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November 15, 2013

Mr. Naiel Hussein, P.E.
Parsons Brinckerhoff
2545 Farmers Drive, Suite 350
Columbus, Ohio 43235

**Reference:** **Final Subsurface Exploration Report for HAN-75-14.39**
**Bridge No. HAN-75-1526 L&R over US 68 Ramp A**
**Findlay, Hancock County, Ohio**
**PID No. 87005**
**PGI Project No. G13011G**

Dear Ms. Hussein:

Enclosed please find our Final Subsurface Exploration Report for the above referenced project. Our services included a geotechnical field exploration, laboratory testing, engineering analysis, and related design and construction recommendations. These services have been provided in accordance with our proposal dated January 16, 2013. It is important that the items under "**Limitations**" be precisely followed and complied with.

We appreciate the opportunity of working with you on this project and we invite you to contact us at (440) 717-1415 when we can be of further assistance.

Respectfully,

**PRO GEOTECH, INC.**

Shan Sivakumaran, P.E.
Project Manager/Geotechnical Engineer

Walid I. Najjar, P.E.
Senior Geotechnical Engineer

Enclosure
G13011Grpt/HAN-75-1526Bridges/SS/11/15/2013

# FINAL
# SUBSURFACE EXPLORATION REPORT
# FOR HAN-75-14.39
# BRIDGE NO. HAN-75-1526 L&R OVER US 68 RAMP A

**HANCOCK COUNTY, OHIO**
**PGI PROJECT NO. G13011G**
**PID NO. 87005**

**PREPARED FOR:**

**PARSONS BRINCKERHOFF**

**PREPARED BY:**

**PRO GEOTECH, INC.**

**NOVEMBER 15, 2013**

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## 1.0 EXECUTIVE SUMMARY

This report has been prepared for the HAN-75-14.39 project which calls for design and construction of the Interstate Route 75 (IR-75) mainline Bridge Nos. HAN-75-1526 Left & Right over U.S. Route 68 (US 68) Ramp A as part of redesigning the IR-75/US 68 Interchange in Findlay, Hancock County, Ohio. A total of six (6) bridge test borings identified as B-016-1-13, B-017-0-13, B-018-0-13, B-019-0-13, B-020-0-13, and B-020-1-13 were advanced for bridge and MSE wall foundations design purposes. Test borings B-016-1-13, B-017-0-13, and B-018-0-13 were advanced in the vicinity of the proposed rear abutment and MSE wall while test borings B-019-0-13, B-020-0-13, and B-020-1-13 were advanced in the vicinity of the proposed forward abutment and MSE wall. These structural test borings were advanced to approximate depths ranging from 13.0 to 45.0 feet below the existing ground or IR 75 pavement shoulder surface. Soil information obtained from test boring B-092-0-13 which was advanced for US 68 Ramp A design purposes in the vicinity of the proposed bridge will be used to design the rear MSE wall.

Subsurface soil Conditions: The subsurface soils encountered in the test borings consisted of both fill materials and natural soils in all of the test borings with the exception of B-020-1-13 which consisted entirely of natural soils. The fill material encountered above the natural soils consisted of silt and clay (A-6a), silty clay (A-6b), and clay (A-7-6). The approximate thickness of the fill materials ranged from 3.5 feet in test borings B-116-1-13, B-117-0-13, and B-119-0-13 to 27 feet in B-018-0-13 above the natural soils. Natural soils encountered above bedrock in the test borings consisted of both cohesive and non-cohesive soils. Cohesive soils encountered consisted of sandy silt (A-4a), silt and clay (A-6a), and silty clay (A-6b) while non-cohesive soils encountered consisted of non-plastic/granular stone fragments with sand (A-1-b), non-plastic sandy silt (A-4a), and non-plastic silt (A-4b). Bedrock was encountered in all test boring locations at approximate depths ranging 8.0 feet to 33.5 feet below the existing ground surface. The consistency of the cohesive soils ranged from "soft" to "stiff", but was generally “stiff” to "very stiff". The relative density of the non-cohesive soils ranged from “loose” to “very dense”, but was generally “medium dense”. All of the test borings were terminated after obtaining rock core samples.

Bedrock Conditions: The core samples consisted of dolomite of the Tymochtee/Greenfield Group. The dolomite was light gray to gray, severely to slightly weathered, and strong. Bedding within the dolomite was generally very thin to medium and was highly fractured to moderately fractured. No slickensides were observed and the fractures were typically tight to narrow and slightly rough to very rough. The

compressive strength of the core specimens ranged from 11,682 psi in test boring B-017-0-13 to 25,119 psi in test boring B-020-1-13 which characterizes them as "strong" to "very strong", respectively. The Rock Quality Designation (RQD) for the core samples ranged from 0% to 85% and averaged 49% based on individual runs. The Rock Mass Rating obtained for the bedrock core samples according to LRFD Table 10.4.6.4-1 varied from 55 to 62 and is classified as "Fair Rock" to "Good Rock".

Bridge Foundation Systems: Soil and rock information obtained from structural test borings B-017-0-13, B-018-0-13, B-019-0-13, and B-020-0-13 were used to provide foundation recommendations for the proposed bridge abutments. The proposed superstructure loads should be transferred to the underlying bedrock by means of end bearing H piles.

According to the ODOT *Bridge Design Manual* Section 204.4, the end bearing H-piles should be installed in pre-bored holes with a minimum embedment length of 5 feet into bedrock. These pre-bored holes should be backfilled with Class C concrete up to the top of the leveling pad elevation. The end bearing H-piles should also be installed with a minimum embedment length of 15.0 feet below the bottom of the MSE Wall. H-pile sizes HP-10X42 or HP-12X53 may be selected for the abutment locations. The total factored load on each HP-10X42 pile and HP-12X53 pile should not exceed the corresponding maximum structural resistance of 310 kips and 380 kips, respectively as per the ODOT *Bridge Design Manual* Section 202.2.3.2.a. Note that the above mentioned structural resistance values can be used only on the axial loaded piles that have a negligible bending moment. The estimated pile parameters for end bearing piles at each boring location are summarized in Table 6.1.1. The pile cut-off elevations at the abutments were extracted from the final structure site plan provided by PB personnel. Based on the factored axial loads acting on the piles, the estimated maximum total settlement and differential settlement will not exceed one inch and one half inch, respectively.

**Table 6.1.1 - Estimated Design Parameters for H-Piles**

| Boring No. | Bottom of MSE Wall Elevation | Pile Cut-off Elevation (ft) | Pile Tip Elevation (ft) | Estimated Effective Pile Length (ft) | Pile Type | Pile Size | Maximum Factored Structural Resistance/pile |
|---|---|---|---|---|---|---|---|
| B-017-0-13 | 779.0 | 796.0 | 764.0 | 35 | H-Pile | 10X42 | 310 kips |
| B-017-0-13 | 779.0 | 796.0 | 764.0 | 35 | H-Pile | 12X53 | 380 kips |
| B-018-0-13 | 781.0 | 798.9 | 766.0 | 35 | H-Pile | 10X42 | 310 kips |
| B-018-0-13 | 781.0 | 798.9 | 766.0 | 35 | H-Pile | 12X53 | 380 kips |
| B-019-0-13 | 781.0 | 798.3 | 766.0 | 35 | H-Pile | 10X42 | 310 kips |
| B-019-0-13 | 781.0 | 798.3 | 766.0 | 35 | H-Pile | 12X53 | 380 kips |

| Boring No. | Bottom of MSE Wall Elevation | Pile Cut-off Elevation (ft) | Pile Tip Elevation (ft) | Estimated Effective Pile Length (ft) | Pile Type | Pile Size | Maximum Factored Structural Resistance/pile |
|---|---|---|---|---|---|---|---|
| B-020-0-13 | 782.0 | 801.2 | 767.0 | 35 | H-Pile | 10X42 | 310 kips |
| B-020-0-13 | 782.0 | 801.2 | 767.0 | 35 | H-Pile | 12X53 | 380 kips |

Negative skin friction will develop along the pile section between the bottom of the proposed MSE Wall and the top of bedrock due to the consolidation of the foundation soils caused by construction of the MSE Walls. In order to avoid this negative skin friction, the piles should be installed after completion of the waiting period to complete the primary consolidation of the foundation soils. Refer to Section 6.2 "MSE Wall Foundation System" for the length of Waiting period. However if piles are to be installed before the construction of MSE Walls, the piles should be designed in accordance with section 202.2.3.2.c – "Down Drag Forces on Piles" of the ODOT Bridge Design Manual issued in January 2007.

MSE Wall Foundation Systems: Soil and rock information obtained from structural test borings B-116-1-13, B-017-0-13, B-018-0-13, B-019-0-13, B-020-0-13, and B-020-1-0-13 were used to provide foundation recommendations for the proposed MSE Walls. Soil information obtained from test boring B-092-0-13 which was advanced for US 68 Ramp A design purposes in the vicinity of this proposed bridge was used to design the rear MSE wall. As per the boring logs, bedrock was encountered at depths ranging from 6.6 feet to 10.4 feet below the bottom of the rear MSE Wall while bedrock was encountered at depths ranging from 10.9 feet to 12.4 feet below the bottom of the forward MSE Wall.

The foundation soils encountered below the bottom of the MSE Walls consisted of both fill and natural soils above bedrock and were predominantly cohesive in nature. The consistency of the fill and natural cohesive soils ranged from "hard" to "soft" but was generally "medium stiff" to "stiff". These cohesive soils encountered in all test boring locations will not support the applied loads from the MSE Walls. Therefore, PGI recommends performing ground improvement on the foundation soils at the rear and forward MSE Walls in the vicinity of these test boring locations. Ground improvements should be performed by removing soils below the bottom of the MSE Walls and replacing it with compacted ODOT Item 203 Granular Material, Type C, in accordance with Supplemental Specification 840. Table 6.2.1 summarizes the proposed excavation depths and grade elevations below the bottom of the MSE Walls at each test boring location.

**Table 6.2.1 – Summary of Excavation Depths for Ground Improvements**

| Boring No. | MSE Wall Location | Existing Ground Elevation (feet) | Bottom of MSE Wall Elevation (feet) | Excavation Depth Below MSE Wall (feet) | Excavation Grade Elevation (feet) |
|---|---|---|---|---|---|
| B-016-1-13 | Rear | 778.9 | 777.5 | 4.6 | 772.9 |
| B-017-0-13 | Rear | 780.6 | 779.0 | 5.6 | 773.4 |
| B-018-0-13 | Rear | 802.2 | 781.0 | 5.8 | 775.2 |
| B-092-0-13 | Rear | 807.6 | 782.0 | 5.4 | 776.6 |
| B-019-0-13 | Forward | 779.5 | 781.0 | 3.5 * | 776.0 |
| B-020-0-13 | Forward | 803.1 | 782.0 | 2.4 | 779.6 |
| B-020-1-13 | Forward | 784.5 | 783.0 | 4.5 | 778.5 |

- Excavation Depth below Existing Ground

Bearing capacity analysis was performed by using effective and total stress shear strength parameters to estimate the nominal bearing resistance of the strip footings supported on granular/cohesive soils. Nominal bearing resistance corresponding to bearing elevation at each boring location is summarized in Table 6.2.2 for PB personnel to verify the applied design pressure at Strength and Extreme Limit States for the rear and forward abutment MSE Walls.

**Table 6.2.2 – Estimated Design Parameters at Strength Limit State for MSE Walls**

| Boring No. | Location | Depth of Bottom of Footing Below Final Grade (feet) | Width of Strip Footing (feet) | Proposed Bearing Elevation (feet) | Factored Bearing Resistance (ksf) |
|---|---|---|---|---|---|
| B-016-1-13 | Rear MSE Wall | 6.9 | 22.8 | 777.5 | 13.7 |
| B-017-0-13 | Rear MSE Wall | 6.9 | 22.8 | 779.0 | 13.7 |
| B-018-0-13 | Rear MSE Wall | 6.9 | 22.8 | 781.0 | 14.2 |
| B-092-0-13 | Rear MSE Wall | 6.9 | 22.8 | 782.0 | 14.2 |
| B-019-0-13 | Forward MSE Wall | 5.0 | 22.1 | 781.0 | 10.8 |
| B-020-0-13 | Forward MSE Wall | 5.0 | 22.1 | 782.0 | 7.2 |
| B-020-1-13 | Forward MSE Wall | 5.0 | 22.1 | 783.0 | 10.8 |

Consolidation settlement analysis was performed using estimated soil parameters derived from laboratory moisture content tests and our experience. Table 6.2.3 summarizes the applied bearing pressure at the Service Limit State and footing size used to calculate the estimated settlement for the MSE Walls. Based on the settlement analysis, the estimated total and differential settlement of the underlying

foundation soils will be within the tolerable total settlement of 12 inches and differential settlement of one percent for MSE Walls. Settlement in granular soil will occur immediately during construction.

**Table 6.2.3 – Estimated Design Parameters at Service Limit State for MSE Walls**

| Boring No. | Location | Effective Footing Width (feet) | Applied Bearing Pressure (psf) | Immediate Settlement (inches) | Consolidation Settlement (inches) | Total Settlement (inches) |
|---|---|---|---|---|---|---|
| B-016-1-13 | Rear MSE Wall | 22.8 | 6000 | 0.78 | 0.18 | 0.96 |
| B-017-0-13 | Rear MSE Wall | 22.8 | 6000 | 1.02 | 0.0 | 1.02 |
| B-018-0-13 | Rear MSE Wall | 22.8 | 6000 | 0.40 | 2.23 | 2.63 |
| B-092-0-13 | Rear MSE Wall | 22.8 | 6000 | 0.34 | 2.81 | 3.15 |
| B-019-0-13 | Forward MSE Wall | 22.1 | 6000 | 1.77 | 3.13 | 4.90 |
| B-020-0-13 | Forward MSE Wall | 22.1 | 6000 | 0.78 | 4.52 | 5.30 |
| B-020-1-13 | Forward MSE Wall | 22.1 | 6000 | 0.84 | 5.88 | 6.72 |

Based on these settlement calculations, the estimated total consolidation settlement will exceed one inch at most boring locations. Approach slabs and pavement cannot tolerate consolidation settlement of more than one (1) inch. If the approach slabs and pavement are constructed immediately upon completion of the MSE Wall construction, it will result in damage to the approach slab and pavement. Therefore, a waiting period for pavement construction after completing the MSE Wall is required to allow the foundation soil to consolidate. Based on our calculations, it is recommended that a waiting period of 30 days is required after completing the MSE Wall and before constructing the approach slab and pavement.

Global stability analyses were performed using the GSTABL7 with STEDwin, version 2.0 program that was developed by Mr. Garry H. Gregory, P.E. to estimate the Factor of Safety for the proposed MSE Walls. Trial failure surfaces were generated using the method of slices for short term and long-term stability. The Modified Bishop Method of slices was used to generate circular trial failure surfaces. Table 6.2.4 summarizes the safety factors for the short term and long term stability of the proposed MSE Walls. Based on this slope stability analysis, the calculated Safety Factors for both short term and long term meet the required Safety Factors specified in the ODOT Embankment Checklist.

**Table 6.2.4 –Summary of Critical Factors of Safety for MSE Walls**

| Boring No | Location | Stability | Method Used | Factor of Safety |
|---|---|---|---|---|
| B-016-0-13 | Rear MSE Wall | Short Term | Circular | 2.23 |
| | Rear MSE Wall | Long Term | Circular | 2.00 |
| B-020-0-13 | Forward MSE Wall | Short Term | Circular | 2.54 |
| | Forward MSE Wall | Long Term | Circular | 2.20 |

Lateral Earth Pressures and Abutment Drainage: The MSE wall system supplier is responsible for internal stability design, including checking both pullout and rupture of the reinforcements and abutment drainage. Freely draining material must be placed behind the bridge abutments in accordance with ODOT Item 518 - "Drainage of Structures". The porous backfill should be placed a minimum of two (2) feet in thickness normal to the abutment walls. It is suggested that filter fabric, ODOT Item 712.09, Type A, be placed between Item 518 porous backfill material and Item 203 embankment material. This will ensure that fine particles from within the embankment do not migrate into the voids of the porous backfill.

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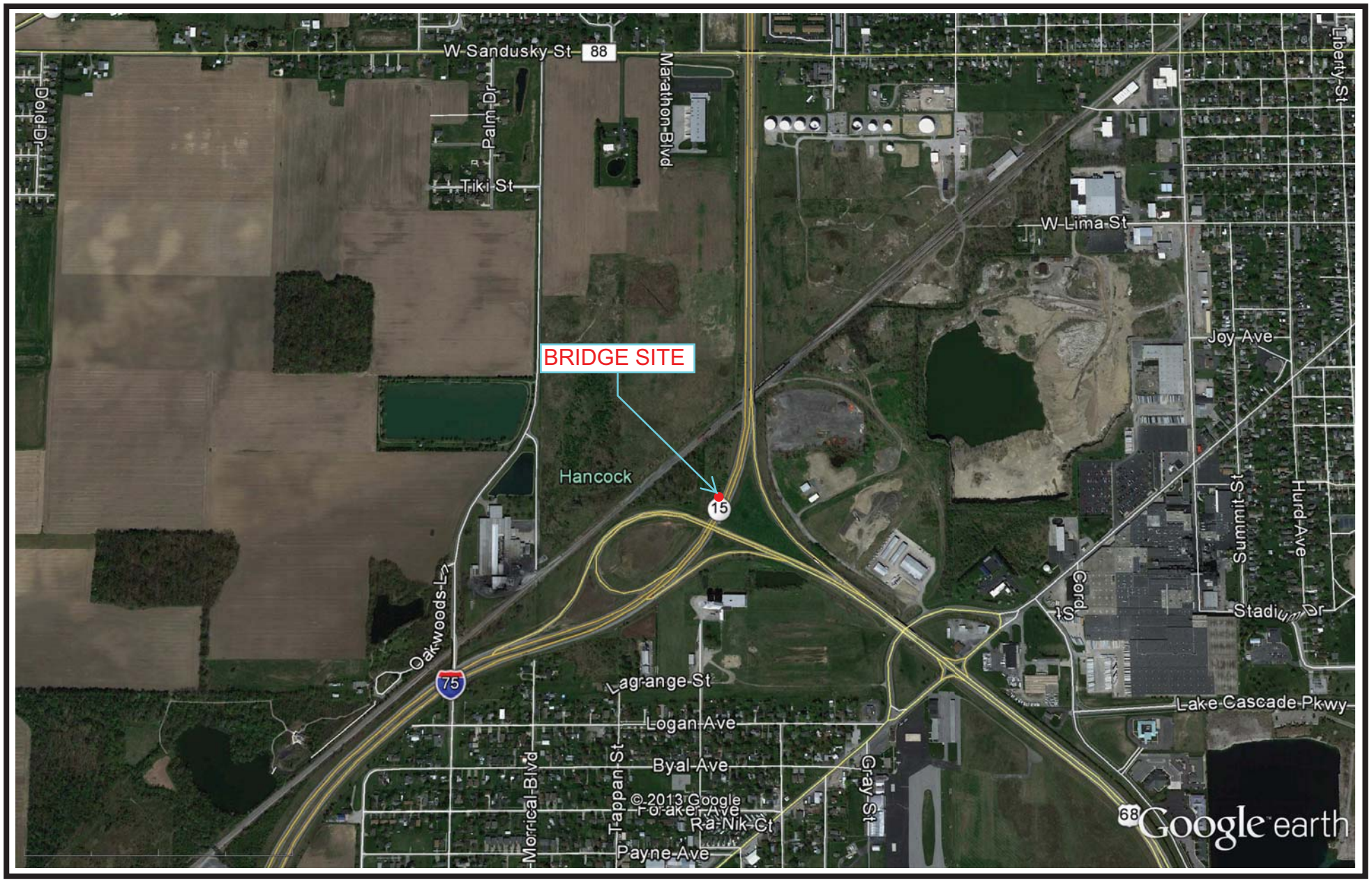
# 2.0 INTRODUCTION

This report has been prepared for the HAN-75-14.39 project which calls for design and construction of the Interstate Route 75 (IR-75) mainline Bridge Nos. HAN-75-1526 Left & Right over U.S. Route 68 (US 68) Ramp A as part of redesigning the IR-75/US 68 Interchange in Findlay, Hancock County, Ohio. It represents the intent of Parsons Brinckerhoff (PB) the design engineer, and the Ohio Department of Transportation (ODOT), the owner, to secure subsurface information at the selected locations in accordance with ODOT's *Specifications for Geotechnical Explorations*, and to obtain recommendations regarding geotechnical factors pertaining to the design and construction of this project.

## 2.1 Project Description

Present plans call for the design and construction of the proposed Bridge Nos. HAN-75-1526 Left & Right which will carry IR-75 mainline vehicular traffic over US 68 Ramp A. The design information provided by PB personnel indicates that the proposed bridges will be single span structures with an approximate span length of 105 feet. The proposed superstructures will be wide flange pre-stressed concrete I beams with reinforced concrete decking on modified semi-integral abutments. Retaining walls consisting of Mechanically Stabilized Earth (MSE) Wall System will be used to retain the abutment fill at both rear and forward abutments of these bridges. These bridges are to be designed based on HL-93 loading criteria and the ODOT Bridge Design Manual, issued in 2007 which includes LRFD Bridge Design Specifications. The Site Location Map is shown in Figure 2.1.

This report has been developed based on the field exploration program, laboratory testing, and information secured for site-specific studies. It must be noted that, as with any exploration program, the site exploration identifies actual subsurface conditions only at those locations where samples were obtained. The data derived through sampling and laboratory testing is reduced by geotechnical engineers and geologists who then render an opinion regarding the overall subsurface conditions and their likely reaction on the site. The actual site conditions may differ from those inferred to exist. Therefore, although a fair amount of subsurface data has been assembled during this exploration, this report may not provide all of the geotechnical data needed for construction of this project. This report was prepared using English units.

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PROJECT: HAN-75-14.39

IR 75 MAINLINE BRIDGE NO. HAN-75-1526 OVER US 68 RAMP A

SITE LOCATION MAP (FIGURE 2.1)

**2.2 Scope of Services**

The scope of services for this project was in accordance with Pro Geotech, Inc. (PGI) Proposal No. PG12067 dated January 16, 2013 and governed by ODOT's *Specifications for Geotechnical Explorations* dated January 2007 and updated January 20, 2012 and ODOT's Bridge Design Manual, issued in 2007 and AASHTO LRFD Bridge Design Specifications, 6th Edition hereafter referred to as ODOT Specifications. Our scope of services consisted of the execution of the following tasks:

***Phase I – Planning and Marking Test Borings,*** which primarily consisted of planning the field portion of our subsurface exploration, performing the site reconnaissance to evaluate the proposed project site from a geotechnical standpoint, reviewing and compiling all existing geology of the project site obtained from ODOT and ODNR sources, marking the test boring locations, obtaining necessary permits, and notifying the Ohio Utility Protection Services (OUPS) about the proposed drilling operations.

***Phase II - Test Boring and Sampling Program,*** which primarily consisted of field verification of the test boring locations with regards to the underground utilities, advancing the test borings at the site, conducting field tests, sampling the subsurface materials, and preparing field drilling logs.

Our scope of services included advancing six (6) test borings in the vicinity of proposed Bridge Nos. HAN-75-1526 Left & Right over US 68 Ramp A and retaining walls for structural foundation design purposes. These structural test borings for the bridges and retaining walls were to be advanced to approximate depths ranging from 25.0 feet to 50.0 feet below the existing ground surface and IR 75 pavement shoulder, and included obtaining 5 to 10 feet of rock core at each boring location. All test borings were advanced in accordance with the ODOT *Specifications for Geotechnical Explorations*. The groundwater conditions were monitored during and upon completion of the drilling operations. PGI provided all of the traffic control needed during the fieldwork.

***Phase III - Testing Program,*** which consisted of performing soil classification and engineering properties tests on selected soil and rock samples, and classifying the soils in accordance with the ODOT Soil Classification System.

***Phase IV - Geotechnical Exploration Report,*** which included the following:

- A brief description of the project and our exploration methods
- Typed drilling logs and laboratory test results

- A description of subsurface soil, rock, and groundwater conditions
- Discussions pertaining to earthwork considerations, groundwater management, and construction monitoring
- Foundation recommendations for the bridges and retaining walls including shallow and deep foundations
- Preparation of ODOT Geotechnical Design Check Lists
- Preparation of Geotechnical Structure Foundation Exploration Plans

The scope of services did not include any environmental assessments for the presence or absence of wetlands or hazardous or toxic materials in the soil, surface water, groundwater or air, on, below, or around this site. Any statement in this report or on the boring logs regarding odors, colors or unusual or suspicious items or conditions is strictly for the client's information.

## 3.0 GEOLOGY AND OBSERVATIONS OF THE PROJECT SITE

### 3.1 Geology

Based on information obtained from the Physiographic Regions of Ohio, the project site lies on the Huron-Erie Lake Plains and Till Plains Sections of the Central Lowland Province. The southern part of the project site is located within the Findlay Embayment District of the Maumee Lake Plains Region of the Huron-Erie Lake Plains Section while the northern part of the project site is located within the Central Ohio Clayey Till Plain Region of the Till Plains Section. The Columbus Escarpment separates the Findlay Embayment District from the Central Ohio Clayey Till Plain Region. The project site is located at approximate elevations ranging from 776 feet to 830 feet. According to Bulletin 44, *Geology of Water in Ohio* (issued in 1943 and reprinted in 1968), both the Illinoian and Wisconsin Glaciers passed over the area and left a coating of drift materials (largely till) ranging from 5 feet to 100 feet in thickness. The main geologic deposit in the southern part of the project site consists of silty to gravelly Wisconsinan-age lacustrine deposits and wave-planed clay till; ground moraine, flat to gently undulating over Dolomite bedrock of Silurian-age. The northern part of the project site consists of clayey, high-lime Wisconsinan-age till; lake-planed moraine, very flat, planed by waves in glacial lakes; small patches of sand, silt, or clay over Dolomite bedrock of Silurian-age. Based on the *Soil Survey of Hancock County, Ohio* and from the *U.S. Department of Agriculture, Natural Resource Conservation Service* website, the natural site soils in the vicinity of the project area consist primarily of layers of loam, clay loam, fine sandy loam, silty

clay loam, and silty clay. These soils are classified as A-4, A-6, and A-7 based on the AASHTO Soil Classification System. However, the project site has incurred cut and fill operations due to construction of existing IR-75. Thus the composition of the surface and subsurface soils has changed from natural in most areas.

Based on information obtained from the Ohio Geological Survey, bedrock in the vicinity of the project site was deposited during the Upper and Lower Silurian Period of the Paleozoic Era and is expected to consist of Tymochtee/Greenfield Group dolomite. Tymochtee Group dolomite is described as shades of gray and brown, very finely crystalline which occurs as thin to massive beds with carbonaceous shale laminae and beds. Greenfield Group dolomite is described as shades of gray and brown; very finely to coarsely crystalline which occurs as massive beds to laminae; argillaceous and locally brecciated in the lower portion. According to ODNR's Ohio Gas and Oil Wells Locator website, many active and abandoned wells are located within the project site. According to ODNR's Ohio Mines Locator website, no abandoned underground or surface mines are present in the immediate vicinity of the project site. Based on the Ohio Division of Geological Survey Interactive Map of Ohio Mineral Industries, an active limestone industrial quarry is located approximately 0.4 miles southwest of the project site. According to ODNR, the project site is located outside of the "Probable Karst Regions" of Ohio and outside of the "Landslide-Prone Areas" of Ohio. According to ODNR website, two (2) earthquakes occurred; one in 1990 with magnitude of 2.3 Richter Scale and another in 2011 with magnitude of 2.4 Richter Scale within Hancock County. Their epicenters were located respectively approximately 8.8 miles to the northeast in Big Lick Township and 14.2 miles to the south in Delaware Township.

### 3.2 Observations

The reconnaissance of the project site was performed by one of PGI's geotechnical engineers in July 2013. The project site is located in a rural area with closest building located within an approximate distance of 800 feet from the bridge site. The existing bridge which is to be replaced with this proposed structure is located approximately 300 feet south along the IR 75 mainline. The embankment section of existing IR-75 SB mainline located within the proposed bridge site generally appeared to be in good condition with no surface erosion observed. No visible signs of embankment slope instability were observed and embankment settlement was not observed. Tall cattail wetland vegetation was observed along the drainage ditch which appears to be a wetland area and will cross the proposed rear MSE Wall on the west side of the proposed structure. This site is covered with grass, small bushes, and few trees and is relatively flat.

# 4.0 EXPLORATION

## 4.1 Historic and Project Exploration Program

No Historical records of a geotechnical exploration were available from the ODOT Geotechnical Documents Management System ftp site for the existing IR 75 mainline bridges over Ramps US 68 NB to IR-75 SB and IR 75 SB to US 68 SB. However, historic information from previous geotechnical exploration for IR-75 mainline bridge over Norfolk Southern Railroad which is located 800 feet to the north of the proposed bridge site is available from the ODOT Geotechnical Documents Management System. This historic geotechnical exploration performed in December 1987 consists of structure foundation exploration sheets. All of the relevant historic information discussed above is included in Appendix B.

In order to explore the subsurface conditions at the project site, drilling, sampling, and field testing operations were performed in July and August 2013. A total of six (6) bridge test borings identified as B-016-1-13, B-017-0-13, B-018-0-13, B-019-0-13, B-020-0-13, and B-020-1-13 were advanced for bridge and MSE wall foundations design purposes. Test borings B-016-1-13, B-017-0-13, and B-018-0-13 were advanced in the vicinity of the proposed rear abutment and MSE wall while test borings B-019-0-13, B-020-0-13, and B-020-1-13 were advanced in the vicinity of the proposed forward abutment and MSE wall. These structural test borings were advanced to approximate depths ranging from 13.0 to 45.0 feet below the existing ground or IR 75 pavement shoulder surface. Soil information obtained from test boring B-092-0-13 which was advanced for US 68 Ramp A design purposes in the vicinity of the proposed bridge will be used to design the rear MSE wall.

The test borings were marked in the field by PGI based on boring location plans developed by PGI personnel and after obtaining approval from PB personnel. Site geometry, utility locations, overhead height, and accessibility were also taken into account when locating the test borings**.** At the time of test boring location selection, the vertical soil sampling intervals were determined based on the needs for design and construction of the project. An All Terrain Vehicle (ATV) mounted Diedrich 90 and Truck mounted CME 55 drill rigs were used to advance the test borings. All borings were advanced using 2.25-inch and 3.25-inch inside diameter, continuous flight hollow stem augers (HSA). Representative disturbed samples of the soils were collected at intervals in accordance with the ODOT Specifications. A standard 2.0-inch outside diameter split-barrel sampler was driven into the soil by means of a 140-lb hammer falling freely through a distance of 30-inches in accordance with the Standard Penetration Test (ASTM D 1586). Where bedrock was encountered, all test borings were advanced and the rock was sampled using type NX and NQ series core barrels, water method. All test borings were monitored for the presence of

groundwater during drilling operations and upon completion. All test borings were backfilled with compacted soil cuttings and/or bentonite mix at the end of drilling operations for safety purposes.

Latitude/longitude and northing/easting coordinates, stations and offsets, and surface elevations at the drilled test boring locations were provided to PGI by PB personnel. The typed drilling logs, Boring Location Map, and soil boring profiles are included in Appendix A. Northing and easting coordinates shown on the Soil Boring Profile sheets are grid. A project adjustment factor (PAF) of 1.00009818 was used to convert the grid coordinates to ground coordinates for this project. The typed drilling logs are included in Appendix A. These logs show the SPT resistance values (N-values) for each soil sample taken in the test borings and present the classification and description of soils encountered at various depths in the test borings. The N-values as measured in the field have been corrected to an equivalent rod energy ratio of 60% ($N_{60}$) in accordance with ODOT's *Specifications for Geotechnical Explorations*. The sample depth shown on the logs and laboratory test results indicate the top of each sampling or testing interval.

### 4.2 Laboratory Testing Program

All and rock soil samples obtained during the drilling and sampling operations were returned to PGI's geotechnical soils laboratory in Cleveland, Ohio. Upon arrival, the samples were visually examined and classified by a geotechnical engineer and a geologist to verify the classifications made in the field and to note any additional characteristics, which may not have been observed in the field.

Moisture content determination tests were performed on all soil samples as per ODOT specifications. Additional laboratory soil tests were performed on selected soil samples for the purpose of soil classification and for analysis of engineering characteristics. These tests consisted of Particle-Size Analysis, Liquid and Plastic Limit, Plasticity Index Determination of Soils, Organic Content of Organic Soils, and Unconfined Compressive Strength of Rock Core Samples. All laboratory tests were performed in accordance with the ASTM or other standards listed in "Laboratory Test Standards" located in Appendix B. The results of the laboratory tests are also included in Appendix B. The soils were classified in accordance with the ODOT Soil Classification System, a description of which is also included in Appendix B.

Upon completion of the laboratory testing, all samples were placed in storage at PGI's Cleveland facility. Unless otherwise requested in writing, the soil and rock samples will be retained through completion and ODOT approval of Stage 2 Plans.

# 5.0 FINDINGS

## 5.1 Subsurface Soil Conditions

The surficial and subsurface soil conditions in the vicinity of this proposed bridge were determined from the soil information obtained from project test borings B-016-1-13, B-017-0-13, B-018-0-13, B-019-0-13, B-020-0-13, and B-020-1-13. All test borings with the exception of B-018-0-13 and B-020-0-13 were advanced through 8 inches each of topsoil. Test borings B-018-0-13 and B-020-0-13 were each advanced through 5 inches of asphalt pavement above 7 inches of concrete pavement. The subsurface soils encountered in the test borings consisted of both fill materials and natural soils in all of the test borings with the exception of B-020-1-13 which consisted entirely of natural soils. The fill material encountered above the natural soils consisted of silt and clay (A-6a), silty clay (A-6b), and clay (A-7-6). The approximate thickness of the fill materials ranged from 3.5 feet in test borings B-116-1-13, B-117-0-13, and B-119-0-13 to 27 feet in B-018-0-13 above the natural soils. Natural soils encountered above bedrock in the test borings consisted of both cohesive and non-cohesive soils. Cohesive soils encountered consisted of sandy silt (A-4a), silt and clay (A-6a), and silty clay (A-6b) while non-cohesive soils encountered consisted of non-plastic/granular stone fragments with sand (A-1-b), non-plastic sandy silt (A-4a), and non-plastic silt (A-4b). Bedrock was encountered in all test boring locations at approximate depths ranging 8.0 feet to 33.5 feet below the existing ground surface.

The laboratory test results indicated that the moisture contents of the tested cohesive soil samples ranged from 9% to 31%. The moisture contents of the tested non-cohesive soils ranged from 8% to 13%. The consistency of the cohesive soils ranged from "soft" to "stiff", but was generally “stiff” to "very stiff". The relative density of the non-cohesive soils ranged from “loose” to “very dense”, but was generally “medium dense”.

Four of the five cohesive soil samples tested for Atterberg Limits had natural moisture contents greater than or equal to their plastic limits but less than their liquid limits. The remaining cohesive sample had a moisture content within 3% of its plastic limit. Normally, soils with moisture contents greater than or equal to their liquid limits are in a liquid state and have no shear strength. Soils with moisture contents greater than or equal to their plastic limits and less than their liquid limits are in a plastic state, and have the potential of volume change under certain loading conditions. The oven dried liquid limit tests performed on the split spoon samples obtained at 1.0 feet in test boring B-016-1-13 measured 45% and at 23.5 feet in B-018-0-13 measured 27%. The Organic Content tests performed on the split spoon samples obtained at 1.0 feet in test boring B-016-1-13 measured 4.7% and at 23.5 feet in

B-018-0-13 measured 3.6%, which characterizes them as moderately organic and slightly organic, respectively. All of the test borings were terminated after obtaining rock core samples. For specific conditions at various depths, please refer to the individual test boring logs located in Appendix A of this report. For complete moisture contents and Atterberg limit test results, please refer to the laboratory test results in Appendix B.

### 5.2 Bedrock Conditions

Bedrock was encountered in all of the test borings. Bedrock was split spoon sampled until little or no penetration or recovery was encountered. Bedrock core samples were then obtained using NX and NQ diamond impregnated core barrels. The coring operations were performed in accordance with the procedure for Diamond Core Drilling for Site Investigations (ASTM D 2113). The core samples consisted of dolomite of the Tymochtee/Greenfield Group. The dolomite was light gray to gray, severely to slightly weathered, and strong. Bedding within the dolomite was generally very thin to medium and was highly fractured to moderately fractured. No slickensides were observed and the fractures were typically tight to narrow and slightly rough to very rough. The compressive strength of the core specimens ranged from 11,682 psi in test boring B-017-0-13 to 25,119 psi in test boring B-020-1-13 which characterizes them as “strong” to “very strong”, respectively.

The Rock Quality Designation (RQD) for the core samples ranged from 0% to 85% and averaged 49% based on individual runs. The results of these measurements are summarized in Table 5.2.1. Table 5.2.2 summarizes the results of unconfined compressive strength tests performed at the laboratory on the rock core specimens at various depths. The Rock Mass Rating obtained for the bedrock core samples according to LRFD Table 10.4.6.4-1 varied from 55 to 62 and is classified as “Fair Rock” to “Good Rock”. The Rock Mass Rating spreadsheets are included in Appendix B. Refer to the drilling logs in Appendix A and rock core photos in Appendix B for additional bedrock information. Also refer to “Bedrock Descriptions” in Appendix B for general bedrock information.

**Table 5.2.1 – Bedrock Information**

| Boring Number | Rock Core Run No. | Top of Bedrock Elevations (ft) | Rock Core Run Elevations (ft) | Length of Core Run (ft) | Recovery (%) | RQD (%) |
|---|---|---|---|---|---|---|
| B-016-1-13 | NX-1 | 770.9 | 770.9 | 1.5 | 100 | 0 |
| | NX-2 | | 769.4 | 3.5 | 98 | 56 |
| B-017-0-13 | NX-1 | 771.1 | 770.1 | 10.0 | 100 | 48 |
| B-018-0-13 | NQ-1 | 770.7 | 768.2 | 10.0 | 78 | 70 |
| B-019-0-13 | NX-1 | 769.5 | 769.0 | 10.0 | 100 | 45 |
| B-020-0-13 | NQ-1 | 769.6 | 768.1 | 5.0 | 91 | 60 |
| | NQ-2 | | 763.1 | 5.0 | 100 | 85 |
| B-020-1-13 | NX-1 | 772.1 | 771.0 | 5.0 | 100 | 28 |

Elevations were provided by PB personnel

**Table 5.2.2 – Unconfined Compressive Strength Test Results of Rock Core Specimen**

| Boring No. | Specimen Depth (ft) | Rock Type | Unit Weight (pcf) | UCCS (psi) |
|---|---|---|---|---|
| B-016-1-13 | 10.5 | Dolomite | 169.37 | 14,460 |
| B-017-0-13 | 16.0 | Dolomite | 170.15 | 11,682 |
| B-018-0-13 | 36.5 | Dolomite | 161.58 | 13,068 |
| B-019-0-13 | 14.5 | Dolomite | 167.29 | 17,035 |
| B-020-0-13 | 40.5 | Dolomite | 161.29 | 20,551 |
| B-020-1-13 | 14.0 | Dolomite | 162.83 | 25,119 |

UCCS-Unconfined Compressive Strength

### 5.3 Groundwater Conditions

The groundwater levels were measured where encountered in all of the test boring locations during drilling operations and before the rock coring operations. Groundwater was encountered during drilling operations in one of the six test borings advanced during our field work. The groundwater level was measured at a depth of 9.0 feet (elevation 771.6 feet) during drilling prior to rock coring operations in test boring B-017-0-13. Groundwater levels were not recorded upon completion of rock coring operations due to water used for rock coring. It should be noted that groundwater elevations are subject to seasonal fluctuations. Groundwater monitoring wells are essential to accurately define the position of the groundwater table; however, installation of monitoring wells was not included in our scope of services. All test borings were backfilled upon completion for safety purposes.

## 6.0 ANALYSIS AND RECOMMENDATIONS

Based upon the findings of the field exploration program, laboratory testing, and subsequent engineering analysis, the following sections have been prepared to address the geotechnical aspects related to the design and construction of IR 75 Mainline Bridge Nos. HAN-75-1526 L&R over US 68 Ramp A. Site plans provided by PB personnel indicates that the bridge abutment above the MSE wall embankment will be supported on piles at the rear and forward abutment locations. Elevations of the bottom of the proposed MSE Walls at the rear and forward abutment locations will range from 777.5 feet to 781.0 feet and 781.0 feet to 783.0 feet, respectively. The foundation recommendations are provided in accordance with the ODOT *Bridge Design Manual* issued in 2007 using *LRFD Bridge Design Specifications.*

### 6.1 Bridge Foundation Systems

Soil and rock information obtained from structural test borings B-017-0-13, B-018-0-13, B-019-0-13, and B-020-0-13 were used to provide foundation recommendations for the proposed bridge abutments. Structural test borings B-017-0-13 and B-018-0-13 were advanced in the vicinity of the proposed rear abutment while structural test borings B-019-0-13 and B-020-0-13 were advanced in the vicinity of the proposed forward abutment. As per the boring logs for this bridge, bedrock was encountered at depths ranging from 7.9 feet to 10.4 feet below the bottom of the rear MSE Wall and 11.5 feet to 12.4 feet below the bottom of the forward MSE Wall. Since bedrock was encountered at relatively shallow depths below the bottom of the proposed MSE Walls at these test boring locations, the proposed superstructure loads may be transferred to the underlying bedrock by means of spread footings. However, according to ODOT *Bridge Design Manual* Section 204.4, MSE Wall supported abutments should be supported on piles regardless of the proximity of bedrock to the MSE Wall foundation. Therefore the proposed superstructure loads should be transferred to the underlying bedrock by means of end bearing H piles.

According to the ODOT *Bridge Design Manual* Section 204.4, the end bearing H-piles should be installed in pre-bored holes with a minimum embedment length of 5 feet into bedrock. These pre-bored holes should be backfilled with Class C concrete up to the top of the leveling pad elevation. The end bearing H-piles should also be installed with a minimum embedment length of 15.0 feet below the bottom of the MSE Wall. H-pile sizes HP-10X42 or HP-12X53 may be selected for the abutment locations. The total factored load on each HP-10X42 pile and HP-12X53 pile should not exceed the corresponding maximum structural resistance of 310 kips and 380 kips, respectively as per the ODOT *Bridge Design*

*Manual* Section 202.2.3.2.a. Note that the above mentioned structural resistance values can be used only on the axial loaded piles that have a negligible bending moment. The estimated pile parameters for end bearing piles at each boring location are summarized in Table 6.1.1. The pile cut-off elevations at the abutments were extracted from the final structure site plan provided by PB personnel.

**Table 6.1.1 - Estimated Design Parameters for H-Piles**

| Boring No. | Bottom of MSE Wall Elevation | Pile Cut-off Elevation (ft) | Pile Tip Elevation (ft) | Estimated Effective Pile Length (ft) | Pile Type | Pile Size | Maximum Factored Structural Resistance/pile |
|---|---|---|---|---|---|---|---|
| B-017-0-13 | 779.0 | 796.0 | 764.0 | 35 | H-Pile | 10X42 | 310 kips |
| B-017-0-13 | 779.0 | 796.0 | 764.0 | 35 | H-Pile | 12X53 | 380 kips |
| B-018-0-13 | 781.0 | 798.9 | 766.0 | 35 | H-Pile | 10X42 | 310 kips |
| B-018-0-13 | 781.0 | 798.9 | 766.0 | 35 | H-Pile | 12X53 | 380 kips |
| B-019-0-13 | 781.0 | 798.3 | 766.0 | 35 | H-Pile | 10X42 | 310 kips |
| B-019-0-13 | 781.0 | 798.3 | 766.0 | 35 | H-Pile | 12X53 | 380 kips |
| B-020-0-13 | 782.0 | 801.2 | 767.0 | 35 | H-Pile | 10X42 | 310 kips |
| B-020-0-13 | 782.0 | 801.2 | 767.0 | 35 | H-Pile | 12X53 | 380 kips |

Based on the factored axial loads acting on the piles, the estimated maximum total settlement and differential settlement will not exceed one inch and one half inch, respectively. It is recommended that the piles be spaced a minimum of three (3) pile diameters on center. Seepage into the pre-bored holes may occur within the soil overburden during pile installation. If any water is present in the bottom of the holes, it should be removed before placing concrete. The pile supported abutments may experience horizontal movement caused by lateral loads and overturning moments. Since piles are extended into bedrock, group effects of the piles can be neglected. The pile supported abutments may experience horizontal movement caused by lateral loads and overturning moments. A lateral load analysis should be performed using LPILE 5.0 computer program by Ensoft for selected pile size and embedment lengths to check whether lateral resistance is adequate to support lateral loads and overturning moments. Table 6.1.2 summarizes the rock parameters to perform lateral load analyses using the LPILE Program.

**Table 6.1.2 - Estimated Rock Parameters for Lateral Load Analyses**

| Rock | Unit Weight (pci) | Unconfined Compressive Strength (psi) |
|---|---|---|
| Strong Rock | 0.095 | 5000 |

Pile sections within the MSE Walls should be encased above the existing ground in corrugated pipe filled with granular material to eliminate any down drag on this portion of the piles and protect against construction operations. Negative skin friction will develop along the pile section between the bottom of the proposed MSE Wall and the top of bedrock due to the consolidation of the foundation soils caused by construction of the MSE Walls. In order to avoid this negative skin friction, the piles should be installed after completion of the waiting period to complete the primary consolidation of the foundation soils. Refer to Section 6.2 "MSE Wall Foundation System" for the length of Waiting period. However if piles are to be installed before the construction of MSE Walls, the piles should be designed in accordance with section 202.2.3.2.c – "Down Drag Forces on Piles" of the ODOT Bridge Design Manual issued in January 2007. Un-factored down drag load of 14 kips and 18 kips were estimated within the downdrag zone for using 12inches (for pile size 10X42) and 14 inches (for pile size 12X53) diameter, respectively for H-piles covered with concrete.

All H-piles should be installed in accordance with ODOT Item 507 - *Bearing Piles*, of the ODOT *Construction and Material Specifications Manual* dated January 2013. For detailed pile foundation design refer to Section 303.4.2 - "Pile Foundations" and other related sections of the *ODOT Bridge Design Manual* issued in July 2007.

## 6.2 MSE Wall Foundation Systems

Based on the site plan provided by PB personnel, the maximum height of the MSE Walls will be 32.5 feet and 31.5 feet at the rear and forward abutment locations, respectively. The foundation width of the MSE Walls at the rear and forward abutment locations will be 22.8 feet and 22.1 feet based upon a minimum strap length equal to 70% of the wall height. At the time of this final report submittal, applied bearing pressures at the bottom of the MSE walls were not available to PGI. However, it is assumed that maximum applied bearing pressures at the Strength Limit State and Service Limit State will be 7000 psf and 6000 psf, respectively at both rear and forward MSE Walls. Soil and rock information obtained from structural test borings B-016-1-13, B-017-0-13, B-018-0-13, B-019-0-13, B-020-0-13, and B-020-1-0-13 were used to provide foundation recommendations for the proposed MSE Walls. Structural test borings B-016-1-13, B-017-0-13, and B-018-0-13 were advanced in the vicinity of the proposed rear MSE Wall

while structural test borings B-019-0-13, B-020-0-13, and B-020-1-0-13 were advanced in the vicinity of proposed forward MSE Wall. Soil information obtained from test boring B-092-0-13 which was advanced for US 68 Ramp A design purposes in the vicinity of this proposed bridge was used to design the rear MSE wall. As per the boring logs, bedrock was encountered at depths ranging from 6.6 feet to 10.4 feet below the bottom of the rear MSE Wall while bedrock was encountered at depths ranging from 10.9 feet to 12.4 feet below the bottom of the forward MSE Wall.

The foundation soils encountered below the bottom of the MSE Walls consisted of both fill and natural soils above bedrock and were predominantly cohesive in nature. The consistency of the fill and natural cohesive soils ranged from "hard" to "soft" but was generally "medium stiff" to "stiff". These cohesive soils encountered in all test boring locations will not support the applied loads from the MSE Walls. Therefore, PGI recommends performing ground improvement on the foundation soils at the rear and forward MSE Walls in the vicinity of these test boring locations. Ground improvements should be performed by removing soils below the bottom of the MSE Walls and replacing it with compacted ODOT Item 203 Granular Material, Type C, in accordance with Supplemental Specification 840. Table 6.2.1 summarizes the proposed excavation depths and grade elevations below the bottom of the MSE Walls at each test boring location. The ground improvements must be performed a minimum of 3 feet beyond the perimeter foundation of all MSE Walls. Additional granular material should be filled in the vicinity of test boring location B-019-0-13 at the forward MSE Wall to bring up the grade to the bottom of the proposed MSE Wall.

**Table 6.2.1 – Summary of Excavation Depths for Ground Improvements**

| Boring No. | MSE Wall Location | Existing Ground Elevation (feet) | Bottom of MSE Wall Elevation (feet) | Excavation Depth Below MSE Wall (feet) | Excavation Grade Elevation (feet) |
|---|---|---|---|---|---|
| B-016-1-13 | Rear | 778.9 | 777.5 | 4.6 | 772.9 |
| B-017-0-13 | Rear | 780.6 | 779.0 | 5.6 | 773.4 |
| B-018-0-13 | Rear | 802.2 | 781.0 | 5.8 | 775.2 |
| B-092-0-13 | Rear | 807.6 | 782.0 | 5.4 | 776.6 |
| B-019-0-13 | Forward | 779.5 | 781.0 | 3.5 * | 776.0 |
| B-020-0-13 | Forward | 803.1 | 782.0 | 2.4 | 779.6 |
| B-020-1-13 | Forward | 784.5 | 783.0 | 4.5 | 778.5 |

- Excavation Depth below Existing Ground

Bearing capacity analysis was performed by using effective and total stress shear strength parameters to estimate the nominal bearing resistance of the strip footings supported on granular soils. Results of the bearing capacity analysis are attached in Appendix B. Nominal bearing resistance corresponding to bearing elevation at each boring location is summarized in Table 6.2.2 for PB personnel to verify the applied design pressure at Strength and Extreme Limit States for the rear and forward abutment MSE Walls. Because the nominal bearing resistance was computed using a semi empirical method, a resistance factor ($\phi$) of 0.45 was applied to compute the factored bearing resistance at Strength Limit State.

**Table 6.2.2 – Estimated Design Parameters at Strength Limit State for MSE Walls**

| Boring No. | Location | Depth of Bottom of Footing Below Final Grade (feet) | Width of Strip Footing (feet) | Proposed Bearing Elevation (feet) | Factored Bearing Resistance (ksf) |
|---|---|---|---|---|---|
| B-016-1-13 | Rear MSE Wall | 6.9 | 22.8 | 777.5 | 13.7 |
| B-017-0-13 | Rear MSE Wall | 6.9 | 22.8 | 779.0 | 13.7 |
| B-018-0-13 | Rear MSE Wall | 6.9 | 22.8 | 781.0 | 14.2 |
| B-092-0-13 | Rear MSE Wall | 6.9 | 22.8 | 782.0 | 14.2 |
| B-019-0-13 | Forward MSE Wall | 5.0 | 22.1 | 781.0 | 10.8 |
| B-020-0-13 | Forward MSE Wall | 5.0 | 22.1 | 782.0 | 7.2 |
| B-020-1-13 | Forward MSE Wall | 5.0 | 22.1 | 783.0 | 10.8 |

Consolidation settlement analysis was performed using estimated soil parameters derived from laboratory moisture content tests and our experience. Results of the settlement analysis are attached in Appendix B. Table 6.2.3 summarizes the applied bearing pressure at the Service Limit State and footing size used to calculate the estimated settlement for the MSE Walls. Based on the settlement analysis, the estimated total and differential settlement of the underlying foundation soils will be within the tolerable total settlement of 12 inches and differential settlement of one percent for MSE Walls. Settlement in granular soil will occur immediately during construction.

**Table 6.2.3 – Estimated Design Parameters at Service Limit State for MSE Walls**

| Boring No. | Location | Effective Footing Width (feet) | Applied Bearing Pressure (psf) | Immediate Settlement (inches) | Consolidation Settlement (inches) | Total Settlement (inches) |
|---|---|---|---|---|---|---|
| B-016-1-13 | Rear MSE Wall | 22.8 | 6000 | 0.78 | 0.18 | 0.96 |
| B-017-0-13 | Rear MSE Wall | 22.8 | 6000 | 1.02 | 0.0 | 1.02 |
| B-018-0-13 | Rear MSE Wall | 22.8 | 6000 | 0.40 | 2.23 | 2.63 |
| B-092-0-13 | Rear MSE Wall | 22.8 | 6000 | 0.34 | 2.81 | 3.15 |
| B-019-0-13 | Forward MSE Wall | 22.1 | 6000 | 1.77 | 3.13 | 4.90 |
| B-020-0-13 | Forward MSE Wall | 22.1 | 6000 | 0.78 | 4.52 | 5.30 |
| B-020-1-13 | Forward MSE Wall | 22.1 | 6000 | 0.84 | 5.88 | 6.72 |

The amount of settlement varies from location to location based on the soil type and layer thickness of the foundation soils. Based on these settlement calculations, the estimated total consolidation settlement will exceed one inch at most boring locations. Approach slabs and pavement cannot tolerate consolidation settlement of more than one (1) inch. If the approach slabs and pavement are constructed immediately upon completion of the MSE Wall construction, it will result in damage to the approach slab and pavement. Therefore, a waiting period for pavement construction after completing the MSE Wall is required to allow the foundation soil to consolidate. Based on our calculations, it is recommended that a waiting period of 30 days is required after completing the MSE Wall and before constructing the approach slab and pavement. This waiting period was calculated using coefficient of consolidation ($C_v$) of 0.27 square feet/day, 6 feet thickness, and double sided drainage for foundation soils. Installing settlement plates within the proposed MSE Wall area, on each side of the bridge will be required to measure the amount and rate of consolidation settlement. By measuring this consolidation settlement, it can confirm when the remaining consolidation settlement at each location is less than what the approach slabs or pavement can tolerate. The settlement devices should be installed at the top of the existing foundation soils before any fill is being placed. PGI recommends installing settlement devices to measure the settlement in the vicinity of Stations 806+00, CL and 807+32, RT. The survey should be performed weekly to measure the settlement. The final survey is complete when there is no change in four (4) weekly consecutive settlement readings. The waiting period should be either 30 days after completion of MSE Wall construction or when no change in four weekly consecutive settlement readings occurs in the field which ever come last.

If MSE Wall footings support the horizontal or inclined loads, failure by sliding must also be analyzed at Strength and Extreme Limit States. In order to calculate factored nominal sliding resistance between the interface of the footing and the granular soils, an internal friction angle of 30 degree is estimated for granular soil. A resistance factor ($\phi$) of 0.85 should be applied to compute factored sliding resistance when checking sliding at Strength Limit State. Global stability analyses were performed using the GSTABL7 with STEDwin, version 2.0 program that was developed by Mr. Garry H. Gregory, P.E. to estimate the Factor of Safety for the proposed MSE Walls. The foundation soil profiles below the proposed MSE Walls were estimated from information obtained from the test borings. The phreatic surface was approximated from the water level reading measured at test boring location B-017-0-13. For slope stability analysis, shear strength soil parameters used in this analysis were obtained from the laboratory tests performed on the undisturbed soil samples obtained from the ramp test borings and from our experience with similar types of soils. Trial failure surfaces were generated using the method of slices for short term and long-term stability. The Modified Bishop Method of slices was used to generate circular trial failure surfaces. Table 6.2.4 summarizes the safety factors for the short term and long term stability of the proposed MSE Walls. Based on this slope stability analysis, the calculated Safety Factors for both short term and long term meet the required Safety Factors specified in the ODOT Embankment Checklist. Slope analyses critical failure circles are included in Appendix B.

**Table 6.2.4 –Summary of Critical Factors of Safety for MSE Walls**

| Boring No | Location | Stability | Method Used | Factor of Safety |
|---|---|---|---|---|
| B-016-0-13 | Rear MSE Wall | Short Term | Circular | 2.23 |
| | Rear MSE Wall | Long Term | Circular | 2.00 |
| B-020-0-13 | Forward MSE Wall | Short Term | Circular | 2.54 |
| | Forward MSE Wall | Long Term | Circular | 2.20 |

The excavated foundation soil subgrade should be examined by competent geotechnical personnel. If any fill materials/highly compressible materials or areas of low bearing capacity with excessive moisture (soft pockets) are encountered, they should be removed as directed by on site geotechnical personnel and replaced with ODOT Item 203 Granular Material, Type C. The MSE Wall design should be in accordance with the ODOT Bridge Design Manual issued in January 2007, Section 204.6.2.1. The backfill material in the reinforced zone and retained soil zone should be as per Section 204.6.2.1 F specifications.

### 6.3 Lateral Earth Pressures and Abutment Drainage

The MSE Wall system supplier must be responsible for internal stability design, including checking both pullout and rupture of the reinforcements and abutment drainage. Freely draining material must be placed behind the bridge abutments in accordance with ODOT Item 518 - "Drainage of Structures". The porous backfill should be placed a minimum of two (2) feet in thickness normal to the abutment walls. It is suggested that filter fabric, ODOT Item 712.09, Type A, be placed between Item 518 porous backfill material and Item 203 embankment material. This will ensure that fine particles from within the embankment do not migrate into the voids of the porous backfill.

### 6.4 Approach Slab Design Parameters

During construction of the project, the proposed approach slabs will be constructed on the proposed embankment subgrade fill soils. Therefore, the soil parameters derived from the actual fill soils should be used for pavement design. Representative samples of proposed borrow materials should be tested and CBR values should be derived prior to construction.

### 6.5 Groundwater Management

The groundwater level was measured in one (1) of the six (6) test borings (B-017-0-13) at a depth of 9.0 feet (elevation 771.6 feet) during drilling operations. If the bottom depth of the excavation for the structure abutments extends below the water level at the boring location, water infiltration is anticipated. Moderate to high volume pumping or dewatering will be required. Pumping can be controlled through the use of sump pumps. It must be noted that the groundwater levels during construction may vary due to seasonal fluctuations, and groundwater may occur where not encountered previously.

### 6.6 Earthwork and Construction Monitoring

All excavation and backfilling operations should be conducted in accordance with ODOT's *Construction and Materials Specifications*, Item 503 - "Excavation for Structures" issued in January 2013 and under the supervision of competent geotechnical personnel. All excavations should comply with all current and applicable local, state, and federal safety codes, regulations and practices, including the Occupational Safety and Health Administration (OSHA). All topsoil should be removed before the start of construction. A drainage ditch which appears to be wetland will cross the proposed rear MSE Wall on the west side of the proposed structure. Soft soils on the bottom of the drainage ditch must be completely removed before backfilling with granular soils. If proposed cut slopes for the structure foundation are to be

exposed for an extended period of time, they must be constructed using a two (2) horizontal to one (1) vertical slope for excavation in cohesive soils. Soil and rock excavations are expected during construction of the project. It is expected that some harder, less weathered bedrock will be present in the pre-bored holes. Therefore special drilling equipment should be required.

All fill material must be approved by a qualified geotechnical engineer prior to placement. The fill materials should be placed in lifts of eight (8) inches in thickness (loose measure) and be compacted to an unyielding condition in accordance with ODOT 203.07 "Compaction and Moisture Requirements" specifications. The top 12 inches of the fill in pavement subgrade areas should be placed in lifts of eight (8) inches in thickness (loose measure) and be compacted to an unyielding condition in accordance with ODOT 204.03 "Compaction of the Subgrade" specifications. All in-place density tests should be performed as per Supplement 1015 "Compaction Testing of Unbound Materials" during earthwork construction. The tests should be performed by a qualified soil technician under the supervision of PGI or other geotechnical-engineering firms and in accordance with the appropriate ASTM procedures.

## 7.0 LIMITATIONS

This report is subject to the following conditions and limitations:

**7.1** The subsurface conditions described are based on an examination of the soil and rock samples at the sampling intervals. Varying soil deposits, including fill material, may exist between the sampling intervals and between the test boring locations. Variation in subsurface conditions from those indicated in this report may become apparent during the earthwork and/or installation of the foundations. Such variations may require changes and/or modifications in our recommendations. Such changes may cause time delays and/or additional costs. Owners must be made aware of these limitations and must incorporate them in the design budget and scheduling of the project.

**7.2** The design of the proposed project does not vary from the technical information provided and specified in this report. All changes in the design must be reviewed by our geotechnical engineers. PGI cannot assume any responsibility for interpretations made by others of the subsurface conditions and their behavior based on this report.

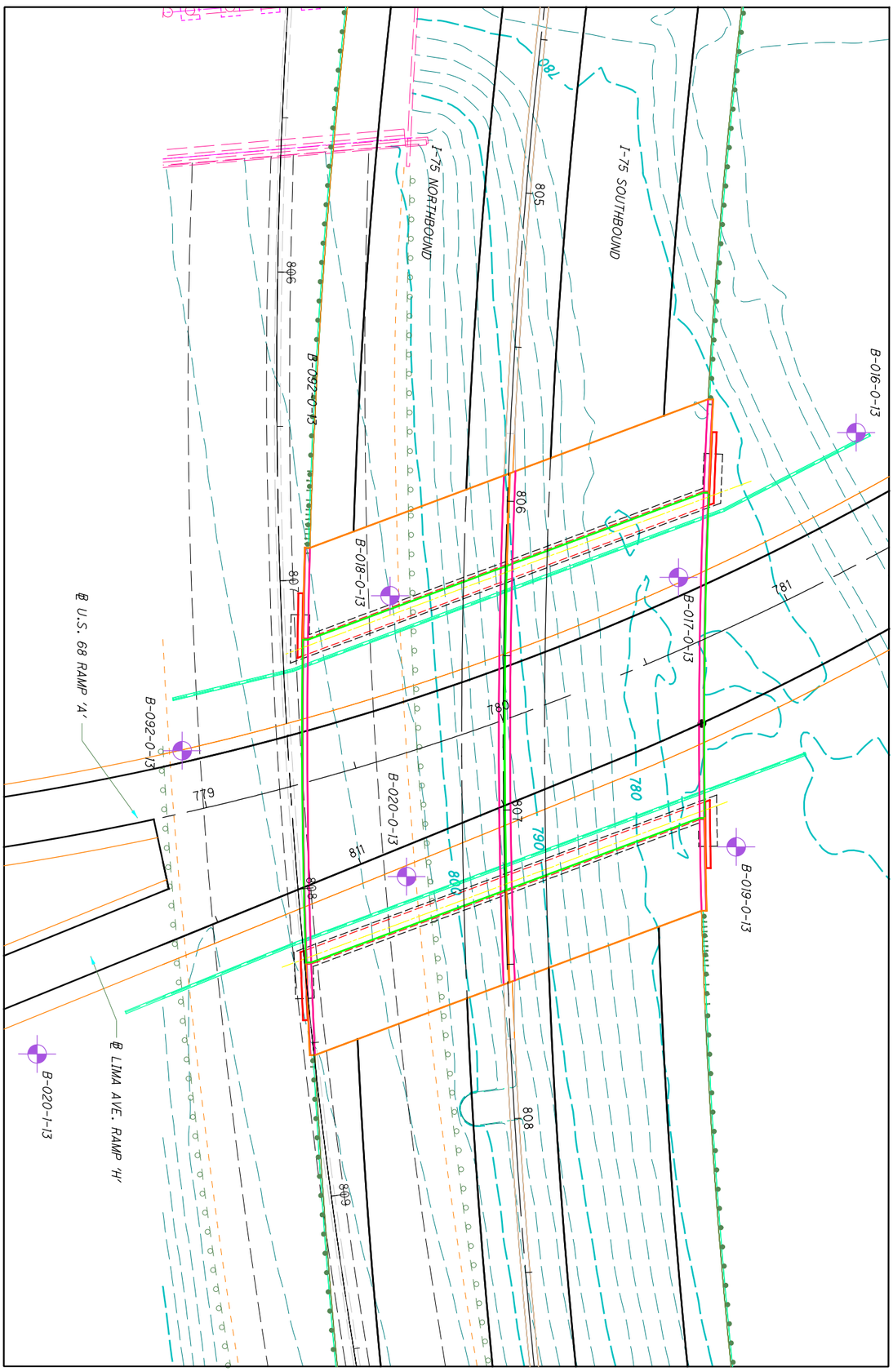
**7.3** All earthwork and foundation construction must be performed under the supervision of a Professional Engineer in accordance with ODOT Construction Specifications.

**7.4** The subsurface exploration for this project is strictly from a geotechnical standpoint. An environmental site assessment was not included in the scope of these geotechnical services.

**7.5** All sheeting, shoring, and bracing of trenches, pits and excavations should be made the responsibility of the contractor and should comply with all current and applicable local, state and federal safety codes, regulations and practices, including the Occupational Safety and Health Administration (OSHA).

# APPENDICES

# APPENDIX A




| | | | | | |
|---|---|---|---|---|---|
| | 1 / 1 | HAN-75-14.39 | BORING LOCATION MAP - BRIDGE NO. HAN-075-1526 L&R<br>I-75 OVER LIMA AVE. RAMP "A" AND RAMP "H" | DRAWN DH<br>CHECKED SM | 20<br>10 40<br>HORIZONTAL SCALE IN FEET |

| | | | |
|---|---|---|---|
| PROJECT: HAN-75-1526 L&R | DRILLING FIRM / OPERATOR: B-M / JOSH DEAN | DRILL RIG: DIEDRICH D-90 ATV | STATION / OFFSET: 781+46, 38 LT |
| TYPE: BRIDGE REPLACEMENT | SAMPLING FIRM / LOGGER: PGI / F.BUSHER | HAMMER: DIEDRICH AUTOMATIC | ALIGNMENT: IR-75 BASELINE |
| PID: 87005 BR ID: HAN-75-1526 | DRILLING METHOD: 3.25" HSA | CALIBRATION DATE: 9/18/12 | ELEVATION: 778.9 (MSL) EOB: 13.0 ft. |
| START: 7/19/13 END: 7/19/13 | SAMPLING METHOD: SPT/NX | ENERGY RATIO (%): 80.2 | LAT / LONG: 41.026882210, 83.674322080 |

EXPLORATION ID B-016-1-13

PAGE 1 OF 1

| MATERIAL DESCRIPTION AND NOTES | ELEV. | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GR | CS | FS | SI | CL | LL | PL | PI | WC | ODOT CLASS (GI) | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 778.9 | | | | | | | | | | | | | | | | | |
| TOPSOIL (8" THICK) | 778.2 | | | | | | | | | | | | | | | | | |
| STIFF, DARK BROWN, **CLAY**, LITTLE SAND, FILL, MODERATELY ORGANIC, MOIST | 775.4 | 1 2 3 | 3 4 6 | 13 | 94 | SS-1 | 3.75 | 0 | 2 | 12 | 38 | 48 | 50 | 25 | 25 | 24 | A-7-6 (16) | |
| STIFF, GRAY AND BROWN, **SILTY CLAY**, LITTLE SAND, TRACE STONE FRAGMENTS AND ROOTS, MOIST | 772.9 | 4 5 | 3 4 5 | 12 | 89 | SS-2 | 3.25 | - | - | - | - | - | - | - | - | 24 | A-6b (V) | |
| HARD, BROWN, **SANDY SILT**, SOME CLAY, LITTLE STONE FRAGMENTS AND ROOTS, DAMP @8.0'; AUGER REFUSAL, BEGAN CORING BEDROCK | 770.9 | 6 7 | 6 11 37 | 64 | 100 | SS-3 | 4.5+ | - | - | - | - | - | - | - | - | 12 | A-4a (V) | |
| | | TR 8 | | | | | | | | | | | | | | | | |
| **DOLOMITE**, LIGHT GRAY, MODERATELY TO SLIGHTLY WEATHERED, STRONG, VERY THIN TO THIN BEDDED, FRACTURED TO MODERATELY FRACTURED, TIGHT APERTURE WIDTH, SLIGHTLY ROUGH. @10.5'; U.C. STRENGTH = 14,460 psi. | 765.9 | 9 10 11 12 EOB 13 | 0 | | 100 | NX-1 | | | | | | | | | | | CORE | |
| | | | 56 | | 98 | NX-2 | | | | | | | | | | | CORE | |

NOTES: GROUNDWATER WAS NOT ENCOUNTERED DURING DRILLING. NO READING WAS TAKEN UPON COMPLETION DUE TO WATER USED DURING ROCK CORING OPERATIONS.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: HOLE WAS BACKFILLED WITH SOIL CUTTINGS

STANDARD ODOT SOIL BORING LOG (8.5 X 11)-OH DOT.GDT-11/4/13 13:39-\\CLEDC01\PUBLIC\PROJECT FILES\13 PROJECTS\G13011G HAN-75\LAB DATA SHEETS\BRIDGES\1526 I75 TUNNEL BR.GPJ

| | | | | | |
|---|---|---|---|---|---|
| PROJECT: HAN-75-1526 L&R | DRILLING FIRM / OPERATOR: B-M / JOSH DEAN | DRILL RIG: DIEDRICH D-90 ATV | STATION / OFFSET: 806+23, 56 LT | EXPLORATION ID B-017-0-13 |
| TYPE: BRIDGE REPLACEMENT | SAMPLING FIRM / LOGGER: PGI / W. NAJJAR | HAMMER: DIEDRICH AUTOMATIC | ALIGNMENT: IR-75 BASELINE | |
| PID: 87005 BR ID: HAN-75-1526 | DRILLING METHOD: 3.25" HSA | CALIBRATION DATE: 9/18/12 | ELEVATION: 780.6 (MSL) EOB: 20.5 ft. | PAGE 1 OF 1 |
| START: 7/25/13 END: 7/25/13 | SAMPLING METHOD: SPT/NX | ENERGY RATIO (%): 80.2 | LAT / LONG: 41.026922720, 83.674058460 | |

| MATERIAL DESCRIPTION AND NOTES | ELEV. | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOPSOIL (8" THICK) | 780.6 / 779.9 | | | | | | | | | | | | | | | | | |
| VERY STIFF, DARK BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE STONE FRAGMENTS, TRACE ROOTS, FILL, DAMP | 777.1 | 1–3 | 3 5 8 | 17 | 78 | SS-1 | 3.50 | - | - | - | - | - | - | - | - | 16 | A-6a (V) | |
| STIFF, BROWN, **SILTY CLAY**, SOME SAND, MOIST | 774.6 | 4–5 | 3 4 4 | 11 | 100 | SS-2 | 2.25 | 0 | 2 | 26 | 30 | 42 | 38 | 19 | 19 | 21 | A-6b (11) | |
| SOFT, BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE STONE FRAGMENTS, MOIST TO WET | 773.4 | 6–7 | 1 1 1 | 3 | 89 | SS-3 | 1.25 | - | - | - | - | - | - | - | - | 31 | A-6a (V) | |
| MEDIUM DENSE TO DENSE, BROWN, **STONE FRAGMENTS WITH SAND**, LITTLE FINES, DAMP TO WET @8.5'; ROCK IN SPOON TIP AND LOW RECOVERY | 771.1 W / TR | 8–9 | 13 37 50/2" | - | 7 | SS-4 | - | - | - | - | - | - | - | - | - | 8 | A-1-b (V) | |
| POSSIBLE DOLOMITE BEDROCK NOTE: AUGERED TO 10.5', BEGAN CORING BEDROCK | 770.1 | 10 | | | | | | | | | | | | | | | | |
| **DOLOMITE**, LIGHT GRAY, MODERATELY WEATHERED, STRONG, VERY THIN TO THIN BEDDED, FRACTURED TO MODERATELY FRACTURED, TIGHT APERTURE WIDTH, SLIGHTLY ROUGH. @16.0'; U.C. STRENGTH = 11,682 psi. | 760.1 EOB | 11–20 | 48 | | 100 | NX-1 | | | | | | | | | | | CORE | |

NOTES: GROUNDWATER WAS ENCOUNTERED AT 9.0' DURING DRILLING AND NO READING WAS TAKEN UPON COMPLETION OF DRILLING DUE TO ROCK CORING OPERATIONS.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: HOLE WAS BACKFILLED WITH 1.5 BAGS SOIL CUTTINGS/BENTONITE PELLETS

STANDARD ODOT SOIL BORING LOG (8.5 X 11)-OH DOT.GDT-11/4/13 13:39-\\CLEDC01\PUBLIC\PROJECT FILES\13 PROJECTS\G13011G HAN-75\LAB DATA SHEETS\BRIDGES\1526 I75 TUNNEL BR.GPJ

| | | | |
|---|---|---|---|
| PROJECT: HAN-75-1526 L&R | DRILLING FIRM / OPERATOR: DLZ / JOHN | DRILL RIG: CME 55 TRUCK | STATION / OFFSET: 806+21, 37 RT |
| TYPE: BRIDGE REPLACEMENT | SAMPLING FIRM / LOGGER: PGI / W. NAJJAR | HAMMER: CME AUTOMATIC | ALIGNMENT: IR-75 BASELINE |
| PID: 87005 BR ID: HAN-75-1526 | DRILLING METHOD: 2.25" SSA | CALIBRATION DATE: 6/13/13 | ELEVATION: 802.2 (MSL) EOB: 44.0 ft. |
| START: 7/9/13 END: 7/10/13 | SAMPLING METHOD: SPT / NQ | ENERGY RATIO (%): 70.2 | LAT / LONG: 41.026817900, 83.673749350 |

EXPLORATION ID B-018-0-13



| MATERIAL DESCRIPTION AND NOTES | ELEV. | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASPHALT PAVEMENT (5.0" THICK) | 802.2 | | | | | | | | | | | | | | | | | |
| CONCRETE PAVEMENT (7.0" THICK) | 801.9 | | | | | | | | | | | | | | | | | |
| DAMP BROWN STONE AND CONCRETE FRAGMENTS WITH SAND (ROADBASE) | 801.0 | | 8 14 6 | 23 | 50 | SS-1 | - | - | - | - | - | - | - | - | - | 12 | A-1-b (V) | |
| VERY STIFF TO STIFF, BROWN AND GRAY TO BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE STONE FRAGMENTS, FILL, DAMP TO MOIST | 799.2 | | 2 8 8 | 19 | 78 | SS-2 | 4.50 | - | - | - | - | - | - | - | - | 17 | A-6a (V) | |
| @6.0'; STIFF, MOIST | | | 3 6 6 | 14 | 33 | SS-3 | 2.50 | - | - | - | - | - | - | - | - | 22 | A-6a (V) | |
| @8.5'; STIFF, BROWN | | | 8 7 6 | 15 | 67 | SS-4 | 3.00 | - | - | - | - | - | - | - | - | 16 | A-6a (V) | |
| VERY STIFF, BROWN, **SANDY SILT**, SOME CLAY, LITTLE STONE FRAGMENTS, FILL, MOIST | 791.2 | | 4 5 9 | 16 | 50 | SS-5 | 4.00 | - | - | - | - | - | - | - | - | 14 | A-4a (V) | |
| VERY STIFF, BROWN AND DARK BROWN, **SILTY CLAY**, LITTLE SAND, TRACE STONE FRAGMENTS, FILL, DAMP | 788.7 | | 4 8 11 | 22 | 78 | SS-6 | 4.5+ | - | - | - | - | - | - | - | - | 19 | A-6b (V) | |
| @16.0'; DARK BROWN | | | 6 9 15 | 28 | 44 | SS-7 | 4.5+ | - | - | - | - | - | - | - | - | 16 | A-6b (V) | |
| @18.5'; BROWN | | | 5 7 10 | 20 | 56 | SS-8 | 4.5+ | - | - | - | - | - | - | - | - | 18 | A-6b (V) | |
| @21.0'; BROWN | | | 4 6 9 | 18 | 56 | SS-9 | 4.50 | - | - | - | - | - | - | - | - | 19 | A-6b (V) | |
| STIFF, BLACK, **SILT AND CLAY**, "AND" SAND, TRACE STONE FRAGMENTS, FILL, SLIGHTLY ORGANIC, MOIST | 778.2 | | 2 3 5 | 9 | 100 | SS-10 | 2.25 | 2 | 3 | 40 | 28 | 27 | 29 | 18 | 11 | 22 | A-6a (4) | |
| BROWN AND GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE STONE FRAGMENTS, MOIST | 775.2 | | 4 5 8 | 15 | 100 | SS-11 | 2.50 | - | - | - | - | - | - | - | - | 19 | A-6a (V) | |

| PID: 87005 | BR ID: HAN-75-1526 | PROJECT: HAN-75-1526 L&R | STATION / OFFSET: 806+21, 37 RT | START: 7/9/13 | END: 7/10/13 | PG 2 OF 2 | B-018-0-13 |
|---|---|---|---|---|---|---|---|

| MATERIAL DESCRIPTION AND NOTES | ELEV. | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BROWN AND GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE STONE FRAGMENTS, MOIST *(continued)* | 772.2 | | | | | | | | | | | | | | | | | |
| | 770.7 | TR | | | | | | | | | | | | | | | | |
| POSSIBLE GRAY DOLOMITE BEDROCK @33.5'; NO SPLIT SPOON RECOVERY | | 31 | | | | | | | | | | | | | | | | |
| @34.0'; AUGER REFUSAL, BEGAN CORING BEDROCK | | 32 | | | | | | | | | | | | | | | | |
| | | 33 | | | | | | | | | | | | | | | | |
| | 768.2 | | 50/3" | - | 0 | SS-12 | - | - | - | - | - | - | - | - | - | - | Rock (V) | |
| **DOLOMITE**, LIGHT GRAY, SLIGHTLY WEATHERED, STRONG, JOINTED, HIGHLY TO MODERATELY FRACTURED, APERTURE WIDTH TIGHT TO NARROW, SLIGHTLY TO VERY ROUGH; RQD 70%, REC 78%. | | 34 | | | | | | | | | | | | | | | | |
| @36.5'; U.C. STRENGTH = 13,068 psi. | | 35 | | | | | | | | | | | | | | | | |
| | | 36 | | | | | | | | | | | | | | | | |
| | | 37 | | | | | | | | | | | | | | | | |
| | | 38 | | | | | | | | | | | | | | | | |
| | | 39 | 70 | | 78 | NQ-1 | | | | | | | | | | | CORE | |
| | | 40 | | | | | | | | | | | | | | | | |
| | | 41 | | | | | | | | | | | | | | | | |
| | | 42 | | | | | | | | | | | | | | | | |
| | | 43 | | | | | | | | | | | | | | | | |
| | 758.2 | EOB 44 | | | | | | | | | | | | | | | | |

NOTES: GROUNDWATER WAS NOT ENCOUNTERED DURING DRILLING. NO READING WAS TAKEN UPON COMPLETION DUE TO WATER USED DURING ROCK CORING OPERATIONS.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: HOLE WAS BACKFILLED WITH SOIL CUTTINGS

| | | | |
|---|---|---|---|
| PROJECT: HAN-75-1526 L&R | DRILLING FIRM / OPERATOR: B-M / JOSH DEAN | DRILL RIG: DIEDRICH D-90 ATV | STATION / OFFSET: 807+13, 75 LT |
| TYPE: BRIDGE REPLACEMENT | SAMPLING FIRM / LOGGER: PGI / W. NAJJAR | HAMMER: DIEDRICH AUTOMATIC | ALIGNMENT: IR-75 BASELINE |
| PID: 87005 BR ID: HAN-75-1526 | DRILLING METHOD: 3.25" HSA | CALIBRATION DATE: 9/18/12 | ELEVATION: 779.5 (MSL) EOB: 20.5 ft. |
| START: 7/25/13 END: 7/25/13 | SAMPLING METHOD: SPT/NX | ENERGY RATIO (%): 80.2 | LAT / LONG: 41.027158610, 83.673971270 |

EXPLORATION ID B-019-0-13

PAGE 1 OF 1

| MATERIAL DESCRIPTION AND NOTES | ELEV. | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GR | CS | FS | SI | CL | LL | PL | PI | WC | ODOT CLASS (GI) | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 779.5 | | | | | | | | | | | | | | | | | |
| TOPSOIL (8" THICK) | 778.8 | | | | | | | | | | | | | | | | | |
| STIFF, DARK BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE STONE FRAGMENTS, FILL, DAMP | 776.0 | 1 2 3 | 3 3 8 | 15 | 100 | SS-1 | 4.5+ | - | - | - | - | - | - | - | - | 18 | A-6a (V) | |
| VERY STIFF, MOTTLED BROWN AND GRAY, **SILTY CLAY**, SOME SAND, DAMP | 773.5 | 4 5 6 7 | 4 5 7 | 16 | 100 | SS-2 | 3.50 | 0 | 2 | 21 | 33 | 44 | 38 | 20 | 18 | 20 | A-6b (11) | |
| LOOSE, BROWN, **NON-PLASTIC SANDY SILT**, LITTLE STONE FRAGMENTS, DAMP | 771.0 | 8 | 1 2 3 | 7 | 17 | SS-3 | -- | - | - | - | - | - | - | - | - | 9 | A-4a (V) | |
| VERY DENSE, BROWN AND GRAY, **NON-PLASTIC SANDY SILT**, SOME STONE FRAGMENTS, DAMP @10.0'; DRILLING WAS HARDER | 769.5 | 9 10 TR | 14 17 23 | 53 | 100 | SS-4 | -- | - | - | - | - | - | - | - | - | 8 | A-4a (V) | |
| POSSIBLE DOLOMITE BEDROCK NOTE: AUGERED TO 10.5' AND BEGAN CORING BEDROCK | 769.0 | 11 | | | | | | | | | | | | | | | | |
| **DOLOMITE**, GRAY, SEVERELY TO MODERATELY WEATHERED, VERY STRONG, THIN TO MEDIUM BEDDED, JOINTED, HIGHLY TO MODERATELY FRACTURED, APERTURE WIDTH TIGHT TO NARROW, SLIGHTLY TO VERY ROUGH. @14.5'; U.C. STRENGTH = 17,035 psi. | 759.0 | 12 13 14 15 16 17 18 19 20 EOB | 45 | | 100 | NX-1 | | | | | | | | | | | CORE | |

NOTES: GROUNDWATER WAS NOT ENCOUNTERED DURING DRILLING. NO READING WAS TAKEN UPON COMPLETION DUE TO WATER USED DURING ROCK CORING OPERATIONS.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: HOLE WAS BACKFILLED WITH SOIL CUTTINGS

STANDARD ODOT SOIL BORING LOG (8.5 X 11)-OH DOT.GDT-11/4/13 13:39-\\CLEDC01\PUBLIC\PROJECT FILES\13 PROJECTS\G13011G HAN-75\LAB DATA SHEETS\BRIDGES\1526 I75 TUNNEL BR.GPJ

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| PROJECT: HAN-75-1526 L&R | DRILLING FIRM / OPERATOR: DLZ / JOHN | DRILL RIG: CME 55 TRUCK | STATION / OFFSET: 807+21, 32 RT | EXPLORATION ID B-020-0-13 |
| TYPE: BRIDGE REPLACEMENT | SAMPLING FIRM / LOGGER: PGI / W. NAJJAR | HAMMER: CME AUTOMATIC | ALIGNMENT: IR-75 BASELINE | |
| PID: 87005 BR ID: HAN-75-1526 | DRILLING METHOD: 2.25" SSA | CALIBRATION DATE: 6/13/13 | ELEVATION: 803.1 (MSL) EOB: 45.0 ft. | PAGE 1 OF 2 |
| START: 7/8/13 END: 7/9/13 | SAMPLING METHOD: SPT / NQ | ENERGY RATIO (%): 70.2 | LAT / LONG: 41.027045710, 83.673612780 | |

| MATERIAL DESCRIPTION AND NOTES | ELEV. | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASPHALT PAVEMENT (5.0" THICK) | 803.1 | | | | | | | | | | | | | | | | | |
| CONCRETE PAVEMENT (7.0" THICK) | 802.7 | | | | | | | | | | | | | | | | | |
| BROWN STONE AND CONCRETE FRAGMENTS WITH SAND AND SILT (ROADBASE) | 802.1 | | | | | | | | | | | | | | | | | |
| VERY STIFF TO HARD, BROWN AND GRAY TO BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE TO SOME STONE FRAGMENTS, FILL, DAMP | 801.1 | 1 | 6 9 13 | 26 | 67 | SS-12 | - | - | - | - | - | - | - | - | - | 22 | A-6a (V) | |
| | | 2 | | | | | | | | | | | | | | | | |
| | | 3 | | | | | | | | | | | | | | | | |
| | | 4 | 2 5 10 | 18 | 89 | SS-3 | 2.50 | - | - | - | - | - | - | - | - | 15 | A-6a (V) | |
| | | 5 | | | | | | | | | | | | | | | | |
| @6.0'; HARD | | 6 | | | | | | | | | | | | | | | | |
| | | 7 | 8 14 18 | 37 | 78 | SS-4 | 4.5+ | - | - | - | - | - | - | - | - | 12 | A-6a (V) | |
| | | 8 | | | | | | | | | | | | | | | | |
| @8.5'; HARD, BROWN, SOME STONE FRAGMENTS | | 9 | 10 21 15 | 42 | 78 | SS-5 | 2.50 | - | - | - | - | - | - | - | - | 9 | A-6a (V) | |
| | | 10 | | | | | | | | | | | | | | | | |
| @11.0'; STIFF, BROWN | | 11 | | | | | | | | | | | | | | | | |
| | | 12 | 4 5 7 | 14 | 94 | SS-6 | 4.5+ | - | - | - | - | - | - | - | - | 17 | A-6a (V) | |
| | 789.6 | 13 | | | | | | | | | | | | | | | | |
| VERY STIFF, BROWN AND BLACK TO BROWN, **SILTY CLAY**, TRACE TO LITTLE SAND, TRACE STONE FRAGMENTS, FILL, MOIST | | 14 | 5 9 13 | 26 | 100 | SS-7 | 4.5+ | - | - | - | - | - | - | - | - | 20 | A-6b (V) | |
| @14.0'; BLACK | | 15 | | | | | | | | | | | | | | | | |
| @16.0'; DARK BROWN, LITTLE SAND | | 16 | | | | | | | | | | | | | | | | |
| | | 17 | 4 6 12 | 21 | 89 | SS-8 | 3.00 | - | - | - | - | - | - | - | - | 22 | A-6b (V) | |
| | | 18 | | | | | | | | | | | | | | | | |
| @18.5'; BROWN, LITTLE SAND | | 19 | 4 6 8 | 16 | 89 | SS-9 | 4.50 | - | - | - | - | - | - | - | - | 21 | A-6b (V) | |
| | 782.1 | 20 | | | | | | | | | | | | | | | | |
| VERY STIFF, MOTTLED BROWN AND GRAY, **SILTY CLAY**, LITTLE SAND, TRACE STONE FRAGMENTS, MOIST | | 21 | | | | | | | | | | | | | | | | |
| | | 22 | 6 10 11 | 25 | 100 | SS-10 | 3.50 | - | - | - | - | - | - | - | - | 20 | A-6b (V) | |
| | 780.1 | 23 | | | | | | | | | | | | | | | | |
| MEDIUM DENSE, BROWN AND GRAY TO BROWN, **NON-PLASTIC SILT**, LITTLE SAND, MOIST | | 24 | 8 9 14 | 27 | 100 | SS-11 | - | 0 | 2 | 11 | 61 | 26 | 24 | 19 | 5 | 13 | A-4b (8) | |
| | | 25 | | | | | | | | | | | | | | | | |
| | | 26 | | | | | | | | | | | | | | | | |
| | | 27 | | | | | | | | | | | | | | | | |
| | | 28 | | | | | | | | | | | | | | | | |
| @28.5'; BROWN, TRACE SAND | | 29 | 5 5 9 | 16 | 100 | SS-12 | - | - | - | - | - | - | - | - | - | 20 | A-4b (V) | |

| PID: 87005 | BR ID: HAN-75-1526 | PROJECT: HAN-75-1526 L&R | STATION / OFFSET: 807+21, 32 RT | START: 7/8/13 | END: 7/9/13 | PG 2 OF 2 | B-020-0-13 |
|---|---|---|---|---|---|---|---|

| MATERIAL DESCRIPTION AND NOTES | ELEV. | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MEDIUM DENSE, BROWN AND GRAY TO BROWN, **NON-PLASTIC SILT**, LITTLE SAND, MOIST *(continued)* | 773.1 | 31 32 33 | | | | | | | | | | | | | | | | |
| | 769.6 | TR | | | | | | | | | | | | | | | | |
| GRAY DOLOMITE BEDROCK<br>NOTE: AUGERED TO 35.0', BEGAN CORING BEDROCK | 768.1 | 34 | 50/3" | - | 100 | SS-13 | - | - | - | - | - | - | - | - | - | 13 | Rock (V) | |
| **DOLOMITE**, LIGHT GRAY, SLIGHTLY WEATHERED, STRONG, JOINTED, HIGHLY TO MODERATELY FRACTURED, APERTURE WIDTH TIGHT TO NARROW, SLIGHTLY TO VERY ROUGH; RQD 60%, REC 92%. | 763.1 | 35 36 37 38 39 | 60 | | 91 | NQ-1 | | | | | | | | | | | CORE | |
| **DOLOMITE**, LIGHT GRAY, SLIGHTLY WEATHERED, VERY STRONG, JOINTED, HIGHLY TO MODERATELY FRACTURED, APERTURE WIDTH TIGHT TO NARROW, SLIGHTLY TO VERY ROUGH; RQD 85%, REC 100%.<br>@40.5'; U.C. STRENGTH = 20,551 psi. | 758.1 | 40 41 42 43 44 45<br>EOB | 85 | | 100 | NQ-2 | | | | | | | | | | | CORE | |

NOTES: GROUNDWATER WAS NOT ENCOUNTERED DURING DRILLING. NO READING WAS TAKEN UPON COMPLETION DUE TO WATER USED DURING ROCK CORING OPERATIONS.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: HOLE WAS BACKFILLED WITH SOIL CUTTINGS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| PROJECT: HAN-75-1526 L&R | DRILLING FIRM / OPERATOR: B-M / JOSH DEAN | DRILL RIG: DIEDRICH D-90 ATV | STATION / OFFSET: 807+72, 153 RT | EXPLORATION ID B-020-1-13 |
| TYPE: BRIDGE REPLACEMENT | SAMPLING FIRM / LOGGER: PGI / W. NAJJAR | HAMMER: DIEDRICH AUTOMATIC | ALIGNMENT: IR-75 BASELINE | |
| PID: 87005 BR ID: HAN-75-1526 | DRILLING METHOD: 3.25" HSA | CALIBRATION DATE: 9/18/12 | ELEVATION: 784.5 (MSL) EOB: 18.5 ft. | PAGE 1 OF 1 |
| START: 7/29/13 END: 7/29/13 | SAMPLING METHOD: SPT/NX | ENERGY RATIO (%): 80.2 | LAT / LONG: 41.027032460, 83.673132280 | |

| MATERIAL DESCRIPTION AND NOTES | ELEV. | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOPSOIL (8" THICK) | 784.5 | | | | | | | | | | | | | | | | | |
| MEDIUM STIFF TO VERY STIFF, BROWN, **SILTY CLAY**, LITTLE SAND, TRACE STONE FRAGMENTS, MOIST TO DAMP | 783.9 | | 2 2 4 | 8 | 83 | SS-1 | 4.5+ | 2 | 4 | 16 | 35 | 43 | 39 | 19 | 20 | 20 | A-6b (12) | |
| @3.5'; VERY STIFF, DAMP | | | 7 8 12 | 27 | 89 | SS-2 | 4.5+ | - | - | - | - | - | - | - | - | 18 | A-6b (V) | |
| STIFF TO MEDIUM STIFF, BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE STONE FRAGMENTS, MOIST TO DAMP | 778.5 | | 5 6 5 | 15 | 78 | SS-3 | 2.25 | - | - | - | - | - | - | - | - | 19 | A-6a (V) | |
| @8.5'; MEDIUM STIFF, DAMP | | | 2 2 4 | 8 | 33 | SS-4 | 3.50 | - | - | - | - | - | - | - | - | 18 | A-6a (V) | |
| | 772.6 | | 3 4 5 | 12 | 50 | SS-5A&B | 3.00 | - | - | - | - | - | - | - | - | 18 | A-6a (V) | |
| MEDIUM DENSE, BROWN, **NON-PLASTIC SANDY SILT**, WET | 772.1 | TR | | | | | -- | - | - | - | - | - | - | - | - | 29 | A-4a (V) | |
| POSSIBLE DOLOMITE BEDROCK @13.5' AUGER RESUSAL, BEGAN CORING BEDROCK | 771.0 | | | | | | | | | | | | | | | | | |
| **DOLOMITE**, LIGHT GRAY, SLIGHTLY WEATHERED, VERY STRONG, JOINTED, FRACTURED TO MODERATELY FRACTURED, APERTURE WIDTH TIGHT TO NARROW, SLIGHTLY TO VERY ROUGH. @14.0'; U.C. STRENGTH = 25,119 psi. | | | 28 | | 100 | NX-1 | | | | | | | | | | | CORE | |
| | 766.0 | EOB | | | | | | | | | | | | | | | | |

NOTES: GROUNDWATER WAS NOT ENCOUNTERED DURING DRILLING. NO READING WAS TAKEN UPON COMPLETION DUE TO WATER USED DURING ROCK CORING OPERATIONS.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: HOLE WAS BACKFILLED WITH SOIL CUTTINGS

STANDARD ODOT SOIL BORING LOG (8.5 X 11)-OH DOT.GDT-11/4/13 13:39-\\CLEDC01\PUBLIC\PROJECT FILES\13 PROJECTS\G13011G HAN-75\LAB DATA SHEETS\BRIDGES\1526 I75 TUNNEL BR.GPJ

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| PROJECT: HAN-75-14.39 | DRILLING FIRM / OPERATOR: DLZ / ALAN | DRILL RIG: CME 75 TRUCK | STATION / OFFSET: 778+96, 20 LT | EXPLORATION ID B-092-0-13 |
| TYPE: RAMP RE-ALIGNMENT | SAMPLING FIRM / LOGGER: PGI / W. NAJJAR | HAMMER: CME AUTOMATIC | ALIGNMENT: US 68 RAMP A BASELINE | |
| PID: 87005 BR ID: | DRILLING METHOD: 3.25" HSA | CALIBRATION DATE: 1/6/12 | ELEVATION: 807.6 (MSL) EOB: 36.0 ft. | PAGE 1 OF 2 |
| START: 8/26/13 END: 8/26/13 | SAMPLING METHOD: SPT | ENERGY RATIO (%): 77 | LAT / LONG: 41.026853920, 83.673448490 | |

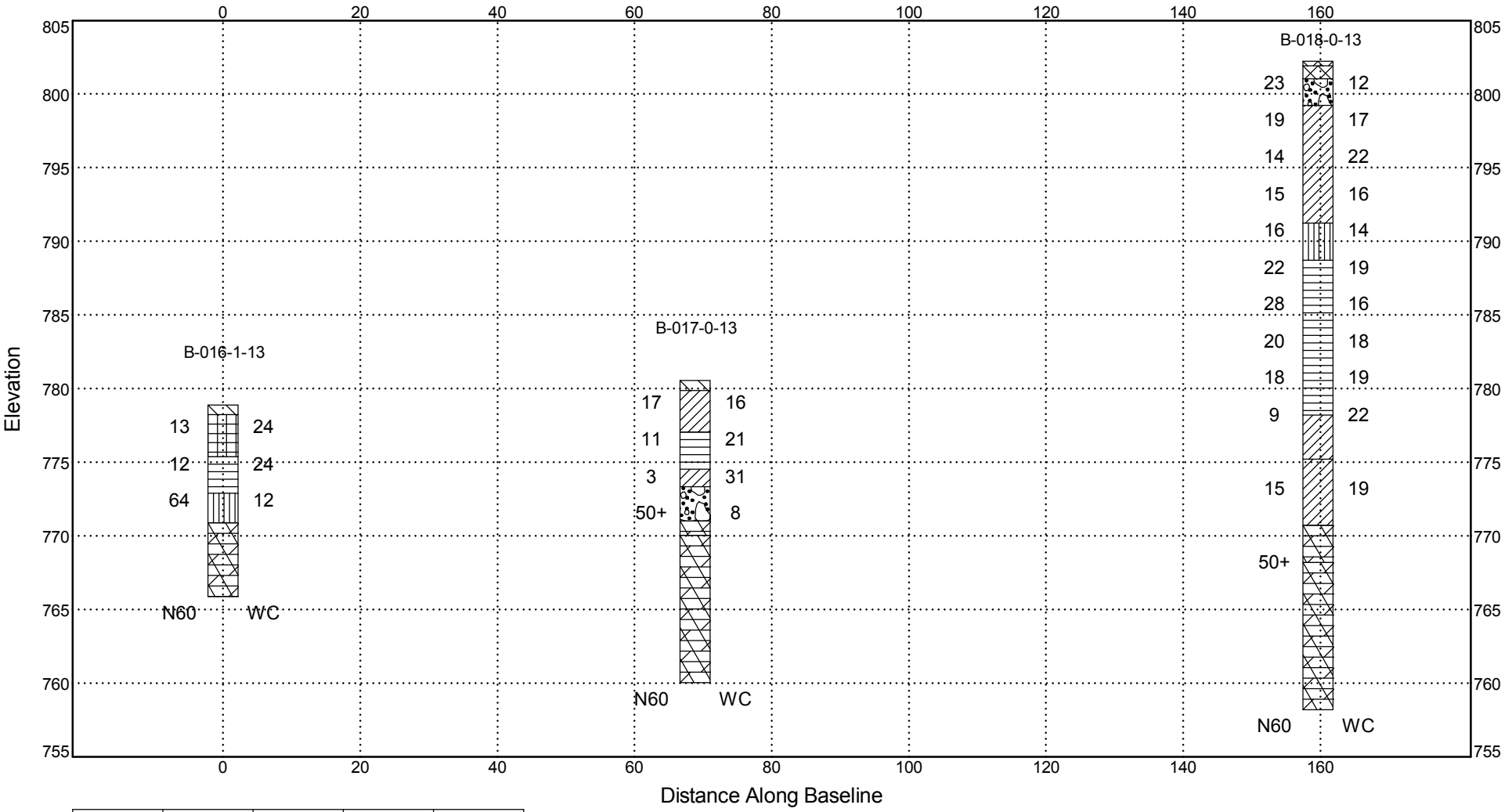
| MATERIAL DESCRIPTION AND NOTES | ELEV. | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ASPHALT PAVEMENT (5" THICK) | 807.2 | | | | | | | | | | | | | | | | | |
| CONCRETE PAVEMENT (7.4" THICK) | 806.6 | | | | | | | | | | | | | | | | | |
| BROWN STONE FRAGMENTS WITH SAND, LITTLE FINES (12" THICK ROADBASE) | 805.6 | | | | | | | | | | | | | | | | | |
| HARD, BROWN, **SANDY SILT**, SOME CLAY, TRACE STONE FRAGMENTS, FILL, DAMP | 804.1 | | 23 16 10 | 33 | 83 | SS-1 | 4.5+ | - | - | - | - | - | - | - | - | 12 | A-4a (V) | |
| VERY STIFF TO STIFF, BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE STONE FRAGMENTS, FILL, MOIST | | | 5 5 7 | 15 | 67 | SS-2 | 3.50 | - | - | - | - | - | - | - | - | 18 | A-6a (V) | |
| @6.0'; STIFF | 799.1 | | 4 3 6 | 12 | 78 | SS-3 | 3.50 | - | - | - | - | - | - | - | - | 16 | A-6a (V) | |
| VERY STIFF, BROWN AND GRAY TO GRAY, **SANDY SILT**, SOME CLAY, LITTLE STONE FRAGMENTS, FILL, DAMP | | | 4 5 8 | 17 | 83 | SS-4 | 4.5+ | - | - | - | - | - | - | - | - | 13 | A-4a (V) | |
| | | | 4 6 7 | 17 | 89 | SS-5 | 4.5+ | - | - | - | - | - | - | - | - | 14 | A-4a (V) | |
| @13.5'; GRAY | 791.6 | | 5 5 8 | 17 | 94 | SS-6 | 4.5+ | - | - | - | - | - | - | - | - | 14 | A-4a (V) | |
| VERY STIFF, GREENISH GRAY TO BROWN, **SILTY CLAY**, TRACE TO LITTLE SAND, TRACE STONE FRAGMENTS, FILL, MOIST TO DAMP | | | 4 5 9 | 18 | 61 | SS-7 | 3.00 | - | - | - | - | - | - | - | - | 21 | A-6b (V) | |
| @18.5'; DAMP | | | 4 6 9 | 19 | 50 | SS-8 | - | - | - | - | - | - | - | - | - | 18 | A-6b (V) | |

| PID: 87005 | BR ID: | PROJECT: HAN-75-14.39 | STATION / OFFSET: 778+96, 20 LT | START: 8/26/13 | END: 8/26/13 | PG 2 OF 2 | B-092-0-13 |
|---|---|---|---|---|---|---|---|

| MATERIAL DESCRIPTION AND NOTES | ELEV. | DEPTHS | SPT/ RQD | $N_{60}$ | REC (%) | SAMPLE ID | HP (tsf) | GRADATION (%) GR | CS | FS | SI | CL | ATTERBERG LL | PL | PI | WC | ODOT CLASS (GI) | BACK FILL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VERY STIFF, GREENISH GRAY TO BROWN, **SILTY CLAY**, TRACE TO LITTLE SAND, TRACE STONE FRAGMENTS, FILL, MOIST TO DAMP *(continued)* | 787.6 | | | | | | | | | | | | | | | | | |
| DAMP @21'; PUSHED SHELBY TUBE | | 21 | | | | | | | | | | | | | | | | |
| | | 22 | | | 89 | ST-9 | - | - | - | - | - | - | - | - | - | - | A-6b (V) | |
| | | 23 | | | | | | | | | | | | | | | | |
| @23.5'; BROWN, LITTLE SAND, DAMP | | 24 | 6 9 10 | 24 | 89 | SS-10 | 4.50 | - | - | - | - | - | - | - | - | 17 | A-6b (V) | |
| | | 25 | | | | | | | | | | | | | | | | |
| @26.0'; BROWN, LITTLE SAND, DAMP | | 26 | 4 6 7 | 17 | 94 | SS-11 | 4.00 | - | - | - | - | - | - | - | - | 19 | A-6b (V) | |
| | 779.1 | 27 | | | | | | | | | | | | | | | | |
| STIFF, DARK BROWN, **SANDY SILT**, SOME CLAY, TRACE STONE FRAGMENTS, FILL, MOIST | | 28 | | | | | | | | | | | | | | | | |
| | | 29 | 3 5 5 | 13 | 100 | SS-12 | 3.00 | 1 | 4 | 41 | 30 | 24 | 30 | 22 | 8 | 21 | A-4a (4) | |
| | 776.6 | 30 | | | | | | | | | | | | | | | | |
| STIFF TO VERY STIFF, GREENISH BROWN, **SILTY CLAY**, SOME SAND, TRACE STONE FRAGMENTS, MOIST | | 31 | 3 5 5 | 13 | 100 | SS-13 | 2.50 | - | - | - | - | - | - | - | - | 18 | A-6b (V) | |
| | | 32 | | | | | | | | | | | | | | | | |
| | | 33 | | | | | | | | | | | | | | | | |
| | | 34 | 4 5 9 | 18 | 94 | SS-14 | 2.25 | 2 | 6 | 17 | 37 | 38 | 33 | 16 | 17 | 24 | A-6b (11) | |
| VERY STIFF @36'; SPLIT SPOON AND AUGER REFUSAL AND POSSIBLE DOLOMITE BEDROCK | | 35 | | | | | | | | | | | | | | | | |
| | 771.6 | EOB 36 | 50/0" | - | | SS-15 | - | - | - | - | - | - | - | - | - | - | Rock (V) | |

NOTES: GROUNDWATER WAS NOT ENCOUNTERED DURING DRILLING OR UPON COMPLETION OF DRILLING OPERATIONS.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: HOLE WAS BACKFILLED WITH SOIL CUTTINGS




| Borehole | North | East | Elev. | Depth |
|---|---|---|---|---|
| B-016-1-13 | 497739 | 1644509 | 778.9 | 13.0 |
| B-017-0-13 | 497753 | 1644582 | 780.6 | 20.5 |
| B-018-0-13 | 497713 | 1644667 | 802.2 | 44.0 |

DISTANCES:

| | |
|---|---|
| Beginning | 0 |
| Ending | 160 |
| VIEWING ANGLES (degrees): | |
| Horizontal | 0.0 |
| Vertical | 0.0 |

| Position | North | East |
|---|---|---|
| Left, Front | 497750 | 1644511 |
| Right, Front | 497719 | 1644668 |
| Left, Back | 497750 | 1644511 |
| Right, Back | 497719 | 1644668 |

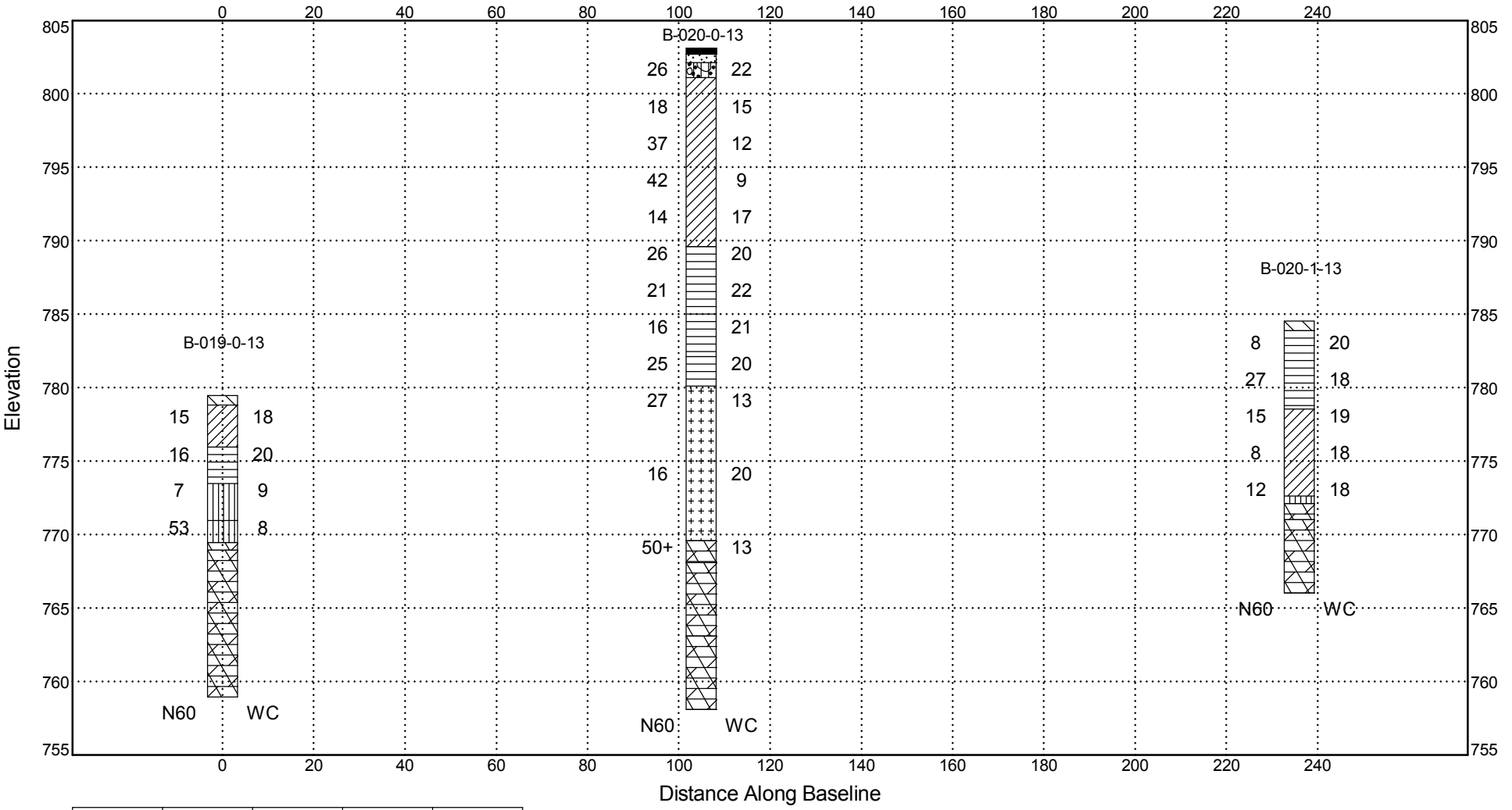
SOIL BORINGS PROFILE
REAR ABUTMENT

HAN-75-14.39 - BRIDGE NO. HAN-75-1526

FINDLAY, HANCOCK COUNTY, OHIO

| PROJECT # | DATE | PLATE |
|---|---|---|
| 87005 | Nov 13 | 1 |

PROFILE ODOT-PRIMENG.GDT-11/4/13 14:33-M:\PROJECT FILES\13 PROJECTS\G13011G HAN-75\LAB DATA SHEETS\BRIDGES\1526 I75 TUNNEL BR.GPJ




| Borehole | North | East | Elev. | Depth |
|---|---|---|---|---|
| B-019-0-13 | 497838 | 1644607 | 779.5 | 20.5 |
| B-020-0-13 | 497796 | 1644705 | 803.1 | 45.0 |
| B-020-1-13 | 497789 | 1644838 | 784.5 | 18.5 |

DISTANCES:
Beginning 0
Ending 240
VIEWING ANGLES (degrees):
Horizontal 0.0
Vertical 0.0

| Position | North | East |
|---|---|---|
| Left, Front | 497830 | 1644605 |
| Right, Front | 497783 | 1644841 |
| Left, Back | 497830 | 1644605 |
| Right, Back | 497783 | 1644841 |

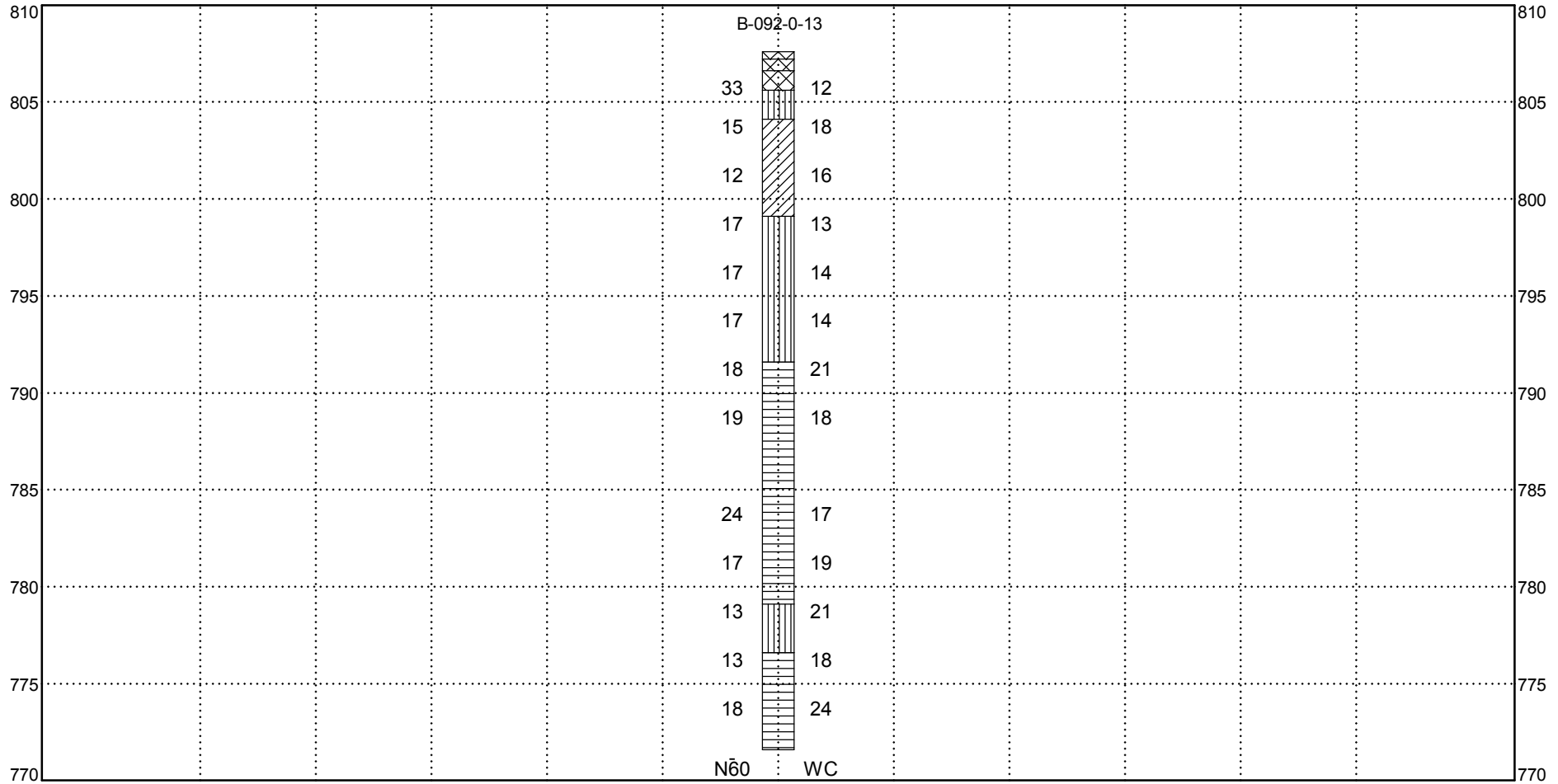
SOIL BORINGS PROFILE
FORWARD ABUTMENT

HAN-75-14.39 - BRIDGE NO. HAN-75-1526

FINDLAY, HANCOCK COUNTY, OHIO

| PROJECT # | DATE | PLATE |
|---|---|---|
| 87005 | Nov 13 | 1 |

PROFILE ODOT-PRIMENG.GDT-11/4/13 14:42-M:\PROJECT FILES\13 PROJECTS\G13011G HAN-75\LAB DATA SHEETS\BRIDGES\1526 I75 TUNNEL BR.GPJ




| Borehole | North | East | Elev. | Depth |
|---|---|---|---|---|
| B-092-0-13 | 497725 | 1644750 | 807.6 | 36.0 |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

DISTANCES:

| | |
|---|---|
| Beginning | 0 |
| Ending | 2 |

VIEWING ANGLES (degrees):

| | |
|---|---|
| Horizontal | 0.0 |
| Vertical | 0.0 |

| Position | North | East |
|---|---|---|
| Left, Front | | |
| Right, Front | | |
| Left, Back | | |
| Right, Back | | |

SOIL BORINGS PROFILE
REAR ABUTMENT

HAN-75-14.39 - BRIDGE NO. HAN-75-1526

FINDLAY, HANCOCK COUNTY, OHIO

| PROJECT # | DATE | PLATE |
|---|---|---|
| 87005 | Nov 13 | 1 |

PROFILE ODOT-PRIMENG.GDT-11/4/13 13:55-M:\PROJECT FILES\13 PROJECTS\G13011G HAN-75\LAB DATA SHEETS\HAN-75 RAMPS.GPJ

# APPENDIX B

| Boring Number | Sample Number | Depth (ft) | Water Content % | Liquid Limit % | Plastic Limit % | Plast. Index | Organic Content % | Agg. % | Coarse Sand % | Fine Sand % | Silt % | Silt&Clay Comb. % | Clay % | Soil Description | Class. Symbol |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B-016-1-13 | SS-1 | 1.0 | 24 | 50 | 25 | 25 | 4.7 | 0 | 2 | 12 | 38 | 86 | 48 | DARK BROWN CLAY, LITTLE SAND, MODERATELY ORGANIC (FILL) | A-7-6 (16) |
| B-016-1-13 | SS-2 | 3.5 | 24 | | | | | | | | | | | GRAY AND BROWN SILTY CLAY, LITTLE SAND, TRACE STONE FRAGS & ROOTS | A-6b (V) |
| B-016-1-13 | SS-3 | 6.0 | 12 | | | | | | | | | | | BROWN SANDY SILT, SOME CLAY, LITTLE ROCK FRAGS & ROOTS | A-4a (V) |
| B-017-0-13 | SS-1 | 1.0 | 16 | | | | | | | | | | | DARK BROWN SILT AND CLAY, LITTLE SAND, TRACE STONE FRAGS & ROOTS (FILL) | A-6a (V) |
| B-017-0-13 | SS-2 | 3.5 | 21 | 38 | 19 | 19 | | 0 | 3 | 26 | 30 | 72 | 42 | BROWN SILTY CLAY, SOME SAND | A-6b (11) |
| B-017-0-13 | SS-3 | 6.0 | 31 | | | | | | | | | | | BROWN SILT AND CLAY, LITTLE SAND, TRACE STONE FRAGMENTS | A-6a (V) |
| B-017-0-13 | SS-4 | 8.5 | 8 | | | | | | | | | | | BROWN STONE FRAGMENTS WITH SAND, LITTLE FINES | A-1-b (V) |
| B-018-0-13 | SS-1 | 1.0 | 12 | | | | | | | | | | | BROWN STONE AND CONCRETE FRAGMENTS WITH SAND (BASE) | A-1-b (V) |
| B-018-0-13 | SS-2 | 3.5 | 17 | | | | | | | | | | | BROWN AND GRAY SILT AND CLAY, LITTLE SAND, TRACE STONE FRAGS (FILL) | A-6a (V) |
| B-018-0-13 | SS-3 | 6.0 | 22 | | | | | | | | | | | BROWN AND GRAY SILT AND CLAY, LITTLE SAND, TRACE STONE FRAGS (FILL) | A-6a (V) |
| B-018-0-13 | SS-4 | 8.5 | 16 | | | | | | | | | | | BROWN SILT AND CLAY, LITTLE SAND, TRACE STONE FRAGMENTS (FILL) | A-6a (V) |
| B-018-0-13 | SS-5 | 11.0 | 14 | | | | | | | | | | | BROWN SANDY SILT, SOME CLAY, LITTLE STONE FRAGMENTS (FILL) | A-4a (V) |
| B-018-0-13 | SS-6 | 13.5 | 19 | | | | | | | | | | | BROWN & DARK BROWN SILTY CLAY, LITTLE SAND, TRACE STONE FRAGMENTS (FILL) | A-6b (V) |
| B-018-0-13 | SS-7 | 16.0 | 16 | | | | | | | | | | | DARK BROWN SILTY CLAY, LITTLE SAND, TRACE STONE FRAGMENTS (FILL) | A-6b (V) |
| B-018-0-13 | SS-8 | 18.5 | 18 | | | | | | | | | | | BROWN SILTY CLAY, LITTLE SAND, TRACE STONE FRAGMENTS (FILL) | A-6b (V) |
| B-018-0-13 | SS-9 | 21.0 | 19 | | | | | | | | | | | BROWN SILTY CLAY, LITTLE SAND, TRACE STONE FRAGMENTS (FILL) | A-6b (V) |
| B-018-0-13 | SS-10 | 23.5 | 22 | 29 | 18 | 11 | 3.6 | 2 | 3 | 40 | 28 | 55 | 27 | BLACK SILT AND CLAY, "AND" SAND, SLIGHTLY ORGANIC (FILL) | A-6a (4) |
| B-018-0-13 | SS-11 | 28.5 | 19 | | | | | | | | | | | BROWN AND GRAY SILT AND CLAY, LITTLE SAND, TRACE STONE FRAGMENTS | A-6a (V) |
| B-019-0-13 | SS-1 | 1.0 | 18 | | | | | | | | | | | DARK BROWN SILT AND CLAY, LITTLE SAND, TRACE STONE FRAGMENTS (FILL) | A-6a (V) |
| B-019-0-13 | SS-2 | 3.5 | 20 | 38 | 20 | 18 | | 0 | 3 | 21 | 33 | 77 | 44 | MOTTLED BROWN AND GRAY SILTY CLAY, SOME SAND | A-6b (11) |
| B-019-0-13 | SS-3 | 6.0 | 9 | | | | | | | | | | | BROWN NON-PLASTIC SANDY SILT, LITTLE STONE FRAGMENTS | A-4a (V) |
| B-019-0-13 | SS-4 | 8.5 | 8 | | | | | | | | | | | BROWN AND GRAY NON-PLASTIC SANDY SILT, SOME STONE FRAGMENTS | A-4a (V) |
| B-020-0-13 | SS-1 | 1.0 | 22 | | | | | | | | | | | BROWN STONE AND CONCRETE FRAGS WITH SAND AND SILT (BASE) | A-6a (V) |
| B-020-0-13 | SS-2 | 3.5 | 15 | | | | | | | | | | | BROWN AND GRAY SILT AND CLAY, LITTLE SAND, TRACE STONE FRAGMENTS (FILL) | A-6a (V) |
| B-020-0-13 | SS-3 | 6.0 | 12 | | | | | | | | | | | BROWN AND GRAY SILT AND CLAY, LITTLE SAND, TRACE STONE FRAGMENTS (FILL) | A-6a (V) |
| B-020-0-13 | SS-4 | 8.5 | 9 | | | | | | | | | | | BROWN SILT AND CLAY, SOME STONE FRAGMENTS, LITTLE SAND (FILL) | A-6a (V) |
| B-020-0-13 | SS-5 | 11.0 | 17 | | | | | | | | | | | BROWN SILT AND CLAY, LITTLE SAND, TRACE STONE FRAGMENTS (FILL) | A-6a (V) |
| B-020-0-13 | SS-6 | 13.5 | 20 | | | | | | | | | | | BROWN AND BLACK SILTY CLAY, TRACE SAND, TRACE STONE FRAGMENTS (FILL) | A-6b (V) |
| B-020-0-13 | SS-7 | 16.0 | 22 | | | | | | | | | | | DARK BROWN SILTY CLAY, LITTLE SAND, TRACE STONE FRAGMENTS (FILL) | A-6b (V) |

Pro Geotech, Inc.

TR.-TRACE, BR.-BROWN, LI.-LITTLE,
S/F-STONE FRAGMENTS, SO.-SOME,
RB-ROADBASE, NP-NON-PLASTIC,
POSS-POSSIBLE, MOD-MODERATELY

# Summary of Laboratory Results

Client: PARSONS BRINKERHOFF
Project: HAN-75-14.39-BRIDGE NOS. HAN-75-1526 L&R
Location: FINDLAY, HANCOCK COUNTY, OHIO
PID Number: 87005

| Boring Number | Sample Number | Depth (ft) | Water Content % | Liquid Limit % | Plastic Limit % | Plast. Index | Specific Gravity | Agg. % | Coarse Sand % | Fine Sand % | Silt % | Silt&Clay Comb. % | Clay % | Soil Description | Class. Symbol |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B-020-0-13 | SS-8 | 18.5 | 21 | | | | | | | | | | | BROWN SILTY CLAY, LITTLE SAND, TRACE STONE FRAGMENTS (FILL) | A-6b (V) |
| B-020-0-13 | SS-9 | 21.0 | 20 | | | | | | | | | | | BROWN, MOTTLED GRAY SILTY CLAY, LITTLE SAND, TRACE STONE FRAGS | A-6b (V) |
| B-020-0-13 | SS-10 | 23.5 | 13 | 24 | 19 | 5 | | 0 | 1 | 11 | 61 | 87 | 26 | GRAY AND BROWN, NON-PLASTIC SILT, LITTLE SAND | A-4b (8) |
| B-020-0-13 | SS-11 | 28.5 | 20 | | | | | | | | | | | BROWN, NON-PLASTIC SILT, TRACE SAND | A-4b (V) |
| B-020-0-13 | SS-12 | 33.5 | 13 | | | | | | | | | | | GRAY DOLOMITE BEDROCK | Rock (V) |
| B-020-1-13 | SS-1 | 1.0 | 20 | 39 | 19 | 20 | | 2 | 4 | 16 | 35 | 78 | 43 | BROWN SILTY CLAY, LITTLE SAND, TRACE STONE FRAGMENTS | A-6b (12) |
| B-020-1-13 | SS-2 | 3.5 | 18 | | | | | | | | | | | BROWN SILTY CLAY, LITTLE SAND, TRACE STONE FRAGMENTS | A-6b (V) |
| B-020-1-13 | SS-3 | 6.0 | 19 | | | | | | | | | | | BROWN SILT AND CLAY, LITTLE SAND, TRACE STONE FRAGMENTS | A-6a (V) |
| B-020-1-13 | SS-4 | 8.5 | 18 | | | | | | | | | | | BROWN SILT AND CLAY, LITTLE SAND, TRACE STONE FRAGMENTS | A-6a (V) |
| B-020-1-13 | SS-5A | 11.0 | 18 | | | | | | | | | | | BROWN SILT AND CLAY, LITTLE SAND, TRACE STONE FRAGMENTS | A-6a (V) |
| B-020-1-13 | SS-5B | 11.9 | 29 | | | | | | | | | | | BROWN NON-PLASTIC SANDY SILT | A-4a (V) |



Pro Geotech, Inc.

TR.-TRACE, BR.-BROWN, LI.-LITTLE,
S/F-STONE FRAGMENTS, SO.-SOME,
RB-ROADBASE, NP-NON-PLASTIC,
POSS-POSSIBLE, MOD-MODERATELY

## Summary of Laboratory Results

Client: PARSONS BRINKERHOFF
Project: HAN-75-14.39-BRIDGE NOS. HAN-75-1526 L&R
Location: FINDLAY, HANCOCK COUNTY, OHIO
PID Number: 87005

| Boring Number | Sample Number | Depth (ft) | Water Content % | Liquid Limit % | Plastic Limit % | Plast. Index | Specific Gravity | Agg. % | Coarse Sand % | Fine Sand % | Silt % | Silt&Clay Comb. % | Clay % | Soil Description | Class. Symbol |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B-092-0-13 | SS-1 | 1.5 | 12 | | | | | | | | | | | BROWN SANDY SILT, SOME CLAY, TRACE STONE FRAGMENTS (FILL) | A-4a (V) |
| B-092-0-13 | SS-2 | 3.5 | 18 | | | | | | | | | | | BROWN SILT AND CLAY, LITTLE SAND, TRACE STONE FRAGMENTS (FILL) | A-6a (V) |
| B-092-0-13 | SS-3 | 6.0 | 16 | | | | | | | | | | | BROWN SILT AND CLAY, LITTLE SAND, TRACE STONE FRAGMENTS (FILL) | A-6a (V) |
| B-092-0-13 | SS-4 | 8.5 | 13 | | | | | | | | | | | BROWN AND GRAY SANDY SILT, SOME CLAY, LITTLE STONE FRAGMENTS (FILL) | A-4a (V) |
| B-092-0-13 | SS-5 | 11.0 | 14 | | | | | | | | | | | BROWN AND GRAY SANDY SILT, SOME CLAY, LITTLE STONE FRAGMENTS (FILL) | A-4a (V) |
| B-092-0-13 | SS-6 | 13.5 | 14 | | | | | | | | | | | GRAY SANDY SILT, SOME CLAY, LITTLE STONE FRAGMENTS (FILL) | A-4a (V) |
| B-092-0-13 | SS-7 | 16.0 | 21 | | | | | | | | | | | GREENISH GRAY SILTY CLAY, TRACE SAND, TRACE STONE FRAGMENTS (FILL) | A-6b (V) |
| B-092-0-13 | SS-8 | 18.5 | 18 | | | | | | | | | | | GREENISH GRAY SILTY CLAY, TRACE SAND, TRACE STONE FRAGMENTS (FILL) | A-6b (V) |
| B-092-0-13 | ST-9 | 21.0 | | | | | | | | | | | | BROWN SILTY CLAY, LITTLE SAND, TRACE STONE FRAGMENTS (FILL) | A-6b (V) |
| B-092-0-13 | SS-10 | 23.5 | 17 | | | | | | | | | | | BROWN SILTY CLAY, LITTLE SAND, TRACE STONE FRAGMENTS (FILL) | A-6b (V) |
| B-092-0-13 | SS-11 | 26.0 | 19 | | | | | | | | | | | BROWN SILTY CLAY, LITTLE SAND, TRACE STONE FRAGMENTS (FILL) | A-6b (V) |
| B-092-0-13 | SS-12 | 28.5 | 21 | 30 | 22 | 8 | | 1 | 4 | 41 | 30 | 54 | 24 | DARK BROWN SANDY SILT, SOME CLAY, TRACE STONE FRAGMENTS (FILL) | A-4a (4) |
| B-092-0-13 | SS-13 | 31.0 | 18 | | | | | | | | | | | GREENISH BROWN SILTY CLAY, SOME SAND, TRACE STONE FRAGMENTS (FILL) | A-6b (V) |
| B-092-0-13 | SS-14 | 33.5 | 24 | 33 | 16 | 17 | | 2 | 6 | 17 | 37 | 75 | 38 | GREENISH BROWN SILTY CLAY, SOME SAND, TRACE STONE FRAGMENTS (FILL) | A-6b (11) |
| B-092-0-13 | SS-15 | 36.0 | | | | | | | | | | | | NO RECOVERY | Rock (V) |

Pro Geotech, Inc.

TR.-TRACE, BR.-BROWN, LI.-LITTLE, S/F-STONE FRAGMENTS, SO.-SOME, RB-ROADBASE, NP-NON-PLASTIC, POSS-POSSIBLE, MOD-MODERATELY

## Summary of Laboratory Results

Client: PARSONS BRINKERHOFF
Project: HAN-75-14.39
Location: HANCOCK COUNTY, OHIO
PID Number: 87005

**PROJECT No.: G13011G**
**PROJECT: HAN-75-14.39-Bridge Nos. HAN-75-1526 L & R**

# ORGANIC MATTER CONTENT OF SOIL (ASTM D 2974)

| Split Spoon Sample | Oven Dried Moisture Content % | Furnace Temperature ($^{o}$C) | Ash Content (%) | Organic Matter (%) |
|---|---|---|---|---|
| B-016-1-13 @ 1.0' | 23.8 | 440 | 95.3 | 4.7 |
| B-018-0-13 @ 23.5' | 22.4 | 440 | 96.4 | 3.6 |

Pro Geotech, Inc.

# Compressive Strength of Rock
## ASTM D 7012

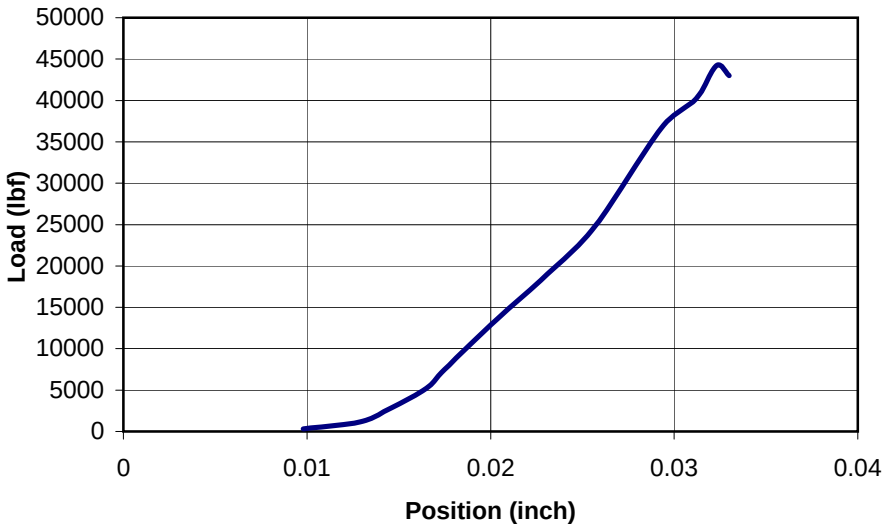
| | | | | | |
|---|---|---|---|---|---|
| PROJECT | HAN-75-14.39 | PGI PROJECT NO. | G13011G | DATE | 9/16/2013 |
| STRUCTURE: | IR-75 Mainline Bridge No. HAN-75-1526 over US 68 Ramp A | | | | |
| BORING NUMBER | B-016-1-13 | TOP DEPTH (FT) | 10.5 | BOTTOM DEPTH (FT) | 10.8 |
| SAMPLE NUMBER | NX-2 | DISTRICT | 1 | PID NO. | 87005 |
| COUNTY | HANCOCK | ROUTE | 75 | SECTION | 1526 |
| STATION | 781+45.98 | OFFSET | 37.7' | OFFSET DIRECTION | LEFT |

| | |
|---|---|
| FORMATION | TYMOCHTEE / GREENFIELD GROUP |
| DESCRIPTION | Dolomite, light gray, moderately weathered, strong. |

| MEASUREMENT | LENGTH (INCH) | DIAMETER (INCH) |
|---|---|---|
| 1 | 3.872 | 1.965 |
| 2 | 3.878 | 1.975 |
| 3 | 3.879 | 1.972 |
| AVERAGE | 3.876 | 1.971 |

| | |
|---|---|
| LENGTH/DIAMETER | 1.97 |
| CORRECTION FACTOR | 1.00 |
| AREA (SQ. INCH) | 3.050 |
| MASS (GRAMS) | 525.65 |
| UNIT WEIGHT (LBS/FT$^3$) | 169.37 |

| |
|---|
| MAXIMUM LOAD (LBS) |
| 44192 |
| COMPRESSIVE STRENGTH (PSI) |
| 14460 |
| TIME OF TEST (MINUTES) |
| 3:40 |
| LOADING DIRECTION |
| PERPENDICULAR TO BEDDING |
| TECHNICIAN |
| F. BUSHER |




BEFORE TESTING

AFTER FAILURE

Pro Geotech, Inc.

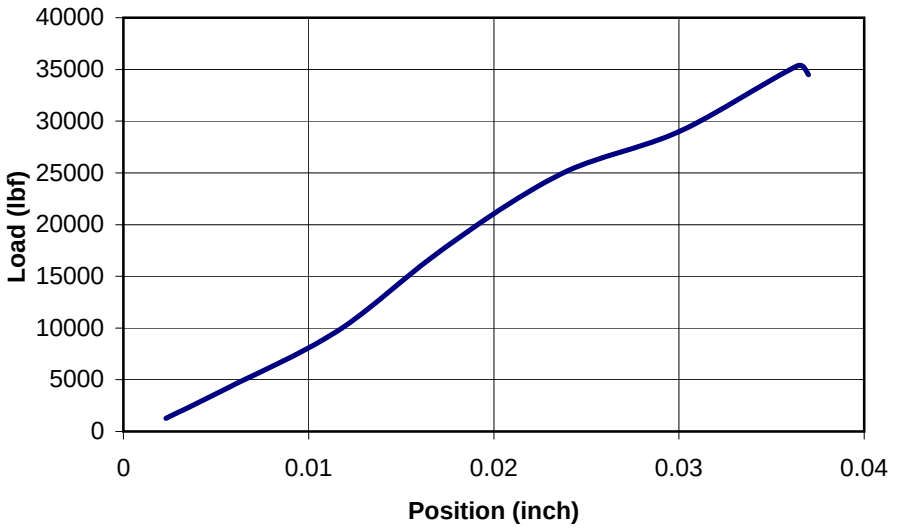
# Compressive Strength of Rock
## ASTM D 7012

| | | | | | |
|---|---|---|---|---|---|
| PROJECT | HAN-75-14.39 | PGI PROJECT NO. | G13011G | DATE | 9/16/2013 |
| STRUCTURE: | IR-75 Mainline Bridge No. HAN-75-1526 over US 68 Ramp A | | | | |
| BORING NUMBER | B-017-0-13 | TOP DEPTH (FT) | 16.0 | BOTTOM DEPTH (FT) | 16.3 |
| SAMPLE NUMBER | NX-1 | DISTRICT | 1 | PID NO. | 87005 |
| COUNTY | HANCOCK | ROUTE | 75 | SECTION | 1526 |
| STATION | 806+23.24 | OFFSET | 56.1' | OFFSET DIRECTION | LEFT |

| | |
|---|---|
| FORMATION | TYMOCHTEE / GREENFIELD GROUP |
| DESCRIPTION | Dolomite, light gray, moderately weathered, strong. |

| MEASUREMENT | LENGTH (INCH) | DIAMETER (INCH) | | | |
|---|---|---|---|---|---|
| 1 | 3.789 | 1.957 | | LENGTH/DIAMETER | 1.93 |
| 2 | 3.791 | 1.964 | | CORRECTION FACTOR | 1.00 |
| 3 | 3.787 | 1.957 | | AREA (SQ. INCH) | 3.015 |
| | | | | MASS (GRAMS) | 510.24 |
| AVERAGE | 3.789 | 1.959 | | UNIT WEIGHT (LBS/FT$^3$) | 170.15 |

| |
|---|
| MAXIMUM LOAD (LBS) |
| 35366 |
| COMPRESSIVE STRENGTH (PSI) |
| 11682 |
| TIME OF TEST (MINUTES) |
| 3.32 |
| LOADING DIRECTION |
| PERPENDICULAR TO BEDDING |
| TECHNICIAN |
| F. BUSHER |




BEFORE TESTING

AFTER FAILURE

Pro Geotech, Inc.

# Compressive Strength of Rock
## ASTM D 7012

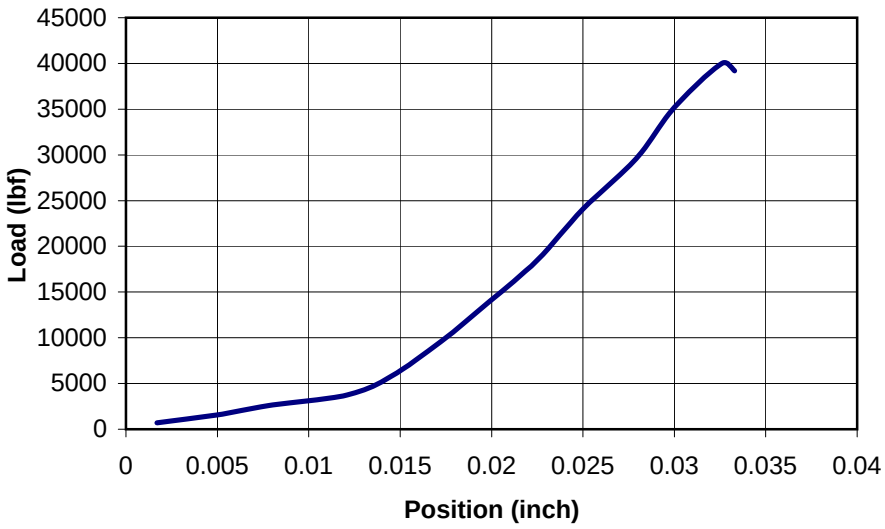
| | | | | | |
|---|---|---|---|---|---|
| PROJECT | HAN-75-14.39 | PGI PROJECT NO. | G13011G | DATE | 10/18/2013 |
| STRUCTURE: | IR-75 Mainline Bridge No. HAN-75-1526 over US 68 Ramp A | | | | |
| BORING NUMBER | B-018-0-13 | TOP DEPTH (FT) | 36.5 | BOTTOM DEPTH (FT) | 36.8 |
| SAMPLE NUMBER | NQ-1 | DISTRICT | 1 | PID NO. | 87005 |
| COUNTY | HANCOCK | ROUTE | 75 | SECTION | 1526 |
| STATION | 806+31.33 | OFFSET | 37.01' | OFFSET DIRECTION | RIGHT |

| | |
|---|---|
| FORMATION | TYMOCHTEE / GREENFIELD GROUP |
| DESCRIPTION | Dolomite, light gray, slightly weathered, strong. |

| MEASUREMENT | LENGTH (INCH) | DIAMETER (INCH) |
|---|---|---|
| 1 | 3.999 | 1.970 |
| 2 | 3.991 | 1.975 |
| 3 | 4.003 | 1.977 |
| AVERAGE | 3.998 | 1.974 |

| | |
|---|---|
| LENGTH/DIAMETER | 2.03 |
| CORRECTION FACTOR | 1.00 |
| AREA (SQ. INCH) | 3.060 |
| MASS (GRAMS) | 518.91 |
| UNIT WEIGHT (LBS/FT$^3$) | 161.58 |

| |
|---|
| MAXIMUM LOAD (LBS) |
| 39994 |
| COMPRESSIVE STRENGTH (PSI) |
| 13068 |
| TIME OF TEST (MINUTES) |
| 4:00 |
| LOADING DIRECTION |
| PERPENDICULAR TO BEDDING |
| TECHNICIAN |
| F. BUSHER |




BEFORE TESTING

AFTER FAILURE

Pro Geotech, Inc.

# Compressive Strength of Rock
## ASTM D 7012

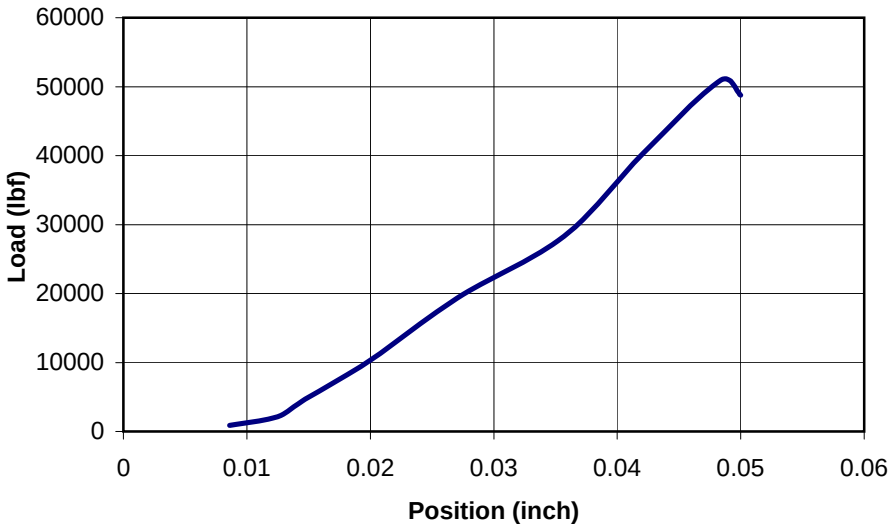
| | | | | | |
|---|---|---|---|---|---|
| PROJECT | HAN-75-14.39 | PGI PROJECT NO. | G13011G | DATE | 9/6/2013 |
| STRUCTURE: | IR-75 Mainline Bridge No. HAN-75-1526 over US 68 Ramp A | | | | |
| BORING NUMBER | B-019-0-13 | TOP DEPTH (FT) | 14.5 | BOTTOM DEPTH (FT) | 14.8 |
| SAMPLE NUMBER | NX-1 | DISTRICT | 1 | PID NO. | 87005 |
| COUNTY | HANCOCK | ROUTE | 75 | SECTION | 1526 |
| STATION | 807+13.28 | OFFSET | 75.12' | OFFSET DIRECTION | LEFT |

| | |
|---|---|
| FORMATION | TYMOCHTEE / GREENFIELD GROUP |
| DESCRIPTION | Dolomite, gray, moderately weathered, very strong. |

| MEASUREMENT | LENGTH (INCH) | DIAMETER (INCH) |
|---|---|---|
| 1 | 4.167 | 1.956 |
| 2 | 4.201 | 1.946 |
| 3 | 4.173 | 1.953 |
| AVERAGE | 4.180 | 1.952 |

| | |
|---|---|
| LENGTH/DIAMETER | 2.14 |
| CORRECTION FACTOR | 1.00 |
| AREA (SQ. INCH) | 2.992 |
| MASS (GRAMS) | 549.18 |
| UNIT WEIGHT (LBS/FT$^3$) | 167.29 |

| |
|---|
| MAXIMUM LOAD (LBS) |
| 50961 |
| COMPRESSIVE STRENGTH (PSI) |
| 17035 |
| TIME OF TEST (MINUTES) |
| 3.32 |
| LOADING DIRECTION |
| PERPENDICULAR TO BEDDING |
| TECHNICIAN |
| F. BUSHER |




BEFORE TESTING

AFTER FAILURE

Pro Geotech, Inc.

# Compressive Strength of Rock
## ASTM D 7012

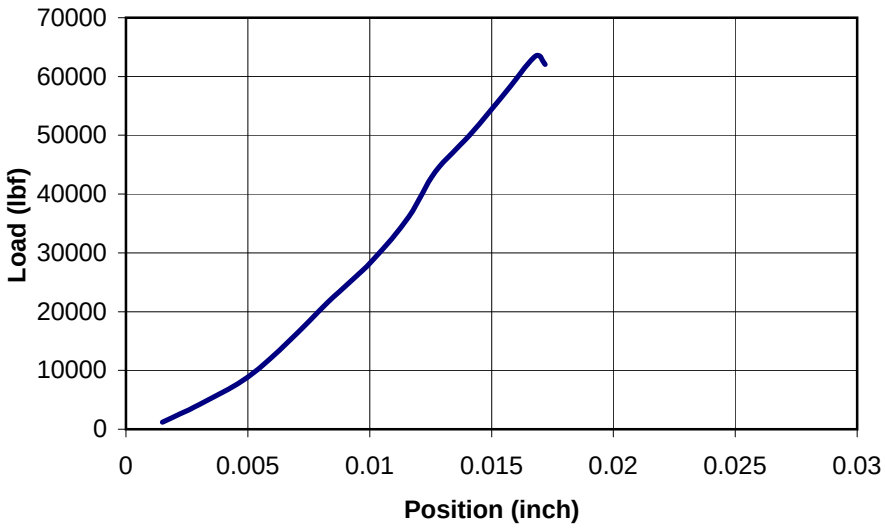
| | | | | | |
|---|---|---|---|---|---|
| PROJECT | HAN-75-14.39 | PGI PROJECT NO. | G13011G | DATE | 9/6/2013 |
| STRUCTURE: | IR-75 Mainline Bridge No. HAN-75-1526 over US 68 Ramp A | | | | |
| BORING NUMBER | B-020-0-13 | TOP DEPTH (FT) | 40.5 | BOTTOM DEPTH (FT) | 40.8 |
| SAMPLE NUMBER | NQ-2 | DISTRICT | 1 | PID NO. | 87005 |
| COUNTY | HANCOCK | ROUTE | 75 | SECTION | 1526 |
| STATION | 807+20.86 | OFFSET | 31.75' | OFFSET DIRECTION | RIGHT |

| | |
|---|---|
| FORMATION | TYMOCHTEE / GREENFIELD GROUP |
| DESCRIPTION | Dolomite, light gray, slightly weathered, very strong. |

| MEASUREMENT | LENGTH (INCH) | DIAMETER (INCH) |
|---|---|---|
| 1 | 4.220 | 1.990 |
| 2 | 4.216 | 1.976 |
| 3 | 4.221 | 1.984 |
| AVERAGE | 4.219 | 1.983 |

| | |
|---|---|
| LENGTH/DIAMETER | 2.13 |
| CORRECTION FACTOR | 1.00 |
| AREA (SQ. INCH) | 3.089 |
| MASS (GRAMS) | 551.85 |
| UNIT WEIGHT (LBS/FT$^3$) | 161.29 |

| |
|---|
| MAXIMUM LOAD (LBS) |
| 63491 |
| COMPRESSIVE STRENGTH (PSI) |
| 20551 |
| TIME OF TEST (MINUTES) |
| 4:00 |
| LOADING DIRECTION |
| PERPENDICULAR TO BEDDING |
| TECHNICIAN |
| F. BUSHER |




BEFORE TESTING

AFTER FAILURE

Pro Geotech, Inc.

# Compressive Strength of Rock
## ASTM D 7012

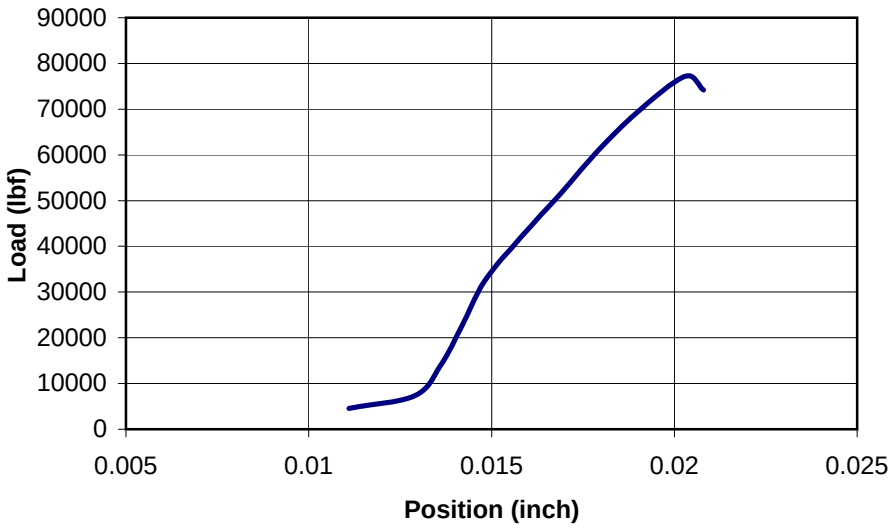
| | | | | | |
|---|---|---|---|---|---|
| PROJECT | HAN-75-14.39 | PGI PROJECT NO. | G13011G | DATE | 9/6/2013 |
| STRUCTURE: | IR-75 Mainline Bridge No. HAN-75-1526 over US 68 Ramp A | | | | |
| BORING NUMBER | B-020-1-13 | TOP DEPTH (FT) | 14.0 | BOTTOM DEPTH (FT) | 40.8 |
| SAMPLE NUMBER | NX-1 | DISTRICT | 1 | PID NO. | 87005 |
| COUNTY | HANCOCK | ROUTE | 75 | SECTION | 1526 |
| STATION | 807+71.93 | OFFSET | 153.24' | OFFSET DIRECTION | RIGHT |

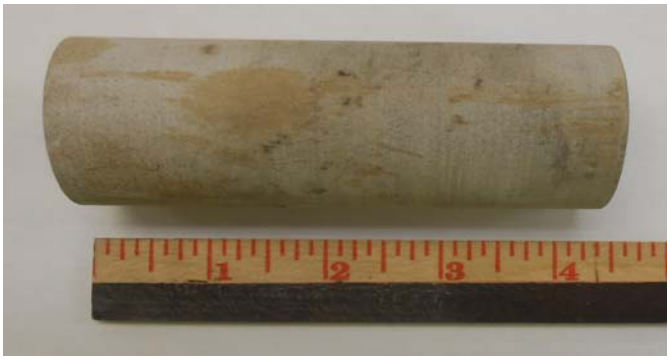
| | |
|---|---|
| FORMATION | TYMOCHTEE / GREENFIELD GROUP |
| DESCRIPTION | Dolomite, light gray, slightly weathered, very strong. |

| MEASUREMENT | LENGTH (INCH) | DIAMETER (INCH) |
|---|---|---|
| 1 | 4.135 | 1.975 |
| 2 | 4.145 | 1.985 |
| 3 | 4.132 | 1.973 |
| AVERAGE | 4.137 | 1.978 |

| | |
|---|---|
| LENGTH/DIAMETER | 2.09 |
| CORRECTION FACTOR | 1.00 |
| AREA (SQ. INCH) | 3.072 |
| MASS (GRAMS) | 543.20 |
| UNIT WEIGHT (LBS/FT$^3$) | 162.83 |

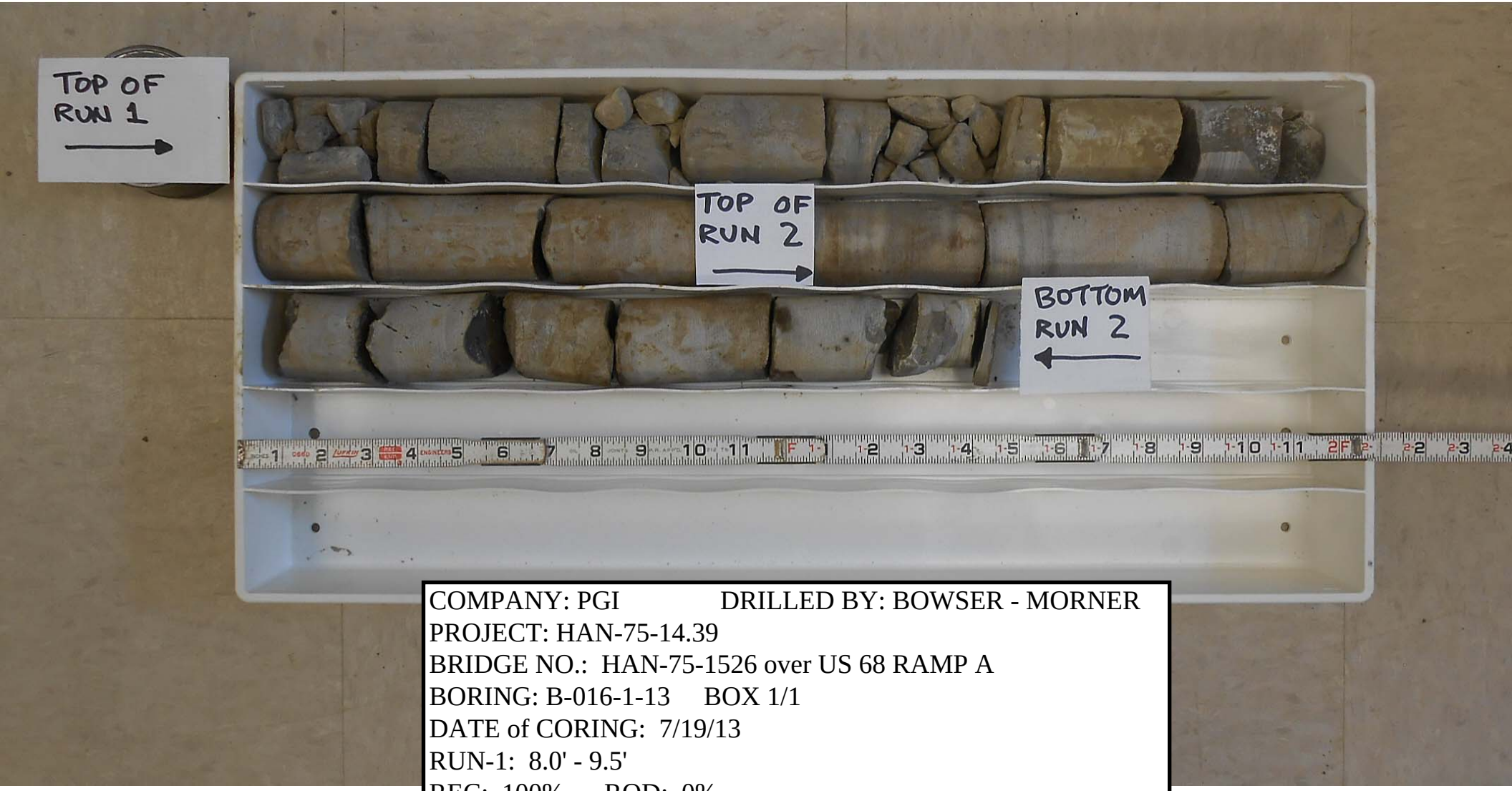
| | |
|---|---|
| MAXIMUM LOAD (LBS) | 77160 |
| COMPRESSIVE STRENGTH (PSI) | 25119 |
| TIME OF TEST (MINUTES) | 6:20 |
| LOADING DIRECTION | PERPENDICULAR TO BEDDING |
| TECHNICIAN | F. BUSHER |



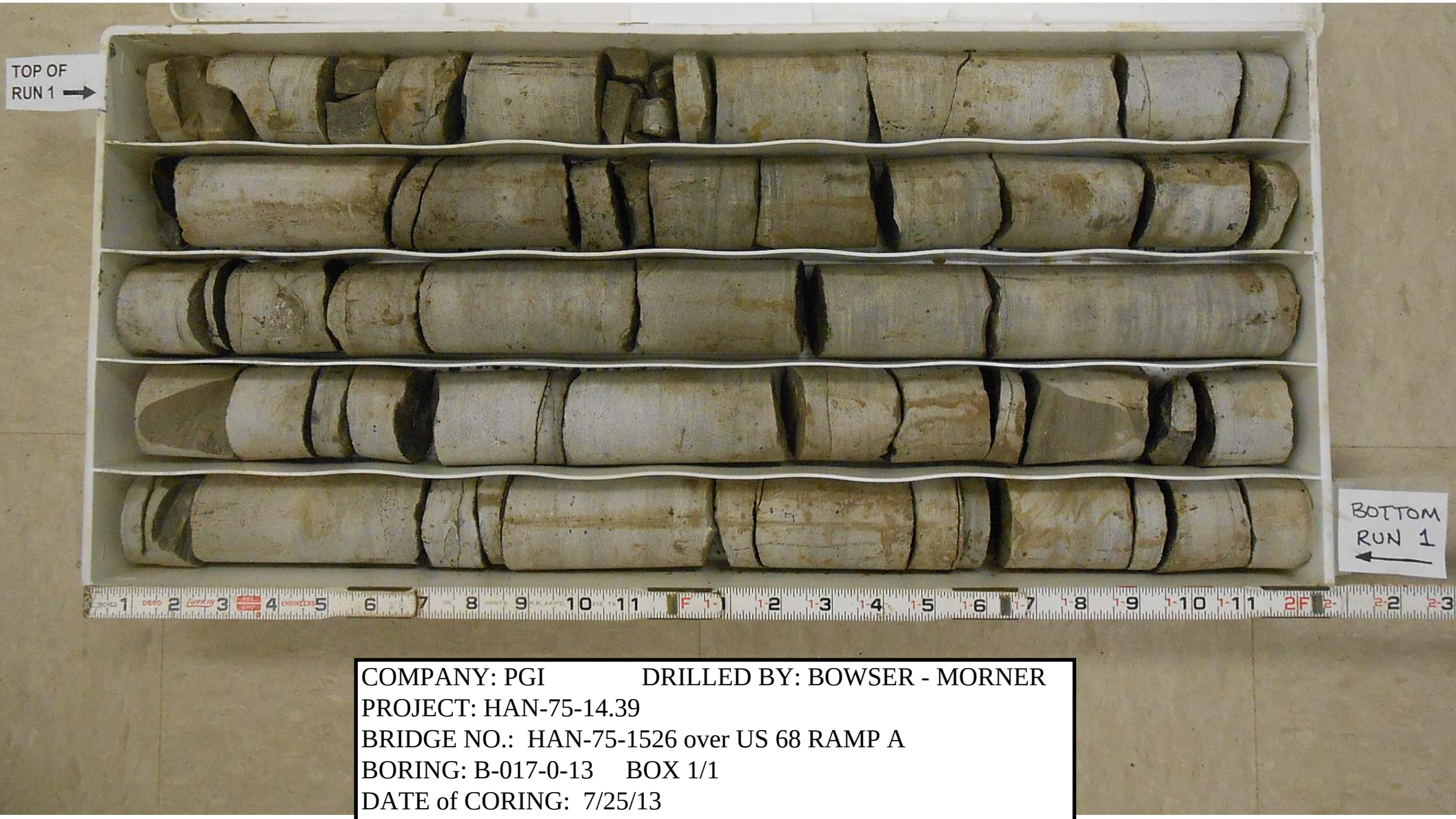



BEFORE TESTING

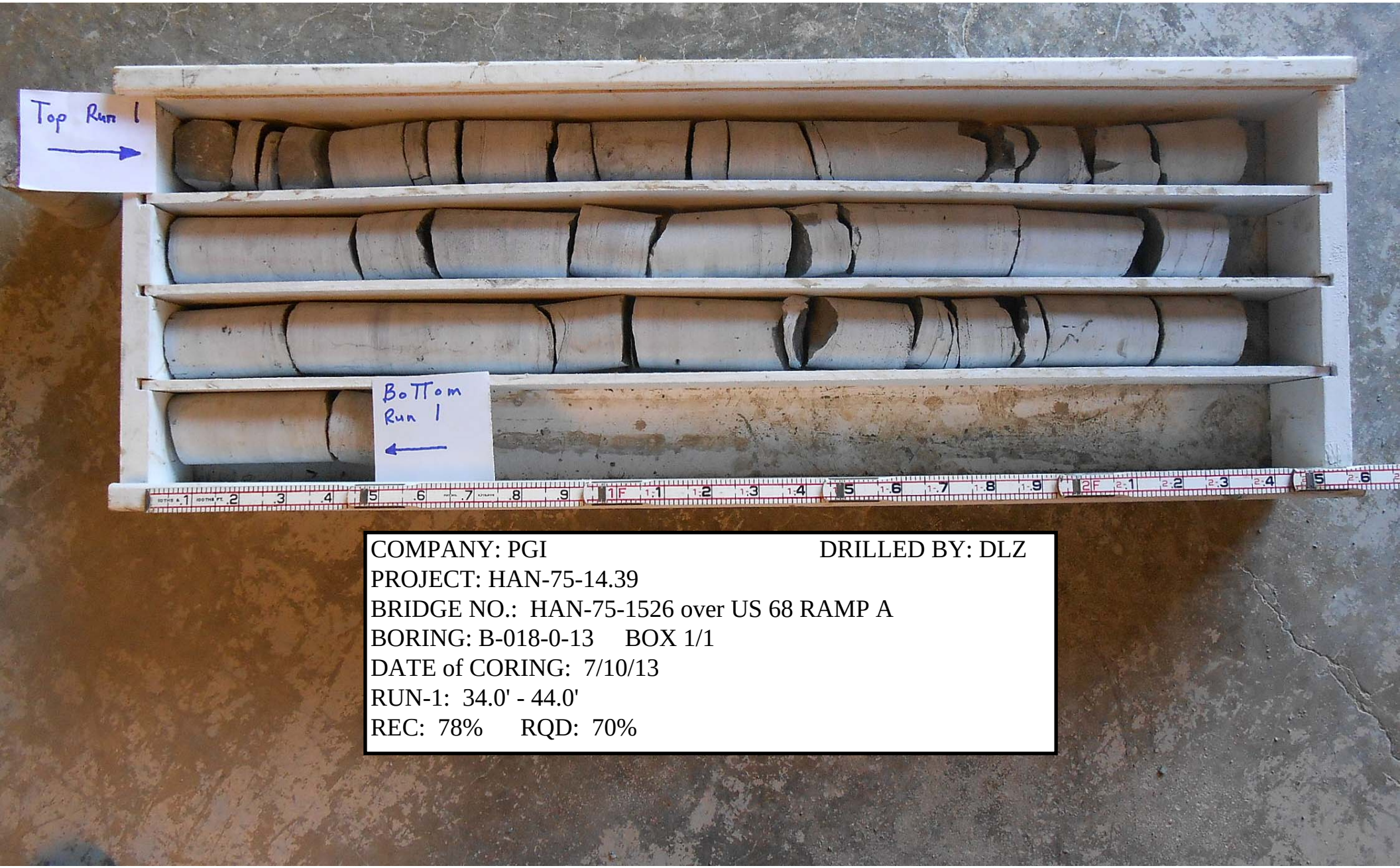
AFTER FAILURE




COMPANY: PGI DRILLED BY: BOWSER - MORNER
PROJECT: HAN-75-14.39
BRIDGE NO.: HAN-75-1526 over US 68 RAMP A
BORING: B-016-1-13 BOX 1/1
DATE of CORING: 7/19/13
RUN-1: 8.0' - 9.5'
REC: 100% RQD: 0%
RUN-2: 9.5' - 13.0'
REC: 98% RQD: 56%

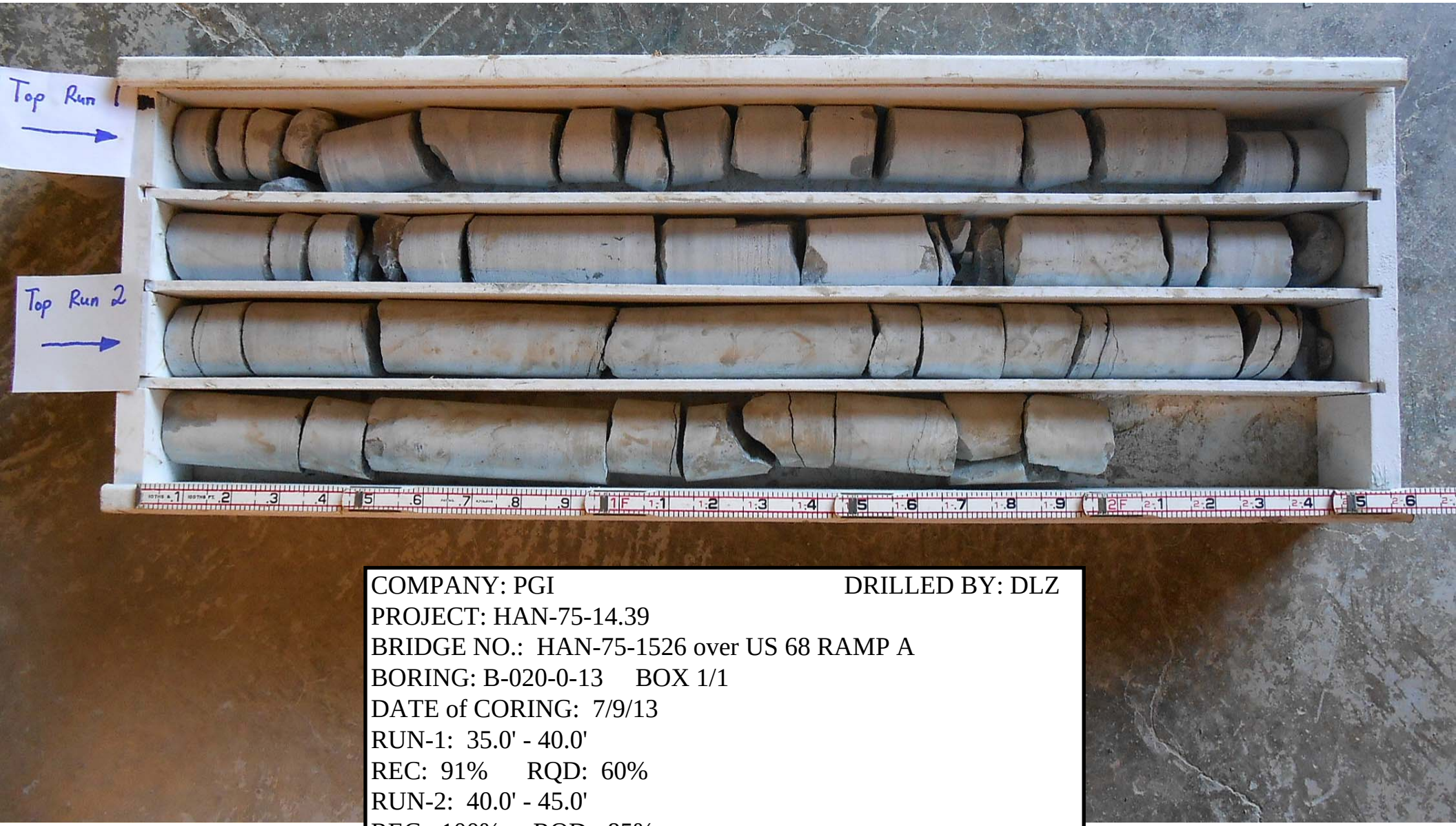



COMPANY: PGI DRILLED BY: BOWSER - MORNER
PROJECT: HAN-75-14.39
BRIDGE NO.: HAN-75-1526 over US 68 RAMP A
BORING: B-017-0-13 BOX 1/1
DATE of CORING: 7/25/13
RUN-1: 10.5' - 20.5'
REC: 100% RQD: 48%




COMPANY: PGI DRILLED BY: DLZ
PROJECT: HAN-75-14.39
BRIDGE NO.: HAN-75-1526 over US 68 RAMP A
BORING: B-018-0-13 BOX 1/1
DATE of CORING: 7/10/13
RUN-1: 34.0' - 44.0'
REC: 78% RQD: 70%


COMPANY: PGI DRILLED BY: BOWSER - MORNER
PROJECT: HAN-75-14.39
BRIDGE NO.: HAN-75-1526 over US 68 RAMP A
BORING: B-019-0-13 BOX 1/1
DATE of CORING: 7/25/13
RUN-1: 10.5' - 20.5'
REC: 100% RQD: 45%




COMPANY: PGI DRILLED BY: DLZ
PROJECT: HAN-75-14.39
BRIDGE NO.: HAN-75-1526 over US 68 RAMP A
BORING: B-020-0-13 BOX 1/1
DATE of CORING: 7/9/13
RUN-1: 35.0' - 40.0'
REC: 91% RQD: 60%
RUN-2: 40.0' - 45.0'
REC: 100% RQD: 85%


COMPANY: PGI DRILLED BY: BOWSER - MORNER
PROJECT: HAN-75-14.39
BRIDGE NO.: HAN-75-1526 over US 68 RAMP A
BORING: B-020-1-13 BOX 1/1
DATE of CORING: 7/29/13
RUN-1: 13.5' - 18.5'
REC: 100% RQD: 28%

| ROCK MASS RATING From Table 10.4.6.4-1 | |
|---|---|
| **Project:** HAN-75-14.39 | **Project No.:** G13011G |
| **Structure:** IR-75 Mainline Bridge No. HAN-75-1526 over US 68 Ramp A | |
| **Boring No.:** B-016-1-13 | **Substructure Unit:** South MSE Wall |
| **Strength of Intact Rock Material** | |
| Uniaxial Compressive Strength | 2082 ksf |
| Relative Rating | 11 |
| **Drill Core Quality RQD** | |
| RQD | 56% |
| Relative Rating | 14 |
| **Joint Conditions** | |
| Spacing of Joints | 2" to 1' |
| Relative Rating | 10 |
| Conditions of Joints | Slightly Rough Surfaces, Separation < 0.05", and Hard Joint Wall |
| Relative Rating | 20 |
| **Ground water Conditions** | |
| Relative Rating | 4 |
| **Strike & Dip Orientation of Joint** | |
| Relative Rating | 0 |
| Total Mass Rating | 59 |
| Class No | III |
| Description | Fair Rock |
| **Boring No.:** B-020-1-13 | **Substructure Unit:** North MSE Wall |
| **Strength of Intact Rock Material** | |
| Uniaxial Compressive Strength | 3617 ksf |
| Relative Rating | 14 |
| **Drill Core Quality RQD** | |
| RQD | 28% |
| Relative Rating | 8 |
| **Joint Conditions** | |
| Spacing of Joints | 2" to 1' |
| Relative Rating | 10 |
| Conditions of Joints | Slightly Rough Surfaces, Separation < 0.05", and Hard Joint Wall |
| Relative Rating | 20 |
| **Ground water Conditions** | |
| Relative Rating | 4 |
| **Strike & Dip Orientation of Joint** | |
| Relative Rating | 0 |
| Total Mass Rating | 56 |
| Class No | III |
| Description | Fair Rock |

## ROCK MASS RATING From Table 10.4.6.4-1

**Project:** HAN-75-14.39 **Project No.:** G13011G

**Structure:** IR-75 Mainline Bridge No. HAN-75-1526 over US 68 Ramp A

**Boring No.:** B-017-0-13 **Substructure Unit:** Rear Abutment

| | |
|---|---|
| **Strength of Intact Rock Material** | |
| Uniaxial Compressive Strength | 1682 ksf |
| Relative Rating | 9 |
| **Drill Core Quality RQD** | |
| RQD | 48% |
| Relative Rating | 12 |
| **Joint Conditions** | |
| Spacing of Joints | 2" to 1' |
| Relative Rating | 10 |
| Conditions of Joints | Slightly Rough Surfaces, Separation < 0.05", and Hard Joint Wall |
| Relative Rating | 20 |
| **Ground water Conditions** | |
| Relative Rating | 4 |
| **Strike & Dip Orientation of Joint** | |
| Relative Rating | 0 |
| Total Mass Rating | 55 |
| Class No | III |
| Description | Fair Rock |

**Boring No.:** B-018-0-13 **Substructure Unit:** Rear Abutment

| | |
|---|---|
| **Strength of Intact Rock Material** | |
| Uniaxial Compressive Strength | 1882 ksf |
| Relative Rating | 10 |
| **Drill Core Quality RQD** | |
| RQD | 70% |
| Relative Rating | 16 |
| **Joint Conditions** | |
| Spacing of Joints | 2" to 1' |
| Relative Rating | 10 |
| Conditions of Joints | Slightly Rough Surfaces, Separation < 0.05", and Hard Joint Wall |
| Relative Rating | 19 |
| **Ground water Conditions** | |
| Relative Rating | 4 |
| **Strike & Dip Orientation of Joint** | |
| Relative Rating | 0 |
| Total Mass Rating | 59 |
| Class No | III |
| Description | Fair Rock |

## ROCK MASS RATING From Table 10.4.6.4-1

**Project:** HAN-75-14.39 **Project No.:** G13011G

**Structure:** IR-75 Mainline Bridge No. HAN-75-1526 over US 68 Ramp A

**Boring No.:** B-019-0-13 **Substructure Unit:** Forward Abutment

| | |
|---|---|
| **Strength of Intact Rock Material** | |
| Uniaxial Compressive Strength | 2453 ksf |
| Relative Rating | 13 |
| **Drill Core Quality RQD** | |
| RQD | 45% |
| Relative Rating | 12 |
| **Joint Conditions** | |
| Spacing of Joints | 2" to 1' |
| Relative Rating | 11 |
| Conditions of Joints | Slightly Rough Surfaces, Separation < 0.05", and Hard Joint Wall |
| Relative Rating | 20 |
| **Ground water Conditions** | |
| Relative Rating | 4 |
| **Strike & Dip Orientation of Joint** | |
| Relative Rating | 0 |
| Total Mass Rating | 60 |
| Class No | III |
| Description | Fair Rock |

**Boring No.:** B-020-0-13 **Substructure Unit:** Forward Abutment

| | |
|---|---|
| **Strength of Intact Rock Material** | |
| Uniaxial Compressive Strength | 2959 ksf |
| Relative Rating | 13 |
| **Drill Core Quality RQD** | |
| RQD | 73% |
| Relative Rating | 16 |
| **Joint Conditions** | |
| Spacing of Joints | 2" to 1' |
| Relative Rating | 10 |
| Conditions of Joints | Slightly Rough Surfaces, Separation < 0.05", and Hard Joint Wall |
| Relative Rating | 19 |
| **Ground water Conditions** | |
| Relative Rating | 4 |
| **Strike & Dip Orientation of Joint** | |
| Relative Rating | 0 |
| Total Mass Rating | 62 |
| Class No | II |
| Description | Good Rock |

# BEARING CAPACITY ANALYSIS

| | |
|---|---|
| Project | **HAN-75-14.39-Bridge No. HAN-75-1526** |
| Project# | **G13011G** |
| Bore# | **B-016-1-13 (Rear MSE Wall)** |
| Method | **AASHTO 10.6.3.1.2** |
| **Foundation Dimension** | |
| Width of Footing ($B_f$) (feet) | 22.8 |
| Length of Footing ($L_f$) (feet) | 240.0 |
| Length ($L_f$)/Width ($B_f$) (>5 is continous footing) | 10.5 |
| Type of Footing | Strip |
| Footing Bearing Elevation (feet) | 777.5 |
| Depth of Footing ($D_f$) Feet below Proposed Grade | 6.9 |
| Depth of Groundwater Table below Footing (ft) | 6.6 |
| Height of Slope (Hs) (feet) | Flat Ground |
| **Soil Parameters** | |
| Undrained Shear Strength/Cohesion (psf) | 0 |
| Angle of internal friction (Phi ) Degrees | 30 |
| Unit Weight of soil above base of footing (pcf) | 125 |
| Unit Weight of soil below base of footing (pcf) | 125 |
| **Bearing Capacity Factors** | |
| $N_c$ | 30.14 |
| $N_q$ | 18.40 |
| $N\gamma$ | 22.40 |
| **Shape Correction Factors** | |
| $s_c$ | 1.00 |
| $s_q$ | 1.00 |
| $s_\gamma$ | 0.70 |
| **Load Inclination Factors** | |
| ic | 1.0 |
| iq | 1.0 |
| $i_\gamma$ | 1.0 |
| **Correction for Water Table** | |
| $D_f+1.5B_f$ | 41.1 |
| $C_{wq}$ | 1.0 |
| $C_{wr}$ | 0.7 |
| **Embedment Depth Correction Factor** | |
| Df/Bf | 0.3 |
| $d_q$ | 1.0 |
| **Bearing Capacity Terms** | |
| Cohesion Term | 0 |
| Surcharge Term | 15870 |
| Unit Weight Term | 14747 |
| Nominal Bearing Resistence ( psf) | 30617 |
| Factored Bearing Resistence ( psf) | 13778 |

**AASHTO Eqn 10.6.3.1.2a**

qn = c*Nc*Sc*ic + (Gamma)*Df*Nq*sq*dq*iq*Cwq+0.5*(Gamma)*Bf*Nr*sr*ir*Cw2

# BEARING CAPACITY ANALYSIS

| | |
|---|---|
| Project | **HAN-75-14.39-Bridge No. HAN-75-1526** |
| Project# | **G13011G** |
| Bore# | **B-017-0-13 (Rear MSE Wall)** |
| Method | **AASHTO 10.6.3.1.2** |
| **Foundation Dimension** | |
| Width of Footing ($B_f$) (feet) | 22.8 |
| Length of Footing ($L_f$) (feet) | 240.0 |
| Length ($L_f$)/Width ($B_f$) (>5 is continous footing) | 10.5 |
| Type of Footing | Strip |
| Footing Bearing Elevation (feet) | 779.0 |
| Depth of Footing ($D_f$) Feet below Proposed Grade | 6.9 |
| Depth of Groundwater Table below Footing (ft) | 5.6 |
| Height of Slope (Hs) (feet) | Flat Ground |
| **Soil Parameters** | |
| Undrained Shear Strength/Cohesion (psf) | 0 |
| Angle of internal friction (Phi ) Degrees | 30 |
| Unit Weight of soil above base of footing (pcf) | 125 |
| Unit Weight of soil below base of footing (pcf) | 125 |
| **Bearing Capacity Factors** | |
| $N_c$ | 30.14 |
| $N_q$ | 18.40 |
| $N\gamma$ | 22.40 |
| **Shape Correction Factors** | |
| $s_c$ | 1.00 |
| $s_q$ | 1.00 |
| $s_\gamma$ | 0.70 |
| **Load Inclination Factors** | |
| ic | 1.0 |
| iq | 1.0 |
| $i_\gamma$ | 1.0 |
| **Correction for Water Table** | |
| $D_f+1.5B_f$ | 41.1 |
| $C_{wq}$ | 1.0 |
| $C_{wr}$ | 0.7 |
| **Embedment Depth Correction Factor** | |
| Df/Bf | 0.3 |
| $d_q$ | 1.0 |
| **Bearing Capacity Terms** | |
| Cohesion Term | 0 |
| Surcharge Term | 15870 |
| Unit Weight Term | 14747 |
| Nominal Bearing Resistence ( psf) | 30617 |
| Factored Bearing Resistence ( psf) | 13778 |

**AASHTO Eqn 10.6.3.1.2a**

qn = c*Nc*Sc*ic + (Gamma)*Df*Nq*sq*dq*iq*Cwq+0.5*(Gamma)*Bf*Nr*sr*ir*Cw2

# BEARING CAPACITY ANALYSIS

| | |
|---|---|
| Project | **HAN-75-14.39-Bridge No. HAN-75-1526** |
| Project# | **G13011G** |
| Bore# | **B-018-0-13 (Rear MSE Wall)** |
| Method | **AASHTO 10.6.3.1.2** |
| **Foundation Dimension** | |
| Width of Footing ($B_f$) (feet) | 22.8 |
| Length of Footing ($L_f$) (feet) | 240.0 |
| Length ($L_f$)/Width ($B_f$) (>5 is continous footing) | 10.5 |
| Type of Footing | Strip |
| Footing Bearing Elevation (feet) | 781.0 |
| Depth of Footing ($D_f$) Feet below Proposed Grade | 6.9 |
| Depth of Groundwater Table below Footing (ft) | 10.3 |
| Height of Slope (Hs) (feet) | Flat Ground |
| **Soil Parameters** | |
| Undrained Shear Strength/Cohesion (psf) | 0 |
| Angle of internal friction (Phi ) Degrees | 30 |
| Unit Weight of soil above base of footing (pcf) | 125 |
| Unit Weight of soil below base of footing (pcf) | 125 |
| **Bearing Capacity Factors** | |
| $N_c$ | 30.14 |
| $N_q$ | 18.40 |
| $N\gamma$ | 22.40 |
| **Shape Correction Factors** | |
| $s_c$ | 1.00 |
| $s_q$ | 1.00 |
| $s_\gamma$ | 0.70 |
| **Load Inclination Factors** | |
| ic | 1.0 |
| iq | 1.0 |
| $i_\gamma$ | 1.0 |
| **Correction for Water Table** | |
| $D_f+1.5B_f$ | 41.1 |
| $C_{wq}$ | 1.0 |
| $C_{wr}$ | 0.7 |
| **Embedment Depth Correction Factor** | |
| Df/Bf | 0.3 |
| $d_q$ | 1.0 |
| **Bearing Capacity Terms** | |
| Cohesion Term | 0 |
| Surcharge Term | 15870 |
| Unit Weight Term | 15864 |
| Nominal Bearing Resistence ( psf) | 31734 |
| Factored Bearing Resistence ( psf) | 14280 |

**AASHTO Eqn 10.6.3.1.2a**

qn = c*Nc*Sc*ic + (Gamma)*Df*Nq*sq*dq*iq*Cwq+0.5*(Gamma)*Bf*Nr*sr*ir*Cw2

# BEARING CAPACITY ANALYSIS

| | |
|---|---|
| Project | **HAN-75-14.39-Bridge No. HAN-75-1526** |
| Project# | **G13011G** |
| Bore# | **B-092-0-13 (Rear MSE Wall)** |
| Method | **AASHTO 10.6.3.1.2** |
| **Foundation Dimension** | |
| Width of Footing ($B_f$) (feet) | 22.8 |
| Length of Footing ($L_f$) (feet) | 240.0 |
| Length ($L_f$)/Width ($B_f$) (>5 is continous footing) | 10.5 |
| Type of Footing | Strip |
| Footing Bearing Elevation (feet) | 782.0 |
| Depth of Footing ($D_f$) Feet below Proposed Grade | 6.9 |
| Depth of Groundwater Table below Footing (ft) | 10.4 |
| Height of Slope (Hs) (feet) | Flat Ground |
| **Soil Parameters** | |
| Undrained Shear Strength/Cohesion (psf) | 0 |
| Angle of internal friction (Phi ) Degrees | 30 |
| Unit Weight of soil above base of footing (pcf) | 125 |
| Unit Weight of soil below base of footing (pcf) | 125 |
| **Bearing Capacity Factors** | |
| $N_c$ | 30.14 |
| $N_q$ | 18.40 |
| $N\gamma$ | 22.40 |
| **Shape Correction Factors** | |
| $s_c$ | 1.00 |
| $s_q$ | 1.00 |
| $s_\gamma$ | 0.70 |
| **Load Inclination Factors** | |
| ic | 1.0 |
| iq | 1.0 |
| $i_\gamma$ | 1.0 |
| **Correction for Water Table** | |
| $D_f+1.5B_f$ | 41.1 |
| $C_{wq}$ | 1.0 |
| $C_{wr}$ | 0.7 |
| **Embedment Depth Correction Factor** | |
| Df/Bf | 0.3 |
| $d_q$ | 1.0 |
| **Bearing Capacity Terms** | |
| Cohesion Term | 0 |
| Surcharge Term | 15870 |
| Unit Weight Term | 15864 |
| Nominal Bearing Resistence ( psf) | 31734 |
| Factored Bearing Resistence ( psf) | 14280 |

**AASHTO Eqn 10.6.3.1.2a**

qn = c*Nc*Sc*ic + (Gamma)*Df*Nq*sq*dq*iq*Cwq+0.5*(Gamma)*Bf*Nr*sr*ir*Cw2

# BEARING CAPACITY ANALYSIS

| | |
|---|---|
| Project | **HAN-75-14.39-Bridge No. HAN-75-1526** |
| Project# | **G13011G** |
| Bore# | **B-019-0-13 (Forward MSE Wall)** |
| Method | **AASHTO 10.6.3.1.2** |
| **Foundation Dimension** | |
| Width of Footing ($B_f$) (feet) | 22.1 |
| Length of Footing ($L_f$) (feet) | 222.0 |
| Length ($L_f$)/Width ($B_f$) (>5 is continous footing) | 10.0 |
| Type of Footing | Strip |
| Footing Bearing Elevation (feet) | 781.0 |
| Depth of Footing ($D_f$) Feet below Proposed Grade | 5.0 |
| Depth of Groundwater Table below Footing (ft) | 8.5 |
| Height of Slope (Hs) (feet) | Flat Ground |
| **Soil Parameters** | |
| Undrained Shear Strength/Cohesion (psf) | 0 |
| Angle of internal friction (Phi ) Degrees | 30 |
| Unit Weight of soil above base of footing (pcf) | 125 |
| Unit Weight of soil below base of footing (pcf) | 125 |
| **Bearing Capacity Factors** | |
| $N_c$ | 30.14 |
| $N_q$ | 18.40 |
| $N\gamma$ | 22.40 |
| **Shape Correction Factors** | |
| $s_c$ | 1.00 |
| $s_q$ | 1.00 |
| $s_\gamma$ | 0.60 |
| **Load Inclination Factors** | |
| ic | 1.0 |
| iq | 1.0 |
| $i_\gamma$ | 1.0 |
| **Correction for Water Table** | |
| $D_f+1.5B_f$ | 38.2 |
| $C_{wq}$ | 1.0 |
| $C_{wr}$ | 0.7 |
| **Embedment Depth Correction Factor** | |
| Df/Bf | 0.2 |
| $d_q$ | 1.0 |
| **Bearing Capacity Terms** | |
| Cohesion Term | 0 |
| Surcharge Term | 11500 |
| Unit Weight Term | 12624 |
| Nominal Bearing Resistence ( psf) | 24124 |
| Factored Bearing Resistence ( psf) | 10856 |

**AASHTO Eqn 10.6.3.1.2a**

qn = c*Nc*Sc*ic + (Gamma)*Df*Nq*sq*dq*iq*Cwq+0.5*(Gamma)*Bf*Nr*sr*ir*Cw2

# BEARING CAPACITY ANALYSIS

| | |
|---|---|
| Project | **HAN-75-14.39-Bridge No. HAN-75-1526** |
| Project# | **G13011G** |
| Bore# | **B-020-0-13 (Forward MSE Wall)** |
| Method | **AASHTO 10.6.3.1.2** |
| **Foundation Dimension** | |
| Width of Footing ($B_f$) (feet) | 22.1 |
| Length of Footing ($L_f$) (feet) | 222.0 |
| Length ($L_f$)/Width ($B_f$) (>5 is continous footing) | 10.0 |
| Type of Footing | Strip |
| Footing Bearing Elevation (feet) | 782.0 |
| Depth of Footing ($D_f$) Feet below Proposed Grade | 5.0 |
| Depth of Groundwater Table below Footing (ft) | 11.4 |
| Height of Slope (Hs) (feet) | Flat Ground |
| **Soil Parameters** | |
| Undrained Shear Strength/Cohesion (psf) | 3000 |
| Angle of internal friction (Phi ) Degrees | 0 |
| Unit Weight of soil above base of footing (pcf) | 125 |
| Unit Weight of soil below base of footing (pcf) | 125 |
| **Bearing Capacity Factors** | |
| $N_c$ | 5.14 |
| $N_q$ | 1.00 |
| $N\gamma$ | 0.00 |
| **Shape Correction Factors** | |
| $s_c$ | 1.00 |
| $s_q$ | 1.00 |
| $s_\gamma$ | 1.00 |
| **Load Inclination Factors** | |
| ic | 1.0 |
| iq | 1.0 |
| $i_\gamma$ | 1.0 |
| **Correction for Water Table** | |
| $D_f+1.5B_f$ | 38.2 |
| $C_{wq}$ | 1.0 |
| $C_{wr}$ | 0.7 |
| **Embedment Depth Correction Factor** | |
| Df/Bf | 0.2 |
| $d_q$ | 1.0 |
| **Bearing Capacity Terms** | |
| Cohesion Term | 15420 |
| Surcharge Term | 625 |
| Unit Weight Term | 0 |
| Nominal Bearing Resistence ( psf) | 16045 |
| Factored Bearing Resistence ( psf) | 7220 |

**AASHTO Eqn 10.6.3.1.2a**

qn = c*Nc*Sc*ic + (Gamma)*Df*Nq*sq*dq*iq*Cwq+0.5*(Gamma)*Bf*Nr*sr*ir*Cw2

# BEARING CAPACITY ANALYSIS

| | |
|---|---|
| Project | **HAN-75-14.39-Bridge No. HAN-75-1526** |
| Project# | **G13011G** |
| Bore# | **B-020-1-13 (Forward MSE Wall)** |
| Method | **AASHTO 10.6.3.1.2** |
| **Foundation Dimension** | |
| Width of Footing ($B_f$) (feet) | 22.1 |
| Length of Footing ($L_f$) (feet) | 222.0 |
| Length ($L_f$)/Width ($B_f$) (>5 is continous footing) | 10.0 |
| Type of Footing | Strip |
| Footing Bearing Elevation (feet) | 783.0 |
| Depth of Footing ($D_f$) Feet below Proposed Grade | 5.0 |
| Depth of Groundwater Table below Footing (ft) | 8.9 |
| Height of Slope (Hs) (feet) | Flat Ground |
| **Soil Parameters** | |
| Undrained Shear Strength/Cohesion (psf) | 0 |
| Angle of internal friction (Phi ) Degrees | 30 |
| Unit Weight of soil above base of footing (pcf) | 125 |
| Unit Weight of soil below base of footing (pcf) | 125 |
| **Bearing Capacity Factors** | |
| $N_c$ | 30.14 |
| $N_q$ | 18.40 |
| $N\gamma$ | 22.40 |
| **Shape Correction Factors** | |
| $s_c$ | 1.00 |
| $s_q$ | 1.00 |
| $s_\gamma$ | 0.60 |
| **Load Inclination Factors** | |
| ic | 1.0 |
| iq | 1.0 |
| $i_\gamma$ | 1.0 |
| **Correction for Water Table** | |
| $D_f+1.5B_f$ | 38.2 |
| $C_{wq}$ | 1.0 |
| $C_{wr}$ | 0.7 |
| **Embedment Depth Correction Factor** | |
| Df/Bf | 0.2 |
| $d_q$ | 1.0 |
| **Bearing Capacity Terms** | |
| Cohesion Term | 0 |
| Surcharge Term | 11500 |
| Unit Weight Term | 12624 |
| Nominal Bearing Resistence ( psf) | 24124 |
| Factored Bearing Resistence ( psf) | 10856 |

**AASHTO Eqn 10.6.3.1.2a**

qn = c*Nc*Sc*ic + (Gamma)*Df*Nq*sq*dq*iq*Cwq+0.5*(Gamma)*Bf*Nr*sr*ir*Cw2

| MSE WALL SETTLEMENT ANALYSES - Rear MSE Wall | | | | | | |
|---|---|---|---|---|---|---|
| **Project:** | HAN-75-14.39 - Bridge No. HAN-68-1526 | | **Project #** | G13011G | **Test Boring #** | B-016-1-13 |
| **Type of Foundation** | Compression Index (Cc) (From Lab Test) | | | Depth of Groundwater Level below Ground (feet) | | 8 |
| Shallow Foundation (Strip) | Recompression Index (Cr) (From Lab Test) | | | Unit Weight of Water (pcf) | | 62.4 |
| Length = 240.0' | Depth of Footing ($D_f$) below ground (feet) | | 1.4 | Specific Gravity of Soil Solids (G) | | |
| Width = 22.8' | Applied Design Pressure (psf) | | 6,000 | Unit Weight of Soil above the base of foundation (pcf) | | 125 |
| **Depth Below the Foundation (Z)** | **AVERAGE PROPERTIES** | | **CALCULATIONS** | | | **Total** |
| $D_f$=-1.4' & Z=0.0 | Thickness of Layer (feet) | 4.6 | OB Pressure at the top Layer(psf) | | 175 | **Setlement** |
| | Estimated SPT Value ($N_{60}$) | 15 | OB Pressure at the center Layer (psf) | | 463 | **( inches)** |
| | Specific Gravity of Soil Solids (G) | 2.65 | Excess Pressure At Center Due to appliedLoad | | 5450 | |
| (Above the Water Table) | Moisture content ( %) | 8 | Bearing Capacity Index (C) | | 78 | |
| Z=2.30' (At Centre of Layer) | Liquid Limit (%) | NP | Immediate Settlement in Foundation Soil (inches) | | 0.78 | **0.78** |
| | Plastic Limit (%) | NP | Initial Void Ratio ($e_0$) | | 0.43 | |
| | Plasticity Index (%) | NP | | | | |
| | Unit Weight of soil (pcf) | 125 | | | | |
| $D_f$=6.0' & Z=4.6' | Submerged Unit Weight of Soil (pcf) | | OB Pressure at the bottom Layer (psf) | | 750 | |
| $D_f$=6.0' & Z=4.6' | Thickness of Layer (feet) | 2 | OB Pressure at the top Layer(psf) | | 750 | **Setlement** |
| | Ave. Corrected SPT Value ($N_{60}$) | 64 | OB Pressure at the center Layer (psf) | | 890 | **( inches)** |
| | Specific Gravity of Soil Solids (G) | 2.7 | Excess Pressure At Center Due to appliedLoad | | 4817 | |
| (Below the Water Table) | Moisture content ( %) | 12 | Compression Index ($C_c$) | | 0.12 | |
| Z=5.6' (At Centre of Layer) | Liquid Limit (%) | | Recompression Index ($C_r$) | | 0.012 | 0.012 |
| | Plastic Limit (%) | | Initial Void Ratio ($e_0$) | | 0.35 | |
| | Plasticity Index (%) | | Settlement due to compression ( inches) | | 1.72 | |
| | Unit Weight of soil (pcf) | 140 | Settlement due to recompression (inches) | | 0.17 | **0.17** |
| $D_f$=8.0' & Z=6.6' | Submerged Unit Weight of Soil (pcf) | | OB Pressure at the bottom Layer (psf) | | 1030 | |
| | | | | **Total Settlement:** | | **0.96** |
| | | | | **Consolidation Settlement:** | | **0.18** |
| | | | | **Immediate Settlement:** | | **0.78** |

| MSE WALL SETTLEMENT ANALYSES - Rear MSE Wall | | | | | | |
|---|---|---|---|---|---|---|
| **Project:** | HAN-75-14.39 - Bridge No. HAN-68-1526 | | **Project #** | G13011G | **Test Boring #** | B-017-0-13 |
| **Type of Foundation** | Compression Index (Cc) (From Lab Test) | | | Depth of Groundwater Level below Ground (feet) | | 7 |
| Shallow Foundation (Strip) | Recompression Index (Cr) (From Lab Test) | | | Unit Weight of Water (pcf) | | 62.4 |
| Length = 240.0' | Depth of Footing ($D_f$) below ground (feet) | | 1.6 | Specific Gravity of Soil Solids (G) | | |
| Width = 22.8' | Applied Design Pressure (psf) | | 6,000 | Unit Weight of Soil above the base of foundation (pcf) | | 125 |
| **Depth Below the Foundation (Z)** | **AVERAGE PROPERTIES** | | **CALCULATIONS** | | | **Total** |
| $D_f$=1.6' & Z=0.0 | Thickness of Layer (feet) | 5.6 | OB Pressure at the top Layer(psf) | | 200 | **Setlement** |
| | Estimated SPT Value ($N_{60}$) | 15 | OB Pressure at the center Layer (psf) | | 550 | **( inches)** |
| | Specific Gravity of Soil Solids (G) | 2.65 | Excess Pressure At Center Due to appliedLoad | | 5344 | |
| (Above the Water Table) | Estimated Moisture content ( %) | 8 | Bearing Capacity Index (C) | | 78 | |
| Z=2.8' (At Centre of Layer) | Liquid Limit (%) | NP | Immediate Settlement in Foundation Soil (inches) | | 0.89 | **0.89** |
| | Plastic Limit (%) | NP | Initial Void Ratio ($e_0$) | | 0.43 | |
| | Plasticity Index (%) | NP | | | | |
| | Unit Weight of soil (pcf) | 125 | | | | |
| $D_f$=7.2' & Z=5.6' | Submerged Unit Weight of Soil (pcf) | | OB Pressure at the bottom Layer (psf) | | 900 | |
| $D_f$=7.2' & Z=5.6' | Thickness of Layer (feet) | 2.3 | OB Pressure at the top Layer(psf) | | 900 | **Setlement** |
| | Ave. Corrected SPT Value ($N_{60}$) | 50+ | OB Pressure at the center Layer (psf) | | 989 | **( inches)** |
| | Specific Gravity of Soil Solids (G) | 2.65 | Excess Pressure At Center Due to appliedLoad | | 4629 | |
| (Below the Water Table) | Moisture content ( %) | 8 | Bearing Capacity Index (C) | | 153 | |
| Z=6.75' (At Centre of Layer) | Liquid Limit (%) | NP | Immediate Settlement in Foundation Soil (inches) | | 0.14 | **0.14** |
| | Plastic Limit (%) | NP | Initial Void Ratio ($e_0$) | | 0.28 | |
| | Plasticity Index (%) | NP | | | | |
| | Unit Weight of soil (pcf) | 140 | | | | |
| $D_f$=9.5' & Z=7.9' | Submerged Unit Weight of Soil (pcf) | 77.6 | OB Pressure at the bottom Layer (psf) | | 1078 | |
| | | | | **Total Settlement:** | | **1.02** |
| | | | | **Consolidation Settlement:** | | **0** |
| | | | | **Immediate Settlement:** | | **1.02** |

## MSE WALL SETTLEMENT ANALYSES - Rear MSE Wall

| | | | | | |
|---|---|---|---|---|---|
| **Project:** | HAN-75-14.39 - Bridge No. HAN-68-1526 | **Project #** | G13011G | **Test Boring #** | B-018-0-13 |
| **Type of Foundation** | Compression Index (Cc) (From Lab Test) | | Depth of Groundwater Level below Ground (feet) | | 31.5 |
| Shallow Foundation (Strip) | Recompression Index (Cr) (From Lab Test) | | Unit Weight of Water (pcf) | | 62.4 |
| Length = 240.0' | Depth of Footing ($D_f$) below ground (feet) | 21.2 | Specific Gravity of Soil Solids (G) | | |
| Width = 22.8' | Applied Design Pressure (psf) | 6,000 | Unit Weight of Soil above the base of foundation (pcf) | | 125 |

| **Depth Below the Foundation (Z)** | **AVERAGE PROPERTIES** | | **CALCULATIONS** | | **Total** |
|---|---|---|---|---|---|
| $D_f$=21.2' & Z=0.0 | Thickness of Layer (feet) | 5.8 | OB Pressure at the top Layer(psf) | 2650 | **Setlement** |
| | Estimated SPT Value ($N_{60}$) | 15 | OB Pressure at the center Layer (psf) | 3013 | **( inches)** |
| | Specific Gravity of Soil Solids (G) | 2.65 | Excess Pressure At Center Due to appliedLoad | 5375 | |
| (Above the Water Table) | Estimated Moisture content ( %) | 8 | Bearing Capacity Index (C) | 78 | |
| Z=2.65' (At Centre of Layer) | Liquid Limit (%) | NP | Immediate Settlement in Foundation Soil (inches) | 0.40 | **0.40** |
| | Plastic Limit (%) | NP | Initial Void Ratio ($e_0$) | 0.43 | |
| | Plasticity Index (%) | NP | | | |
| | Unit Weight of soil (pcf) | 125 | | | |
| $D_f$=27.0' & Z=5.3' | Submerged Unit Weight of Soil (pcf) | | OB Pressure at the bottom Layer (psf) | 3375 | |
| $D_f$=27.0' & Z=5.3' | Thickness of Layer (feet) | 4.5 | OB Pressure at the top Layer(psf) | 3375 | **Setlement** |
| | Ave. Corrected SPT Value ($N_{60}$) | 15 | OB Pressure at the center Layer (psf) | 3656 | **( inches)** |
| | Specific Gravity of Soil Solids (G) | 2.7 | Excess Pressure At Center Due to appliedLoad | 4507 | |
| (Below the Water Table) | Moisture content ( %) | 19 | Compression Index ($C_c$) | 0.19 | 0.19 |
| Z=7.55' (At Centre of Layer) | Liquid Limit (%) | 29 | Recompression Index ($C_r$) | 0.019 | |
| | Plastic Limit (%) | 18 | Initial Void Ratio ($e_0$) | 0.60 | |
| | Plasticity Index (%) | 11 | Settlement due to compression ( inches) | 2.23 | **2.23** |
| | Unit Weight of soil (pcf) | 125 | Settlement due to recompression (inches) | 0.22 | |
| $D_f$=31.5' & Z=9.8' | Submerged Unit Weight of Soil (pcf) | | OB Pressure at the bottom Layer (psf) | 3938 | |

| | |
|---|---|
| **Total Settlement:** | **2.63** |
| **Consolidation Settlement:** | **2.23** |
| **Immediate Settlement:** | **0.4** |

## MSE WALL SETTLEMENT ANALYSES - Rear MSE Wall

| | | | | | | |
|---|---|---|---|---|---|---|
| **Project:** | HAN-75-14.39 - Bridge No. HAN-68-1526 | | **Project #** | G13011G | **Test Boring #** | B-092-0-13 |
| **Type of Foundation** | Compression Index (Cc) (From Lab Test) | | | Depth of Groundwater Level below Ground (feet) | | 36 |
| Shallow Foundation (Strip) | Recompression Index (Cr) (From Lab Test) | | | Unit Weight of Water (pcf) | | 62.4 |
| Length = 240.0' | Depth of Footing ($D_f$) below ground (feet) | | 25.6 | Specific Gravity of Soil Solids (G) | | |
| Width = 22.8' | Applied Design Pressure (psf) | | 6,000 | Unit Weight of Soil above the base of foundation (pcf) | | 125 |
| **Depth Below the Foundation (Z)** | **AVERAGE PROPERTIES** | | **CALCULATIONS** | | | **Total** |
| $D_f$=25.6' & Z=0.0 | Thickness of Layer (feet) | 5.4 | OB Pressure at the top Layer(psf) | | 3200 | **Setlement** |
| | Estimated SPT Value ($N_{60}$) | 15 | OB Pressure at the center Layer (psf) | | 3538 | **( inches)** |
| | Specific Gravity of Soil Solids (G) | 2.65 | Excess Pressure At Center Due to appliedLoad | | 5365 | |
| (Above the Water Table) | Estimated Moisture content ( %) | 8 | Bearing Capacity Index (C) | | 78 | |
| Z=2.7' (At Centre of Layer) | Liquid Limit (%) | NP | Immediate Settlement in Foundation Soil (inches) | | 0.33 | **0.33** |
| | Plastic Limit (%) | NP | Initial Void Ratio ($e_0$) | | 0.43 | |
| | Plasticity Index (%) | NP | | | | |
| | Unit Weight of soil (pcf) | 125 | | | | |
| $D_f$=31.0' & Z=5.4' | Submerged Unit Weight of Soil (pcf) | | OB Pressure at the bottom Layer (psf) | | 3875 | |
| $D_f$=31.0' & Z=5.4' | Thickness of Layer (feet) | 5 | OB Pressure at the top Layer(psf) | | 3875 | **Setlement** |
| | Ave. Corrected SPT Value ($N_{60}$) | 18 | OB Pressure at the center Layer (psf) | | 4200 | **( inches)** |
| | Specific Gravity of Soil Solids (G) | 2.7 | Excess Pressure At Center Due to appliedLoad | | 4456 | |
| (Below the Water Table) | Moisture content ( %) | 24 | Compression Index ($C_c$) | | 0.24 | 0.24 |
| Z=7.90' (At Centre of Layer) | Liquid Limit (%) | 33 | Recompression Index ($C_r$) | | 0.024 | |
| | Plastic Limit (%) | 16 | Initial Void Ratio ($e_0$) | | 0.61 | |
| | Plasticity Index (%) | 17 | Settlement due to compression ( inches) | | 2.81 | **2.81** |
| | Unit Weight of soil (pcf) | 130 | Settlement due to recompression (inches) | | 0.28 | |
| $D_f$=36.0' & Z=10.4' | Submerged Unit Weight of Soil (pcf) | | OB Pressure at the bottom Layer (psf) | | 4525 | |

| | |
|---|---|
| **Total Settlement:** | **3.15** |
| **Consolidation Settlement:** | **2.81** |
| **Immediate Settlement:** | **0.34** |

## BRIDGE NO. HAN-75-1526 L & R
## Stress Distribution using 2 V : 1 H Slope Method for Strip Footing

**Boring No.: B-016-1-13**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Width of the footing B (feet)** | **22.8** | **Applied Design Pressure (psf)** | | | | **6000** | | | |
| Depth (Z) below the footing ( feet) | 2.3 | 5.6 | | | | | | | |
| Vertical Stress Intensity at Z q (psf) | 5450 | 4817 | | | | | | | |

**Boring No.: B-017-0-13**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Width of the footing B (feet)** | **22.8** | **Applied Design Pressure (psf)** | | | | **6000** | | | |
| Depth (Z) below the footing ( feet) | 2.8 | 6.75 | | | | | | | |
| Vertical Stress Intensity at Z q (psf) | 5344 | 4629 | | | | | | | |

**Boring No.: B-018-0-13**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Width of the footing B (feet)** | **22.8** | **Applied Design Pressure (psf)** | | | | **6000** | | | |
| Depth (Z) below the footing ( feet) | 2.65 | 7.55 | | | | | | | |
| Vertical Stress Intensity at Z q (psf) | 5375 | 4507 | | | | | | | |

**Boring No.: B-092-0-13**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Width of the footing B (feet)** | **22.8** | **Applied Design Pressure (psf)** | | | | **6000** | | | |
| Depth (Z) below the footing ( feet) | 2.7 | 7.9 | | | | | | | |
| Vertical Stress Intensity at Z q (psf) | 5365 | 4456 | | | | | | | |

| MSE WALL SETTLEMENT ANALYSES - Forward MSE Wall | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project:** | HAN-75-14.39 - Bridge No. HAN-68-1526 | | **Project #** | G13011G | **Test Boring #** | | B-019-0-13 |
| **Type of Foundation** | Compression Index (Cc) (From Lab Test) | | | Depth of Groundwater Level below Ground (feet) | | | 10 |
| Shallow Foundation (Strip) | Recompression Index (Cr) (From Lab Test) | | | Unit Weight of Water (pcf) | | | 62.4 |
| Length = 222.0' | Depth of Footing ($D_f$) below ground (feet) | | -1.5 | Specific Gravity of Soil Solids (G) | | | |
| Width = 22.1' | Applied Design Pressure (psf) | | 6,000 | Unit Weight of Soil above the base of foundation (pcf) | | | 125 |
| **Depth Below the Foundation (Z)** | **AVERAGE PROPERTIES** | | **CALCULATIONS** | | | | **Total** |
| $D_f$=-1.5' & Z=0.0 | Thickness of Layer (feet) | 5 | OB Pressure at the top Layer(psf) | | 0 | | **Setlement** |
| | Estimated SPT Value ($N_{60}$) | 15 | OB Pressure at the center Layer (psf) | | 313 | | **( inches)** |
| | Specific Gravity of Soil Solids (G) | 2.65 | Excess Pressure At Center Due to appliedLoad | | 5390 | | |
| (Above the Water Table) | Estimated Moisture content ( %) | 8 | Bearing Capacity Index (C) | | 78 | | |
| Z=2.5' (At Centre of Layer) | Liquid Limit (%) | NP | Immediate Settlement in Foundation Soil (inches) | | 0.97 | | **0.97** |
| | Plastic Limit (%) | NP | Initial Void Ratio ($e_0$) | | 0.43 | | |
| | Plasticity Index (%) | NP | | | | | |
| | Unit Weight of soil (pcf) | 125 | | | | | |
| $D_f$=3.5' & Z=5.0' | Submerged Unit Weight of Soil (pcf) | | OB Pressure at the bottom Layer (psf) | | 625 | | |
| $D_f$=3.5' & Z=5.0' | Thickness of Layer (feet) | 2.5 | OB Pressure at the top Layer(psf) | | 625 | | **Setlement** |
| | Ave. Corrected SPT Value ($N_{60}$) | 16 | OB Pressure at the center Layer (psf) | | 781 | | **( inches)** |
| | Specific Gravity of Soil Solids (G) | 2.7 | Excess Pressure At Center Due to appliedLoad | | 4677 | | |
| (Below the Water Table) | Moisture content ( %) | 20 | Compression Index ($C_c$) | | 0.2 | | 0.2 |
| Z=6.25' (At Centre of Layer) | Liquid Limit (%) | 38 | Recompression Index ($C_r$) | | 0.02 | | |
| | Plastic Limit (%) | 20 | Initial Void Ratio ($e_0$) | | 0.62 | | |
| | Plasticity Index (%) | 18 | Settlement due to compression ( inches) | | 3.13 | | **3.13** |
| | Unit Weight of soil (pcf) | 125 | Settlement due to recompression (inches) | | 0.31 | | |
| $D_f$=6.0' & Z=7.5' | Submerged Unit Weight of Soil (pcf) | | OB Pressure at the bottom Layer (psf) | | 938 | | |
| $D_f$=6.0' & Z=7.5 | Thickness of Layer (feet) | 2.5 | OB Pressure at the top Layer(psf) | | 938 | | **Setlement** |
| | Estimated SPT Value ($N_{60}$) | 7 | OB Pressure at the center Layer (psf) | | 1081 | | **( inches)** |
| | Specific Gravity of Soil Solids (G) | 2.65 | Excess Pressure At Center Due to appliedLoad | | 4298 | | |
| (Above the Water Table) | Moisture content ( %) | 9 | Bearing Capacity Index (C) | | 30 | | |
| Z=8.75' (At Centre of Layer) | Liquid Limit (%) | NP | Immediate Settlement in Foundation Soil (inches) | | 0.70 | | **0.70** |
| | Plastic Limit (%) | NP | Initial Void Ratio ($e_0$) | | 0.57 | | |
| | Plasticity Index (%) | NP | | | | | |
| | Unit Weight of soil (pcf) | 115 | | | | | |
| $D_f$=8.5' & Z=10.0' | Submerged Unit Weight of Soil (pcf) | | OB Pressure at the bottom Layer (psf) | | 1225 | | |

| **Project:** | HAN-75-14.39 - Bridge No. HAN-68-1526 | | **Project #** | G13011G | **Test Boring #** | B-019-0-13 |
|---|---|---|---|---|---|---|
| $D_f$=8.5' & Z=10.0' | Thickness of Layer (feet) | 1.5 | OB Pressure at the top Layer(psf) | | 1225 | **Setlement** |
| | Estimated SPT Value ($N_{60}$) | 53 | OB Pressure at the center Layer (psf) | | 1330 | **( inches)** |
| | Specific Gravity of Soil Solids (G) | 2.65 | Excess Pressure At Center Due to appliedLoad | | 4037 | |
| (Above the Water Table) | Moisture content ( %) | 8 | Bearing Capacity Index (C) | | 110 | |
| Z=10.75' (At Centre of Layer) | Liquid Limit (%) | NP | Immediate Settlement in Foundation Soil (inches) | | 0.10 | **0.10** |
| | Plastic Limit (%) | NP | Initial Void Ratio ($e_0$) | | 0.28 | |
| | Plasticity Index (%) | NP | | | | |
| | Unit Weight of soil (pcf) | 140 | | | | |
| $D_f$=10.0' & Z=11.5' | Submerged Unit Weight of Soil (pcf) | | OB Pressure at the bottom Layer (psf) | | 1435 | |
| | | | | | **Total Settlement:** | **4.9** |
| | | | | | **Consolidation Settlement:** | **3.13** |
| | | | | | **Immediate Settlement:** | **1.77** |

| MSE WALL SETTLEMENT ANALYSES - Forward MSE Wall | | | | | | |
|---|---|---|---|---|---|---|
| **Project:** | HAN-75-14.39 - Bridge No. HAN-68-1526 | | **Project #** | G13011G | **Test Boring #** | B-020-0-13 |
| **Type of Foundation** | Compression Index (Cc) (From Lab Test) | | | Depth of Groundwater Level below Ground (feet) | | 33.5 |
| Shallow Foundation (Strip) | Recompression Index (Cr) (From Lab Test) | | | Unit Weight of Water (pcf) | | 62.4 |
| Length = 222.0' | Depth of Footing ($D_f$) below ground (feet) | | 21.1 | Specific Gravity of Soil Solids (G) | | |
| Width = 22.1' | Applied Design Pressure (psf) | | 6,000 | Unit Weight of Soil above the base of foundation (pcf) | | 125 |
| **Depth Below the Foundation (Z)** | **AVERAGE PROPERTIES** | | **CALCULATIONS** | | | **Total** |
| $D_f$=21.1' & Z=0.0' | Thickness of Layer (feet) | 2.4 | OB Pressure at the top Layer(psf) | | 2638 | **Setlement** |
| | Ave. Corrected SPT Value ($N_{60}$) | 15 | OB Pressure at the center Layer (psf) | | 2788 | **( inches)** |
| | Specific Gravity of Soil Solids (G) | 2.65 | Excess Pressure At Center Due to appliedLoad | | 5691 | |
| (Above the Water Table) | Estimated Moisture content ( %) | 8 | Compression Index ($C_c$) | | 0.08 | 0.21 |
| Z=1.2' (At Centre of Layer) | Liquid Limit (%) | NP | Recompression Index ($C_r$) | | 0.008 | |
| | Plastic Limit (%) | NP | Initial Void Ratio ($e_0$) | | 0.43 | |
| | Plasticity Index (%) | NP | Settlement due to compression ( inches) | | 0.78 | **0.78** |
| | Unit Weight of soil (pcf) | 125 | Settlement due to recompression (inches) | | 0.08 | |
| $D_f$=23.5' & Z=2.4' | Submerged Unit Weight of Soil (pcf) | | OB Pressure at the bottom Layer (psf) | | 2938 | |
| $D_f$=23.5' & Z=2.4' | Thickness of Layer (feet) | 5 | OB Pressure at the top Layer(psf) | | 2938 | **Setlement** |
| | Ave. Corrected SPT Value ($N_{60}$) | 27 | OB Pressure at the center Layer (psf) | | 3275 | **( inches)** |
| | Specific Gravity of Soil Solids (G) | 2.7 | Excess Pressure At Center Due to appliedLoad | | 4911 | |
| (Above the Water Table) | Moisture content ( %) | 13 | Compression Index ($C_c$) | | 0.13 | 0.13 |
| Z=4.9' (At Centre of Layer) | Liquid Limit (%) | 24 | Recompression Index ($C_r$) | | 0.013 | |
| | Plastic Limit (%) | 19 | Initial Void Ratio ($e_0$) | | 0.41 | |
| | Plasticity Index (%) | 5 | Settlement due to compression ( inches) | | 2.20 | **2.20** |
| | Unit Weight of soil (pcf) | 135 | Settlement due to recompression (inches) | | 0.22 | |
| $D_f$=28.5' & Z=7.4' | Submerged Unit Weight of Soil (pcf) | | OB Pressure at the bottom Layer (psf) | | 3613 | |
| $D_f$=28.5' & Z=7.4' | Thickness of Layer (feet) | 5 | OB Pressure at the top Layer(psf) | | 3613 | **Setlement** |
| | Ave. Corrected SPT Value ($N_{60}$) | 16 | OB Pressure at the center Layer (psf) | | 3925 | **( inches)** |
| | Specific Gravity of Soil Solids (G) | 2.7 | Excess Pressure At Center Due to appliedLoad | | 4144 | |
| (Above the Water Table) | Moisture content ( %) | 20 | Compression Index ($C_c$) | | 0.2 | 0.2 |
| Z=9.9' (At Centre of Layer) | Liquid Limit (%) | 24 | Recompression Index ($C_r$) | | 0.02 | |
| | Plastic Limit (%) | 19 | Initial Void Ratio ($e_0$) | | 0.62 | |
| | Plasticity Index (%) | 5 | Settlement due to compression ( inches) | | 2.32 | **2.32** |
| | Unit Weight of soil (pcf) | 125 | Settlement due to recompression (inches) | | 0.23 | |
| $D_f$=33.5' & Z=12.4' | Submerged Unit Weight of Soil (pcf) | | OB Pressure at the bottom Layer (psf) | | 4238 | |

| Project: | HAN-75-14.39 - Bridge No. HAN-68-1526 | | Project # | G13011G | Test Boring # | B-020-0-13 |
|---|---|---|---|---|---|---|
| | | | | | Total Settlement: | 5.3 |
| | | | | | Consolidation Settlement: | 4.52 |
| | | | | | Immediate Settlement: | 0.78 |
| | | | | | | |
| | | | | | | |
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| | | | | | | |

| MSE WALL SETTLEMENT ANALYSES - Forward MSE Wall | | | | | | |
|---|---|---|---|---|---|---|
| **Project:** | HAN-75-14.39 - Bridge No. HAN-68-1526 | | **Project #** | G13011G | **Test Boring #** | B-020-1-13 |
| **Type of Foundation** | Compression Index (Cc) (From Lab Test) | | | Depth of Groundwater Level below Ground (feet) | | 12.4 |
| Shallow Foundation (Strip) | Recompression Index (Cr) (From Lab Test) | | | Unit Weight of Water (pcf) | | 62.4 |
| Length = 222.0' | Depth of Footing ($D_f$) below ground (feet) | | 1.5 | Specific Gravity of Soil Solids (G) | | |
| Width = 22.1' | Applied Design Pressure (psf) | | 6,000 | Unit Weight of Soil above the base of foundation (pcf) | | 125 |
| **Depth Below the Foundation (Z)** | **AVERAGE PROPERTIES** | | **CALCULATIONS** | | | **Total** |
| $D_f$=-1.5' & Z=0.0 | Thickness of Layer (feet) | 4.5 | OB Pressure at the top Layer(psf) | | 188 | **Setlement** |
| | Estimated SPT Value ($N_{60}$) | 15 | OB Pressure at the center Layer (psf) | | 469 | **( inches)** |
| | Specific Gravity of Soil Solids (G) | 2.65 | Excess Pressure At Center Due to appliedLoad | | 5446 | |
| (Above the Water Table) | Estimated Moisture content ( %) | 8 | Bearing Capacity Index (C) | | 78 | |
| Z=2.25' (At Centre of Layer) | Liquid Limit (%) | NP | Immediate Settlement in Foundation Soil (inches) | | 0.76 | **0.76** |
| | Plastic Limit (%) | NP | Initial Void Ratio ($e_0$) | | 0.43 | |
| | Plasticity Index (%) | NP | | | | |
| | Unit Weight of soil (pcf) | 125 | | | | |
| $D_f$=6.0' & Z=4.5' | Submerged Unit Weight of Soil (pcf) | | OB Pressure at the bottom Layer (psf) | | 750 | |
| $D_f$=6.0' & Z=4.5' | Thickness of Layer (feet) | 5.9 | OB Pressure at the top Layer(psf) | | 750 | **Setlement** |
| | Ave. Corrected SPT Value ($N_{60}$) | 12 | OB Pressure at the center Layer (psf) | | 1119 | **( inches)** |
| | Specific Gravity of Soil Solids (G) | 2.7 | Excess Pressure At Center Due to appliedLoad | | 4487 | |
| (Above the Water Table) | Moisture content ( %) | 19 | Compression Index ($C_c$) | | 0.19 | 0.19 |
| Z=7.45' (At Centre of Layer) | Liquid Limit (%) | | Recompression Index ($C_r$) | | 0.019 | |
| | Plastic Limit (%) | | Initial Void Ratio ($e_0$) | | 0.60 | |
| | Plasticity Index (%) | | Settlement due to compression ( inches) | | 5.87 | **5.87** |
| | Unit Weight of soil (pcf) | 125 | Settlement due to recompression (inches) | | 0.59 | |
| $D_f$=11.9' & Z=10.4' | Submerged Unit Weight of Soil (pcf) | | OB Pressure at the bottom Layer (psf) | | 1488 | |

| **Project:** | HAN-75-14.39 - Bridge No. HAN-68-1526 | | **Project #** | G13011G | **Test Boring #** | B-020-1-13 |
|---|---|---|---|---|---|---|
| $D_f$=11.9' & Z=10.4' | Thickness of Layer (feet) | 0.5 | OB Pressure at the top Layer(psf) | | 1488 | **Setlement** |
| | Estimated SPT Value ($N_{60}$) | 10 | OB Pressure at the center Layer (psf) | | 1516 | **( inches)** |
| | Specific Gravity of Soil Solids (G) | 2.65 | Excess Pressure At Center Due to appliedLoad | | 4049 | |
| (Above the Water Table) | Moisture content ( %) | 9 | Bearing Capacity Index (C) | | 40 | |
| Z=10.65' (At Centre of Layer) | Liquid Limit (%) | NP | Immediate Settlement in Foundation Soil (inches) | | 0.08 | **0.08** |
| | Plastic Limit (%) | NP | Initial Void Ratio ($e_0$) | | 0.57 | |
| | Plasticity Index (%) | NP | | | | |
| | Unit Weight of soil (pcf) | 115 | | | | |
| $D_f$=12.4' & Z=10.9' | Submerged Unit Weight of Soil (pcf) | | OB Pressure at the bottom Layer (psf) | | 1545 | |

| | |
|---|---|
| **Total Settlement:** | **6.72** |
| **Consolidation Settlement:** | **5.88** |
| **Immediate Settlement:** | **0.84** |

## BRIDGE NO. HAN-75-1526 L & R
## Stress Distribution using 2 V : 1 H Slope Method for Strip Footing

**Boring No.: B-019-0-13**

| **Width of the footing B (feet)** | **22.1** | **Applied Design Pressure (psf)** | | | | **6000** | | | |
|---|---|---|---|---|---|---|---|---|---|
| Depth (Z) below the footing ( feet) | 2.5 | 6.25 | 8.75 | 10.75 | | | | | |
| Vertical Stress Intensity at Z q (psf) | 5390 | 4677 | 4298 | 4037 | | | | | |

**Boring No.: B-020-0-13**

| **Width of the footing B (feet)** | **22.1** | **Applied Design Pressure (psf)** | | | | **6000** | | | |
|---|---|---|---|---|---|---|---|---|---|
| Depth (Z) below the footing ( feet) | 1.2 | 4.9 | 9.9 | | | | | | |
| Vertical Stress Intensity at Z q (psf) | 5691 | 4911 | 4144 | | | | | | |

**Boring No.: B-020-1-13**

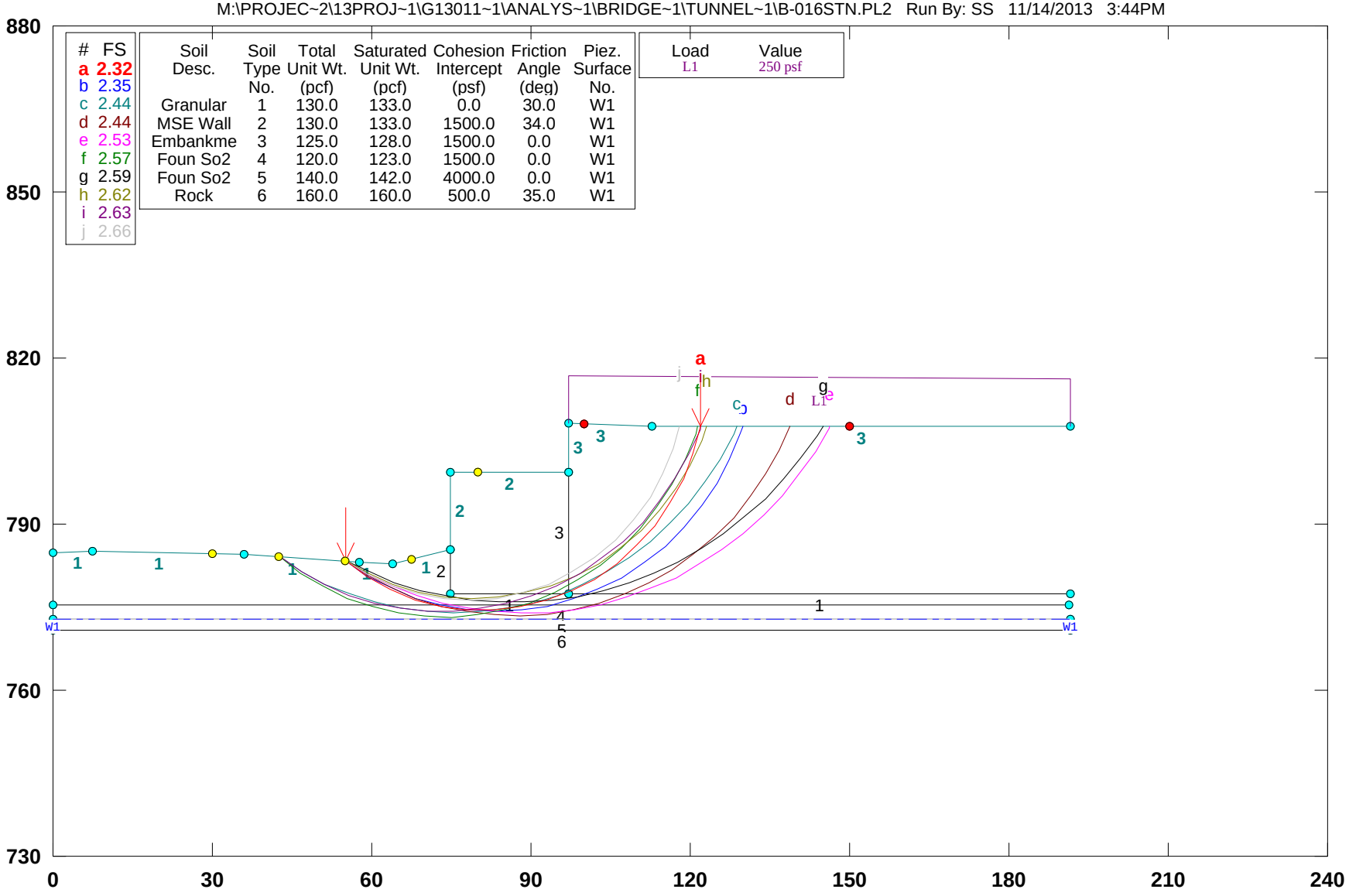
| **Width of the footing B (feet)** | **22.1** | **Applied Design Pressure (psf)** | | | | **6000** | | | |
|---|---|---|---|---|---|---|---|---|---|
| Depth (Z) below the footing ( feet) | 2.25 | 7.45 | 10.65 | | | | | | |
| Vertical Stress Intensity at Z q (psf) | 5446 | 4487 | 4049 | | | | | | |

**Boring No.:**

| **Width of the footing B (feet)** | | **Applied Design Pressure (psf)** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Depth (Z) below the footing ( feet) | | | | | | | | | |
| Vertical Stress Intensity at Z q (psf) | | | | | | | | | |

# HAN-75-14.39-Bridge No. HAN-75-1526-RearMSE Wall Global Stability Analysis-ST

M:\PROJEC~2\13PROJ~1\G13011~1\ANALYS~1\BRIDGE~1\TUNNEL~1\B-016STN.PL2 Run By: SS 11/14/2013 3:44PM




| # | FS |
|---|---|
| a | 2.32 |
| b | 2.35 |
| c | 2.44 |
| d | 2.44 |
| e | 2.53 |
| f | 2.57 |
| g | 2.59 |
| h | 2.62 |
| i | 2.63 |
| j | 2.66 |

| Soil Desc. | Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Piez. Surface No. |
|---|---|---|---|---|---|---|
| Granular | 1 | 130.0 | 133.0 | 0.0 | 30.0 | W1 |
| MSE Wall | 2 | 130.0 | 133.0 | 1500.0 | 34.0 | W1 |
| Embankme | 3 | 125.0 | 128.0 | 1500.0 | 0.0 | W1 |
| Foun So2 | 4 | 120.0 | 123.0 | 1500.0 | 0.0 | W1 |
| Foun So2 | 5 | 140.0 | 142.0 | 4000.0 | 0.0 | W1 |
| Rock | 6 | 160.0 | 160.0 | 500.0 | 35.0 | W1 |

| Load | Value |
|---|---|
| L1 | 250 psf |

**GSTABL7 v.2 FSmin=2.32**

**Safety Factors Are Calculated By The Modified Bishop Method**

GSTABL7

# HAN-75-14.39-Bridge No. HAN-75-1526-RearMSE Wall Global Stability Analysis-LT

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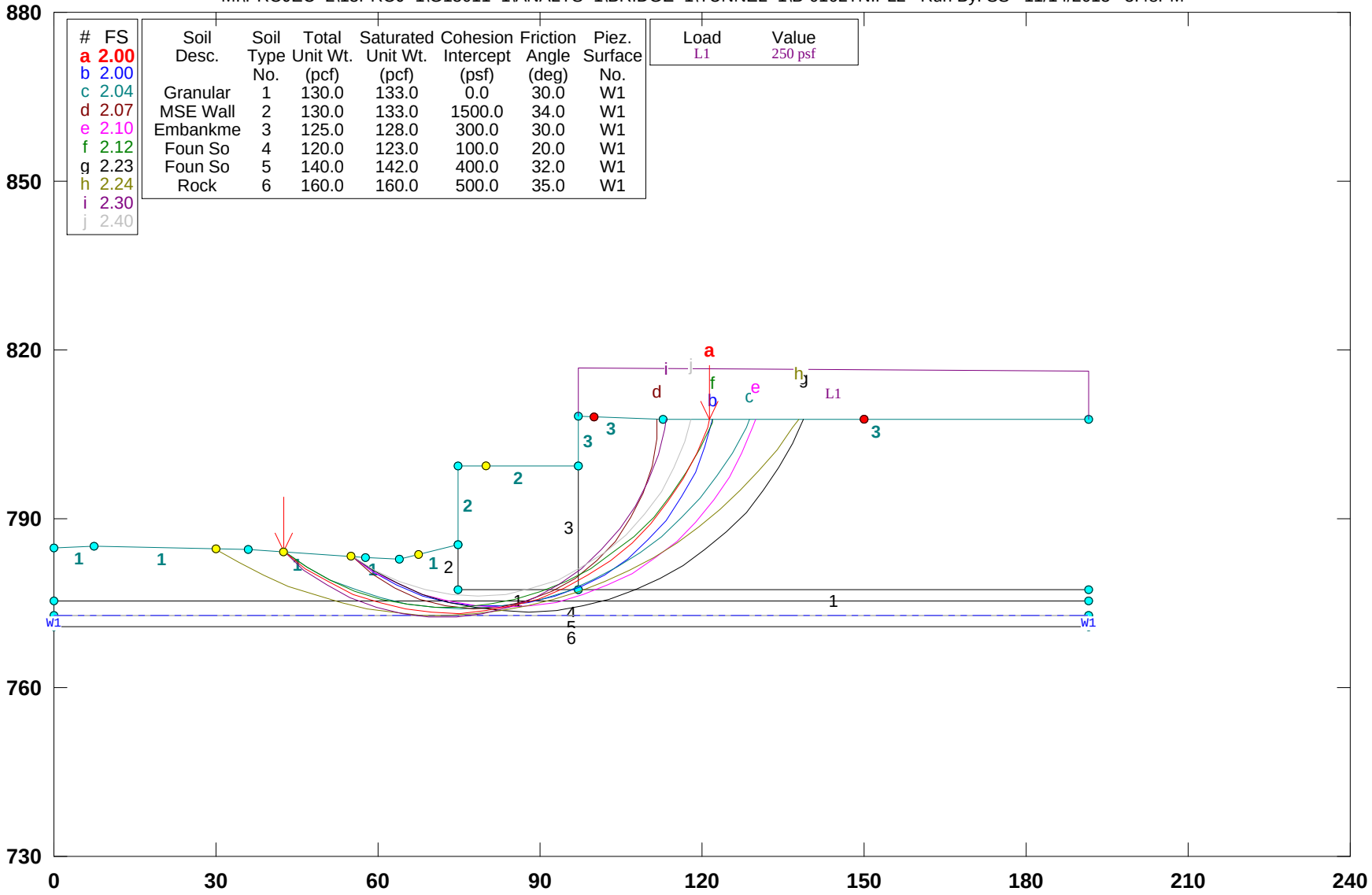



**GSTABL7 v.2 FSmin=2.00**

**Safety Factors Are Calculated By The Modified Bishop Method**

GSTABL7

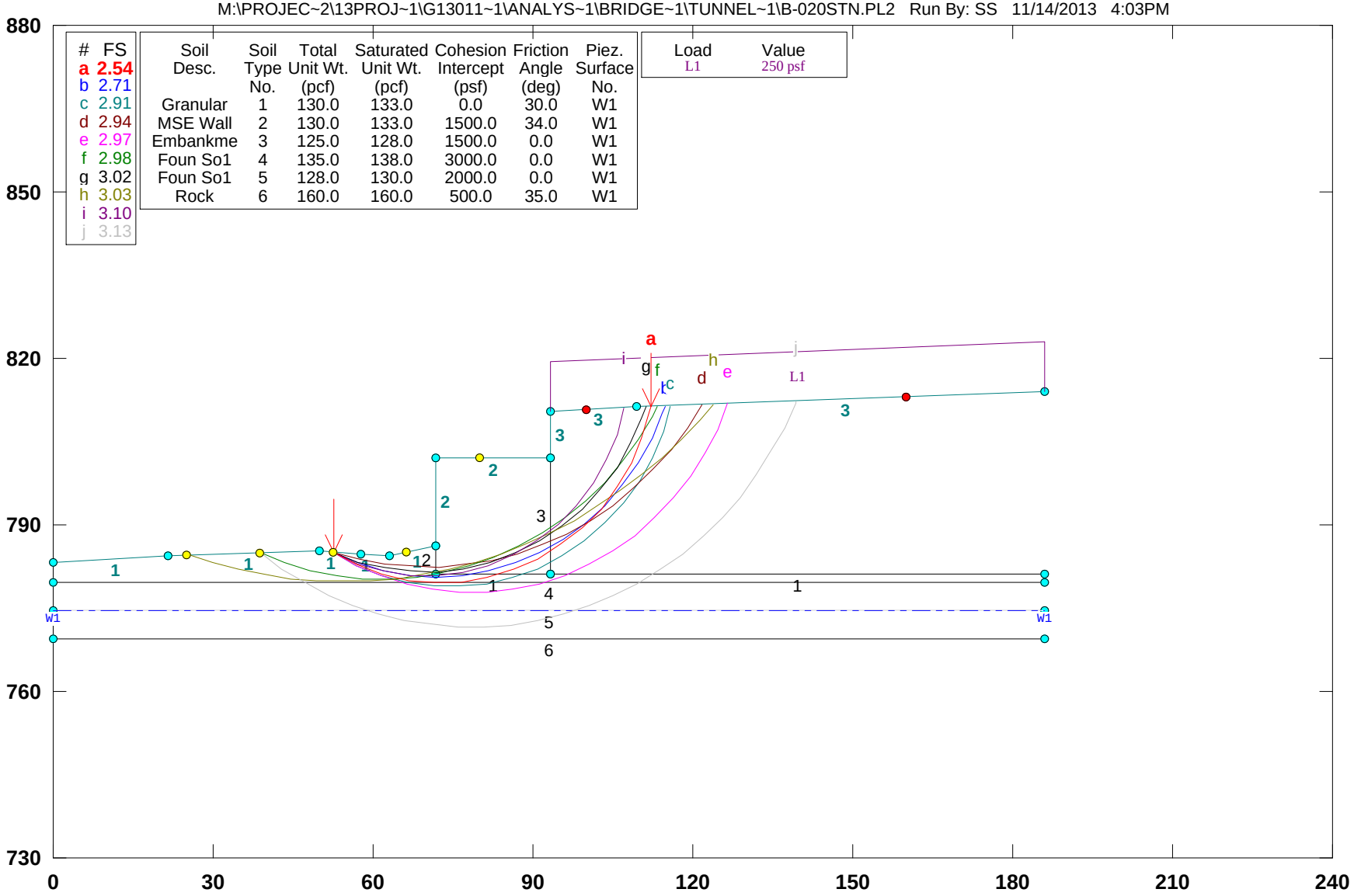
# HAN-75-14.39-Bridge No. HAN-75-1526-Forward MSEWall Global Stability Analysis-ST

M:\PROJEC~2\13PROJ~1\G13011~1\ANALYS~1\BRIDGE~1\TUNNEL~1\B-020STN.PL2 Run By: SS 11/14/2013 4:03PM

| # | FS |
|---|---|
| a | 2.54 |
| b | 2.71 |
| c | 2.91 |
| d | 2.94 |
| e | 2.97 |
| f | 2.98 |
| g | 3.02 |
| h | 3.03 |
| i | 3.10 |
| j | 3.13 |

| Soil Desc. | Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Piez. Surface No. |
|---|---|---|---|---|---|---|
| Granular | 1 | 130.0 | 133.0 | 0.0 | 30.0 | W1 |
| MSE Wall | 2 | 130.0 | 133.0 | 1500.0 | 34.0 | W1 |
| Embankme | 3 | 125.0 | 128.0 | 1500.0 | 0.0 | W1 |
| Foun So1 | 4 | 135.0 | 138.0 | 3000.0 | 0.0 | W1 |
| Foun So1 | 5 | 128.0 | 130.0 | 2000.0 | 0.0 | W1 |
| Rock | 6 | 160.0 | 160.0 | 500.0 | 35.0 | W1 |

| Load | Value |
|---|---|
| L1 | 250 psf |




**GSTABL7 v.2 FSmin=2.54**

**Safety Factors Are Calculated By The Modified Bishop Method**

GSTABL7

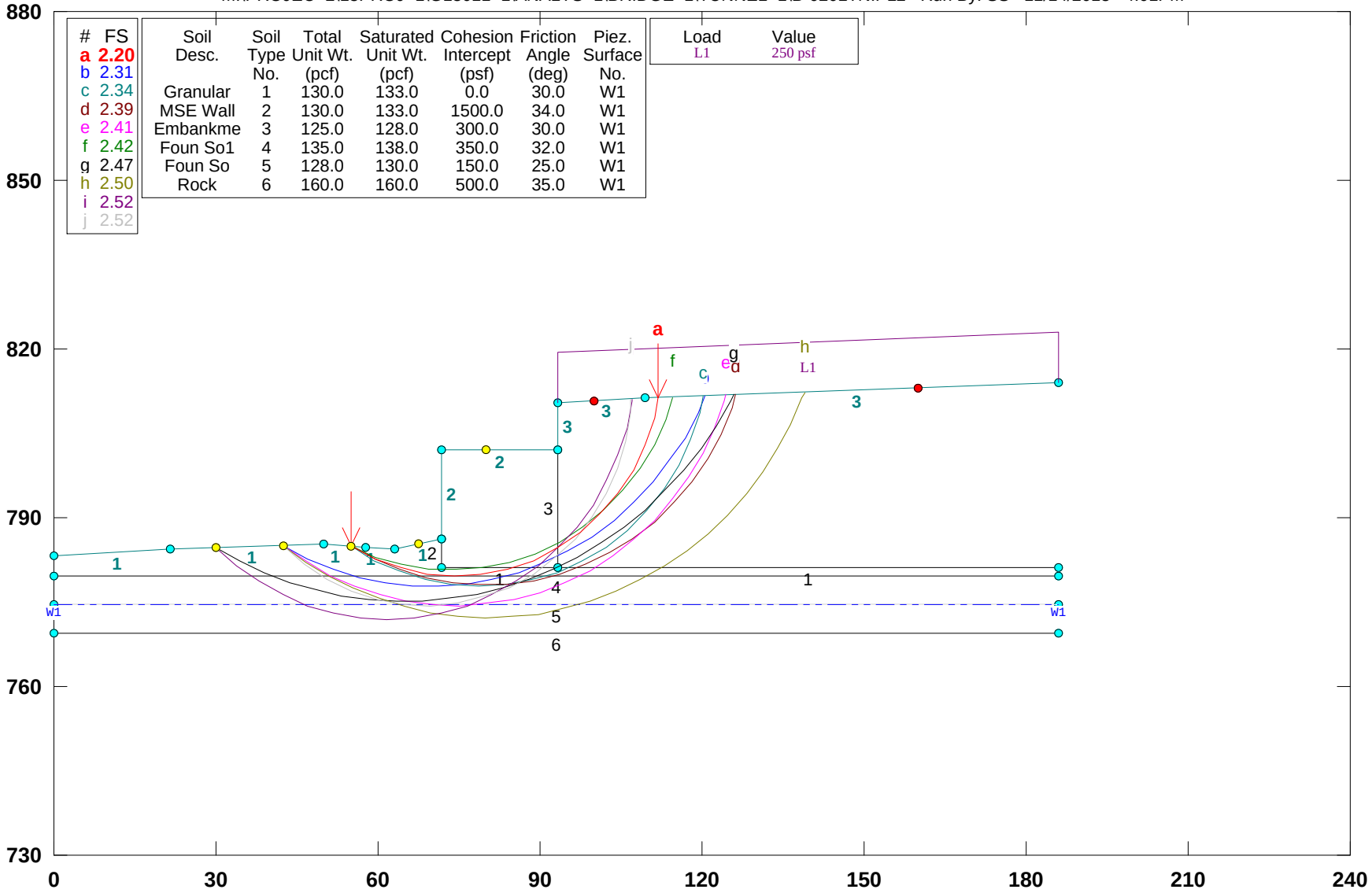
# HAN-75-14.39-Bridge No. HAN-75-1526-Forward MSEWall Global Stability Analysis-LT

M:\PROJEC~2\13PROJ~1\G13011~1\ANALYS~1\BRIDGE~1\TUNNEL~1\B-020LTN.PL2 Run By: SS 11/14/2013 4:01PM

| # | FS |
|---|---|
| a | 2.20 |
| b | 2.31 |
| c | 2.34 |
| d | 2.39 |
| e | 2.41 |
| f | 2.42 |
| g | 2.47 |
| h | 2.50 |
| i | 2.52 |
| j | 2.52 |

| Soil Desc. | Soil Type No. | Total Unit Wt. (pcf) | Saturated Unit Wt. (pcf) | Cohesion Intercept (psf) | Friction Angle (deg) | Piez. Surface No. |
|---|---|---|---|---|---|---|
| Granular | 1 | 130.0 | 133.0 | 0.0 | 30.0 | W1 |
| MSE Wall | 2 | 130.0 | 133.0 | 1500.0 | 34.0 | W1 |
| Embankme | 3 | 125.0 | 128.0 | 300.0 | 30.0 | W1 |
| Foun So1 | 4 | 135.0 | 138.0 | 350.0 | 32.0 | W1 |
| Foun So | 5 | 128.0 | 130.0 | 150.0 | 25.0 | W1 |
| Rock | 6 | 160.0 | 160.0 | 500.0 | 35.0 | W1 |

| Load | Value |
|---|---|
| L1 | 250 psf |




**GSTABL7 v.2 FSmin=2.20**

**Safety Factors Are Calculated By The Modified Bishop Method**

GSTABL7

## VI.D. Geotechnical Reports

| C-R-S: HAN-75-14.39-Bridge No. HAN-75-1526 | PID: 87005 | Reviewer: SS | Date: 11/3/2013 |
|---|---|---|---|

| General | | | |
|---|---|---|---|
| Y [N] X | 1 | Has the first complete version of a geotechnical report being submitted been labeled as 'Draft'? | |
| [Y] N X | 2 | Subsequent to ODOT's review and approval, has the complete version of the revised geotechnical report being submitted been labeled 'Final'? | |
| [Y] N X | 3 | Have all geotechnical reports being submitted been titled correctly as prescribed in Section 705.1 of the SGE? | |
| [Y] N X | 4 | Have all geotechnical reports included each of the sections as described in Sections 705.2 through 705.8.4 of the SGE? | |

Notes:

## IV.A Foundations/Structures - Non-bridge Applications

| C-R-S: HAN-75-14.39- Bridge No. HAN-75-1526 | PID: 87005 | Reviewer: SS | Date: 11/3/2013 |
|---|---|---|---|

If you do not have such a foundation or structure on the project, you do not have to fill out this checklist.

| **Soil and Bedrock Strength Data** | | |
|---|---|---|
| [Y] N X 1 | Has the shear strength of the foundation soils been determined? | |
| | Check method used: | |
| | 9 laboratory shear tests | |
| | [9] estimation from SPT or field tests | |
| Y N [X] 2 | Have sufficient soil shear strength, consolidation, and other parameters been determined so that the required allowable loads for the foundation/structure can be designed? | |
| [Y] N X 3 | Has the shear strength of the foundation bedrock been determined? | |
| | Check method used: | |
| | 9 laboratory shear tests | |
| | [9] other List Other items: | Unconfined Compression Strength of Bedrock |

Notes:

Stage 1:

## IV.A Foundations/Structures - Non-bridge Applications

| | | | | | |
|---|---|---|---|---|---|
| **Spread Footings** | | | | | |
| Y | [N] | | 4 | Are there spread footings on the project? | |
| | | | | If no, go to Question **11** | |
| Y | N | X | 5 | Has the recommended bottom of footing elevation and reason for this recommendation been provided? | |
| Y | N | X | | a Has the recommended bottom of footing elevation taken scour from streams or other water flow into account? | |
| | | | 6 | Were representative sections analyzed for the entire length of the structure for the following: | |
| Y | N | X | | a bearing capacity? | |
| Y | N | X | | b sliding? | |
| Y | N | X | | c Overturning? | |
| Y | N | X | | d settlement? | |
| Y | N | X | 7 | Has the need for a shear key been evaluated? | |
| Y | N | X | | a If needed, have the details been included in the plans? | |
| Y | N | X | 8 | If special conditions exist (e.g. geometry, sloping rock, varying soil conditions), was the bottom of footing “stepped” to accommodate them? | |
| Y | N | X | 9 | Has the recommended allowable soil or rock bearing pressure been provided? | |
| Y | N | X | 10 | If weak soil is present at the proposed foundation level, has the removal / treatment of this soil been developed and included in the plans? | |
| Y | N | X | | a Have the procedure and quantities related to this removal / treatment been included in the plans? | |

Notes:

Stage 1:

## IV.A Foundations/Structures - Non-bridge Applications

| | | | | |
|---|---|---|---|---|
| **Pile Structures - Bridge** | | | | |
| [Y] N | | 11 | Are there piles on the project?<br>If no, go to Question **17** | |
| [Y] N | | 12 | Has an appropriate pile type been selected?<br>Check the type selected:<br>9 H-pile (driven)<br>[9] H-pile (drilled)<br>9 Cast In-place Concrete<br>9 other List Other items: | |
| [Y] N | X | 13 | Have the estimated pile length or tip elevation and section (diameter) been specified?<br>Check method used:<br>9 SPILE, DRIVEN, PICAP3 or equivalent software<br>[9] hand calculations | |
| | | 14 | If required for design, have sufficient soil parameters been provided and calculations performed to evaluate the: | |
| Y [N] | X | | a Lateral load capacity and maximum deflection of the piles? | To be performed by PB |
| [Y] N | X | | b Vertical load capacity and maximum settlement of the piles? | |
| Y N | [X] | | c Negative skin friction on piles driven through new embankment or soft foundation layers? | |
| Y N | [X] | | d Potential for and impact of lateral squeeze from soft foundation soils? | |
| Y N | [X] | 15 | If piles are to be driven <u>to bedrock, have "pile points"</u> been recommended to assure secure contact with the rock surface, as per BDM 202.2.3.2.a? | Piles are to be installed by preboring into the soil and bedrock |
| Y N | [X] | 16 | If subsurface obstacles exist, has preboring been recommended to avoid these obstructions? | |

Notes:

Stage 1:

## IV.A Foundations/Structures - Non-bridge Applications

| Drilled Shafts | | | | | |
|---|---|---|---|---|---|
| Y | [N] | | 17 | Are there drilled shafts on the project? | |
| | | | | If no, go to the next checklist. | |
| Y | N | X | 18 | Have the drilled shaft diameter and embedment length been specified? | |
| Y | N | X | 19 | Have the recommended drilled shaft diameter and embedment been developed based on side friction and end bearing for vertical loading situations? | |
| | | | 20 | For shafts undergoing lateral loading, have the following been determined: | |
| Y | N | X | | a. maximum lateral shear | |
| Y | N | X | | b. maximum bending moment | |
| Y | N | X | | c. maximum deflection | |
| Y | N | X | | d. reinforcement design | |
| Y | N | X | 21 | Generally, bedrock sockets are 6" smaller in diameter than the soil embedment section of the drilled shaft. Has this factor been accounted for in the drilled shaft design? | |
| Y | N | X | 22 | If a bedrock socket is required below soil embedment, have separate quantities been estimated based on shaft diameters and materials to be excavated? | |
| Y | N | X | 23 | Has the site been assessed for groundwater influence? | |
| Y | N | X | | a If yes, if artesian flow is a potential concern, does the design address control of groundwater flow during construction? | |
| Y | N | X | 24 | If special construction features (e.g., slurry, casing, load tests) are required, have all the proper items been included in the plans? | |

Notes:

Stage 1

:

# LABORATORY TEST STANDARDS

| STANDARDS | REFERENCE NUMBER |
|---|---|

## I. Soil/Rock Testing

| | |
|---|---|
| Description and Identification of Soils (Visual-Manual Procedures) | ASTM D 2488 |
| Classification of Soils for Engineering Purposes (U.S.C.S.) | ASTM D 2487 |
| Laboratory Determination of Water (Moisture) Content of Soil and Rock | ASTM D 2216 |
| Classification for Sizes of Aggregate for Road and Bridge Construction | ASTM D 488 |
| Liquid Limit, Plastic Limit, and Plasticity Index of Soils…. | ASTM D 4318 |
| Shrinkage Factors of Soils by Mercury Method | ASTM D 427 |
| Moisture, Ash, and Organic Matter of Peat and Other Organic Soils | ASTM D 2974 |
| Specific gravity of Soils | ASTM D 854 |
| Direct Shear Test of Soils under Consolidated Drained Conditions | ASTM D 3080 |
| Particle-Size Analysis of Soils | ASTM D 422 |
| Unconfined Compressive Strength of Cohesive Soils | ASTM D 2166 |
| Unconfined Compressive Strength of Intact Rock Core Specimens | ASTM D 2938 |
| Slake Durability Index of Shale/Similar Weak Rock Test | ASTM D 4644 |
| Point Load Test of Rock Core Specimens | ISRM*/ASTM D5731 |
| CBR (California Bearing Ration) of Laboratory-Compacted Soils | ASTM D 1883 |
| Laboratory Compaction Characteristics of Soil using Standard Effort | ASTM D 698 |
| Laboratory Compaction Characteristics of Soil using Modified Effort | ASTM D 1557 |
| One-Dimensional Consolidation Properties of Soils | ASTM D 2435 |
| One-Dimensional Swell or Settlement Potential of Cohesive Soils | ASTM D 4546 |
| pH of Soil | ASTM D 4972 |

* ISRM - International Society for Rock Mechanics

## II. Concrete Testing

| | |
|---|---|
| Compressive Strength of Cylindrical Concrete Specimens | ASTM C 39 |
| Acid-Soluble Chloride in Mortar and Concrete | ASTM C 1152 |

# CLASSIFICATION OF SOILS

Ohio Department of Transportation

(The classification of a soil is found by proceeding from top to bottom of the chart.
The first classification that the test data fits is the correct classification.)

| SYMBOL | DESCRIPTION | Classifcation AASHTO | Classifcation OHIO | $LL_0/LL \times 100$* | % Pass #40 | % Pass #200 | Liquid Limit (LL) | Plastic Index (PI) | Group Index Max. | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
|  | Gravel and/or Stone Fragments | A-1-a | | | 30 Max. | 15 Max. | | 6 Max. | 0 | Min. of 50% combined gravel, cobble and boulder sizes |
|  | Gravel and/or Stone Fragments with Sand | A-1-b | | | 50 Max. | 25 Max. | | 6 Max. | 0 | |
|  | Fine Sand | A-3 | | | 51 Min. | 10 Max. | NON-PLASTIC | | 0 | |
|  | Coarse and Fine Sand | -- | A-3a | | | 35 Max. | | 6 Max. | 0 | Min. of 50% combined coarse and fine sand sizes |
|  | Gravel and/or Stone Fragments with Sand and Silt | A-2-4<br>A-2-5 | | | | 35 Max. | 40 Max.<br>41 Min. | 10 Max. | 0 | |
|  | Gravel and/or Stone Fragments with Sand, Silt and Clay | A-2-6<br>A-2-7 | | | | 35 Max. | 40 Max.<br>41 Min. | 11 Min. | 4 | |
|  | Sandy Silt | A-4 | A-4a | 76 Min. | | 36 Min. | 40 Max. | 10 Max. | 8 | Less than 50% silt sizes |
|  | Silt | A-4 | A-4b | 76 Min. | | 50 Min. | 40 Max. | 10 Max. | 8 | 50% or more silt sizes |
|  | Elastic Silt and Clay | A-5 | | 76 Min. | | 36 Min. | 41 Min. | 10 Max. | 12 | |
|  | Silt and Clay | A-6 | A-6a | 76 Min. | | 36 Min. | 40 Max. | 11 - 15 | 10 | |
|  | Silty Clay | A-6 | A-6b | 76 Min. | | 36 Min. | 40 Max. | 16 Min. | 16 | |
|  | Elastic Clay | A-7-5 | | 76 Min. | | 36 Min. | 41 Min. | $\leq$LL-30 | 20 | |
|  | Clay | A-7-6 | | 76 Min. | | 36 Min. | 41 Min. | >LL-30 | 20 | |
|  | Organic Silt | A-8 | A-8a | 75 Max. | | 36 Min. | | | | W/o organics would classify as A-4a or A-4b |
|  | Organic Clay | A-8 | A-8b | 75 Max. | | 36 Min. | | | | W/o organics would classify as A-5, A-6a, A-6b, A-7-5 or A-7-6 |

MATERIAL CLASSIFIED BY VISUAL INSPECTION

 Sod and Topsoil

 Pavement or Base

 Uncontrolled Fill (Describe)

 Bouldery Zone

 Peat, S-Sedimentary W-Woody F-Fibrous L-Loamy & etc

* Only perform the oven-dried liquid limit test and this calculation if organic material is present in the sample.

## APPENDIX A.1 - ODOT Quick Reference for Visual Description of Soils

**1) STRENGTH OF SOIL:**

| Non-Cohesive (granular) Soils - Compactness | |
|---|---|
| **Description** | **Blows Per Ft.** |
| **Very Loose** | ≤ 4 |
| **Loose** | 5 – 10 |
| **Medium Dense** | 11 – 30 |
| **Dense** | 31 – 50 |
| **Very Dense** | > 50 |

**2) COLOR :**

If a color is a uniform color throughout, the term is single, modified by an adjective such as light or dark. If the predominate color is shaded by a secondary color, the secondary color procedes the primary color. If two major and distinct colors are swirled throughout the soil, the colors are modified by the term "mottled"

**3) PRIMARY COMPONENT**

Use **DESCRIPTION** from ODOT Soil Classification Chart on Back

Cohesive (fine grained) Soils - Consistency

| Description | Qu (TSF) | Blows Per Ft. | Hand Manipulation |
|---|---|---|---|
| **Very Soft** | <0.25 | <2 | Easily penetrates 2" by fist |
| **Soft** | 0.25-0.5 | 2 - 4 | Easily penetrates 2" by thumb |
| **Medium Stiff** | 0.5-1.0 | 5 - 8 | Penetrates by thumb with moderate effort |
| **Stiff** | 1.0-2.0 | 9 - 15 | Readily indents by thumb, but not penetrate |
| **Very Stiff** | 2.0-4.0 | 16 - 30 | Readily indents by thumbnail |
| **Hard** | >4.0 | >30 | Indent with difficulty by thumbnail |

**4) COMPONENT MODIFIERS:**

| Description | Percentage By Weight |
|---|---|
| **Trace** | 0% - 10% |
| **Little** | 10% - 20% |
| **Some** | 20% - 35% |
| **"And"** | 35% -50% |

**5) Soil Organic Content**

| Description | % by Weight |
|---|---|
| **Slightly Organic** | 2% - 4% |
| **Moderately Organic** | 4% - 10% |
| **Highly Organic** | > 10% |

**6) Relative Visual Moisture**

| Description | Criteria | |
|---|---|---|
| | **Cohesive Soil** | **Non-cohesive Soils** |
| **Dry** | Powdery;<br>Cannot be rolled;<br>Water content well below the plastic limit | No moisture present |
| **Damp** | Leaves very little moisture when pressed between fingers;<br>Crumbles at or before rolled to $^1/_8$";<br>Water content below plastic limit | Internal moisture, but no to little surface moisture |
| **Moist** | Leaves small amounts of moisture when pressed between fingers;<br>Rolled to $^1/_8$" or smaller before crumbling;<br>Water content above plastic limit to -3% of the liquid limit | Free water on surface, moist (shiny) appearance |
| **Wet** | Very mushy;<br>Rolled multiple times to $^1/_8$" or smaller before crumbles;<br>Near or above the liquid limit | Voids filled with free water, can be poured from split spoon. |

# APPENDIX A.2 - ODOT Quick Reference Guide for Rock Description

**1) ROCK TYPE:** Common rock types are: Claystone; Coal; Dolomite; Limestone; Sandstone; Siltstone; & Shale.

**2) COLOR:** To be determined when rock is wet. When using the GSA Color charts use only Name, not code.

**3) WEATHERING**

| Description | Field Parameter |
|---|---|
| **Unweathered** | No evidence of any chemical or mechanical alternation of the rock mass. Mineral crystals have a bright appearance with no discoloration. Fractures show little or no staining on surfaces. |
| **Slightly weathered** | Slight discoloration of the rock surface with minor alterations along discontinuities. Less than 10% of the rock volume presents alteration. |
| **Moderately weathered** | Portions of the rock mass are discolored as evident by a dull appearance. Surfaces may have a pitted appearance with weathering "halos" evident. Isolated zones of varying rock strengths due to alteration may be present. 10 to 15% of the rock volume presents alterations. |
| **Highly weathered** | Entire rock mass appears discolored and dull. Some pockets of slightly to moderately weathered rock may be present and some areas of severely weathered materials may be present. |
| **Severely weathered** | Majority of the rock mass reduced to a soil-like state with relic rock structure discernable. Zones of more resistant rock may be present, but the material can generally be molded and crumbled by hand pressures. |

**4) RELATIVE STRENGTH**

| Description | Field Parameter |
|---|---|
| **Very Weak** | Core can be carved with a knife and scratched by fingernail. Can be excavated readily with a point of a pick. Pieces 1 inch or more in thickness can be broken by finger pressure. |
| **Weak** | Core can be grooved or gouged readily by a knife or pick. Can be excavated in small fragments by moderate blows of a pick point. Small, thin pieces can be broken by finger pressure. |
| **Slightly Strong** | Core can be grooved or gouged 0.05 inch deep by firm pressure of a knife or pick point. Can be excavated in small chips to pieces about 1-inch maximum size by hard blows of the point of a geologist's pick. |
| **Moderately Strong** | Core can be scratched with a knife or pick. Grooves or gouges to ¼" deep can be excavated by hand blows of a geologist's pick. Requires moderate hammer blows to detach hand specimen. |
| **Strong** | Core can be scratched with a knife or pick only with difficulty. Requires hard hammer blows to detach hand specimen. Sharp and resistant edges are present on hand specimen. |
| **Very Strong** | Core cannot be scratched by a knife or sharp pick. Breaking of hand specimens requires hard repeated blows of the geologist hammer. |
| **Extremely strong** | Core cannot be scratched by a knife or sharp pick. Chipping of hand specimens requires hard repeated blows of the geologist hammer. |

**5) TEXTURE**

| Component | | Grain Diameter |
|---|---|---|
| **Boulder** | | >12" |
| **Cobble** | | 3"-12" |
| **Gravel** | | 0.08"-3" |
| **Sand** | **Coarse** | 0.02"-0.08" |
| | **Medium** | 0.01"-0.02" |
| | **Fine** | 0.005"-0.01" |
| | **Very fine** | 0.003"-0.005" |

**6) BEDDING**

| Description | Thickness |
|---|---|
| **Very Thick** | >36" |
| **Thick** | 18" – 36" |
| **Medium** | 10" – 18" |
| **Thin** | 2" – 10" |
| **Very Thin** | 0.4" – 2" |
| **Laminated** | 0.1" – 0.4" |
| **Thinly Laminated** | <0.1" |

## 7) DESCRIPTORS

| | | |
|---|---|---|
| Arenaceous – sandy | Argillaceous - clayey | Brecciated – contains angular to subangular gravel |
| Calcareous - contains calcium carbonate | Carbonaceous - contains carbon | Cherty- contains chert fragments |
| Conglomeritic - contains rounded to subrounded gravel | Crystalline – contains crystalline structure | Dolomitic- contains calcium/magnesium carbonate |
| Ferriferous – contains iron | Fissile – thin planner partings | Fossiliferous – contains fossils |
| Friable – easily broken down | Micaceous – contains mica | Pyritic – contains pyrite |
| Siliceous – contains silica | Stylolitic – contain stylotites (suture like structure) | Vuggy – contains openings |

## 8) DISCONTINUITIES

**a) Discontinuity Types**

| Type | Parameters |
|---|---|
| ***Fault*** | Fracture which expresses displacement parallel to the surface that does not result in a polished surface. |
| ***Joint*** | Planar fracture that does not express displacement. Generally occurs at regularly spaced intervals. |
| ***Shear*** | Fracture which expresses displacement parallel to the surface that results in polished surfaces or slickensides. |
| ***Bedding*** | A surface produced along a bedding plane. |
| ***Contact*** | A surface produced along a contact plane. (generally not seen in Ohio) |
| | |

**b) Degree of Fracturing**

| Description | Spacing |
|---|---|
| **Unfractured** | > 10 ft |
| **Intact** | 3 ft. – 10 ft. |
| **Slightly fractured** | 1 ft – 3 ft |
| **Moderately fractured** | 4 in. – 12 in. |
| **Fractured** | 2 in – 4 in. |
| **Highly fractured** | < 2 in. |

**c) Aperture Width**

| Description | Spacing |
|---|---|
| **Open** | > 0.2 in. |
| **Narrow** | 0.05 in. - 0.2 in. |
| **Tight** | <0.05 in. |
| | |

**d) Surface Roughness**

| Description | Criteria |
|---|---|
| **Very Rough** | Near vertical steps and ridges occur on the discontinuity surface. |
| **Slightly Rough** | Asperities on the discontinuity surface are distinguishable and can be felt. |
| **Slickensided** | Surface has a smooth, glassy finish with visual evidence of striation. |
| | |

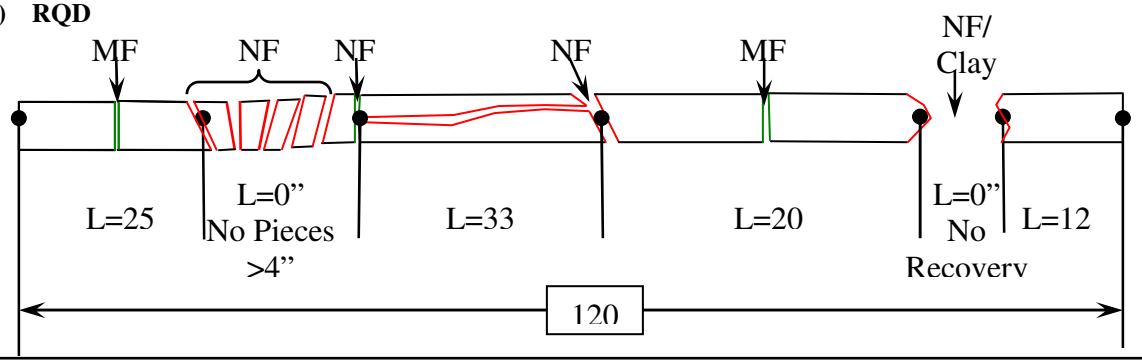
**10) LOSS**

$$Run\ Loss = \left(\frac{L_R - R_R}{L_R}\right) * 100 \qquad Unit\ Loss = \left(\frac{L_U - R_U}{L_U}\right) * 100$$

$L_R$=Run Length $R_R$=Run Recovery

$L_U$=Rock Unit Length $R_U$=Rock Unit Recovery

## 9) RQD




$$RQD = \left(\frac{\sum Length\ of\ Pieces > 4inches}{Total\ Length\ of\ Core}\right) * 100$$

$$RQD = \left(\frac{25+33+20+12}{120}\right) * 100 = 75\%$$