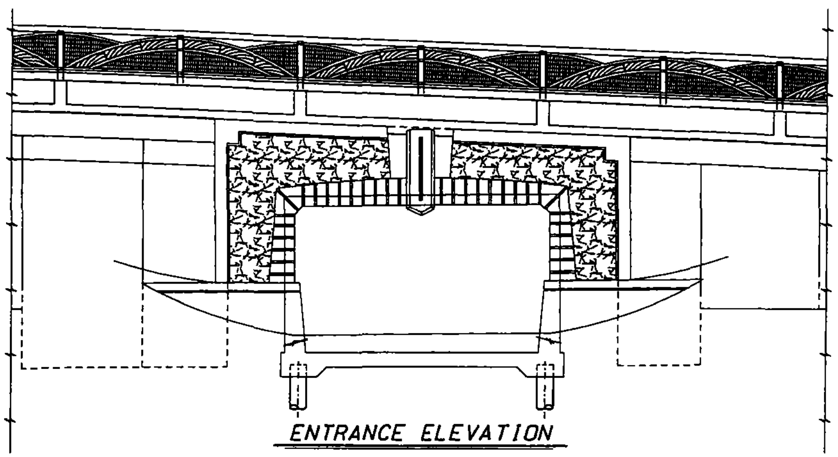
DESIGN MAXIMUM COVER = 5.23'

DESIGN MINIMUM COVER = 2.02'

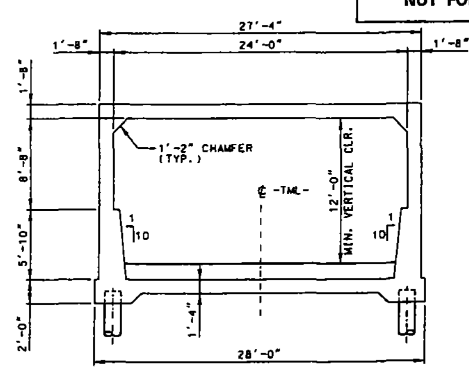
SOIL DRY UNIT WEIGHT = XX #/CF

SOIL SUBMERGED UNIT WEIGHT = XX #/CF

PRELIMINARY
NOT FOR CONSTRUCTION



ENTRANCE ELEVATION



SECTION THRU STRUCTURE

REVISIONS

NO.	DATE	BY	REMARKS

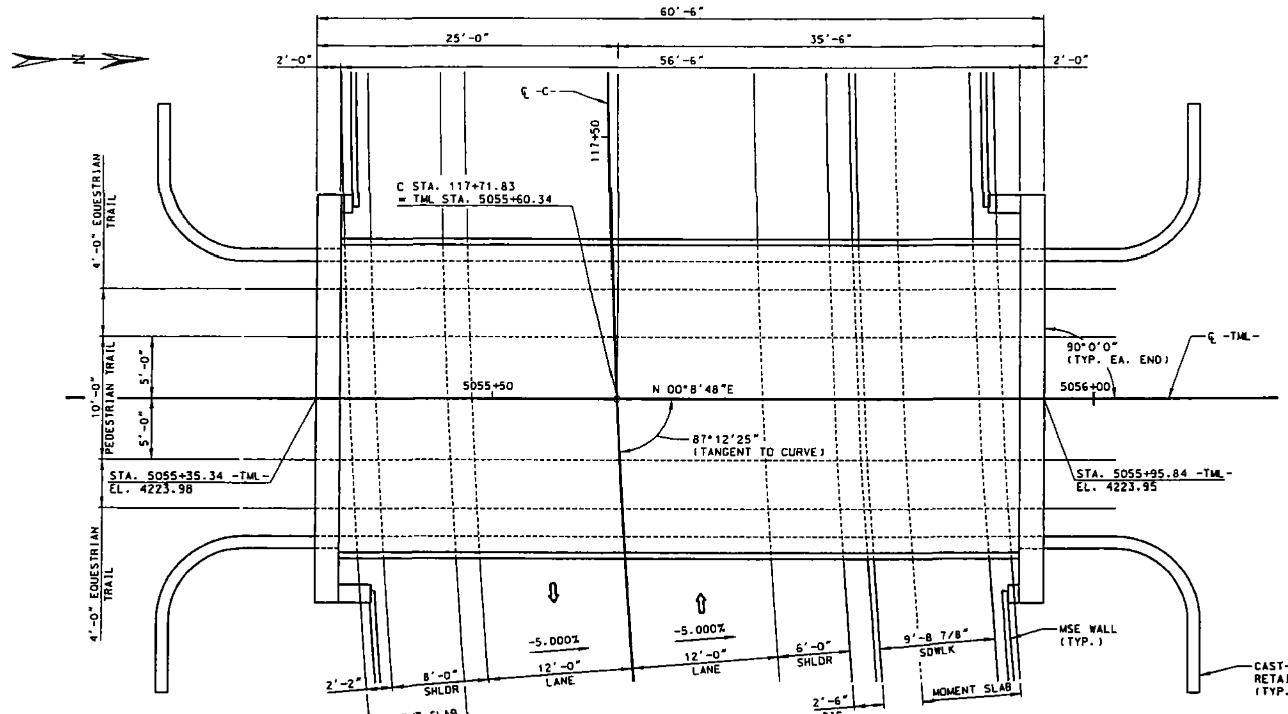
UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
STRUCTURES DIVISION

DESIGN JBT 6/06 CHECK DVP 6/06
DRAWN BAH 6/06 CHECK JBT 6/06
QUANT JBT 6/06 CHECK DVP 6/06

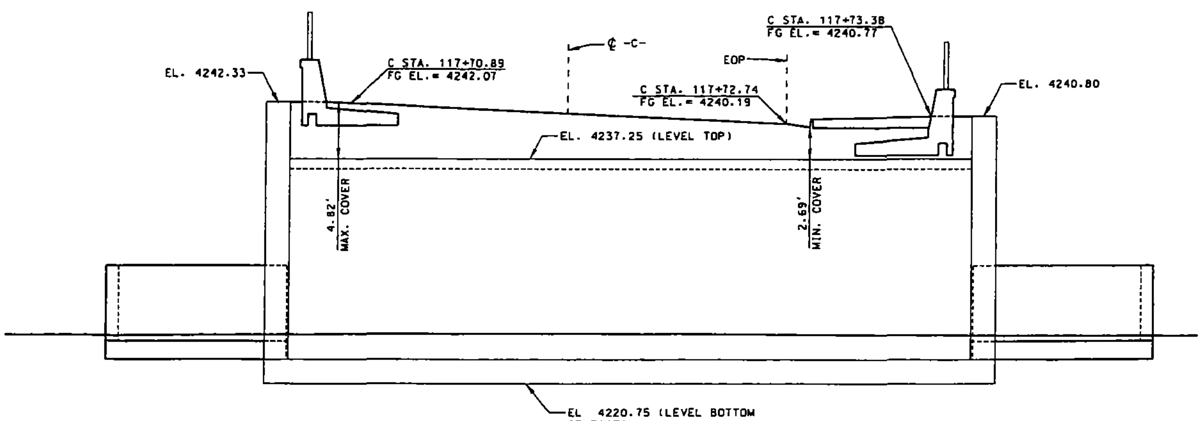
APPROVAL RECOMM. ____ DATE ____ SENIOR DESIGN ENGINEER
APPROVED ____ DATE ____ UDOT BRIDGE ENGINEER

LEGACY PARKWAY
CENTER ST. OVER MULTI-USE TRAIL
SITUATION LAYOUT 1
PROJECT NUMBER SP-0067(5)0

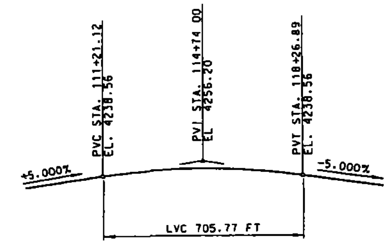
SL / DAVIS
COUNTY
D-842
DRG. NO.
SHT. 1 OF X



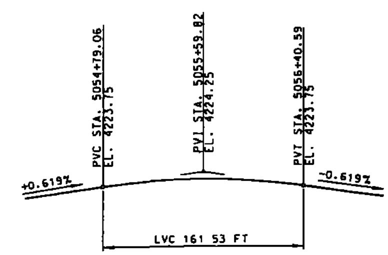
PLAN



LONGITUDINAL SECTION ALONG -TML-



C PROFILE



TML PROFILE

CURVE DATA

C-03

Δ = 18°13'13" LT
R = 654.00'
L = 207.98'
T = 104.87'
PI STA. 118+41.34
PC STA. 117+36.47
PT STA. 119+44.44

PRELIMINARY
NOT FOR CONSTRUCTION

	LEFT		RIGHT	
C STATION	GRADE	MODE	GRADE	MODE
117+36.470	-3.000%	LINEAR	+3.000%	LINEAR
117+77.000	-5.000%	CONSTANT	+5.000%	CONSTANT

SUPERELEVATION TABLE

REVISIONS

NO.	DATE	BY	REMARKS

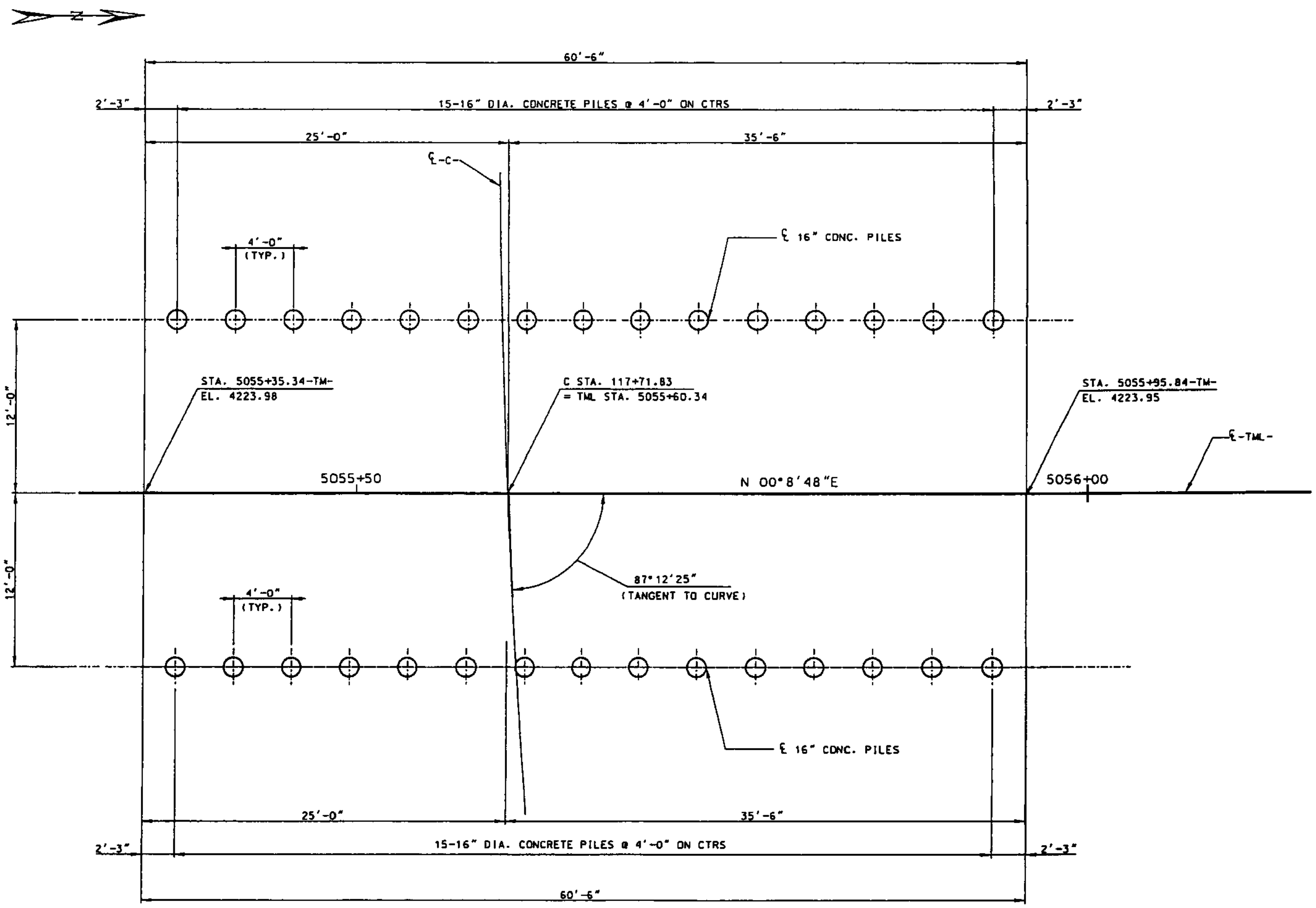
UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
STRUCTURES DIVISION

DESIGN JBT 6/06 — CHECK DVP 6/06
DRAWN JLG 6/06 — CHECK JBT 6/06
QUANT JBT 6/06 — CHECK DVP 6/06

APPROVAL RECOMM. — DATE — SENIOR DESIGN ENGINEER
APPROVED — DATE — UDOT BRIDGE ENGINEER

LEGACY PARKWAY
CENTER ST. OVER MULTI-USE TRAIL
SITUATION & LAYOUT 2
PROJECT NUMBER SP-0067(510)

SL / DAVIS
COUNTY
D-842
DRG. NO
SHT 2 OF X



PLAN

PILE DATA					
LOCATION	PILE SIZE (IN)	ESTIMATED PILE TIP ELEVATION (FT)	MINIMUM PILE TIP ELEVATION (FT)	SERVICE LOAD (DL + LL) PER PILE (KIP)	REQUIRED DRIVING RESISTANCE (KIP)
ABUT 1	16	XXXX.X	XXXX.X	160	XXX
ABUT 2	16	XXXX.X	XXXX.X	160	XXX

PRELIMINARY
NOT FOR CONSTRUCTION

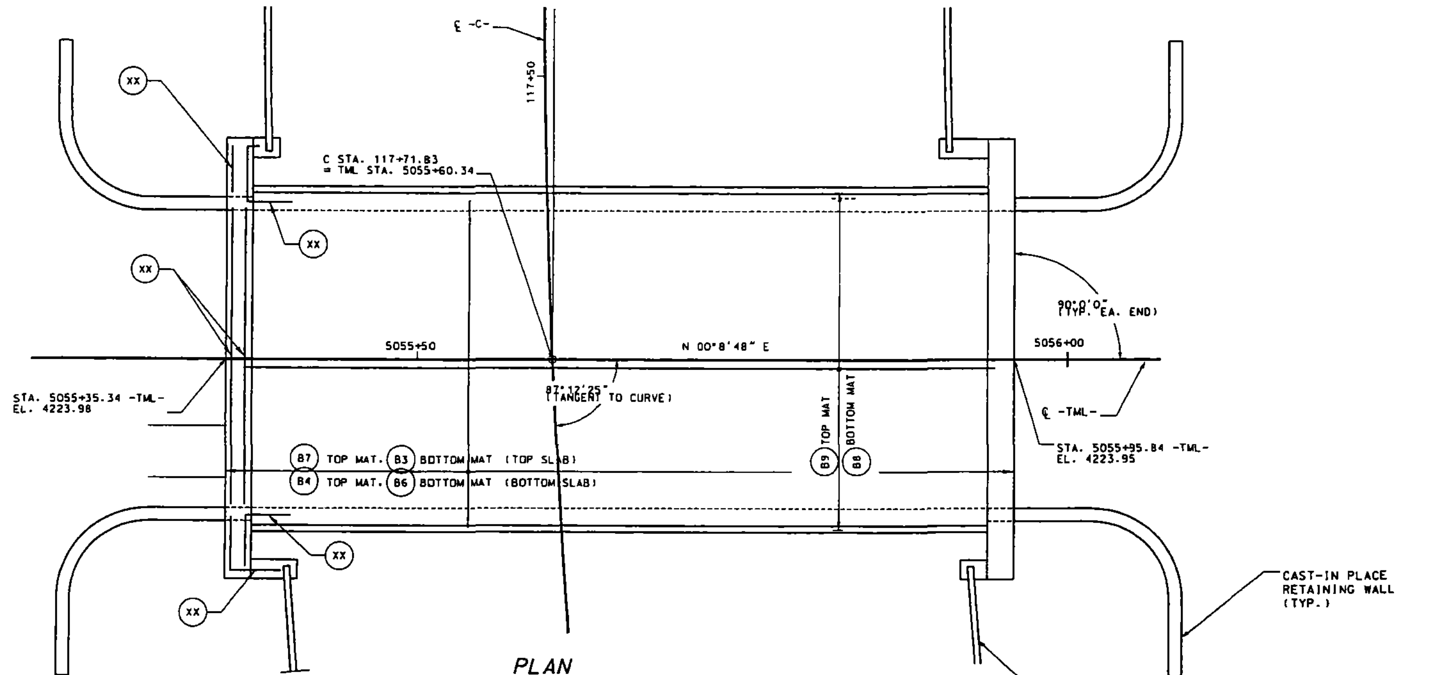
UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
STRUCTURES DIVISION

DESIGN VLC 6/06 CHECK XXX 6/06
DRAWN STM 6/06 CHECK XXX 6/06
QUANT XXX 6/06 CHECK XXX 6/06

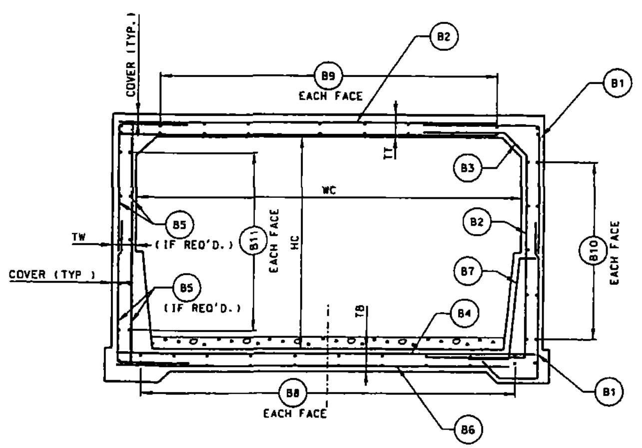
REVISIONS

LEGACY PARKWAY
CENTER ST. OVER MULTI-USE TRAIL
FOUNDATION PLAN
PROJECT NUMBER SP-0067(5)0

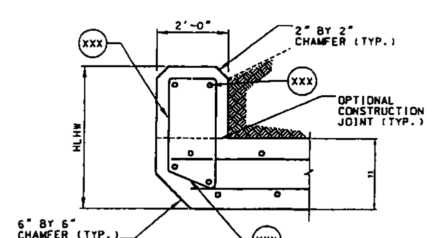
SL / DAVIS
COUNTY
D-842
BRIDGE NO.
SHT 4 OF X



PLAN



SECTION THRU STRUCTURE



LEFT HEADWALL SECTION

(RIGHT HEADWALL SIMILAR)

PRELIMINARY
NOT FOR CONSTRUCTION

NOTES:

1. DESIGN SPECIFICATION: AASHTO LRFD 2004 W/ 2005, 2006 INTERIMS
   DESIGN LOADING: HL-93
   REINFORCING STEEL: ASTM A615/A615-96a
   SURFACE TREATMENT: ALL CONCRETE SURFACE SHALL RECEIVE A GENERAL SURFACE FINISH
2. SEE ROADWAY PLANS FOR TUNNEL LOCATION, ROADWAY SKEW ANGLE AND ROADWAY CROSS SECTION.
3. DURING CONSTRUCTION PROVIDE SUPPORT FOR LOADS IN EXCESS OF AASHTO HL-93
4. SPACE BARS B8 (TOP) AND B9 (BOTTOM) WITH A BAR IN EACH CORNER AND THE REMAINING BARS PLACED AT EQUAL SPACING.
5. PLACE BARS B10 AT EVEN SPACES BETWEEN CORNER BARS B8 (TOP) AND B9 (BOTTOM).

NO.	DATE	BY	REMARKS
			REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
STRUCTURES DIVISION

DESIGN VLC 6/06	CHECK XXX 6/06	
DRAWN STM 6/06	CHECK XXX 6/06	
QUANT XXX 6/06	CHECK XXX 6/06	

APPROVAL RECOMM. — DATE — SENIOR DESIGN ENGINEER
APPROVED — DATE — UDOT BRIDGE ENGINEER

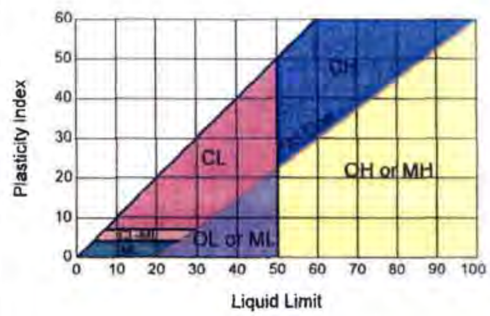
LEGACY PARKWAY
CENTER ST. OVER MULTI-USE TRAIL
BRIDGE DETAILS
PROJECT NUMBER SP-0067(5)10

SL / DAVIS
COUNTY
D-842
BRIDGE NO.
SHT 5 OF X

APPENDIX B
Test Hole Logs

Unified Soil Classification System

Major Divisions			Group Symbols	Typical Names	Laboratory Classification Criteria		
COARSE-GRAINED SOILS *more than half of material is larger than No. 200 sieve*	**Gravels** *more than half of coarse fraction is larger than No. 4 sieve size*	**Clean Gravels** *little or no fines*	GW	Well graded gravels, gravel-sand mixtures, little or no fines	*For laboratory classification of coarse-grained soils*	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines	Determine percentage of gravel and sand from grain-size curve. Depending on percentage of fines (*fraction smaller than No. 200 sieve size*), coarse-grained soils are classified as follows: **Less than 5%** GW, GP, SW, SP **More than 12%** GM, GC, SM, SC **5% to 12%** Borderline cases requiring use of dual symbols**	Not meeting all gradation requirements for GW	
		Gravels With Fines *appreciable amount of fines*	GM* d / u	Silty gravels, poorly graded gravel-sand-silt mixtures		Atterberg limits below "A" line, or PI less than 4	Above "A" line with PI between 4 and 7 are borderline cases requiring uses of dual symbols
			GC	Clayey gravels, poorly graded gravel-sand-clay mixtures		Atterberg limits above "A" line, or PI greater	
	Sands *more than half of coarse fraction is smaller than No. 4 sieve size*	**Clean Sands** *little or no fines*	SW	Well graded sands, gravelly sands, little or no fines		$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			SP	Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with Fines *appreciable amount of fines*	SM* d / u	Silty sands, poorly graded sand-silt mixtures		Atterberg limits below "A" line, or PI less than 4	Above "A" line with PI between 4 and 7 are borderline cases requiring uses of dual symbols
			SC	Clayey sands, poorly graded sand-clay mixtures		Atterberg limits above "A" line, or PI greater	
FINE-GRAINED SOILS *more than half of material is smaller than No. 200 sieve*	**Silts and Clays** *liquid limit is less than 50*		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	*For laboratory classification of fine-grained soils*		
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
			OL	Organic silts and organic silt-clays of low plasticity			
	Silts and Clays *liquid limit is greater than 50*		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts			
			CH	Inorganic clays of high plasticity, fat clays			
			OH	Organic clays of medium to high plasticity, organic silts			
HIGHLY ORGANIC SOILS			Pt	Peat and other highly organic soils			



Plasticity Chart

*Division of GM and SM groups into subdivisions of **d** and **u** for roads and airfields only. Subdivision is based on Atterberg limits; suffix **d** used when liquid limit is 28 or less and the PI is 6 or less, the suffix **u** used when liquid limit is greater than 28.

***Borderline classification*: Soils possessing characteristics of two groups are designated by combinations of group symbols. (For example **GW-GC**, well graded gravel-sand mixture with clay biner.)

NEW TEST HOLES

(2006)

DRILL HOLE LOG

BORING NO. RSB-11-607

SHEET 1 OF 3

PROJECT: LEGACY PARKWAY - F-717 (CENTER STREET OVER LEGACY PKWY)

CLIENT: UTAH DEPARTMENT OF TRANSPORTATION

PROJECT NUMBER: 200601.111

LOCATION: ABUTMENT 1; N 354,312 , E 51,331

DATE STARTED: 2/23/06

DRILLING METHOD: CME-55 NO. 1 / N.W. CASING W/TRICONE BIT

DATE COMPLETED: 2/25/06

DRILLER: T. KERN

GROUND ELEVATION: 4218.4'

DEPTH TO WATER - INITIAL: ∇ 5.0' **AFTER 24 HOURS:** ▼ N.M.

LOGGED BY: M. HANSEN

Elev. (ft)	Depth (ft)	Lithology	Sample: Type	Sample: Rec. (in)	Sample: See Legend	Sample: USCS (AASHTO)	Material Description		Dry Density (pcf)	Moisture Content (%)	Atter.: Liquid Limit	Atter.: Plast. Index	Gradation: Gravel (%)	Gradation: Sand (%)	Gradation: Silt/Clay (%)	Other Tests
				10	6,9,6,(31)	GP-GM	brown, moist, med. dense	SILTY GRAVEL W/SAND								
4215																
∇	5			7	2,1,2,(6) 0.35	CL	very lt. brown, very moist, firm	LEAN CLAY								pH Resist. Sulfate
4210				17	Pushed 0.52	CL (A-6(18))	very lt. brown, very moist, stiff		81.2	38.4	38	18	0	3	97	CT UC
	10			18	0/16",1,(2) 0.36	CL	mottled rusty-brown & gray, moist, soft to firm	LEAN CLAY W/SILTY SAND LENSES								
4205																
	15			14	0.38 Pushed	CL (A-6(16))	gray, moist, firm	LEAN CLAY		31.5	36	15	0	1	99	
						SM	gray, wet, loose	SILTY SAND								
				18	0,1/12",(2) 0.10	CL	gray-brown w/someblack, very moist, very soft	LEAN CLAY W/FEW SILTY SAND LAYERS TO 2" THICK very slight odor								
4200																
	20			18	Pushed 0.50	ML (A-4(0))	gray, very moist, firm	SANDY SILT		22.5		NP	0	25	75	
						CL (A-6(23))	gray, very moist, firm		87.8	30.2	40	23	0	2	98	CT UC TS
4195								LEAN CLAY								
	25			18	1,1/12",(1) 0.27	CL	bluish-gray-brown, very moist, soft									
4190																
	30			17	3,8,11,(23) 0.25	ML (A-4(0))	gray-brown, wet, med. dense	SANDY SILT		26.1		NP	0	34	66	
4185																
	35			10	0/3",1,5,4,(10)	SM	gray, wet, loose	SILTY SAND								
4180																
	40			15	Pushed 0.36	CL,SM (A-6(12))	gray, moist, firm	LEAN CLAY W/SILTY SAND LENSES & LAYERS TO 5" THICK & FROM 0.5" TO 6" APART	81.7	42.1	32	12	0	3	97	CT
4175				19	0/12",5,(5) 0.53	CL,SM	gray, moist, stiff									
	45							SAND W/SILT								
4170				19	2,12,28,(40)	SP-SM (A-3(0))	gray, wet, dense			20.7		NP	0	92	8	

_OGV1_COLOR_111_LOGS_COLOR.GPJ US EVAL.GDT 6/30/06

LEGEND:

DISTURBED SAMPLE 2,3,2,(6) ← Blow Count per 6"; ← $(N_1)_{60}$ Value; 0.45 ← Torvane (tsf)

UNDISTURBED SAMPLE PUSHED 0.45 ← Torvane (tsf)

OTHER TESTS
UC = Unconfined Compression
CT = Consolidation
DS = Direct Shear
TS = Triaxial Shear
CBR = California Bearing Ratio
= Potential Liquefaction
= Potential Liquefaction & Lateral Spread

RB&G ENGINEERING INC.
PROVO, UTAH

DRILL HOLE LOG

BORING NO. RSB-11-607

PROJECT: LEGACY PARKWAY - F-717 (CENTER STREET OVER LEGACY PKWY)
CLIENT: UTAH DEPARTMENT OF TRANSPORTATION
LOCATION: ABUTMENT 1; N 354,312 , E 51,331
DRILLING METHOD: CME-55 NO. 1 / N.W. CASING W/TRICONE BIT
DRILLER: T. KERN
DEPTH TO WATER - INITIAL: ∇ 5.0' **AFTER 24 HOURS:** ▼ N.M.

PROJECT NUMBER: 200601.111
DATE STARTED: 2/23/06
DATE COMPLETED: 2/25/06
GROUND ELEVATION: 4218.4'
LOGGED BY: M. HANSEN

Elev. (ft)	Depth (ft)	Rec. (in)	See Legend	USCS (AASHTO)	Material Description	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plast. Index	Gravel (%)	Sand (%)	Silt/Clay (%)	Other Tests
					SAND W/SILT								
4165	55	18	13,20,23,(41)	SM	dk. gray, wet, dense — SILTY SAND								
4160	60	12	Pushed 0.42	CL (A-6(20))	dk. gray, very moist, firm — LEAN CLAY	69.7	52.5	40	19	0	1	99	CT UC
4155	65	16	13,17,17,(30)	SP-SM	gray, wet, dense								
4150	70	18	16,24,23,(40)	SP-SM (A-2-4(0))	gray, wet, dense — SAND W/SILT		21.7		NP	1	88	11	DS
4145	75	11	13,13,11,(20)	SP-SM	gray, wet, med. dense								
4140	80	15	8,15,6,(17) 0.54	CL	gray, moist, stiff								
4135	85	18	2,8,4,(9) 0.51	CL (A-4(9))	gray, moist, stiff — LEAN CLAY		28.9	31	10	0	7	93	
4130	90	18	6,6,5,(8) 0.64	CL	gray, moist, stiff								
4125	95	16	Pushed	CL (A-6(16))	gray, wet, stiff	91.2	28.3	37	19	0	14	86	CT
				SP-SM	gray, wet, med. dense								
		15	4,17,25,(31)	SP-SM	gray, wet, dense — SAND W/SILT								
4120		14	11,8,9,(12)	SP-SM	gray, wet, med. dense								

LEGEND:

DISTURBED SAMPLE — 2,3,2,(6) = Blow Count per 6", $(N_1)_{60}$ Value; 0.45 = Torvane (tsf)

UNDISTURBED SAMPLE — PUSHED; 0.45 = Torvane (tsf)

OTHER TESTS
UC = Unconfined Compression
CT = Consolidation
DS = Direct Shear
TS = Triaxial Shear
CBR = California Bearing Ratio
(red) = Potential Liquefaction
(blue) = Potential Liquefaction & Lateral Spread

RB&G ENGINEERING INC.
PROVO, UTAH

DRILL HOLE LOG

BORING NO. RSB-11-607

PROJECT: LEGACY PARKWAY - F-717 (CENTER STREET OVER LEGACY PKWY)

CLIENT: UTAH DEPARTMENT OF TRANSPORTATION

LOCATION: ABUTMENT 1; N 354,312 , E 51,331

DRILLING METHOD: CME-55 NO. 1 / N.W. CASING W/TRICONE BIT

DRILLER: T. KERN

DEPTH TO WATER - INITIAL: ∇ 5.0' **AFTER 24 HOURS:** ▼ N.M.

PROJECT NUMBER: 200601.111

DATE STARTED: 2/23/06

DATE COMPLETED: 2/25/06

GROUND ELEVATION: 4218.4'

LOGGED BY: M. HANSEN

Elev. (ft)	Depth (ft)	Lithology	Sample: Type	Sample: Rec. (in)	Sample: See Legend	Sample: USCS (AASHTO)	Material Description		Dry Density (pcf)	Moisture Content (%)	Atter.: Liquid Limit	Atter.: Plast. Index	Gradation: Gravel (%)	Gradation: Sand (%)	Gradation: Silt/Clay (%)	Other Tests
								SAND W/SILT								
4115	105		■	16	16,17,23,(28)	SM (A-4(0))	gray, wet, dense			24.2		NP	0	62	38	
								SILTY SAND								
4110	110		■	17	7,8,6,(10)	SM	gray, wet, med. dense									
4105	115		■	18	6,7,6,(9) 0.74	CL (A-7-6(24))	gray, moist, stiff	LEAN CLAY		28.6	42	25	0	6	94	
4100			⊠	0	Pushed	-										
	120		■	12	2,18,18,(24) 0.56	CL	gray, moist, stiff	LEAN CLAY W/SILT LENSES & LAYERS								
4095	125		■	14	1,5,5,(6) 0.30	CL	gray, moist, firm									
			⊠	14	Pushed 0.36	CL (A-6(13))	gray, moist, firm	LEAN CLAY	99.7	26	32	15	0	6	94	CT
4090	130															
4085	135															
4080	140															
4075	145															
4070																

LEGEND:

DISTURBED SAMPLE ■ 2,3,2,(6) — Blow Count per 6"; (6) — $(N_1)_{60}$ Value; 0.45 — Torvane (tsf)

UNDISTURBED SAMPLE ⊠ PUSHED 0.45 — Torvane (tsf)

OTHER TESTS
UC = Unconfined Compression
CT = Consolidation
DS = Direct Shear
TS = Triaxial Shear
CBR = California Bearing Ratio
🟥 = Potential Liquefaction
🟦 = Potential Liquefaction & Lateral Spread

DRILL HOLE LOG

BORING NO. RSB-11-608

PROJECT: LEGACY PARKWAY - F-717 (CENTER STREET OVER LEGACY PKWY)
CLIENT: UTAH DEPARTMENT OF TRANSPORTATION
LOCATION: ABUTMENT 2; N ~354,310 , E ~51,518
DRILLING METHOD: CME-55 NO. 2 / N.W. CASING W/TRICONE BIT
DRILLER: D. SAMPSON
DEPTH TO WATER - INITIAL: ∇ N.M. **AFTER 24 HOURS:** ▼ 4.7'

PROJECT NUMBER: 200601.111
DATE STARTED: 3/2/06
DATE COMPLETED: 3/8/06
GROUND ELEVATION: ~4219'
LOGGED BY: C.S., N.B., M.H.

Elev. (ft)	Depth (ft)	Sample: Rec. (in)	Sample: See Legend	Sample: USCS (AASHTO)	Material Description		Dry Density (pcf)	Moisture Content (%)	Atter.: Liquid Limit	Atter.: Plast. Index	Gradation: Gravel (%)	Gradation: Sand (%)	Gradation: Silt/Clay (%)	Other Tests
		11	8,12,18,(47)	GM	rust-brown, slightly moist, med. dense	SILTY GRAVEL W/SAND								
						SILTY SAND								
4215	5													
		13	2,2,2,(6)	SM CL	gray, moist, loose tan, moist, soft									
4210	10													
		18	Pushed *0.64*	CL (*A-6(14)*)	gray-brown, moist, stiff	LEAN CLAY W/SAND LENSES 1" TO 7" APART	83.3	38.5	36	13	0	1	99	CT UC
4205	15													
		15	2,2,6,(10) *0.37*	CL SM	gray-brown, moist, firm gray, wet, loose									
4200						SILTY SAND								
	20													
		19	Pushed *0.49 (clay)*	SM (*A-2-4(0)*) CL	gray, wet gray, wet, firm			32.1		NP	0	68	32	
4195	25					LEAN CLAY								
		21	2,1,2,(3) *0.57,0.42*	CL	gray/brown, moist, firm									
4190						SILTY SAND								
	30													
		18	Pushed	ML	gray, wet	SANDY SILT W/CLAY & SILTY SAND LAYERS TO 3" THICK								
		18	7,7,4,(10) *0.28*	ML	gray, wet									
4185	35	19	2,2,2,(4) *0.47*	CL	gray, moist, firm	LEAN CLAY								
		19	7,5,4,(8) *0.50,0.25*	ML	gray, moist, firm									
4180	40													
		18	Pushed *0.42*	ML (*A-4(0)*)	gray, moist, firm	SANDY SILT W/LEAN CLAY LENSES & LAYERS TO 1" THICK		25.3		NP	0	46	54	
4175	45													
		16	*0.24* 5,12,19,(25)	ML SM	gray, very moist, soft gray, wet, med. dense	SILTY SAND								
4170														

RB&G ENGINEERING INC.
PROVO, UTAH

LEGEND:

DISTURBED SAMPLE: 2,3,2,(6) — Blow Count per 6"; (6) — $(N_1)_{60}$ Value; *0.45* — Torvane (tsf)

UNDISTURBED SAMPLE: PUSHED; *0.45* — Torvane (tsf)

OTHER TESTS
UC = Unconfined Compression
CT = Consolidation
DS = Direct Shear
TS = Triaxial Shear
CBR = California Bearing Ratio
= Potential Liquefaction
= Potential Liquefaction & Lateral Spread

DRILL HOLE LOG

BORING NO. RSB-11-608

PROJECT: LEGACY PARKWAY - F-717 (CENTER STREET OVER LEGACY PKWY)
CLIENT: UTAH DEPARTMENT OF TRANSPORTATION
LOCATION: ABUTMENT 2; N ~354,310 , E ~51,518
DRILLING METHOD: CME-55 NO. 2 / N.W. CASING W/TRICONE BIT
DRILLER: D. SAMPSON
DEPTH TO WATER - INITIAL: ∇ N.M. **AFTER 24 HOURS:** ▼ 4.7'

PROJECT NUMBER: 200601.111
DATE STARTED: 3/2/06
DATE COMPLETED: 3/8/06
GROUND ELEVATION: ~4219'
LOGGED BY: C.S., N.B., M.H.

Elev. (ft)	Depth (ft)	Sample Type	Rec. (in)	See Legend	USCS (AASHTO)	Material Description		Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plast. Index	Gravel (%)	Sand (%)	Silt/Clay (%)	Other Tests
		Pushed	5	Pushed 0.35	CL	gray, very moist, firm	SANDY LEAN CLAY W/SAND LAYERS TO 2" THICK								
		Disturbed	15	7,10,12,(17) 0.80	CL	brown-gray, moist, stiff									
4165	55				SM	gray, wet	SILTY SAND								
		Pushed	21	Pushed 0.28,0.53	CL (A-6(20))	gray, moist, firm to stiff	LEAN CLAY W/SILT LENSES 0.5" TO 3" APART	68.6	49.5	40	19	0	1	99	CT UC TS
4160	60	Disturbed	12	12,21,28,(34)	SP-SM	gray-brown, wet, dense	SAND W/SILT								
4155	65	Disturbed	14	18,20,23,(29)	SP-SM (A-3(0))	gray-brown, wet, dense			25.3		NP	0	94	6	
4150	70	Disturbed	14	15,24,29,(34)	SP-SM	gray, wet, very dense									
4145	75	Disturbed	14	30,36,38,(46)	SP-SM (A-3(0))	gray, wet, very dense			22		NP	0	90	10	
4140	80	Disturbed	14	18,31,32,(38)	SP-SM	gray, wet, very dense									
4135	85	Pushed	22	Pushed 0.68	CL (A-6(20))	gray, moist, stiff	LEAN CLAY	93.3	29.8	40	19	0	4	96	CT
4130	90	Pushed	18	Pushed 0.71	CL	gray-brown, moist, stiff									
4125	95				ML	greenish-gray-brown, wet, stiff/med. dense	SANDY SILT								
		Disturbed	12	6,7,17,(13)	SP-SM	greenish-gray-brown, wet, med. dense	SAND W/SILT								
4120															

LEGEND:

DISTURBED SAMPLE — 2,3,2,(6) ← Blow Count per 6"; ← $(N_1)_{60}$ Value; 0.45 ← Torvane (tsf)

UNDISTURBED SAMPLE — PUSHED 0.45 ← Torvane (tsf)

OTHER TESTS
UC = Unconfined Compression
CT = Consolidation
DS = Direct Shear
TS = Triaxial Shear
CBR = California Bearing Ratio
= Potential Liquefaction
= Potential Liquefaction & Lateral Spread

RB&G ENGINEERING INC.
PROVO, UTAH

DRILL HOLE LOG

BORING NO. RSB-11-608

SHEET 3 OF 3

PROJECT: LEGACY PARKWAY - F-717 (CENTER STREET OVER LEGACY PKWY)
CLIENT: UTAH DEPARTMENT OF TRANSPORTATION
LOCATION: ABUTMENT 2; N ~354,310 , E ~51,518
DRILLING METHOD: CME-55 NO. 2 / N.W. CASING W/TRICONE BIT
DRILLER: D. SAMPSON
DEPTH TO WATER - INITIAL: ∇ N.M. **AFTER 24 HOURS:** ▼ 4.7'

PROJECT NUMBER: 200601.111
DATE STARTED: 3/2/06
DATE COMPLETED: 3/8/06
GROUND ELEVATION: ~4219'
LOGGED BY: C.S., N.B., M.H.

Elev. (ft)	Depth (ft)	Lithology	Sample Type	Sample Rec. (in)	Sample See Legend	Sample USCS (AASHTO)	Material Description	Dry Density (pcf)	Moisture Content (%)	Atter. Liquid Limit	Atter. Plast. Index	Gradation Gravel (%)	Gradation Sand (%)	Gradation Silt/Clay (%)	Other Tests
				16	25,36,31,(36)	SP-SM	gray, wet, very dense SAND W/SILT								

Elevation scale: 4115, 4110, 4105, 4100, 4095, 4090, 4085, 4080, 4075, 4070
Depth scale: 105, 110, 115, 120, 125, 130, 135, 140, 145

LOGV1_COLOR 111_LOGS_COLOR.GPJ US EVAL.GDT 6/30/06

RB&G ENGINEERING INC.
PROVO, UTAH

LEGEND:

DISTURBED SAMPLE — 2,3,2,(6) ← Blow Count per 6" ← $(N_1)_{60}$ Value; 0.45 ← Torvane (tsf)

UNDISTURBED SAMPLE — PUSHED; 0.45 ← Torvane (tsf)

OTHER TESTS
UC = Unconfined Compression
CT = Consolidation
DS = Direct Shear
TS = Triaxial Shear
CBR = California Bearing Ratio
= Potential Liquefaction
= Potential Liquefaction & Lateral Spread

PREVIOUS TEST HOLES

(by others)

Legacy Parkway - Preferred Alternative
I-215 to I-15/US 89 Interchange
KLEINFELDER
Project No. 35-8163-05

FIELD TEST BORING LOG

Boring: **SB-11-259**
Sheet 1 of 3

Boring: SB-11-259
Sheet 1 of 3

Elevation (m)	SAMPLE DESCRIPTION (ASTM D 2488/D 2487)	Depth ft	Depth m	Graphic Log	SAMPLE Type	Recovery (mm)	Soil Classification USCS	Soil Classification AASHTO	N, Blows per 0.15 m (or interval shown)	● SPT $(N_1)_{60}$ ○ SPT $(N_1)_{60}$ (Greater than 50 Blows)	S_U, kPa (torvane in italics)	Dry Density, kN/m³	Moisture, %	Liquid Limit	Plasticity Index	% Passing No. 200	Other Tests
1285	Lean CLAY - wet, dark brown in top 0.3 m and gray in bottom 0.3 m, frequent roots				BAG		CL	A-6									
	- very soft, light brown, with occasional seams of very fine-grained sands	5	1		SPT	610			0 0 0 2	0							pH WSS R
	- medium stiff, with 150 mm silty sand layer	10	3		P	610					*38*						
	- very soft, gray to black, mottled light brown, with frequent seams of very fine-grained seams	15			SPT	610			1 0 1 0	1							
1280			5														
	- medium stiff	20	6		P						*38*						
	- very soft	25			SPT	610			0 0 2 3	2							
	Silty SAND - medium stiff, wet, gray	30	9		P		SM	A-2-4			17 *34*	15.3	27	31	6	50	C SG
1275	Lean CLAY - wet, gray	35			SPT	610	CL	A-6	3 3 2 4	5							
		40	12		P	0											
	Silty SAND - wet, gray				P	0	SM	A-2-4									
	Sandy SILT - very stiff, wet, gray, frequent seams of silty sand	45			SPT	305	ML	A-4	3 7 17 28	23							
1270	Silty SAND - dense, wet, gray, with frequent layers of poorly graded sand	50	15		SPT		SM	A-2-4	9 14 22 30	33							
		55	17														
	- medium dense	60	18		SPT	610			7 7 10 17	14							
		65	19														

Logged by: M. Bostrom
Date Start: 1/26/00
Date Finish: 1/29/00
Station: 5+389.204 2.96 RT
Line: CENTER STREET
Coordinates (m): N 107,991.325 E 15,633.072
Elevation (m): 1285.193
Total Depth Drilled (m): 50.6
Drill Contractor: Haz-tech
Driller: R. Knott
Rig Type: CME-850
Drilling Method: Mud Rotary
Hammer Type: Automatic
Rod Type: NW
Boring Diameter: 121 mm

LEGEND/NOTES

Elevations based upon North American Vertical Datum of 1988 (NAVD '88)

Coordinates are NAD '83

▽ = Observed Groundwater depth at time of drilling

Blows = Number of blows required to drive split spoon sampler 150 mm or interval shown

USCS = Unified Soil Classification System

AASHTO = American Association of State Highway and Transportation Officials

* = See Key to Soil Logs for list of abbreviations and descriptions of tests

SAMPLE TYPE

SPT = Standard Penetration Test, 34.9mm ID and 50.8mm OD split spoon sampler

MC = Modified California Sampler, 50.8mm ID and 63.5mm OD split spoon sampler

P = Piston Sampler, 76.2 mm OD

SH = Shelby Tube, 76.2mm OD, pushed

BAG = Bulk Sample

Legacy Parkway - Preferred Alternative
I-215 to I-15/US 89 Interchange
KLEINFELDER
Project No. 35-8163-05

FIELD TEST BORING LOG

Boring: **SB-11-259**

Sheet 2 of 3

Boring: SB-11-259
Sheet 2 of 3

Elevation (m)	SAMPLE DESCRIPTION (ASTM D 2488/D 2487)	Depth ft	Depth m	Type	Recovery (mm)	USCS	AASHTO	N, Blows per 0.15 m (or interval shown)	SPT $(N_1)_{60}$	S_u, kPa (torvane in italics)	Dry Density, kN/m³	Moisture, %	Liquid Limit	Plasticity Index	% Passing No. 200	Other Tests
1265	Silty SAND - medium dense, wet, gray, with frequent layers of poorly graded sand (continued)	70	21	SPT	457			6 13 25 30	29							
	Poorly Graded SAND - medium dense, wet, gray, coarse-grained, frequent layers of silty sand	75	23	SPT	610	SP	A-3	6 17 23 28	29							
	Silty CLAY - stiff, wet, gray, with occasional layers of very fine sand	80	24	SPT	610	CL-ML	A-6	9 5 7 10	9							
1260	- medium stiff	90	27	P	610					74 *43*	16.8	23	35	16	93	C TR SG
1255	- very stiff, frequent layers of silt and poorly graded sand	100	30	SPT	457			14 23 13 17	24							
	SILT - medium stiff, wet, gray	110	33	P	508	ML	A-4			*34*						
1250		120	36	SPT	610			7 7 7 9	8							
	Silty SAND - moist, bluish-gray, fine-grained	130	39	P	457	SM	A-2-4									

● SPT $(N_1)_{60}$
○ SPT $(N_1)_{60}$ (Greater than 50 Blows)
0 25 50

Test Results *

Logged by	M. Bostrom
Date Start:	1/26/00
Date Finish:	1/29/00
Station:	5+389.204 2.96 RT
Line:	CENTER STREET
Coordinates (m):	N 107,991.325 E 15,633.072
Elevation (m):	1285.193
Total Depth Drilled (m)	50.6
Drill Contractor	Haz-tech
Driller:	R. Knott
Rig Type:	CME-850
Drilling Method.	Mud Rotary
Hammer Type:	Automatic
Rod Type:	NW
Boring Diameter	121 mm

LEGEND/NOTES

Elevations based upon North American Vertical Datum of 1988 (NAVD '88)

Coordinates are NAD '83

∇ = Observed Groundwater depth at time of drilling

Blows = Number of blows required to drive split spoon sampler 150 mm or interval shown

USCS = Unified Soil Classification System

AASHTO = American Association of State Highway and Transportation Officials

* = See Key to Soil Logs for list of abbreviations and descriptions of tests

SAMPLE TYPE

SPT = Standard Penetration Test, 34 9mm ID and 50 8mm OD split spoon sampler

MC = Modified California Sampler, 50.8mm ID and 63.5mm OD split spoon sampler

P = Piston Sampler, 76 2 mm OD

SH = Shelby Tube, 76 2mm OD, pushed

BAG = Bulk Sample

UTDOT Z003881.GPJ 8/30/00

Legacy Parkway - Preferred Alternative
I-215 to I-15/US 89 Interchange
KLEINFELDER
Project No. 35-8163-05

FIELD TEST BORING LOG

Boring: SB-11-259
Sheet 3 of 3

Boring: SB-11-259
Sheet 3 of 3

Elevation (m)	SAMPLE DESCRIPTION (ASTM D 2488/D 2487)	Depth ft	Depth m	Type	Recovery (mm)	USCS	AASHTO	N, Blows per 0.15 m (or interval shown)	SPT (N1)60
1245	Silty SAND - moist, bluish-gray, fine-grained (continued)								
	Lean CLAY - medium stiff, wet, olive-gray, with frequent silt layers 0.15 to 0.3 m thick	135	41	SPT	610	CL	A-6	5 3 9 13	7
		145	44	P	356				
1240		155	47	SPT				3 3 8 7	5
1235		165	50	P	0				
1230		195	59						

Test Results *: S_u, kPa (torvane in italics) / Dry Density, kN/m³ / Moisture, % / Liquid Limit / Plasticity Index / % Passing No. 200 / Other Tests

● SPT $(N_1)_{60}$
○ SPT $(N_1)_{60}$ (Greater than 50 Blows)

Logged by:	M. Bostrom
Date Start:	1/26/00
Date Finish:	1/29/00
Station:	5+389.204 2.96 RT
Line:	CENTER STREET
Coordinates (m):	N 107,991.325 E 15,633.072
Elevation (m):	1285.193
Total Depth Drilled (m):	50.6
Drill Contractor	Haz-tech
Driller	R. Knott
Rig Type	CME-850
Drilling Method	Mud Rotary
Hammer Type	Automatic
Rod Type	NW
Boring Diameter	121 mm

LEGEND/NOTES

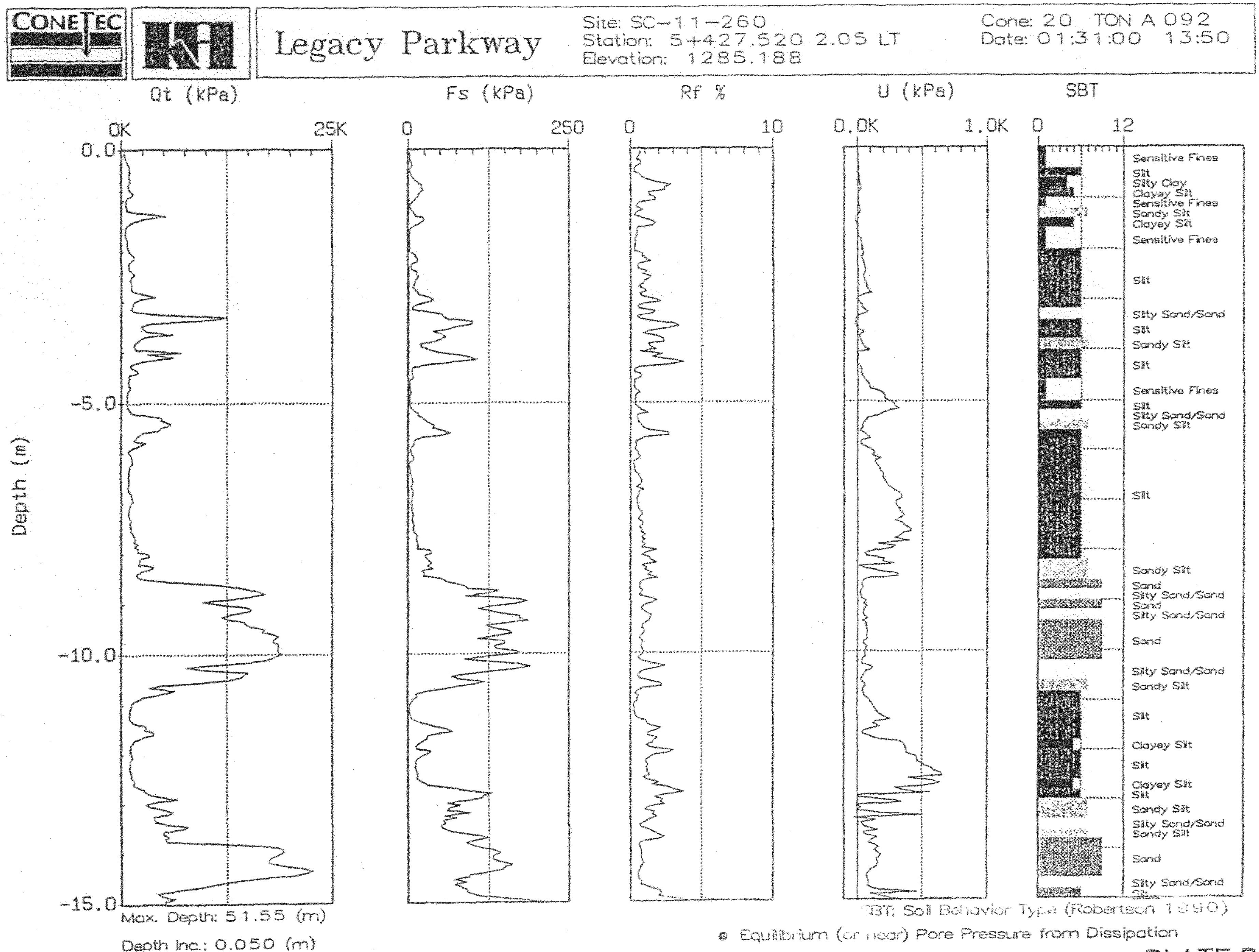
Elevations based upon North American Vertical Datum of 1988 (NAVD '88)

Coordinates are NAD '83

∇ = Observed Groundwater depth at time of drilling
Blows = Number of blows required to drive split spoon sampler 150 mm or interval shown
USCS = Unified Soil Classification System
AASHTO = American Association of State Highway and Transportation Officials
* = See Key to Soil Logs for list of abbreviations and descriptions of tests

SAMPLE TYPE

SPT = Standard Penetration Test, 34.9mm ID and 50.8mm OD split spoon sampler
MC = Modified California Sampler, 50.8mm ID and 63.5mm OD split spoon sampler
P = Piston Sampler, 76.2 mm OD
SH = Shelby Tube, 76.2mm OD, pushed
BAG = Bulk Sample

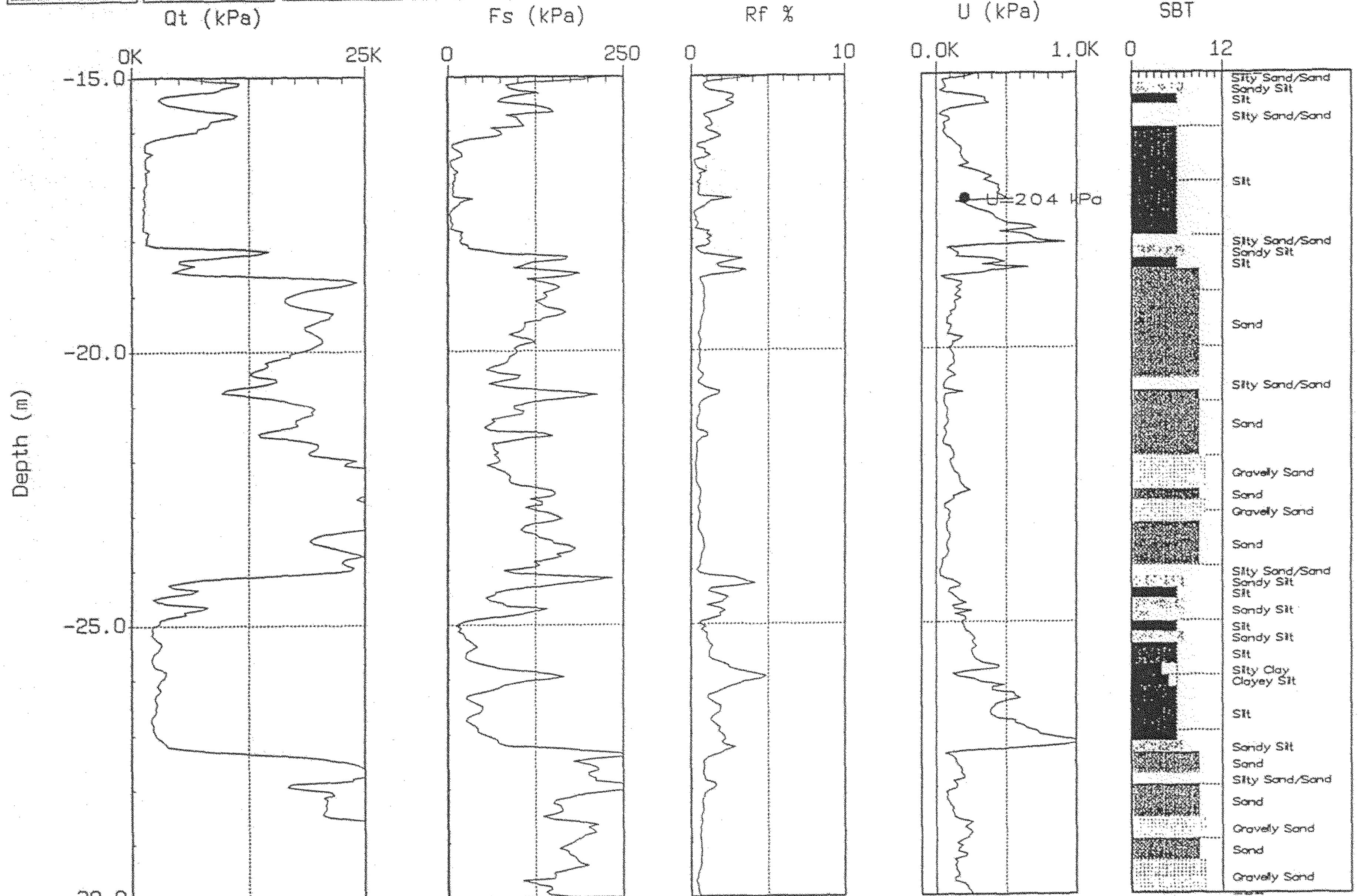

CONETEC
Legacy Parkway
Site: SC-11-260
Station: 5+427.520 2.05 LT
Elevation: 1285.188
Cone: 20 TON A 092
Date: 01:31:00 13:50
Qt (kPa)
Fs (kPa)
Rf %
U (kPa)
SBT
0K
25K
0
250
0
10
0.0K
1.0K
0
12
0.0
-5.0
-10.0
-15.0
Depth (m)
Sensitive Fines
Silt
Silty Clay
Clayey Silt
Sensitive Fines
Sandy Silt
Clayey Silt
Sensitive Fines
Silt
Silty Sand/Sand
Silt
Sandy Silt
Silt
Sensitive Fines
Silt
Silty Sand/Sand
Sandy Silt
Silt
Sandy Silt
Sand
Silty Sand/Sand
Sand
Silty Sand/Sand
Sand
Silty Sand/Sand
Sandy Silt
Silt
Clayey Silt
Silt
Clayey Silt
Silt
Sandy Silt
Silty Sand/Sand
Sandy Silt
Sand
Silty Sand/Sand
Silt
Max. Depth: 51.55 (m)
Depth Inc.: 0.050 (m)
SBT: Soil Behavior Type (Robertson 1990)
Equilibrium (or near) Pore Pressure from Dissipation
PLATE B-97

CONETEC

Legacy Parkway

Site: SC-11-260
Station: 5+427.520 2.05 LT
Elevation: 1285.188

Cone: 20 TON A 092
Date: 01:31:00 13:50

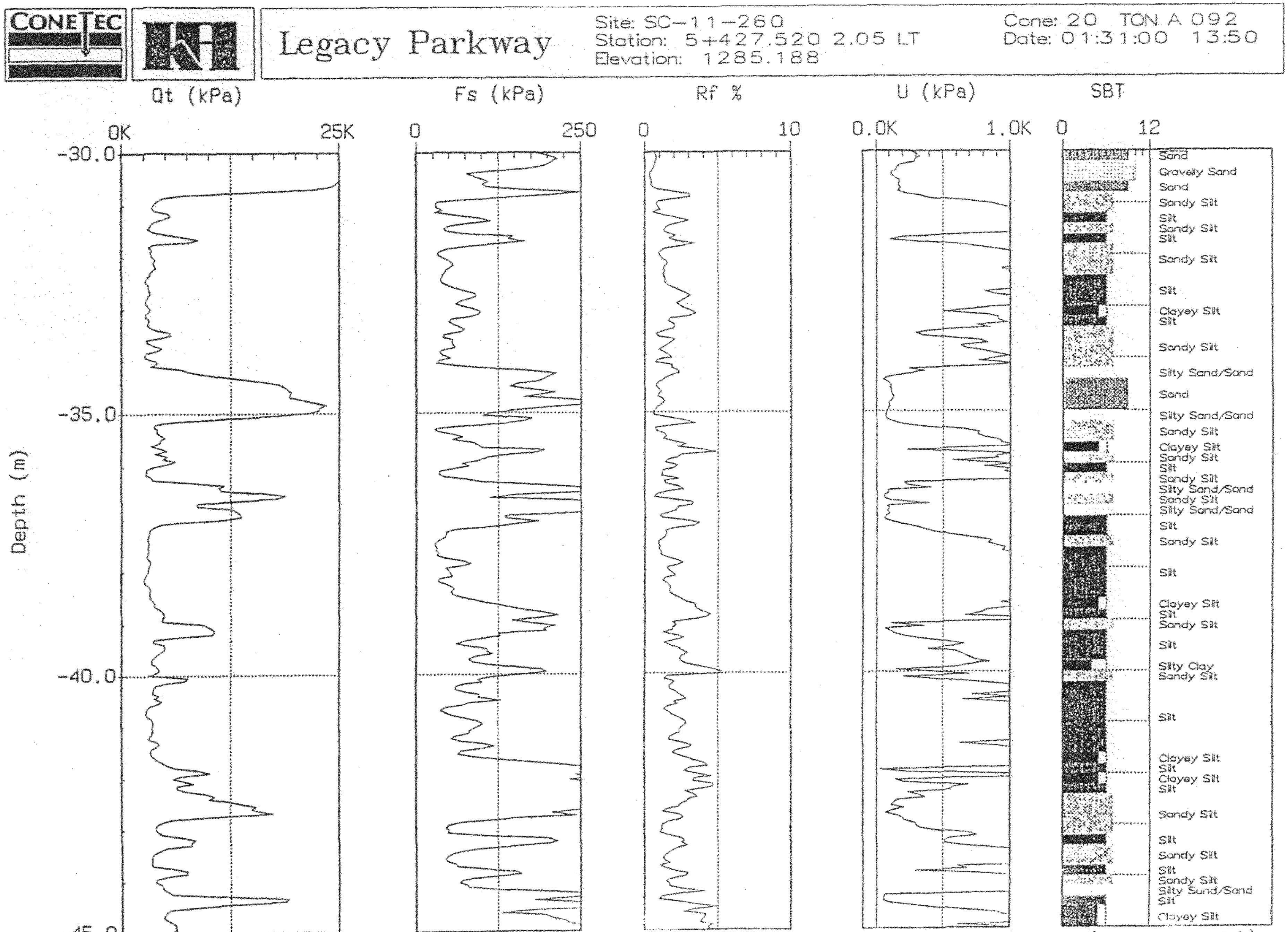


Max. Depth: 51.55 (m)

Depth Inc.: 0.050 (m)

SBT: Soil Behavior Type (Robertson 1990)

● Equilibrium (or near) Pore Pressure from Dissipation



Max. Depth: 51.55 (m)

Depth Inc.: 0.050 (m)

SBT: Soil Behavior Type (Robertson 1990)

* Equilibrium (or near) Pore Pressure from Dissipation

PLATE B-99

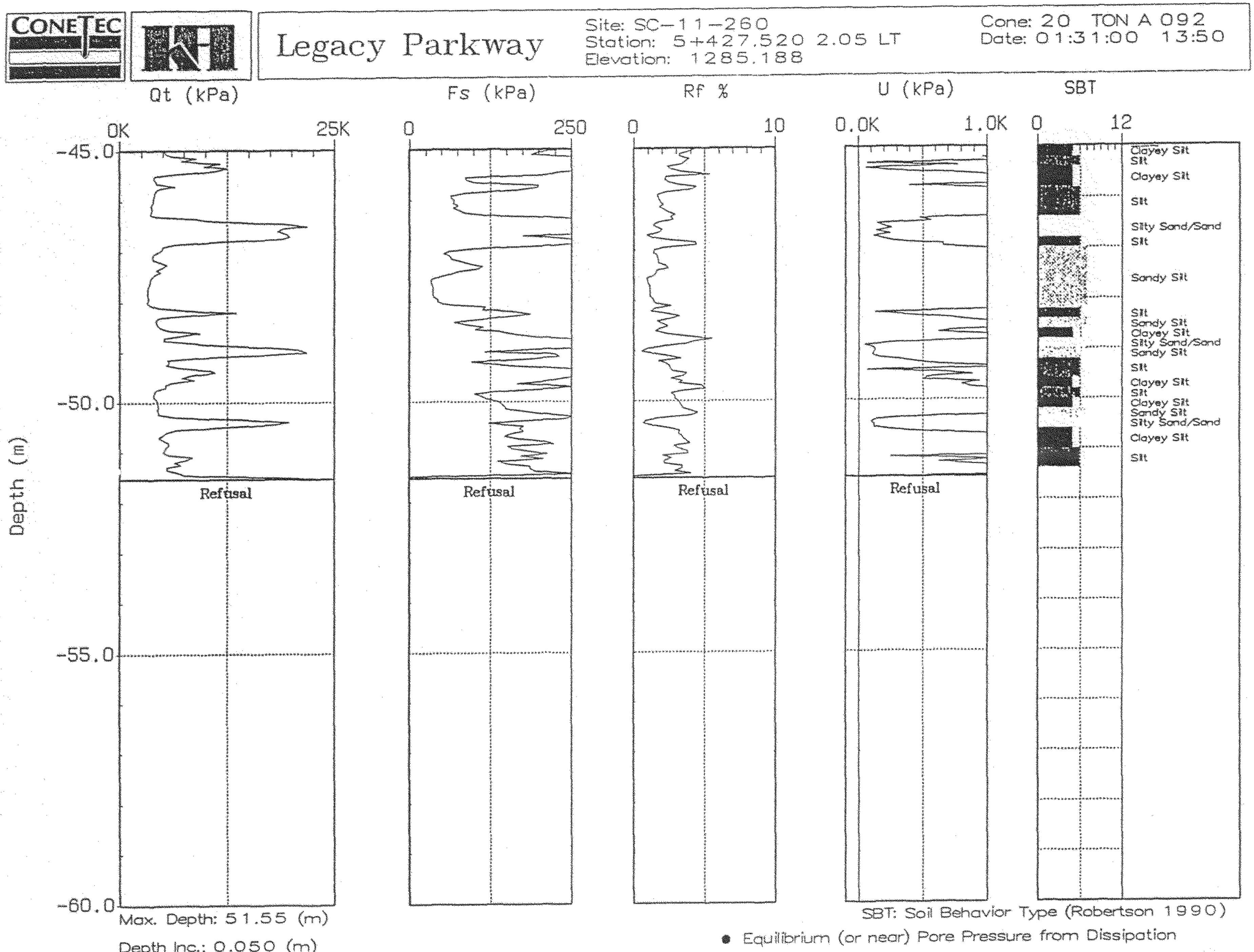
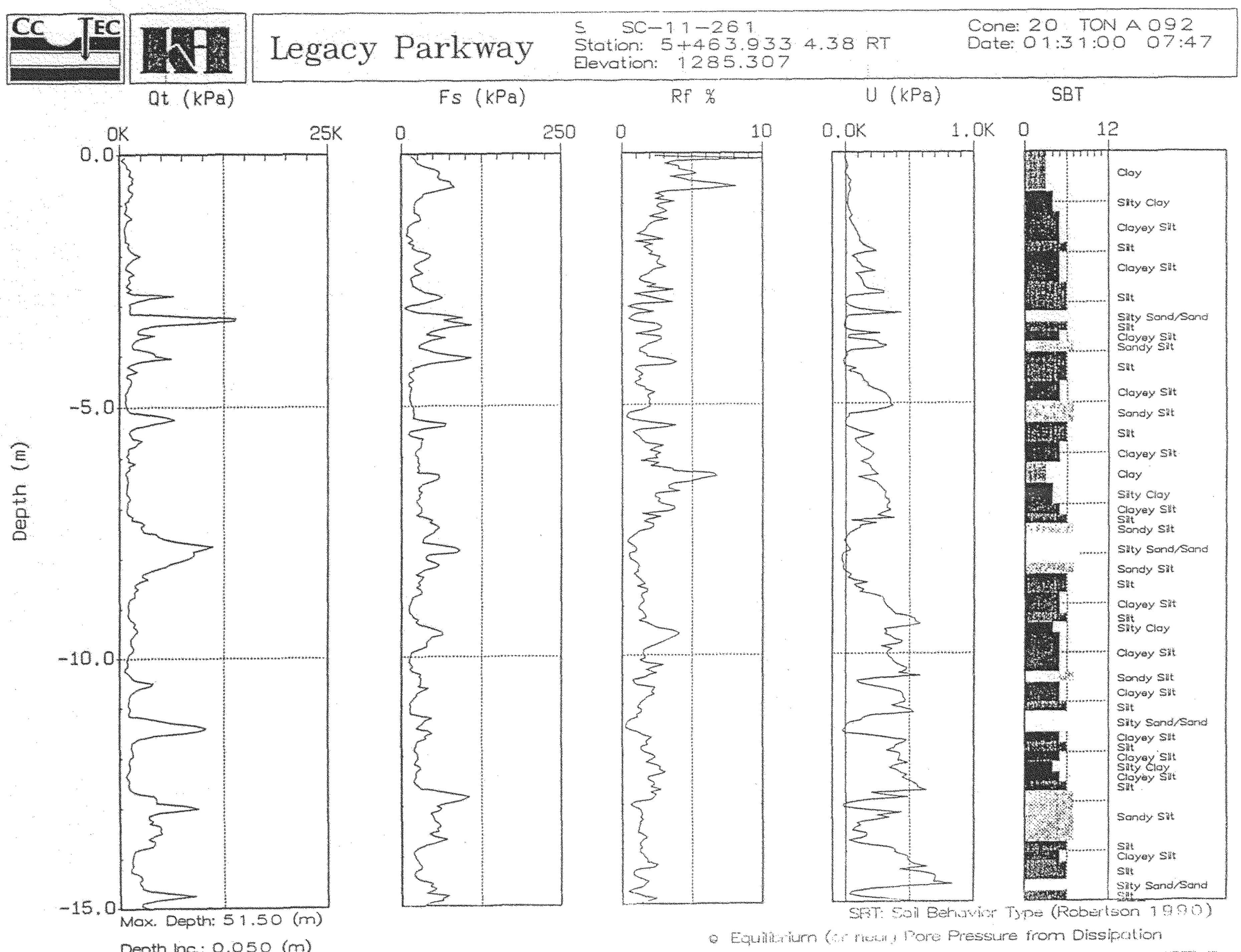

CONETEC
Legacy Parkway
Site: SC-11-260
Station: 5+427.520 2.05 LT
Elevation: 1285.188
Cone: 20 TON A 092
Date: 01:31:00 13:50
Qt (kPa)
Fs (kPa)
Rf %
U (kPa)
SBT
0K
25K
0
250
0
10
0.0K
1.0K
0
12
-45.0
-50.0
-55.0
-60.0
Depth (m)
Refusal
Refusal
Refusal
Refusal
Clayey Silt
Silt
Clayey Silt
Silt
Silty Sand/Sand
Silt
Sandy Silt
Silt
Sandy Silt
Clayey Silt
Silty Sand/Sand
Sandy Silt
Silt
Clayey Silt
Silt
Clayey Silt
Sandy Silt
Silty Sand/Sand
Clayey Silt
Silt
Max. Depth: 51.55 (m)
Depth Inc.: 0.050 (m)
SBT: Soil Behavior Type (Robertson 1990)
● Equilibrium (or near) Pore Pressure from Dissipation

PLATE B-100



CC TEC
Legacy Parkway
S SC-11-261
Station: 5+463.933 4.38 RT
Elevation: 1285.307
Cone: 20 TON A 092
Date: 01:31:00 07:47
Qt (kPa)
Fs (kPa)
Rf %
U (kPa)
SBT
0K
25K
0
250
0
10
0.0K
1.0K
0
12
0.0
-5.0
-10.0
-15.0
Depth (m)
Clay
Silty Clay
Clayey Silt
Silt
Clayey Silt
Silt
Silty Sand/Sand
Silt
Clayey Silt
Sandy Silt
Silt
Clayey Silt
Sandy Silt
Silt
Clayey Silt
Clay
Silty Clay
Clayey Silt
Silt
Sandy Silt
Silty Sand/Sand
Sandy Silt
Silt
Clayey Silt
Silt
Silty Clay
Clayey Silt
Sandy Silt
Clayey Silt
Silt
Silty Sand/Sand
Clayey Silt
Silt
Clayey Silt
Silty Clay
Clayey Silt
Silt
Sandy Silt
Silt
Clayey Silt
Silt
Silty Sand/Sand
Silt
Max. Depth: 51.50 (m)
Depth Inc.: 0.050 (m)
SBT: Soil Behavior Type (Robertson 1990)
Equilibrium (or near) Pore Pressure from Dissipation

PLATE B-101

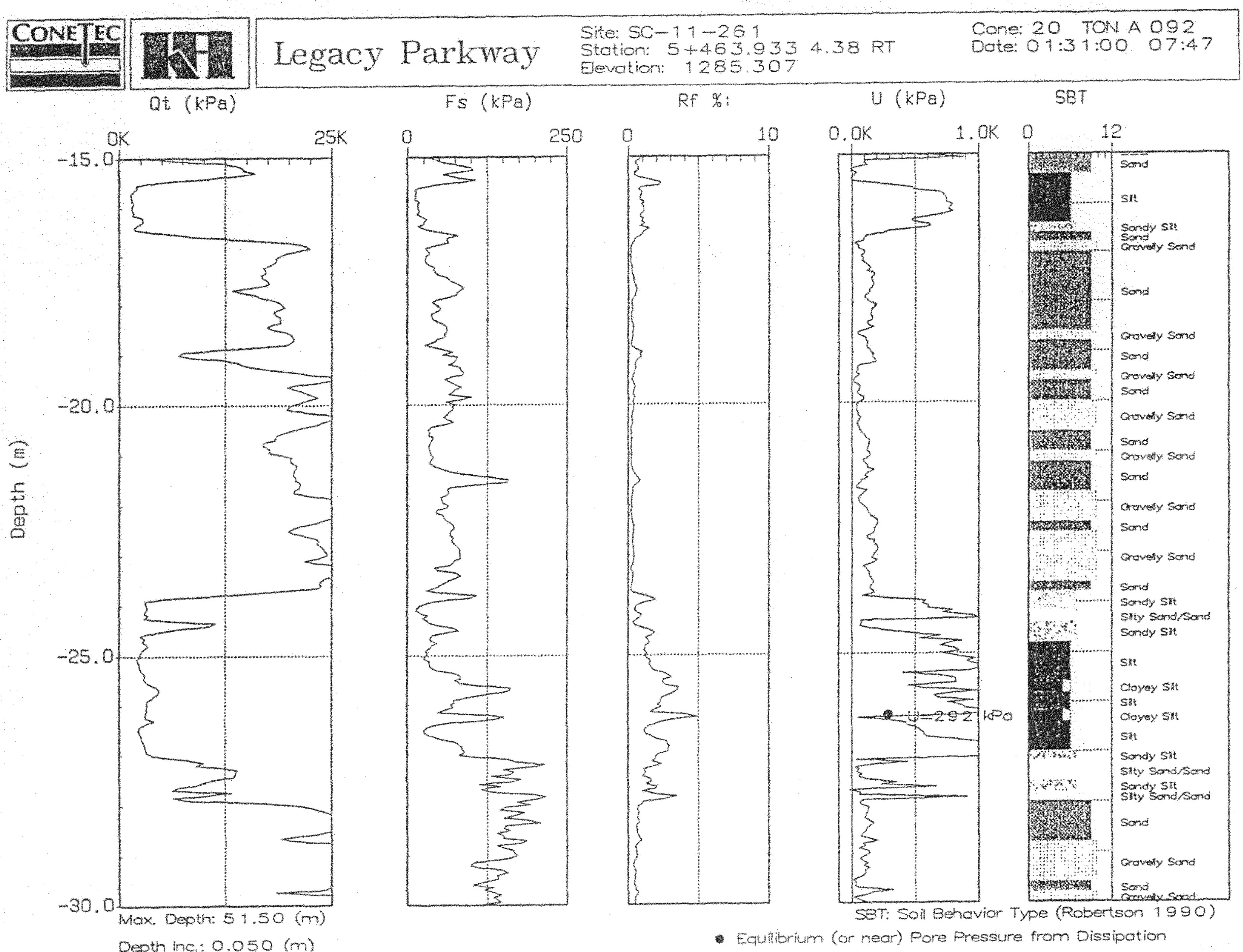
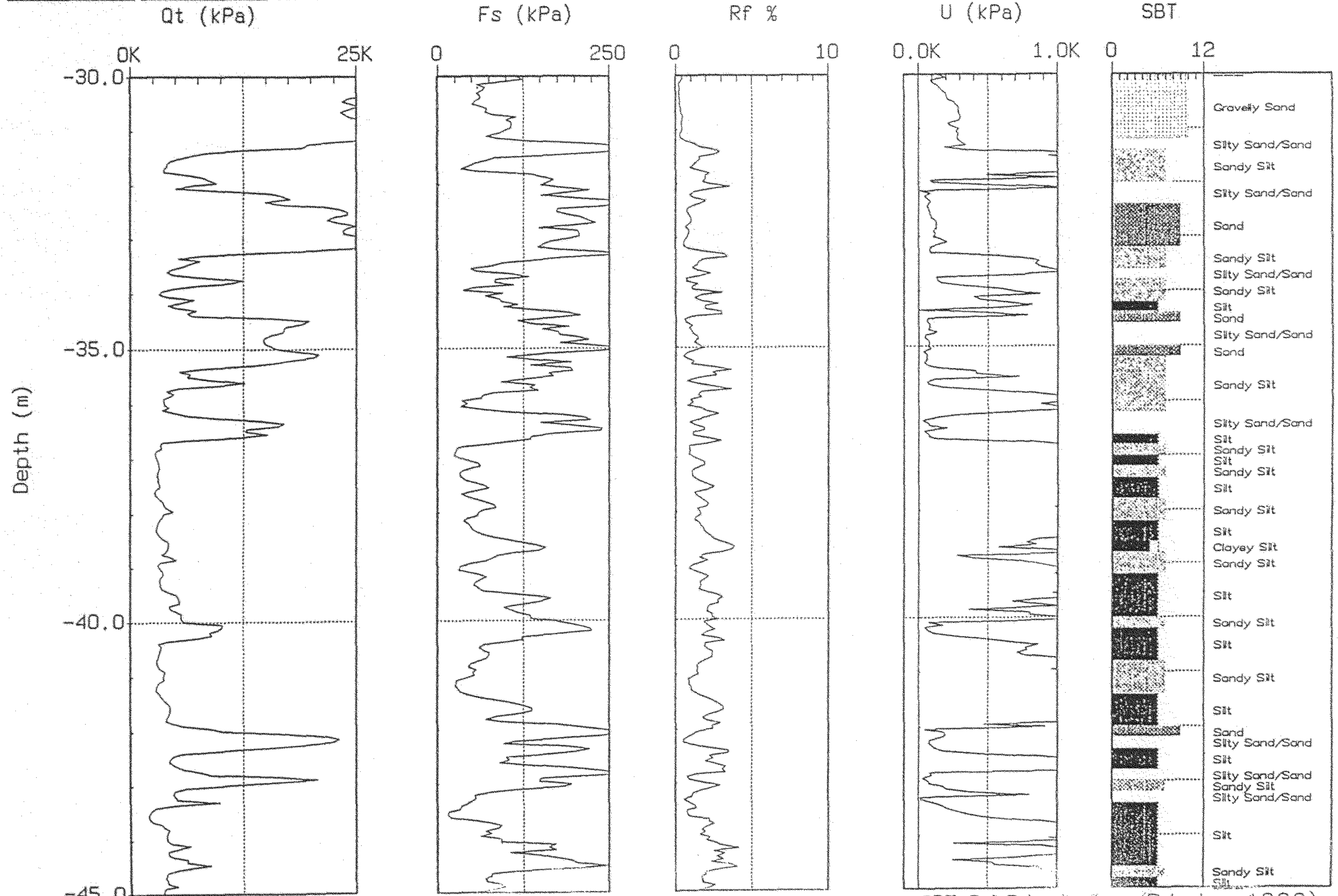

CONETEC
Legacy Parkway
Site: SC-11-261
Station: 5+463.933 4.38 RT
Elevation: 1285.307
Cone: 20 TON A 092
Date: 01:31:00 07:47
Qt (kPa)
Fs (kPa)
Rf %:
U (kPa)
SBT
0K
25K
0
250
0
10
0.0K
1.0K
0
12
-15.0
-20.0
-25.0
-30.0
Depth (m)
U=292 kPa
Sand
Silt
Sandy Silt
Sand
Gravelly Sand
Sand
Gravelly Sand
Sand
Gravelly Sand
Sand
Gravelly Sand
Sand
Gravelly Sand
Sand
Gravelly Sand
Sand
Gravelly Sand
Sand
Sandy Silt
Silty Sand/Sand
Sandy Silt
Silt
Clayey Silt
Silt
Clayey Silt
Silt
Sandy Silt
Silty Sand/Sand
Sandy Silt
Silty Sand/Sand
Sand
Gravelly Sand
Sand
Gravelly Sand
Max. Depth: 51.50 (m)
Depth Inc.: 0.050 (m)
SBT: Soil Behavior Type (Robertson 1990)
● Equilibrium (or near) Pore Pressure from Dissipation

PLATE B-102

Legacy Parkway

S . SC-11-261
Station: 5+463.933 4.38 RT
Elevation: 1285.307

Cone: 20 TON A.092
Date: 01:31:00 07:47



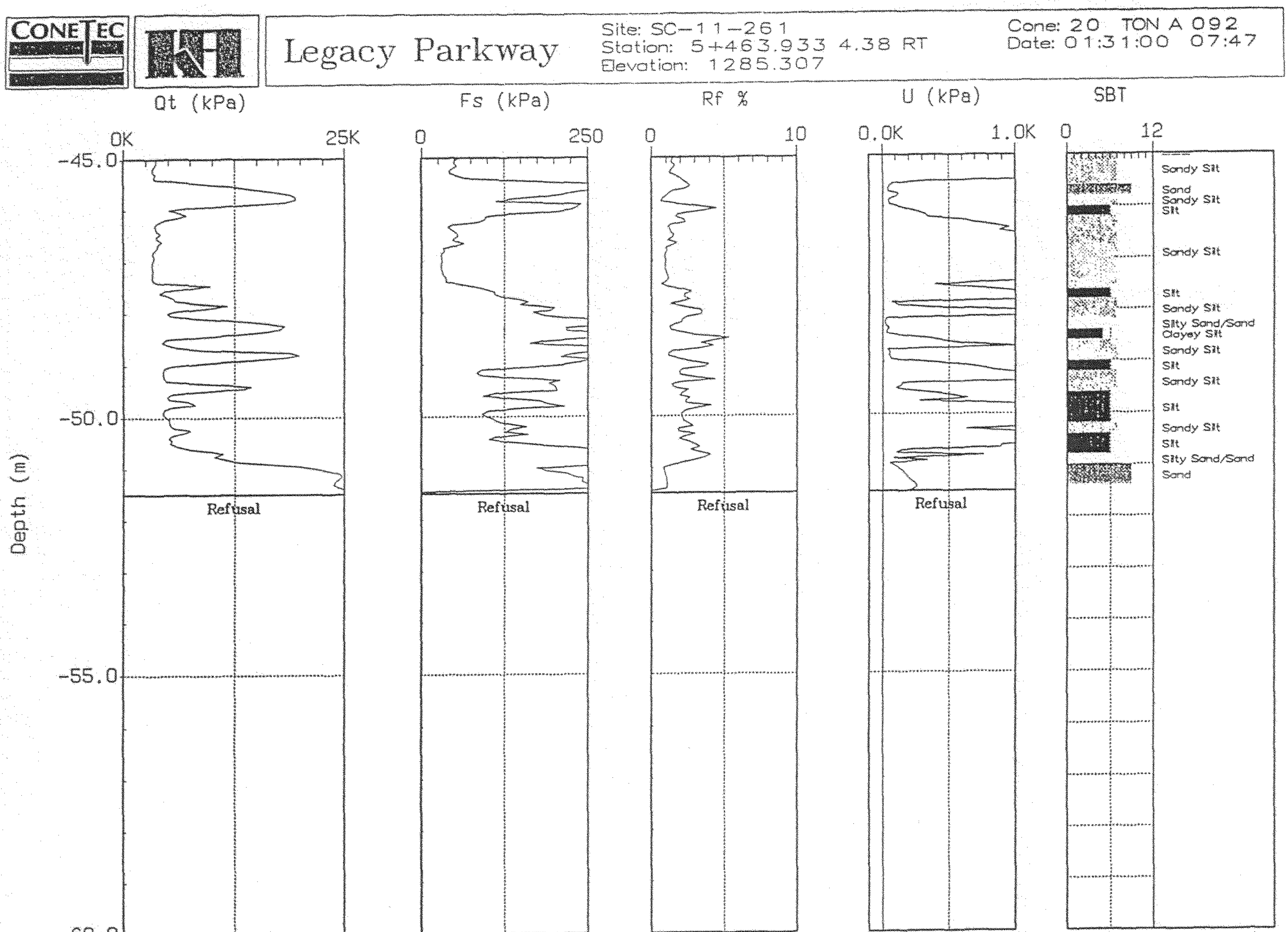
Max. Depth: 51.50 (m)

Depth Inc.: 0.050 (m)

SBT: Soil Behavior Type (Robertson 1990)

● Equilibrium (or near) Pore Pressure from Dissipation

PLATE B-103



Max. Depth: 51.50 (m)

Depth Inc.: 0.050 (m)

SBT: Soil Behavior Type (Robertson 1990)

● Equilibrium (or near) Pore Pressure from Dissipation

PLATE B-104

Legacy Parkway - Preferred Alternative
I-215 to I-15/US 89 Interchange

KLEINFELDER

Project No. 35-8163-05

FIELD TEST BORING LOG

Boring **SB-11-262**

Sheet 1 of 3

Boring: SB-11-262
Sheet 1 of 3

Elevation (m)	SAMPLE DESCRIPTION (ASTM D 2488/D 2487)	Depth ft	Depth m	Type	Recovery (mm)	USCS	AASHTO	N, Blows per 0.15 m (or interval shown)	SPT $(N_1)_{60}$	S_u, kPa (torvane in italics)	Dry Density, kN/m³	Moisture, %	Liquid Limit	Plasticity Index	% Passing No. 200	Other Tests
	FILL: Silty GRAVEL - loose, moist	0	0	SPT	330			1 2 2 4	6							
1285		5	2	SH	457											pH WSS R
	SILT - moist, light brown					ML	A-4									
	Lean CLAY - very soft, moist, red mottling, frequent micaceous sand seams 3 mm thick	10	3	SPT	432	CL	A-6	0 0 1 4	2							
		15	5	SH	356											SV
	Sandy SILT - very soft, wet, gray, frequent sand seams					ML	A-4									
1280	- medium stiff, moist, bluish-gray	20	6	SPT	610			1 2 2 1	6							
		25	8	SH	457					21 *38*	17.3	10	29	9	77	SV C SG
		30	9	SPT	559			3 2 2 3	6							
1275		35	11	SH	559					37 *24*	15.0	29				
	Fat CLAY - soft, wet, black to blackish-gray, occasional 3 mm thick sand seams	40	12	SPT	610	CH	A-7-6	0 0 3 3	4			51	72	44		
		45	14	SH	0											
	- stiff, interbedded with silt and sand seams			SPT	610			3 3 8 9	12							
		50	15	SH	0											
1270	- very stiff		16	SPT	610			8 9 10 9	21							
		55	17	SH						62 *67*	13.6	33	61	35	99	C SG
	Silty SAND - medium dense, wet, gray	60	18	SPT	610	SM	A-2-4	0 6 14 24	20							
		65	19													

● SPT $(N_1)_{60}$
○ SPT $(N_1)_{60}$ (Greater than 50 Blows)

Test Results *

Logged by:	M. Hislop
Date Start:	1/26/00
Date Finish:	1/28/00
Station:	5+495.950 0.22 LT
Line:	CENTER STREET
Coordinates (m):	N 107,993.664 E 15,739.839
Elevation (m):	1286.123
Total Depth Drilled (m)	46.3
Drill Contractor	RC Exploration
Driller:	M. Labenski
Rig Type	Diedrich D-120 ATV
Drilling Method	Hollow-Stem Auger
Hammer Type	Automatic
Rod Type:	AW
Boring Diameter:	152 mm

LEGEND/NOTES

Elevations based upon North American Vertical Datum of 1988 (NAVD '88)

Coordinates are NAD '83

⊻ = Observed Groundwater depth at time of drilling

Blows = Number of blows required to drive split spoon sampler 150 mm or interval shown

USCS = Unified Soil Classification System

AASHTO = American Association of State Highway and Transportation Officials

* = See Key to Soil Logs for list of abbreviations and descriptions of tests

SAMPLE TYPE

SPT = Standard Penetration Test, 34.9mm ID and 50.8mm OD split spoon sampler

MC = Modified California Sampler, 50.8mm ID and 63.5mm OD split spoon sampler

P = Piston Sampler, 76.2 mm OD

SH = Shelby Tube, 76.2mm OD, pushed

BAG = Bulk Sample

UTDOT Z003SB1.GPJ 6/28/00

Legacy Parkway - Preferred Alternative
I-215 to I-15/US 89 Interchange
KLEINFELDER
Project No. 35-8163-05

FIELD TEST BORING LOG

Boring: **SB-11-262**
Sheet 2 of 3

Boring: SB-11-262
Sheet 2 of 3

Elevation (m)	SAMPLE DESCRIPTION (ASTM D 2488/D 2487)	Depth ft	Depth m	Sample Type	Recovery (mm)	Soil Classification USCS	Soil Classification AASHTO	N, Blows per 0.15 m (or interval shown)	● SPT $(N_1)_{60}$	S_u, kPa	Dry Density, kN/m³	Moisture, %	Liquid Limit	Plasticity Index	% Passing No. 200	Other Tests
	Silty SAND - medium dense, wet, gray (continued)															
1265		70	21, 22													
	- dense	75	23	SPT	305			14 15 20 23	32							
	- occasional poorly graded sand layers	80	24, 25	SPT	610			8 11 28 36	34							
1260		85	26, 27													
	SILT - hard, wet, light brown, with clay layers up to 0.3 m	90	28	SPT	457	ML	A-4	15 20 30 36	41							
		95	29	SPT	610			15 20 24 24	35							
	- occasional poorly graded sand layers	100	30, 31	SPT	610			7 8 37 37	35							
1255		105	32, 33													
	- very stiff, light brown	110	34	SPT	610			11 11 15 18	19							
1250		115	35, 36													
	Lean CLAY - stiff, wet, light brown, occasional silt layers up to 0.15 m	120	37	SPT	610	CL	A-6	0 8 8 9	12							
		125	38, 39	SPT	610			9 15 27 25	29							
		130		SPT					45							

○ SPT $(N_1)_{60}$ (Greater than 50 Blows)

Test Results *

Logged by:	M. Hislop
Date Start:	1/26/00
Date Finish	1/28/00
Station.	5+495.950 0.22 LT
Line.	CENTER STREET
Coordinates (m)	N 107,993.664 E 15,739.839
Elevation (m)	1286.123
Total Depth Drilled (m):	46.3
Drill Contractor	RC Exploration
Driller	M. Labenski
Rig Type	Diedrich D-120 ATV
Drilling Method	Hollow-Stem Auger
Hammer Type	Automatic
Rod Type	AW
Boring Diameter:	152 mm

LEGEND/NOTES

Elevations based upon North American Vertical Datum of 1988 (NAVD '88)

Coordinates are NAD '83

∇ = Observed Groundwater depth at time of drilling

Blows = Number of blows required to drive split spoon sampler 150 mm or interval shown

USCS = Unified Soil Classification System

AASHTO = American Association of State Highway and Transportation Officials

* = See Key to Soil Logs for list of abbreviations and descriptions of tests

SAMPLE TYPE

SPT = Standard Penetration Test, 34.9mm ID and 50.8mm OD split spoon sampler

MC = Modified California Sampler, 50.8mm ID and 63.5mm OD split spoon sampler

P = Piston Sampler, 76.2 mm OD

SH = Shelby Tube, 76.2mm OD, pushed

BAG = Bulk Sample

Boring: SB-11-262
Sheet 3 of 3

SAMPLE DESCRIPTION
(ASTM D 2488/D 2487)

Elevation (m)	Sample Description	Depth (ft)	Depth (m)	Type	Recovery (mm)	USCS	AASHTO	N, Blows per 0.15 m (or interval shown)	SPT $(N_1)_{60}$
	SILT - hard, wet, light brown, trace of clay seams				610	ML	A-4	8 28 38 41	
1245	Lean CLAY - very stiff, wet, gray - light brown	135	41	SPT	457	CL	A-6	7 11 15 21	17
	- olive-gray, trace of sand seams up to 4 mm thick	140	43	SPT	610			10 17 23 21	26
		145	44	SPT	610			11 18 22 21	26
		150	46	SPT	610			8 20 26 21	30
1240									

Elevation scale (m): 1245, 1240, 1235, 1230

Depth scale ft: 135, 140, 145, 150, 155, 160, 165, 170, 175, 180, 185, 190, 195

Depth scale m: 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59

Graphic Log

● SPT $(N_1)_{60}$
○ SPT $(N_1)_{60}$ (Greater than 50 Blows)
0 25 50

Test Results *: S_u, kPa (torvane in italics) | Dry Density, kN/m³ | Moisture, % | Liquid Limit | Plasticity Index | % Passing No. 200 | Other Tests

Legacy Parkway - Preferred Alternative
I-215 to I-15/US 89 Interchange
KLEINFELDER
Project No. 35-8163-05

FIELD TEST BORING LOG

Boring: **SB-11-262**

Sheet 3 of 3

Logged by:	M. Hislop
Date Start:	1/26/00
Date Finish:	1/28/00
Station:	5+495.950 0.22 LT
Line:	CENTER STREET
Coordinates (m):	N 107,993.664 E 15,739.839
Elevation (m).	1286.123
Total Depth Drilled (m).	46.3
Drill Contractor	RC Exploration
Driller:	M. Labenski
Rig Type	Diedrich D-120 ATV
Drilling Method:	Hollow-Stem Auger
Hammer Type	Automatic
Rod Type	AW
Boring Diameter	152 mm

LEGEND/NOTES

Elevations based upon North American Vertical Datum of 1988 (NAVD '88)

Coordinates are NAD '83

∇ = Observed Groundwater depth at time of drilling

Blows = Number of blows required to drive split spoon sampler 150 mm or interval shown

USCS = Unified Soil Classification System

AASHTO = American Association of State Highway and Transportation Officials

* = See Key to Soil Logs for list of abbreviations and descriptions of tests

SAMPLE TYPE

SPT = Standard Penetration Test, 34.9mm ID and 50.8mm OD split spoon sampler

MC = Modified California Sampler, 50.8mm ID and 63.5mm OD split spoon sampler

P = Piston Sampler, 76.2 mm OD

SH = Shelby Tube, 76.2mm OD, pushed

BAG = Bulk Sample

UTDOT 2003SB1.GPJ 5/30/00

Legacy Parkway - Preferred Alternative
I-215 to I-15/US 89 Interchange
KLEINFELDER
Project No. 35-8163-05

FIELD TEST BORING LOG

Boring: **RB-368**

Sheet 1 of 2

Logged by:	W. Lewis
Date Start:	2/6/00
Date Finish:	2/7/00
Station:	5+309.965 0.06 LT
Line:	Center Street
Coordinates (m):	N 107,994.964 E 15,553.859
Elevation (m):	1285.236
Total Depth Drilled (m):	23.5
Drill Contractor:	Layne Christensen
Driller:	C. Davis
Rig Type:	Mobile B-59
Drilling Method:	Mud Rotary
Hammer Type:	Safety
Rod Type:	AW
Boring Diameter:	133 mm

Boring: RB-368
Sheet 1 of 2

SAMPLE DESCRIPTION (ASTM D 2488/D 2487)

Elevation (m)	Sample Description	Type	Recovery (mm)	USCS	AASHTO	N, Blows per 0.15 m (or interval shown)	SPT $(N_1)_{60}$	S_u, kPa (torvane in italics)	Dry Density, kN/m³	Moisture, %	Liquid Limit	Plasticity Index	% Passing No. 200	Other Tests
1285	Silty SAND - medium stiff, moist, light gray-brown	MC	508	SM	A-2-4	3 3 4 5	9							
	Lean CLAY - soft to medium stiff, wet, light gray, with minor light brown mottling	SPT	483	CL	A-7-6	2 1 2 2	5							
		P	584					*14*						
	- with silt lenses	SPT	610			1 1 1 2	2							
		MC	584			2 3 2 3	5							
		SPT	610			3 2 3 6	7							
		P	559					14 *29*	13.3	38	43	18		C TR SG
1280	Silty SAND - loose, wet, gray, fine-grained			SM	A-2-4									
	Sandy SILT - soft to medium stiff, wet, gray	SPT	356	ML	A-4	1 1 1 1	2							
		MC	152			1 3 2 3	5							
		SPT	457			1 2 2 3	4							
		P	610					*38*						
	Silty SAND - loose, wet, light brown, with trace clay, fine-grained with mica flakes	SPT	356	SM	A-2-4	1 3 5 5	8							
	Silty CLAY - soft, wet, gray, with occasional fine-grained sand	MC	508	CL-ML	A-6	1 1 2 4	3							
		SPT	508			2 5 12 15	17							
1275	Silty SAND - medium dense, wet, gray , fine-grained, with mica flakes			SM	A-2-4									
		P	610					*24*						
		SPT	356			2 1 3 6	4							
	SILT - soft, wet, dark gray, with occasional fine-sand	MC	610	ML	A-4	2 2 2 4	4							
	- medium stiff	SPT	610			2 3 2 3	5							
		P	610					*43*	13.0	39				C SG
		SPT	610			1 2 5 7	8							
1270	Silty SAND - medium dense, wet, gray, fine-grained	SPT	457	SM	A-2-4	1 12 15 16	30							
	SILT with sand - very stiff, wet, dark gray	P	508	ML	A-2-4			36 *29*	17.1	24			76	
		SPT	508			3 6 16 15	25							

Test Results *

● SPT $(N_1)_{60}$
○ SPT $(N_1)_{60}$ (Greater than 50 Blows)

LEGEND/NOTES

Elevations based upon North American Vertical Datum of 1988 (NAVD '88)

Coordinates are NAD '83

∇ = Observed Groundwater depth at time of drilling

Blows = Number of blows required to drive split spoon sampler 150 mm or interval shown

USCS = Unified Soil Classification System

AASHTO = American Association of State Highway and Transportation Officials

* = See Key to Soil Logs for list of abbreviations and descriptions of tests

SAMPLE TYPE

SPT = Standard Penetration Test, 34.9mm ID and 50.8mm OD split spoon sampler

MC = Modified California Sampler, 50.8mm ID and 63.5mm OD split spoon sampler

P = Piston Sampler, 76.2 mm OD

SH = Shelby Tube, 76.2mm OD, pushed

BAG = Bulk Sample

UTDOT Z003RB.GPJ 8/30/00

Legacy Parkway - Preferred Alternative
I-215 to I-15/US 89 Interchange

KLEINFELDER

Project No. 35-8163-05

FIELD TEST BORING LOG

Boring: **RB-368**

Sheet 2 of 2

Boring: RB-368
Sheet 2 of 2

SAMPLE DESCRIPTION (ASTM D 2488/D 2487)

Elevation (m)	Sample Description	Depth (ft)	Depth (m)	Type	Recovery (mm)	USCS	AASHTO	N, Blows per 0.15 m (or interval shown)	SPT $(N_1)_{60}$
1265	Silty SAND - dense, wet, gray			P	0				
				P	305	SM	A-2-4		
		70	21–22	SPT	559			8 20 21 30	45
	- medium dense	75	23	SPT	584			6 12 15 27	29

Test Results *: S_u, kPa (torvane in italics); Dry Density, kN/m³; Moisture, %; Liquid Limit; Plasticity Index; % Passing No. 200; Other Tests

Logged by: W. Lewis
Date Start: 2/6/00
Date Finish: 2/7/00
Station: 5+309.965 0.06 LT
Line: Center Street
Coordinates (m): N 107,994.964 E 15,553.859
Elevation (m): 1285.236
Total Depth Drilled (m): 23.5
Drill Contractor: Layne Christensen
Driller: C. Davis
Rig Type: Mobile B-59
Drilling Method: Mud Rotary
Hammer Type: Safety
Rod Type: AW
Boring Diameter: 133 mm

LEGEND/NOTES

Elevations based upon North American Vertical Datum of 1988 (NAVD '88)

Coordinates are NAD '83

∇ = Observed Groundwater depth at time of drilling

Blows = Number of blows required to drive split spoon sampler 150 mm or interval shown

USCS = Unified Soil Classification System

AASHTO = American Association of State Highway and Transportation Officials

* = See Key to Soil Logs for list of abbreviations and descriptions of tests

SAMPLE TYPE

SPT = Standard Penetration Test, 34.9mm ID and 50.8mm OD split spoon sampler

MC = Modified California Sampler, 50.8mm ID and 63.5mm OD split spoon sampler

P = Piston Sampler, 76.2 mm OD

SH = Shelby Tube, 76.2mm OD, pushed

BAG = Bulk Sample

UTDOT 2503R8.GPJ 8/30/00

Elevation (m)	SAMPLE DESCRIPTION (ASTM D 2488/D 2487)	Type	Recovery (mm)	USCS	AASHTO	N, Blows per 0.15 m (or interval shown)	SPT $(N_1)_{60}$	S_u kPa (torvane in italics)	Dry Density, kN/m³	Moisture, %	Liquid Limit	Plasticity Index	% Passing No. 200	Other Tests
	Lean CLAY - stiff, moist, light gray-brown	MC	508	CL	A-7-6	3 3 4 5	9							
∇	- wet	SPT	559			3 1 3 2								
1285	medium stiff	P	254					*34*	11.5	48	48	25	99	C TR SG
	Silty SAND - loose, wet, light grayish-brown, fine to medium-grained	SPT	610	SM	A-2-4	1 1 2 4	3							
	Lean CLAY - soft, wet, light brown with yellow-brown mottling			CL	A-7-6									
		MC	610			1 1 2 1	3							
		SPT	457			1 1 1 1	2							
	- gray, with organics	P	610					*14*						
	SILT - soft, wet, dark gray	SPT	610	ML	A-4	1 1 2 4	3							
	Silty SAND - loose, wet, gray			SM	A-2-4									
1280	SILT - soft, wet, dary gray, with organics and seams of fine-grained sand	MC	610	ML	A-4	1 1 1 1	2							
		SPT	610			1 2 1 6	3							
	Silty SAND - loose, wet, gray			SM	A-2-4									
	SILT - soft, wet, dark gray, with organics	P	559	ML	A-4			57						
		SPT	610			1 1 1 1	2							
		MC	610			1 1 2 2	3							
		SPT	610			2 2 3 4	5							
	- medium stiff, green-gray	P	508					*34*						
1275	- soft, wet, mottled green-gray and dark gray, with fine-grained sand, mica flakes with trace clay	SPT	610			1 1 2 2	3							
		MC	610			1 1 1 2	2							
		SPT	610			3 6 3 3	8							
	Silty SAND - loose, wet, gray, fine-grained			SM	A-2-4									
	Lean CLAY - soft, wet, dark gray	P	610	ML	A-7-6			60 *53*	15.3	28	45	25	86	
	- medium stiff	SPT	559			2 3 4 5	7							
		SPT	533			2 2 2 3	4							
1270	- soft	P	305					*57*	15.3	28			97	C SG
	- medium stiff	SPT	559			4 5 4 6	8							

Depth ft: 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65
Depth m: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19

Boring: RB-369
Sheet 1 of 2

Graphic Log

● SPT $(N_1)_{60}$
○ SPT $(N_1)_{60}$ (Greater than 50 Blows)
0 25 50

Test Results *

UTDOT Z003RB.GPJ 8/30/00

Legacy Parkway - Preferred Alternative
I-215 to I-15/US 89 Interchange

KLEINFELDER

Project No. 35-8163-05

FIELD TEST BORING LOG

Boring: RB-369

Sheet 1 of 2

Logged by:	W. Lewis
Date Start:	2/8/00
Date Finish:	2/8/00
Station:	5+569.100 3.99 LT
Line:	Center Street
Coordinates (m):	N 108,005.988 E 15,811.167
Elevation (m):	1286.162
Total Depth Drilled (m):	23.5
Drill Contractor:	Layne Christensen
Driller:	C. Davis
Rig Type:	Mobile B-59
Drilling Method:	Mud Rotary
Hammer Type:	Safety
Rod Type.	AW
Boring Diameter:	133 mm

LEGEND/NOTES

Elevations based upon North American Vertical Datum of 1988 (NAVD '88)

Coordinates are NAD '83

∇ = Observed Groundwater depth at time of drilling

Blows = Number of blows required to drive split spoon sampler 150 mm or interval shown

USCS = Unified Soil Classification System

AASHTO = American Association of State Highway and Transportation Officials

* = See Key to Soil Logs for list of abbreviations and descriptions of tests

SAMPLE TYPE

SPT = Standard Penetration Test, 34.9mm ID and 50.8mm OD split spoon sampler

MC = Modified California Sampler, 50.8mm ID and 63.5mm OD split spoon sampler

P = Piston Sampler, 76.2 mm OD

SH = Shelby Tube, 76.2mm OD, pushed

BAG = Bulk Sample

Legacy Parkway - Preferred Alternative
I-215 to I-15/US 89 Interchange

KLEINFELDER

Project No. 35-8163-05

FIELD TEST BORING LOG

Boring: **RB-369**

Sheet 2 of 2

Boring: RB-369
Sheet 2 of 2

Elevation (m)	SAMPLE DESCRIPTION (ASTM D 2488/D 2487)	Depth (ft)	Depth (m)	Graphic Log	Type	Recovery (mm)	USCS	AASHTO	N, Blows per 0.15 m (or interval shown)	● SPT $(N_1)_{60}$ ○ SPT $(N_1)_{60}$ (Greater than 50 Blows) 0 25 50	S_u, kPa (torvane in italics)	Dry Density, kN/m³	Moisture, %	Liquid Limit	Plasticity Index	% Passing No. 200	Other Tests
	Lean CLAY - medium stiff, wet, dark gray (continued)				P	305											
1265	Silty SAND - medium dense, wet, light brownish-gray, fine-grained	70	21		SPT	533	SM	A-2-4	5 10 17 20	24							
		75	23		SPT	330			5 7 14 20	21							

Elevation scale (m): 1265, 1260, 1255, 1250

Depth scale (ft): 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130

Depth scale (m): 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39

Test Results *

Logged by: W. Lewis
Date Start: 2/8/00
Date Finish: 2/8/00
Station: 5+569.100 3.99 LT
Line: Center Street
Coordinates (m): N 108,005.988 E 15,811.167
Elevation (m): 1286.162
Total Depth Drilled (m): 23.5
Drill Contractor: Layne Christensen
Driller: C. Davis
Rig Type: Mobile B-59
Drilling Method: Mud Rotary
Hammer Type: Safety
Rod Type: AW
Boring Diameter: 133 mm

LEGEND/NOTES

Elevations based upon North American Vertical Datum of 1988 (NAVD '88)

Coordinates are NAD '83

∇ = Observed Groundwater depth at time of drilling

Blows = Number of blows required to drive split spoon sampler 150 mm or interval shown

USCS = Unified Soil Classification System

AASHTO = American Association of State Highway and Transportation Officials

* = See Key to Soil Logs for list of abbreviations and descriptions of tests

SAMPLE TYPE

SPT = Standard Penetration Test, 34.9mm ID and 50.8mm OD split spoon sampler

MC = Modified California Sampler, 50.8mm ID and 63.5mm OD split spoon sampler

P = Piston Sampler, 76.2 mm OD

SH = Shelby Tube, 76.2mm OD, pushed

B BAG = Bulk Sample

UTDOT Z003RB.GPJ 8/30/00

APPENDIX C
Laboratory Testing

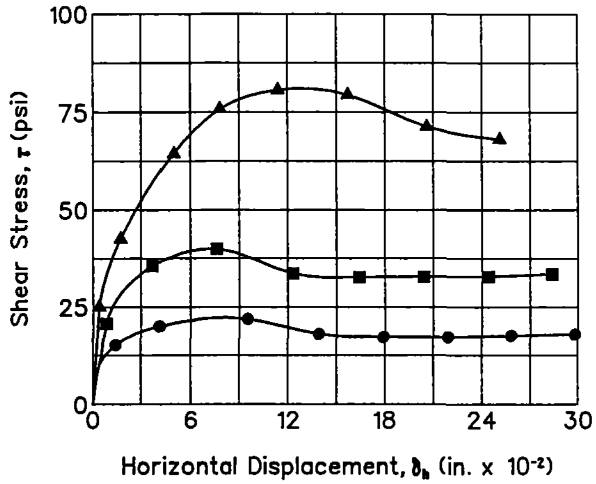
Table 1

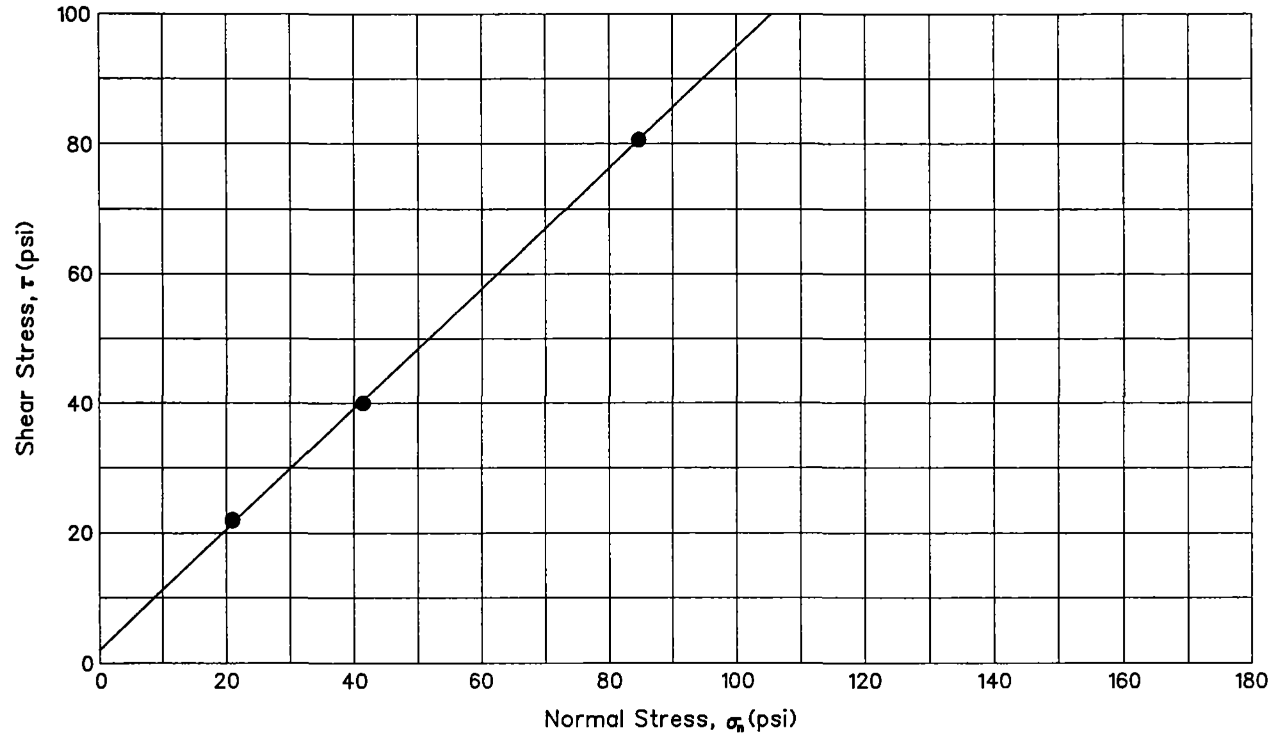
SUMMARY OF TEST DATA

PROJECT Legacy Parkway — PROJECT NO. 200601-111
LOCATION Structure F-717 (Center Street over Legacy Parkway) — FEATURE Foundations

HOLE NO.	DEPTH BELOW GROUND SURFACE (ft)	STANDARD PENETRATION BLOWS PER FOOT	IN-PLACE		UNCONFINED COMPRESSIVE STRENGTH (psf)	ATTERBERG LIMITS			MECHANICAL ANALYSIS			UNIFIED SOIL CLASSIFICATION SYSTEM / (AASHTO Classification)
			DRY UNIT WEIGHT (pcf)	MOISTURE (%)		LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX (%)	PERCENT GRAVEL	PERCENT SAND	PERCENT SILT & CLAY	
RSB-11-607	7-8.5	Shelby	81.2	38.4	1209	38	20	18	0	3	97	CL / A-6(18)
	15-16.5	Shelby		31.9		36	21	15	0	1	99	CL / A-6(16)
	20-20.5	Shelby		22.5				NP	0	25	75	ML / A-4(0)
	20.5-21.5	Shelby	87.8	30.2	863	40	17	23	0	2	98	CL / A-6(23)
	30-31.5	19		26.1				NP	0	34	66	ML / A-4(0)
	40-41.5	Shelby	81.7	42.1		32	20	12	0	3	97	CL / A-6(12)
	48.5-50	40		20.7				NP	0	92	8	SP-SM / A-3(0)
	58.5-60	Shelby	69.7	52.5	1872	40	21	19	0	1	99	CL / A-6(20)
	68.5-70	47		21.7				NP	1	88	11	SP-SM / A-2-4(0)
	83.5-85	21		28.9		31	21	10	0	7	93	CL / A-4(9)
	93.5-95	Shelby	91.2	28.3		37	18	19	0	14	86	CL / A-6(16)
	103.5-105	40		24.2				NP	0	62	38	SM / A-4(0)
	113.5-115	13		28.6		42	17	25	0	6	94	CL / A-7-6(24)
	126.5-128	Shelby	99.7	26.0		32	17	15	0	6	94	CL / A-6(13)
RSB-11-608	10-11.5	Shelby	83.3	38.5	1575	36	23	13	0	1	99	CL / A-6(14)
	20-21.5	Shelby		32.1				NP	0	68	32	SM / A-2-4(0)
	40-41.5	Shelby		25.3				NP	0	46	54	ML / A-4(0)
	55-56.5	Shelby	68.6	49.5	2815	40	21	19	0	1	99	CL / A-6(20)
	65-66.5	43		25.3				NP	0	94	6	SP / A-3(0)
	75-76.5	74		22.0				NP	0	90	10	SP-SM / A-3(0)
	85-86.5	Shelby	93.3	29.8		40	21	19	0	4	96	CL / A-6(20)

NP=Nonplastic





Test No. or Symbol	Sample Size (inches)	Sample Data: Dry Density (pcf)	Sample Data: Moisture Content (%)	Degree of Saturation (%)	Normal Stress δ_n (psi)	Maximum Shear Stress τ (psi)	Strain Rate (inches/minute)	Shear Strength Parameters: Friction Angle φ (degrees)	Shear Strength Parameters: Cohesion (c/psi)
●	2.375	98.9	23.3	~100	20.9	22.0	0.0009	42.6	2
■	2.375	98.9	24.2	~100	41.4	40.0	0.0009		
▲	2.375	97.8	24.2	~100	84.6	80.6	0.0009		

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Provo, Utah

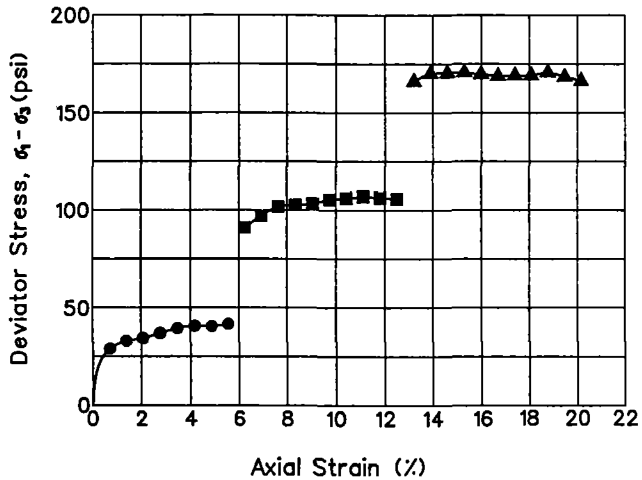
DIRECT SHEAR TEST

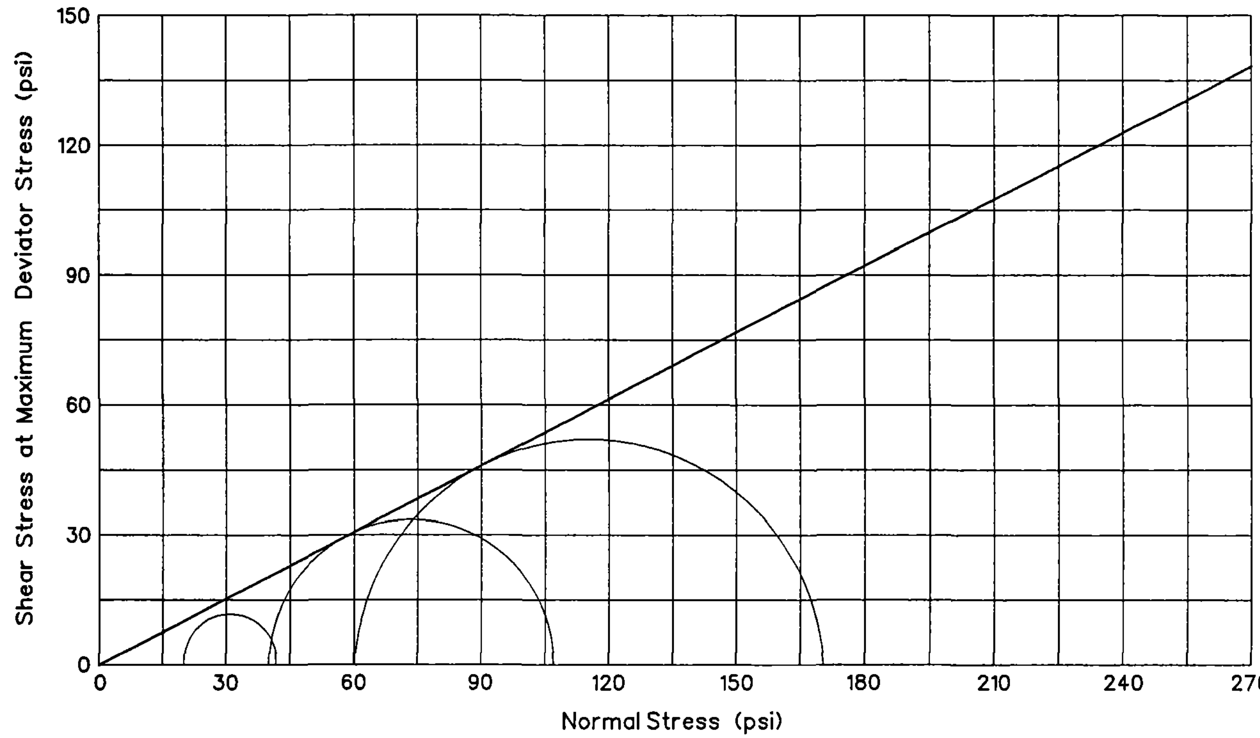
Project: *Legacy Parkway - Structure F-717*
(Center Street over Legacy Parkway)
Davis County, Utah

HOLE NO.: RSB-11-607

DEPTH: 68.5'-70'

Figure





MULTI-STAGE CONSOLIDATED UNDRAINED W/PORE PRESSURE MEASUREMENTS:

TOTAL STRESS FAILURE ENVELOPE

Test No. or Symbol	Sample Data		Degree of Saturation (%)	Confining Pressure (psi)	Maximum Deviator Stress (psi)	Strength Values at Failure		Sample Size, L/D (inches)	Strain Rate (inches/ minute)
	Dry Density (pcf)	Moisture Content (%)				Friction Angle ϕ (degrees)	Cohesion (c/psi)		
●	86.8	34.2	~100	20	41.7	27.3	0	2.88/1.38	0.001
■	86.8	34.2	~100	40	107.0				
▲	86.8	34.2	~100	60	170.5				

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Provo, Utah

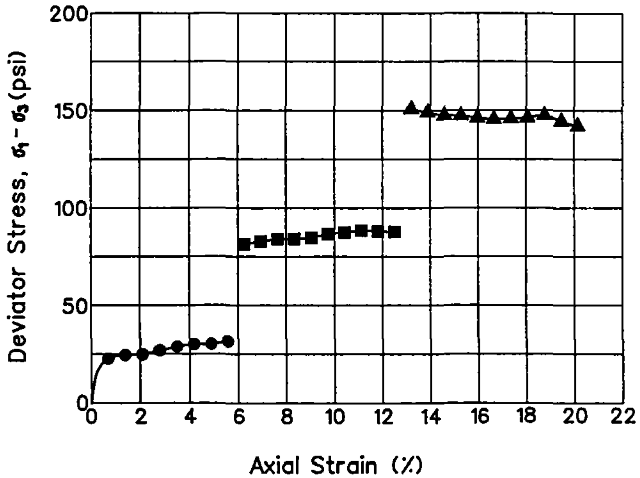
TRIAXIAL SHEAR TEST

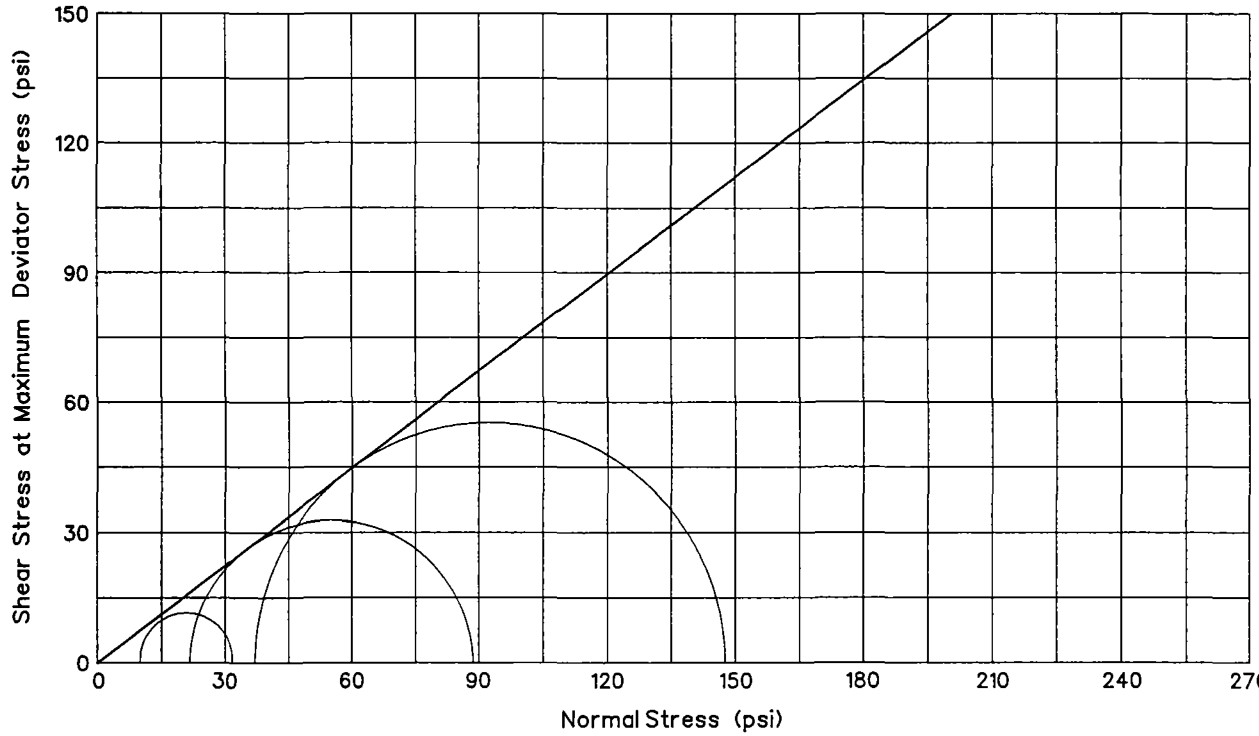
Project: *Legacy Parkway - Structure F-717*
(Center Street over Legacy Parkway)
Davis County, Utah

HOLE NO.: RSB-11-607

DEPTH: 20'-21.5'

Figure





MULTI-STAGE CONSOLIDATED UNDRAINED W/PORE PRESSURE MEASUREMENTS:

EFFECTIVE STRESS FAILURE ENVELOPE

Test No. or Symbol	Sample Data		Degree of Saturation (%)	Confining Pressure (psi)	Maximum Deviator Stress (psi)	Strength Values at Failure		Sample Size, L/D (inches)	Strain Rate (inches/minute)
	Dry Density (pcf)	Moisture Content (%)				Friction Angle ϕ (degrees)	Cohesion (c/psi)		
●	86.8	34.2	~100	10.0	31.7				
■	86.8	34.2	~100	21.6	88.6	36.9	0	2.88/1.38	0.001
▲	86.8	34.2	~100	37.0	147.5				

RB&G ENGINEERING INC.
Provo, Utah

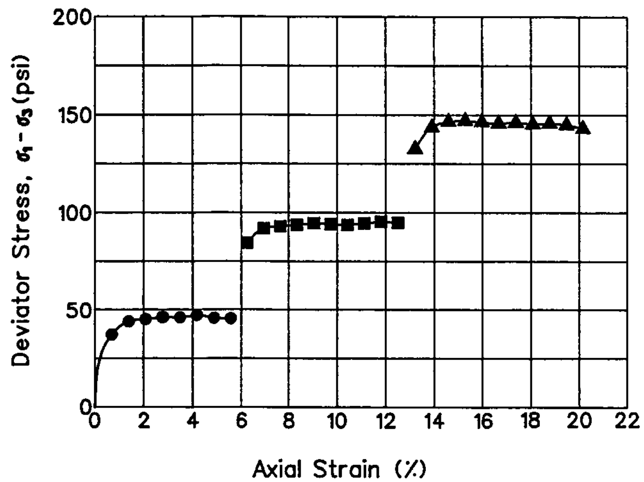
TRIAXIAL SHEAR TEST

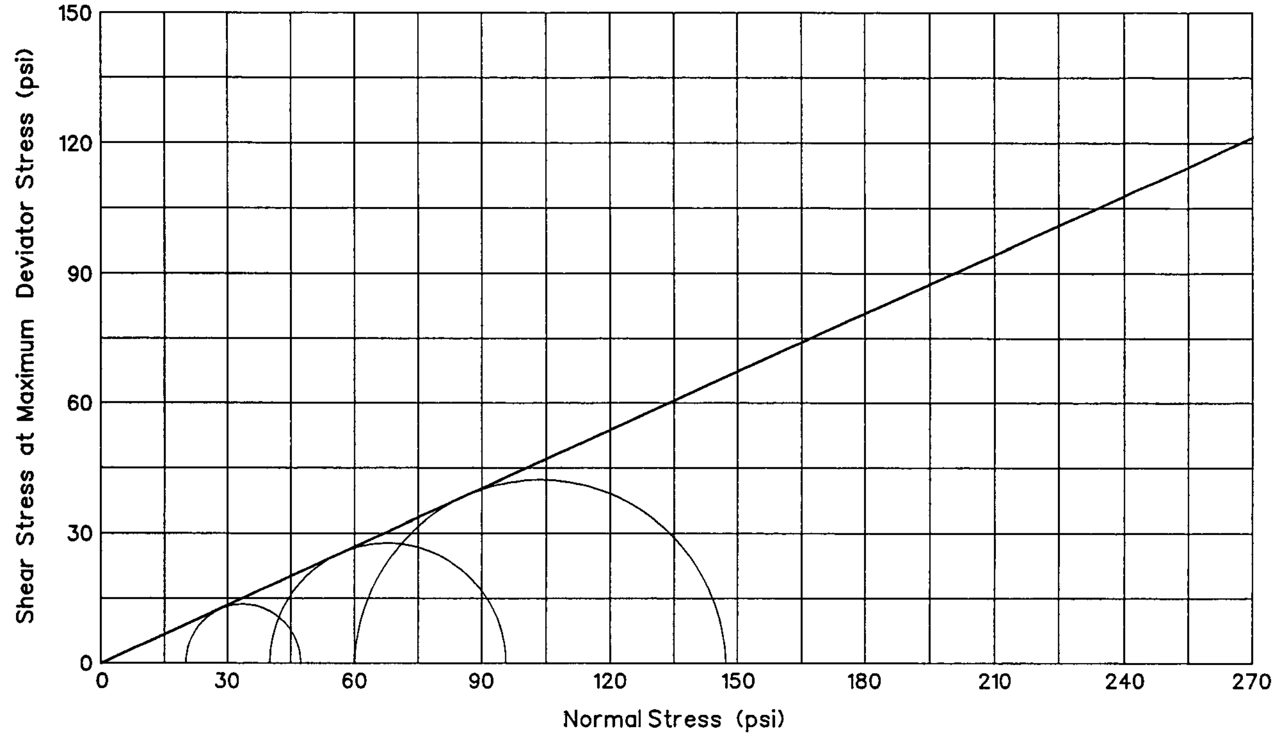
Project: *Legacy Parkway - Structure F-717*
(Center Street over Legacy Parkway)
Davis County, Utah

HOLE NO.: RSB-11-607

DEPTH: 20'-21.5'

Figure





MULTI-STAGE CONSOLIDATED UNDRAINED W/PORE PRESSURE MEASUREMENTS:

TOTAL STRESS FAILURE ENVELOPE

Test No. or Symbol	Sample Data		Degree of Saturation (%)	Confining Pressure (psi)	Maximum Deviator Stress (psi)	Strength Values at Failure		Sample Size, L/D (inches)	Strain Rate (inches/ minute)
	Dry Density (pcf)	Moisture Content (%)				Friction Angle ϕ (degrees)	Cohesion (c/psi)		
●	81.1	40.0	~100	20	47.3	24.1	0	2.88/1.38	0.001
■	81.1	40.0	~100	40	95.5				
▲	81.1	40.0	~100	60	147.2				

RB&G ENGINEERING INC.
Provo, Utah

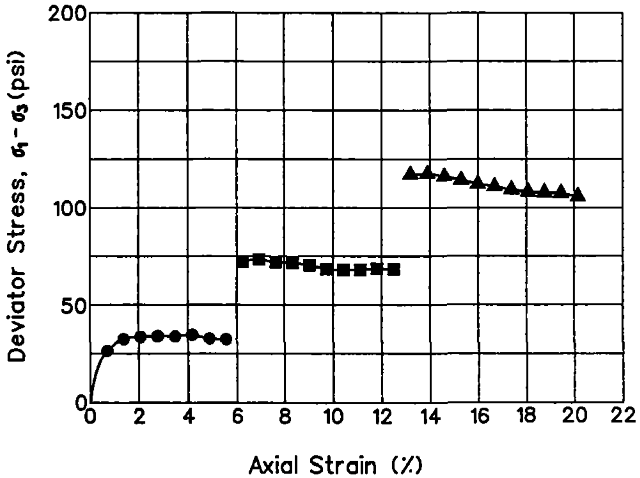
TRIAXIAL SHEAR TEST

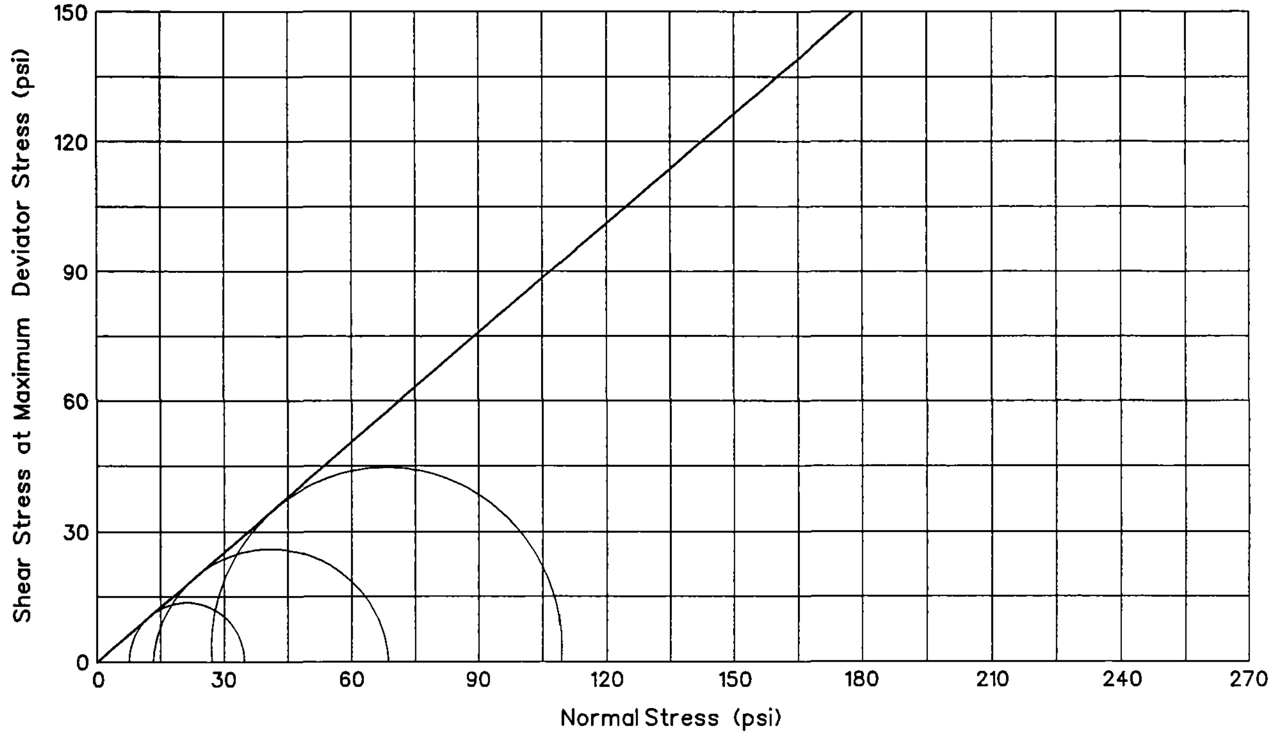
Project: *Legacy Parkway - Structure F-717*
(Center Street over Legacy Parkway)
Davis County, Utah

HOLE NO.: RSB-11-608

DEPTH: 55'-56.5'

Figure





MULTI-STAGE CONSOLIDATED UNDRAINED W/PORE PRESSURE MEASUREMENTS:

EFFECTIVE STRESS FAILURE ENVELOPE

Test No. or Symbol	Sample Data		Degree of Saturation (%)	Confining Pressure (psi)	Maximum Deviator Stress (psi)	Strength Values at Failure		Sample Size, L/D (inches)	Strain Rate (inches/minute)
	Dry Density (pcf)	Moisture Content (%)				Friction Angle ϕ (degrees)	Cohesion (c/psi)		
●	81.1	40.0	~100	7.5	34.8	40.0	0	2.88/1.38	0.001
■	81.1	40.0	~100	13.2	68.7				
▲	81.1	40.0	~100	27.0	114.2				

RB&G ENGINEERING INC.
Provo, Utah

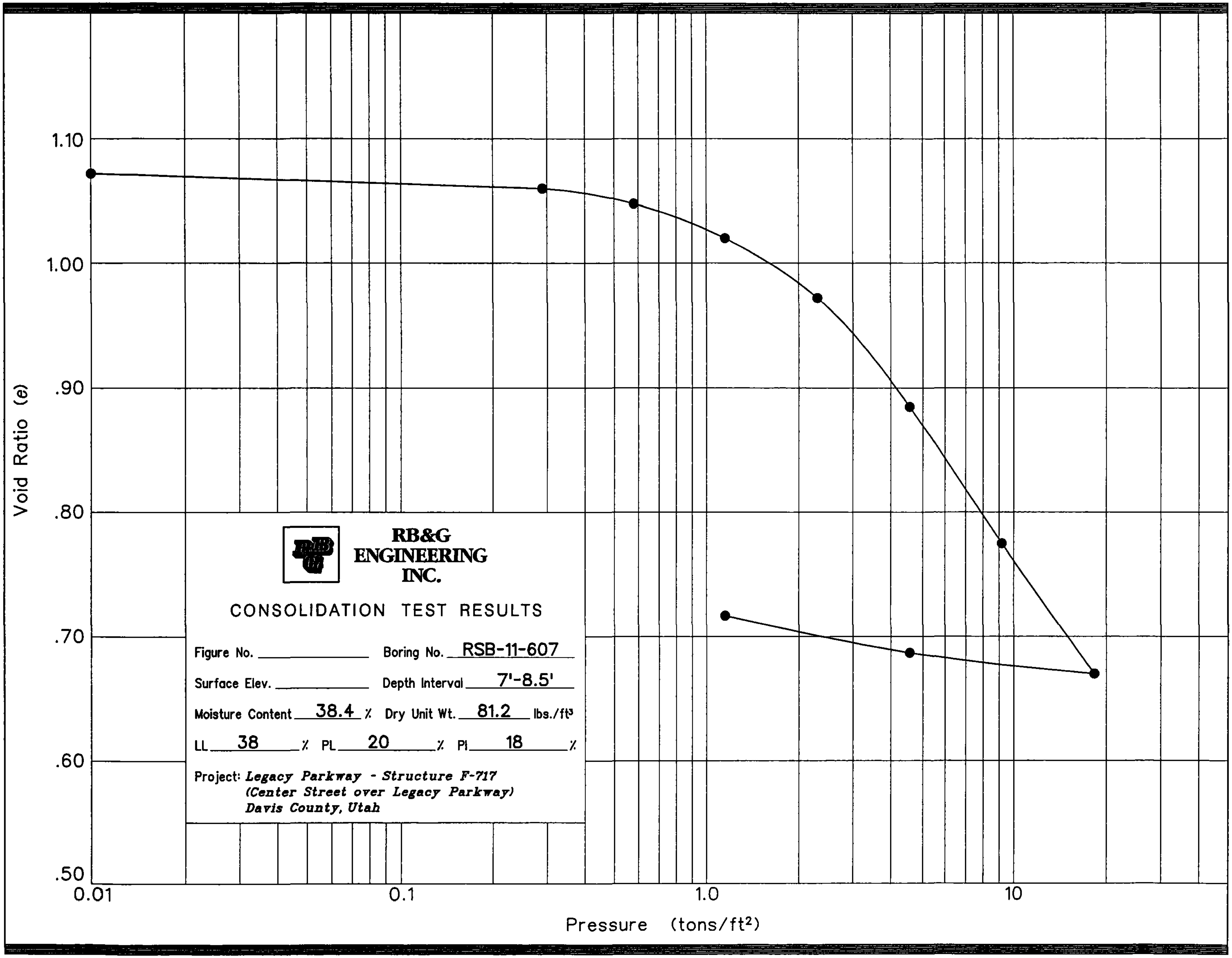
TRIAXIAL SHEAR TEST

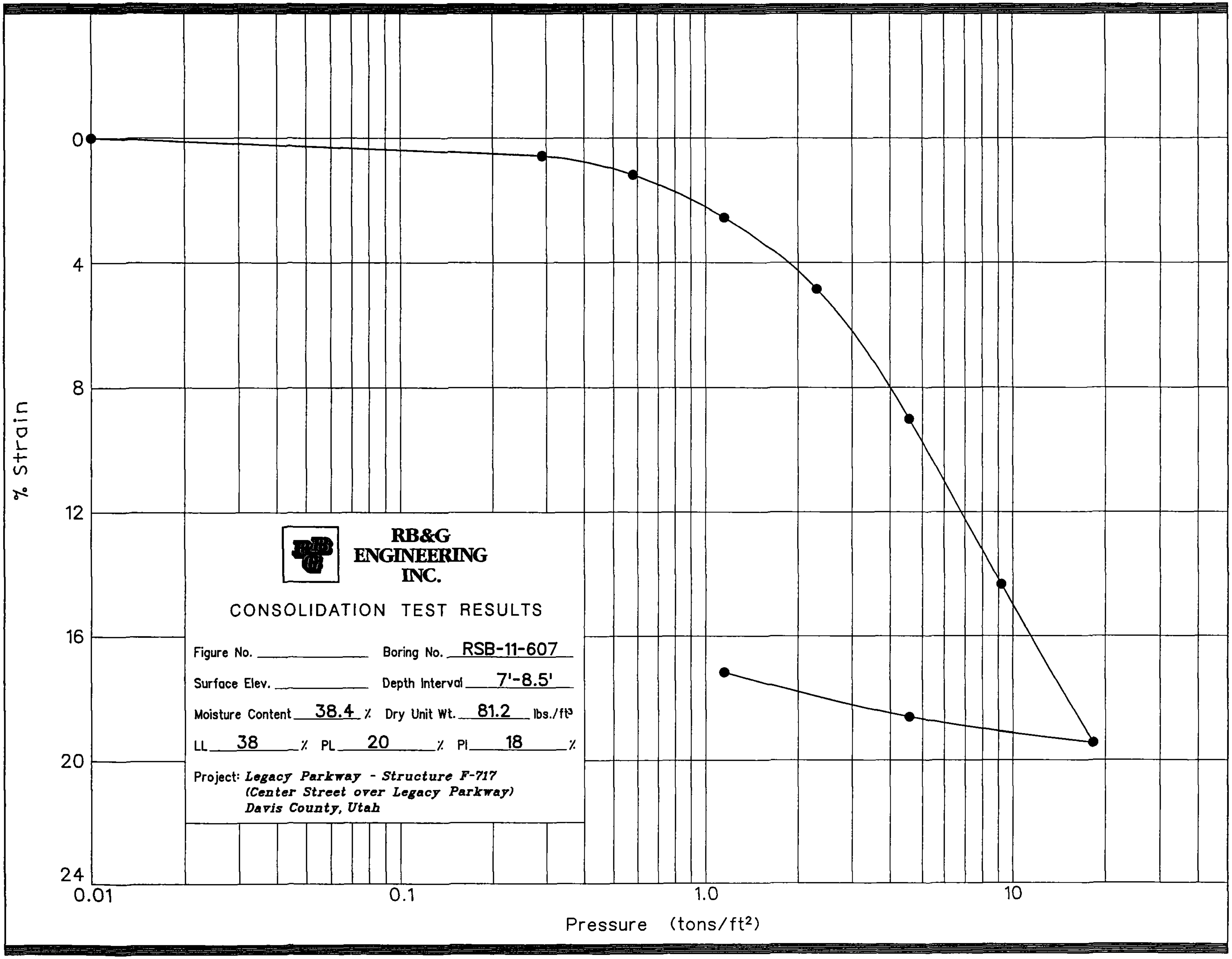
Project: *Legacy Parkway - Structure F-717*
(Center Street over Legacy Parkway)
Davis County, Utah

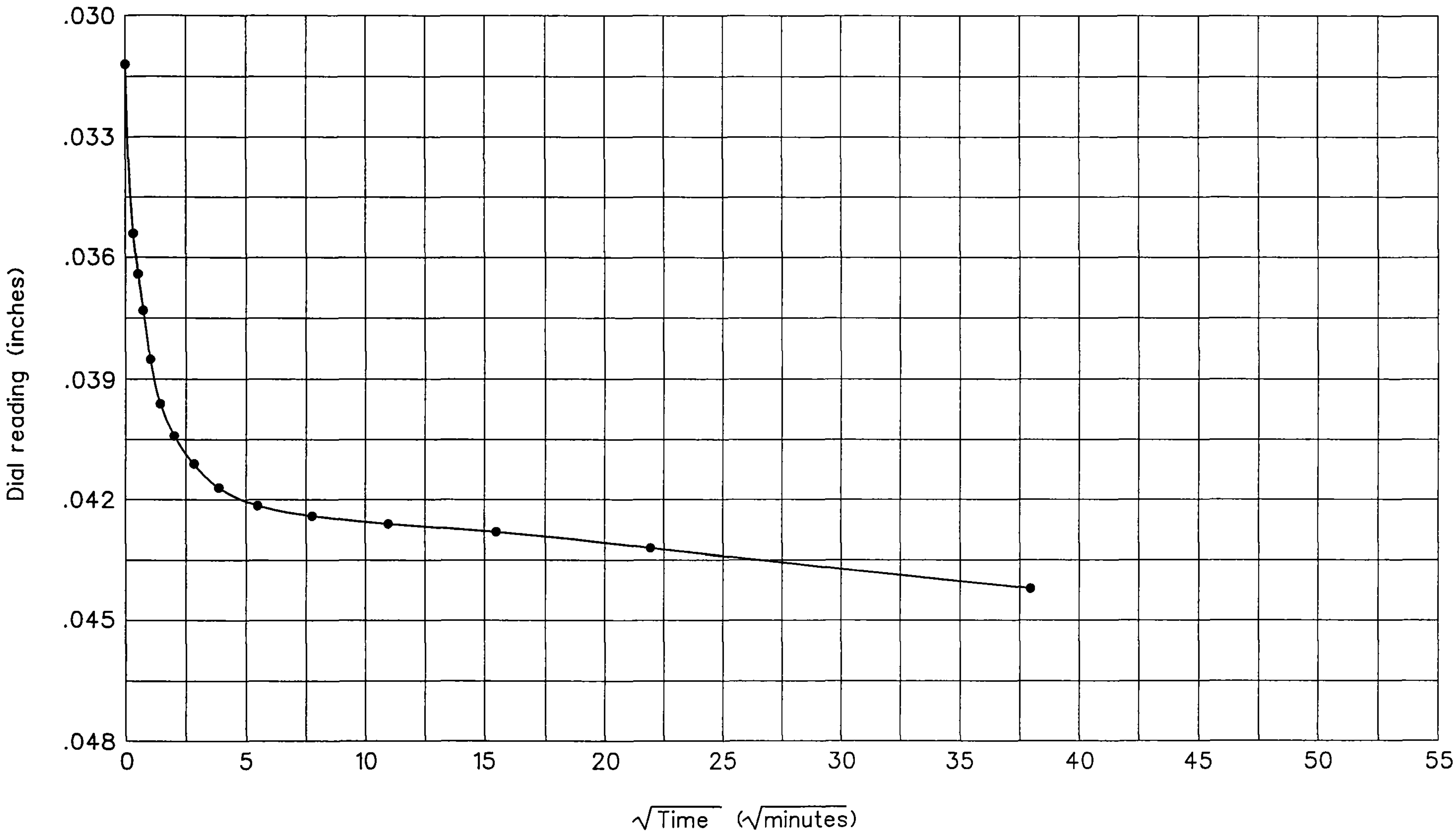
HOLE NO.: RSB-11-608

DEPTH: 55'-56.5'

Figure


1.10
1.00
.90
.80
.70
.60
.50
Void Ratio (e)
0.01
0.1
1.0
10
Pressure (tons/ft²)
RB&G ENGINEERING INC.
CONSOLIDATION TEST RESULTS
Figure No.
Boring No. RSB-11-607
Surface Elev.
Depth Interval 7'-8.5'
Moisture Content 38.4 % Dry Unit Wt. 81.2 lbs./ft³
LL 38 % PL 20 % PI 18 %
Project: Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah


RB&G ENGINEERING INC.
CONSOLIDATION TEST RESULTS
Figure No.
Boring No. RSB-11-607
Surface Elev.
Depth Interval 7'-8.5'
Moisture Content 38.4 %
Dry Unit Wt. 81.2 lbs./ft³
LL 38 %
PL 20 %
PI 18 %
Project: Legacy Parkway - Structure F-717 (Center Street over Legacy Parkway) Davis County, Utah
% Strain
0
4
8
12
16
20
24
0.01
0.1
1.0
10
Pressure (tons/ft²)



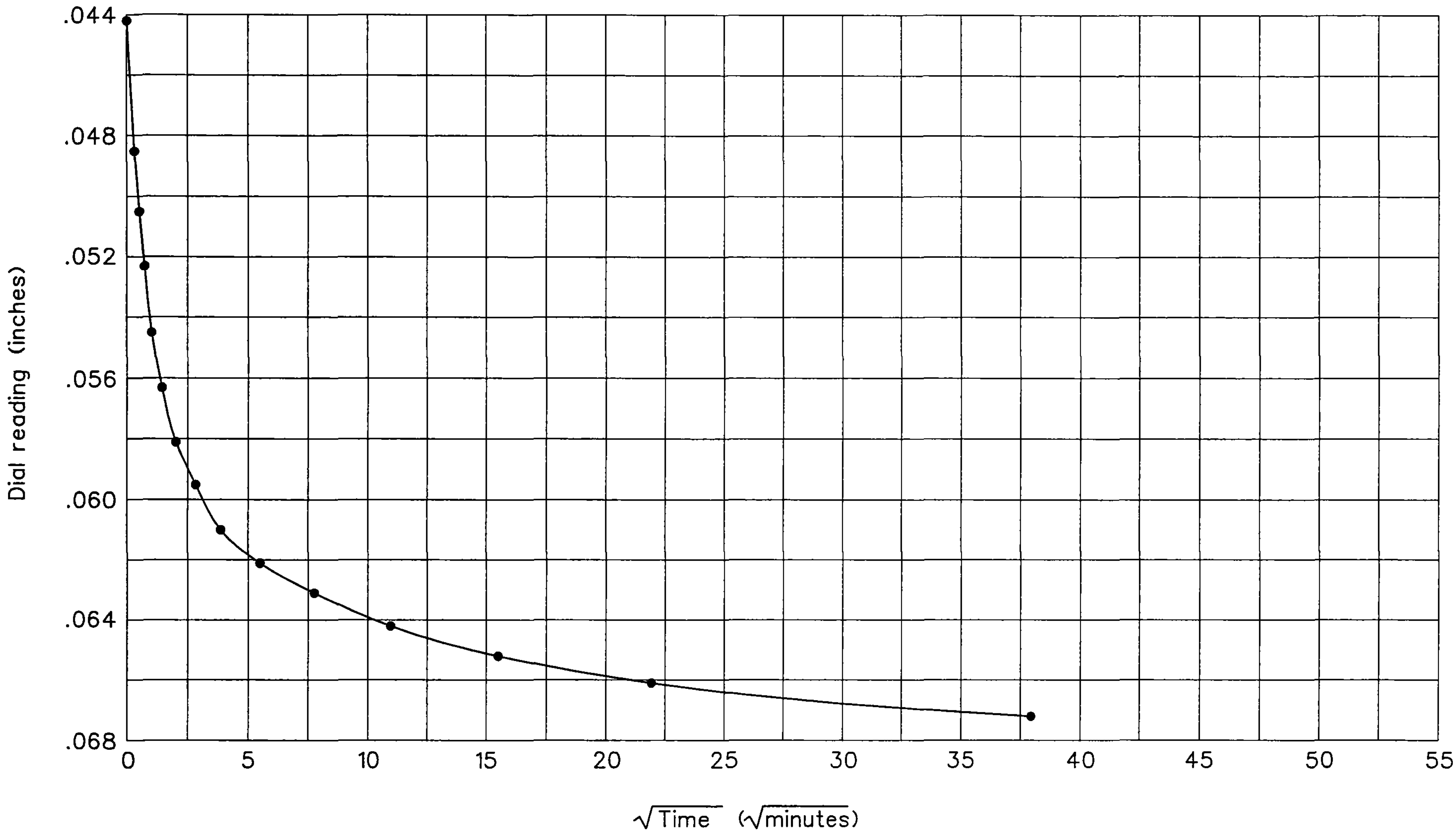
RB&G ENGINEERING INC.
Provo, Utah

Hole no.: RSB-11-607
Depth: 7'-8.5'
Load: 1.15 to 2.30 tons

TIME CONSOLIDATION

Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah

Figure



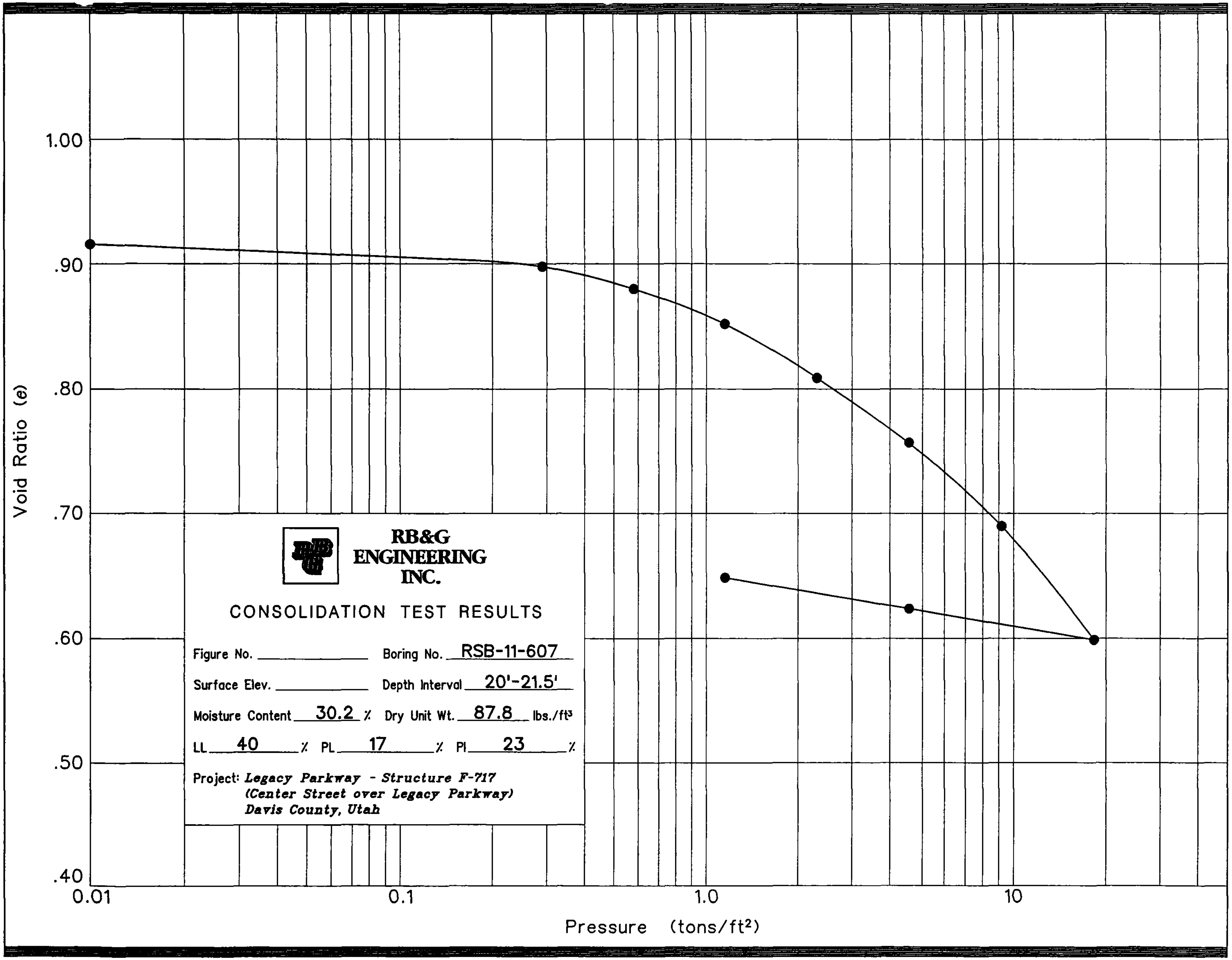
RB&G ENGINEERING INC.
Provo, Utah

Hole no.: RSB-11-607
Depth: 7'-8.5'
Load: 2.30 to 4.60 tons

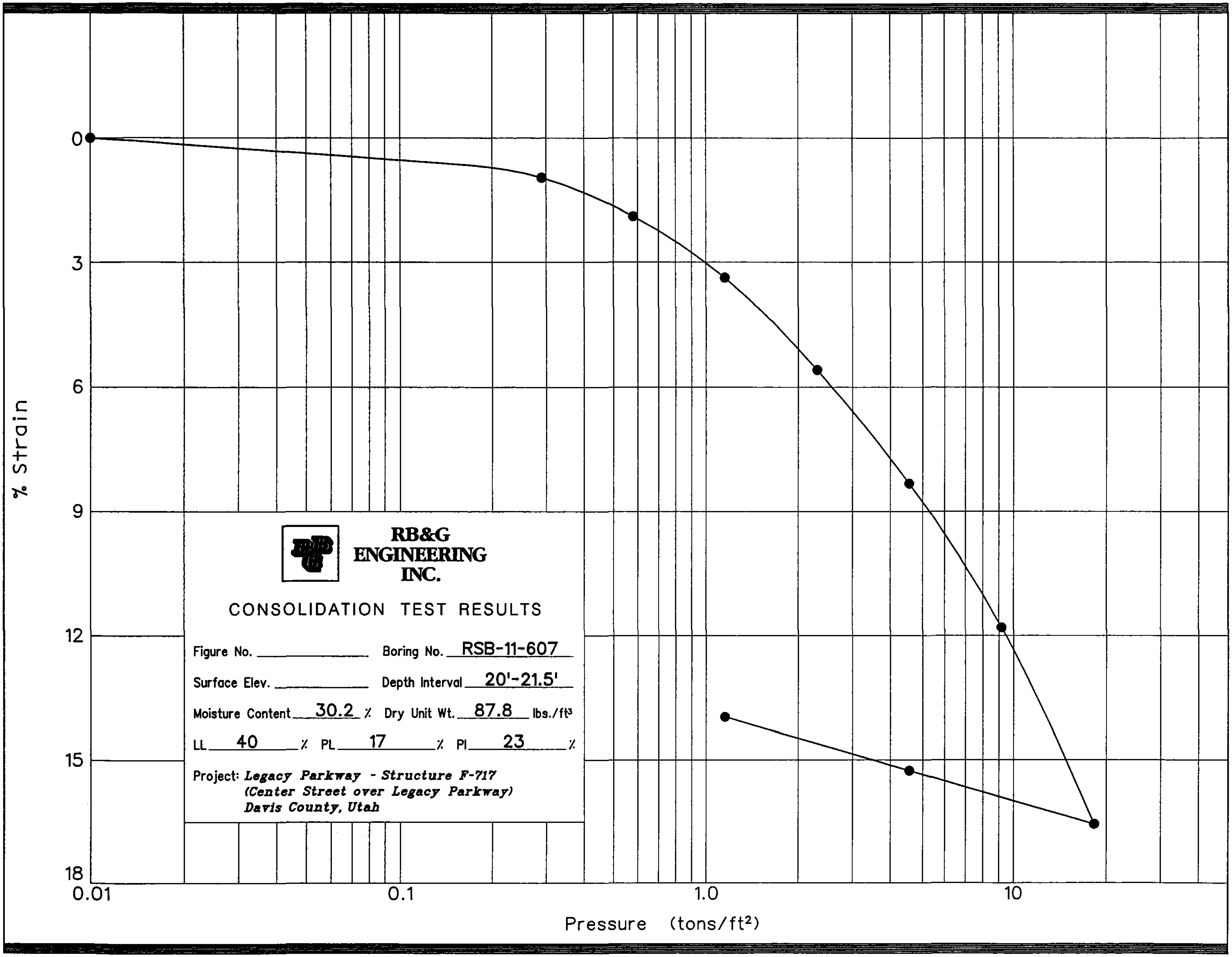
TIME CONSOLIDATION

Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah

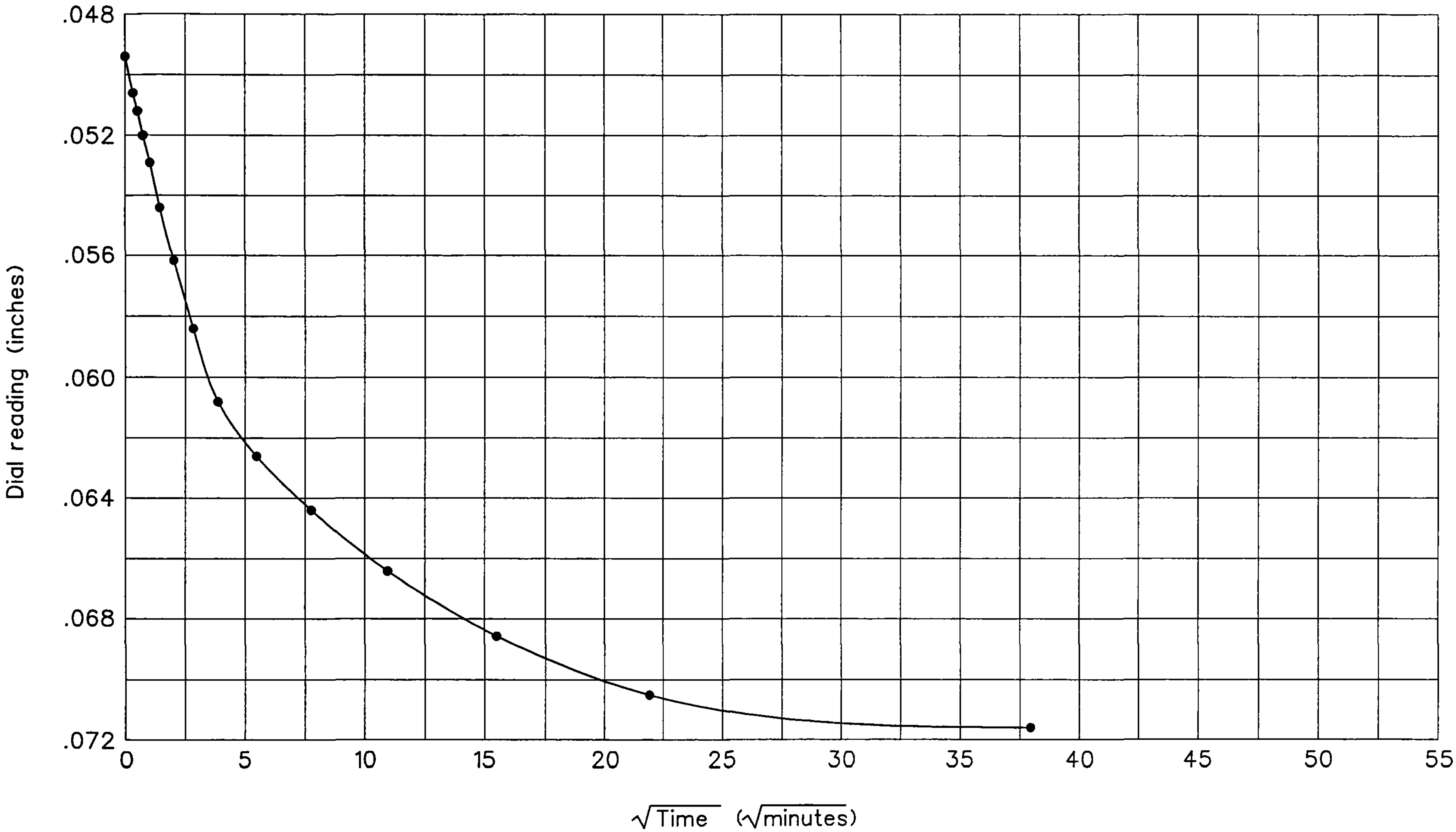
Figure



RB&G ENGINEERING INC.
CONSOLIDATION TEST RESULTS
Figure No. ______ Boring No. RSB-11-607
Surface Elev. ______ Depth Interval 20'-21.5'
Moisture Content 30.2 % Dry Unit Wt. 87.8 lbs./ft³
LL 40 % PL 17 % PI 23 %
Project: Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah
Void Ratio (e)
1.00
.90
.80
.70
.60
.50
.40
0.01
0.1
1.0
10
Pressure (tons/ft²)



% Strain
0
3
6
9
12
15
18
0.01
0.1
1.0
10
Pressure (tons/ft²)
RB&G ENGINEERING INC.
CONSOLIDATION TEST RESULTS
Figure No.
Boring No. RSB-11-607
Surface Elev.
Depth Interval 20'-21.5'
Moisture Content 30.2 %
Dry Unit Wt. 87.8 lbs./ft³
LL 40 %
PL 17 %
PI 23 %
Project: Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah



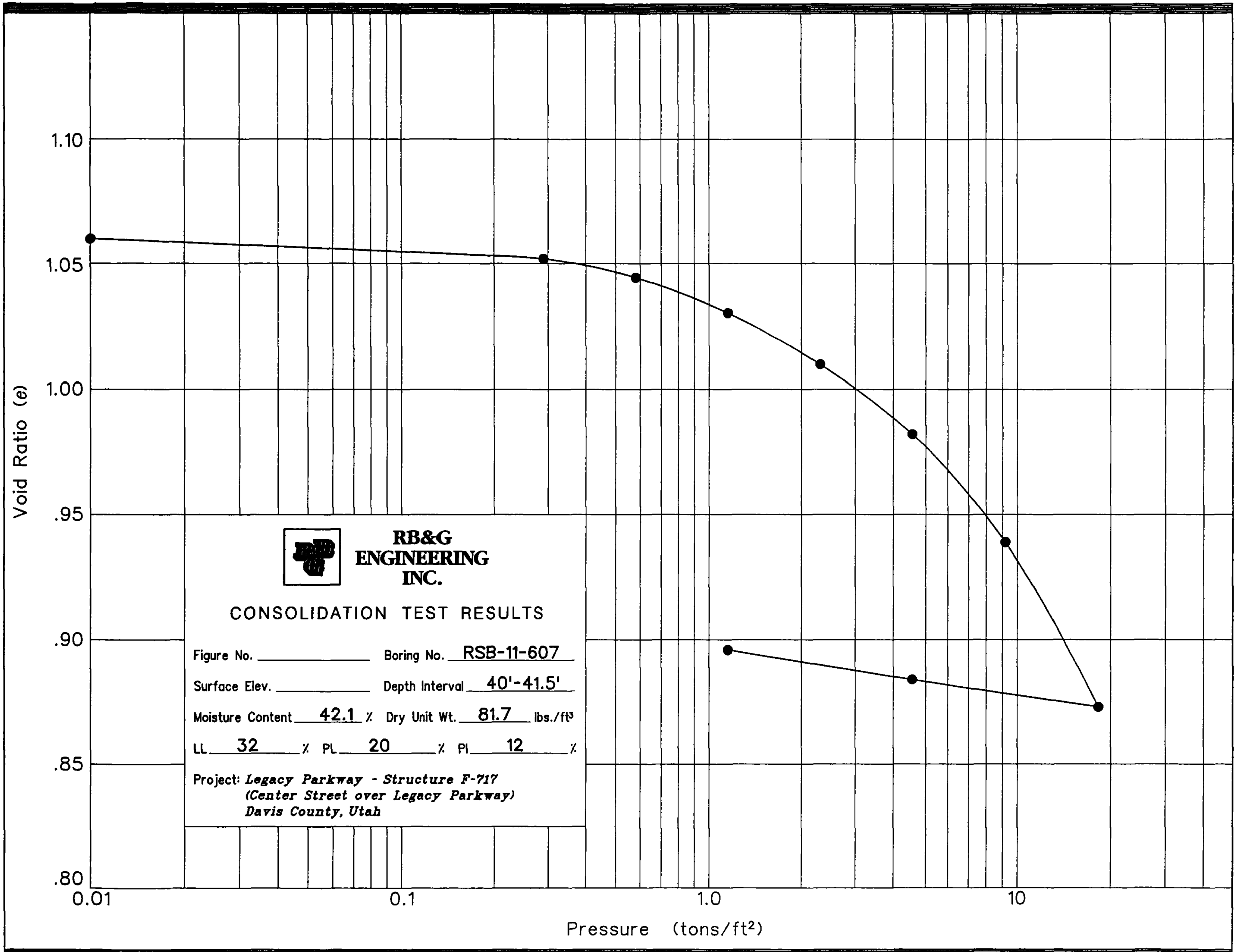
RB&G ENGINEERING INC.
Provo, Utah

Hole no.: RSB-11-607
Depth: 20'-21.5'
Load: 2.30 to 4.60 tons

TIME CONSOLIDATION

Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah

Figure



RB&G ENGINEERING INC.

CONSOLIDATION TEST RESULTS

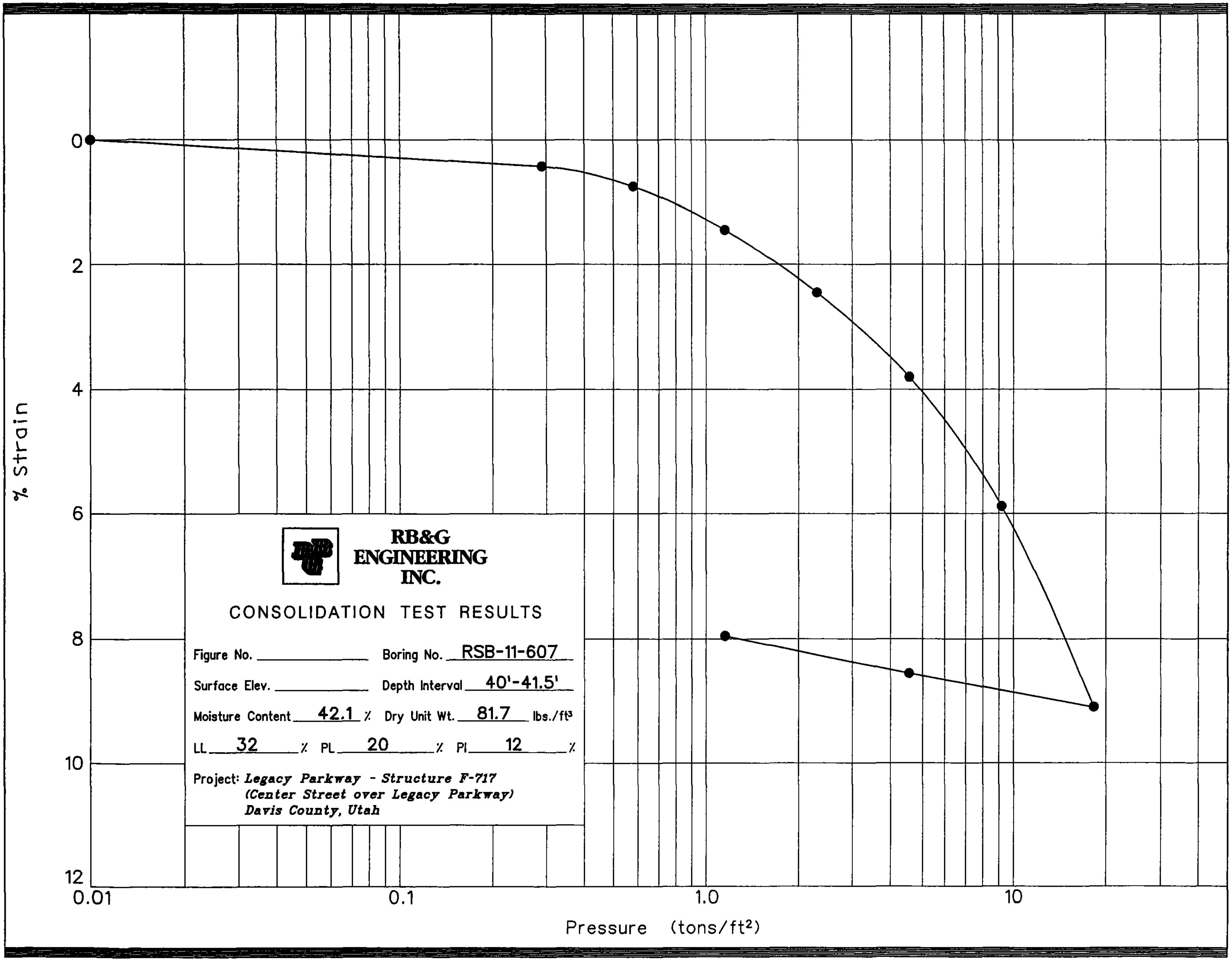
Figure No. ______ Boring No. RSB-11-607

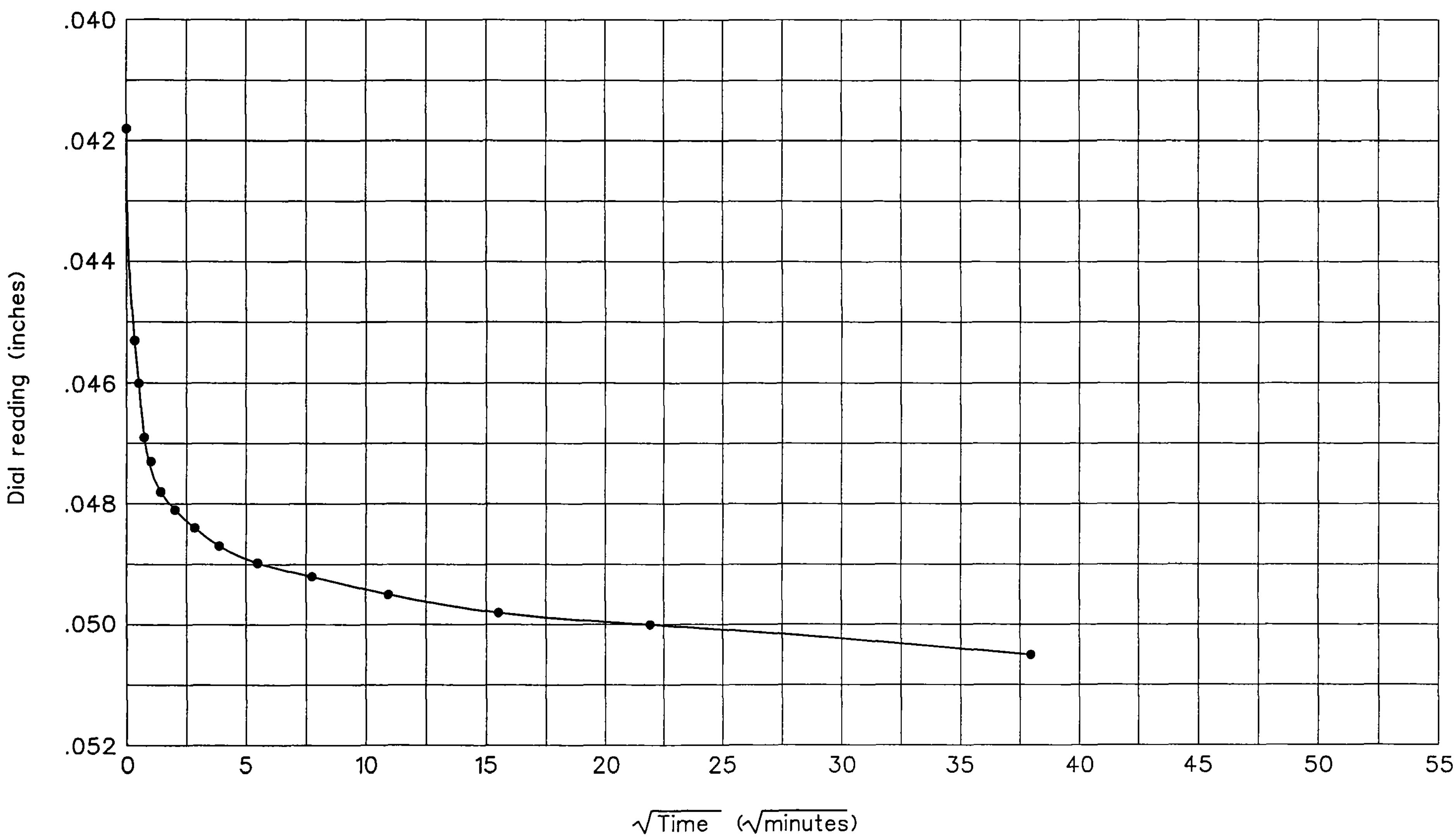
Surface Elev. ______ Depth Interval 40'-41.5'

Moisture Content 42.1 % Dry Unit Wt. 81.7 lbs./ft³

LL 32 % PL 20 % PI 12 %

Project: *Legacy Parkway - Structure F-717*
(Center Street over Legacy Parkway)
Davis County, Utah


% Strain
0
2
4
6
8
10
12
0.01
0.1
1.0
10
Pressure (tons/ft²)
RB&G ENGINEERING INC.
CONSOLIDATION TEST RESULTS
Figure No.
Boring No. RSB-11-607
Surface Elev.
Depth Interval 40'-41.5'
Moisture Content 42.1 % Dry Unit Wt. 81.7 lbs./ft³
LL 32 % PL 20 % PI 12 %
Project: Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah



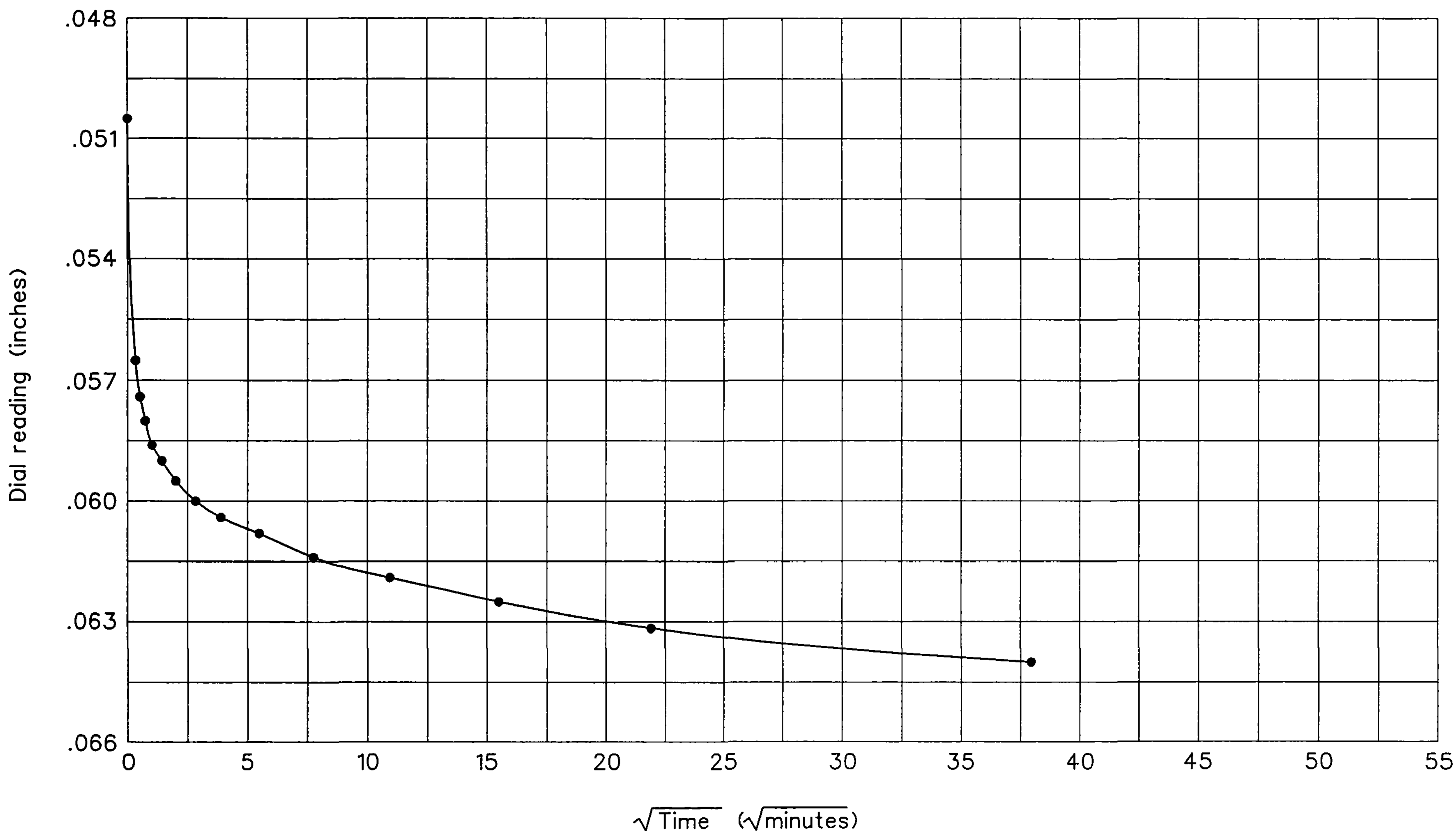
RB&G ENGINEERING INC. Provo, Utah	

Hole no.: RSB-11-607
Depth: 40'-41.5'
Load: 2.30 to 4.60 tons

TIME CONSOLIDATION

Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah

Figure



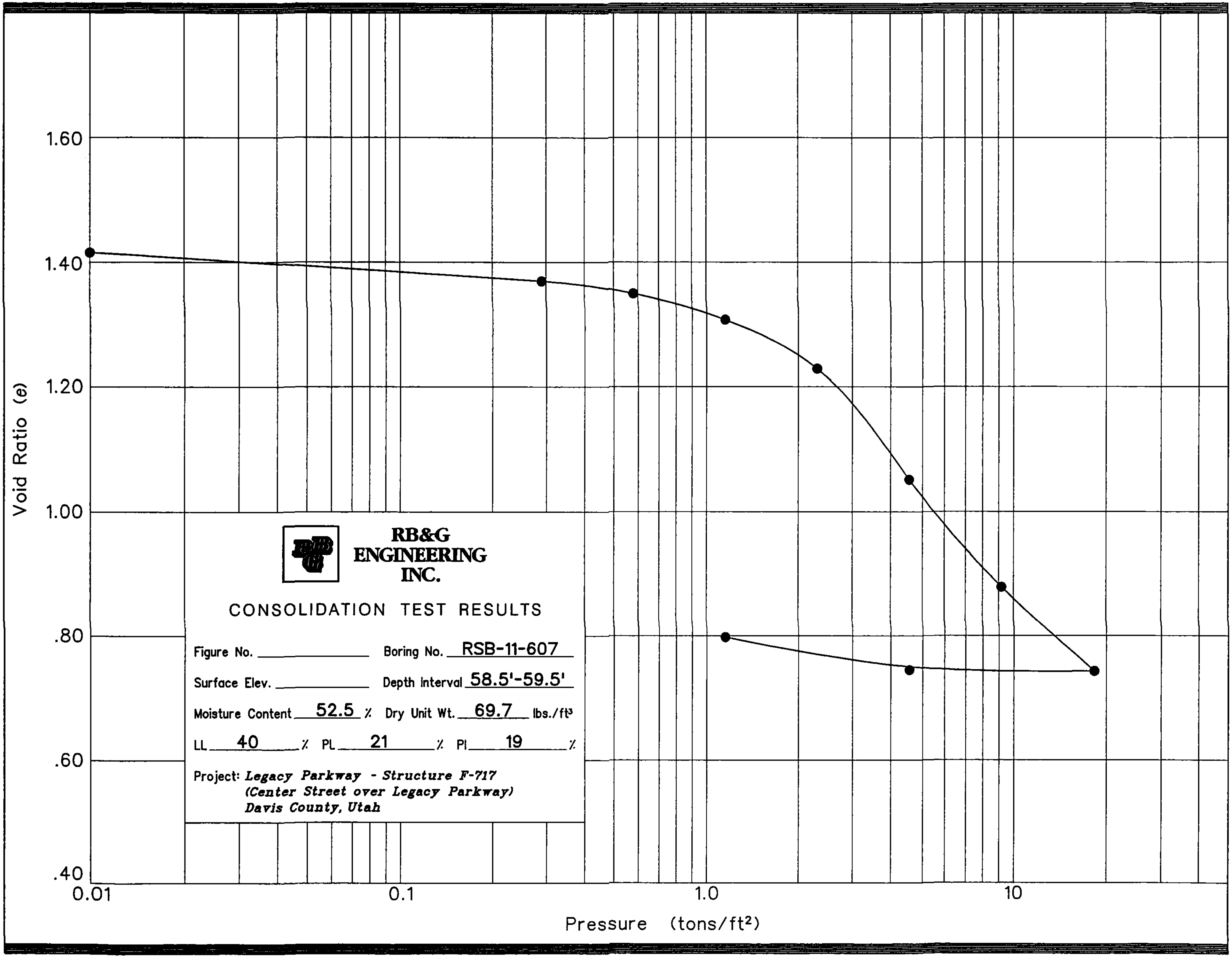
RB&G ENGINEERING INC.
Provo, Utah

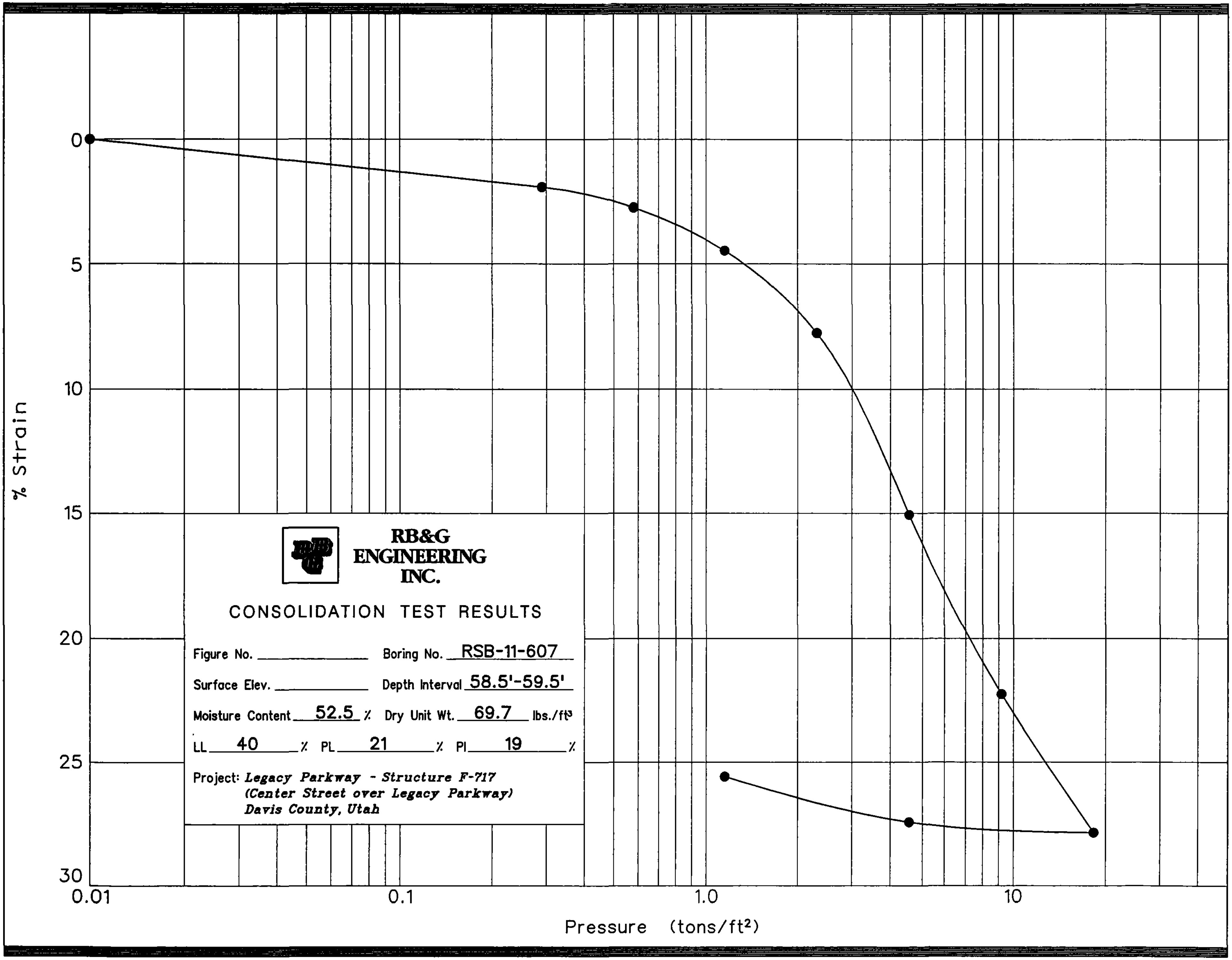
Hole no.: RSB-11-607
Depth: 40'-41.5'
Load: 4.60 to 9.20 tons

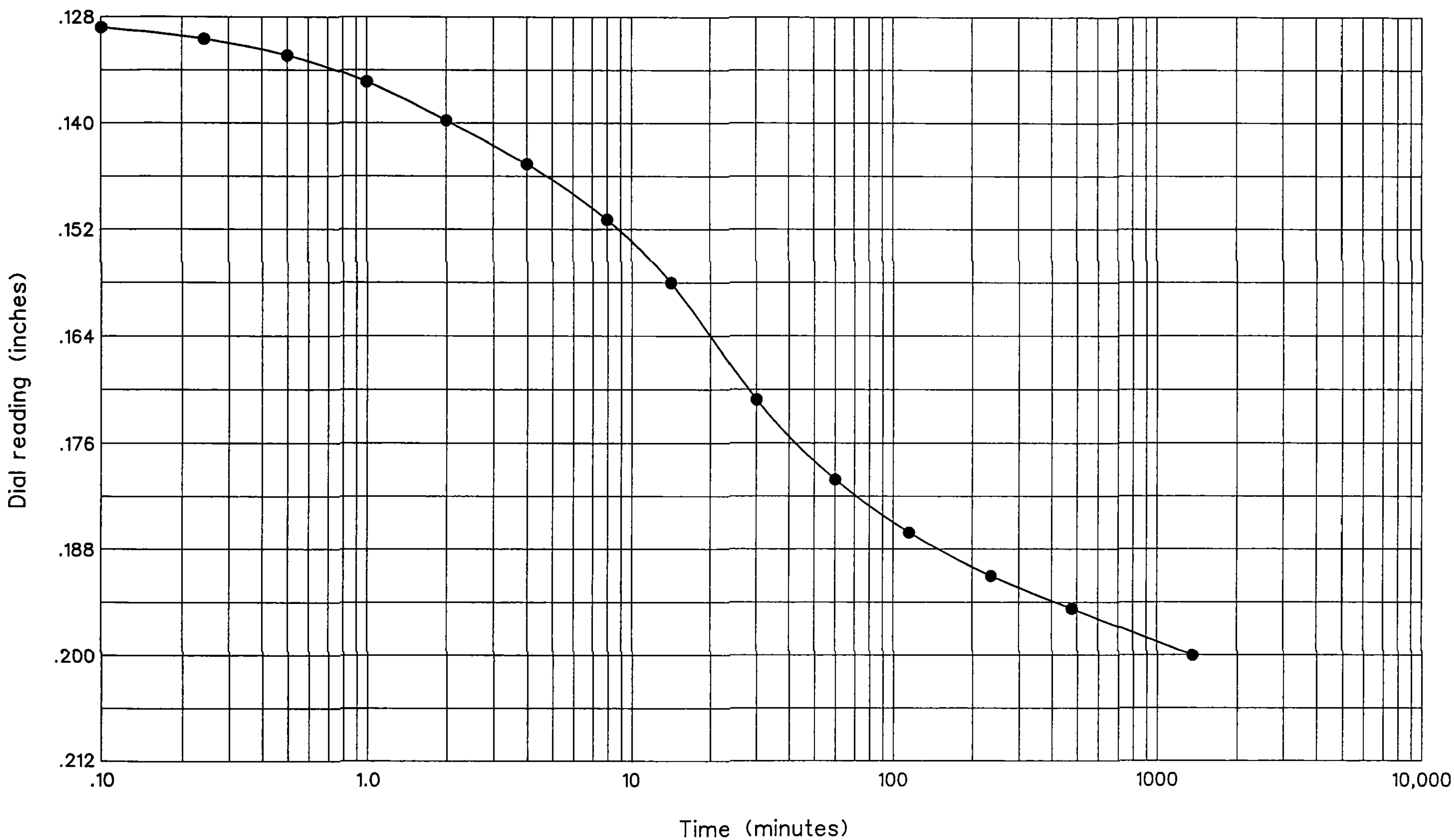
TIME CONSOLIDATION

Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah

Figure


1.60
1.40
1.20
1.00
.80
.60
.40
Void Ratio (e)
0.01
0.1
1.0
10
Pressure (tons/ft²)
RB&G ENGINEERING INC.
CONSOLIDATION TEST RESULTS
Figure No.
Boring No. RSB-11-607
Surface Elev.
Depth Interval 58.5'-59.5'
Moisture Content 52.5 % Dry Unit Wt. 69.7 lbs./ft³
LL 40 % PL 21 % PI 19 %
Project: Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah


% Strain
0
5
10
15
20
25
30
0.01
0.1
1.0
10
Pressure (tons/ft²)
RB&G ENGINEERING INC.
CONSOLIDATION TEST RESULTS
Figure No.
Boring No. RSB-11-607
Surface Elev.
Depth Interval 58.5'-59.5'
Moisture Content 52.5 %
Dry Unit Wt. 69.7 lbs./ft³
LL 40 %
PL 21 %
PI 19 %
Project: Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah



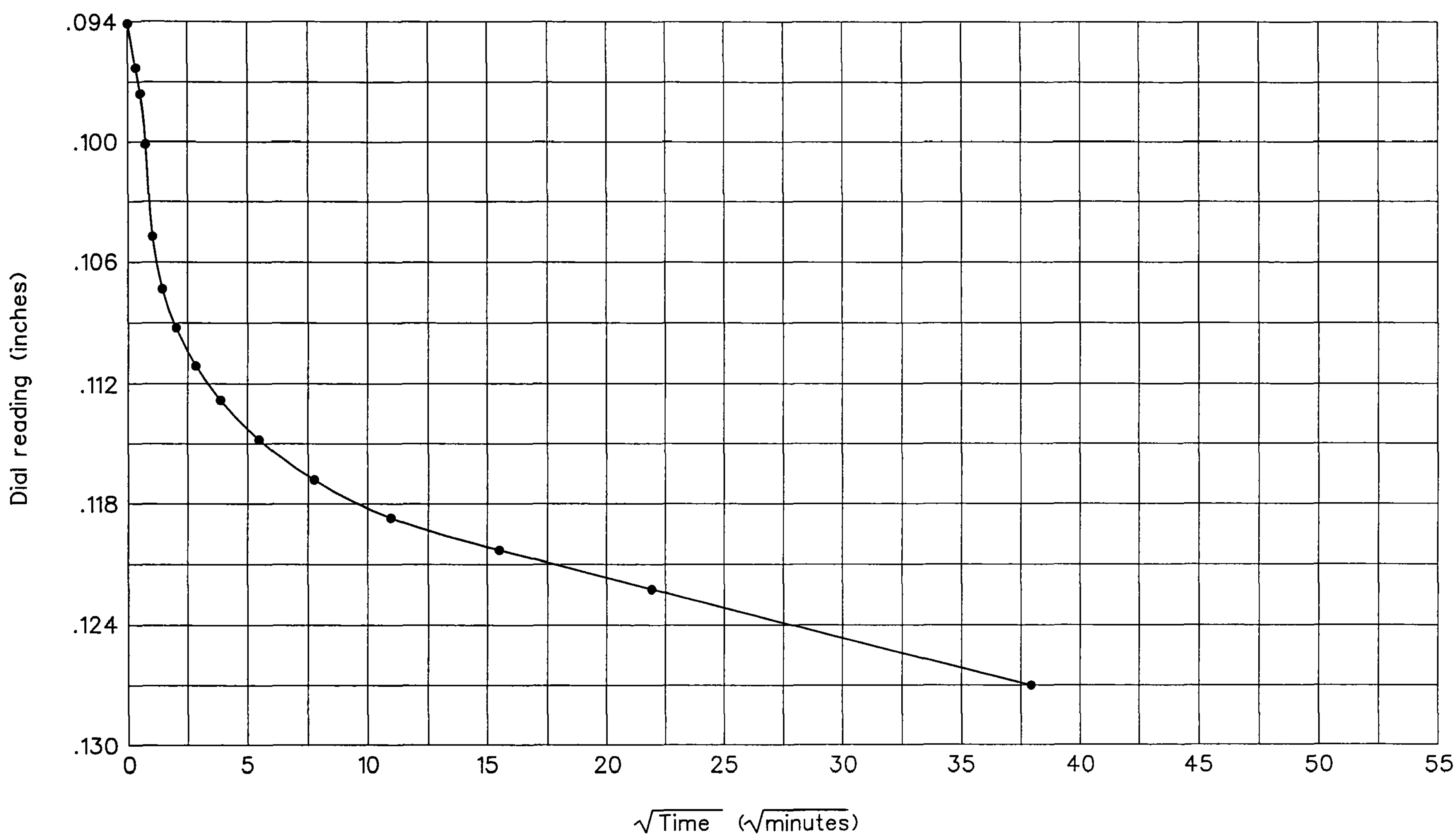
RB&G ENGINEERING INC.
Provo, Utah

Hole no.: RSB-11-607
Depth: 58.5'-59.5'
Load: 4.60 to 9.20 tons

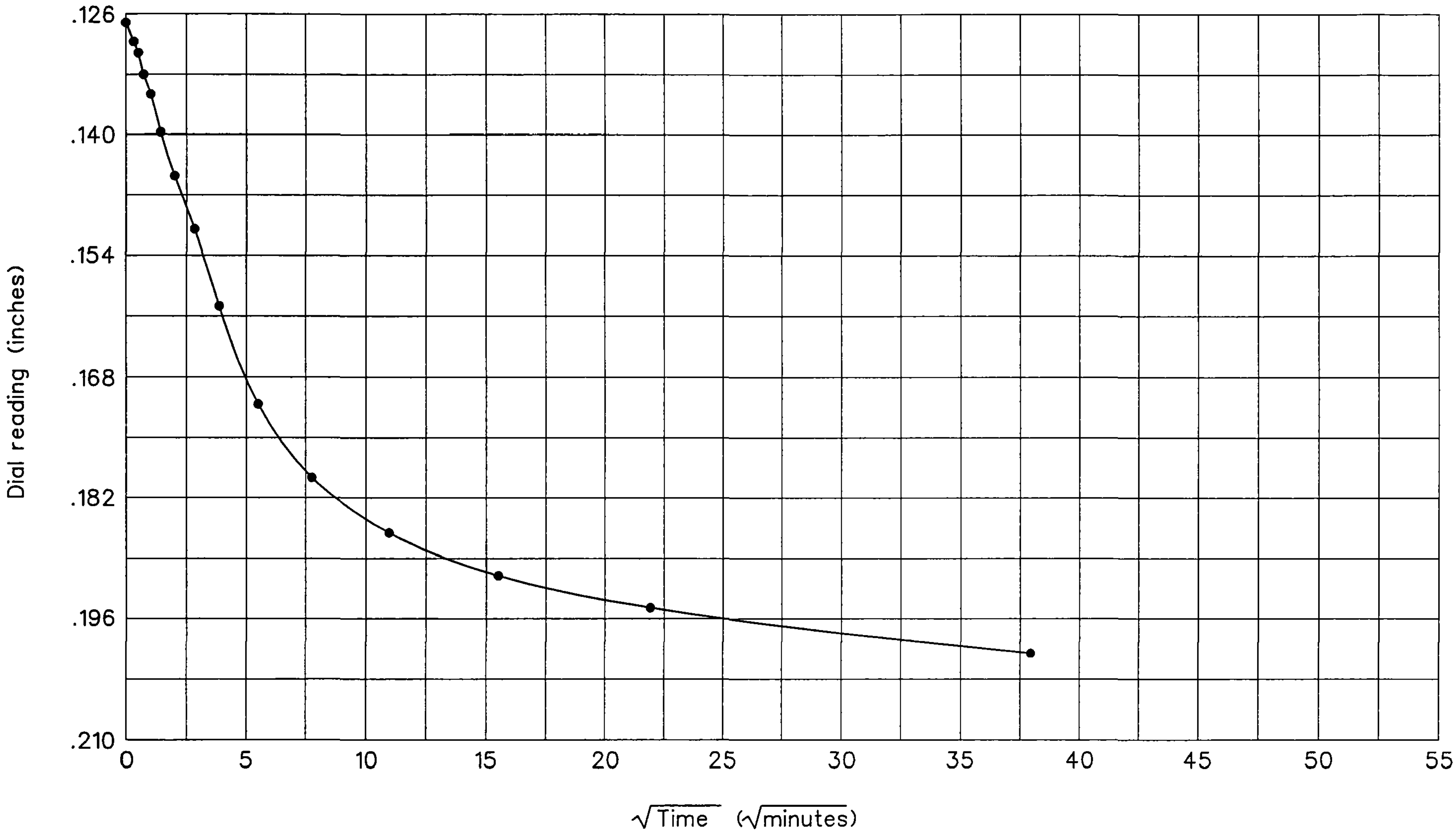
TIME CONSOLIDATION

Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah

Figure



RB&G ENGINEERING INC. Provo, Utah	Hole no.: RSB-11-607 Depth: 58.5'-59.5' Load: 2.30 to 4.60 tons	TIME CONSOLIDATION *Legacy Parkway - Structure F-717* *(Center Street over Legacy Parkway)* *Davis County, Utah*	Figure



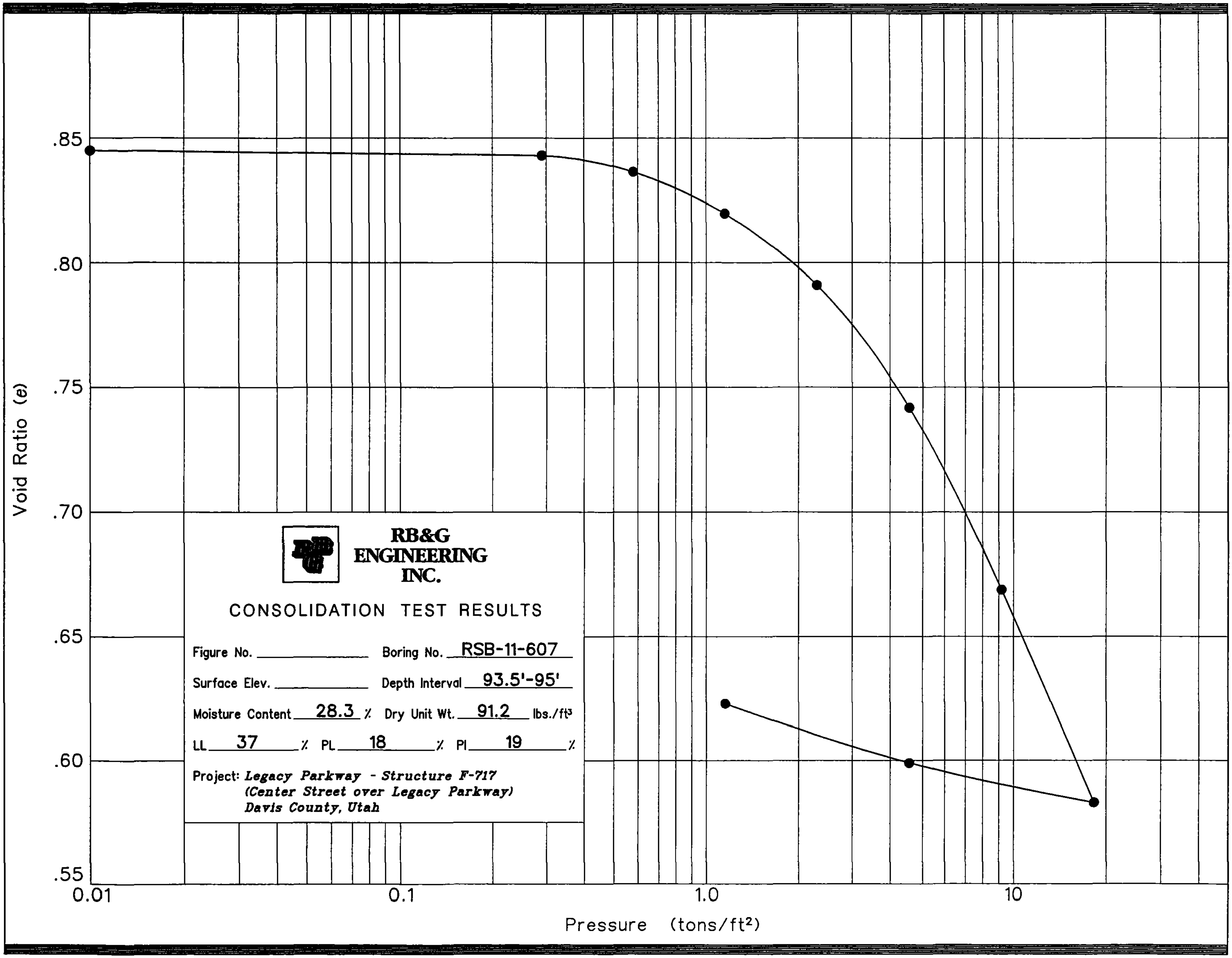
RB&G ENGINEERING INC.
Provo, Utah

Hole no.: RSB-11-607
Depth: 58.5'-59.5'
Load: 4.60 to 9.20 tons

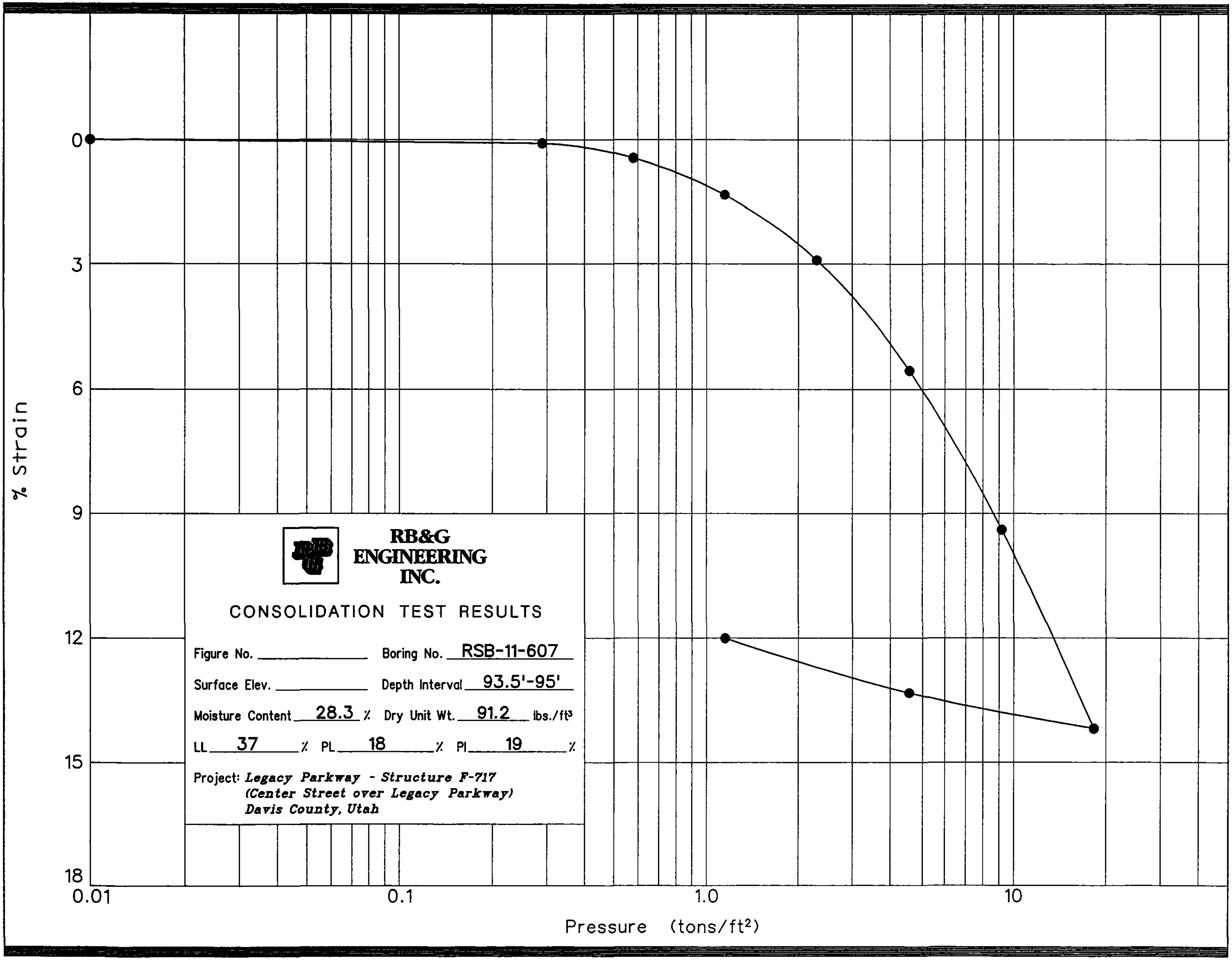
TIME CONSOLIDATION

Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah

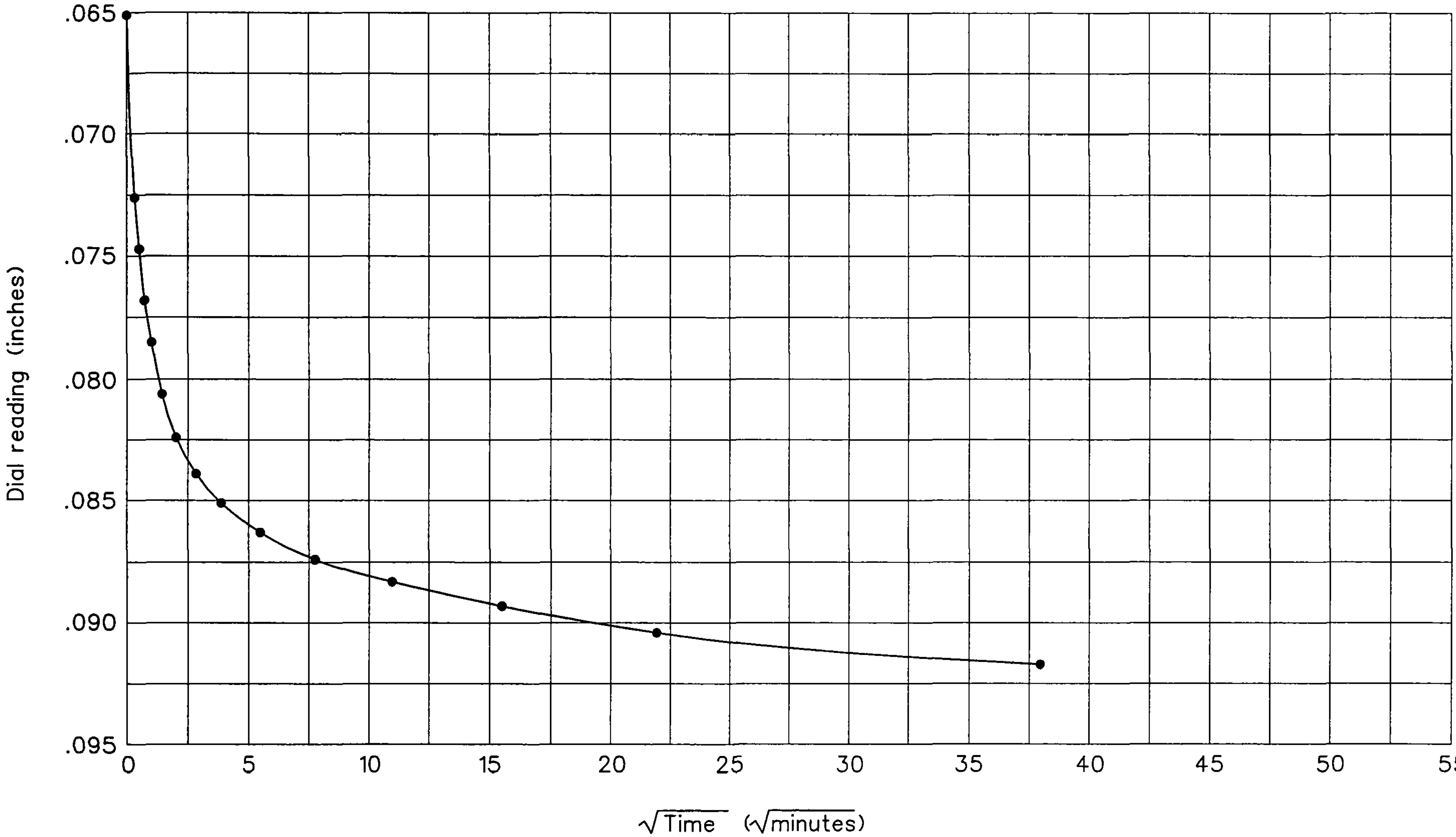
Figure



.85
.80
.75
.70
.65
.60
.55
Void Ratio (e)
0.01
0.1
1.0
10
Pressure (tons/ft²)
RB&G ENGINEERING INC.
CONSOLIDATION TEST RESULTS
Figure No.
Boring No. RSB-11-607
Surface Elev.
Depth Interval 93.5'-95'
Moisture Content 28.3 %
Dry Unit Wt. 91.2 lbs./ft³
LL 37 %
PL 18 %
PI 19 %
Project: Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah



% Strain
0
3
6
9
12
15
18
0.01
0.1
1.0
10
Pressure (tons/ft²)
RB&G ENGINEERING INC.
CONSOLIDATION TEST RESULTS
Figure No.
Boring No. RSB-11-607
Surface Elev.
Depth Interval 93.5'-95'
Moisture Content 28.3 %
Dry Unit Wt. 91.2 lbs./ft³
LL 37 %
PL 18 %
PI 19 %
Project: Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah



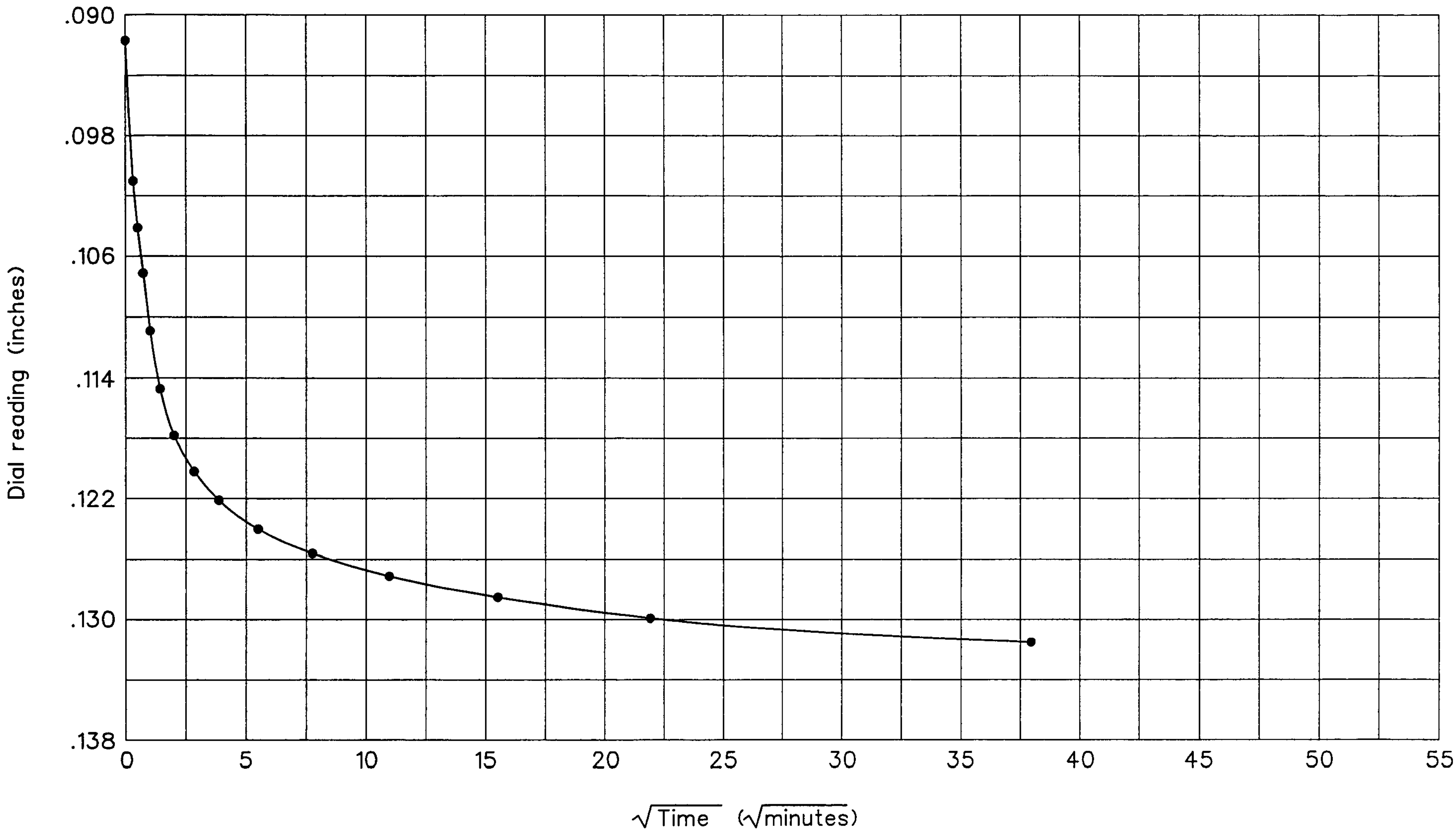
RB&G ENGINEERING INC.
Provo, Utah

Hole no.: RSB-11-607
Depth: 93.5'-95'
Load: 4.60 to 9.20 tons

TIME CONSOLIDATION

Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah

Figure



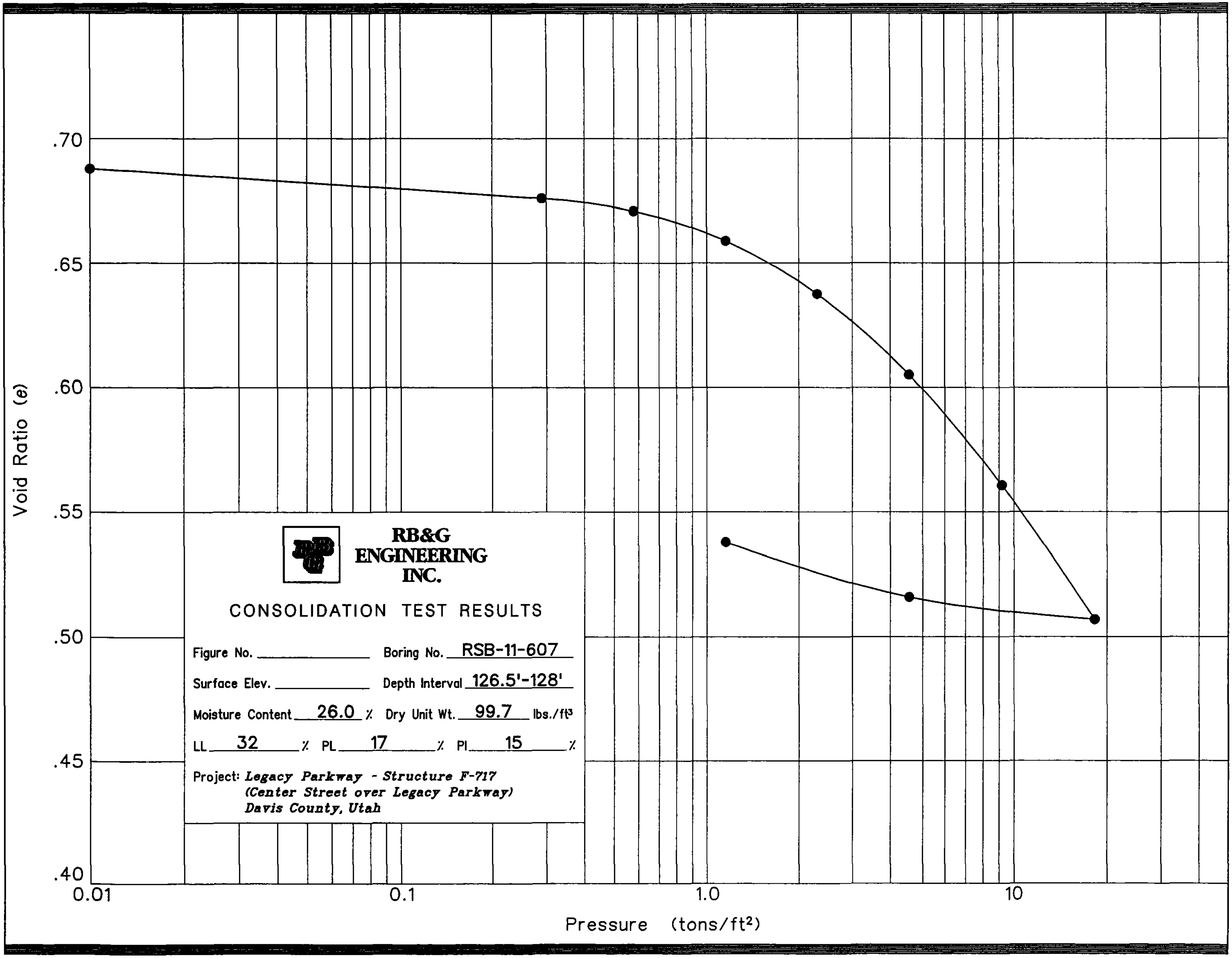
RB&G ENGINEERING INC.
Provo, Utah

Hole no.: RSB-11-607
Depth: 93.5'-95'
Load: 9.20 to 18.40 tons

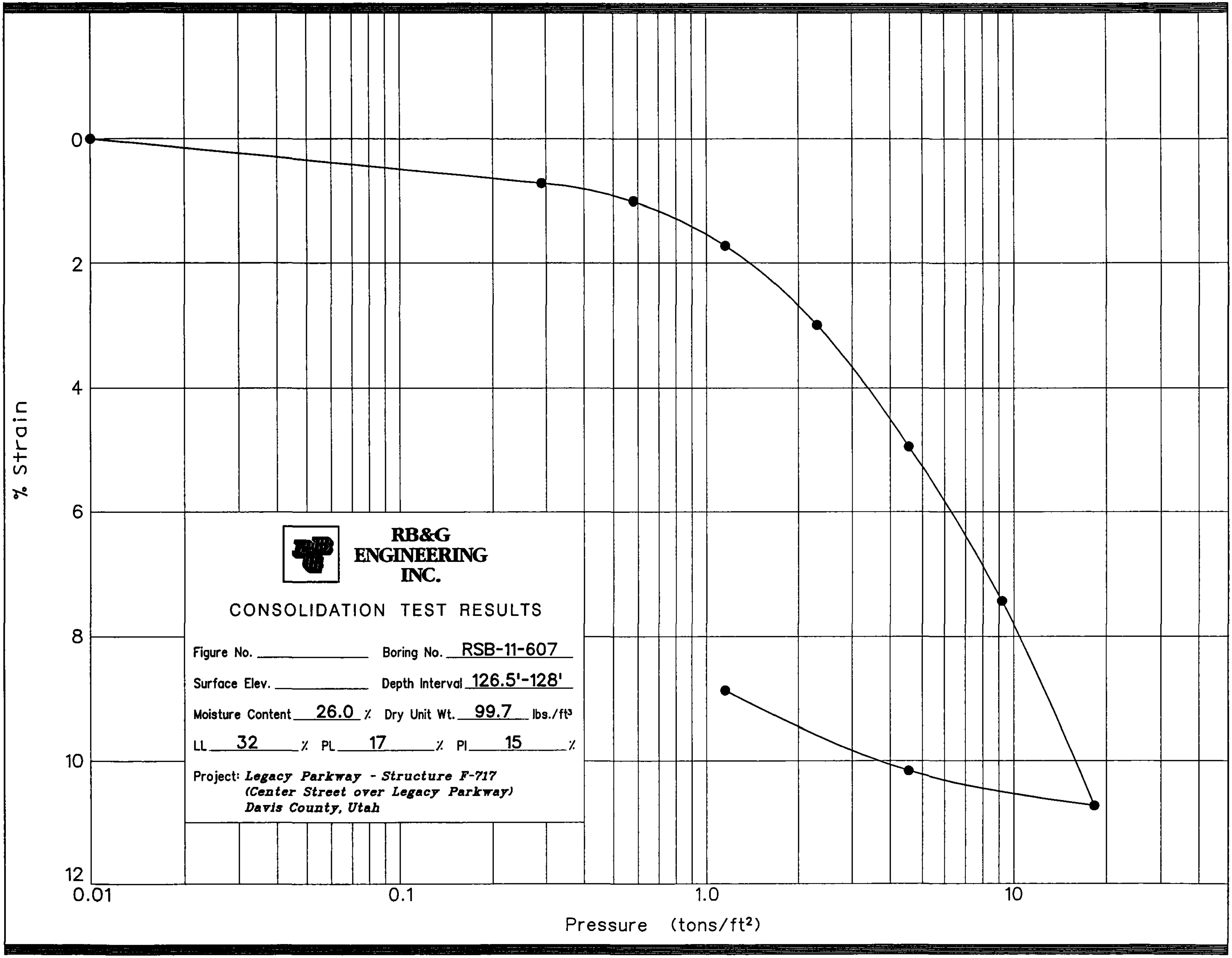
TIME CONSOLIDATION

Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah

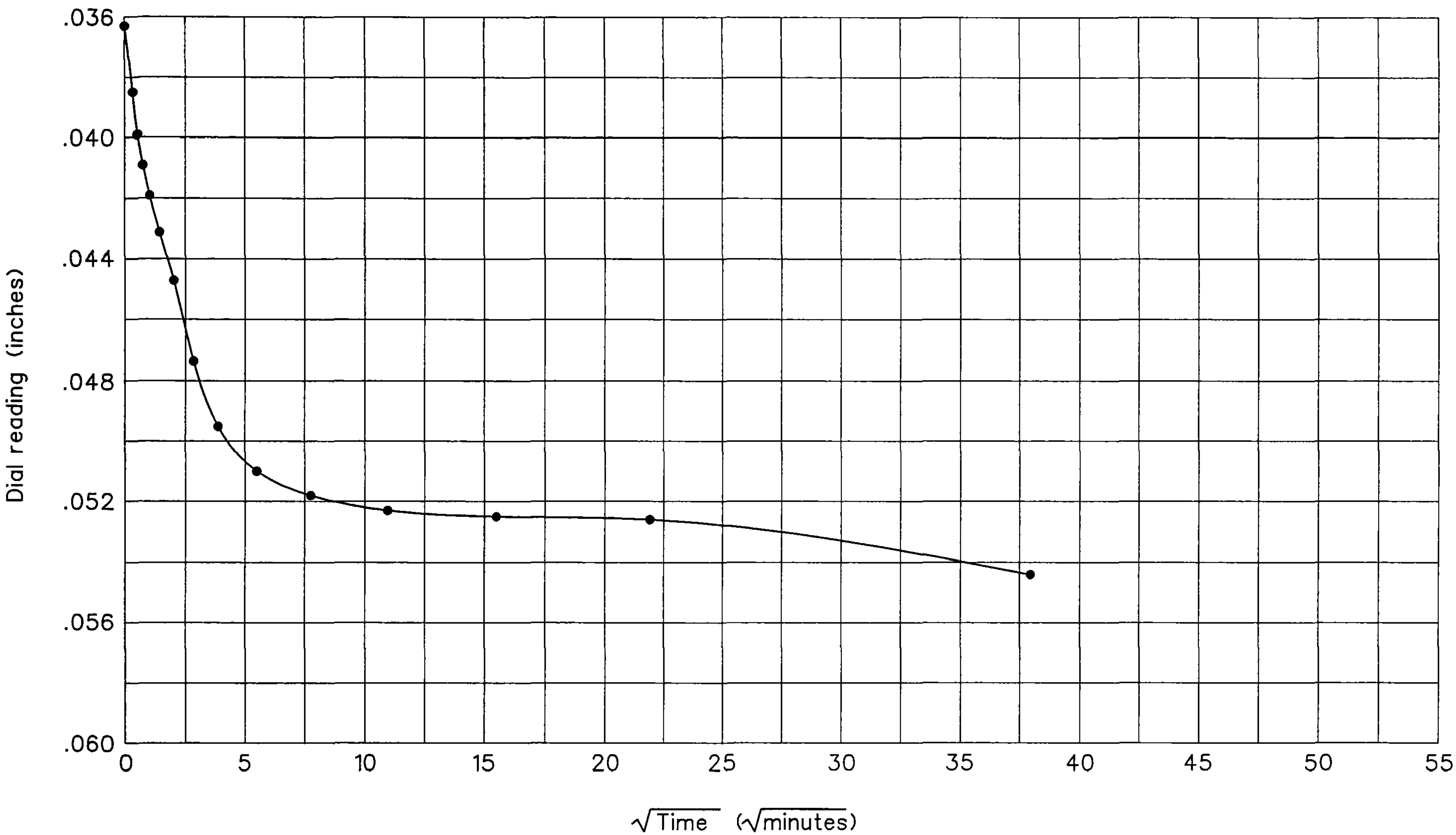
Figure



Void Ratio (e)
.70
.65
.60
.55
.50
.45
.40
0.01
0.1
1.0
10
Pressure (tons/ft²)
RB&G ENGINEERING INC.
CONSOLIDATION TEST RESULTS
Figure No.
Boring No. RSB-11-607
Surface Elev.
Depth Interval 126.5'-128'
Moisture Content 26.0 % Dry Unit Wt. 99.7 lbs./ft³
LL 32 % PL 17 % PI 15 %
Project: Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah



RB&G ENGINEERING INC.
CONSOLIDATION TEST RESULTS
Figure No.
Boring No. RSB-11-607
Surface Elev.
Depth Interval 126.5'-128'
Moisture Content 26.0 %
Dry Unit Wt. 99.7 lbs./ft³
LL 32 %
PL 17 %
PI 15 %
Project: Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah
% Strain
0
2
4
6
8
10
12
0.01
0.1
1.0
10
Pressure (tons/ft²)



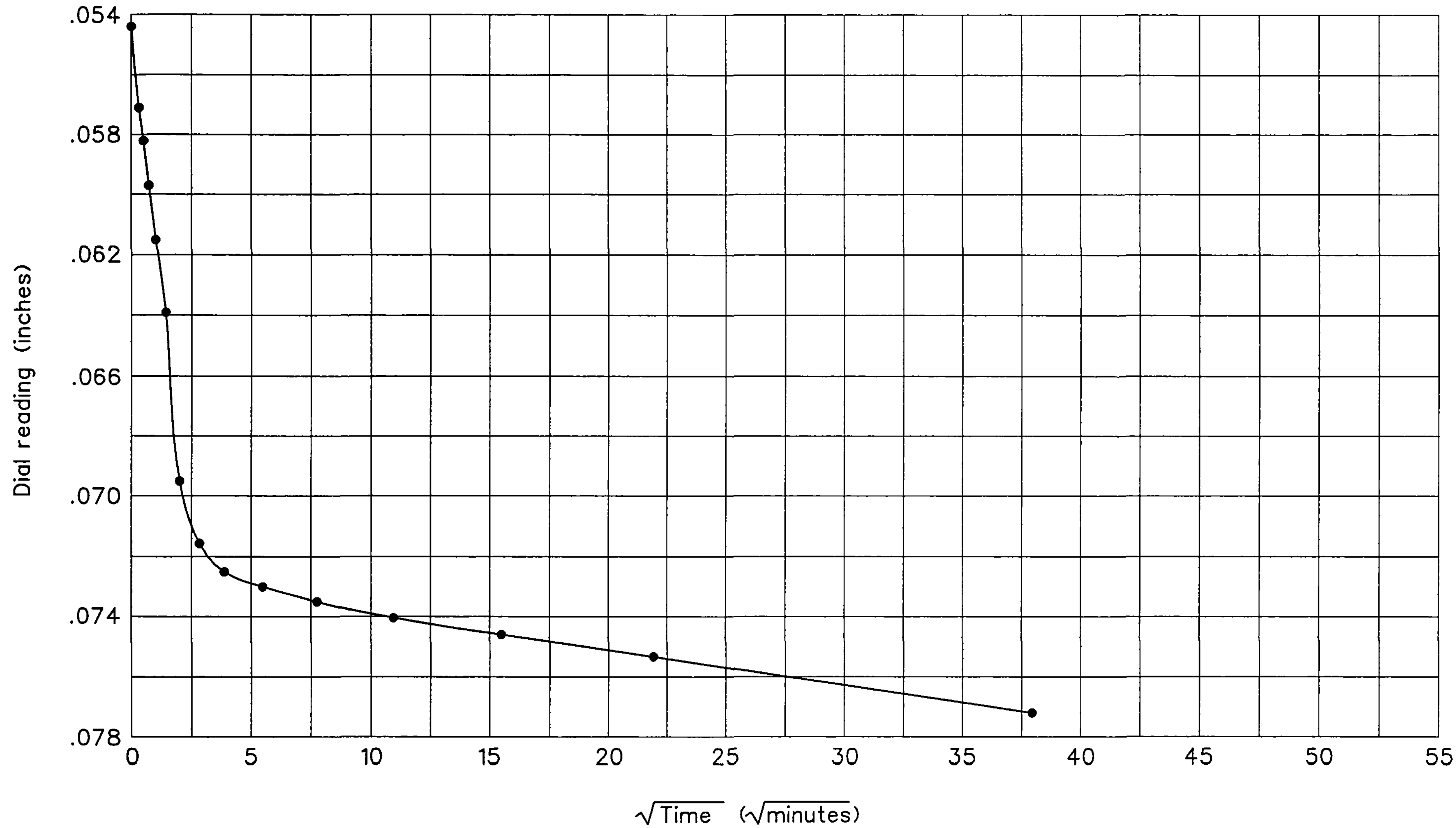
RB&G ENGINEERING INC.
Provo, Utah

Hole no.: RSB-11-607
Depth: 126.5'-128'
Load: 4.60 to 9.20 tons

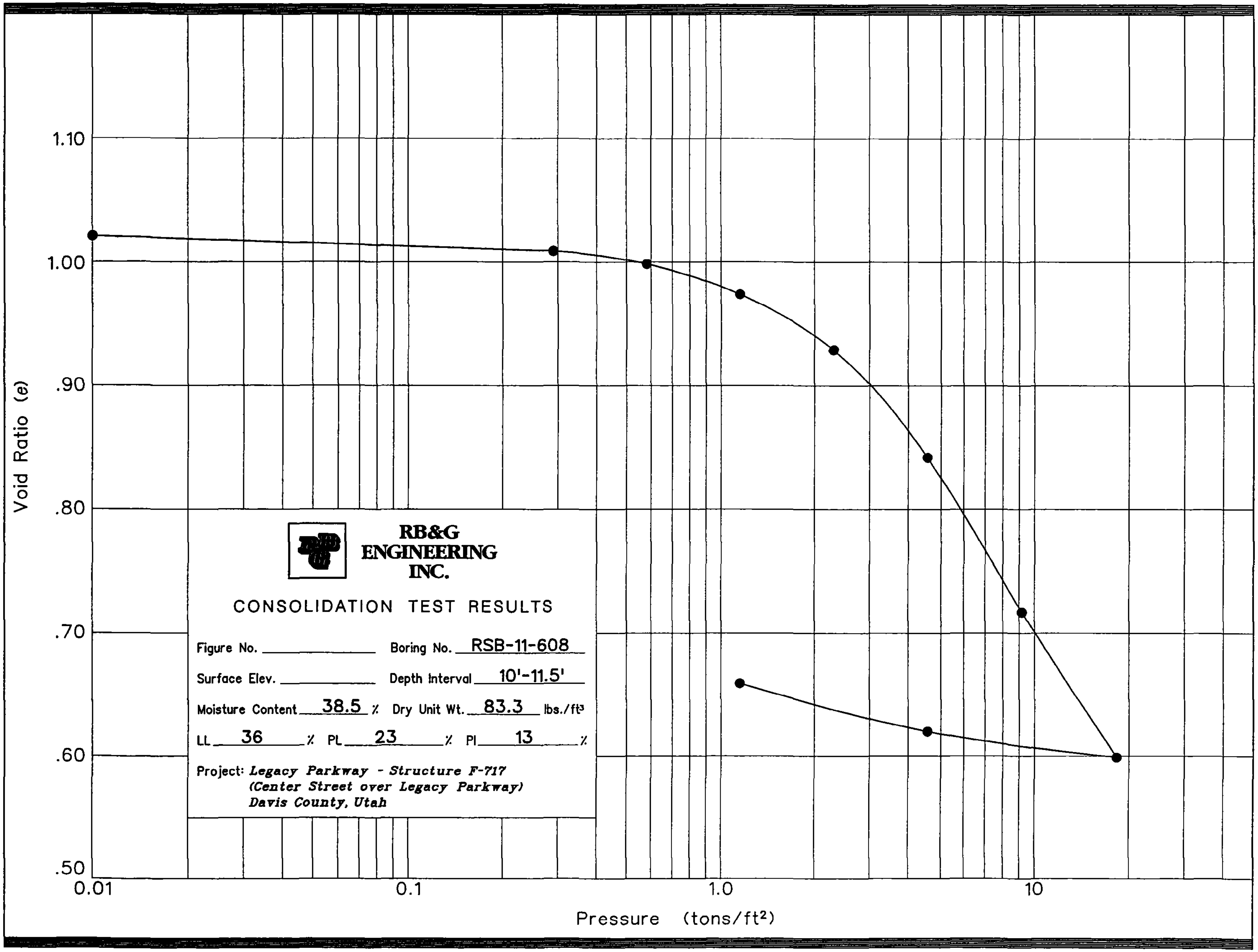
TIME CONSOLIDATION

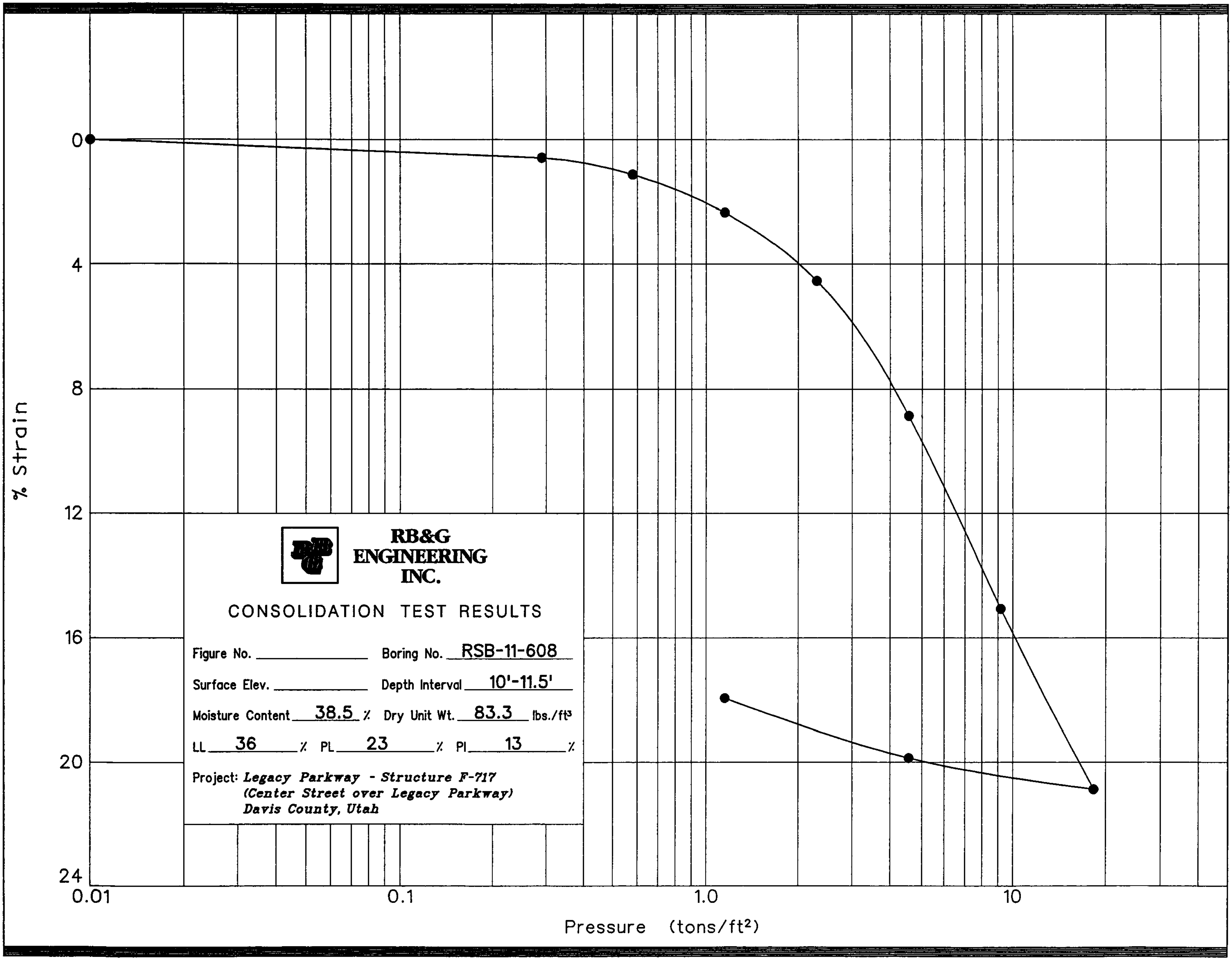
Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah

Figure



RB&G ENGINEERING INC. Provo, Utah	Hole no.: RSB-11-607 Depth: 126.5'-128' Load: 9.20 to 18.40 tons	**TIME CONSOLIDATION** *Legacy Parkway - Structure F-717* *(Center Street over Legacy Parkway)* *Davis County, Utah*	Figure


RB&G ENGINEERING INC.
CONSOLIDATION TEST RESULTS
Figure No.
Boring No. RSB-11-608
Surface Elev.
Depth Interval 10'-11.5'
Moisture Content 38.5 %
Dry Unit Wt. 83.3 lbs./ft³
LL 36 %
PL 23 %
PI 13 %
Project: Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah
Void Ratio (e)
1.10
1.00
.90
.80
.70
.60
.50
0.01
0.1
1.0
10
Pressure (tons/ft²)



RB&G ENGINEERING INC.

CONSOLIDATION TEST RESULTS

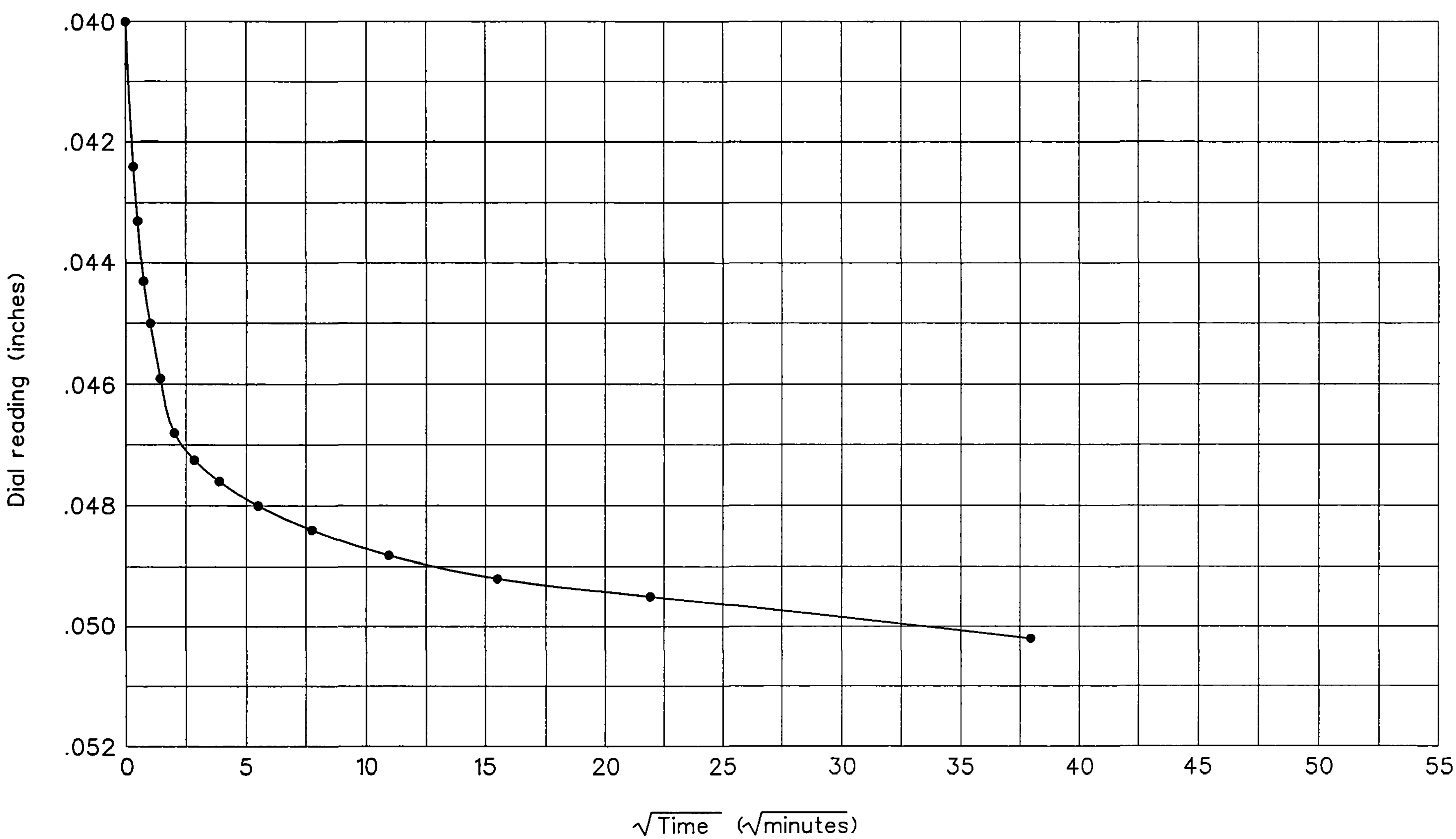
Figure No. ______ Boring No. RSB-11-608

Surface Elev. ______ Depth Interval 10'-11.5'

Moisture Content 38.5 % Dry Unit Wt. 83.3 lbs./ft³

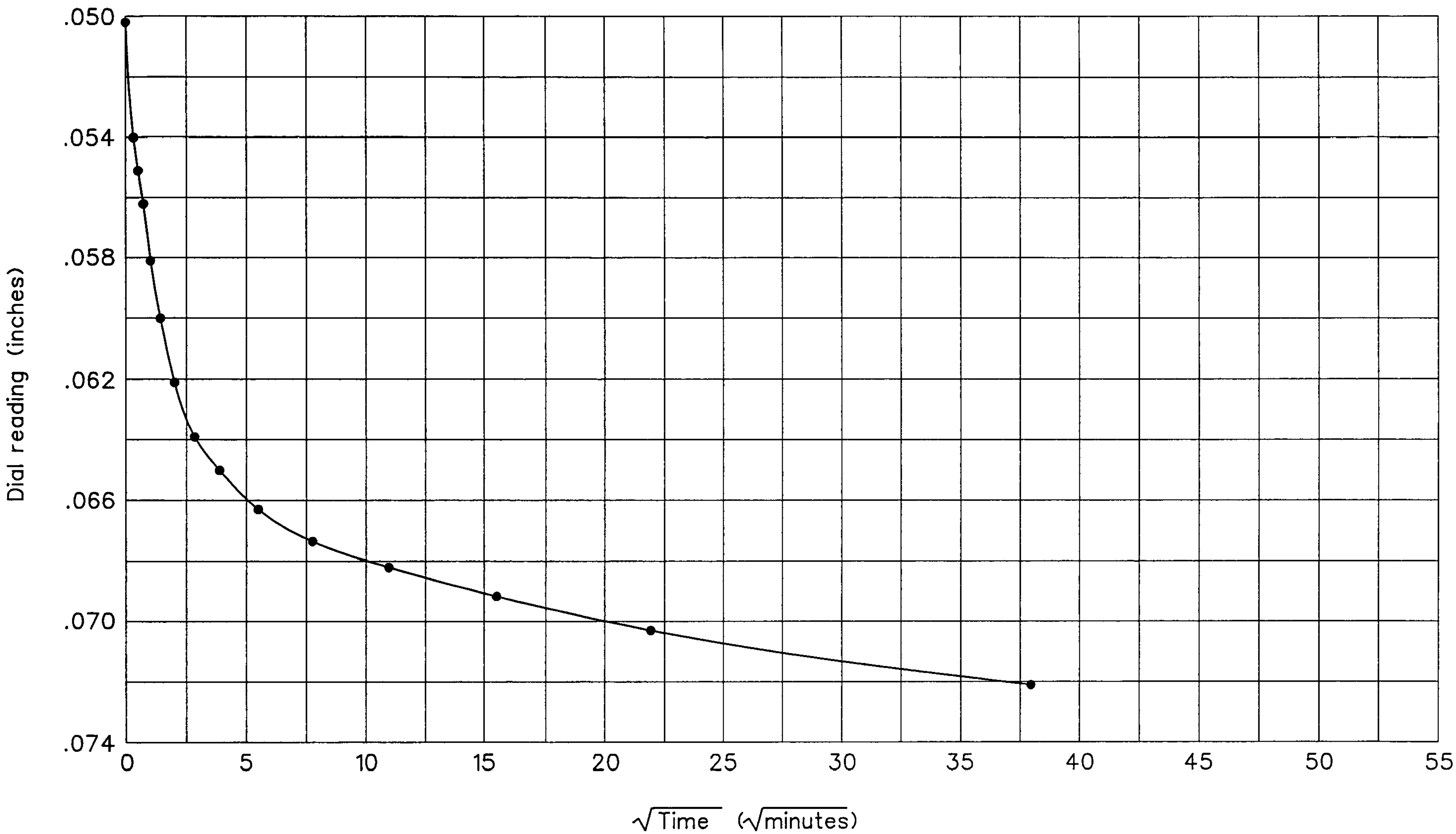
LL 36 % PL 23 % PI 13 %

Project: *Legacy Parkway - Structure F-717*
(Center Street over Legacy Parkway)
Davis County, Utah



RB&G ENGINEERING INC. Provo, Utah	Hole no.: RSB-11-608 Depth: 10'-11.5' Load: 1.15 to 2.30 tons	TIME CONSOLIDATION *Legacy Parkway - Structure F-717* *(Center Street over Legacy Parkway)* *Davis County, Utah*

Figure



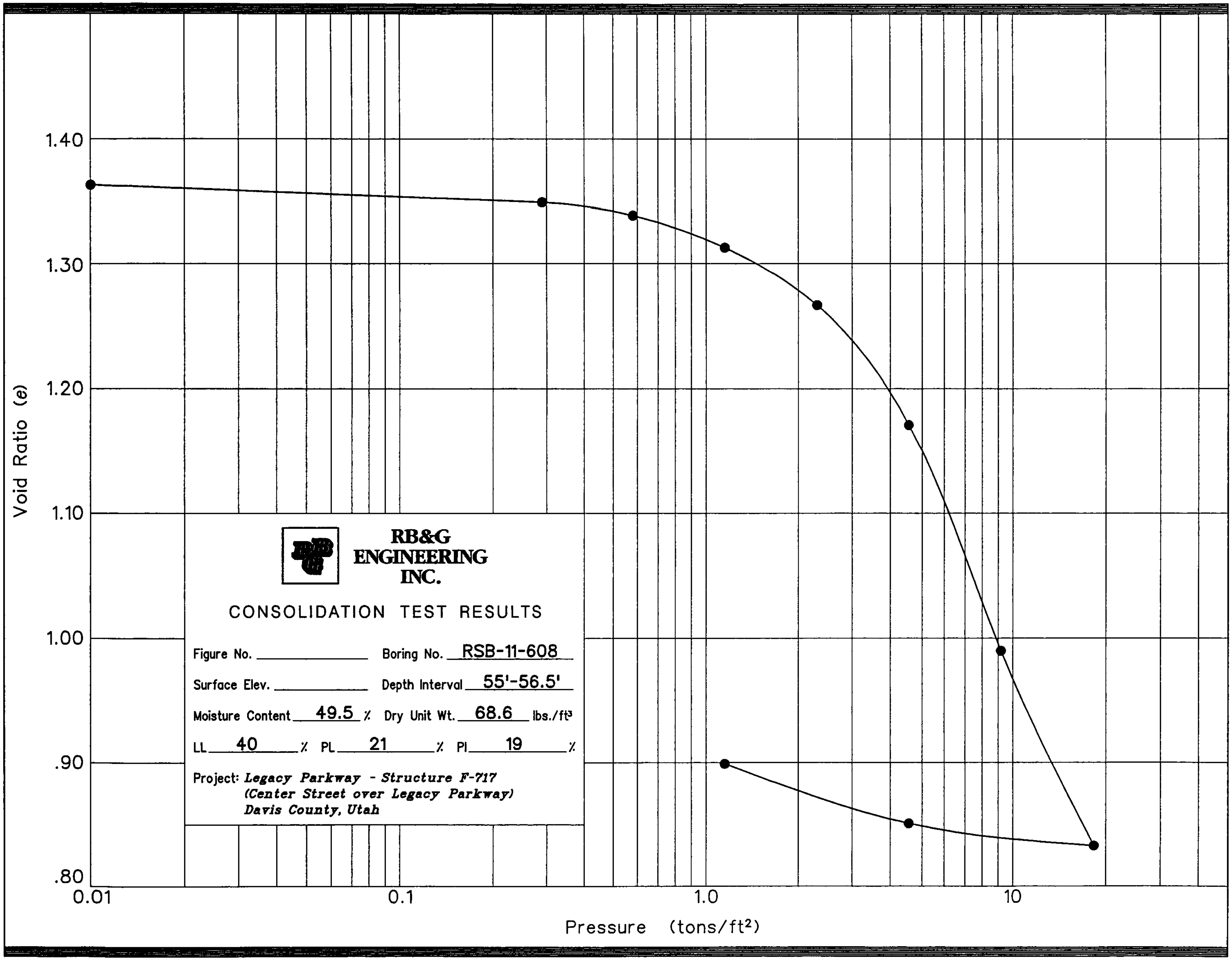
RB&G ENGINEERING INC.
Provo, Utah

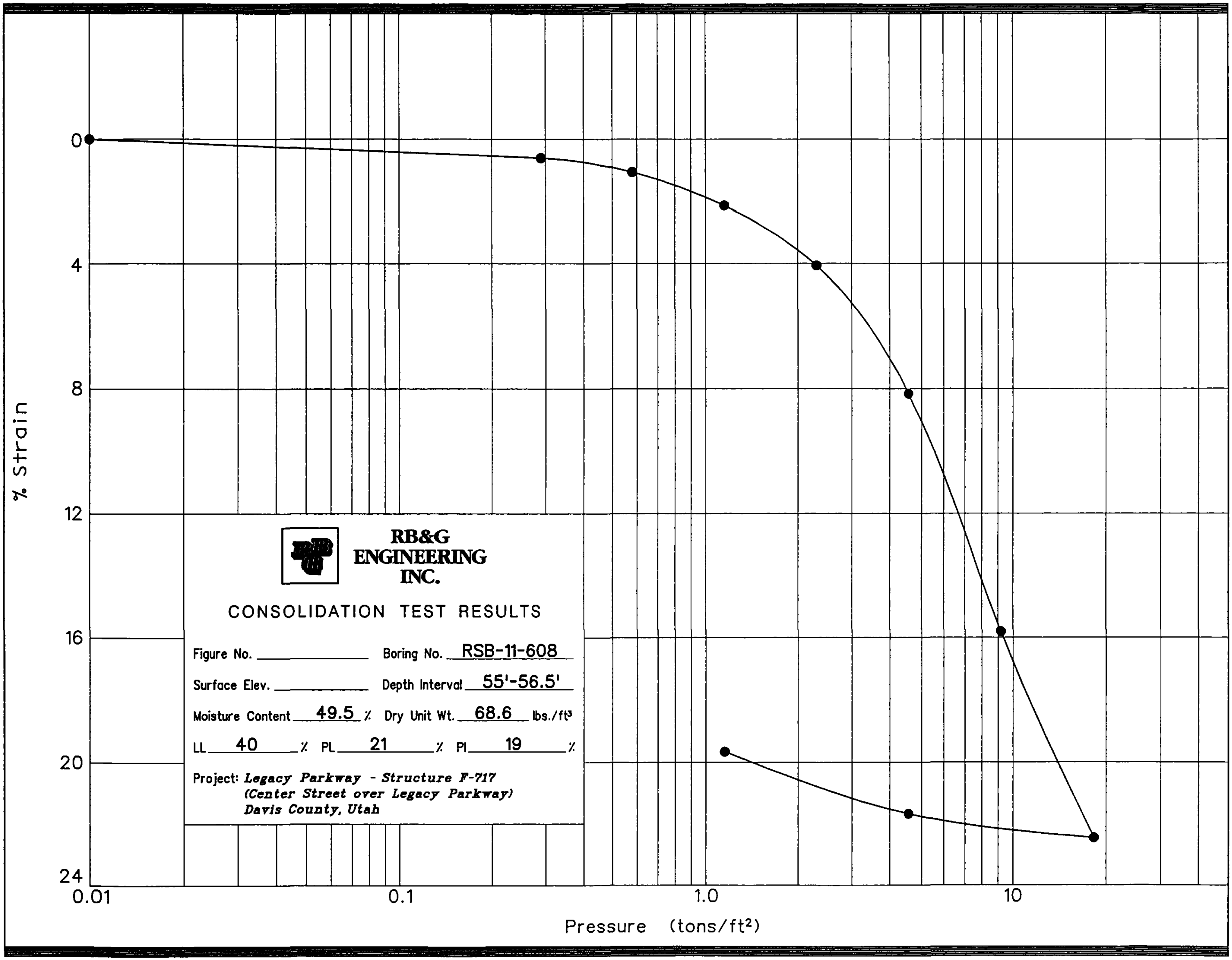
Hole no.: RSB-11-608
Depth: 10'-11.5'
Load: 2.30 to 4.60 tons

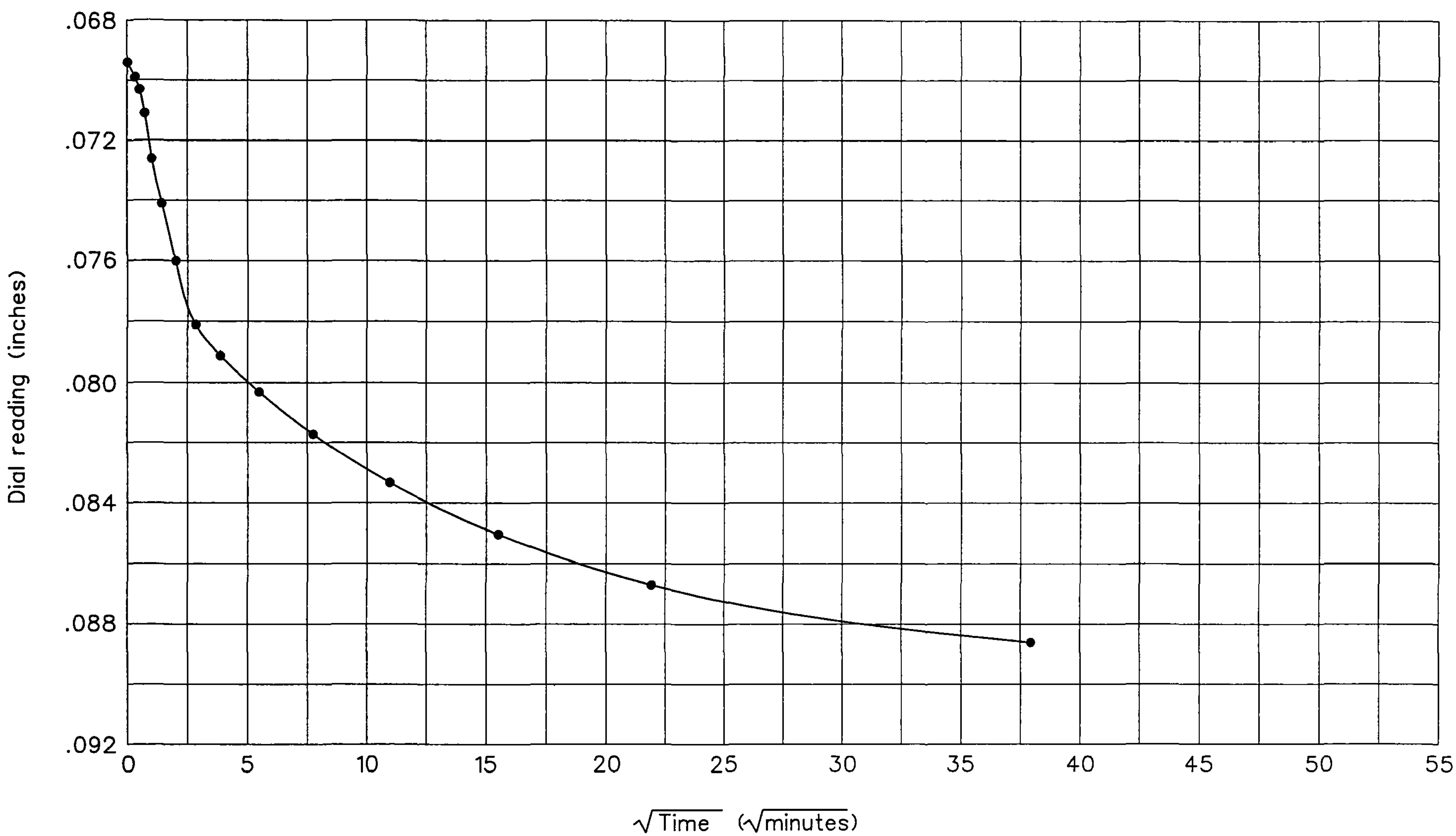
TIME CONSOLIDATION

Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah

Figure


1.40
1.30
1.20
1.10
1.00
.90
.80
Void Ratio (e)
0.01
0.1
1.0
10
Pressure (tons/ft²)
RB&G ENGINEERING INC.
CONSOLIDATION TEST RESULTS
Figure No.
Boring No. RSB-11-608
Surface Elev.
Depth Interval 55'-56.5'
Moisture Content 49.5 % Dry Unit Wt. 68.6 lbs./ft³
LL 40 % PL 21 % PI 19 %
Project: Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah


0
4
8
12
16
20
24
% Strain
0.01
0.1
1.0
10
Pressure (tons/ft²)
RB&G ENGINEERING INC.
CONSOLIDATION TEST RESULTS
Figure No.
Boring No. RSB-11-608
Surface Elev.
Depth Interval 55'-56.5'
Moisture Content 49.5 % Dry Unit Wt. 68.6 lbs./ft³
LL 40 % PL 21 % PI 19 %
Project: Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah



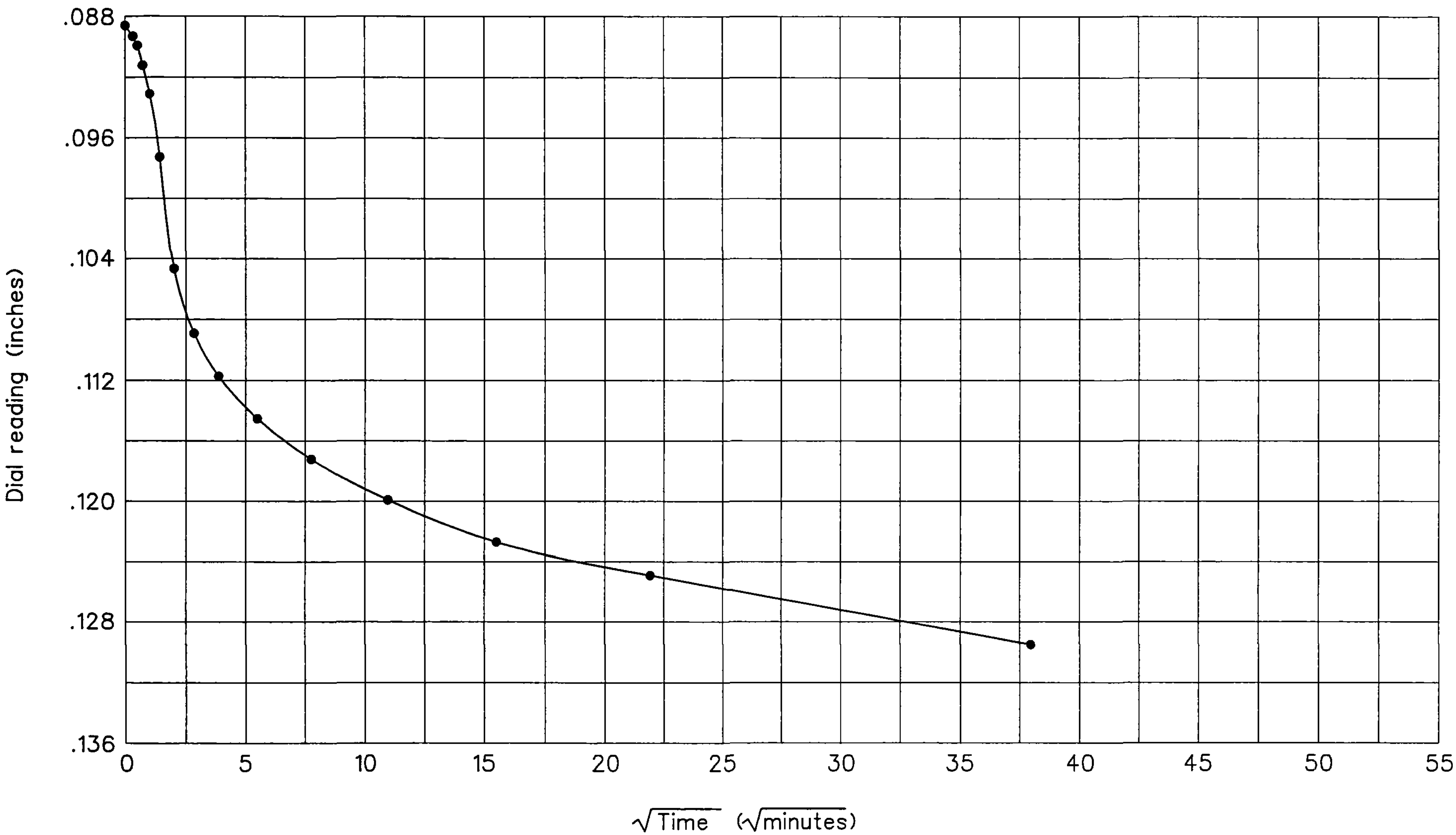
RB&G ENGINEERING INC.
Provo, Utah

Hole no.: RSB-11-608
Depth: 55'-56.5'
Load: 2.30 to 4.60 tons

TIME CONSOLIDATION

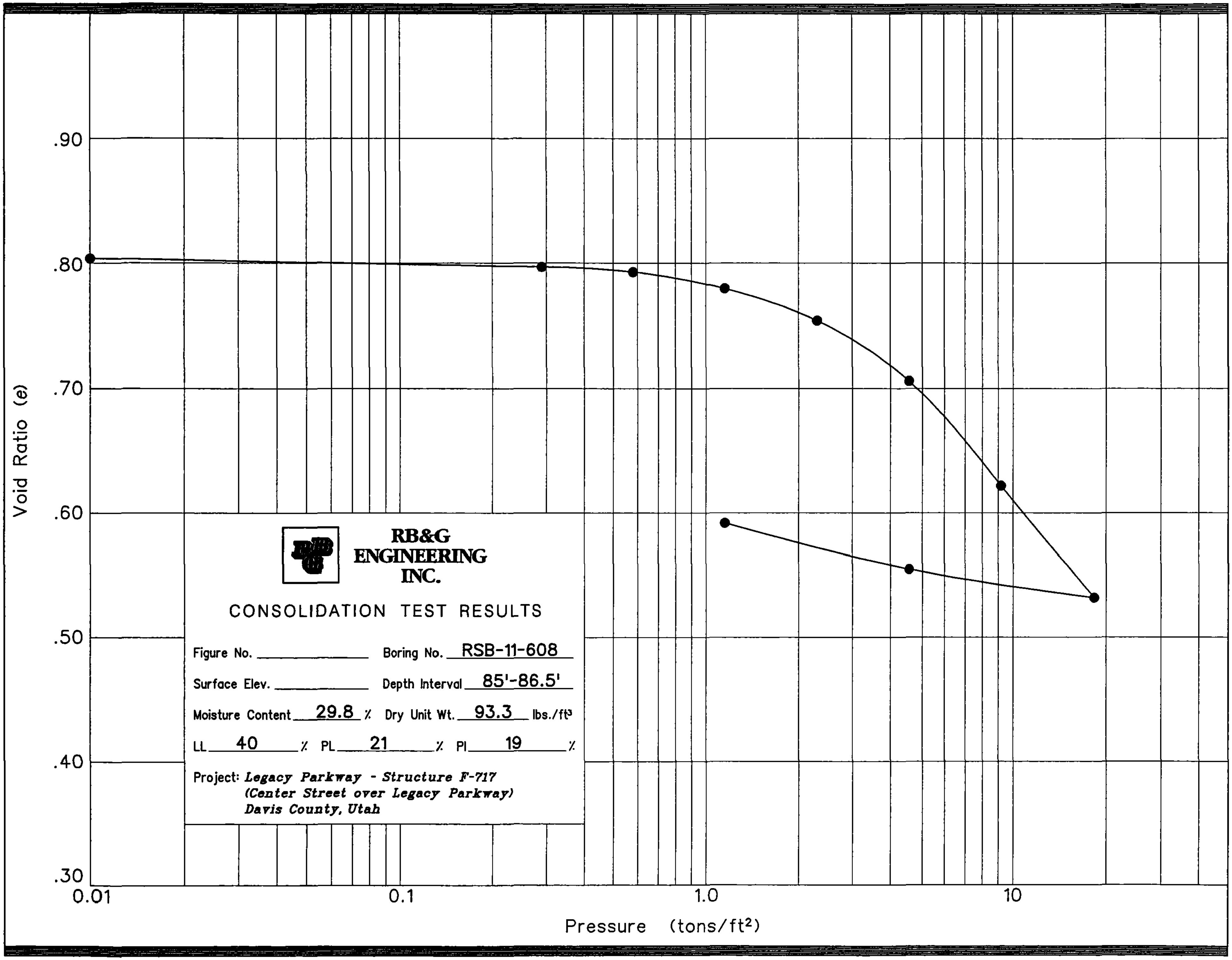
Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah

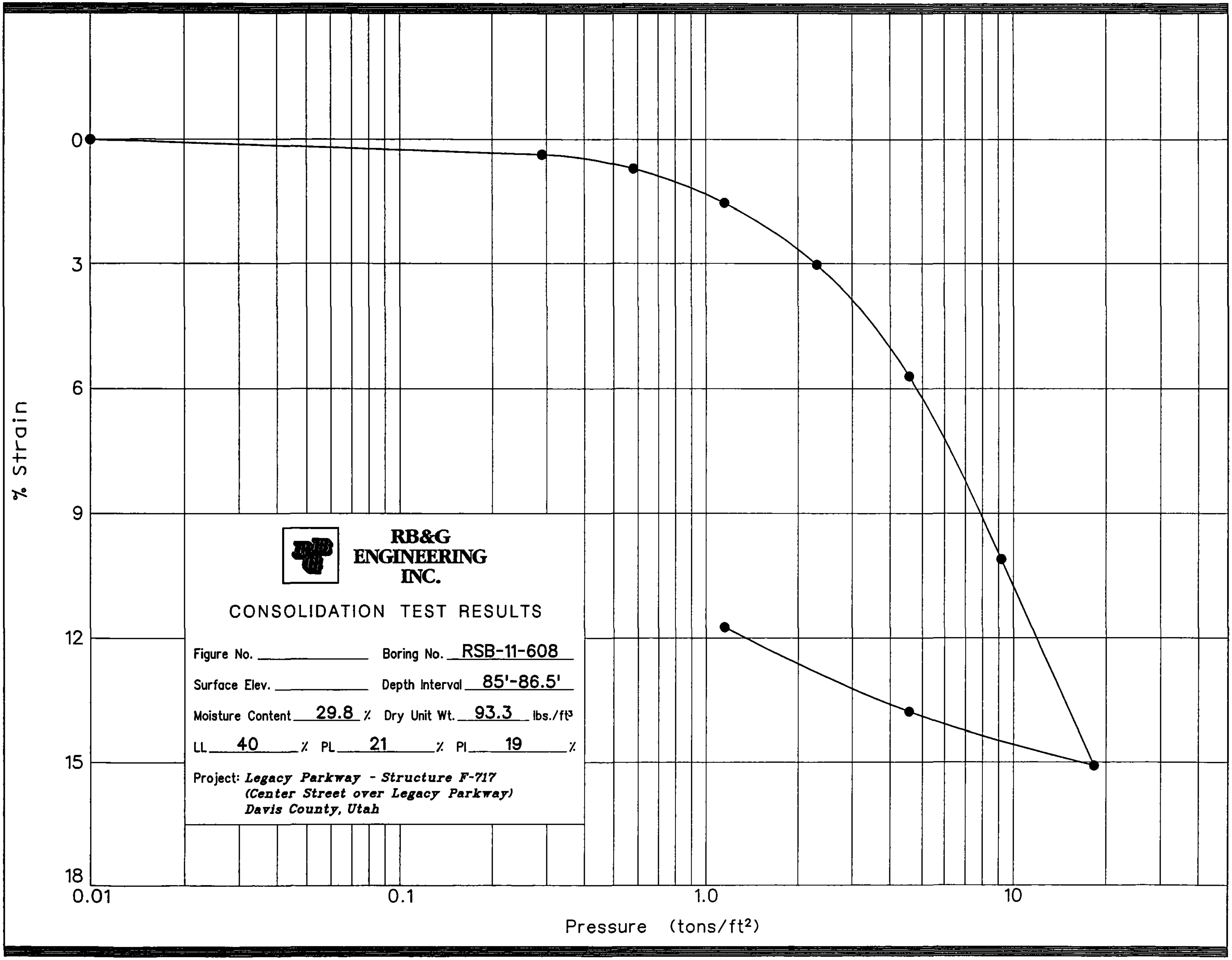
Figure



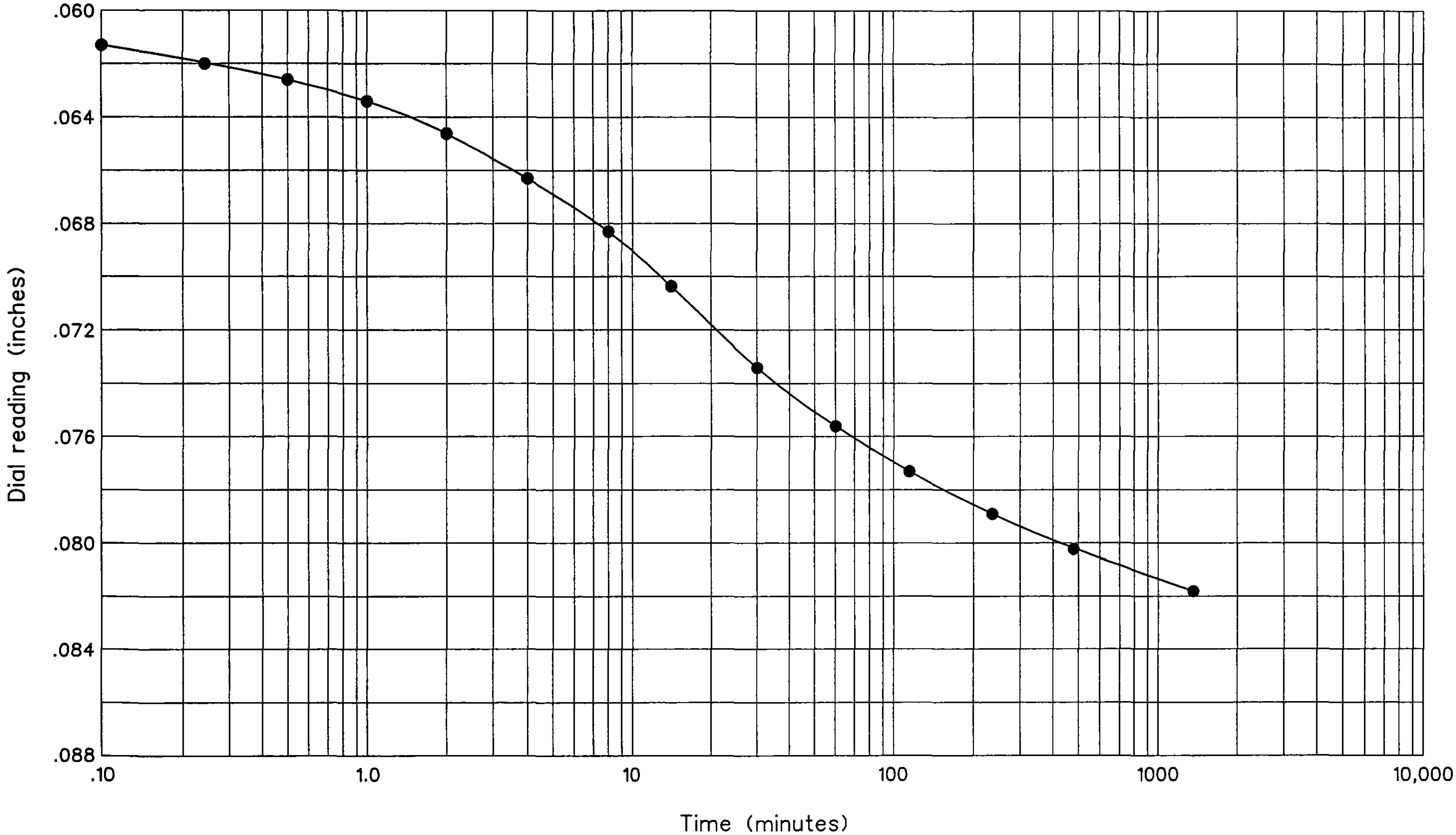
RB&G ENGINEERING INC. Provo, Utah	Hole no.: RSB-11-608 Depth: 55'-56.5' Load: 4.60 to 9.20 tons	TIME CONSOLIDATION *Legacy Parkway - Structure F-717* *(Center Street over Legacy Parkway)* *Davis County, Utah*

Figure

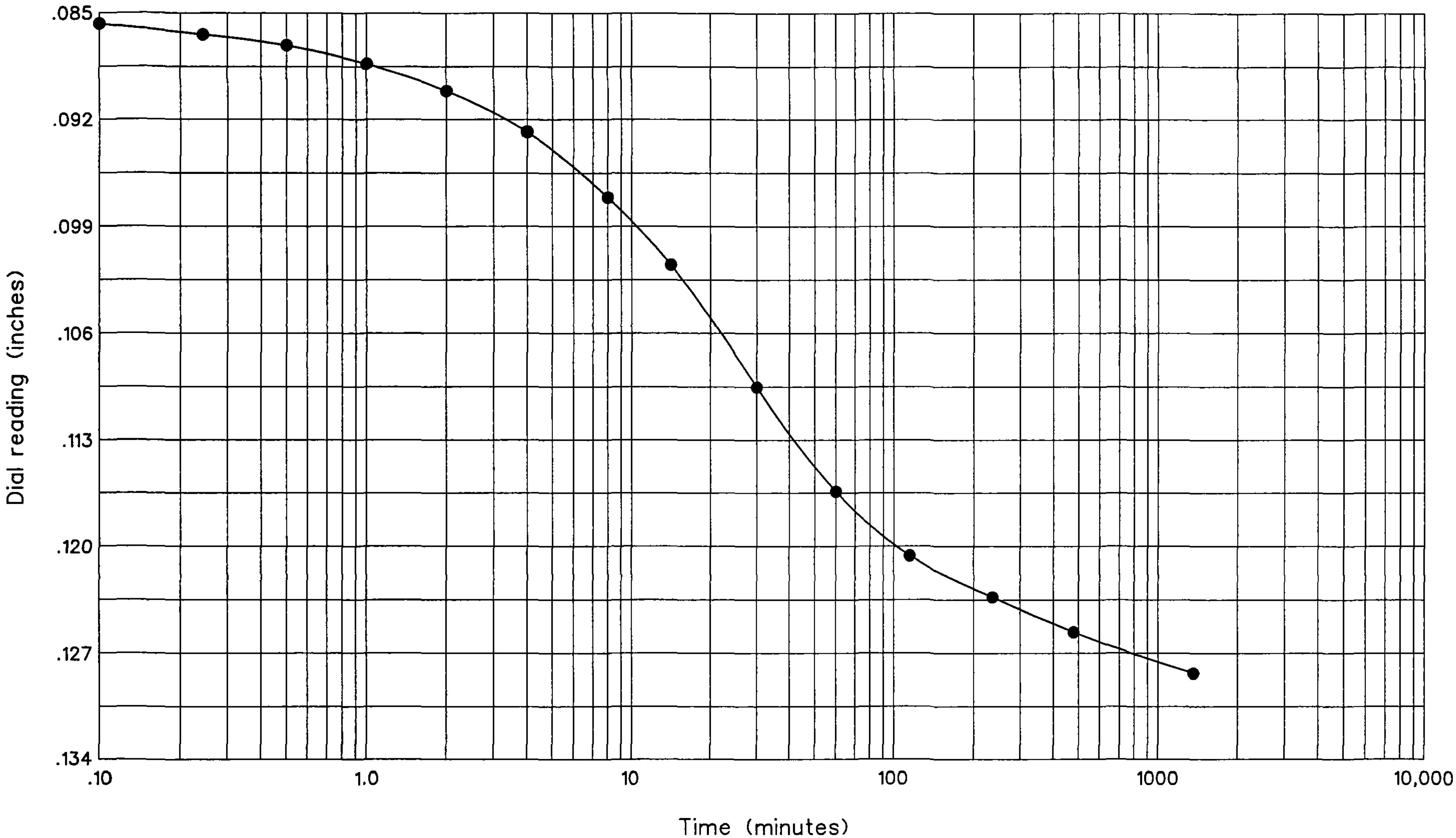

RB&G
ENGINEERING
INC.
CONSOLIDATION TEST RESULTS
Figure No. ____
Boring No. RSB-11-608
Surface Elev. ____
Depth Interval 85'-86.5'
Moisture Content 29.8 %
Dry Unit Wt. 93.3 lbs./ft³
LL 40 %
PL 21 %
PI 19 %
Project: Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah
Void Ratio (e)
.90
.80
.70
.60
.50
.40
.30
0.01
0.1
1.0
10
Pressure (tons/ft²)



% Strain
0
3
6
9
12
15
18
0.01
0.1
1.0
10
Pressure (tons/ft²)
RB&G ENGINEERING INC.
CONSOLIDATION TEST RESULTS
Figure No.
Boring No. RSB-11-608
Surface Elev.
Depth Interval 85'-86.5'
Moisture Content 29.8 %
Dry Unit Wt. 93.3 lbs./ft³
LL 40 %
PL 21 %
PI 19 %
Project: Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah



RB&G ENGINEERING INC. Provo, Utah	Hole no.: RSB-11-608 Depth: 85'-86.5' Load: 4.60 to 9.20 tons	TIME CONSOLIDATION *Legacy Parkway - Structure F-717* *(Center Street over Legacy Parkway)* *Davis County, Utah*	Figure



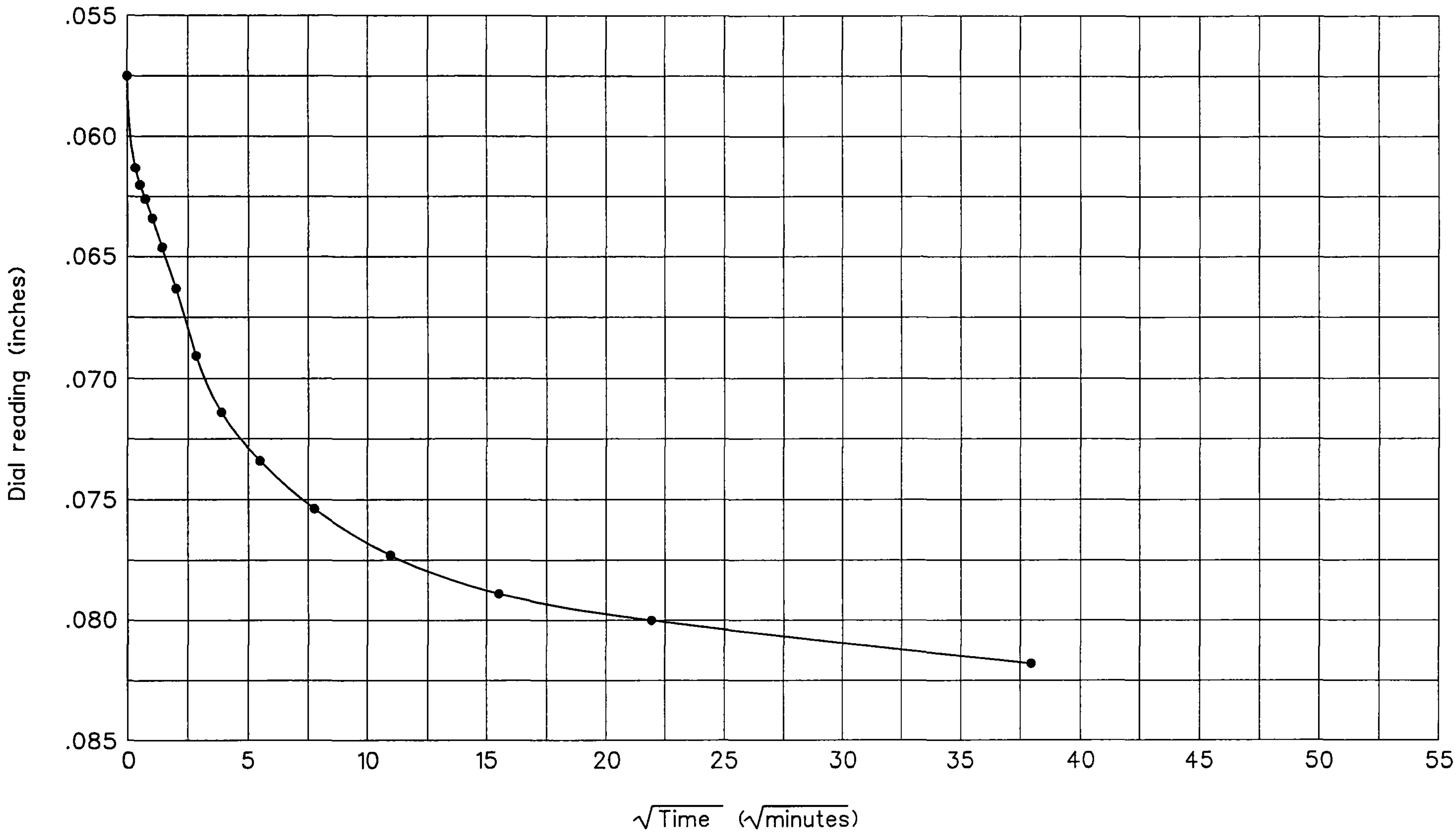
RB&G ENGINEERING INC.
Provo, Utah

Hole no.: RSB-11-608
Depth: 85'-86.5'
Load: 9.20 to 18.40 tons

TIME CONSOLIDATION

Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah

Figure



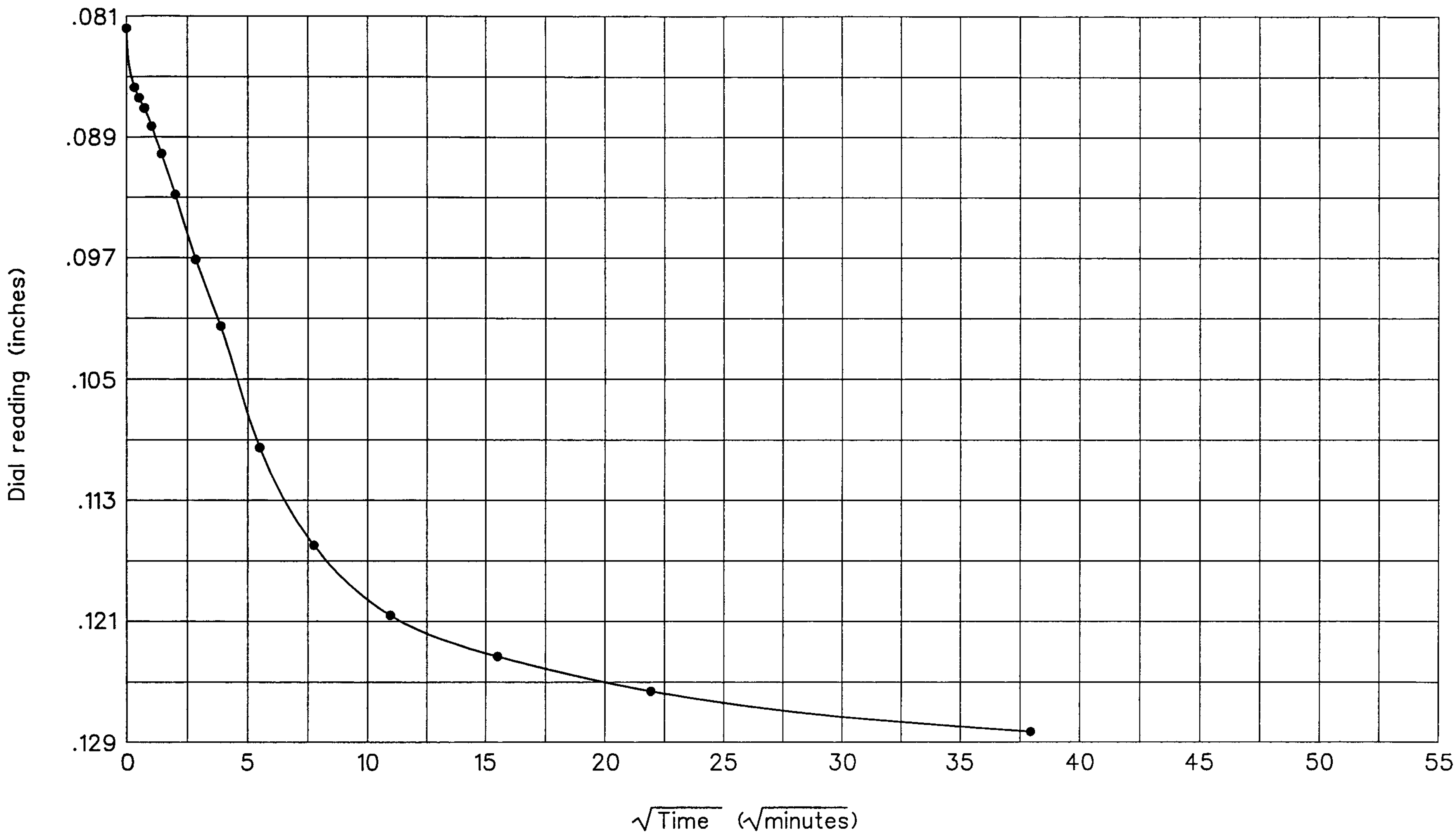
RB&G ENGINEERING INC.
Provo, Utah

Hole no.: RSB-11-608
Depth: 85'-86.5'
Load: 4.60 to 9.20 tons

TIME CONSOLIDATION

Legacy Parkway - Structure F-717
(Center Street over Legacy Parkway)
Davis County, Utah

Figure



RB&G ENGINEERING INC. Provo, Utah	Hole no.: RSB-11-608 Depth: 85'-86.5' Load: 9.20 to 18.40 tons	**TIME CONSOLIDATION** *Legacy Parkway - Structure F-717* *(Center Street over Legacy Parkway)* *Davis County, Utah*

Figure

Recommendations for LPILE and GROUP analyses.

Project: Legacy Parkway
Structure No: F-717 FAK No: 11
Description: Center Street over Legacy Parkway

Exist. Ground Surface Elev: 4218 ft
Est. Pile Tip Elev: 4150 ft
Pile Length Below Ground: 68 ft

Pile Type: Closed-End Pipe Pile
Size: 16 inch O.D.
Water Table: Upper 5 feet

Soil Layers

Thickness (ft)	Top Elev (ft)	Bottom Elev (ft)	Soil Type (p-y model)	Eff. Unit Wt. (pci)	Cohesion (psi)	Strain Factor ε_{50}	Friction Angle (degrees)	p-y Modulus, k (pci)	Max Unit Resistance Side (psi)	Max Unit Resistance End (psi)
5	4218	4213	Sand (Reese)	0.030	0	0	32	35	1.0	0
11	4213	4202	Soft Clay (Matlock)	0.030	4.9	0.015	0	40	4.0	0
12	4202	4190	Soft Clay (Matlock)	0.030	3.1	0.02	0	30	3.0	0
9	4190	4181	Liquefiable Sand	0.030	0	0	0	10	2.0	0
9	4181	4172	Sand (Reese)	0.030	0	0	30	30	6.5	0
16	4172	4156	Soft Clay (Matlock)	0.024	6.6	0.010	0	70	6.6	0
15	4156	4141	Sand (Reese)	0.033	0	0	36	120	18.8	1052

Other Considerations

Corrosion of Pipe Pile
Reduce Pipe pile wall thickness by 1/16 inch to account for corrosion.

Group Effects
Use P-Multipliers for pile groups as outlined in AASHTO LRFD 2006 Interim Section 10.7.2.4

Abutment Fill
For the length of the pile extending through the abutment fill:
For Effective Unit Weights use 0.069 pci (regular weight) or 0.046 pci (pumice)
Assume Friction Angle of 38 degrees. Consider reduced parameters for loading towards MSE wall face.

MSE Walls
For piles located less than 6B from MSE wall, use P-Multiplier of 0.3 or less for the MSE fill layer when loading is perpendicular to MSE wall face. MSE wall designer should be notified if MSE fill will be relied upon for lateral pile resistance.

Legacy Parkway Project

Summary of Lateral Earth Pressure Recommendations

Recommended Soil Parameters

Fill Description	Total Unit Weight (pcf)	Internal Friction Angle (degrees)	Cohesion (psf)	Comments
Sandy Gravel	150	38	0	Recommend 150 pcf and 38 degrees for loads, and 125 pcf and 34 degrees for resistance.*
Silty Sand	125	34	0	
Pumice	85	38	0	Recommend 85 pcf for loads and 80 pcf for resistance.*

*Recommendations per Memo dated April 18, 2006

In the equations listed herein:

γ = effective unit weight of soil

H = height of wall

(1) Active Lateral Earth Force (yielding walls)

$P_A = 0.5K_A\gamma H^2$ (triangular distribution)

$K_A = 0.24$ for Sandy Gravel and Pumice

0.28 for Silty Sand

(2) Passive Lateral Earth Force (yielding walls)

$P_P = 0.5K_P\gamma H^2$ (triangular distribution)

$K_P = 4.2$ for Sandy Gravel and Pumice

3.5 for Silty Sand

(3) At-Rest Lateral Earth Force (non-yielding walls)

$P_O = 0.5K_O\gamma H^2$ (triangular distribution)

$K_O = 0.38$ for Sandy Gravel and Pumice

0.44 for Silty Sand

(4) At-Rest Lateral Earth Force Modified for Compaction (non-yielding walls)

Use if activity of mechanical compaction equipment is anticipated within a distance equal to half the wall height.

General Equations for walls less than about 8 feet high

$P_O^* = 0.5K_O\gamma H^2$ (triangular distribution)

$K_O^* = 2.8$ for Sandy Gravel and Pumice

Walls greater than 8 feet high should be considered on a case-by-case basis.
Pressures listed above may be reduced by limiting size of compaction equipment permitted within a distance equal to half the wall height.

(5) Seismic Lateral Earth Forces (yielding walls)

Probabilistic Peak Ground Accelerations

General Bridge Site Location	10% PE in 50 Years	2% PE in 50 Years
From Mill Creek North	0.22g - 0.26g	0.60g - 0.63g
South of Mill Creek	0.26g - 0.30g	0.65g - 0.73g

Equations by Okabe (1926) and Mononobe and Matsuo (1929), referenced in Kramer (1996)

Total Active Thrust

$P_{AE} = 0.5K_{AE}\gamma H^2$

K_{AE} = (see table below)

Dynamic Component

$\Delta P_{AE} = P_{AE} - P_A$

P_A has triangular distribution (resultant at H/3 above base of wall)

ΔP_{AE} acts at about 0.6H above base of wall (same direction as P_A)

(5) Seismic Lateral Earth Forces (continued from previous page)

Total Passive Thrust

$P_{PE} = 0.5K_{PE}\gamma H^2$

$K_{PE} =$ (see table below)

Dynamic Component

$\Delta P_{PE} = P_P - P_{PE}$ $\quad$ P_P has triangular distribution (resultant at H/3 above base of wall)

ΔP_{PE} acts at about 0.6H above base of wall (opposite P_P)

Dynamic Earth Pressure Coefficients (for minimal wall displacement)*

Case	Friction Angle	Peak Ground Acceleration			
		0.25	0.30	0.63	0.73
Active (K_{AE})	38	0.35	0.38	0.65	0.77
	34	0.41	0.44	0.75	0.92
Passive (K_{PE})	38	3.77	3.68	3.01	2.76
	34	3.14	3.05	2.39	2.11

* Assumes k_h = 0.8PGHA. See memo dated April 18, 2006

*Dynamic Earth Pressure Coefficients (for wall displacement up to 10A inches**)*

Case	Friction Angle	Peak Ground Acceleration			
		0.25	0.30	0.63	0.73
Active (K_{AE})	38	0.31	0.32	0.44	0.49
	34	0.36	0.37	0.51	0.56
Passive (K_{PE})	38	3.94	3.89	3.51	3.38
	34	3.29	3.24	2.89	2.77

** Assumes k_h = 0.5PGHA. See memo dated April 18, 2006

(6) Seismic Lateral Earth Pressures (non-yielding walls)

Equations by Wood (1973), referenced in Kramer (1996)

Dynamic Thrust

$\Delta P_{eq} = a_h\gamma H^2$

a_h= Peak Ground Acceleration Coefficient (PGA/g)

Dynamic Overturning Moment

$\Delta M_{eq} = 0.53a_h\gamma H^3$

Point of Application of Dynamic Thrust

$h_{eq} = \Delta M_{eq}/\Delta P_{eq}$

$\approx 0.53H$

References

Kramer, S. (1996). "Geotechnical earthquake engineering," Prentice Hall, Upper Saddle River, NJ.

Mononobe, N. and Matsuo, H. (1929). "On the determination of earth pressures during earthquakes," *Proceedings, World Engineering Congress,* 9 p.

Okabe, S. (1926). "General theory of earth pressures," *Journal of the Japan Society of Civil Engineering*, Vol. 12, No. 1.

Memo

To: Sohail T. Khan, P.E; Larry Reasch, P.E.
From: Brad Price / Rob Johnson
CC: Steven K. Doerrer, PE; Brian Byrne, PE
Date: April 18, 2006
Re: Response to Design Criteria Questions

Responses to the questions submitted by Steven Doerrer are listed below. The email listing the questions is also attached for reference:

1) As discussed on last week's conference call (4/26/06), recommended total unit weights for fill material are as follows:

   - Regular-Weight Fill – 150 pcf for load calculations, 125 pcf for resistance calculations
   - Lightweight Fill (Pumice) – 85 pcf for load calculations, 80 pcf for resistance calculations

   It has been noted that the unit weight of regular-weight fill varies widely depending upon the source. However, it is our understanding that it is not desirable to limit the potential regular-weight borrow sources by specifying a permissible range of fill unit weight. In the interest of conservatism, we recommend using the larger unit weight to calculate soil loads, and the smaller unit weight to calculate soil resistance. The following values are recommended for fill friction angle:

   - Regular-Weight Fill – 38 degrees for load calculations, 34 degrees for resistance
   - Lightweight Fill (Pumice) – 38 degrees for load and resistance calculations

2) The Mononobe-Okabe equations are in accordance with AASHTO LRFD A11.1.1.1 and do not include inertia forces. Page 11-85 of the AASHTO LRFD states that it is not conservative to neglect inertia forces of the abutment mass. We believe it is appropriate to add seismic inertia forces of the heel backfill and concrete abutments.

3) The dynamic earth pressure coefficients provided previously, K_{AE} and K_{PE}, are for total active and passive thrust, respectively, and include both static and dynamic components. The dynamic components are ΔK_{AE} and ΔK_{PE} and are computed by subtracting the static force from the total thrust as shown on the memo. It should be noted that the equations by Wood (1973) for non-yielding walls provide only the dynamic thrust components of force and moment, and do not include static components.

4) In the memo dated 04/17/06, the horizontal acceleration coefficient k_h was assumed to be 80% of the peak horizontal ground acceleration coefficient for calculation of the Mononobe-

Okabe coefficients K_{AE} and K_{PE}. AASHTO LRFD A11.1.1.2 states that a k_h value equal to ½ the PHGA is adequate for most design purposes, provided that allowance is made for an outward displacement of the abutment of up to 10A inches (see page 11-88), where A is the maximum acceleration coefficient (PHGA). Mononobe-Okabe coefficients *for the 50% reduction* are summarized below, and may be used if allowance is made for the corresponding displacement.

Case	Friction Angle	Peak Ground Acceleration Coefficient			
		0.25	0.30	0.63	0.73
Active (K_{AE})	38	0.31	0.32	0.44	0.49
	34	0.36	0.37	0.51	0.56
Passive (K_{PE})	38	3.94	3.89	3.51	3.38
	34	3.29	3.24	2.89	2.77

If displacement must be minimized, we recommend that the factors shown in the initial memo (04/17/06) be used.

It should be noted that the Mononobe-Okabe factors provided to date neglect vertical acceleration. Seed and Whitman (1970) concluded that vertical accelerations can be ignored when the Mononobe-Okabe analysis is used to estimate P_{AE} for typical wall design (see Kramer, 1996). It is estimated that positive vertical accelerations, if considered, may increase the Seismic Active Thrust coefficient (K_{AE}) by as much as 30%. If desired, the coefficients on the table above can be refined to consider vertical acceleration once Peak Vertical Ground Accelerations have been determined (see Response No. 7 below).

5) We can evaluate the potential pile capacities at different depths and provide results along with uplift. It is assumed that the request of estimated pile tip elevations for compression resistance of 70, 100, and 120 tons applies only to the Pedestrian Bridge over Legacy Parkway (P-21). At any bridge we can evaluate the potential for providing a specific resistance per pile if we are provided with the desired resistance values (see also Response No. 6 below). The given extreme event capacities assume a resistance factor of 1.0, and are reduced for potential liquefaction.

6) It is possible to consider pile diameters larger than 16", although driven piles with diameters/widths greater than 16" are somewhat rare locally and local pile driving capabilities may be limited. Also, it is our understanding that a consistent pile section is preferred for the project to limit potential errors and confusion (primarily during construction). Is increased axial resistance the only reason for considering larger diameter piles? We would like to know the specific purpose for considering other diameters (such as target resistance values), as it would be inefficient to estimate capacities for an unlimited range of diameters, toe elevations, etc.

7) Kleinfelder is working on site-specific response spectra for 1250 West and State Street. It is our understanding that this data will be used to develop general response spectra (including vertical accelerations) for use at all bridge sites.

8) It was agreed at a previous meeting that the structural firms would perform the LPILE analysis using soil parameters provided by the geotechnical engineer. We recommend that p-

multipliers be used as input in LPILE or GROUP to account for group effects. As noted on the LPILE parameters sheet included with the initial recommendations for each structure, p-multipliers for laterally-loaded pile groups are outlined in AASHTO LRFD 10.7.2.4. The factors listed in the 2006 LRFD interim are in relatively good agreement with full-scale pile group lateral load tests performed at the Salt Lake City International Airport, where shallow soils are reasonably representative of the shallow soils typically encountered at the Legacy bridge sites.