Stantec

Stantec Consulting Services Inc.
10200 Alliance Road, Suite 300, Cincinnati OH 45242

December 14, 2023
File: 175538118

Attention: Daniel J. Lorenz, PE
LPA Manager
Ohio Department of Transportation, District 11
2201 Reiser Avenue SE
New Philadelphia, Ohio 44663

Reference: Report of Geotechnical Exploration (FINAL)
BEL-CR4-27.05 Bridge Replacement, PID 117373
Belmont County, Ohio

Dear Mr. Lorenz,

Stantec Consulting Services Inc. (Stantec) has completed the final geotechnical exploration report for the replacement of Glenns Run Road (County Road 4) Bridge over Glenns Run in Belmont County, Ohio. The enclosed report contains a brief description of the site, geologic conditions encountered, the scope of work performed, and geotechnical recommendations for the proposed bridge replacement.

Regards,

Stantec Consulting Services Inc.

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Attachment: Report of Geotechnical Exploration (FINAL)

Cc: Terry D. Lively, PE, PS – Belmont County Engineer, Bill Marty, PE – Carpenter Marty Transportation, Greg Johnson, PE – Carpenter Marty Transportation, Jeff Peyton – Ohio Department of Transportation

BEL-CR4-27.05 Bridge Replacement over Glenns Run

Report of Structure Foundation Exploration (Final)

PID No. 117373

Belmont County, Ohio

December 14, 2023

Prepared for:

Ohio Department of Transportation, District 11

Prepared by:

Stantec Consulting Services Inc.
Cincinnati, Ohio

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Executive Summary

The replacement of the County Route 4 bridge over Glenn's Run in Belmont County, Ohio is planned. Stantec Consulting Services Inc. (Stantec) was contracted by the Ohio Department of Transportation (ODOT) to perform the geotechnical exploration for the project and provide recommendations for the design and construction of the replacement bridge foundations. The existing bridge is a 69-foot-long pony truss structure and is planned to be replaced with a 84-foot-long single span bridge.

Two borings were advanced behind the existing bridge abutments for this project to obtain geotechnical data for the proposed bridge foundations. The surface material encountered in the borings advanced near the proposed abutment locations consisted of 6 to 8 inches of asphalt pavement underlain by about 6 to 8 inches of aggregate base. In B-001, the soil below the surface materials is loose to medium dense gravel and stone fragments with silt and clay (A-2-4), and stiff silt and clay (A-6a). Liquid limits ranged from 30 to 38 and plasticity indices varied from 8 to 15. In B-002, soil below the surface materials is stiff clay (A-7-6) and medium dense gravel and stone fragments with sand, silt, and clay (A-2-7). Liquid limits were 42 and 43 and the plasticity index varied from 16 to 18.

Bedrock was encountered at depths of 14.0 feet (Elevation 691.3) and 12.8 feet (Elevation 692.9) at B-001 and B-002, respectively. Bedrock is interbedded shale and limestone, red claystone, and red and gray shale. Limestone was described as slightly weathered, moderately fractured and very strong. Shale and claystone were described as slightly weathered, moderately fractured and weak.

Groundwater was encountered in both borings during drilling. Groundwater was observed at depths of about 14.0 feet (Elevation 691.3) and 11.2 feet (Elevation 694.5) at B-001 and B-002, respectively. Groundwater readings were taken before rock coring.

It is recommended that the replacement bridge be supported by pre-bored steel H-piles or drilled shafts socketed into bedrock. Spread footings are not recommended based on the history of high scourability of bedrock at the site and on nearby bridges. Prebored steel H-piles should be extended a minimum of 10 feet into bedrock. The recommended tip elevation for drilled shafts is 688 feet or below, based on the presence of a severely weathered clayey bedrock seam in boring B-002-0-23 from an elevation of 690.9 to 688.3. Abutment walls and sheeting and shoring systems should be designed to withstand the development of lateral earth pressures and hydrostatic pressures. The recommended D50 value for soil scour analysis is 1.1 mm. The bedrock at the site should be considered non-scour resistant according to ODOT BDM 305.2.1.2.b with a recommended Erodibility Index of 2.8. The project site classifies as Seismic Site Class D based on the observed subsurface conditions.

1.0 INTRODUCTION

The replacement of the County Route (CR) 4 bridge over Glenns Run in Belmont County, Ohio is planned. Stantec Consulting Services Inc. (Stantec) was contracted by the Ohio Department of Transportation (ODOT) to perform the geotechnical exploration for the project and provide recommendations for the design and construction of the replacement bridge foundations. The existing bridge is a 69-foot-long pony truss structure and is planned to be replaced with a 84-foot-long single span bridge. Figure 1 shows the site vicinity.

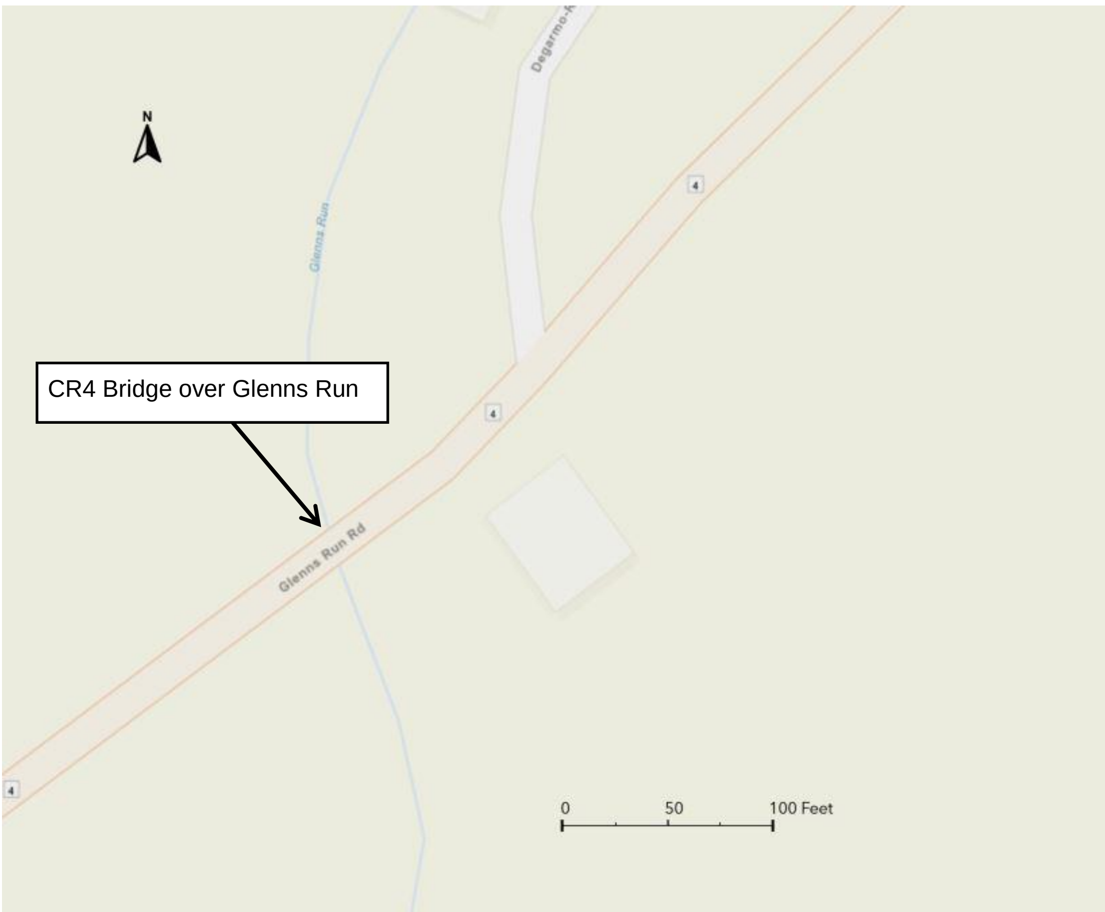


Figure 1. Site Vicinity
(Source: ESRI Community Map Contributors)

2.0 GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1 GENERAL

The Physiographic Regions of Ohio Map (Brockman, 1998) indicates that the project site is located within the Little Switzerland Plateau physiographic region. The region is characterized by a high relief plateau with elevations of 540 to 1400 feet. Bedrock at the site is Pennsylvanian-age Conemaugh group comprising of mostly fine-grained bedrock that include cyclic sequences of gray and red shale, sandstone, siltstone, limestone, and a few coal seams. Soils typically are red and brown silty-clay loam colluvium and landslide deposits.

2.2 SOIL GEOLOGY

The soil survey (Web Soil Survey of Belmont County, Ohio, United States Department of Agriculture (USDA), 2023) indicates that the project site is underlain primarily by colluvium soils from the Richland silt loam complex. The typical profile of the Richland complex includes 0 to 5 inches of silt loam followed by 5 to 55 inches of clay loam and 55 to 80 inches of channery clay loam. The soils are well drained with a moderately high to high capacity to transmit water.

2.3 BEDROCK GEOLOGY

Bedrock mapping (Ohio Geology Interactive Map ODNR, 2023) and Geology and Coal Resources of Belmont County, Ohio (BerryHill Jr., 1963) indicates that the overburden soils at the project site are underlain primarily by Pennsylvanian aged sedimentary bedrock from the Conemaugh Formation. The Conemaugh Group is comprised of shale, siltstone, sandstone, mudstone and scarce amounts of limestone and coal. The bedrock is described as shades of gray, green, red, brown, and black and ranges in thickness from 350 to 490 feet.

The Ohio Water Wells Database (ODNR, 2023) shows records of a 56 feet deep well located 0.14 miles northeast of the site. According to the well log, bedrock is cyclic sequences of shale and limestone with top of rock being 15 feet deep.

2.4 HYDROLOGY

The proposed bridge crosses Glenns Run, which flows west to Florence, Ohio, crosses below State Route 7 and discharges into the Ohio River. Glenn’s Run receives an annual precipitation of about 40.2 inches.

2.5 HYDROGEOLOGY

According to the Groundwater Resources of Belmont County map (ODNR, 1985), the project site is in an area where wells with yields of 6 gallons per minute can be achieved. The principal aquifer in the area is limestone, sandstone, and shale.

A search was performed using the ODNR Ohio Water Wells Map (2023) to determine if any water wells are located near the project site. According to the map, three water wells have been drilled within 0.6 miles of the project footprint. The well logs indicate a bedrock depth ranging from 10 to 17 feet. The bedrock encountered at all three wells was described as shale and limestone. Only one of the logs has records of static water depth. The static water depth is recorded as 26 feet.

2.6 GEOLOGIC HAZARDS

Geologic Hazard mapping (Ohio Geology Interactive Map ODNR, 2023) indicates the possible geologic hazards within the project site vicinity are abandoned underground mines, karsts, landslides, and seismic activity. There are two abandoned underground coal mines near the project footprint. One mine, the Dorothy-Barton mine, abandoned in 1960, is located to the north of the project site while the other mine, the Burlington mine abandoned in 1925, is located south of the project site. The mines' peripheries are within a 500-foot radius of the project site.

Overall, Karst features in Belmont County are rare. The Karst Interactive Map (Ohio Geology Interactive Map ODNR, 2023) indicates one suspected Karst about 3 miles away from the project area. It is the only documented Karst reported in the county.

Compared to the rest of Ohio, Belmont County is relatively prone to landslides. Historical records in the ODOT Transportation Information Mapping System show numerous slide repairs in the county. Pennsylvanian-age red mudstone are the most prone to landslides, forming rotational slumps and earthflows when wet. Sandstone rock falls from steep slopes are also common (Hansen, 1995).

According to the ODNR Geologic Hazards database (Ohio Geology Interactive Map ODNR, 2023), Ohio has a relatively limited amount of seismic activity. There have been four documented earthquake epicenters within a 10-mile radius of the project site. The earthquakes epicenters are with moment magnitudes ranging from 1.2 to 1.4. The available data reviewed included events that occurred in Ohio from 1804 to present day.

2.7 SITE RECONNAISSANCE

Stantec representatives visited the site on February 17, 2023 to mark boring locations and perform site reconnaissance. The project site surrounding area has sparse residences and forested hills on either side. While the pavement was in very good condition, the bridge structure was rusted, and the concrete abutment walls cracked. The stringer end beams, floor beams and truss frames were rusty. Debris and remains of fallen concrete fragments were observed below the abutment walls. The road surface was approximately 15 to 20 feet above the water in the creek, which was approximately 6 inches deep with medium flow. The creek was approximately 40 to 50 feet wide below the bridge where its flow was reduced due to a cumulation of muck and concrete and plant debris on the river sides. Elsewhere, the banks of the creek are well vegetated with grass and weeds.

3.0 EXPLORATION

3.1 HISTORIC EXPLORATION PROGRAMS

The ODOT Transportation Information Management Systems (TIMS) provides documentation for two other bridges spanning Glenn's Run. One of the bridges is located east of the project site. The historic exploration (BEL-798-0470), done in 1955, consisted of 2 borings (with both soil sampling and rock coring) and 8 soundings. The overburden material was predominantly classified as fill from a coal mine dump, gray gravelly silt, brown and gray sandy gravelly clay, and brown silty sandy gravel. Bedrock described as shale was encountered at a depth of 14 feet and 26 feet below the ground surface.

The other bridge is located about 1 mile west of the project site (distance is measured along Glenn's Run Road). The historic exploration (BEL-CR4-1.28), done in 1972, consisted of one 15-foot boring that included soil sampling and rock coring. The overburden material was predominantly a brown silty sandy gravel (A-2-4) which was underlain by a 3-foot micaceous sandstone underlain by clayshale. Bedrock was encountered at about 8 feet below ground.

3.2 PROJECT EXPLORATION PROGRAM

Two borings were advanced behind the existing bridge abutments for this project to obtain geotechnical data for the proposed bridge foundations. A summary of these borings is shown in Table 1. Boring locations are shown on the site plan in Appendix A.

Table 1. Boring Summary

Boring No.	Substructure	Station (feet)	Offset (feet)	Ground Surface Elevation (feet)	Boring Depth (feet)	Bottom of Boring Elevation (feet)
B-001-0-23	West Abutment	1429+71.88	11.30 RT	705.3	26.0	679.3
B-002-0-23	East Abutment	1431+02.14	5.74 RT	705.7	22.8	682.9

The borings were advanced in accordance with the January 2023 ODOT Specifications for Geotechnical Explorations (SGE). The borings were performed with a CME 45 truck-mounted drill rig using 3.25-inch inside diameter (ID) hollow stem augers to advance the borings through soil. Standard Penetration Test (SPT) sampling was performed at 2.5 foot or continuous intervals until bedrock was encountered. The energy ratio (ER) for the automatic hammer was measured to be 88.5% on 14th February 2023.

The SPT is performed by advancing a split-spoon sampler, 18 inches in length, with a 140-pound automatic hammer dropping 30 inches at select sampling depth intervals. The number of hammer blows needed to advance the sampler each 6-inch increment is recorded. The blow count from the first 6-inch increment is discarded due to ground disturbance at the bottom of the boing. The sum of blow counts from the last two 6-inch increments is called the field N-value (N_{field}). The field N-value is corrected to an equivalent rod energy ratio of 60 percent (N_{60}) according to the equation below.

$$N_{60} = N_{field} \left(\frac{ER}{60}\right)$$

The depths and elevations of the SPTs with the corresponding N_{60}-values are shown on the boring logs in Appendix A.

Upon getting auger refusal, rock coring was performed in each boring using NQ2-sized equipment. Recovery, core loss and rock quality designation (RQD) values were recorded as percentages for each coring run. The recovery is a measurement of the core sample obtained from a core run. The loss is the difference between the core run and the recovery. The RQD is measured by dividing the sum of all pieces of intact rock core longer than four inches in a run by the total length of the core run. These values are shown on the boring logs contained in Appendix A.

The materials encountered were logged in accordance with the SGE whereby the soil type, consistency and moisture content were noted. The borings were checked for the presence of groundwater during drilling and at its conclusion with the depth of water recorded. The borings were sealed using bentonite chips and capped with asphalt cold patch.

The soil samples obtained from the borings were returned to a geotechnical laboratory for visual classification and tested for water content. Engineering classification testing was performed on samples reflecting each of the main soil horizons. The engineering classification tests conducted on the samples were sieve and hydrometer analysis (ASTM D 422) and Atterberg limits (ASTM D 4318). The samples were classified according to the ODOT classification method. Moisture Content tests followed ASTM D 2216 procedures.

Three rock core samples were subjected to unconfined compressive strength of rock core (UCR) testing (ASTM D 7012). The results of UCR testing are included with the boring logs, while more detailed test results sheets are provided in Appendix B.

4.0 RESULTS

The surface material on both borings consists of 6 to 8 inches of asphalt pavement underlain by 6 to 8 inches of a granular base. In B-001-0-23, the soil layers underlaying the granular base (in order of increasing depth) consist of 6.5 feet of loose to medium dense, brown, gravel and stone fragments with sand and silt (A-2-4); 2.1 feet of stiff, brown, silt and clay (A-6a); and 4.7 feet of medium dense, reddish brown to brown, gravel and stone fragments with sand and silt (A-2-4). The moisture condition of these layers ranged from damp to moist with lab measured moisture content values ranging from 7 to 20 percent and averaging at 15 percent. The liquid limits of soil samples taken at these layers range from 30 to 38 while the plasticity index ranges from 8 to 15.

In B-002-0-23, the soil layers underlying the granular base are predominantly cohesive soils. An 8.9-foot-thick medium stiff, brown clay (A-7-6) layer lies directly below the granular base. Soil samples taken in this layer have a moisture content ranging from 19 to 31 percent and averaging at 24 percent. The liquid limits of the samples are 42 and 43 while the plasticity indices are 16 and 18. Underlaying the clay layer is a 2.9-foot-thick gravel and stone fragments with sand, silt, and clay (A-2-7). A soil sample taken at this layer has a moisture content of 20 percent, liquid limit of 42 and a plasticity index of 17.

Bedrock was encountered at both borings. In B-001-0-23, interbedded shale and limestone was encountered at 14.0 feet. Gray shale was encountered at 14.0 to 14.1 feet, 14.2 to 14.4 feet and 16.2 to 16.5 feet. It was described as moderately weathered and weak. Bedded within the shale was a 0.1-foot-thick weathered, yellowish brown sandstone layer. Light gray limestone was encountered at 14.4 to 16.2 feet. The limestone was described as slightly weathered, moderately fractured and very strong. A limestone sample taken from this layer had an unconfined compressive strength (Qu) of 18,930 psi. Underlaying the limestone is gray shale and red claystone encountered at 16 to 26 feet deep. Both fine-grained, clastic rocks are described as slightly weathered, slightly fractured and weak. A shale sample taken at this zone had a Qu value of 1,045 psi.

In B-002-0-23, gray and red shale was encountered at 12.8 to 22.8 feet deep with 2.5 feet of core loss in between. The core loss occurred at about 14.9 feet below the ground surface and was presumably caused by a clay seam or weak rock getting washed away during the drilling process. Shale was described as moderately weathered, moderately fractured and weak. A sample taken within this layer has a Qu of 763 psi.

Groundwater was encountered during drilling at a depth of 14.0 feet in B-001-0-23 and 11.2 feet in B-002-0-23. Boring logs and photographs of the rock cores are provided in Appendix A and laboratory testing results are presented in Appendix B.

5.0 ANALYSES AND RECOMMENDATIONS

5.1 GENERAL

The recommendations that follow are based on the information discussed in this report and the interpretation of the subsurface conditions encountered at the site during our fieldwork. If future design changes are made, Stantec should be notified so that such changes can be reviewed, and the recommendations amended as necessary.

These conclusions and recommendations are based on data and subsurface conditions from the borings advanced during this exploration using the degree of care and skill ordinarily exercised under similar circumstances by competent members of the engineering profession. No warranties can be made regarding the continuity of conditions. ODOT Office of Geotechnical Engineering (OGE) Geotechnical Design Checklists are provided in Appendix E.

5.2 BRIDGE FOUNDATIONS

It is recommended that the replacement bridge be supported by pre-bored steel H-piles or drilled shafts socketed into bedrock. Spread footings are not recommended based on the history of high scourability of bedrock at the site and on nearby bridges.

5.2.1 Prebored Piles

According to the ODOT Bridge Design Manual (BDM) Section 305.3.5.7, prebored steel H-piles should be extended a minimum of 10 feet into bedrock (for bedrock strength less than 1.5 ksi). The nominal structural resistance of the piles should be determined according to BDM Section 305.3.3 using the resistance factor for axial compression of 0.95. The estimated pre-bored steel H-pile pile tip elevations and lengths are provided in Table 2.

Table 2. Estimated Prebored H-Pile Tip Elevations and Pile Lengths

Substructure	Top of Bedrock Elevation	Estimated Pile Tip Elevation	Estimated Pile Length (feet)
West Abutment	691.3	681.3	15
East Abutment	692.9	682.9	15

5.2.2 Drilled Shafts

The recommended tip elevation of the drilled shafts is 688 feet or below, based on the presence of a severely weathered clayey bedrock seam in boring B-002-0-23 from an elevation of 690.9 to 688.3. The side and tip resistances of the recommended drilled shaft are estimated following guidelines in AASHTO LRFD Bridge Design Specifications 9th Edition (AASHTO LRFD) Article 10.8.3.5 using the compressive strength of bedrock. A conservative compressive strength of 55 ksf is selected based on field and lab testing conditions. A side resistance factor of 0.55 and tip resistance factor of 0.5 are based on recommendations in Table 305-1 in the 2020 ODOT BDM for drilled shafts bearing on rock.

The shaft resistance provided by non-scour resistant bedrock should be neglected as recommended in Section 305.4.1.1 of the 2020 ODOT BDM. At minimum, shaft resistance should be neglected for the top 2 feet of bedrock. Drilled shafts socketed into non-scour resistant bedrock should be extended a minimum of 10 feet below the controlling scour elevation in the bedrock. The recommended side and tip resistances assume a minimum rock socket length of 1.5 times the rock socket diameter as stated in section 305.4.2 of the 2020 ODOT BDM. Side resistance should be neglected for rock sockets with less than 1.5 times the rock socket diameter. Recommended nominal and factored side and tip resistances are provided in Table 3. Supporting calculations are presented in Appendix C.

Table 3. Drilled Shaft Axial Capacity Parameters

Resistance	Nominal (ksf)	Factored (ksf)
Side	10.8	5.9
Tip	137.5	68.8

5.3 LATERAL EARTH PRESSURE

Abutment walls and temporary sheeting and shoring systems should be designed to withstand the development of lateral earth pressures and hydrostatic pressures. The magnitude of such pressures varies based on soil type, permissible wall movement and configuration of backfill. Table 4 provides the recommended lateral earth pressure parameters for on-site cohesive soil and select granular backfill.

Table 4. Lateral Earth Pressure Parameters

Soil Parameter	In-Situ Soil	Select Granular Backfill
Drained Friction Angle (degrees)	28	34
Unit Weight (pcf)		
Moist	125	135
Buoyant	63	73
Earth Pressure Coefficient		
Active Case (K_A)	0.36	0.28
Passive Case (K_P)	2.77	3.85
At-Rest Case (K_0)	0.53	0.56
Equivalent Fluid Unit Weights (pcf)		
Active Case	45	38
Passive Case	346	520
At-Rest Case	33	35

To reduce lateral earth pressures applied to the retaining structures due to hydrostatic buildup, free drainage should be provided in accordance with ODOT Construction and Materials Specifications (CMS) Item 518. Placement of the granular backfill should be in accordance with ODOT CMS Item 518.05 “Porous Backfill”. Positive drainage of the granular backfill using weepholes or pipe drains is necessary to minimize the hydrostatic pressures against the structures. Providing positive drainage from the backfill will allow the use of the design parameters associated with the “drained” condition. If selected walls are capable of deflecting a distance of approximately 0.1 percent of the wall height, then an “active” condition could be used for design. If not, the “at-rest” condition should be used for design.

Backfill comprised of cohesive soils and granular soils with significant clay content can result in high magnitudes of lateral loads due to creep and swelling pressures. These materials are not recommended for use as backfill. It is recommended that a backfill material comprised of free-draining granular material, such as specified under ODOT CMS Item 518.03, be used. The backfill material should be coarse angular gravel with a gradation equivalent to No. 57 aggregate, as specified under ODOT CMS Item 703, Table 703.01-1.

Backfill should be compacted in accordance with ODOT CMS Item 203.07 “Compaction and Moisture Requirements”. Over compaction in areas directly behind structures should be avoided as this can cause damage. Appropriate equipment should be used to obtain the required compaction without causing damage.

5.4 SCOUR ANALYSIS

A scour analysis will be performed by the bridge designer. The recommended D_{50} value of the soil to use for the analysis is 1.1 mm based on gradation testing performed on a bagged sample taken at the stream bottom near the existing bridge abutment. The gradation report for this sample is presented in Appendix B (Lab ID 94).

The bedrock at the site should be considered non-scour resistant according to ODOT BDM 305.2.1.2.b. The erodibility index of bedrock was estimated using the method outlined in the 2012 Hydraulic Engineering Circular

No.18, Evaluating Scour at Bridges 5th Edition Section 4.7.2. Based on the strength, RQD, and joint conditions of the bedrock, the recommended Erodibility Index is 2.8. Calculations of erodibility index are provided in Appendix C.

5.5 SEISMIC SITE CLASSIFICATION

A site-specific seismic site class was developed using SPT-N values developed during the field investigation program. Considering both borings, an average site N-value of 47 was calculated using the method outlined in the AASHTO LRFD Bridge Design Specifications. Based on the estimated N-value and AASHTO LRFD Table 3.10.3.1-1, the site is classified as Seismic Site Class D. Calculations for the seismic analysis are provided in Appendix D.

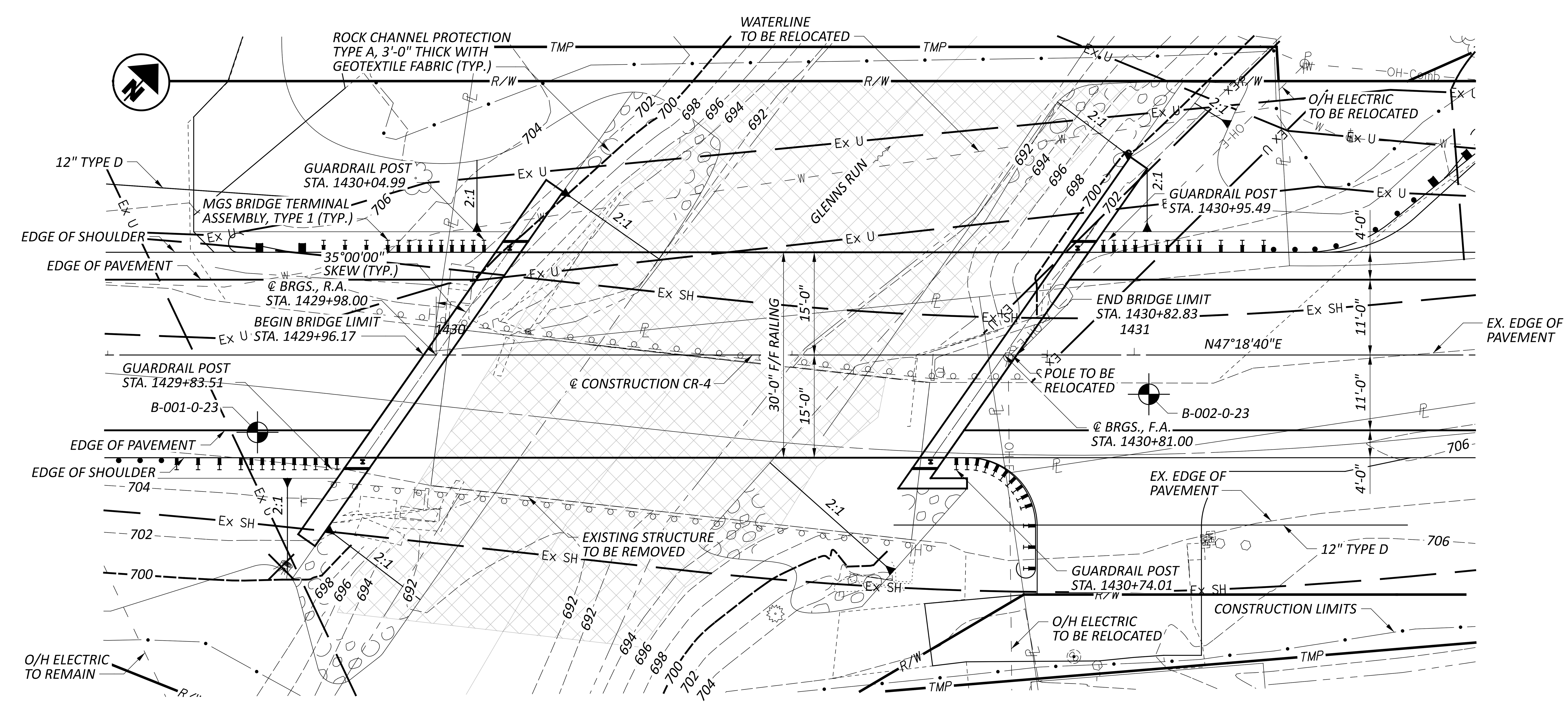
6.0 REFERENCES

BerryHill Jr., H. L. (1963). *Geology and Coal Resources of Belmont County, Ohio.* Ohio Division of Geologic Survey. Washinton: United States Government Printing Office. doi:https://pubs.usgs.gov/pp/0380/report.pdf

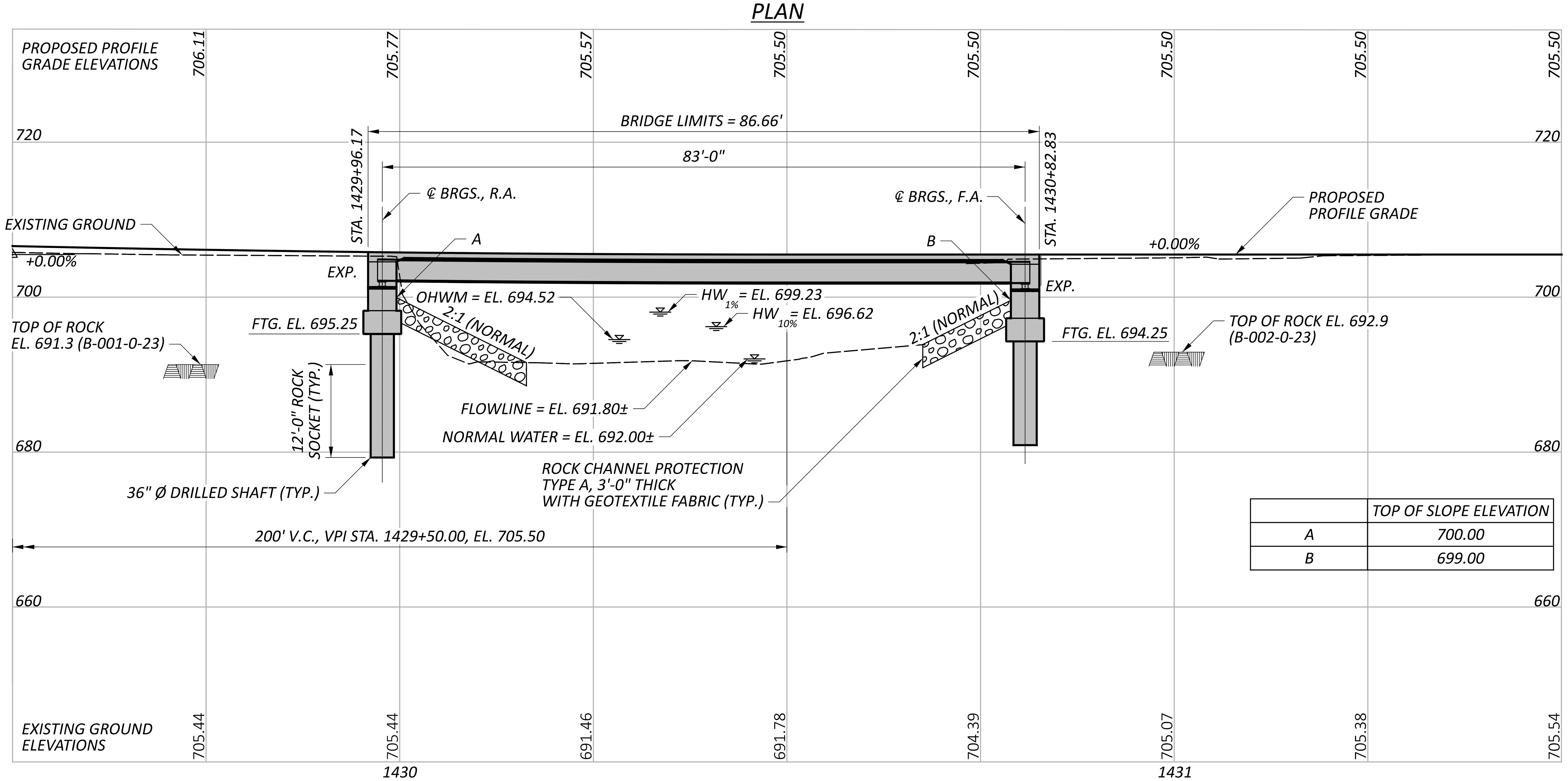
Brockman, S. (1998). *Physiographic Regions of Ohio.* Ohio ecoregions mapping project.

Hansen, M. (1995). *Landslides in Ohio.* Ohio Department of Natural Resources Division of Geological Survey.

APPENDIX A
SITE PLAN, BORING LOGS, ROCK CORE PHOTOS



PLAN



	TOP OF SLOPE ELEVATION
A	700.00
B	699.00

PROFILE

BENCHMARK DATA

BM #1 STA. 1030+81.64, ELEV. 704.857, OFFSET 13.28' LT

FOR ADDITIONAL BENCHMARK INFORMATION. SEE ROADWAY PLAN SHEET P.3/23

NOTES

1. EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.

2. FOR THIS PROJECT, PERMITS FOR SECTIONS 401 AND 404 OF THE CLEAN WATER ACT ARE BASED ON THE LIMITS OF TEMPORARY CONSTRUCTION FILL PLACED IN "WATERS OF THE UNITED STATES", AS SHOWN BELOW. IF EITHER OF THE LIMITS PROVIDED ARE EXCEEDED, THEN A 404/401 PERMIT MODIFICATION WILL BE REQUIRED. IF A PERMIT MODIFICATION IS REQUIRED, REFER TO SS832.09 FOR THE APPLICATION REQUIREMENTS.

PLAN AREA OF TEMPORARY FILL MATERIAL = 0.113 ACRES

DESIGN TRAFFIC:

2024 ADT = 960 2024 ADTT = 96

2044 ADT = 1100 2044 ADTT = 110

DIRECTIONAL DISTRIBUTION = 0.52

LEGEND

PROJECT BORING LOCATION

TEMPORARY ACCESS FILL

HYDRAULIC DATA

DRAINAGE AREA = 8.83 SQ. MILES

Q (10%) = 1540 CFS V (10%) = 9.33 FT/S

Q (1%) = 3120 CFS V (1%) = 13.41 FT/S

STRUCTURE CLEARS THE 10% AEP DESIGN HW BY 4.93 FEET.

EXISTING STRUCTURE

TYPE: SINGLE SPAN STEEL PONY TRUSS WITH CORRUGATED STEEL DECK ON CAPPED STONE ABUTMENTS

SPAN: 69'-0"± C/C BEARINGS

ROADWAY: 24'-0"± FACE/FACE RAILING

LOADING: HS-20

SKEW: NONE

WEARING SURFACE: 3"± ASPHALT

APPROACH SLABS: NONE

ALIGNMENT: TANGENT

CROWN: 0.1875±

STRUCTURE FILE NUMBER: 0734160

DATE BUILT: 1993

DISPOSITION: TO BE REPLACED

PROPOSED STRUCTURE

TYPE: SINGLE SPAN ROLLED STEEL BEAMS WITH COMPOSITE CONCRETE DECK ON CAST-IN-PLACE CONCRETE STEMI-INTEGRAL ABUTMENTS ON DRILLED SHAFTS

SPAN: 83'-0"C/C BEARINGS

ROADWAY: 30'-0" FACE/FACE RAILING

LOADING: HL93

WEARING SURFACE: 0.06 KSF

SKEW: 35°00'00" L.F.

APPROACH SLABS: NONE

ALIGNMENT: TANGENT

CROWN: 0.016 FT/FT

COORDINATES: LATITUDE 40°07'00.02" N

LONGITUDE 80°43'19.62" W

DECK AREA: 2600 SF

SITE PLAN
BRIDGE NO. BEL-CO004-27.460
CR-4 OVER GLENNS RUN

SFN	0000000
DESIGN AGENCY	CARPENTER MARTY Transportation
DESIGNER: JMV	CHECKER: BWR
REVIEWER	GDJ 6-28-23
PROJECT ID	117373
SUBSET: 1	TOTAL: 2
SHEET: P.22	TOTAL: 23

BEL-CR4-27.05

MODEL: CLP_C004 - Plan 1 [Sheet] PAPERSIZE: 34x22 (in.) DATE: 7/10/2023 TIME: 3:11:25 PM USER: BRussell
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Figure No.
1

Title
Boring Location Map

Client/Project
Client: ODOT
Project: BEL-CR4-27.05
Report: Structure Foundation Report

Project Location
Center: 80°43'18"W
40°7'1"N

Prepared by MK on 2023-07-10
TR by EK on 2023-07-10
IR by JM on 2023-07-10

N

0 45 90 180 US Feet

Legend

⊙ Borings

Stantec

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C:\Users\mkakoko\OneDrive - Stantec\Desktop\IMAGE\Templates\GIS\BEL-CR-4.aprx   Revised: 2023-07-10 By: mkakoko

PROJECT: BEL-CR4-27.05	DRILLING FIRM / OPERATOR: STANTEC / BM	DRILL RIG: CME 45C#3 #812	STATION / OFFSET: 1429+72, 11' RT.	EXPLORATION ID B-001-0-23
TYPE: STRUCTURE FOUNDATION	SAMPLING FIRM / LOGGER: STANTEC / MK	HAMMER: CME AUTOMATIC	ALIGNMENT: CR4	
PID: 117373 SFN: 0734160	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 2/14/23	ELEVATION: 705.3 (MSL) EOB: 26.0 ft.	PAGE 1 OF 1
START: 3/2/23 END: 3/2/23	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 88.5	LAT / LONG: 40.116626, -80.722137°	

MATERIAL DESCRIPTION AND NOTES	ELEV. 705.3	DEPTHS
ASPHALT	704.8	
GRANULAR BASE	704.2	
LOOSE TO MEDIUM DENSE, BROWN, **GRAVEL AND/OR STONE FRAGMENTS WITH SAND AND SILT**, LITTLE CLAY, COBBLE @ BOTTOM OF SS-2, DAMP	697.8	
STIFF, BROWN, **SILT AND CLAY**, SOME SAND AND GRAVEL, COBBLE @BOTTOM OF SS-3, DAMP	696.0	
MEDIUM DENSE, REDDISH BROWN TO BROWN, **GRAVEL AND/OR STONE FRAGMENTS WITH SAND AND SILT**, LITTLE CLAY, DAMP TO MOIST @13.5 - 14.0', WEATHERED SHALE	691.3	W 691.3 TR
INTERBEDDED LIMESTONE (95%) AND SHALE (5%), RQD 57%, REC. 95%; **LIMESTONE**, LIGHT GRAY, SLIGHTLY WEATHERED, VERY STRONG, MODERATELY FRACTURED; **SHALE**, GRAY, MODERATELY WEATHERED, WEAK, FINE GRAINED. @14.1' - 14.2', SANDSTONE, YELLOWISH BROWN, MODERATELY WEATHERED, MODERATELY STRONG, MEDIUM TO COARSE GRAINED @14.4'-14.8', Qu = 18930 psi	688.8	
CLAYSTONE, RED, MODERATELY WEATHERED, WEAK, FINE GRAINED, SLIGHTLY FRACTURED; RQD 54%, REC 92%.	687.3	
SHALE, GRAY TO DARK GRAY, SLIGHTLY WEATHERED, WEAK, FINE GRAINED, LAMINATED TO THIN BEDDED, MODERATELY FRACTURED TO FRACTURED; RQD 83%, REC 100%. @20.0' - 20.4', Qu = 1045 psi	679.3	EOB 26

SPT/RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
5 8 5	19	53	SS-1	-	41	23	11	11	14	30	22	8	13	A-2-4 (0)	
2 3 3	9	20	SS-2	-	-	-	-	-	-	-	-	-	-	A-2-4 (V)	
6 6 8	21	33	SS-3	-	40	14	9	12	25	38	23	15	20	A-6a (2)	
7 6 8	21	80	SS-4A	-	-	-	-	-	-	-	-	-	20	A-6a (V)	
			SS-4B	-	53	13	11	14	9	30	21	9	13	A-2-4 (0)	
10 10 15	37	53	SS-5	-	53	11	11	12	13	-	-	-	7	A-2-4 (V)	
6 7 15	32	53	SS-6	-	57	13	10	10	10	31	22	9	15	A-2-4 (0)	
55		95	NQ2-1											CORE	
76		92	NQ2-2											CORE	
76		100	NQ2-3											CORE	

NOTES: AUGER REFUSAL @14.0'. WATER LEVEL IS APPROXIMATE. LEVEL COULDN'T MEASURE THE WATER LEVEL ACCURATELY SINCE IT WAS PICKING MUD

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; BENTONITE CHIPS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 12/11/23 10:11 - \\US0268-PPFSS01\SHARED_PROJECTS\175538118\TECHNICAL_PRODUCTION\FIELD_DATA\BEL-CR4\BORINGS

PROJECT: BEL-CR4-27.05	DRILLING FIRM / OPERATOR: STANTEC / BM	DRILL RIG: CME 45C#3 #812	STATION / OFFSET: 1431+02, 6' RT.	EXPLORATION ID B-002-0-23
TYPE: STRUCTURE FOUNDATION	SAMPLING FIRM / LOGGER: STANTEC / MK	HAMMER: CME AUTOMATIC	ALIGNMENT: CR4	
PID: 117373 SFN: 0734160	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 2/14/23	ELEVATION: 705.7 (MSL) EOB: 22.8 ft.	PAGE 1 OF 1
START: 3/2/23 END: 3/2/23	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 88.5	LAT / LONG: 40.116871, -80.721792°	

MATERIAL DESCRIPTION AND NOTES	ELEV. 705.7	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
ASPHALT	705.1																	
GRANULAR BASE	704.6																	
MEDIUM STIFF, BROWN TO DARK BROWN, **CLAY**, SOME GRAVEL, SOME SAND, SOME SILT, DAMP TO MOIST		3	3 3 4	10	27	SS-1	-	-	-	-	-	-	-	-	-	23	A-7-6 (V)	
@5.6', STONE FRAGMENTS		5	5 2 3	7	100	SS-2A	-	25	15	15	21	24	43	27	16	31	A-7-6 (4)	
						SS-2B	-	-	-	-	-	-	-	-	-	22	A-7-6 (V)	
@7.5'-9.0', SMALL BLACK INCLUSIONS THROUGHOUT SS-3		8	4 4 5	13	73	SS-3	-	35	11	12	16	26	42	24	18	19	A-7-6 (4)	
	695.7																	
MEDIUM STIFF TO STIFF, DARK BROWN, **GRAVEL AND/OR STONE FRAGMENTS WITH SAND, SILT, AND CLAY**, ROUND COBBLES PRESENT, MOIST TO WET		W 694.5	4 8 50	86	87	SS-4	-	54	13	8	11	14	42	25	17	20	A-2-7 (1)	
	692.9	TR																
SHALE, GRAY, MODERATELY WEATHERED, WEAK, FINE GRAINED, LAMINATED TO THIN BEDDED, CALCAREOUS, MODERATELY FRACTURED; RQD 26%, REC 50%. @13.0'-13.4', Qu = 763 psi	690.8		26		50	NQ2-1											CORE	
CORE LOSS: POSSIBLE CLAY SEAM/ SEVERELY WEATHERED ROCK	688.3																	
SHALE, GRAY AND RED, MODERATELY WEATHERED, WEAK, FINE GRAINED, LAMINATED TO THIN BEDDED, MODERATELY FRACTURED; RQD 35%, REC 82%.			35		82	NQ2-2											CORE	
	682.9	EOB																

NOTES: AUGER REFUSAL@12.8'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: ASPHALT PATCH; BENTONITE CHIPS

Stantec
10200 Alliance Road Suite 300
Cincinnati, OH 45242

B-001-0-23

Run #:	Depth		Recovery		RQD	
NQ2-1	14.0’	16.0’	22.8/24	95%	13.2/24	55%
NQ2-2	16.0’	21.0’	55.2/60	92%	45.6/60	76%
BEL-CR4-27.05 PID 117373						

Stantec
10200 Alliance Road Suite 300
Cincinnati, OH 45242

B-001-0-23						

Run #:	Depth		Recovery		RQD	
NQ2-3	21.0’	26.0’	60/60	100%	45.6/60	76%
BEL-CR4-27.05 PID 117373						

Stantec
10200 Alliance Road Suite 300
Cincinnati, OH 45242

B-002-0-23

Run #:	Depth		Recovery		RQD	
NQ2-1	12.8’	17.8’	30/60	50%	15.6/60	26%
NQ2-2	17.8’	22.8’	49.2/60	82%	21/60	35%
BEL-CR4-27.05 PID 117373						

APPENDIX B
LABORATORY TESTING RESULTS

Stantec

Summary of Soil Tests

Project Name	BEL-CR4-27.05	Project Number	175538118
Source	B-001-0-23, 2.5'-4.0'	Lab ID	61
Sample Type	SPT	Date Received	3-14-23
		Date Reported	3-29-23

Test Results

Natural Moisture Content

Test Method: ASTM D 2216

Moisture Content (%): 12.9

Particle Size Analysis

Preparation Method: ASTM D 421

Gradation Method: ASTM D 422

Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
	N/A	
	N/A	
	N/A	
1 1/2"	37.5	100.0
3/4"	19	90.7
3/8"	9.5	82.8
No. 4	4.75	72.6
No. 10	2	58.5
No. 40	0.425	35.7
No. 200	0.075	25.1
	0.02	21.6
	0.005	13.7
	0.002	10.1
Estimated	0.001	7.7

Plus 3 in. Material, Not Included: 0 (%)

	ASTM	ODOT
Range	(%)	(%)
Gravel	27.4	41.5
Coarse Sand	14.1	22.8
Medium Sand	22.8	---
Fine Sand	10.6	10.6
Silt	11.4	11.4
Clay	13.7	13.7

Atterberg Limits

Test Method: ASTM D 4318 Method A

Prepared: Dry

Liquid Limit: 30

Plastic Limit: 22

Plasticity Index: 8

Activity Index: 0.8

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3): N/A

Maximum Dry Density (kg/m^3): N/A

Optimum Moisture Content (%): N/A

Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%): N/A

Compacted Dry Density (lb/ft^3): N/A

Compacted Moisture Content (%): N/A

Specific Gravity

Estimated

Particle Size: No. 10

Specific Gravity at 20° Celsius: 2.70

Classification

Unified Group Symbol: SC

Group Name: Clayey Sand with Gravel

ODOT Classification: A-2-4 (0)

Description: Gravel and/or Stone Fragments w/Sand and Silt

Comments:

Reviewed By REL

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name: BEL-CR4-27.05
Source: B-001-0-23, 2.5'-4.0'
Project Number: 175538118
Lab ID: 61

Sieve Analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared Using: ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: JP
Test Date: 03-23-2023
Date Received: 03-14-2023

Maximum Particle Size: 1 1/2" Sieve

Sieve Size	% Passing
1 1/2"	100.0
3/4"	90.7
3/8"	82.8
No. 4	72.6
No. 10	58.5

Analysis for the Portion Finer than the No. 10 Sieve

Analysis Based on -3 inch Fraction Only

Specific Gravity: 2.7

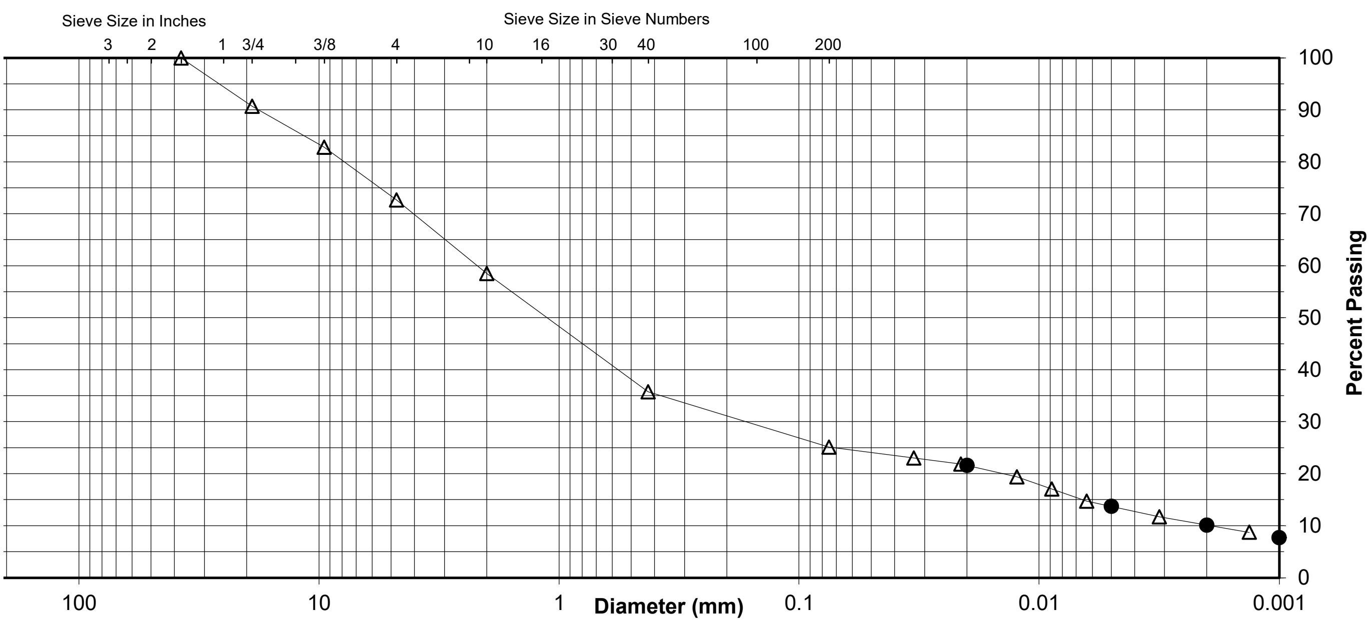
Dispersed Using Apparatus A - Mechanical, for 1 Minute

No. 40	35.7
No. 200	25.1
0.02 mm	21.6
0.005 mm	13.7
0.002 mm	10.1
0.001 mm	7.7

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	9.3	18.1	14.1	22.8	10.6	11.4	13.7

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	41.5	22.8	10.6	15.0	10.1



Comments ______

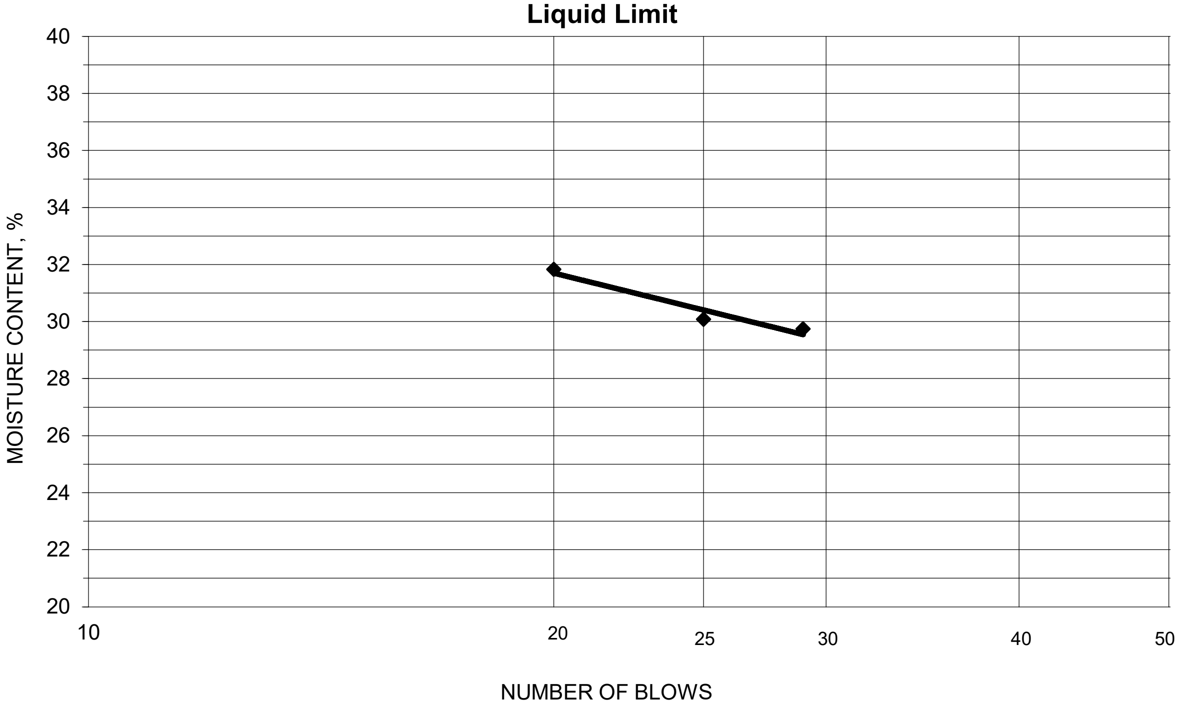
Reviewed By REL

Stantec

ATTERBERG LIMITS

Project	BEL-CR4-27.05	Project No.	175538118
Source	B-001-0-23, 2.5'-4.0'	Lab ID	61
		% + No. 40	64
Tested By	JP	Test Method	ASTM D 4318 Method A
Date Received	03-14-2023		
Test Date	03-29-2023	Prepared	Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
22.48	19.75	10.57	29	29.7	30
23.22	20.32	10.68	25	30.1	
22.37	19.62	10.98	20	31.8	



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
22.50	20.46	11.06	21.7	22	8
22.52	20.48	11.03	21.6		

Remarks:

Reviewed By REL

Stantec

Summary of Soil Tests

Project Name	BEL-CR4-27.05	Project Number	175538118
Source	B-001-0-23, 7.5'-9.0', 9.0'-9.3'	Lab ID	63
Sample Type	SPT Composite	Date Received	3-14-23
		Date Reported	3-29-23

Test Results

Natural Moisture Content

Test Method: ASTM D 2216

Moisture Content (%): 20.2

Particle Size Analysis

Preparation Method: ASTM D 421

Gradation Method: ASTM D 422

Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
	N/A	
	N/A	
	N/A	
1 1/2"	37.5	100.0
3/4"	19	86.5
3/8"	9.5	81.5
No. 4	4.75	72.5
No. 10	2	60.2
No. 40	0.425	46.5
No. 200	0.075	37.3
	0.02	34.7
	0.005	24.9
	0.002	19.5
Estimated	0.001	16.5

Plus 3 in. Material, Not Included: 0 (%)

	ASTM	ODOT
Range	(%)	(%)
Gravel	27.5	39.8
Coarse Sand	12.3	13.7
Medium Sand	13.7	---
Fine Sand	9.2	9.2
Silt	12.4	12.4
Clay	24.9	24.9

Atterberg Limits

Test Method: ASTM D 4318 Method A

Prepared: Dry

Liquid Limit: 38

Plastic Limit: 23

Plasticity Index: 15

Activity Index: 0.8

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3): N/A

Maximum Dry Density (kg/m^3): N/A

Optimum Moisture Content (%): N/A

Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%): N/A

Compacted Dry Density (lb/ft^3): N/A

Compacted Moisture Content (%): N/A

Specific Gravity

Estimated

Particle Size: No. 10

Specific Gravity at 20° Celsius: 2.70

Classification

Unified Group Symbol: SC

Group Name: Clayey Sand with Gravel

ODOT Classification A-6a (2)

Description: Silt and Clay

Comments:

Reviewed By REL

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name BEL-CR4-27.05 | Project Number 175538118
Source B-001-0-23, 7.5'-9.0', 9.0'-9.3' | Lab ID 63

Sieve Analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared Using: ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: JP
Test Date: 03-23-2023
Date Received: 03-14-2023

Maximum Particle Size: 1 1/2" Sieve

Sieve Size	% Passing
1 1/2"	100.0
3/4"	86.5
3/8"	81.5
No. 4	72.5
No. 10	60.2

Analysis for the Portion Finer than the No. 10 Sieve

Analysis Based on -3 inch Fraction Only

Specific Gravity: 2.7

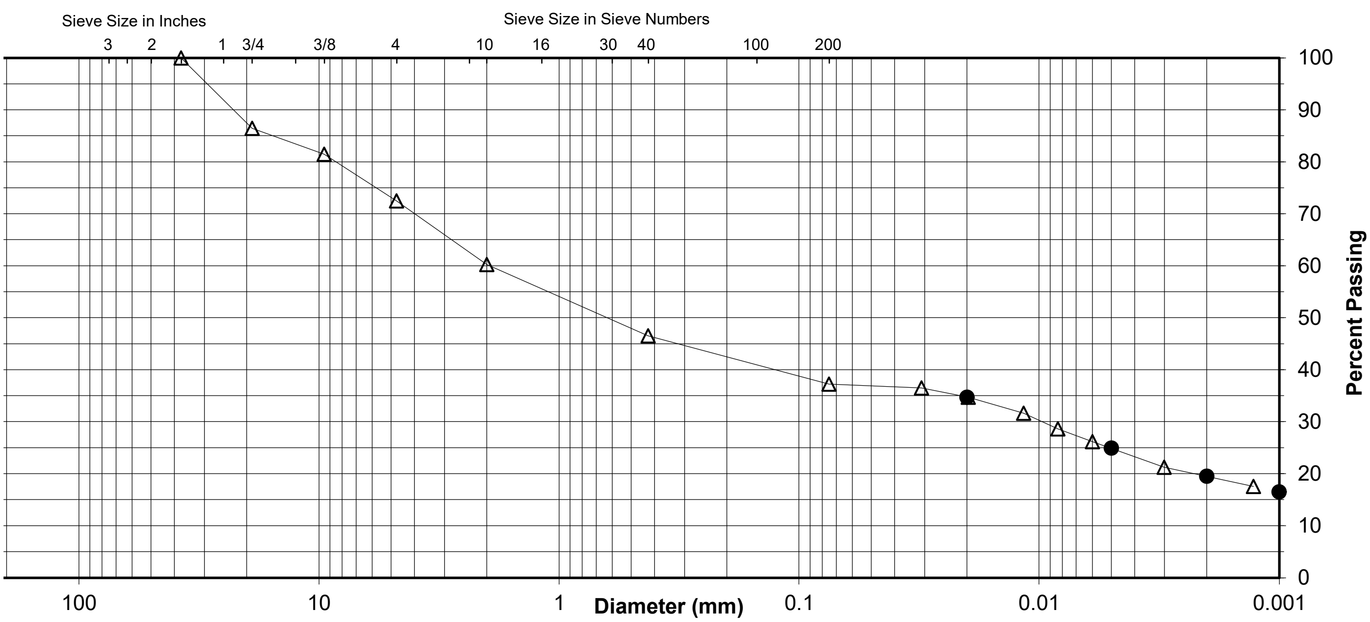
Dispersed Using Apparatus A - Mechanical, for 1 Minute

Sieve Size	% Passing
No. 40	46.5
No. 200	37.3
0.02 mm	34.7
0.005 mm	24.9
0.002 mm	19.5
0.001 mm	16.5

Particle Size Distribution

	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
ASTM	13.5	14.0	12.3	13.7	9.2	12.4	24.9

	Gravel	Coarse Sand	Fine Sand	Silt	Clay
AASHTO	39.8	13.7	9.2	17.8	19.5



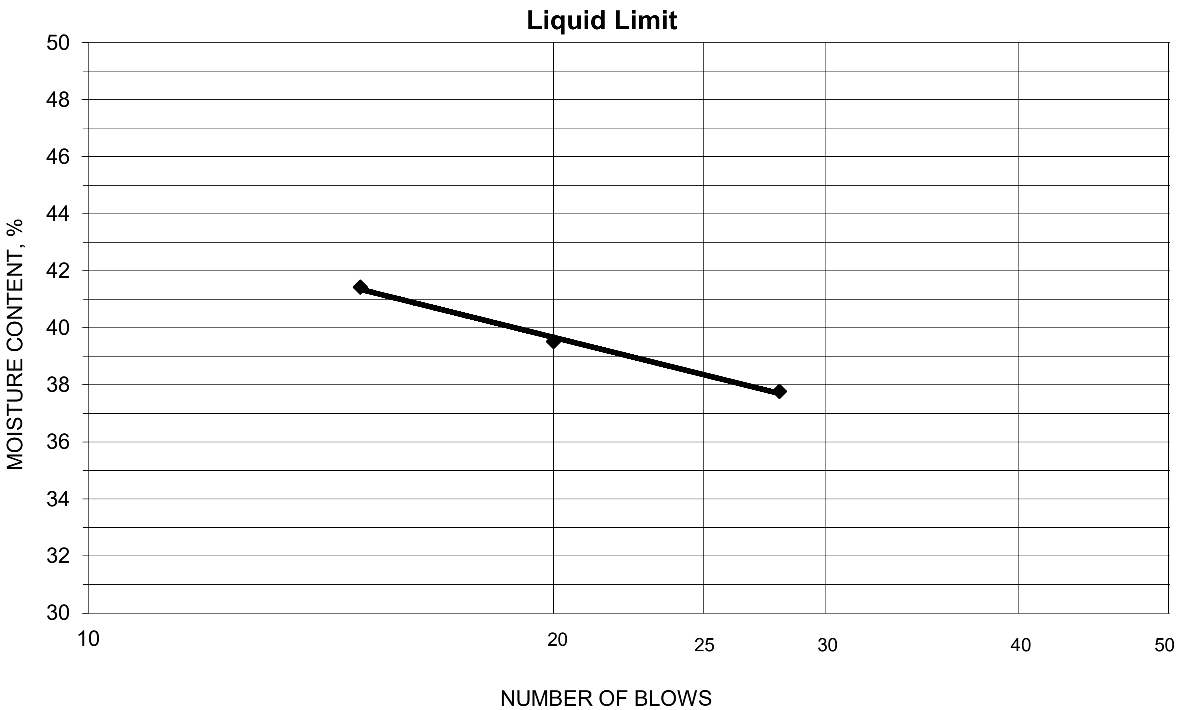
Comments ______________________ Reviewed By REL

Stantec

ATTERBERG LIMITS

Project	BEL-CR4-27.05	Project No.	175538118
Source	B-001-0-23, 7.5'-9.0', 9.0'-9.3'	Lab ID	63
		% + No. 40	53
Tested By	JP	Test Method	ASTM D 4318 Method A
Date Received	03-14-2023		
Test Date	03-29-2023	Prepared	Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
22.33	19.12	10.62	28	37.8	38
22.35	19.05	10.70	20	39.5	
22.34	19.03	11.04	15	41.4	



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
20.54	18.78	11.05	22.8	23	15
21.53	19.56	11.03	23.1		

Remarks: ____________________

Reviewed By REL

Stantec

Summary of Soil Tests

Project Name: BEL-CR4-27.05
Project Number: 175538118
Source: B-001-0-23, 9.3'-10.5'
Lab ID: 66

Sample Type: SPT
Date Received: 3-14-23
Date Reported: 3-29-23

Test Results

Natural Moisture Content

Test Method: ASTM D 2216
Moisture Content (%): 12.7

Particle Size Analysis

Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size: Sieve Size	Particle Size: (mm)	% Passing
	N/A	
	N/A	
	N/A	
1 1/2"	37.5	100.0
3/4"	19	78.2
3/8"	9.5	65.1
No. 4	4.75	56.7
No. 10	2	46.9
No. 40	0.425	33.8
No. 200	0.075	22.6
	0.02	15.2
	0.005	9.0
	0.002	6.1
Estimated	0.001	4.2

Plus 3 in. Material, Not Included: 0 (%)

Range	ASTM (%)	ODOT (%)
Gravel	43.3	53.1
Coarse Sand	9.8	13.1
Medium Sand	13.1	---
Fine Sand	11.2	11.2
Silt	13.6	13.6
Clay	9.0	9.0

Atterberg Limits

Test Method: ASTM D 4318 Method A
Prepared: Dry

Liquid Limit: 30
Plastic Limit: 21
Plasticity Index: 9
Activity Index: 1.5

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3): N/A
Maximum Dry Density (kg/m^3): N/A
Optimum Moisture Content (%): N/A
Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%): N/A
Compacted Dry Density (lb/ft^3): N/A
Compacted Moisture Content (%): N/A

Specific Gravity

Estimated

Particle Size: No. 10
Specific Gravity at 20° Celsius: 2.70

Classification

Unified Group Symbol: GC
Group Name: Clayey Gravel with Sand

ODOT Classification: A-2-4 (0)
Description: Gravel and/or Stone Fragments w/Sand and Silt

Comments:

Reviewed By: REL

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name BEL-CR4-27.05 | Project Number 175538118
Source B-001-0-23, 9.3'-10.5' | Lab ID 66

Sieve Analysis for the Portion Coarser than the No. 10 Sieve

Test Method ASTM D 422
Prepared Using ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By JP
Test Date 03-22-2023
Date Received 03-14-2023

Maximum Particle Size: 1 1/2" Sieve

Sieve Size	% Passing
1 1/2"	100.0
3/4"	78.2
3/8"	65.1
No. 4	56.7
No. 10	46.9

Analysis for the Portion Finer than the No. 10 Sieve

Analysis Based on -3 inch Fraction Only

Specific Gravity 2.7

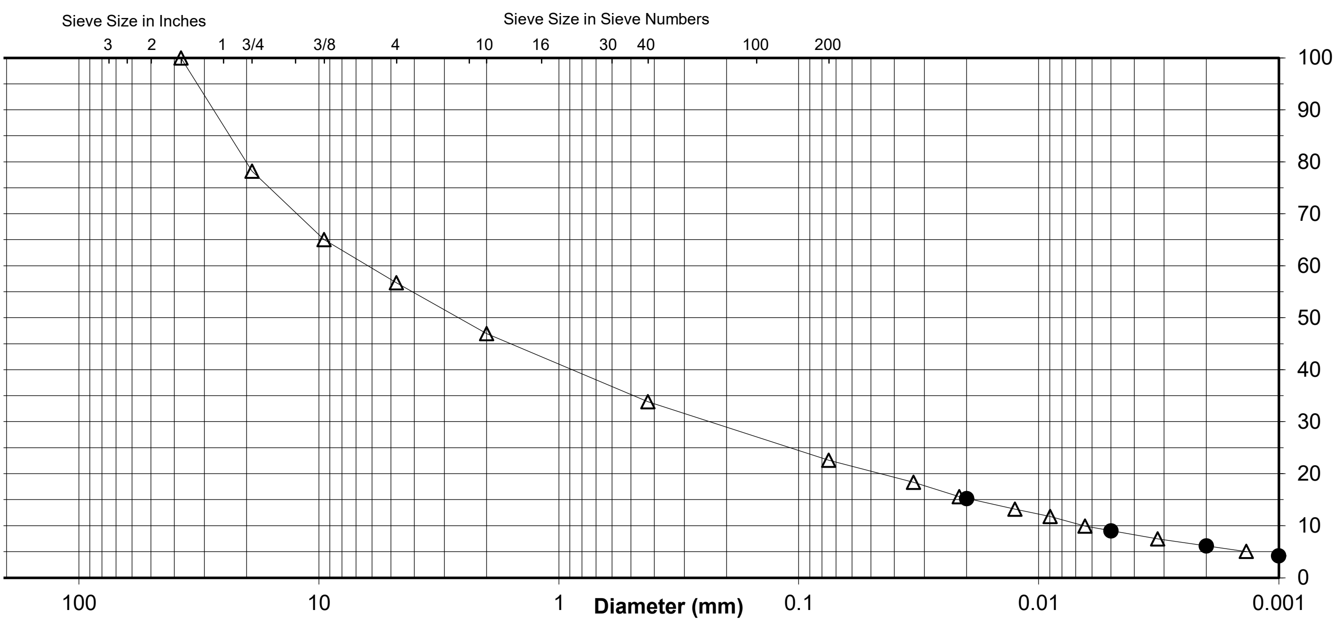
Dispersed Using Apparatus A - Mechanical, for 1 Minute

Sieve Size	% Passing
No. 40	33.8
No. 200	22.6
0.02 mm	15.2
0.005 mm	9.0
0.002 mm	6.1
0.001 mm	4.2

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	21.8	21.5	9.8	13.1	11.2	13.6	9.0

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	53.1	13.1	11.2	16.5	6.1



Comments ______

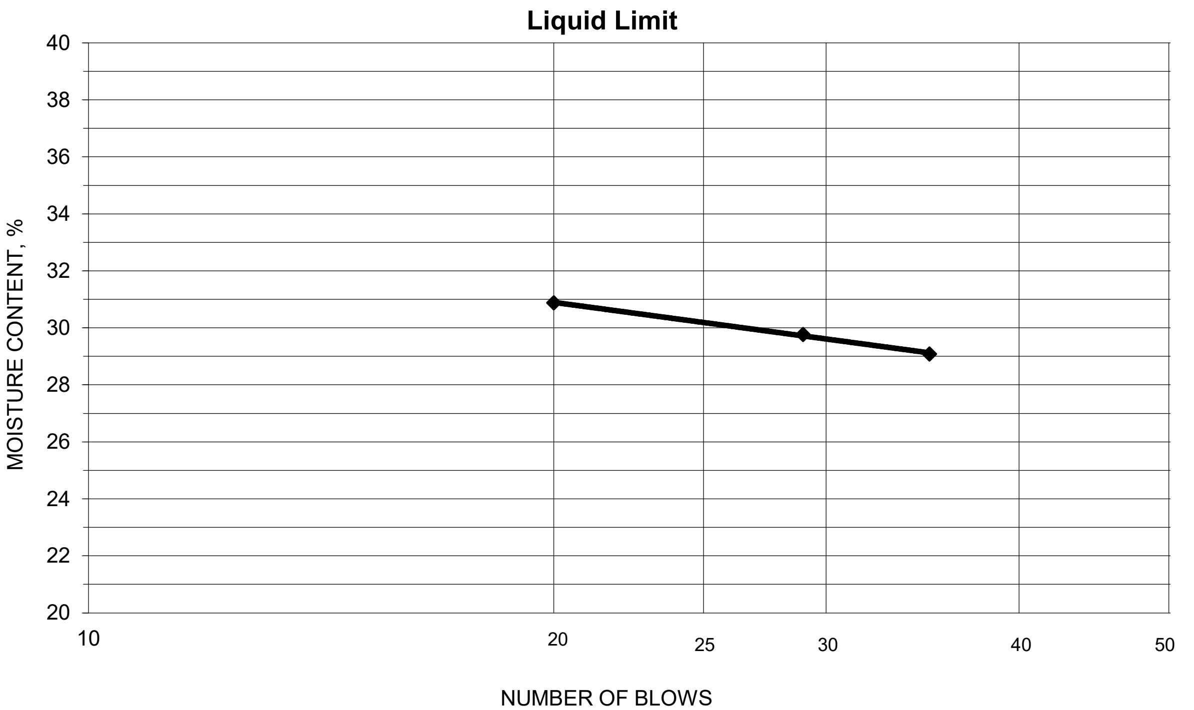
Reviewed By REL

Stantec

ATTERBERG LIMITS

Project	BEL-CR4-27.05	Project No.	175538118
Source	B-001-0-23, 9.3'-10.5'	Lab ID	66
		% + No. 40	66
Tested By	JP	Test Method	ASTM D 4318 Method A
Date Received	03-14-2023		
Test Date	03-28-2023	Prepared	Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
23.17	20.43	11.01	35	29.1	
21.28	18.94	11.08	29	29.8	
22.24	19.60	11.05	20	30.9	30



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
19.96	18.38	10.88	21.1	21	9
18.68	17.28	10.69	21.2		

Remarks:

Reviewed By REL

Stantec

Summary of Soil Tests

Project Name	BEL-CR4-27.05	Project Number	175538118
Source	B-001-0-23, 10.5'-12.0'	Lab ID	67
Sample Type	SPT	Date Received	3-14-23
		Date Reported	3-29-23

Test Results

Natural Moisture Content

Test Method: ASTM D 2216

Moisture Content (%): 7.1

Particle Size Analysis

Preparation Method: ASTM D 421

Gradation Method: ASTM D 422

Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
	N/A	
	N/A	
	N/A	
1 1/2"	37.5	100.0
3/4"	19	80.2
3/8"	9.5	67.9
No. 4	4.75	59.3
No. 10	2	47.0
No. 40	0.425	36.1
No. 200	0.075	25.1
	0.02	18.8
	0.005	12.8
	0.002	9.8
Estimated	0.001	8.3

Plus 3 in. Material, Not Included: 0 (%)

	ASTM	ODOT
Range	(%)	(%)
Gravel	40.7	53.0
Coarse Sand	12.3	10.9
Medium Sand	10.9	---
Fine Sand	11.0	11.0
Silt	12.3	12.3
Clay	12.8	12.8

Atterberg Limits

Test Not Performed

Liquid Limit: N/A

Plastic Limit: N/A

Plasticity Index: N/A

Activity Index: N/A

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3): N/A

Maximum Dry Density (kg/m^3): N/A

Optimum Moisture Content (%): N/A

Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%): N/A

Compacted Dry Density (lb/ft^3): N/A

Compacted Moisture Content (%): N/A

Specific Gravity

Estimated

Particle Size: No. 10

Specific Gravity at 20° Celsius: 2.70

Classification

Unified Group Symbol:

Group Name:

AASHTO Classification:

Comments:

Reviewed By REL

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name	BEL-CR4-27.05	Project Number	175538118
Source	B-001-0-23, 10.5'-12.0'	Lab ID	67

Sieve Analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared Using: ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: JP
Test Date: 03-23-2023
Date Received: 03-14-2023

Maximum Particle Size: 1 1/2" Sieve

Sieve Size	% Passing
1 1/2"	100.0
3/4"	80.2
3/8"	67.9
No. 4	59.3
No. 10	47.0

Analysis for the Portion Finer than the No. 10 Sieve

Analysis Based on -3 inch Fraction Only

Specific Gravity: 2.7

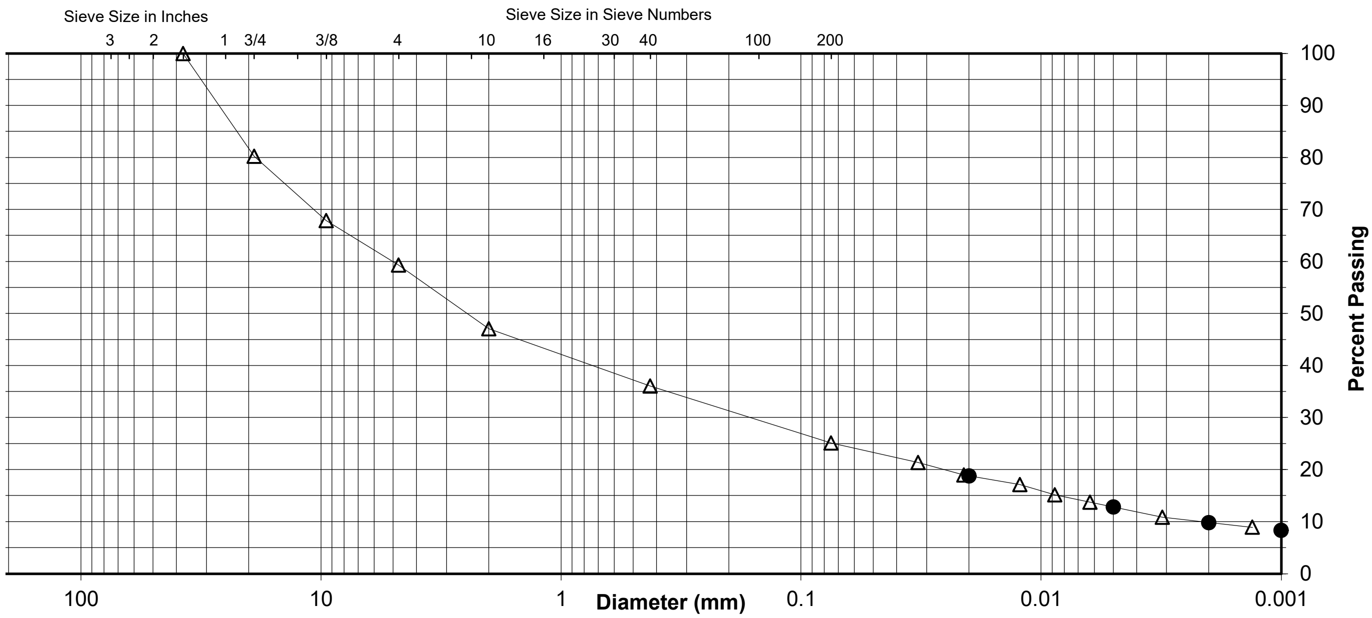
Dispersed Using Apparatus A - Mechanical, for 1 Minute

Sieve Size	% Passing
No. 40	36.1
No. 200	25.1
0.02 mm	18.8
0.005 mm	12.8
0.002 mm	9.8
0.001 mm	8.3

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	19.8	20.9	12.3	10.9	11.0	12.3	12.8

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	53.0	10.9	11.0	15.3	9.8



Comments ______

Reviewed By REL

Stantec

Summary of Soil Tests

Project Name	BEL-CR4-27.05	Project Number	175538118
Source	B-001-0-23, 12.0'-13.5'	Lab ID	68
Sample Type	SPT	Date Received	3-14-23
		Date Reported	3-29-23

Test Results

Natural Moisture Content

Test Method: ASTM D 2216

Moisture Content (%): 15.0

Particle Size Analysis

Preparation Method: ASTM D 421

Gradation Method: ASTM D 422

Hydrometer Method: ASTM D 422

Particle Size Sieve Size	Particle Size (mm)	% Passing
	N/A	
	N/A	
	N/A	
1 1/2"	37.5	100.0
3/4"	19	82.3
3/8"	9.5	68.8
No. 4	4.75	53.6
No. 10	2	42.6
No. 40	0.425	29.6
No. 200	0.075	19.7
	0.02	15.7
	0.005	9.6
	0.002	7.4
Estimated	0.001	5.7

Plus 3 in. Material, Not Included: 0 (%)

Range	ASTM (%)	ODOT (%)
Gravel	46.4	57.4
Coarse Sand	11.0	13.0
Medium Sand	13.0	---
Fine Sand	9.9	9.9
Silt	10.1	10.1
Clay	9.6	9.6

Atterberg Limits

Test Method: ASTM D 4318 Method A

Prepared: Dry

Liquid Limit: 31

Plastic Limit: 22

Plasticity Index: 9

Activity Index: 1.2

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3): N/A

Maximum Dry Density (kg/m^3): N/A

Optimum Moisture Content (%): N/A

Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%): N/A

Compacted Dry Density (lb/ft^3): N/A

Compacted Moisture Content (%): N/A

Specific Gravity

Estimated

Particle Size: No. 10

Specific Gravity at 20° Celsius: 2.70

Classification

Unified Group Symbol: GC

Group Name: Clayey Gravel with Sand

ODOT Classification A-2-4 (0)

Description: Gravel and/or Stone Fragments w/Sand and Silt

Comments:

Reviewed By REL

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name	BEL-CR4-27.05	Project Number	175538118
Source	B-001-0-23, 12.0'-13.5'	Lab ID	68

Sieve Analysis for the Portion Coarser than the No. 10 Sieve

Test Method	ASTM D 422
Prepared Using	ASTM D 421
Particle Shape:	Angular
Particle Hardness:	Hard and Durable
Tested By	JP
Test Date	03-23-2023
Date Received	03-14-2023

Maximum Particle Size: 1 1/2" Sieve

Sieve Size	% Passing
1 1/2"	100.0
3/4"	82.3
3/8"	68.8
No. 4	53.6
No. 10	42.6

Analysis for the Portion Finer than the No. 10 Sieve

Analysis Based on -3 inch Fraction Only

Specific Gravity 2.7

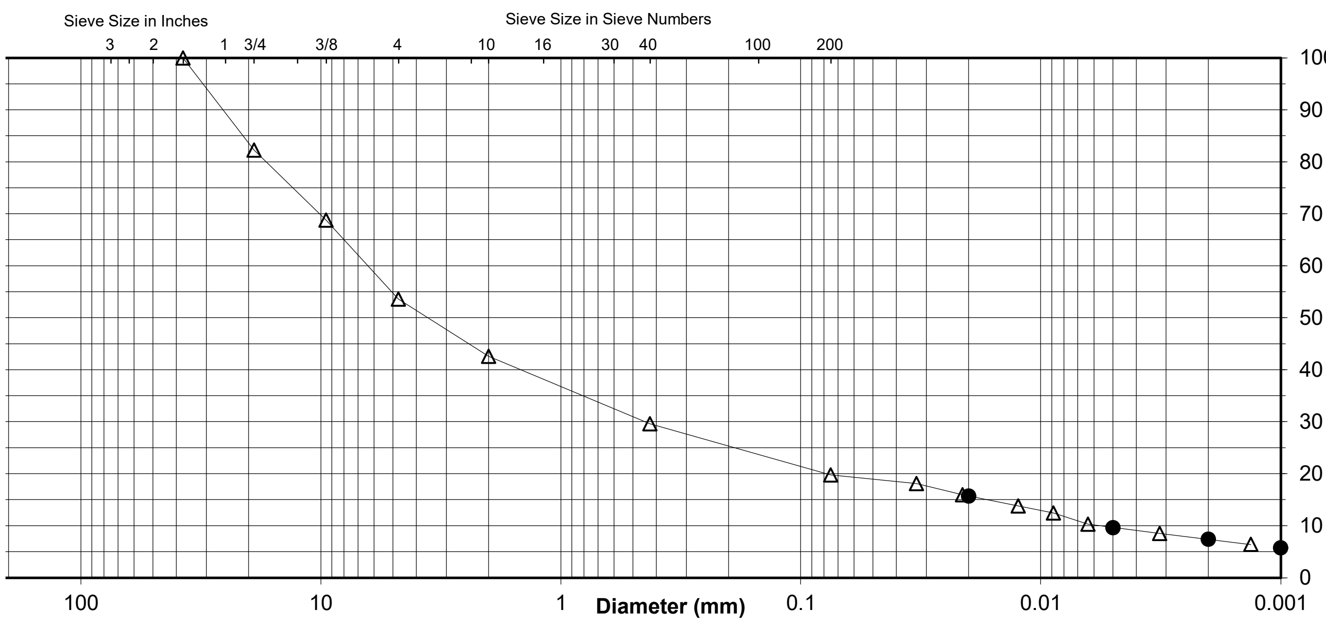
Dispersed Using Apparatus A - Mechanical, for 1 Minute

No. 40	29.6
No. 200	19.7
0.02 mm	15.7
0.005 mm	9.6
0.002 mm	7.4
0.001 mm	5.7

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	17.7	28.7	11.0	13.0	9.9	10.1	9.6

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	57.4	13.0	9.9	12.3	7.4



Comments ______

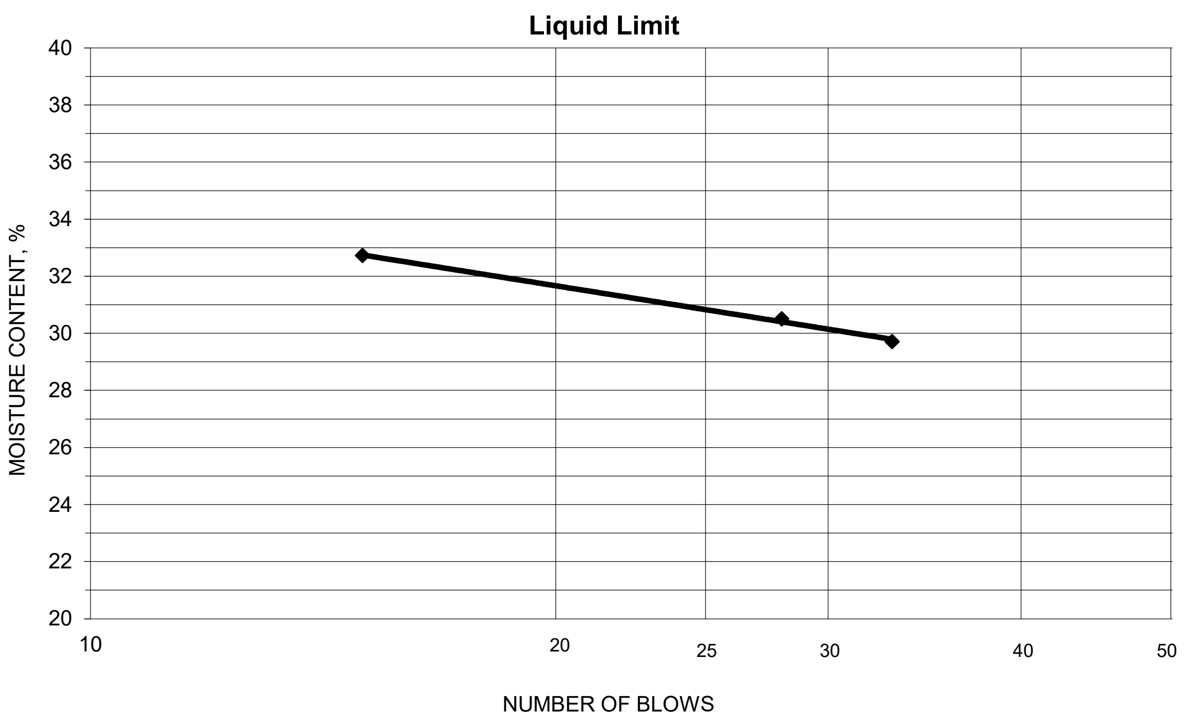
Reviewed By REL

Stantec

ATTERBERG LIMITS

Project	BEL-CR4-27.05	Project No.	175538118
Source	B-001-0-23, 12.0'-13.5'	Lab ID	68
		% + No. 40	70
Tested By	JP	Test Method	ASTM D 4318 Method A
Date Received	03-14-2023		
Test Date	03-29-2023	Prepared	Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
21.75	19.29	11.01	33	29.7	31
22.31	19.65	10.93	28	30.5	
22.68	19.82	11.08	15	32.7	



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
21.71	19.68	10.49	22.1	22	9
21.52	19.62	11.00	22.0		

Remarks:

Reviewed By REL

Stantec

Summary of Soil Tests

Project Name	BEL-CR4-27.05	Project Number	175538118
Source	B-002-0-23, 5.0'-6.0'	Lab ID	70
Sample Type	SPT	Date Received	3-14-23
		Date Reported	3-29-23

Test Results

Natural Moisture Content

Test Method: ASTM D 2216

Moisture Content (%): 30.8

Particle Size Analysis

Preparation Method: ASTM D 421

Gradation Method: ASTM D 422

Hydrometer Method: ASTM D 422

Particle Size: Sieve Size	(mm)	% Passing
	N/A	
	N/A	
	N/A	
	N/A	
3/4"	19	100.0
3/8"	9.5	94.3
No. 4	4.75	85.9
No. 10	2	74.0
No. 40	0.425	59.1
No. 200	0.075	44.5
	0.02	35.8
	0.005	23.8
	0.002	17.8
Estimated	0.001	14.2

Plus 3 in. Material, Not Included: 0 (%)

Range	ASTM (%)	ODOT (%)
Gravel	14.1	26.0
Coarse Sand	11.9	14.9
Medium Sand	14.9	---
Fine Sand	14.6	14.6
Silt	20.7	20.7
Clay	23.8	23.8

Atterberg Limits

Test Method: ASTM D 4318 Method A

Prepared: Dry

Liquid Limit: 43

Plastic Limit: 27

Plasticity Index: 16

Activity Index: 0.9

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3): N/A

Maximum Dry Density (kg/m^3): N/A

Optimum Moisture Content (%): N/A

Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%): N/A

Compacted Dry Density (lb/ft^3): N/A

Compacted Moisture Content (%): N/A

Specific Gravity

Estimated

Particle Size: No. 10

Specific Gravity at 20° Celsius: 2.70

Classification

Unified Group Symbol: SM

Group Name: Silty Sand

ODOT Classification: A-7-6 (4)

Description: Clay

Comments:

Reviewed By REL

Template: tmp_sum_input.xlsm
Version: 20170217
Approved By: RJ

Stantec Consulting Services Inc.
Cincinnati, Ohio

Reported By: REL
Report Date: 03/30/2023

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name: BEL-CR4-27.05
Source: B-002-0-23, 5.0'-6.0'

Project Number: 175538118
Lab ID: 70

Sieve Analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared Using: ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: JP
Test Date: 03-22-2023
Date Received: 03-14-2023

Maximum Particle Size: 3/4" Sieve

Sieve Size	% Passing
3/4"	100.0
3/8"	94.3
No. 4	85.9
No. 10	74.0

Analysis for the Portion Finer than the No. 10 Sieve

Analysis Based on -3 inch Fraction Only

Specific Gravity: 2.7

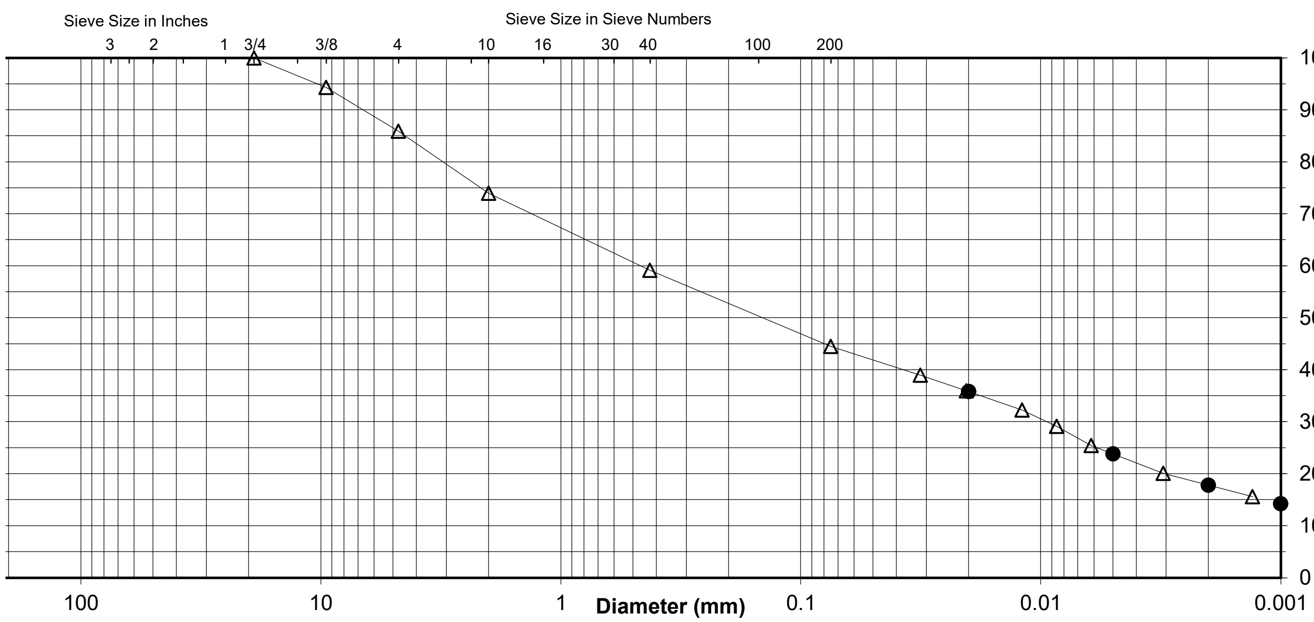
Dispersed Using Apparatus A - Mechanical, for 1 Minute

Sieve Size	% Passing
No. 40	59.1
No. 200	44.5
0.02 mm	35.8
0.005 mm	23.8
0.002 mm	17.8
0.001 mm	14.2

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	14.1	11.9	14.9	14.6	20.7	23.8

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	26.0	14.9	14.6	26.7	17.8



Comments ______

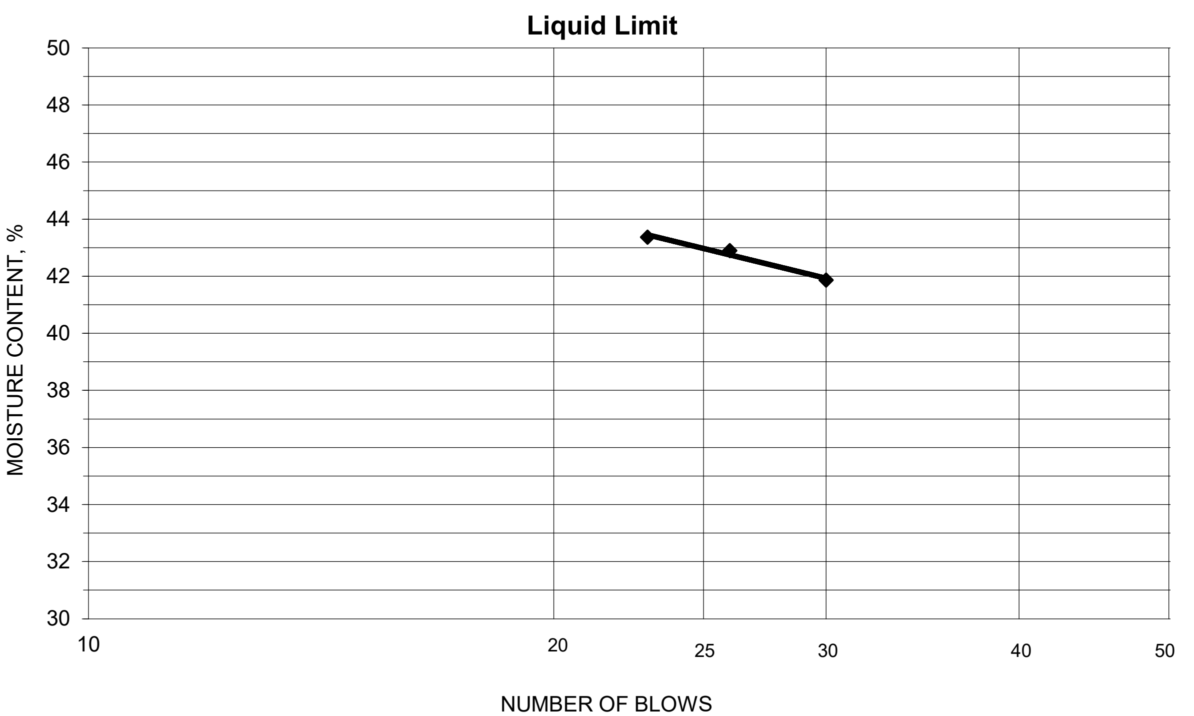
Reviewed By REL

Stantec

ATTERBERG LIMITS

Project	BEL-CR4-27.05	Project No.	175538118
Source	B-002-0-23, 5.0'-6.0'	Lab ID	70
		% + No. 40	41
Tested By	JP	Test Method ASTM D 4318 Method A	Date Received 03-14-2023
Test Date	03-28-2023	Prepared Dry	

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
21.03	17.97	10.66	30	41.9	43
21.53	18.36	10.97	26	42.9	
22.53	19.03	10.96	23	43.4	



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
19.70	17.85	11.08	27.3	27	16
19.09	17.36	11.07	27.5		

Remarks:

Reviewed By REL

Stantec

Summary of Soil Tests

Project Name	BEL-CR4-27.05	Project Number	175538118
Source	B-002-0-23, 7.5'-9.0'	Lab ID	72
Sample Type	SPT	Date Received	3-14-23
		Date Reported	3-29-23

Test Results

Natural Moisture Content

Test Method: ASTM D 2216

Moisture Content (%): 18.6

Particle Size Analysis

Preparation Method: ASTM D 421

Gradation Method: ASTM D 422

Hydrometer Method: ASTM D 422

Particle Size Sieve Size	(mm)	% Passing
	N/A	
	N/A	
	N/A	
1 1/2"	37.5	100.0
3/4"	19	95.7
3/8"	9.5	77.9
No. 4	4.75	72.7
No. 10	2	64.9
No. 40	0.425	54.3
No. 200	0.075	42.0
	0.02	34.8
	0.005	25.9
	0.002	21.0
Estimated	0.001	17.8

Plus 3 in. Material, Not Included: 0 (%)

Range	ASTM (%)	ODOT (%)
Gravel	27.3	35.1
Coarse Sand	7.8	10.6
Medium Sand	10.6	---
Fine Sand	12.3	12.3
Silt	16.1	16.1
Clay	25.9	25.9

Atterberg Limits

Test Method: ASTM D 4318 Method A

Prepared: Dry

Liquid Limit: 42

Plastic Limit: 24

Plasticity Index: 18

Activity Index: 0.9

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3): N/A

Maximum Dry Density (kg/m^3): N/A

Optimum Moisture Content (%): N/A

Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%): N/A

Compacted Dry Density (lb/ft^3): N/A

Compacted Moisture Content (%): N/A

Specific Gravity

Estimated

Particle Size: No. 10

Specific Gravity at 20° Celsius: 2.70

Classification

Unified Group Symbol: SC

Group Name: Clayey Sand with Gravel

ODOT Classification A-7-6 (5)

Description: Clay

Comments:

Reviewed By REL

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name: BEL-CR4-27.05
Source: B-002-0-23, 7.5'-9.0'
Project Number: 175538118
Lab ID: 72

Sieve Analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared Using: ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: JP
Test Date: 03-22-2023
Date Received: 03-14-2023

Maximum Particle Size: 1 1/2" Sieve

Sieve Size	% Passing
1 1/2"	100.0
3/4"	95.7
3/8"	77.9
No. 4	72.7
No. 10	64.9

Analysis for the Portion Finer than the No. 10 Sieve

Analysis Based on -3 inch Fraction Only

Specific Gravity: 2.7

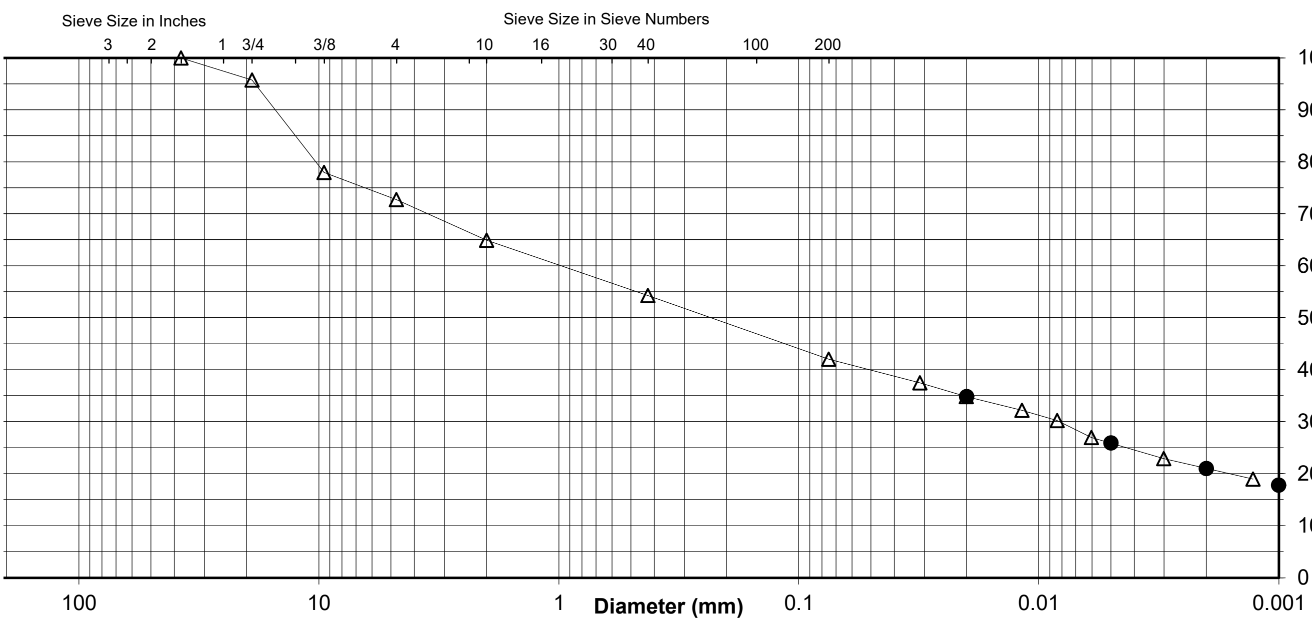
Dispersed Using Apparatus A - Mechanical, for 1 Minute

No. 40	54.3
No. 200	42.0
0.02 mm	34.8
0.005 mm	25.9
0.002 mm	21.0
0.001 mm	17.8

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	4.3	23.0	7.8	10.6	12.3	16.1	25.9

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	35.1	10.6	12.3	21.0	21.0



Comments ______

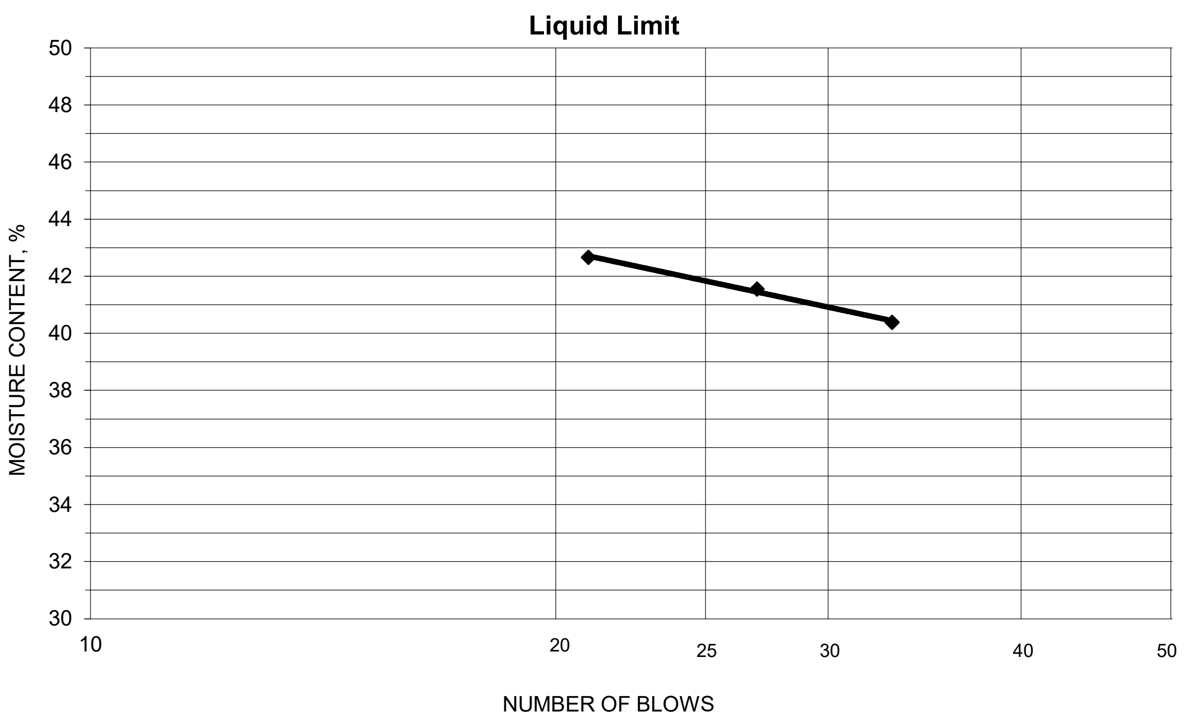
Reviewed By REL

Stantec

ATTERBERG LIMITS

Project	BEL-CR4-27.05	Project No.	175538118
Source	B-002-0-23, 7.5'-9.0'	Lab ID	72
		% + No. 40	46
Tested By	JP	Test Method	ASTM D 4318 Method A
Date Received	03-14-2023		
Test Date	03-28-2023	Prepared	Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
21.64	18.49	10.69	33	40.4	
21.77	18.50	10.63	27	41.6	
22.49	19.03	10.92	21	42.7	42



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
20.65	18.79	11.00	23.9	24	18
21.66	19.60	11.06	24.1		

Remarks: ______________________

Reviewed By REL

Stantec

Summary of Soil Tests

Project Name: BEL-CR4-27.05
Project Number: 175538118
Source: B-002-0-23, 10.0'-11.5'
Lab ID: 73
Sample Type: SPT
Date Received: 3-14-23
Date Reported: 3-29-23

Test Results

Natural Moisture Content
Test Method: ASTM D 2216
Moisture Content (%): 20.4

Atterberg Limits
Test Method: ASTM D 4318 Method A
Prepared: Dry
Liquid Limit: 42
Plastic Limit: 25
Plasticity Index: 17
Activity Index: 1.5

Particle Size Analysis
Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
	N/A	
	N/A	
	N/A	
1 1/2"	37.5	100.0
3/4"	19	84.5
3/8"	9.5	64.0
No. 4	4.75	56.3
No. 10	2	45.9
No. 40	0.425	32.5
No. 200	0.075	24.9
	0.02	19.7
	0.005	14.4
	0.002	11.0
Estimated	0.001	8.7

Plus 3 in. Material, Not Included: 0 (%)

Range	ASTM (%)	ODOT (%)
Gravel	43.7	54.1
Coarse Sand	10.4	13.4
Medium Sand	13.4	---
Fine Sand	7.6	7.6
Silt	10.5	10.5
Clay	14.4	14.4

Moisture-Density Relationship
Test Not Performed
Maximum Dry Density (lb/ft^3): N/A
Maximum Dry Density (kg/m^3): N/A
Optimum Moisture Content (%): N/A
Over Size Correction %: N/A

California Bearing Ratio
Test Not Performed
Bearing Ratio (%): N/A
Compacted Dry Density (lb/ft^3): N/A
Compacted Moisture Content (%): N/A

Specific Gravity
Estimated
Particle Size: No. 10
Specific Gravity at 20° Celsius: 2.70

Classification
Unified Group Symbol: GC
Group Name: Clayey Gravel with Sand
ODOT Classification: A-2-7 (1)
Description: Gravel and/or Stone Fragments w/Sand, Silt & Clay

Comments:

Reviewed By: REL

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name BEL-CR4-27.05 | Project Number 175538118
Source B-002-0-23, 10.0'-11.5' | Lab ID 73

Sieve Analysis for the Portion Coarser than the No. 10 Sieve

Test Method ASTM D 422
Prepared Using ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By JP
Test Date 03-22-2023
Date Received 03-14-2023

Maximum Particle Size: 1 1/2" Sieve

Sieve Size	% Passing
1 1/2"	100.0
3/4"	84.5
3/8"	64.0
No. 4	56.3
No. 10	45.9

Analysis for the Portion Finer than the No. 10 Sieve

Analysis Based on -3 inch Fraction Only

Specific Gravity 2.7

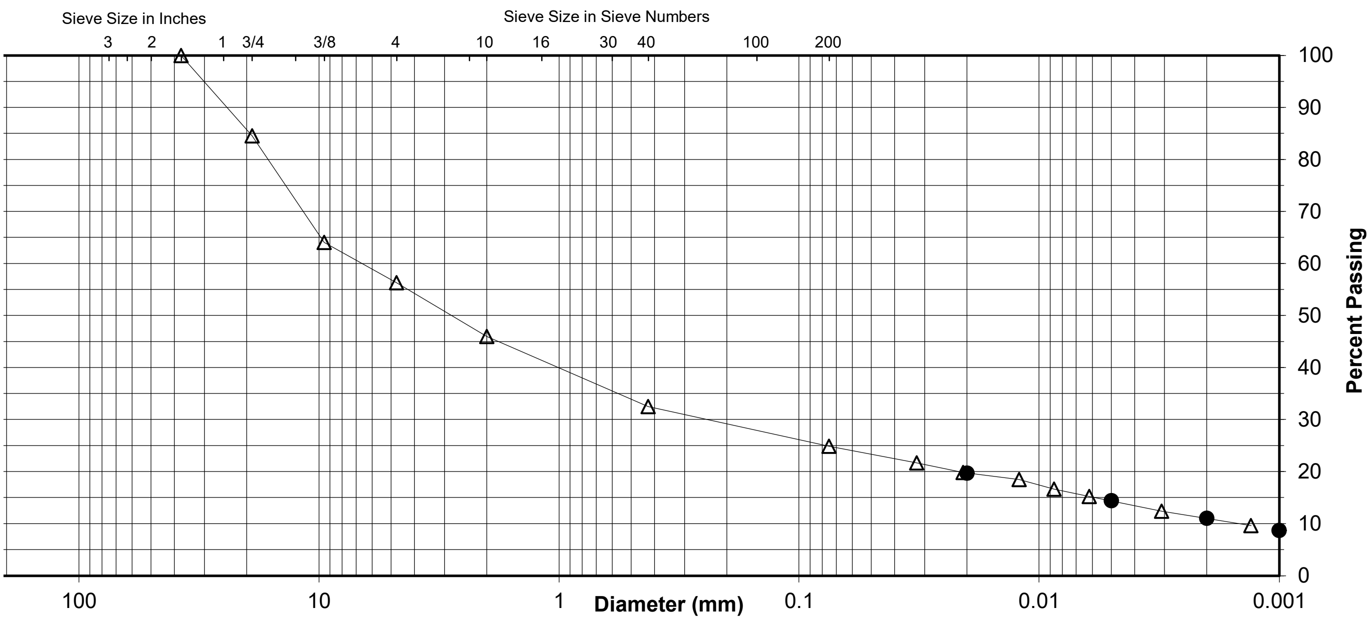
Dispersed Using Apparatus A - Mechanical, for 1 Minute

Sieve Size	% Passing
No. 40	32.5
No. 200	24.9
0.02 mm	19.7
0.005 mm	14.4
0.002 mm	11.0
0.001 mm	8.7

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	15.5	28.2	10.4	13.4	7.6	10.5	14.4

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	54.1	13.4	7.6	13.9	11.0



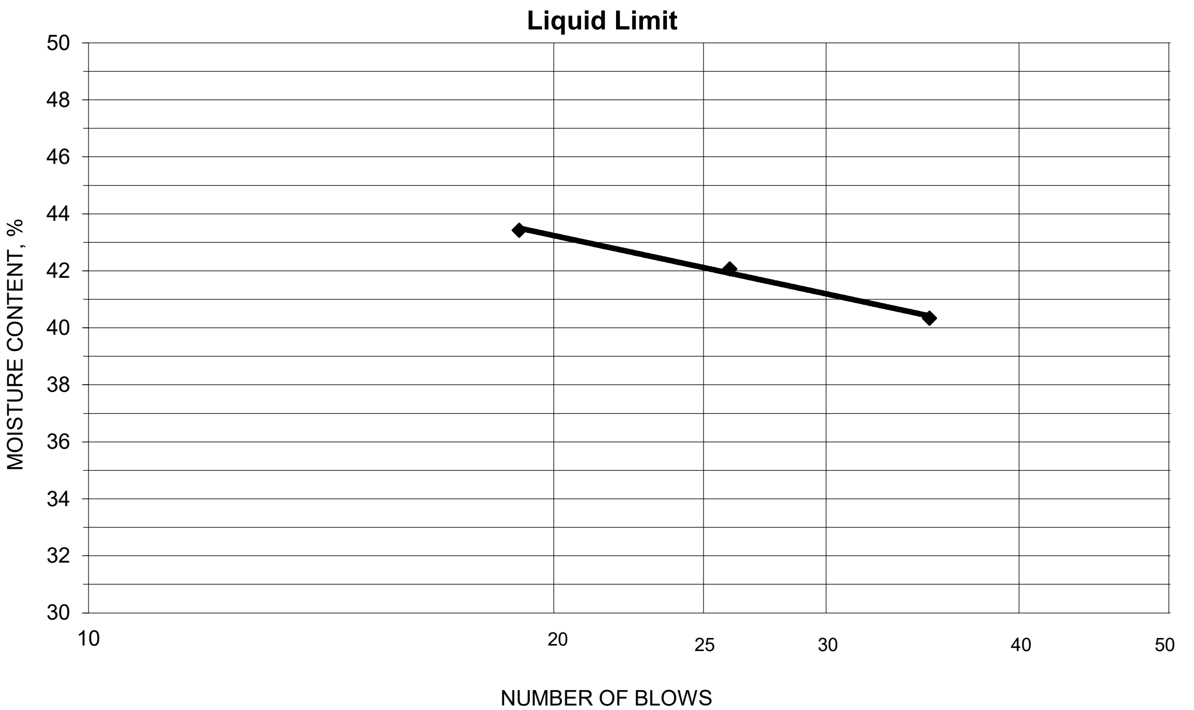
Comments ______ | Reviewed By REL

Stantec

ATTERBERG LIMITS

Project	BEL-CR4-27.05			Project No.	175538118
Source	B-002-0-23, 10.0'-11.5'			Lab ID	73
				% + No. 40	68
Tested By	JP	Test Method	ASTM D 4318 Method A	Date Received	03-14-2023
Test Date	03-28-2023	Prepared	Dry		

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
21.62	18.57	11.01	35	40.3	
21.29	18.27	11.09	26	42.1	
20.60	17.66	10.89	19	43.4	42



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
19.82	18.04	11.03	25.4	25	17
20.67	18.75	11.03	24.9		

Remarks:

Reviewed By REL

Stantec

Summary of Soil Tests

Project Name: BEL-CR4-27.05
Project Number: 175538118
Source: H-001-0-22, 0.0'-2.0'
Lab ID: 74

Sample Type: Bag
Date Received: 3-14-23
Date Reported: 3-29-23

Test Results

Natural Moisture Content

Test Method: ASTM D 2216
Moisture Content (%): 35.1

Particle Size Analysis

Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size Sieve Size	Particle Size (mm)	% Passing
	N/A	
	N/A	
	N/A	
1 1/2"	37.5	100.0
3/4"	19	96.3
3/8"	9.5	80.1
No. 4	4.75	67.9
No. 10	2	58.1
No. 40	0.425	38.1
No. 200	0.075	15.2
	0.02	12.1
	0.005	7.5
	0.002	5.7
Estimated	0.001	4.8

Plus 3 in. Material, Not Included: 0 (%)

Range	ASTM (%)	ODOT (%)
Gravel	32.1	41.9
Coarse Sand	9.8	20.0
Medium Sand	20.0	---
Fine Sand	22.9	22.9
Silt	7.7	7.7
Clay	7.5	7.5

Atterberg Limits

Test Method: ASTM D 4318 Method A
Prepared: Dry

Liquid Limit: NP
Plastic Limit: NP
Plasticity Index: NP
Activity Index: N/A

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3): N/A
Maximum Dry Density (kg/m^3): N/A
Optimum Moisture Content (%): N/A
Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%): N/A
Compacted Dry Density (lb/ft^3): N/A
Compacted Moisture Content (%): N/A

Specific Gravity

Estimated

Particle Size: No. 10
Specific Gravity at 20° Celsius: 2.70

Classification

Unified Group Symbol: SM
Group Name: Silty Sand with Gravel

ODOT Classification: A-1-b (0)
Description: Gravel and/or Stone Fragments with Sand

Comments:

Reviewed By: REL

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name	BEL-CR4-27.05	Project Number	175538118
Source	H-001-0-22, 0.0'-2.0'	Lab ID	74

Sieve Analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared Using: ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: JP
Test Date: 03-22-2023
Date Received: 03-14-2023

Maximum Particle Size: 1 1/2" Sieve

Sieve Size	% Passing
1 1/2"	100.0
3/4"	96.3
3/8"	80.1
No. 4	67.9
No. 10	58.1

Analysis for the Portion Finer than the No. 10 Sieve

Analysis Based on -3 inch Fraction Only

Specific Gravity: 2.7

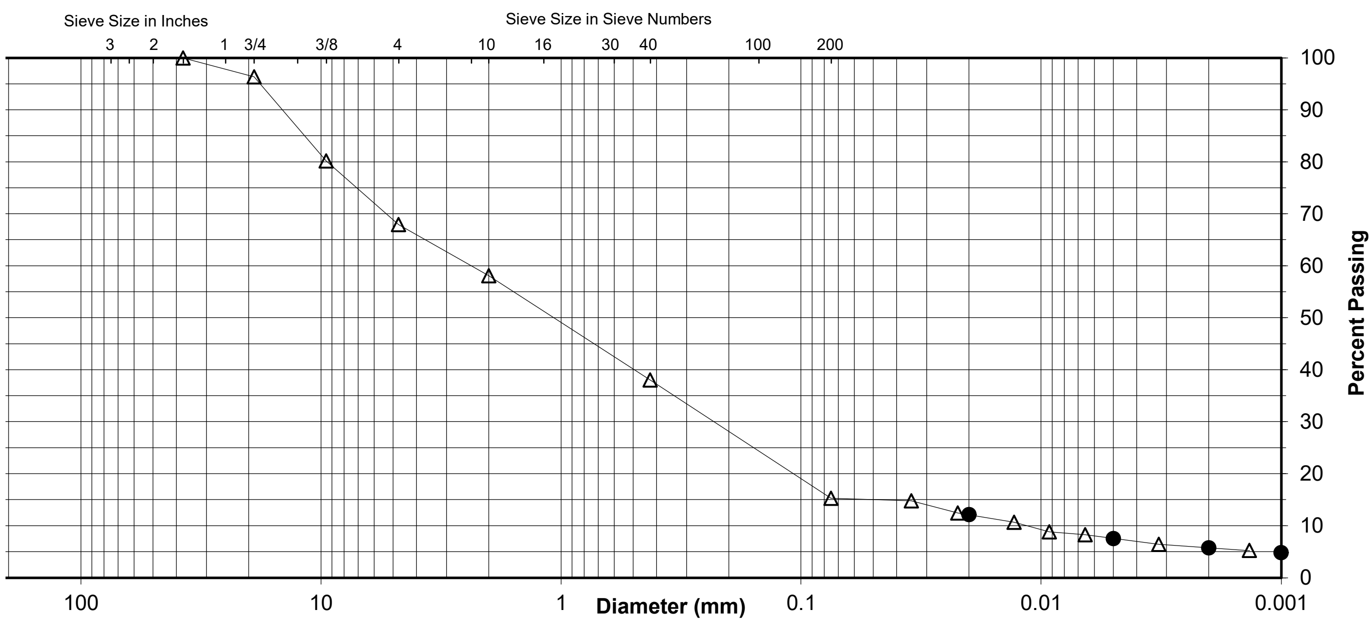
Dispersed Using Apparatus A - Mechanical, for 1 Minute

Sieve Size	% Passing
No. 40	38.1
No. 200	15.2
0.02 mm	12.1
0.005 mm	7.5
0.002 mm	5.7
0.001 mm	4.8

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	3.7	28.4	9.8	20.0	22.9	7.7	7.5

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	41.9	20.0	22.9	9.5	5.7



Comments ______

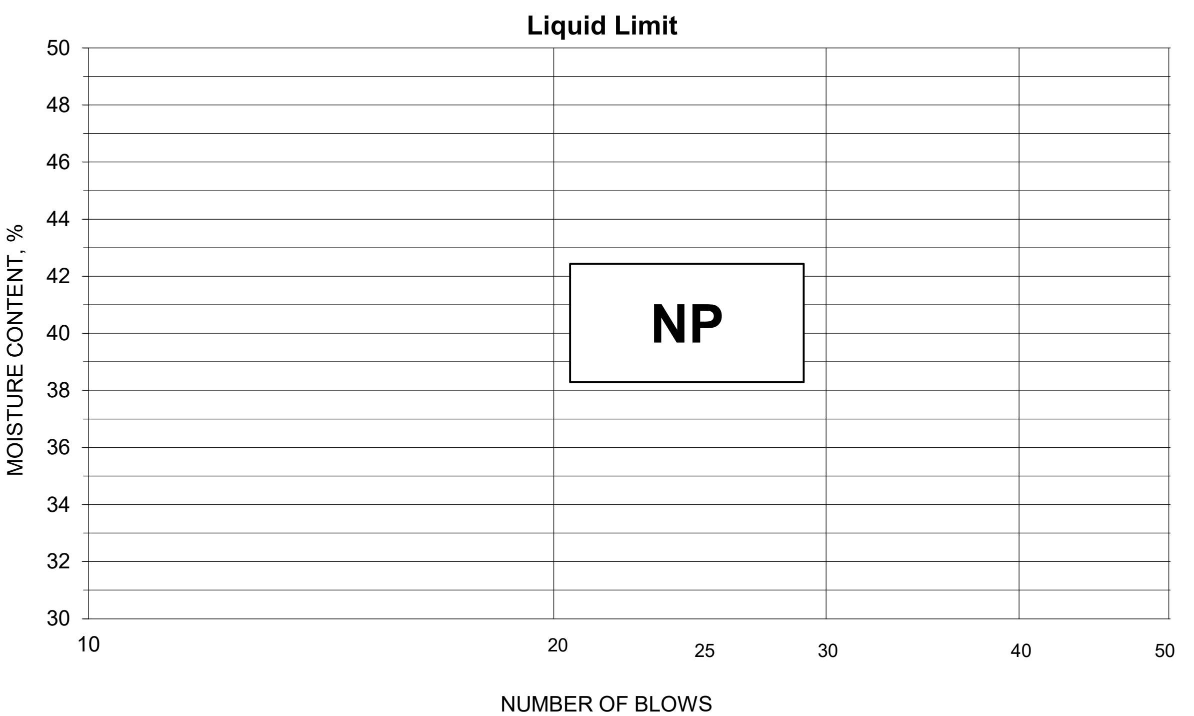
Reviewed By REL

Stantec

ATTERBERG LIMITS

Project	BEL-CR4-27.05	Project No.	175538118
Source	H-001-0-22, 0.0'-2.0'	Lab ID	74
		% + No. 40	62
Tested By	JP	Test Method	ASTM D 4318 Method A
Date Received	03-14-2023		
Test Date	03-28-2023	Prepared	Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index

Remarks:

Reviewed By REL

Stantec

Uniaxial Compressive Strength of Intact Rock Core Specimens

ASTM D 7012, Method C

Project Name: BEL-CR4-27.05 Bridge Replacement
Project Number: 175538118
Lithology: Limestone, gray, moderately hard
Lab ID: UCR-79
Hole Number: B-001-0-23
Depth (ft): 14.4'-14.8'
Date Received: 03/21/2023

Temperature (^{o}C): 22
Moisture Condition: As Prepared, Moist
Date Tested: 03/24/2023

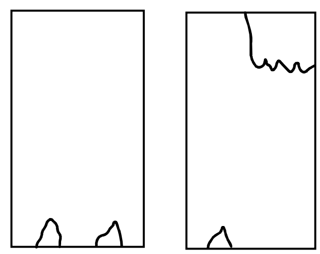
Side Planeness: N/A
Height (in): 4.824
Wet Unit Weight (pcf): 172.6
Perpendicularity: N/A
Diameter (in): 1.975
Dry Unit Weight (pcf): N/A
End Planeness: N/A
Area (in^2): 3.065
Moisture Content (%): N/A
Parallelism: N/A
Dimensions were not confirmed.

Loading Rate (lbf/sec): 182
Peak Load (lbf): 58005

Failure Type: Undetermined

Compressive Strength (psi): 18930
Compressive Strength (psf): 2725920
Compressive Strength (tsf): 1363

Failure Sketches



Comments: Capped ends of specimen with Hydro-stone due to unyielding nature.

Reviewed By: RJ

Template: tmp_ucr_input.xlsm
Version: 20170215
Approved By: RJ

Stantec Consulting Services Inc.
Lexington, Kentucky

Reported By: RJ
Report Date: 03/27/2023

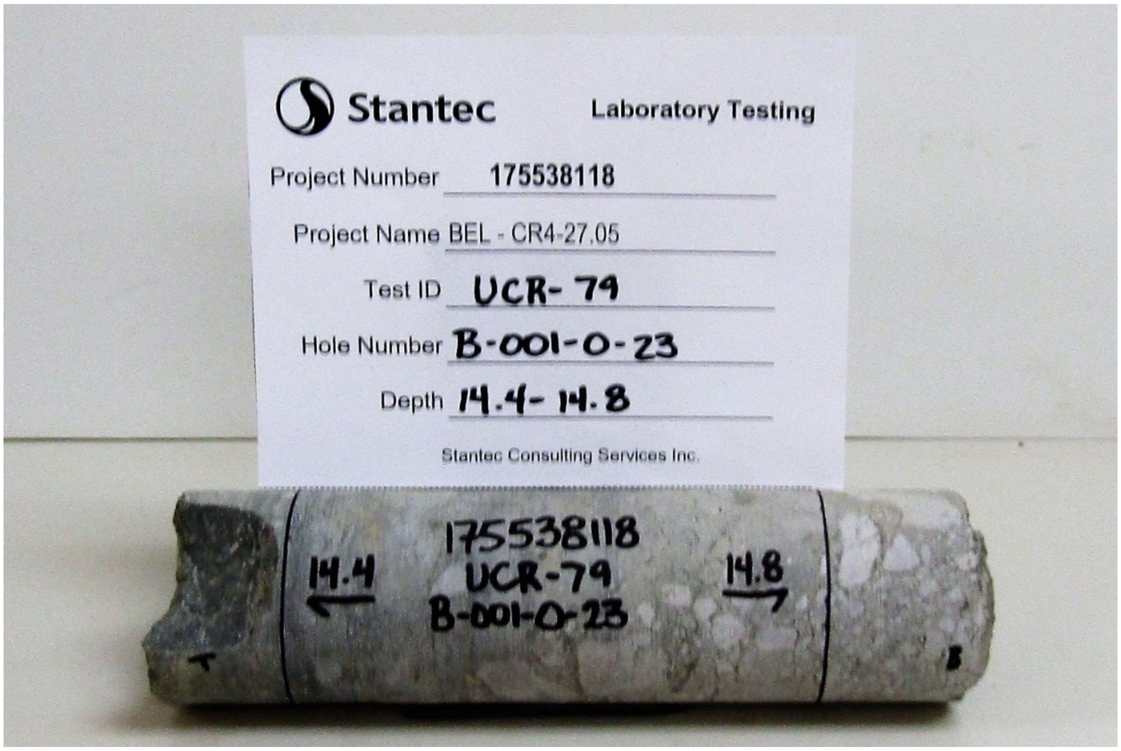
Stantec

Photo Report

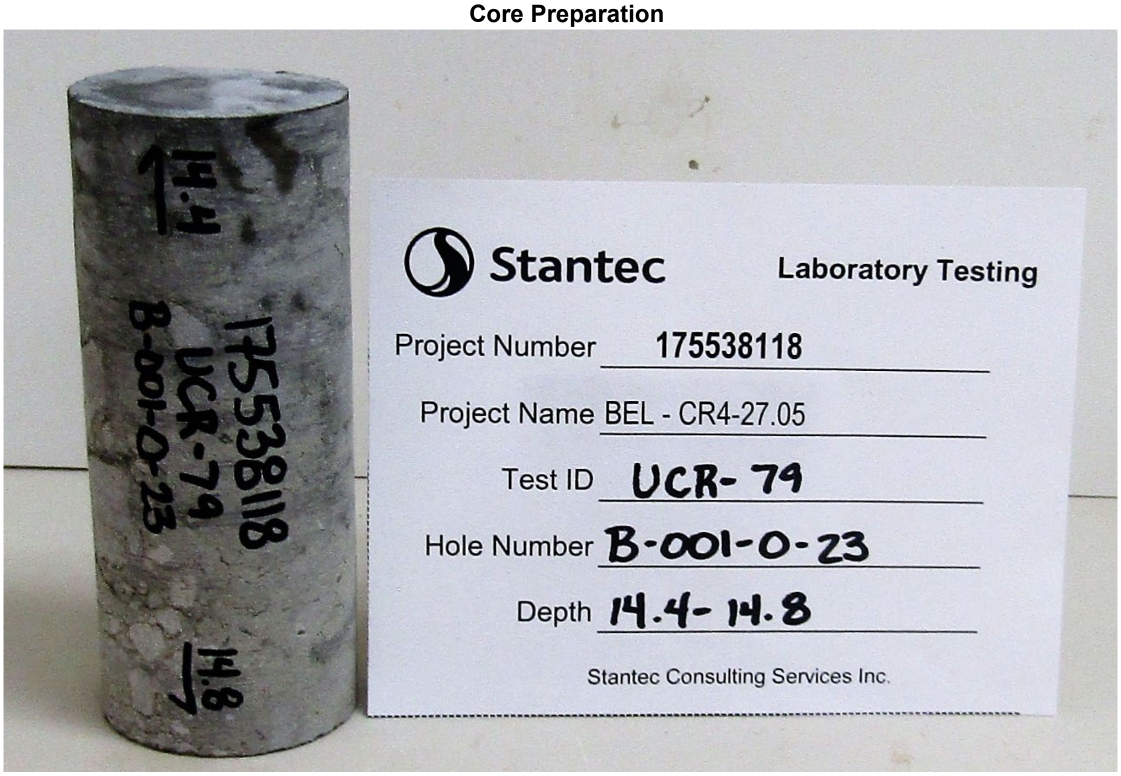
Project Name BEL-CR4-27.05 Bridge Replacement
Lithology Limestone, gray, moderately hard
Hole Number B-001-0-23 Depth (ft) 14.4'-14.8'
Test Type Uniaxial Compressive Strength of Intact Rock Core

Project Number 175538118
Lab ID UCR-79

As Received



Core Preparation



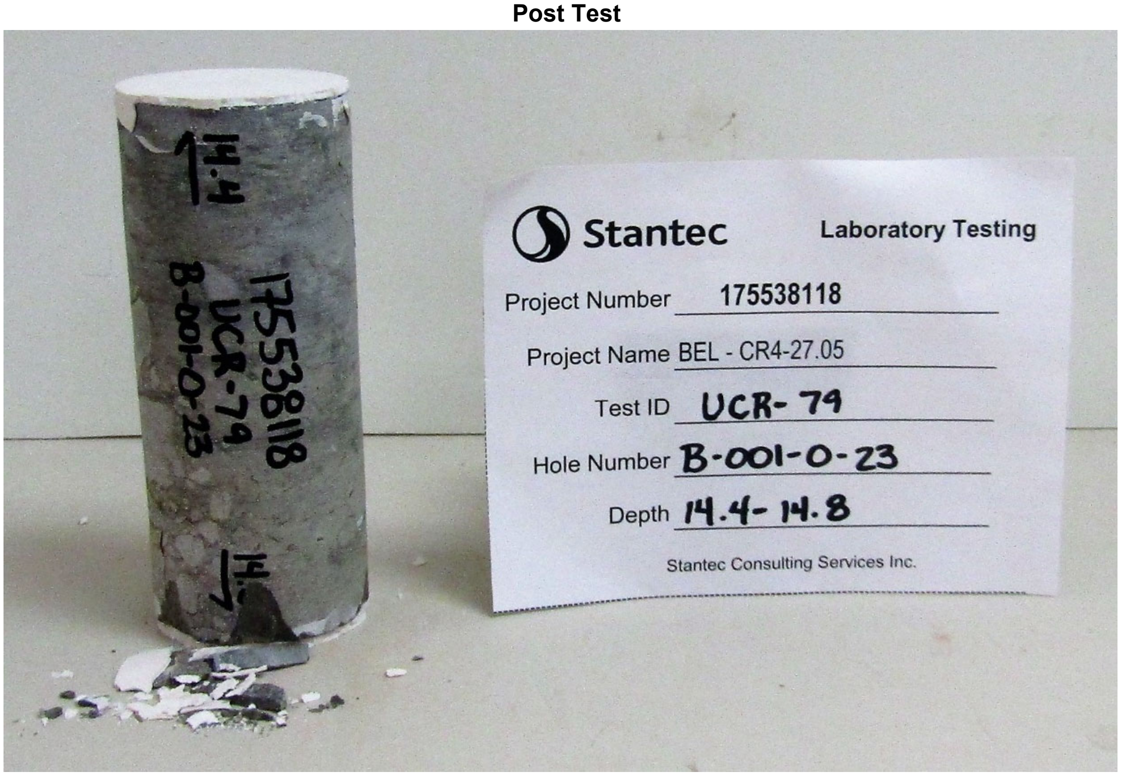
Stantec

Photo Report

Project Name	BEL-CR4-27.05 Bridge Replacement	Project Number	175538118
Lithology	Limestone, gray, moderately hard	Lab ID	UCR-79
Hole Number	B-001-0-23 Depth (ft) 14.4'-14.8'		
Test Type	Uniaxial Compressive Strength of Intact Rock Core		

Core Preparation

Post Test

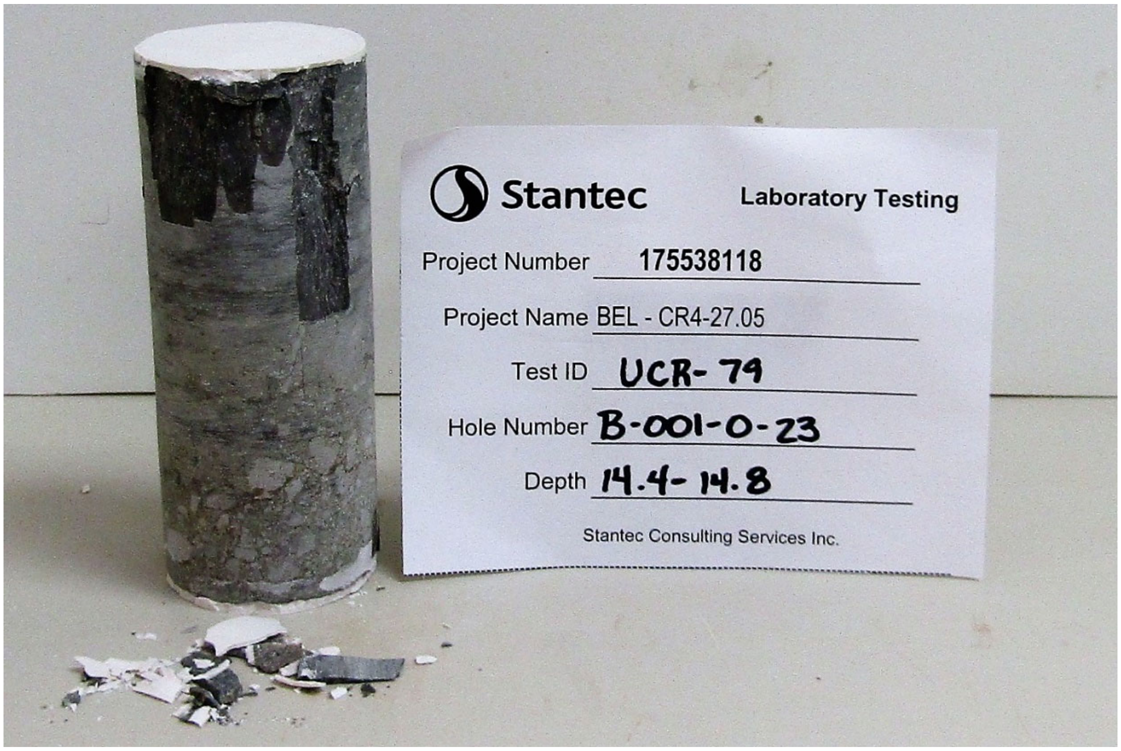


Stantec

Photo Report

Project Name	BEL-CR4-27.05 Bridge Replacement	Project Number	175538118
Lithology	Limestone, gray, moderately hard	Lab ID	UCR-79
Hole Number	B-001-0-23 Depth (ft) 14.4'-14.8'		
Test Type	Uniaxial Compressive Strength of Intact Rock Core		

Post Test



Stantec

Uniaxial Compressive Strength of Intact Rock Core Specimens

ASTM D 7012, Method C

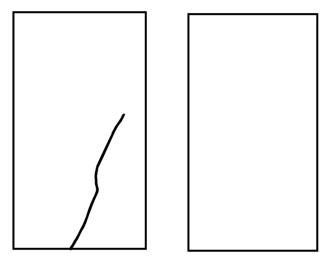
Project Name	BEL-CR4-27.05 Bridge Replacement	Project Number	175538118
Lithology	Shale, gray, moderately hard	Lab ID	UCR-81
Hole Number	B-001-0-23 Depth (ft) 20.0'-20.4'	Date Received	03/21/2023

Temperature (^{o}C)	22	Moisture Condition	As Prepared, Moist	Date Tested	03/24/2023
Side Planeness	N/A	Height (in)	4.885	Wet Unit Weight (pcf)	162.5
Perpendicularity	N/A	Diameter (in)	1.973	Dry Unit Weight (pcf)	N/A
End Planeness	N/A	Area (in^2)	3.056	Moisture Content (%)	N/A
Parallelism	N/A				

Dimensions were not confirmed.

Loading Rate (lbf/sec)	26
Peak Load (lbf)	3193
Failure Type	Undetermined
Compressive Strength (psi)	1045
Compressive Strength (psf)	150480
Compressive Strength (tsf)	75

Failure Sketches



Comments: Fragile nature of specimen inhibited preparation, required capping of ends with Hydro-Stone. Dimensional tolerances were not confirmed.

Reviewed By RJ

Template: tmp_ucr_input.xlsm
Version: 20170215
Approved By: RJ

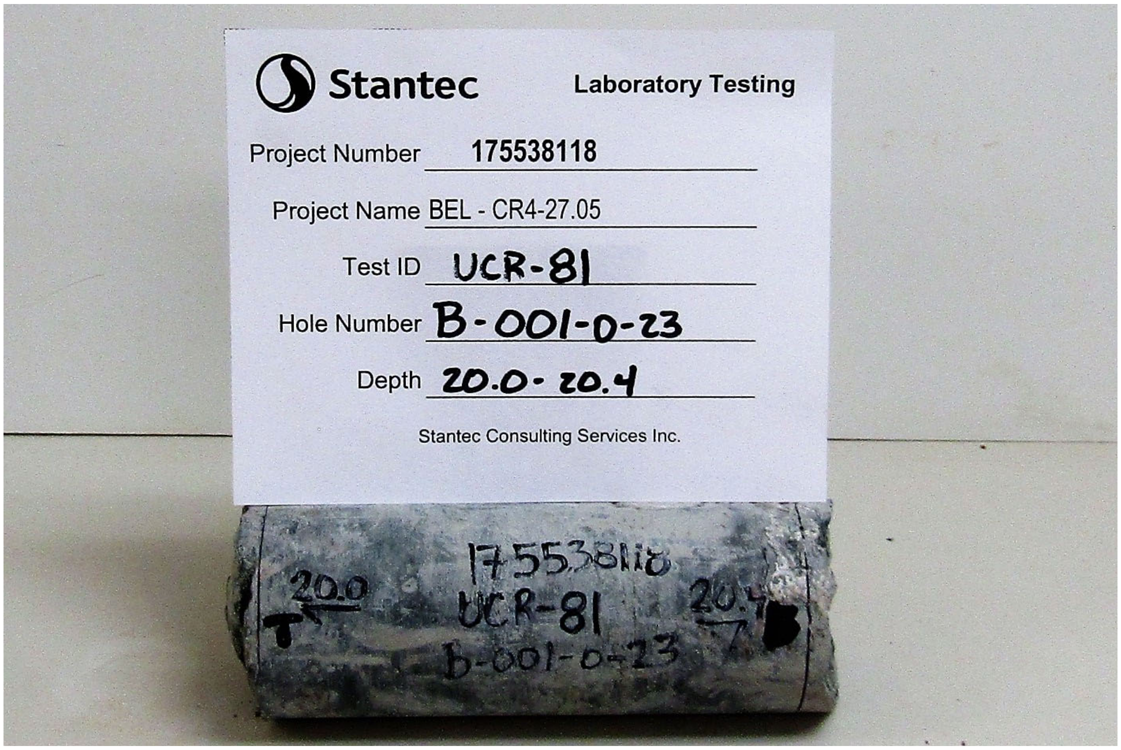
Reported By: RJ
Report Date: 03/27/2023

Stantec

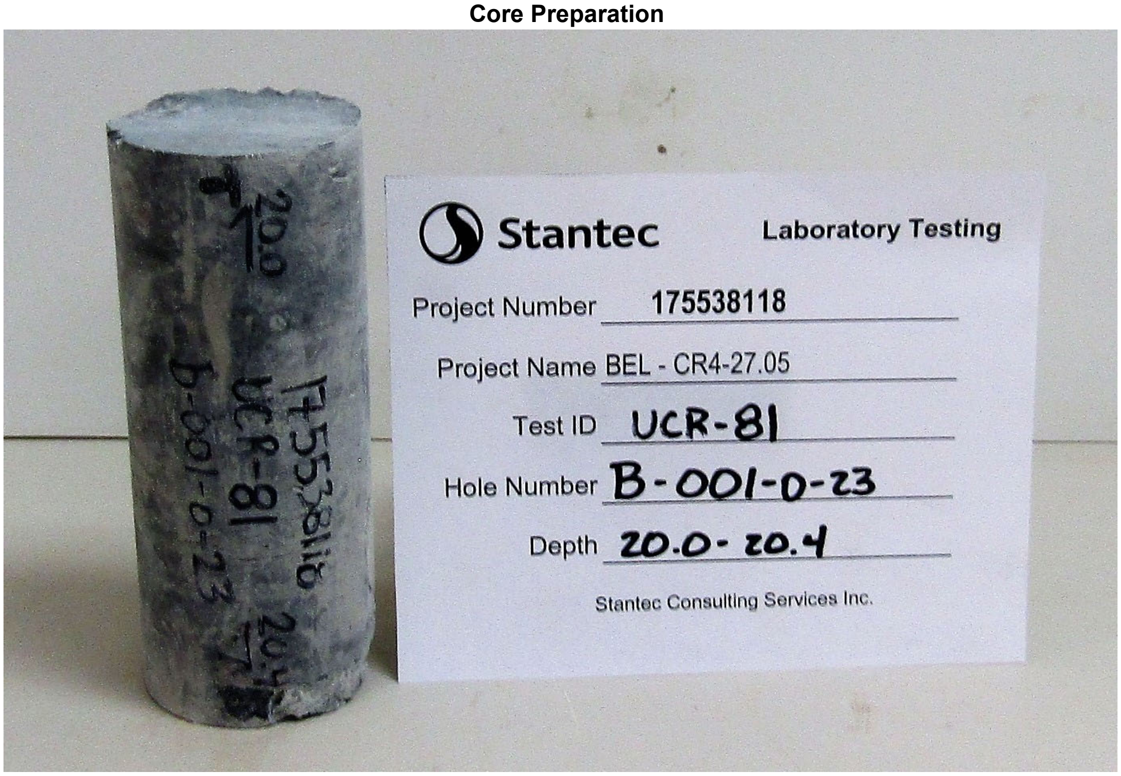
Photo Report

Project Name	BEL-CR4-27.05 Bridge Replacement	Project Number	175538118
Lithology	Shale, gray, moderately hard	Lab ID	UCR-81
Hole Number	B-001-0-23 Depth (ft) 20.0'-20.4'		
Test Type	Uniaxial Compressive Strength of Intact Rock Core		

As Received



Core Preparation



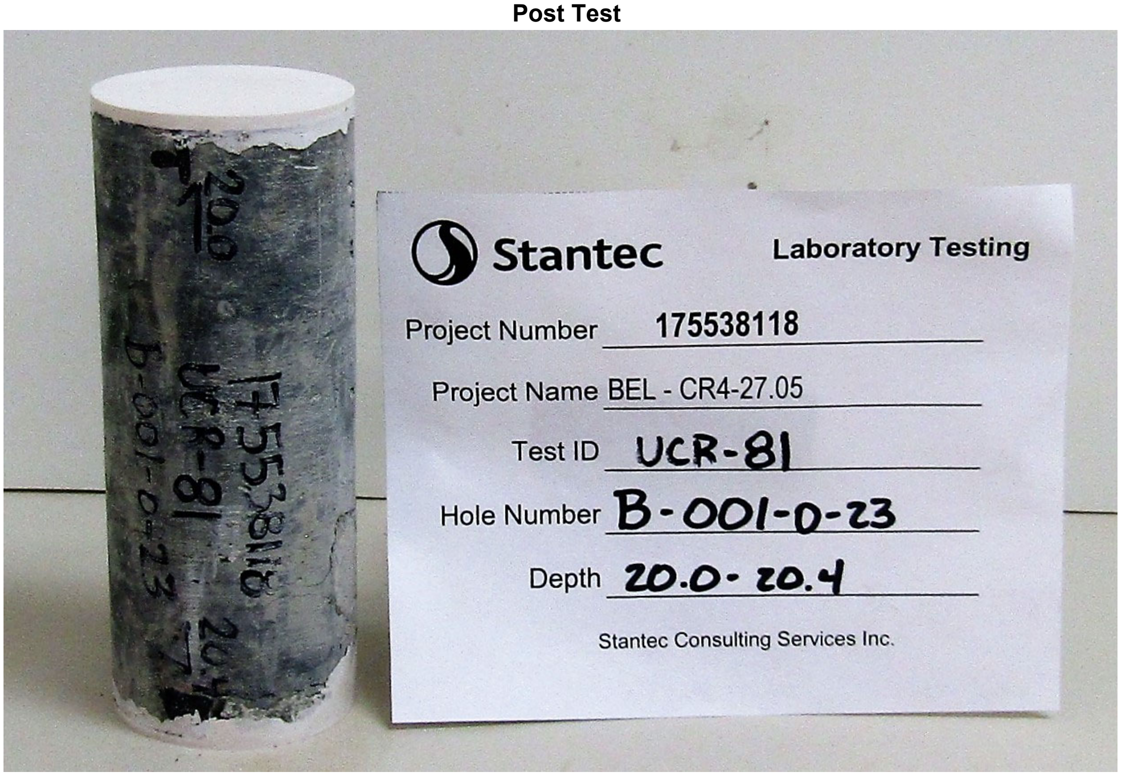
Stantec

Photo Report

Project Name	BEL-CR4-27.05 Bridge Replacement	Project Number	175538118
Lithology	Shale, gray, moderately hard	Lab ID	UCR-81
Hole Number	B-001-0-23 Depth (ft) 20.0'-20.4'		
Test Type	Uniaxial Compressive Strength of Intact Rock Core		

Core Preparation

Post Test

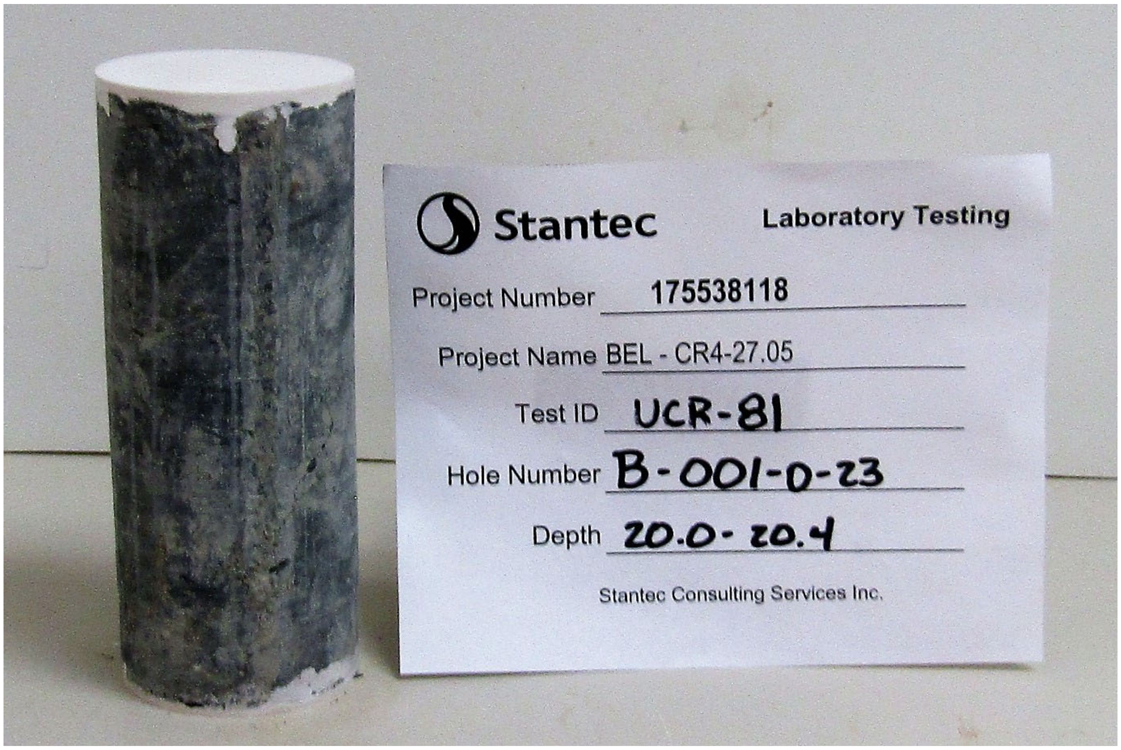


Stantec

Photo Report

Project Name	BEL-CR4-27.05 Bridge Replacement	Project Number	175538118
Lithology	Shale, gray, moderately hard	Lab ID	UCR-81
Hole Number	B-001-0-23 Depth (ft) 20.0'-20.4'		
Test Type	Uniaxial Compressive Strength of Intact Rock Core		

Post Test



Stantec

Uniaxial Compressive Strength of Intact Rock Core Specimens

ASTM D 7012, Method C

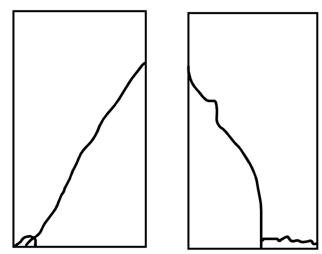
Project Name	BEL-CR4-27.05 Bridge Replacement	Project Number	175538118
Lithology	Shale, gray, moderately hard	Lab ID	UCR-82
Hole Number	B-002-0-23 Depth (ft) 13.0'-13.4'	Date Received	03/21/2023

Temperature (^oC)	23	Moisture Condition	As Prepared, Moist	Date Tested	03/24/2023
Side Planeness	N/A	Height (in)	4.700	Wet Unit Weight (pcf)	165.0
Perpendicularity	N/A	Diameter (in)	1.968	Dry Unit Weight (pcf)	N/A
End Planeness	N/A	Area (in^2)	3.040	Moisture Content (%)	N/A
Parallelism	N/A				

Dimensions were not confirmed.

Loading Rate (lbf/sec)	26
Peak Load (lbf)	2321
Failure Type	Shear
Compressive Strength (psi)	763
Compressive Strength (psf)	109872
Compressive Strength (tsf)	55

Failure Sketches



Comments Fragile nature of specimen inhibited preparation, required capping of ends with Hydro-Stone.
Dimensional tolerances were not confirmed.
Specimen failed prior to expected minimum compressive load.

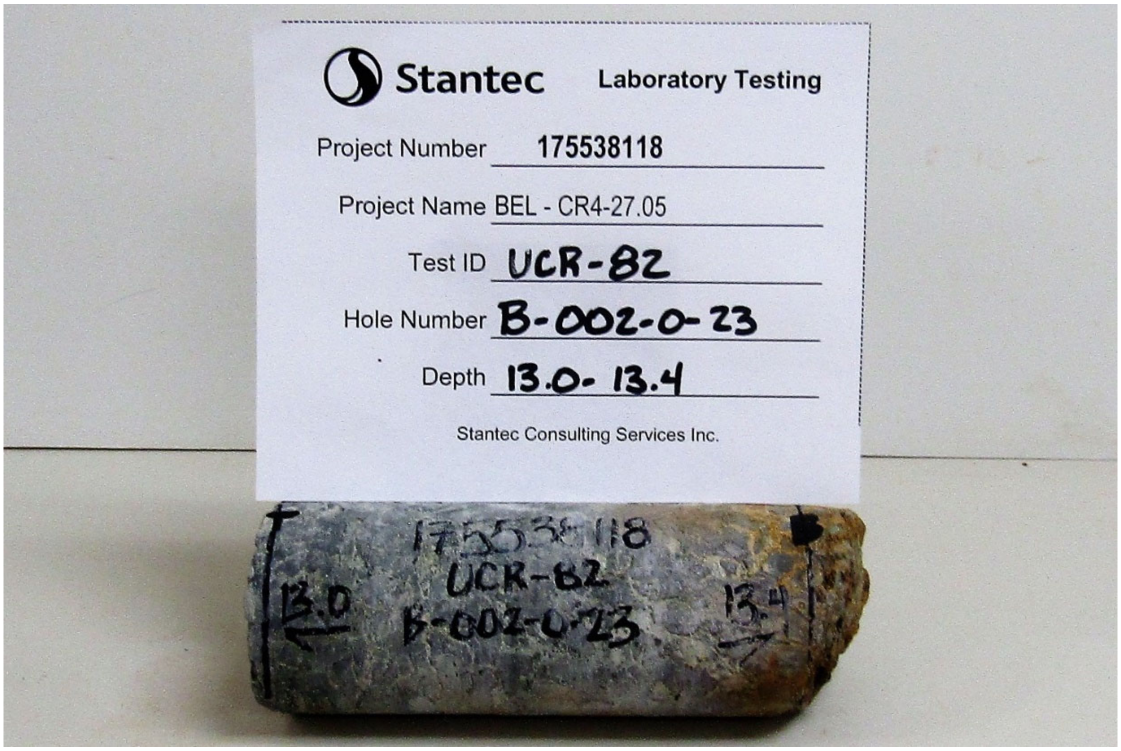
Reviewed By RJ

Stantec

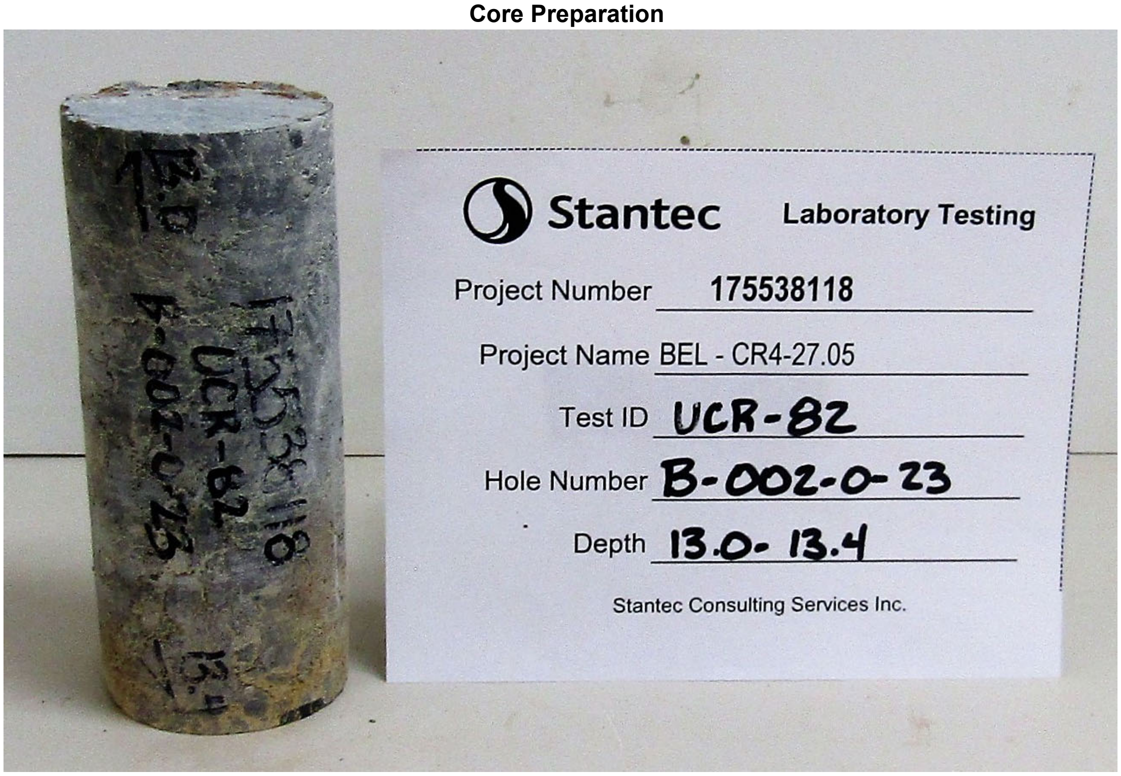
Photo Report

Project Name	BEL-CR4-27.05 Bridge Replacement	Project Number	175538118
Lithology	Shale, gray, moderately hard	Lab ID	UCR-82
Hole Number	B-002-0-23 Depth (ft) 13.0'-13.4'		
Test Type	Uniaxial Compressive Strength of Intact Rock Core		

As Received



Core Preparation

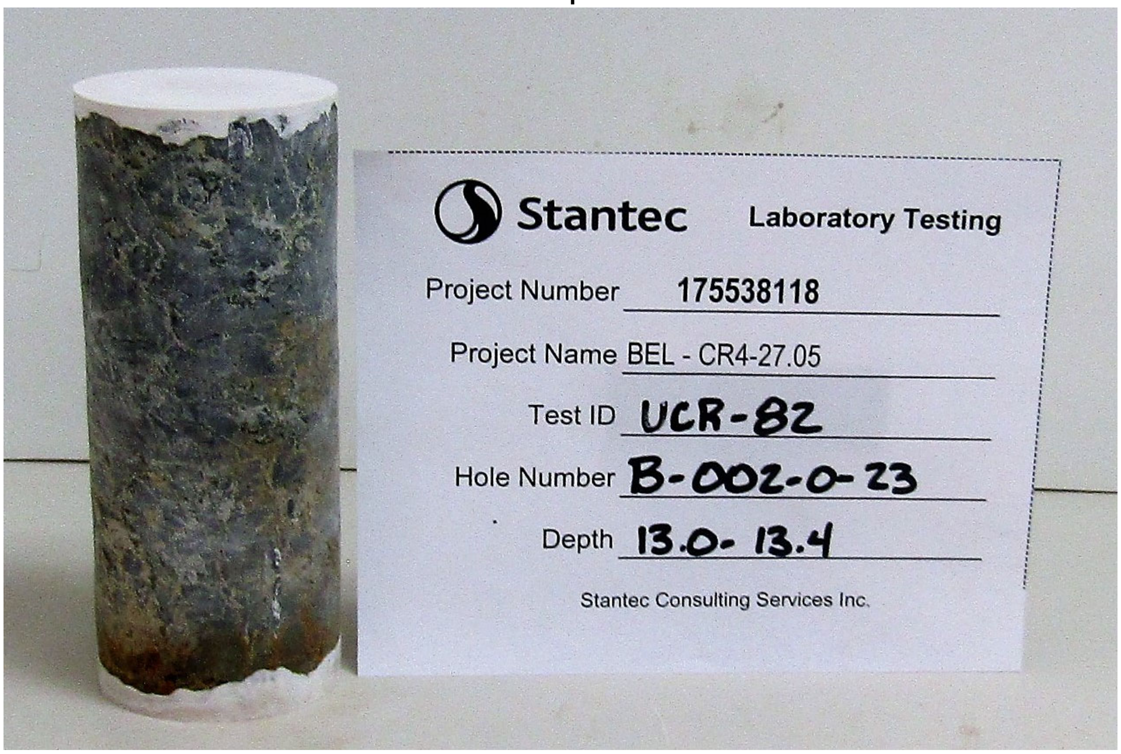


Stantec

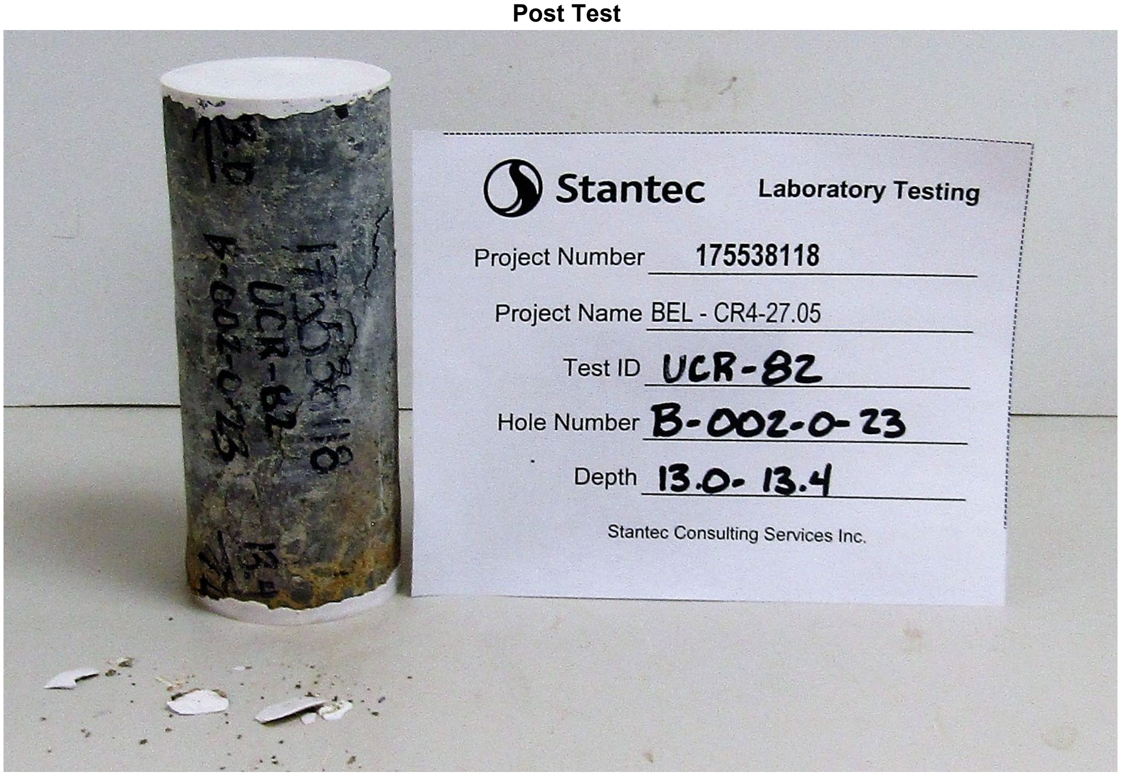
Photo Report

Project Name	BEL-CR4-27.05 Bridge Replacement	Project Number	175538118
Lithology	Shale, gray, moderately hard	Lab ID	UCR-82
Hole Number	B-002-0-23 Depth (ft) 13.0'-13.4'		
Test Type	Uniaxial Compressive Strength of Intact Rock Core		

Core Preparation



Post Test

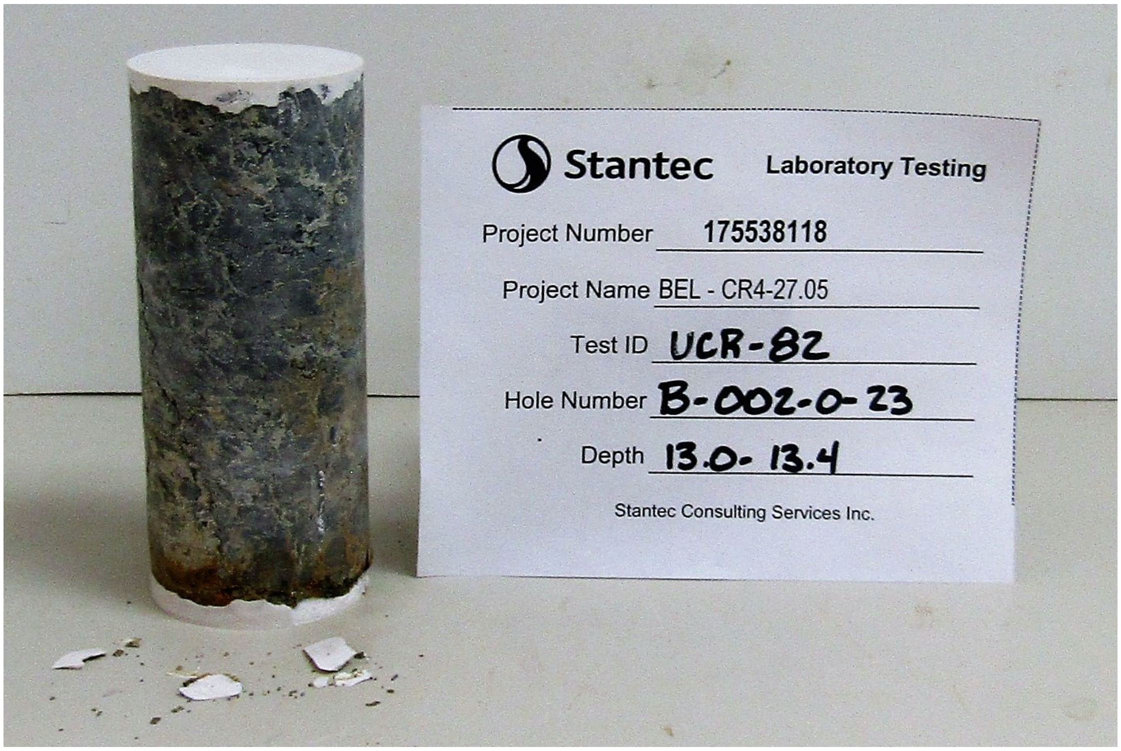


Stantec

Photo Report

Project Name	BEL-CR4-27.05 Bridge Replacement	Project Number	175538118
Lithology	Shale, gray, moderately hard	Lab ID	UCR-82
Hole Number	B-002-0-23 Depth (ft) 13.0'-13.4'		
Test Type	Uniaxial Compressive Strength of Intact Rock Core		

Post Test



APPENDIX C
BRIDGE FOUNDATION CALCULATIONS

Stantec

BEL-CR4-27.05 DRILLED SHAFT AXIAL CAPACITY CALCULATIONS

BEDROCK CONDITIONS

According to boring logs, bedrock at the site is described as shale. Three unconfined compression strength tests were completed on this bedrock. The unconfined compressive strength (q_u) of rock at the site is:

$q_u = 763, 1045,$ and 18930 pounds per square inch (psi)

Converting to kips per square foot (ksf) : $q_u = 110, 151,$ and $2726\ ksf$

A compressive strength of 55 ksf (half of the lowest test) was conservatively selected based on testing and field conditions, considering the non-homogeneous nature of the bedrock and that some of the bedrock was likely softer than the samples tested.

NOMINAL UNIT TIP RESISTANCE

From the AASHTO LRFD 9th Edition, the nominal unit tip resistance (q_p) is determined by:

$q_p = 2.5\, q_u \quad (10.8.3.5.4c - 1)$
$q_p = 2.5(55\ ksf) = 137.5\ ksf$

NOMINAL UNIT SIDE RESISTANCE

From the AASHTO LRFD 9th Edition, the nominal unit side resistance (q_s) is determined by:

$$\frac{q_s}{p_a} = \mathrm{C}\sqrt{\frac{q_u}{p_a}} \quad (10.8.3.5.4b - 1)$$

Where:

p_a = atmospheric pressure taken as 2.12 ksf

C = regression coefficient taken as 1.0 for normal conditions

$$q_s = (2.12\ ksf)\ (1.0)\sqrt{\frac{55\ ksf}{2.12\ ksf}} = 10.8\ ksf$$

FACTORED RESISTANCES

Drilled shaft resistance factors per ODOT BDM Table 305-1:

- Tip Resistance in Rock = 0.50
- Side Resistance in Rock = 0.55

Factored unit tip resistance $= 0.5(137.5\ ksf) = 68.8\ ksf$

Factored unit side resistance $= 0.55(10.8\ ksf) = 5.9\ ksf$

Calculated by: M. Kakoko 04/06/2023
Reviewed by: E. Kistner 04/11/2023

Table 4.20. Geomechanics Rating Adjustment for Joint Orientations (after AASHTO 2010).						
Orientations of Joints		Very Favorable	Favorable	Fair	Unfavorable	Very Unfavorable
Ratings	Tunnels	0	-2	-5	-10	-12
	Foundations	0	-2	-7	-15	-25
	Slopes	0	-5	-25	-50	-60

Table 4.21. Geomechanics Rock Mass Classes Determined From Total Ratings (AASHTO 2010).					
RMR (Note 1)	100 to 81	80 to 61	60 to 41	40 to 21	<20
Class No.	I	II	III	IV	V
Description	Very good rock	Good rock	Fair rock	Poor rock	Very poor rock
Note 1: RMR is adjusted for structural application and rock joint orientation as per Table 4.20 prior to evaluating the Class No.					

The Erodibility Index is identical to Kirsten's excavatability index which is used to characterize rock for determining the power requirements of earth-moving equipment that can rip the subject material. The index is expressed as the product of four parameters:

$$K = (M_s)(K_b)(K_d)(J_s) \quad = (3.95)(5.2)(0.125)(1.09) = 2.8 \tag{4.17}$$

where:

- K = Erodibility Index
- M_s = Intact rock mass strength parameter
- K_b = Block size parameter
- K_d = Shear strength parameter
- J_s = Relative orientation parameter

The values of the parameters are determined by making use of tables and equations published by Annandale (1995) and Kirsten (1982) as provided in Tables 4.22 through 4.26 below. The intact rock mass strength parameter M_s is related to the unconfined compressive strength as shown in Table 4.22.

Joint spacing and the number of joint sets within a rock mass determines the value of K_b for rock. Joint spacing is estimated from borehole data by means of the rock quality designation (RQD) and the number of joint sets is represented by the joint set number (J_n). The values of the joint set numbers (J_n) are found in Table 4.23. As seen in the table, J_n is a function of the number of joint sets, ranging from rock with no or few joints (essentially intact rock), to rock formations consisting of one to more than four joint sets. The classification accounts for rock that displays random discontinuities in addition to regular joint sets. Random joint discontinuities are discontinuities that do not form regular patterns. For example, rock with two joint sets and random discontinuities is classified as having two joint sets plus random. Having determined the values of RQD and J_n, K_b is calculated as:

RQD = 26 and Jn = 5. Kb = 26/5 = 5.2

the lowest RQD is considered

$$K_b = \frac{RQD}{J_n} \tag{4.18}$$

Table 4.22. Values of the Rock Mass Strength Parameter M_s.

Hardness	Identification in Profile	Unconfined Compressive Strength (MPa)	Mass Strength Number (Ms)
Very soft rock	Material crumbles under firm (moderate) blows with sharp end of geological pick and	Less than 1.7	0.87
	can be peeled off with a knife; is too hard to cut triaxial sample by hand.	1.7 – 3.3	1.86
Soft rock	Can just be scraped and peeled with a knife; indentations 1 mm to 3-mm show in the	3.3 – 6.6	3.95
	specimen with firm (moderate) blows of the pick point.	6.6 – 13.2	8.39
Hard rock	Cannot be scraped or peeled with a knife; hand-held specimen can be broken with hammer end of geological pick with a single firm (moderate) blow.	13.2 – 26.4	17.70
Very hard rock	Hand-held specimen breaks with hammer end of pick under more than one blow.	26.4 – 53.0 53.00 – 106.0	35.0 70.0
Extremely hard rock	Specimen requires many blows with geological pick to break through intact material.	Larger than 212.0	280.0

UCS = 130, 7.2, 5.3 MPa from lab testing, use lowest value to be conservative.

With the values of RQD ranging between 5 and 100, and those of J_n ranging between 1 and 5, the value of K_b ranges between 1 and 100 for rock.

Table 4.23. Rock Joint Set Number J_n.

Number of Joint Sets	Joint Set Number (J_n)
Intact, no or few joints/fissures	1.00
One joint/fissure set	1.22
One joint/fissure set plus random	1.50
Two joint/fissure sets	1.83
Two joint/fissure sets plus random	2.24
Three joint/fissure sets	2.73
Three joint/fissure sets plus random	3.34
Four joint/fissure sets	4.09
Multiple joint/fissure sets	5.00

The discontinuity or shear strength number (K_d) is the parameter that represents the relative strength of discontinuities in rock. In rock, it is determined as the ratio between joint wall roughness (J_r) and joint wall alteration (J_a), where J_r represents the degree of roughness of opposing faces of a rock discontinuity, and J_a represents the degree of alteration of the materials that form the faces of the discontinuity. Alteration relates to amendments of the rock surfaces, for example weathering or the presence of cohesive material between the opposing faces of a joint. Values of J_r and J_a can be found in Tables 4.24 and 4.25. The values of K_d calculated with the information in these tables change with the relative degree of resistance offered by the joints. Increases in resistance are characterized by increases in the value of K_d. The shear strength of a discontinuity is directly proportional to the degree of roughness of opposing joint faces and inversely proportional to the degree of alteration.

$$K_d = \frac{J_r}{J_a} \quad = 1.0 / 8 = 0.125 \qquad (4.19)$$

Table 4.24. Joint Roughness Number J_r.	
Condition of Joint	Joint Roughness Number J_r
Stepped joints/fissures	4.0
Rough or irregular, undulating	3.0
Smooth undulating	2.0
Slickensided undulating	1.5
Rough or irregular, planar	1.5
Smooth planar	1.0
Slickensided planar	0.5
Joints/fissures either open or containing relatively soft gouge of sufficient thickness to prevent joint/fissure wall contact upon excavation	1.0
Shattered or micro-shattered clays	1.0

Re: 305.2.1.2.b. Jr = 1.0 also accounts for clay seam in B-002

Table 4.25. Joint Alteration Number J_a.			
Description of Gouge	Joint Alteration Number (J_a) for Joint Separation (mm)		
	1.0 [(1)]	1.0 –5.0[(2)]	5.0[(3)]
Tightly healed, hard, non-softening impermeable filling	0.75	-	-
Unaltered joint walls, surface staining only	1.0	-	-
Slightly altered, non-softening, non-cohesive rock mineral or crushed rock filling	2.0	2.0	4.0
Non-softening, slightly clayey non-cohesive filling	3.0	6.0	10.0
Non-softening, strongly over-consolidated clay mineral filling, with or without crushed rock	3.0	6.0**	10.0
Softening or low friction clay mineral coatings and small quantities of swelling clays	4.0	8.0	13.0
Softening moderately over-consolidated clay mineral filling, with or without crushed rock	4.0	8.00**	13.0
Shattered or micro-shattered (swelling) clay gouge, with or without crushed rock	5.0	10.0**	18.0

Note:
(1) Joint walls effectively in contact.
(2) Joint walls come into contact after approximately 100-mm shear.
(3) Joint walls do not come into contact at all upon shear.
**Also applies when crushed rock occurs in clay gouge without rock wall contact.

Relative orientation, in the case of rock, is a function of the relative shape of the rock and its dip and dip direction relative to the direction of flow. The relative orientation parameter J_s represents the relative ability of earth material to resist erosion due to the structure of the ground. This parameter is a function of the dip and dip direction of the least favorable discontinuity (most easily eroded) in the rock with respect to the direction of flow, and the shape of the material units. These two variables (orientation and shape) affect the ease by which the stream can penetrate the ground and dislodge individual material units.

Conceptually, the function of the relative orientation parameter J_s incorporating shape and orientation is as follows. If rock is dipped against the direction flow, it will be more difficult to scour the rock than when it is dipped in the direction of flow. When it is dipped in the direction of flow, it is easier for the flow to lift the rock, penetrate underneath and remove it. Rock that is dipped against the direction of flow will be more difficult to dislodge. The shape of the rock, represented by the length to width ratio *r*, impacts the erodibility of rock in the following manner. Elongated rock will be more difficult to remove than equi-sided blocks of rock. Therefore, large ratios of *r* represent rock that is more difficult to remove because it represents elongated rock shapes. Values of the relative orientation parameter J_s are provided in Table 4.26.

The material characteristics to quantify the Erodibility Index parameters are generally obtained from borehole data, field observation and testing, and laboratory testing (to obtain the unconfined compressive strength). Depending on the importance of the project, it is also possible to obtain parameter values by making use of geologic descriptions of the material [see tables of Annandale (1995)]. Larger values of the Erodibility Index value K indicate greater resistance to erosion (see Section 7.13).

4.8 SUMMARY

An understanding of soil and rock property classification is important because it provides a basis for describing common engineering properties of geomaterials and how different materials may be expected to behave under various environmental conditions and loads. As noted in Sections 4.2 and 4.3, the physical processes causing erosion of different types of soils and rock vary based on the nature of the material. Various methods for estimating and/or measuring erodibility characteristics also depend of the nature of the material being considered.

The characteristics of soils and rock (the resisting materials) are important to estimating scour and erosion under different combinations of geotechnical and hydraulic conditions. While the most widely used equations for scour assume cohesionless materials such as sand or gravel (see Chapters 6, 7, and 8), some guidance is available for estimating scour components in cohesive soils and rock. Reference is suggested to the following sections:

Section 6.7	Contraction Scour in Cohesive Materials
Section 6.8	Contraction Scour in Erodible Rock
Section 7.12	Pier Scour in Cohesive Materials
Section 7.13	Pier Scour in Erodible Rock

Table 4.26. Relative Orientation Parameter J_s.					
Dip Direction of Closer Spaced Joint Set (degrees)	Dip Angle of Closer Spaced Joint Set (degrees)	Ratio of Joint Spacing, r			
Dip Direction	Dip Angle	Ratio 1:1	Ratio 1:2	Ratio 1:4	Ratio 1:8
180/0	90	1.14	1.20	1.24	1.26
In direction of stream flow	89	0.78	0.71	0.65	0.61
In direction of stream flow	85	0.73	0.66	0.61	0.57
In direction of stream flow	80	0.67	0.60	0.55	0.52
In direction of stream flow	70	0.56	0.50	0.46	0.43
In direction of stream flow	60	0.50	0.46	0.42	0.40
In direction of stream flow	50	0.49	0.46	0.43	0.41
In direction of stream flow	40	0.53	0.49	0.46	0.45
In direction of stream flow	30	0.63	0.59	0.55	0.53
In direction of stream flow	20	0.84	0.77	0.71	0.67
In direction of stream flow	10	1.25	1.10	0.98	0.90
In direction of stream flow	5	1.39	1.23	1.09	1.01
In direction of stream flow	1	1.50	1.33	1.19	1.10
0/180	0	1.14	1.09	1.05	1.02
Against direction of stream flow	-1	0.78	0.85	[illegible]	[illegible]
Against direction of stream flow	-5	0.73	0.79	[illegible]	[illegible]
Against direction of stream flow	-10	0.67	0.72	0.78	0.81
Against direction of stream flow	-20	0.56	0.62	0.66	0.69
Against direction of stream flow	-30	0.50	0.55	0.58	0.60
Against direction of stream flow	-40	0.49	0.52	0.55	0.57
Against direction of stream flow	-50	0.53	0.56	0.59	0.61
Against direction of stream flow	-60	0.63	0.68	0.71	0.73
Against direction of stream flow	-70	0.84	0.91	0.97	1.01
Against direction of stream flow	-80	1.26	1.41	1.53	1.61
Against direction of stream flow	-85	1.39	1.55	1.69	1.77
Against direction of stream flow	-89	1.50	1.68	1.82	1.91
180/0	-90	1.14	1.20	1.24	1.26

r is assumed based on field conditions

Notes:

1. For intact material take $J_s = 1.0$.
2. For values of r greater than 8 take J_s as for r = 8.
3. If the flow direction FD is not in the direction of the true dip TD, the effective dip ED is determined by adding the ground slope to the apparent dip AD: ED = AD + GS

APPENDIX D
SEISMIC SITE CLASSIFICATION

Seismic Site Class Determination
Bridge No. BEL-CR4-27.05

Use the N-method in accordance with ODOT BDM 2020 and AASHTO LRFD Bridge Design Specifications (9th edition, 2020)

B-001

d	N	d/N
4	13	0.307692
2.5	6	0.416667
2.5	14	0.178571
1.5	14	0.107143
1.5	25	0.06
2	22	0.090909
86	100	0.86

N-value	49.48089

B-002

d	N	d/N
4	7	0.571429
2.5	5	0.5
2.5	9	0.277778
3.8	58	0.065517
87.2	100	0.872

N-value	43.73069

N-value-site	47
Site Class	D

*borings close enough hence N values can be averaged

Ohio Department of Transportation
Geotechnical Engineering
Design Checklists

Version 6.0
January 20, 2023

Preface

Geotechnical design features that arise in the development of roadway projects vary both in type and complexity. Cuts, embankments, wetlands, mine issues, and rock slopes are just some geotechnical issues encountered on transportation projects. Consistent and comprehensive reconnaissance, analysis, and plan preparation are necessary to ensure that all possible geotechnical issues that may occur on a project will be adequately identified and accounted for on the final plans.

A set of topical review checklists, a reference list, and a technical publications list have been developed to aid the project development personnel in their production of geotechnically sound project plans. All projects that contain geotechnical related issues will benefit from the use of this document. Although it is expected that the District Geotechnical Engineer will be one of the main users of these checklists, any personnel responsible for a geotechnical aspect of the project plan development will use this document. Possible users of this checklist include, but are not limited to, design and geotechnical Consultants and District and Central Office reviewers and project engineers.

The design checklists are provided to assist the project development personnel in:

- Developing a comprehensive geotechnical scope of services
- Developing and reviewing geotechnical reports and assimilating information
- Analyzing, designing, and reviewing geotechnical related aspects of a transportation project, including needs assessment, plans, and specifications
- Recognizing cost-saving opportunities
- Identifying deficiencies due to inadequate geotechnical exploration, analysis, or design
- Recognizing when to request additional technical assistance from a geotechnical specialist
- Defining areas of needed training

At first glance, the design checklist will seem to be inordinately lengthy. One, however, should not avoid using the checklist because of this. Only on major and complex projects will it be necessary to complete most of the checklist. Just those checklists that pertain to a specific geotechnical feature encountered on the project should be completed. Therefore, for most projects, only a small portion of the checklist will need to be completed.

Since several entities may be involved in the geotechnical development of a transportation project, it is possible that there may be more than one set of checklists completed for a specific project, or different entities may fill out different sections of the checklist. It is anticipated that all completed checklists will be included with the project file in District or Central Office.

<u>To utilize the checklists,</u>

- First fill out the project information on the Checklist Cover tab. The project information in the headings of the rest of the checklists will autopopulate. Also indicate which checklists will be utilized.
- Complete only the checklists that apply to the project by using the dropdown boxes.
- Submit the checklist cover along with all completed checklists with the report and plan submission

Additional topics and questions may be added as the development of these checklists continues and input is received from the users. All additional updates and design guidance will be issued from the Office of Geotechnical Engineering (OGE) and available on the internet at the Design Reference Resource Center and the OGE website. The OGE Administrator will be the point of contact regarding the checklist, and any questions, recommendations, and training requests should be directed to the Office Administrator.

Table of Contents

Symbols and Abbreviations

Y	Yes
N	No
X	Not Applicable (Reason should be explained in the “Notes” area of the checklist)
✓	Selected item utilized

AASHTO	American Association of State Highway and Transportation Officials
AML	Abandoned Mine Land Reclamation Program, DMRM, ODNR
AUMIRA	Manual for Abandoned Underground Mine Inventory and Risk Assessment, ODOT
BDM	Bridge Design Manual, ODOT
CBR	California Bearing Ratio
C&MS	Construction and Material Specifications, ODOT
DGE	District Geotechnical Engineer, ODOT District
DGS	Division of Geological Survey, ODNR
DMRM	Division of Mineral Resources Management, ODNR
DSWC	Division of Soil and Water Conservation, ODA
EPA	Ohio Environmental Protection Agency
FHWA	Federal Highway Administration
F.S.	Factor of Safety
GDM	Geotechnical Design Manual, ODOT
L&D1	Location & Design Manual, Volume 1, ODOT
L&D3	Location & Design Manual, Volume 3, ODOT
LRFD	Load and Resistance Factor Design
N_{60}	Standard Penetration Value, normalized to 60 percent of drill rod energy ratio
ODNR	Ohio Department of Natural Resources
ODOT	Ohio Department of Transportation
OGE	Office of Geotechnical Engineering, ODOT
OSMRE	Office of Surface Mining Reclaimation and Enforcement, U.S. Dept. of the Interior
ROW	Right of Way
RQD	Rock Quality Designation
SDI	Slake Durability Index
SGE	Specifications for Geotechnical Explorations, ODOT
SPT	Standard Penetration Test
TIMS	Transportation Information Mapping System
UBV	Ultimate Bearing Value
	Standard Penetration Test
USGS	U.S. Geological Survey
WEAP	Wave Equation Analysis of Pile Driving (Software)

I. Geotechnical Design Checklists

Project:	**BEL-CR4-27.05**	**PDP Path:**	**N/A**
PID:	**117373**	**Review Stage:**	**FINAL**

Checklist	**Included in This Submission**
II. Reconnaissance and Planning	✓
III. A. Centerline Cuts	
III. B. Embankments	
III. C. Subgrade	
IV. A. Foundations of Structures	✓
IV. B. Retaining Wall	
V. A. Landslide Remediation	
V. B. Rockfall Remediation	
V. C. Wetland or Peat Remediation	
V. D. Underground Mine Remediation	
V. E. Surface Mine Remediation	
V. F. Karst Remediation	
VI. A. Geotechnical Profile	
VI. D. Geotechnical Reports	✓

II. Reconnaissance and Planning Checklist

C-R-S: BEL-CR4-27.05	PID: 117373	Reviewer: E.Kistner	Date: 12/11/2023

Reconnaissance		(Y/N/X)	Notes:
1	Based on Section 302.1 in the SGE, have the necessary plans been developed in the following areas prior to the commencement of the subsurface exploration reconnaissance:	Y	
	Roadway plans	✓	
	Structures plans	✓	
	Geohazards plans	✓	
2	Have the resources listed in Section 302.2.1 of the SGE been reviewed as part of the office reconnaissance?	Y	
3	Have all the features listed in Section 302.3 of the SGE been observed and evaluated during the field reconnaissance?	Y	
4	If notable features were discovered in the field reconnaissance, were the GPS coordinates of these features recorded?	X	

Planning - General		(Y/N/X)	Notes:
5	In planning the geotechnical exploration program for the project, have the specific geologic conditions, the proposed work, and historic subsurface exploration work been considered?	Y	
6	Has the ODOT Transportation Information Mapping System (TIMS) been accessed to find all available historic boring information and inventoried geohazards?	Y	
7	Have the borings been located to develop the maximum subsurface information while using a minimum number of borings, utilizing historic geotechnical explorations to the fullest extent possible?	Y	
8	Have the topography, geologic origin of materials, surface manifestation of soil conditions, and any other special design considerations been utilized in determining the spacing and depth of borings?	Y	
9	Have the borings been located so as to provide adequate overhead clearance for the equipment, clearance of underground utilities, minimize damage to private property, and minimize disruption of traffic, without compromising the quality of the exploration?	Y	

II. Reconnaissance and Planning Checklist

Planning - General		(Y/N/X)	Notes:
10	Have the scaled boring plans, showing all project and historic borings, and a schedule of borings in tabular format, been submitted to the District Geotechnical Engineer?	Y	
	The schedule of borings should present the following information for each boring:		
a.	exploration identification number	Y	
b.	location by station and offset	N	Stationing not available at the time of proposal
c.	estimated amount of rock and soil, including the total for each for the entire program.	Y	

Planning – Exploration Number		(Y/N/X)	Notes:
11	Have the coordinates, stations and offsets of all explorations (borings, soundings, test pits, etc.) been identified?	Y	
12	Has each exploration been assigned a unique identification number, in the following format X-ZZZ-W-YY, as per Section 303.2 of the SGE?	Y	
13	When referring to historic explorations that did not use the identification scheme in 12 above, have the historic explorations been assigned identification numbers according to Section 303.2 of the SGE?	N	No historic borings at the project

II. Reconnaissance and Planning Checklist

Planning – Boring Types		(Y/N/X)	Notes:
14	Based on Sections 303.3 to 303.7.6 of the SGE, have the location, depth, and sampling requirements for the following boring types been determined for the project?	Y	
	Check all boring types utilized for this project:		
	Existing Subgrades (Type A)	✓	
	Roadway Borings (Type B)		
	Embankment Foundations (Type B1)		
	Cut Sections (Type B2)		
	Sidehill Cut Sections (Type B3)		
	Sidehill Cut-Fill Sections (Type B4)		
	Sidehill Fill Sections on Unstable Slopes (Type B5)		
	Geohazard Borings (Type C)		
	Lakes, Ponds, and Low-Lying Areas (Type C1)		
	Peat Deposits, Compressible Soils, and Low Strength Soils (Type C2)		
	Uncontrolled Fills, Waste Pits, and Reclaimed Surface Mines (Type C3)		
	Underground Mines (C4)		
	Landslides (Type C5)		
	Rock Slope (Type C6)		
	Karst (Type C7)		
	Proposed Underground Utilities (Type D)		
	Structure Borings (Type E)		
	Bridges (Type E1)	✓	
	Culverts (Type E2 a,b,c)		
	Retaining Walls (Type E3 a and b)		
	Noise Barrier (Type E4)		
	CCTV & High Mast Lighting Towers (Type E5)		
	Buildings and Salt Domes (Type E6)		

IV.A Foundations of Structures Checklist

C-R-S: BEL-CR4-27.05	PID: 117373	Reviewer: E.Kistner	Date: 12/11/2023

Use this Checklist in conjunction with the bridge foundation design guidance in GDM Section 1300
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)	Notes:
1	Has the shear strength of the foundation soils been determined?	X	
	Check method used:		
	laboratory shear tests		
	estimation from SPT or field tests		
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	
3	Has the shear strength of the foundation bedrock been determined?	Y	
	Check method used:		
	laboratory shear tests	✓	
	other (describe other methods)		
Spread Footings		(Y/N/X)	Notes:
4	Are there spread footings on the project? If no, go to Question 11	X	No spread footings
5	Have the recommended bottom of footing elevation and reason for this recommendation been provided?		
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:		
a.	factored bearing resistance?		
b.	factored sliding resistance?		
c.	eccentric load limitations (overturning)?		
d.	predicted settlement?		
e.	overall (global) stability?		
7	Has the need for a shear key been evaluated?		
a.	If needed, have the details been included in the plans?		
8	If special conditions exist (e.g. geometry, sloping rock, varying soil conditions), was the bottom of footing “stepped” to accommodate them?		
9	Have the Service I and Maximum Strength Limit States for bearing pressure on soil or rock been provided?		

IV.A Foundations of Structures Checklist

Spread Footings		(Y/N/X)	Notes:
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?		
a.	Have the procedure and quantities related to this removal / treatment been included in the plans?		
Pile Structures		(Y/N/X)	Notes:
11	Are there piles on the project? If no, go to Question 17		
12	Has an appropriate pile type been selected?		
	Check the type selected:		
	H-pile (driven)		
	H-pile (prebored)	✓	
	Cast In-place Reinforced Concrete Pipe		
	Micropile		
	Continuous Flight Auger (CFA)		
	other (describe other types)		
13	Have the estimated pile length or tip elevation and section (diameter) based on either the Ultimate Bearing Value (UBV) or the depth to top of bedrock been specified? Indicate method used.	Y	
14	If scour is predicted, has pile resistance in the scour zone been neglected?	✓	
15	Has a wave equation drivability analysis been performed as per BDM 305.3.1.2 to determine whether the pile can be driven to either the UBV, the pile tip elevation, or refusal on bedrock without overstressing the pile?	X	
16	If required for design, have sufficient soil parameters been provided and calculations performed to evaluate the:	Y	
a.	Nominal unit tip resistance and maximum settlement of the piles?	X	
b.	Nominal unit side resistance for each contributing soil layer and maximum deflection of the piles?	X	
c.	Downdrag load on piles driven through new embankment or compressible soil layers, as per BDM 305.3.2.2?	X	
d.	Potential for and impact of lateral squeeze from soft foundation soils?	X	

IV.A Foundations of Structures Checklist

Pile Structures		(Y/N/X)	Notes:
17	If piles are to be driven to strong bedrock (Q_u >7.5 ksi) or through very dense granular soils or overburden containing boulders, have “pile points” been recommended in order to protect the tips of the steel piling, as per BDM 305.3.5.6?	X	
18	If subsurface obstacles exist, has preboring been recommended to avoid these obstructions?	X	
19	If piles will be driven through 15 feet or more of new embankment, has preboring been specified as per BDM 305.3.5.7?	X	

IV.A Foundations of Structures Checklist

Drilled Shafts		(Y/N/X)	Notes:
20	Are there drilled shafts on the project? If no, go to the next checklist.	Y	Report for a geotechnical evaluation, not design.
21	Have the drilled shaft diameter and embedment length been specified?	X	
22	Have the recommended drilled shaft diameter and embedment been developed based on the nominal unit side resistance and nominal unit tip resistance for vertical loading situations?	X	
23	For shafts undergoing lateral loading, have the following been determined:	X	
a.	total factored lateral shear?	X	
b.	total factored bending moment?	X	
c.	maximum deflection?	X	
d.	reinforcement design?	X	
24	If a bedrock socket is required, has a minimum rock socket length equal to 1.5 times the rock socket diameter been used, as per BDM 305.4.2?	Y	Recommendation provided.
25	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?	X	
26	If scour is predicted, has shaft resistance in the scour zone been neglected?	✓	Recommendation provided.
27	Has the site been assessed for groundwater influence?	X	
a.	If yes, and if artesian flow is a potential concern, does the design address control of groundwater flow during construction?	X	
28	Have all the proper items been included in the plans for integrity testing?	X	
29	If special construction features (e.g., slurry, casing, load tests) are required, have all the proper items been included in the plans?	X	
30	If necessary, have wet construction methods been specified?	X	
General		(Y/N/X)	Notes:
31	Has the need for load testing of the foundations been evaluated?	Y	Not necessary.
a.	If needed, have details and plan notes for load testing been included in the plans?	X	

VI.B. Geotechnical Reports

C-R-S: BEL-CR4-27.05	PID: 117373	Reviewer: E.Kistner	Date: 12/11/2023

General		(Y/N/X)	Notes:
1	Has an electronic copy of all geotechnical submissions been provided to the District Geotechnical Engineer (DGE)?	Y	
2	Has the first complete version of a geotechnical report being submitted been labeled as ‘Draft’?	Y	
3	Subsequent to ODOT’s review and approval, has the complete version of the revised geotechnical report being submitted been labeled ‘Final’?	X	
4	Has the boring data been submitted in a native format that is DIGGS (Data Interchange for Geotechnical and Geoenvironmental) compatable? gINT files meet this demand?	X	
5	Does the report cover format follow ODOT's Brand and Identity Guidelines Report Standards found at http://www.dot.state.oh.us/brand/Pages/default.aspx ?	Y	
6	Have all geotechnical reports being submitted been titled correctly as prescribed in Section 706.1 of the SGE?	Y	
Report Body		(Y/N/X)	Notes:
7	Do all geotechnical reports being submitted contain the following:	Y	
a.	an Executive Summary as described in Section 706.2 of the SGE?	Y	
b.	an Introduction as described in Section 706.3 of the SGE?	Y	
c.	a section titled "Geology and Observations of the Project," as described in Section 706.4 of the SGE?	Y	
d.	a section titled "Exploration," as described in Section 706.5 of the SGE?	Y	
e.	a section titled "Findings," as described in Section 706.6 of the SGE?	Y	
f.	a section titled "Analyses and Recommendations," as described in Section 706.7 of the SGE?	Y	
Appendices		(Y/N/X)	Notes:
8	Do all geotechnical reports being submitted contain all applicable Appendices as described in Section 706.8 of the SGE?	Y	

VI.B. Geotechnical Reports

9	Do the Appendices present a site Boring Plan showing all boring locations as described in Section 706.8.1 of the SGE?	Y	

VI.B. Geotechnical Reports

Appendices		(Y/N/X)	Notes:
10	Do the Appendices include boring logs and color pictures of rock, if applicable, as described in Section 706.8.2 of the SGE?	Y	
11	Do the Appendices include reports of undisturbed test data as described in Section 706.8.3 of the SGE?	N	Undisturbed samples were not collected during drilling. Appendices, however, include lab test data for split spoon samples
12	Do the Appendices include calculations in a logical format to support recommendations as described in Section 706.8.4 of the SGE?	Y	