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

July 27, 2023
File: 173609114

Attention: Brandon McNeal, PE
Stantec Consulting Services Inc.
1500 Lake Shore Drive Suite 100
Columbus, Ohio 43204

Reference: Report of Geotechnical Exploration (Final)
BEL-7-22.16 Bridge Rehabilitation, PID 114382
Belmont County, Ohio

Dear Mr. McNeal,

Stantec Consulting Services Inc. (Stantec) has completed the geotechnical exploration report for the rehabilitation of the pedestrian bridge at BEL-7-22.16 over SR 7 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 rehabilitation. The soil profile drawings for the project will be completed at a later time and included with the next design submittal.

Regards,

Stantec Consulting Services Inc.

James A Samples

James Samples EI
Project Engineer in Training

Phone: (513) 842-8204
James.Samples@stantec.com

Eric M. Kistner, PE
Digitally signed by Eric M. Kistner, PE
Date: 2023.07.27 10:21:40 -04'00'

Eric Kistner PE
Geotechnical Project Manager

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Attachment: Report of Geotechnical Exploration (Final)

Stantec

BEL-7-22.16 Bridge Rehabilitation

Report of Geotechnical Exploration (Final)

PID No. 114382

Belmont County, Ohio

July 27, 2023

Prepared for:

Brandon McNeal
Stantec Consulting Services, Inc.
Columbus, Ohio

Prepared by:

Stantec Consulting Services Inc.
Cincinnati, Ohio

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Executive Summary

The Ohio Department of Transportation (ODOT) is planning to rehabilitate the current pedestrian bridge crossing State Route 7 (SR 7) at mile marker 22.16 near Martins Ferry, Ohio in Belmont County (Structure File Number 0700630). As part of the rehabilitation project, the staircase leading to the bridge on the east side of SR 7 is to be replaced. Stantec Consulting Services Inc. (Stantec) has been contracted by ODOT to perform a geotechnical exploration for the project and provide recommendations for the design and construction of the staircase foundation.

The surface material encountered consisted of 6 inches of gravelly topsoil in both borings. Below the surficial soil, fine-grained soils classifying as sandy silt (A-4a), silt (A-4b), and silt and clay (A-6a) were encountered to a depth of 19.5 to 22 feet below the ground surface. These soils were described as dark brown, dark gray, and brown in color, very soft to stiff, and damp to moist. Below the cohesive soils, granular soil described as brown to gray gravel and stone fragments with varying amounts of sand (A-1-a and A-1-b) was encountered to the terminus of each boring. This soil was also described as medium dense to very dense and moist to wet. Bedrock was not encountered in either boring. Groundwater was encountered in both borings while drilling at a depth of 20 feet in B-001-0-22 and 33 feet in B-002-0-22.

Existing plans of the pedestrian bridge show that the staircase is supported by driven 12-inch diameter cast-in-place (CIP) steel pipe piles with estimated pay lengths of 45 feet. The base of the pile cap is shown at Elevation 653. The actual (as-built) lengths of the piles are not shown on the drawings. The plan is to replace the superstructure of the staircase using the existing substructure and foundation system. According to Criteria C in the Ohio Bridge Design Manual 2020 (BDM) Section 405.11.2, the factored geotechnical resistance should be considered 88 kips per pile and according to Criteria D, the factored geotechnical resistance should be considered 71.4 kips per pile. It is recommended that 88 kips per pile be used for design because Criteria C is most applicable considering available data for the existing piles.

1.0 INTRODUCTION

The Ohio Department of Transportation (ODOT) is planning to rehabilitate the current pedestrian bridge crossing State Route 7 (SR 7) at mile marker 22.16 near Martins Ferry, Ohio in Belmont County (Structure File Number 0700630). As part of the rehabilitation project, the staircase leading to the bridge on the east side of SR 7 is to be replaced. Stantec Consulting Services Inc. (Stantec) has been contracted by ODOT to perform a geotechnical exploration for the project and provide recommendations for the design and construction of the staircase foundation. Figure 1 shows the site vicinity.

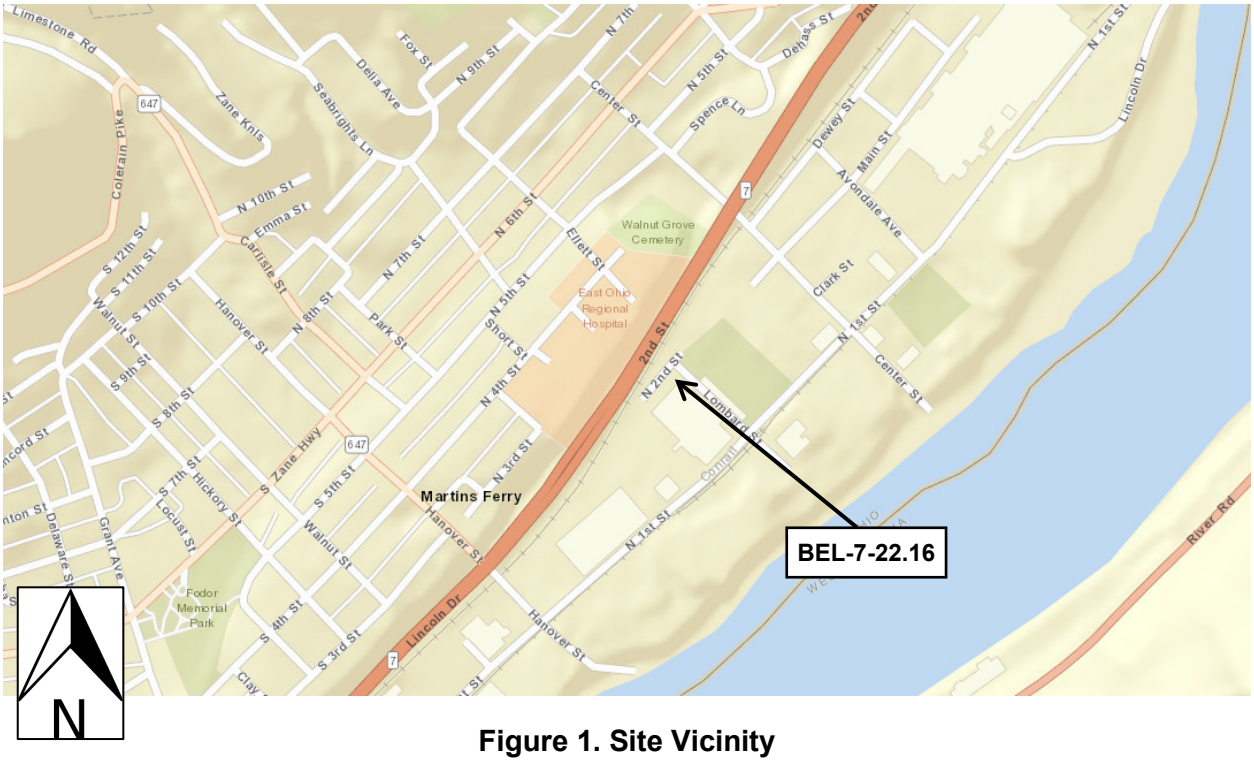


Figure 1. Site Vicinity
(Portion of ODOT Transportation Information Mapping System (TIMS), 2022)

2.0 GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1 GENERAL

The Physiographic Regions of Ohio Map (Ohio Department of Natural Resources (ODNR), 1998) indicates that the project site is located within the Little Switzerland Plateau section of the Appalachian Plateaus province within the Appalachian Highlands division. The Little Switzerland Plateau is characterized by high dissection, high relief (generally 450 feet to 750 feet along the Ohio River), and bedrock which consists of mostly fine-grained rocks. Red shales and red soils are relatively common. Landslides are common within the plateau and high-gradient shale-bottomed streams are subject to flash flooding. The geology of the Little Switzerland Plateau consists of red and brown silty-clay loam colluvium, landslide deposits, cyclic sequences of red and gray shales, siltstones, sandstones, limestones, and coal.

2.2 SOIL GEOLOGY

According to the Quaternary Geology of Ohio map (ODNR, 1999), the project site is underlain by glacial outwash from the Late Wisconsinan age. These sand and gravel deposits are sorted and stratified and occur as valley terraces or low plains. The soil survey (Web Soil Survey of Belmont County, Ohio, United States Department of Agriculture (USDA), 2022) indicates that the soil at the project site is classified as Udorthents-Urban land complex since the area has been developed for industrial use.

2.3 BEDROCK GEOLOGY

Bedrock mapping (Ohio Geology Interactive Map [ODNR, 2022]) and Descriptions of Geologic Map Units (ODNR, 2011) indicates that the overburden soils at the project site are underlain primarily by sedimentary bedrock from the Conemaugh Group from the Pennsylvanian age. The thickness of this rock unit ranges from 350 to 490 feet. The Conemaugh Group consists primarily of shale, siltstone, and mudstone described as gray, green, red, brown, and black in color, calcareous, clayey to sandy, and thin to non-bedded.

According to the Ohio Oil and Gas Well Viewer map (ODNR, 2022), there are active oil and gas wells within the project footprint. There are two active wells located within one mile of the project location.

According to the Ohio Mine Locator (ODNR, 2022), there are no mines within the project footprint. There are abandoned underground coal mine workings located approximately 0.5 miles north of the project site. The Karst Interactive Map (ODNR, 2021) indicates there is one suspected karst feature in Belmont County located approximately 2.4 miles southwest of the project site.

2.4 HYDROLOGY

The Ohio River lies to the east of the project site and runs south and west to the Mississippi River near Cairo, Illinois.

2.5 HYDROGEOLOGY

According to the Groundwater Resources of Belmont County map (ODNR, 1991), the project site is in an area where wells with yields of several hundred gallons per minute can be achieved. Thick, permeable sand and gravel deposits provide large industrial and municipal water supplies. These deposits range from 60 to 85 feet thick and are hydraulically connected to the Ohio River. Horizontal connector wells may provide yields in excess of 1,000 gallons per minute. The wells in this area provide water to much of the county through regional water systems.

A search was performed using the ODNR Ohio Water Wells Map (2021) to determine if any water wells are located near the project site. According to the map, four water wells have been drilled within 0.25 miles of the project footprint. The well logs indicate shale bedrock at a depth of approximately 60 feet. The logs also indicate a static water depth ranging from 28 to 35 feet.

2.6 SEISMIC

A review of the seismic data available in the project vicinity included the OhioSeis database developed by the ODNR, Division of Geological Survey. The review was performed using the internet mapping service (rev. 2012) at the following website: https://gis.ohiodnr.gov/website/dgs/earthquakes/.

Overall, Ohio has a relatively limited amount of seismic activity. There have been no recorded earthquakes in Belmont County. 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 June 10, 2022. The land surrounding the project site can be described as industrial. The existing single-span bridge over SR 7 was observed to be in fair condition, however the staircase leading to the bridge on the east side appeared to be in poor condition. Rust was observed on exposed reinforcing steel under the stairs and rust staining was observed on the concrete. Two borings were staked near the base of the staircase during this site visit.

3.0 EXPLORATION

3.1 HISTORIC EXPLORATION PROGRAMS

The ODOT Traffic Information Management System (TIMS) provides documentation for one geotechnical exploration performed for a project near the site. BEL-7-20.63 included one boring that was completed near the staircase in 1963. This boring indicates that subsurface conditions consist of fill material composed of cinders and ash underlain by dense to very dense sand and gravel. Standard penetration test (SPT) N-values over 50 were encountered at a

depth of 20 feet and extended to the bottom of the boring at a depth of 56 feet. The boring identification and location are shown on the site plan in Appendix A.

3.2 PROJECT EXPLORATION PROGRAM

Two borings were advanced for this project to obtain geotechnical data for the new staircase as part of the bridge rehabilitation project. Both borings were advanced near the base of the existing staircase. 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.	Station (feet)	Offset (feet)	Ground Surface Elevation (feet)	Bottom of Boring Elevation (feet)
B-001-0-22	6+22.7	2.0 Rt.	655.7	584.2
B-002-0-22	5+77.0	16.1 Rt.	657.3	581.0

The borings were advanced in accordance with the ODOT Specifications for Geotechnical Explorations (SGE). The borings were performed with a CME 55 track-mounted drill rig using 3¼-inch inside diameter (ID) hollow stem augers to advance the borings through soil. SPT sampling was performed at 2.5-foot intervals for 30 feet then at 5-foot intervals until 30 consecutive feet of soil reaching 30 blows per foot (bpf) was encountered. The energy ratio (ER) of the automatic hammer and drill rod system was measured to be 93.5 percent May 21, 2021.

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 depth intervals in the boring. 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 boring. The sum of the 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.

The materials encountered were logged by an engineer, with attention given to soil type, consistency, and moisture content. 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 according the ODOT SGE.

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.

4.0 RESULTS

The surface material encountered consisted of 6 inches of gravelly topsoil in both borings. Below the surficial soil, fine-grained soils classifying as sandy silt (A-4a), silt (A-4b), and silt and clay (A-6a) were encountered to a depth of 19.5 to 22 feet below the ground surface. These soils were described as dark brown, dark gray, and brown in color and very soft to stiff (N_{60} values ranged from 0 to 18 blows with an average of 11 blows) and damp to moist (natural moisture contents range from 13 to 31 percent with an average of 22 percent). The liquid limit of this material ranges from 22 to 33 with an average of 28 and the plastic limit ranges from 18 to 23 with an average of 20.

Below the cohesive soils, granular soil described as brown to gray gravel with varying amounts of sand (A-1-a and A-1-b) was encountered to the terminus of each boring. This soil was also described as medium dense to very dense (N_{60} values range from 11 to 87 blows with an average of 40 blows) and moist to wet (natural moisture contents range from 8 to 20 percent with an average of 12 percent).

Bedrock was not encountered in either boring. Groundwater was encountered in both borings while drilling at a depth of 20 feet in B-001-0-22 (elevation 635.7 feet) and 33 feet in B-002-0-22 (elevation 624.3 feet). Groundwater in each boring resulted in heaving sand conditions that required the use of drilling fluid. Boring logs are presented in Appendix A.

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.

5.2 STAIRCASE FOUNDATION

5.2.1 Existing Pile Capacity

Existing plans of the pedestrian bridge show that the staircase is supported by driven 12-inch diameter cast-in-place (CIP) steel pipe piles (friction piles) with estimated pay lengths of 45 feet and minimum bearing capacity of 40 tons (80 kips) per pile. The base of the pile cap is shown at Elevation 653. The actual (as-built) lengths of the piles are not shown on the drawings. The plan is to replace the superstructure of the staircase using the existing substructure and foundation system.

Section 405.11.2 of the ODOT Bridge Design Manual (BDM, 2020 Edition) outlines how an evaluation of existing driven pile foundations for a rehabilitation project should be performed with respect to axial capacity and the LRFD design process based on available information. Criteria A and B in Section 405.11.2 are applicable when dynamic load testing records or pile driving logs are available. Such documentation is not available for this project. Criteria C is applicable when the allowable pile capacities are shown on the original plans. For Criteria C, it is recommended that the allowable capacity be multiplied by 2 to determine nominal capacity then factored by 0.55 to determine factored geotechnical resistance. In the case of the existing staircase foundation:

Factored Geotechnical Resistance = 40 tons x 2 x 0.55 = 44 tons = 88 kips

Criteria D in BDM Section 405.11.2 suggests that geotechnical resistance be determined using static analysis and resistance factors from BDM Table 305.1. An analysis using the computer program APILE Version 2019 was used to approximate the capacity of the existing 12-inch diameter CIP piles. It was assumed that the piles were driven to a tip elevation equal to the pile cap elevation (653) minus the estimated pay length (45 feet), plus the embedment of the pile into the pile cap (6 inches), resulting in a pile tip elevation of 608.5. The undrained shear strengths of cohesive soils were estimated considering results of SPT N-values and hand penetrometer measurements. The angles of internal friction for non-cohesive soils were estimated based on SPT N-values. The following table shows the assumed subsurface profile based on the results of the borings.

Table 2. Assumed Subsurface Profile for APILE Analysis

Elevation Range (feet)	Soil Type	Total Unit Weight (pcf)	Undrained Cohesion (psf)	Drained Angle of Internal Friction (degrees)
653 - 633	Clay	120	1,000	N/A
633 - 620	Sand	130	N/A	32
620 - 580	Sand (below water table)	67.6	N/A	32

The APILE analysis results are provided in Appendix C. Axial pile capacity was estimated using the FHWA Method in the APILE program, which follows the guidance in the AASHTO LRFD. For the FHWA Method, the side resistance (skin friction) of cohesive soils is estimated using Tomlinson's α-Method for cohesive soil (1980 revision). For granular soils, the side and tip resistances are determined using the Norlund/Thurman Method utilizing effective stress and friction angle. Table 305-1 in the BDM specifies resistance factors of 0.35 for side resistance in clay, 0.45 for side resistance in clay sand, and 0.45 for tip resistance in sand. Table 3 summarizes the APILE capacity results for Criteria D.

Table 3. Driven Pile Axial Capacity Estimate

Resistance	Nominal (kips)	Factored (kips)
Side	145.6	59.7
Tip	25.9	11.7
Total	171.5	71.4

Based on the results of the analysis, the ultimate bearing value (UBV) for the existing piles can be taken at 171.5 kips per pile, which is less than the commonly accepted maximum UBV for 12-inch closed-end CIP pipe piles of 330 kips as presented in the ODOT BDM. The factored capacity is 71.4 kips per pile based on resistance factors of 0.35 and 0.45.

In summary, according to Criteria C in BDM 405.11.2, the factored geotechnical resistance should be considered 88 kips per pile and according to Criteria D, the factored geotechnical resistance should be considered 71.4 kips per pile. It is recommended that 88 kips per pile be used for design because Criteria C is most applicable considering available data for the existing piles.

If the existing piles do not have the required capacity, 12-inch closed-diameter CIP pipe piles with a factored capacity of 89.1 kips per pile can be added to meet the required capacity. This factored capacity may be achieved at an elevation of 602.5 feet, or a depth of 50 feet below the pile cap. An estimated pile length of 55 feet is recommended as outlined in BDM 305.3.5.2. APILE results for the new CIP pipe piles are shown in Appendix B. A summary of the APILE results for the new CIP pipe piles is provided in Table 4.

Table 4. Driven Pile Axial Capacity for New CIP Piles

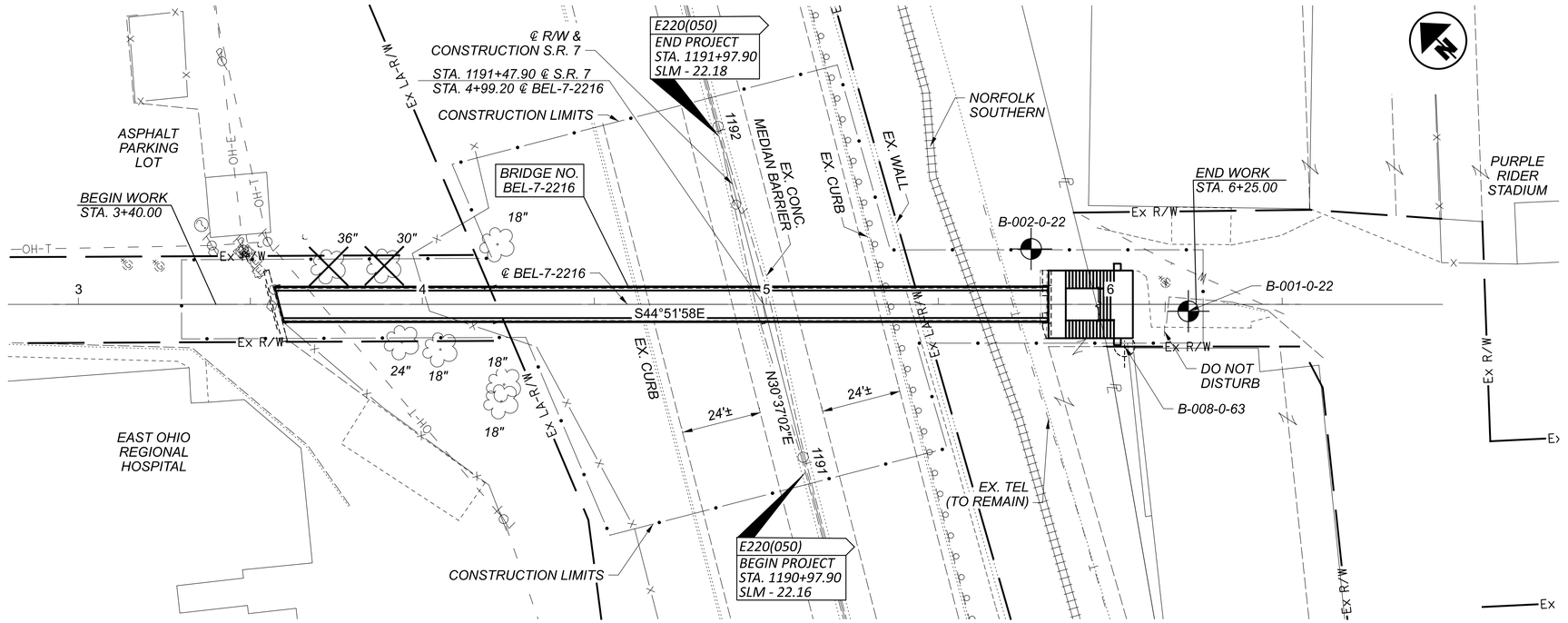
Resistance	Nominal (kips)	Factored (kips)
Side	171.6	77.5
Tip	25.9	11.7
Total	197.5	89.1

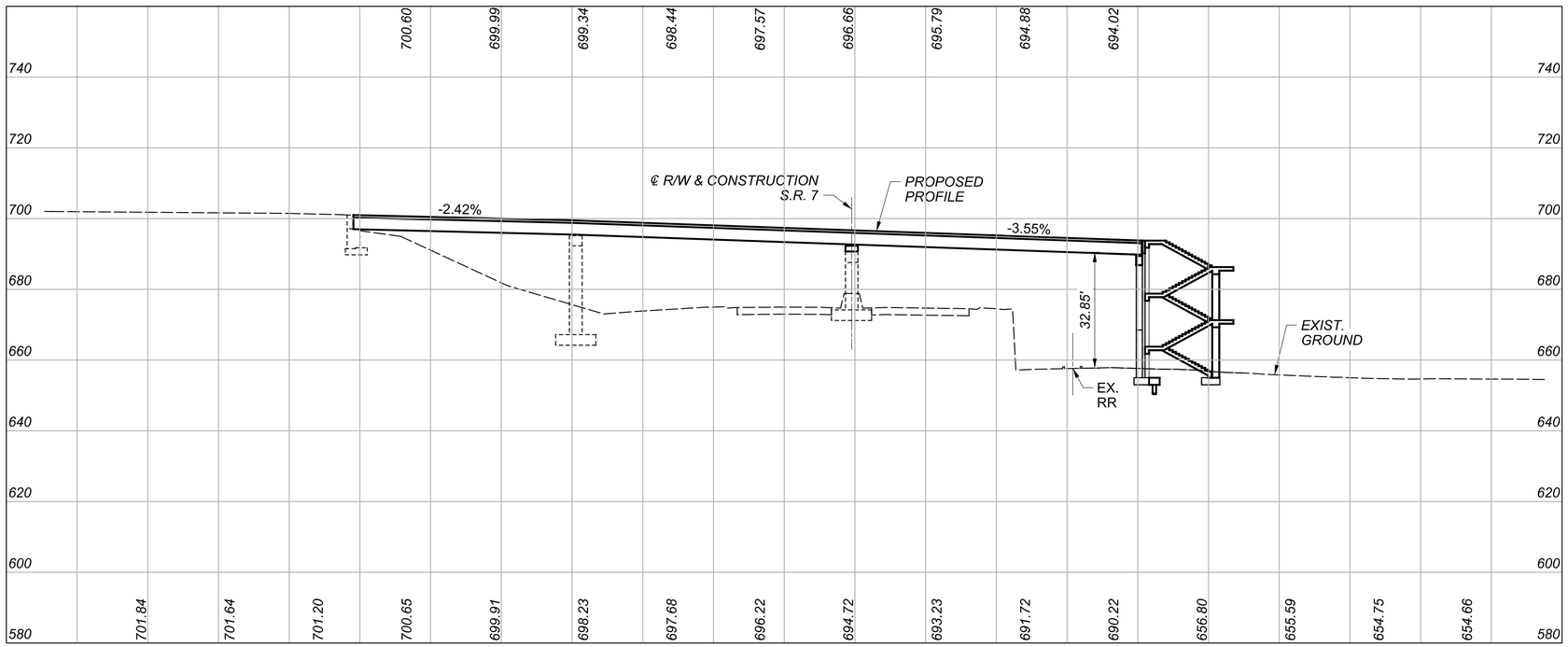
Drivability analyses performed using GRLWEAP indicate a typical pile driving hammer with 20.1 foot-kips of rated energy (i.e., Delmag D 8-22) should be appropriate to achieve the UBV pile resistances presented in Table 4. The maximum computed stresses during driving were estimated to be below the allowable driving stress (0.9 of the yield stress) for the cast-in-place steel pipes with a yield stress of 45 kips per square inch (ksi) for Grade 3 steel and wall thicknesses of 0.250 inches for the piles. Maximum driving stresses of 17.1 ksi and a maximum blow count of 35 blows per foot were estimated. Results from the drivability analyses are included in Appendix B.

5.2.2 Seismic Site Class

A seismic site class evaluation was performed based on methodology presented in AASHTO LRFD Section 3.10.3.1. The average N-value for the upper 100 feet was determined to be 20 based on the two borings advanced for this exploration. According to AASHTO LRFD Table 3.10.3.1-1, Site Class D (stiff soil) is recommended. The derivation of the average N-value is presented in Appendix C.

APPENDIX A
SITE PLAN AND BORING LOGS





HORIZONTAL SCALE IN FEET
0 10 20 40

PLAN AND PROFILE
STA. 1190+97.90 TO STA. 1191+97.90

BEL-7-22.16

DESIGN AGENCY
Stantec
1500 LAKE SHORE DRIVE, SUITE 100
COLUMBUS, OH 43204
(614) 486-4383

DESIGNER SLP
REVIEWER ALB 1/25/23
PROJECT ID 114382
SHEET P.5 TOTAL 7

PROJECT: BEL-7-22.16	DRILLING FIRM / OPERATOR: STANTEC / AC	DRILL RIG: CME 55T#2 (711)	STATION / OFFSET: 6+23, 2' RT.	EXPLORATION ID B-001-0-22
TYPE: STRUCTURE FOUNDATION	SAMPLING FIRM / LOGGER: STANTEC / JS	HAMMER: CME AUTOMATIC	ALIGNMENT: SR 7	
PID: 114382 SFN: 0700630	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 5/21/21	ELEVATION: 655.7 (MSL) EOB: 71.5 ft.	PAGE 1 OF 3
START: 6/28/22 END: 6/28/22	SAMPLING METHOD: SPT	ENERGY RATIO (%): 90*	LAT / LONG: 40.098463, -80.719484	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
DARK GRAY, **GRAVEL**, MIXED WITH TOPSOIL, DAMP	655.7																	
MEDIUM STIFF TO STIFF, DARK GRAY TO BROWN, **SANDY SILT**, SOME GRAVEL, LITTLE CLAY, DAMP TO MOIST	655.2	1	11 7 5	18	78	SS-1	-	-	-	-	-	-	-	-	-	14	A-4a (V)	
		2																
		3	3 3 2	8	100	SS-2	0.50	28	15	14	25	18	32	23	9	19	A-4a (2)	
		4																
		5																
		6	1 2 4	9	67	SS-3	1.50	-	-	-	-	-	-	-	-	29	A-4a (V)	
	648.7	7																
MEDIUM STIFF TO STIFF, BROWN, **SILT AND CLAY**, LITTLE SAND, DAMP TO MOIST		8	2 2 5	11	100	SS-4	2.00	0	1	11	46	42	33	20	13	26	A-6a (9)	
		9																
		10																
		11	2 4 4	12	100	SS-5	1.00	-	-	-	-	-	-	-	-	21	A-6a (V)	
		12																
		13	0 2 2	6	100	SS-6	0.50	-	-	-	-	-	-	-	-	23	A-6a (V)	
	641.2	14																
VERY SOFT TO SOFT, BROWN, **SANDY SILT**, SOME CLAY, MOIST TO WET		15																
		16	0 0 0	0	100	SS-7	0.50	0	0	40	27	33	24	19	5	27	A-4a (5)	
		17																
		18	0 0 1	2	100	SS-8	-	-	-	-	-	-	-	-	-	21	A-4a (V)	
		19																
W 635.7		20																
		21	1 1 2	5	100	SS-9	-	-	-	-	-	-	-	-	-	31	A-4a (V)	
	633.7	22																
MEDIUM DENSE TO DENSE, BROWN TO GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND**, TRACE SILT, TRACE CLAY, MOIST TO WET		23	0 3 6	14	61	SS-10	-	-	-	-	-	-	-	-	-	16	A-1-b (V)	
		24																
		25																
		26	1 2 5	11	33	SS-11	-	-	-	-	-	-	-	-	-	10	A-1-b (V)	
		27																
		28	3 5 8	20	44	SS-12	-	-	-	-	-	-	-	-	-	10	A-1-b (V)	
		29																

PID: 114382	SFN: 0700630	PROJECT: BEL-7-22.16	STATION / OFFSET: 6+23, 2' RT.	START: 6/28/22	END: 6/28/22	PG 2 OF 3	B-001-0-22

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
MEDIUM DENSE TO DENSE, BROWN TO GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND**, TRACE SILT, TRACE CLAY, MOIST TO WET *(continued)*	625.7	31	5 11 9	30	0	SS-13	-	-	-	-	-	-	-	-	-	-	A-1-b (V)	
		35	3 6 6	18	61	SS-14	-	-	-	-	-	-	-	-	-	20	A-1-b (V)	
	615.7	40	20 24 22	69	100	SS-15	-	52	22	14	5	7	18	16	2	11	A-1-a (0)	
VERY DENSE, GRAY, **GRAVEL AND STONE FRAGMENTS**, SOME SAND, TRACE SILT, TRACE CLAY, WET BEGAN ENCOUNTERING HEAVING SANDS, DRILLING FLUID ADDED TO REDUCE HEAVE.		45	16 18 23	62	100	SS-16	-	-	-	-	-	-	-	-	-	8	A-1-a (V)	
		50	7 16 18	51	56	SS-17	-	-	-	-	-	-	-	-	-	8	A-1-a (V)	
		55	14 16 18	51	89	SS-18	-	-	-	-	-	-	-	-	-	14	A-1-a (V)	
		60	18 18 16	51	94	SS-19	-	-	-	-	-	-	-	-	-	12	A-1-a (V)	

PID: 114382	SFN: 0700630	PROJECT: BEL-7-22.16	STATION / OFFSET: 6+23, 2' RT.	START: 6/28/22	END: 6/28/22	PG 3 OF 3	B-001-0-22

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
VERY DENSE, GRAY, **GRAVEL AND STONE FRAGMENTS**, SOME SAND, TRACE SILT, TRACE CLAY, WET *(continued)*	593.6	63																
		64																
		65	28 19 16	53	61	SS-20	-	-	-	-	-	-	-	-	-	11	A-1-a (V)	
		66																
		67																
		68																
		69																
		70	15 22 23	68	100	SS-21	-	59	18	15	5	3	NP	NP	NP	10	A-1-a (0)	
	584.2	71 EOB																

NOTES: BORING TERMINATED AFTER ENCOUNTERING 30 CONTINUOUS FEET OF 30+ BLOW PER FOOT MATERIAL. NO REFUSAL.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED BENTONITE GROUT

PROJECT: BEL-7-22.16	DRILLING FIRM / OPERATOR: STANTEC / AC	DRILL RIG: CME 55T#2 (711)	STATION / OFFSET: 5+77, 16' LT.	EXPLORATION ID B-002-0-22
TYPE: STRUCTURE FOUNDATION	SAMPLING FIRM / LOGGER: STANTEC / JS	HAMMER: CME AUTOMATIC	ALIGNMENT: SR 7	
PID: 114382 SFN: 0700630	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 5/21/21	ELEVATION: 657.3 (MSL) EOB: 76.3 ft.	PAGE 1 OF 3
START: 6/28/22 END: 6/29/22	SAMPLING METHOD: SPT	ENERGY RATIO (%): 90*	LAT / LONG: 40.098588, -80.718550	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
DARK BROWN TO GRAY, **GRAVEL**, MIXED WITH TOPSOIL, DAMP	657.3																	
STIFF, DARK BROWN TO BROWN, **SILT**, LITTLE SAND, SOME CLAY, DAMP TO MOIST	656.8	1	5 8 4	18	67	SS-1	-	-	-	-	-	-	-	-	-	16	A-4b (V)	
		2																
		3	3 8 26	51	100	SS-2	1.50	-	-	-	-	-	-	-	-	19	A-4b (V)	
		4																
		5	8 3 6	14	6	SS-3	-	-	-	-	-	-	-	-	-	13	A-4b (V)	
		6																
		7	2 3 5	12	100	SS-4	2.00	-	-	-	-	-	-	-	-	26	A-4b (V)	
		8																
		9	1 3 6	14	100	SS-5	1.75	0	0	14	63	23	27	20	7	22	A-4b (8)	
		10																
MEDIUM STIFF TO STIFF, BROWN, **SANDY SILT**, TRACE GRAVEL, SOME CLAY, MOIST TO WET	645.3	11	2 3 5	12	89	SS-6	1.50	-	-	-	-	-	-	-	-	21	A-4a (V)	
		12																
		13	2 2 3	8	94	SS-7	-	-	-	-	-	-	-	-	-	23	A-4a (V)	
		14																
		15	0 0 4	6	94	SS-8	-	2	3	41	33	21	22	18	4	23	A-4a (4)	
		16																
MEDIUM DENSE TO DENSE, BROWN TO GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND**, TRACE SILT, TRACE CLAY, MOIST TO WET	637.8	17	5 11 8	29	72	SS-9	-	-	-	-	-	-	-	-	-	12	A-1-b (V)	
		18																
		19	7 7 12	29	72	SS-10	-	-	-	-	-	-	-	-	-	10	A-1-b (V)	
		20																
		21	2 3 13	24	72	SS-11	-	-	-	-	-	-	-	-	-	12	A-1-b (V)	
		22																
		23	5 7 9	24	78	SS-12	-	47	24	20	3	6	16	16	NP	13	A-1-b (0)	
		24																

PID: 114382	SFN: 0700630	PROJECT: BEL-7-22.16	STATION / OFFSET: 5+77, 16' LT.	START: 6/28/22	END: 6/29/22	PG 2 OF 3	B-002-0-22

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
MEDIUM DENSE TO DENSE, BROWN TO GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND**, TRACE SILT, TRACE CLAY, MOIST TO WET *(continued)*	627.3	W 624.3	1 5 6	17	56	SS-13	-	-	-	-	-	-	-	-	-	13	A-1-b (V)	
BEGAN ENCOUNTERING HEAVING SANDS, DRILLING FLUID ADDED TO REDUCE HEAVE.			3 3 4	11	39	SS-14	-	-	-	-	-	-	-	-	-	16	A-1-b (V)	
			9 11 12	35	61	SS-15	-	-	-	-	-	-	-	-	-	11	A-1-b (V)	
DENSE TO VERY DENSE, GRAY, **GRAVEL AND STONE FRAGMENTS**, SOME SAND, TRACE SILT, TRACE CLAY, WET	612.3		22 24 34	87	100	SS-16	-	55	18	15	7	5	17	16	1	13	A-1-a (0)	
			14 13 15	42	78	SS-17	-	-	-	-	-	-	-	-	-	8	A-1-a (V)	
			17 18 18	54	100	SS-18	-	-	-	-	-	-	-	-	-	15	A-1-a (V)	
DENSE TO VERY DENSE, GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND**, TRACE SILT, TRACE CLAY, WET	597.3		18 15 13	42	100	SS-19	-	41	37	15	3	4	NP	NP	NP	10	A-1-b (0)	

PID: 114382	SFN: 0700630	PROJECT: BEL-7-22.16	STATION / OFFSET: 5+77, 16' LT.	START: 6/28/22	END: 6/29/22	PG 3 OF 3	B-002-0-22

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
DENSE TO VERY DENSE, GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND**, TRACE SILT, TRACE CLAY, WET *(continued)*	595.2	63																
		64																
		65	18 17 18	53	89	SS-20	-	-	-	-	-	-	-	-	-	11	A-1-b (V)	
		66																
		67																
		68																
		69																
		70	18 13 23	54	94	SS-21	-	-	-	-	-	-	-	-	-	8	A-1-b (V)	
		71																
		72																
		73																
		74																
		75																
	581.0	76 EOB	15 44 50/4"	-	100	SS-22	-	-	-	-	-	-	-	-	-	16	A-1-b (V)	

NOTES: BORING TERMINATED AFTER ENCOUNTERING 30 CONTINUOUS FEET OF 30+ BLOW PER FOOT MATERIAL. NO REFUSAL.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED BENTONITE GROUT

LOG OF BORING

Date Started 5-9-63 | Sampler Type SS | Dia. 1 3/8" | Water Elev.
Date Completed 5-14-63 | Casing: Length 35' | Dia. 3 1/2"
Boring No. B-8 | Station & Offset 6403, 14' Rt. (FORWARD ABUTMENT) | Surface Elev. 658.0' +

Elev.	Depth	Std. Pen. (N)	Rec. ft.	Loss ft.	Description	Sample No.	Physical Characteristics % Agg	% C.S.	% F.S.	% Silt	% Clay	L.L.	Pl.	W.C.	SHTL. Class.
658.0	0														
	2														
	4														
653.0															
	6	8/11			Dark Brown Silt with Cinders, Ashes, and Stone Fragments	1		V	I	S	U	A	L		
650.5	8	7/8			Brown Silt	2	0	1	17	53	29	27	4	23	
648.0	10	- -			Brown Sandy Silt (Driller's Description)										
645.5	12														
	14	4/4			Brown Sandy Silt	3	0	0	45	31	24	NP	NP	23	
643.0	16	4/5			Brown Sandy Silt	4	0	0	35	37	28	NP	NP	24	
640.5	18	6/13			Brown Silty Sandy Gravel	5	40	8	24	15	13	NP	NP	23	
638.0	20														
	22	15/16			Brown Sandy Gravel	6		V	I	S	U	A	L	11	
	24														
633.0	26	96* (0.8')			Brown Sand	7		V	I	S	U	A	L		
	28														
628.0	30														
	32	80* (0.8')			Brown Gravelly Sand	8	25	58	13	4		NP	NP	19	
	34														
623.0	36	60*			Brown Sand (Wash Sample)	9		V	I	S	U	A	L		
	38														
618.0	40														
	42	50/*			Brown Sandy Gravel	10		V	I	S	U	A	L	10	
	44														
613.0	46	45/*			Brown Sandy Gravel with Stone Fragments	11		V	I	S	U	A	L	11	
	48														
608.0	50														
	52	50* (0.3')			Brown and Gray Gravel	12		V	I	S	U	A	L		
	54														
603.0	56	50*			Brown Gravelly Sand	13	39	29	22	10		NP	NP	11	
	58														
598.0	60	60/*			Brown Sandy Gravel	14	59	21	11	9		NP	NP	9	
575.5															

*REFUSAL - BOTTOM OF BORING

APPENDIX B
PILE CAPACITY ANALYSES

==========

APILE for Windows, Version 2019.9.4

Serial Number : 160705594

A Program for Analyzing the Axial Capacity
and Short-term Settlement of Driven Piles
under Axial Loading.

==========

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Path to file locations : \\US0247-PPFSS01\shared_projects\173609114\BEL-7-2216\114382\401-Engineering_Stantec\Geotechnical\EngData\pile analysis\
Name of input data file : BEL-7-22.16_ult.ap9d
Name of output file : BEL-7-22.16_ult.ap9o
Name of plot output file : BEL-7-22.16_ult.ap9p

Time and Date of Analysis

Date: August 08, 2022 Time: 14:31:08

1

****
* INPUT INFORMATION *
****

BEL-7-22.16

DESIGNER : James Samples

JOB NUMBER : 173609114

METHOD FOR UNIT LOAD TRANSFERS :

- FHWA (Federal Highway Administration)
  Unfactored Unit Side Friction and Unit Side Resistance are used.

COMPUTATION METHOD(S) FOR PILE CAPACITY :

- FHWA (Federal Highway Administration)

TYPE OF LOADING :
- COMPRESSION

PILE TYPE :

Steel pipe pile or non-tapered portion of monotube pile
- Close-Ended Pile

DATA FOR AXIAL STIFFNESS :

- MODULUS OF ELASTICITY = 0.290E+08 PSI
- CROSS SECTION AREA = 9.23 IN2

CIRCULAR PILE PROPERTIES :

- OUTSIDE DIAMETER, OD = 12.00 IN.

- INTERNAL DIAMETER, ID = 11.50 IN.
- TOTAL PILE LENGTH, TL = 45.00 FT.
- BATTER ANGLE = 0.00 DEG
- PILE STICKUP LENGTH, PSL = 0.00 FT.
- ZERO FRICTION LENGTH, ZFL = 0.00 FT.
- INCREMENT OF PILE LENGTH USED IN COMPUTATION = 1.00 FT.
- LENGTH OF ENHANCED END SECTION = 45.00 FT.
- INTERNAL DIAMETER OF ENHANCED END SECTION = 11.50 IN.

PLUGGED/UNPLUGGED CONDITIONS :
Internal Pile Plug Calculated by Program

SOIL INFORMATIONS :

DEPTH FT.	SOIL TYPE	LATERAL EARTH PRESSURE	EFFECTIVE UNIT WEIGHT LB/FT^3	FRICTION ANGLE DEGREES	BEARING CAPACITY FACTOR
0.00	CLAY	0.80*	120.00	0.00	8.00**
20.00	CLAY	0.80*	120.00	0.00	8.00**
20.00	SAND	0.80*	130.00	32.00	28.00**
33.00	SAND	0.80*	130.00	32.00	28.00**
33.00	SAND	0.80*	67.60	32.00	28.00**
73.00	SAND	0.80*	67.60	32.00	28.00**

* VALUE ASSUMED BY THE PROGRAM
** VALUE ESTIMATED BY THE PROGRAM BASED ON FRICTION ANGLE

MAXIMUM UNIT	MAXIMUM UNIT	UNDISTURB SHEAR	REMOLDED SHEAR	BLOW	UNIT SKIN	UNIT END

FRICTION KSF	BEARING KSF	STRENGTH KSF	STRENGTH KSF	COUNT	FRICTION KSF	BEARING KSF
0.10E+08*	0.10E+08*	1.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	1.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00

* MAXIMUM UNIT FRICTION AND/OR MAXIMUM UNIT BEARING
  WERE SET TO BE 0.10E+08 BECAUSE THE USER DOES NOT
  PLAN TO LIMIT THE COMPUTED DATA.

DEPTH FT.	LRFD FACTOR ON UNIT FRICTION	LRFD FACTOR ON UNIT BEARING
0.00	1.000	1.000
20.00	1.000	1.000
20.00	1.000	1.000
33.00	1.000	1.000
33.00	1.000	1.000
73.00	1.000	1.000

1

****
* COMPUTATION RESULT *
****

****
* FED. HWY. METHOD *
****

PILE	TOTAL SKIN	END	ULTIMATE

PENETRATION FT.	FRICTION KIP	BEARING KIP	CAPACITY KIP
0.00	0.0	3.5	3.5
1.00	2.3	3.5	5.9
2.00	4.7	7.1	11.8
3.00	7.0	7.1	14.1
4.00	9.4	7.1	16.4
5.00	11.7	7.1	18.8
6.00	14.1	7.1	21.1
7.00	16.4	7.1	23.5
8.00	18.7	7.1	25.8
9.00	21.1	7.1	28.2
10.00	23.4	7.1	30.5
11.00	25.8	7.1	32.8
12.00	28.1	7.1	35.2
13.00	30.5	7.1	37.5
14.00	32.8	7.1	39.9
15.00	35.2	7.1	42.2
16.00	37.5	7.1	44.6
17.00	39.8	7.1	46.9
18.00	42.2	7.1	49.3
19.00	44.5	10.2	54.7
20.00	46.9	16.5	63.4
21.00	49.3	22.8	72.1
22.00	52.0	25.9	77.9
23.00	54.8	25.9	80.7
24.00	57.7	25.9	83.7
25.00	60.8	25.9	86.7
26.00	64.0	25.9	89.9
27.00	67.3	25.9	93.3
28.00	70.8	25.9	96.7
29.00	74.4	25.9	100.3
30.00	78.1	25.9	104.0
31.00	82.0	25.9	107.9
32.00	86.0	25.9	111.9
33.00	90.1	25.9	116.0
34.00	94.4	25.9	120.3
35.00	98.7	25.9	124.6
36.00	103.0	25.9	129.0
37.00	107.5	25.9	133.4

Apply resistance factor of 0.35 to 46.9 K = 16.4 K

Total factored skin friction = 16.4 + 43.3 = 59.7 K

Apply resistance factor of 0.45 to 96.2K = 43.3 K

38.00	112.0	25.9	137.9
39.00	116.6	25.9	142.5
40.00	121.2	25.9	147.1
41.00	125.9	25.9	151.9
42.00	130.7	25.9	156.7
43.00	135.6	25.9	161.5
44.00	140.5	25.9	166.4
45.00	145.5	25.9	171.4

NOTES:
- AN ASTERISK IS PLACED IN THE END-BEARING COLUMN
  IF THE TIP RESISTANCE IS CONTROLLED BY THE FRICTION
  OF SOIL PLUG INSIDE AN OPEN-ENDED PIPE PILE.

****
* COMPUTE LOAD-DISTRIBUTION AND LOAD-SETTLEMENT *
* CURVES FOR AXIAL LOADING *
****

T-Z CURVE NO.	NO. OF POINTS	DEPTH TO CURVE FT.	LOAD TRANSFER PSI	PILE MOVEMENT IN.
1	10	0.0000E+00		
			0.0000E+00	0.0000E+00
			0.1554E+01	0.1920E-01
			0.2590E+01	0.3720E-01
			0.3885E+01	0.6840E-01
			0.4662E+01	0.9600E-01
			0.5181E+01	0.1200E+00
			0.4662E+01	0.2400E+00
			0.4662E+01	0.3600E+00
			0.4662E+01	0.6000E+00
			0.4662E+01	0.2400E+01
2	10	0.1003E+02		
			0.0000E+00	0.0000E+00
			0.1554E+01	0.1920E-01

```
                                    0.2590E+01      0.3720E-01
                                    0.3885E+01      0.6840E-01
                                    0.4662E+01      0.9600E-01
                                    0.5181E+01      0.1200E+00
                                    0.4662E+01      0.2400E+00
                                    0.4662E+01      0.3600E+00
                                    0.4662E+01      0.6000E+00
                                    0.4662E+01      0.2400E+01
3          10       0.1996E+02
                                    0.0000E+00      0.0000E+00
                                    0.1554E+01      0.1920E-01
                                    0.2590E+01      0.3720E-01
                                    0.3885E+01      0.6840E-01
                                    0.4662E+01      0.9600E-01
                                    0.5181E+01      0.1200E+00
                                    0.4662E+01      0.2400E+00
                                    0.4662E+01      0.3600E+00
                                    0.4662E+01      0.6000E+00
                                    0.4662E+01      0.2400E+01
4          10       0.2000E+02
                                    0.0000E+00      0.0000E+00
                                    0.1554E+01      0.1920E-01
                                    0.2590E+01      0.3720E-01
                                    0.3885E+01      0.6840E-01
                                    0.4662E+01      0.9600E-01
                                    0.5181E+01      0.1200E+00
                                    0.5181E+01      0.2400E+00
                                    0.5181E+01      0.3600E+00
                                    0.5181E+01      0.6000E+00
                                    0.5181E+01      0.2400E+01
5          10       0.2653E+02
                                    0.0000E+00      0.0000E+00
                                    0.2212E+01      0.1920E-01
                                    0.3686E+01      0.3720E-01
                                    0.5530E+01      0.6840E-01
                                    0.6636E+01      0.9600E-01
                                    0.7373E+01      0.1200E+00
                                    0.7373E+01      0.2400E+00
                                    0.7373E+01      0.3600E+00
                                    0.7373E+01      0.6000E+00
```

```
                                    0.7373E+01      0.2400E+01
6         10      0.3296E+02
                                    0.0000E+00      0.0000E+00
                                    0.2781E+01      0.1920E-01
                                    0.4636E+01      0.3720E-01
                                    0.6953E+01      0.6840E-01
                                    0.8344E+01      0.9600E-01
                                    0.9271E+01      0.1200E+00
                                    0.9271E+01      0.2400E+00
                                    0.9271E+01      0.3600E+00
                                    0.9271E+01      0.6000E+00
                                    0.9271E+01      0.2400E+01
7         10      0.3300E+02
                                    0.0000E+00      0.0000E+00
                                    0.2785E+01      0.1920E-01
                                    0.4642E+01      0.3720E-01
                                    0.6963E+01      0.6840E-01
                                    0.8355E+01      0.9600E-01
                                    0.9284E+01      0.1200E+00
                                    0.9284E+01      0.2400E+00
                                    0.9284E+01      0.3600E+00
                                    0.9284E+01      0.6000E+00
                                    0.9284E+01      0.2400E+01
8         10      0.5303E+02
                                    0.0000E+00      0.0000E+00
                                    0.3337E+01      0.1920E-01
                                    0.5562E+01      0.3720E-01
                                    0.8344E+01      0.6840E-01
                                    0.1001E+02      0.9600E-01
                                    0.1112E+02      0.1200E+00
                                    0.1112E+02      0.2400E+00
                                    0.1112E+02      0.3600E+00
                                    0.1112E+02      0.6000E+00
                                    0.1112E+02      0.2400E+01
9         10      0.7296E+02
                                    0.0000E+00      0.0000E+00
                                    0.3337E+01      0.1920E-01
                                    0.5562E+01      0.3720E-01
                                    0.8344E+01      0.6840E-01
                                    0.1001E+02      0.9600E-01
```

0.1112E+02	0.1200E+00
0.1112E+02	0.2400E+00
0.1112E+02	0.3600E+00
0.1112E+02	0.6000E+00
0.1112E+02	0.2400E+01

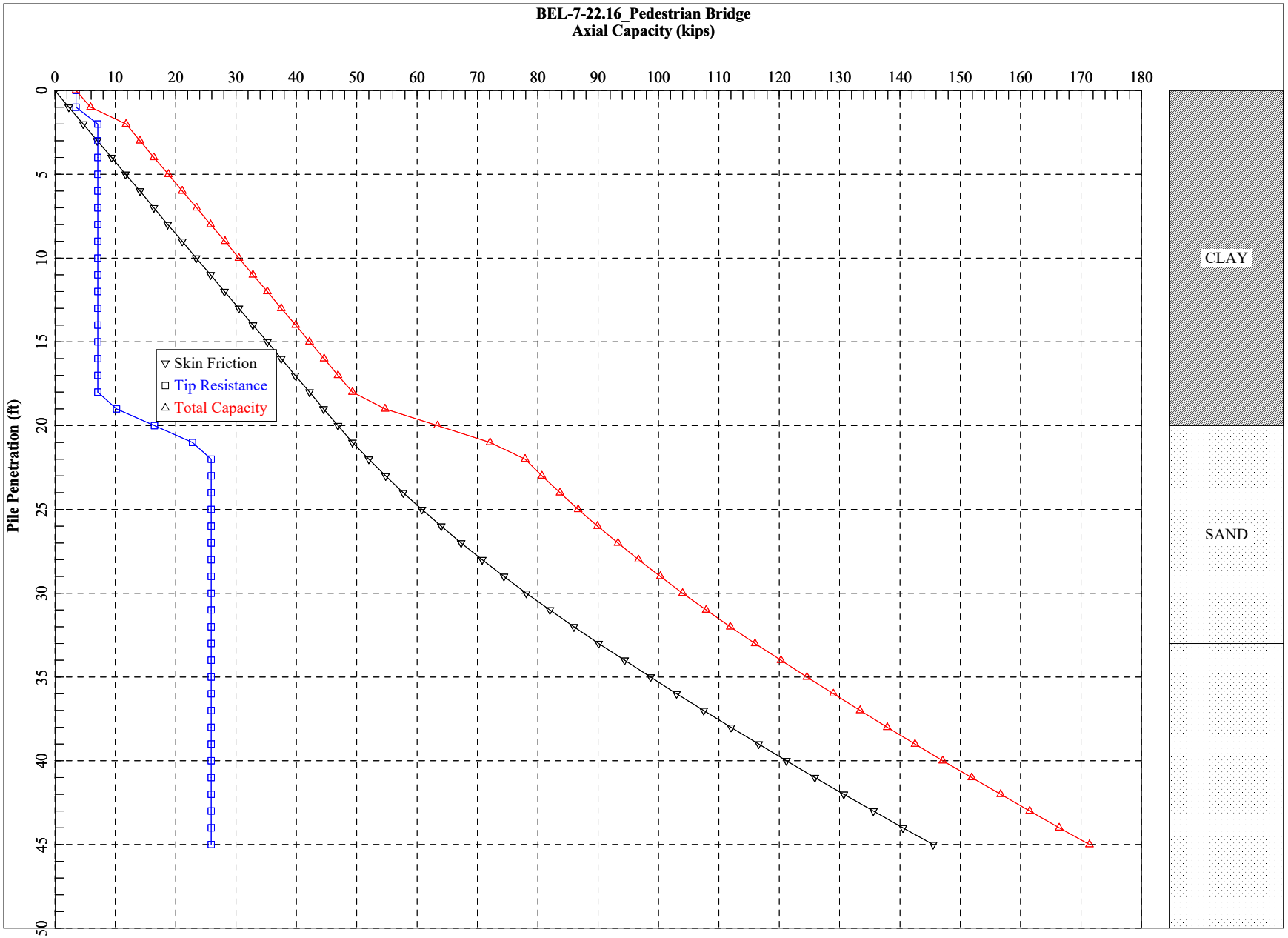
TIP LOAD KIP	TIP MOVEMENT IN.
0.0000E+00	0.0000E+00
0.1620E+01	0.6000E-02
0.3240E+01	0.1200E-01
0.6480E+01	0.2400E-01
0.1296E+02	0.1560E+00
0.1944E+02	0.5040E+00
0.2333E+02	0.8760E+00
0.2592E+02	0.1200E+01
0.2592E+02	0.1800E+01
0.2592E+02	0.2400E+01

LOAD VERSUS SETTLEMENT CURVE

TOP LOAD KIP	TOP MOVEMENT IN.	TIP LOAD KIP	TIP MOVEMENT IN.
0.5285E+00	0.5786E-03	0.2700E-01	0.1000E-03
0.5300E+01	0.5787E-02	0.2700E+00	0.1000E-02
0.2653E+02	0.2924E-01	0.1350E+01	0.5000E-02
0.4868E+02	0.5699E-01	0.2700E+01	0.1000E-01
0.8108E+02	0.1038E+00	0.5400E+01	0.2000E-01
0.1235E+03	0.1901E+00	0.7756E+01	0.5000E-01
0.1420E+03	0.2515E+00	0.9228E+01	0.8000E-01
0.1489E+03	0.2845E+00	0.1021E+02	0.1000E+00
0.1545E+03	0.3964E+00	0.1378E+02	0.2000E+00

BEL-7-22.16_ult

0.1600E+03	0.7076E+00	0.1936E+02	0.5000E+00
0.1632E+03	0.1014E+01	0.2253E+02	0.8000E+00
0.1650E+03	0.1218E+01	0.2432E+02	0.1000E+01
0.1666E+03	0.2221E+01	0.2592E+02	0.2000E+01


BEL-7-22.16_Pedestrian Bridge
Axial Capacity (kips)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
Pile Penetration (ft)
0
5
10
15
20
25
30
35
40
45
50
Skin Friction
Tip Resistance
Total Capacity
CLAY
SAND

```
=============================================================================

                  APILE for Windows, Version 2019.9.4

                   Serial Number :  160705594

                   A Program for Analyzing the Axial Capacity
                   and Short-term Settlement of Driven Piles
                             under Axial Loading.
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\\US0247-PPFSS01\shared_projects\173609114\BEL-7-2216\114382\401-Engineering_Stantec\Geotechnical\EngData\pile
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     Name of plot output file    : BEL-7-22.16_factored.ap9p

     -----------------------------------------------------------------------
                          Time and Date of Analysis
     -----------------------------------------------------------------------

               Date:  July 10, 2023     Time:  10:47:13



1
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          * INPUT INFORMATION *
          **********************
```

BEL-7-22.16

DESIGNER : James Samples

JOB NUMBER : 173609114

METHOD FOR UNIT LOAD TRANSFERS :

- FHWA (Federal Highway Administration)
  Unfactored Unit Side Friction and Unit Side Resistance are used.

COMPUTATION METHOD(S) FOR PILE CAPACITY :

- FHWA (Federal Highway Administration)

TYPE OF LOADING :
- COMPRESSION

PILE TYPE :

Steel pipe pile or non-tapered portion of monotube pile
- Close-Ended Pile

DATA FOR AXIAL STIFFNESS :

- MODULUS OF ELASTICITY = 0.290E+08 PSI
- CROSS SECTION AREA = 13.70 IN2

CIRCULAR PILE PROPERTIES :

- OUTSIDE DIAMETER, OD = 12.00 IN.

- INTERNAL DIAMETER, ID = 11.25 IN.
- TOTAL PILE LENGTH, TL = 60.00 FT.
- BATTER ANGLE = 0.00 DEG
- PILE STICKUP LENGTH, PSL = 0.00 FT.
- ZERO FRICTION LENGTH, ZFL = 0.00 FT.
- INCREMENT OF PILE LENGTH USED IN COMPUTATION = 1.00 FT.
- LENGTH OF ENHANCED END SECTION = 60.00 FT.
- INTERNAL DIAMETER OF ENHANCED END SECTION = 11.25 IN.

PLUGGED/UNPLUGGED CONDITIONS :
Internal Pile Plug Calculated by Program

SOIL INFORMATIONS :

DEPTH FT.	SOIL TYPE	LATERAL EARTH PRESSURE	EFFECTIVE UNIT WEIGHT LB/FT^3	FRICTION ANGLE DEGREES	BEARING CAPACITY FACTOR
0.00	CLAY	0.80*	120.00	0.00	8.00**
20.00	CLAY	0.80*	120.00	0.00	8.00**
20.00	SAND	0.80*	130.00	32.00	28.00**
33.00	SAND	0.80*	130.00	32.00	28.00**
33.00	SAND	0.80*	67.60	32.00	28.00**
73.00	SAND	0.80*	67.60	32.00	28.00**

* VALUE ASSUMED BY THE PROGRAM
** VALUE ESTIMATED BY THE PROGRAM BASED ON FRICTION ANGLE

MAXIMUM UNIT	MAXIMUM UNIT	UNDISTURB SHEAR	REMOLDED SHEAR	BLOW	UNIT SKIN	UNIT END

FRICTION KSF	BEARING KSF	STRENGTH KSF	STRENGTH KSF	COUNT	FRICTION KSF	BEARING KSF
0.10E+08*	0.10E+08*	1.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	1.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00

* MAXIMUM UNIT FRICTION AND/OR MAXIMUM UNIT BEARING
  WERE SET TO BE 0.10E+08 BECAUSE THE USER DOES NOT
  PLAN TO LIMIT THE COMPUTED DATA.

DEPTH FT.	LRFD FACTOR ON UNIT FRICTION	LRFD FACTOR ON UNIT BEARING
0.00	0.350	0.350
20.00	0.350	0.350
20.00	0.450	0.450
33.00	0.450	0.450
33.00	0.450	0.450
73.00	0.450	0.450

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****
* COMPUTATION RESULT *
****

****
* FED. HWY. METHOD *
****

PILE	TOTAL SKIN	END	ULTIMATE

BEL-7-22.16_factored

PENETRATION FT.	FRICTION KIP	BEARING KIP	CAPACITY KIP
0.00	0.0	1.2	1.2
1.00	1.0	1.2	2.3
2.00	2.1	2.5	4.6
3.00	3.1	2.5	5.6
4.00	4.2	2.5	6.6
5.00	5.2	2.5	7.7
6.00	6.3	2.5	8.7
7.00	7.3	2.5	9.8
8.00	8.3	2.5	10.8
9.00	9.4	2.5	11.9
10.00	10.4	2.5	12.9
11.00	11.5	2.5	13.9
12.00	12.5	2.5	15.0
13.00	13.6	2.5	16.0
14.00	14.6	2.5	17.1
15.00	15.6	2.5	18.1
16.00	16.7	2.5	19.2
17.00	17.7	2.5	20.2
18.00	18.8	2.5	21.3
19.00	19.8	3.6	23.4
20.00	21.2	7.4	28.6
21.00	22.5	10.2	32.7
22.00	23.7	11.7	35.4
23.00	24.9	11.7	36.6
24.00	26.3	11.7	37.9
25.00	27.6	11.7	39.3
26.00	29.1	11.7	40.7
27.00	30.6	11.7	42.2
28.00	32.1	11.7	43.8
29.00	33.8	11.7	45.4
30.00	35.4	11.7	47.1
31.00	37.2	11.7	48.8
32.00	39.0	11.7	50.6
33.00	40.8	11.7	52.5
34.00	42.7	11.7	54.4
35.00	44.7	11.7	56.3
36.00	46.7	11.7	58.3
37.00	48.7	11.7	60.3

38.00	50.7	11.7	62.3
39.00	52.7	11.7	64.4
40.00	54.8	11.7	66.5
41.00	57.0	11.7	68.6
42.00	59.1	11.7	70.8
43.00	61.3	11.7	73.0
44.00	63.5	11.7	75.2
45.00	65.8	11.7	77.4
46.00	68.1	11.7	79.7
47.00	70.4	11.7	82.0
48.00	72.7	11.7	84.4
49.00	75.1	11.7	86.7
50.00	77.5	11.7	89.1
51.00	79.9	11.7	91.6
52.00	82.4	11.7	94.1
53.00	84.9	11.7	96.6
54.00	87.4	11.7	99.1
55.00	90.0	11.7	101.6
56.00	92.6	11.7	104.2
57.00	95.2	11.7	106.9
58.00	97.9	11.7	109.5
59.00	100.5	11.7	112.2
60.00	103.3	11.7	114.9

Required factored capacity of 88 kips reached at 50 feet

NOTES:
- AN ASTERISK IS PLACED IN THE END-BEARING COLUMN
  IF THE TIP RESISTANCE IS CONTROLLED BY THE FRICTION
  OF SOIL PLUG INSIDE AN OPEN-ENDED PIPE PILE.

****
* COMPUTE LOAD-DISTRIBUTION AND LOAD-SETTLEMENT *
* CURVES FOR AXIAL LOADING *
****

T-Z CURVE NO.	NO. OF POINTS	DEPTH TO CURVE FT.	LOAD TRANSFER PSI	PILE MOVEMENT IN.

```
1         10      0.0000E+00
                                0.0000E+00      0.0000E+00
                                0.1976E+01      0.1920E-01
                                0.3294E+01      0.3720E-01
                                0.4941E+01      0.6840E-01
                                0.5929E+01      0.9600E-01
                                0.6588E+01      0.1200E+00
                                0.5929E+01      0.2400E+00
                                0.5929E+01      0.3600E+00
                                0.5929E+01      0.6000E+00
                                0.5929E+01      0.2400E+01
2         10      0.1003E+02
                                0.0000E+00      0.0000E+00
                                0.1976E+01      0.1920E-01
                                0.3294E+01      0.3720E-01
                                0.4941E+01      0.6840E-01
                                0.5929E+01      0.9600E-01
                                0.6588E+01      0.1200E+00
                                0.5929E+01      0.2400E+00
                                0.5929E+01      0.3600E+00
                                0.5929E+01      0.6000E+00
                                0.5929E+01      0.2400E+01
3         10      0.1996E+02
                                0.0000E+00      0.0000E+00
                                0.2079E+01      0.1920E-01
                                0.3465E+01      0.3720E-01
                                0.5197E+01      0.6840E-01
                                0.6237E+01      0.9600E-01
                                0.6930E+01      0.1200E+00
                                0.6237E+01      0.2400E+00
                                0.6237E+01      0.3600E+00
                                0.6237E+01      0.6000E+00
                                0.6237E+01      0.2400E+01
4         10      0.2000E+02
                                0.0000E+00      0.0000E+00
                                0.2083E+01      0.1920E-01
                                0.3472E+01      0.3720E-01
                                0.5208E+01      0.6840E-01
                                0.6250E+01      0.9600E-01
```

```
                                    0.6944E+01      0.1200E+00
                                    0.6944E+01      0.2400E+00
                                    0.6944E+01      0.3600E+00
                                    0.6944E+01      0.6000E+00
                                    0.6944E+01      0.2400E+01
5          10       0.2653E+02
                                    0.0000E+00      0.0000E+00
                                    0.2212E+01      0.1920E-01
                                    0.3686E+01      0.3720E-01
                                    0.5530E+01      0.6840E-01
                                    0.6636E+01      0.9600E-01
                                    0.7373E+01      0.1200E+00
                                    0.7373E+01      0.2400E+00
                                    0.7373E+01      0.3600E+00
                                    0.7373E+01      0.6000E+00
                                    0.7373E+01      0.2400E+01
6          10       0.3296E+02
                                    0.0000E+00      0.0000E+00
                                    0.2781E+01      0.1920E-01
                                    0.4636E+01      0.3720E-01
                                    0.6953E+01      0.6840E-01
                                    0.8344E+01      0.9600E-01
                                    0.9271E+01      0.1200E+00
                                    0.9271E+01      0.2400E+00
                                    0.9271E+01      0.3600E+00
                                    0.9271E+01      0.6000E+00
                                    0.9271E+01      0.2400E+01
7          10       0.3300E+02
                                    0.0000E+00      0.0000E+00
                                    0.2785E+01      0.1920E-01
                                    0.4642E+01      0.3720E-01
                                    0.6963E+01      0.6840E-01
                                    0.8355E+01      0.9600E-01
                                    0.9284E+01      0.1200E+00
                                    0.9284E+01      0.2400E+00
                                    0.9284E+01      0.3600E+00
                                    0.9284E+01      0.6000E+00
                                    0.9284E+01      0.2400E+01
8          10       0.5303E+02
                                    0.0000E+00      0.0000E+00
```

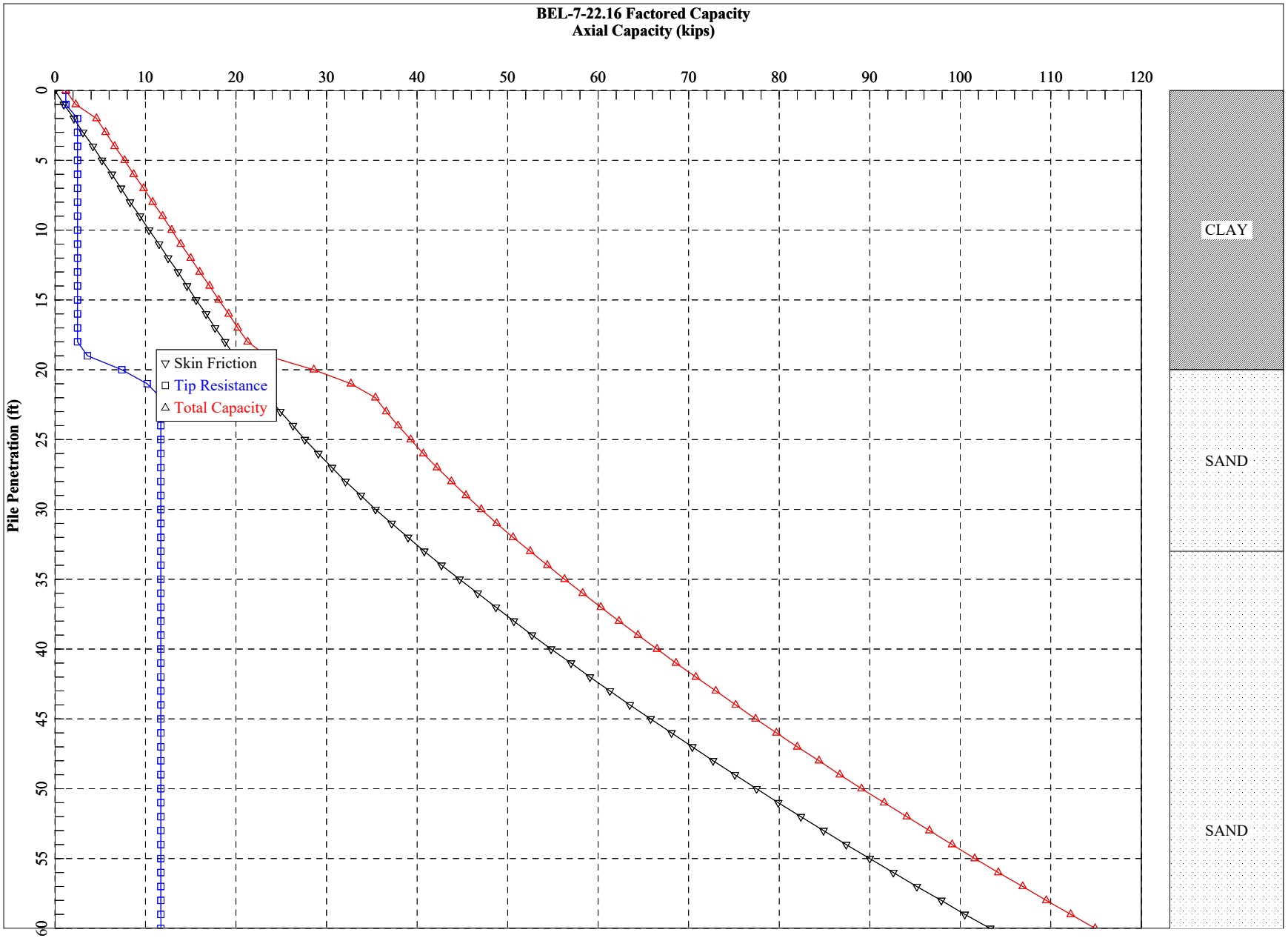
BEL-7-22.16_factored

			0.3707E+01	0.1920E-01
			0.6178E+01	0.3720E-01
			0.9267E+01	0.6840E-01
			0.1112E+02	0.9600E-01
			0.1236E+02	0.1200E+00
			0.1236E+02	0.2400E+00
			0.1236E+02	0.3600E+00
			0.1236E+02	0.6000E+00
			0.1236E+02	0.2400E+01
9	10	0.7296E+02		
			0.0000E+00	0.0000E+00
			0.4028E+01	0.1920E-01
			0.6713E+01	0.3720E-01
			0.1007E+02	0.6840E-01
			0.1208E+02	0.9600E-01
			0.1343E+02	0.1200E+00
			0.1343E+02	0.2400E+00
			0.1343E+02	0.3600E+00
			0.1343E+02	0.6000E+00
			0.1343E+02	0.2400E+01

TIP LOAD KIP	TIP MOVEMENT IN.
0.0000E+00	0.0000E+00
0.1620E+01	0.6000E-02
0.3240E+01	0.1200E-01
0.6480E+01	0.2400E-01
0.1296E+02	0.1560E+00
0.1944E+02	0.5040E+00
0.2333E+02	0.8760E+00
0.2592E+02	0.1200E+01
0.2592E+02	0.1800E+01
0.2592E+02	0.2400E+01

LOAD VERSUS SETTLEMENT CURVE

TOP LOAD KIP	TOP MOVEMENT IN.	TIP LOAD KIP	TIP MOVEMENT IN.
0.1102E+01	0.8807E-03	0.2700E-01	0.1000E-03
0.1110E+02	0.8823E-02	0.2700E+00	0.1000E-02
0.5297E+02	0.4405E-01	0.1350E+01	0.5000E-02
0.9278E+02	0.8355E-01	0.2700E+01	0.1000E-01
0.1455E+03	0.1463E+00	0.5400E+01	0.2000E-01
0.2046E+03	0.2538E+00	0.7756E+01	0.5000E-01
0.2317E+03	0.3251E+00	0.9228E+01	0.8000E-01
0.2419E+03	0.3616E+00	0.1021E+02	0.1000E+00
0.2497E+03	0.4750E+00	0.1378E+02	0.2000E+00
0.2552E+03	0.7851E+00	0.1936E+02	0.5000E+00
0.2584E+03	0.1091E+01	0.2253E+02	0.8000E+00
0.2602E+03	0.1294E+01	0.2432E+02	0.1000E+01
0.2618E+03	0.2297E+01	0.2592E+02	0.2000E+01


BEL-7-22.16 Factored Capacity
Axial Capacity (kips)
0
10
20
30
40
50
60
70
80
90
100
110
120
Pile Penetration (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
Skin Friction
Tip Resistance
Total Capacity
CLAY
SAND
SAND

```
=============================================================================

                  APILE for Windows, Version 2019.9.4

                   Serial Number :  160705594

                   A Program for Analyzing the Axial Capacity
                   and Short-term Settlement of Driven Piles
                             under Axial Loading.
                 (c) Copyright ENSOFT, Inc., 1987-2015
                       All Rights Reserved

=============================================================================


     This program is licensed to :

     Stantec Consulting Services Inc.
     Cincinnati, OHIO / USA

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     Name of plot output file    : BEL-7-22.16_nominal.ap9p

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                          Time and Date of Analysis
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               Date:  July 10, 2023     Time:  10:50:08



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          * INPUT INFORMATION *
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```

BEL-7-22.16

DESIGNER : James Samples

JOB NUMBER : 173609114

METHOD FOR UNIT LOAD TRANSFERS :

- FHWA (Federal Highway Administration)
  Unfactored Unit Side Friction and Unit Side Resistance are used.

COMPUTATION METHOD(S) FOR PILE CAPACITY :

- FHWA (Federal Highway Administration)

TYPE OF LOADING :
- COMPRESSION

PILE TYPE :

Steel pipe pile or non-tapered portion of monotube pile
- Close-Ended Pile

DATA FOR AXIAL STIFFNESS :

- MODULUS OF ELASTICITY = 0.290E+08 PSI
- CROSS SECTION AREA = 9.23 IN2

CIRCULAR PILE PROPERTIES :

- OUTSIDE DIAMETER, OD = 12.00 IN.

- INTERNAL DIAMETER, ID = 11.50 IN.
- TOTAL PILE LENGTH, TL = 65.00 FT.
- BATTER ANGLE = 0.00 DEG
- PILE STICKUP LENGTH, PSL = 0.00 FT.
- ZERO FRICTION LENGTH, ZFL = 0.00 FT.
- INCREMENT OF PILE LENGTH USED IN COMPUTATION = 1.00 FT.
- LENGTH OF ENHANCED END SECTION = 65.00 FT.
- INTERNAL DIAMETER OF ENHANCED END SECTION = 11.50 IN.

PLUGGED/UNPLUGGED CONDITIONS :
Internal Pile Plug Calculated by Program

SOIL INFORMATIONS :

DEPTH FT.	SOIL TYPE	LATERAL EARTH PRESSURE	EFFECTIVE UNIT WEIGHT LB/FT^3	FRICTION ANGLE DEGREES	BEARING CAPACITY FACTOR
0.00	CLAY	0.80*	120.00	0.00	8.00**
20.00	CLAY	0.80*	120.00	0.00	8.00**
20.00	SAND	0.80*	130.00	32.00	28.00**
33.00	SAND	0.80*	130.00	32.00	28.00**
33.00	SAND	0.80*	67.60	32.00	28.00**
73.00	SAND	0.80*	67.60	32.00	28.00**

* VALUE ASSUMED BY THE PROGRAM
** VALUE ESTIMATED BY THE PROGRAM BASED ON FRICTION ANGLE

MAXIMUM UNIT	MAXIMUM UNIT	UNDISTURB SHEAR	REMOLDED SHEAR	BLOW	UNIT SKIN	UNIT END

FRICTION KSF	BEARING KSF	STRENGTH KSF	STRENGTH KSF	COUNT	FRICTION KSF	BEARING KSF
0.10E+08*	0.10E+08*	1.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	1.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00

* MAXIMUM UNIT FRICTION AND/OR MAXIMUM UNIT BEARING
  WERE SET TO BE 0.10E+08 BECAUSE THE USER DOES NOT
  PLAN TO LIMIT THE COMPUTED DATA.

DEPTH FT.	LRFD FACTOR ON UNIT FRICTION	LRFD FACTOR ON UNIT BEARING
0.00	1.000	1.000
20.00	1.000	1.000
20.00	1.000	1.000
33.00	1.000	1.000
33.00	1.000	1.000
73.00	1.000	1.000

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****
* COMPUTATION RESULT *
****

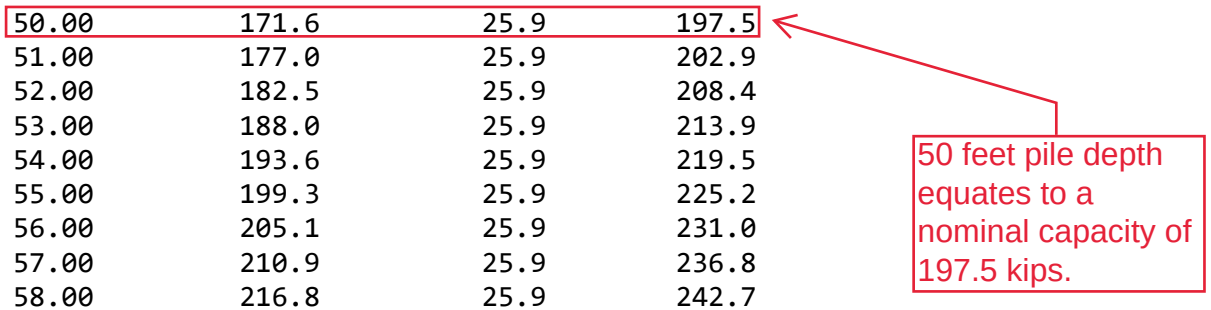
****
* FED. HWY. METHOD *
****

PILE	TOTAL SKIN	END	ULTIMATE

BEL-7-22.16_nominal

PENETRATION FT.	FRICTION KIP	BEARING KIP	CAPACITY KIP
0.00	0.0	3.5	3.5
1.00	2.3	3.5	5.9
2.00	4.7	7.1	11.8
3.00	7.0	7.1	14.1
4.00	9.4	7.1	16.4
5.00	11.7	7.1	18.8
6.00	14.1	7.1	21.1
7.00	16.4	7.1	23.5
8.00	18.7	7.1	25.8
9.00	21.1	7.1	28.2
10.00	23.4	7.1	30.5
11.00	25.8	7.1	32.8
12.00	28.1	7.1	35.2
13.00	30.5	7.1	37.5
14.00	32.8	7.1	39.9
15.00	35.2	7.1	42.2
16.00	37.5	7.1	44.6
17.00	39.8	7.1	46.9
18.00	42.2	7.1	49.3
19.00	44.5	10.2	54.7
20.00	46.9	16.5	63.4
21.00	49.3	22.8	72.1
22.00	52.0	25.9	77.9
23.00	54.8	25.9	80.7
24.00	57.7	25.9	83.7
25.00	60.8	25.9	86.7
26.00	64.0	25.9	89.9
27.00	67.3	25.9	93.3
28.00	70.8	25.9	96.7
29.00	74.4	25.9	100.3
30.00	78.1	25.9	104.0
31.00	82.0	25.9	107.9
32.00	86.0	25.9	111.9
33.00	90.1	25.9	116.0
34.00	94.4	25.9	120.3
35.00	98.7	25.9	124.6
36.00	103.0	25.9	129.0
37.00	107.5	25.9	133.4

38.00	112.0	25.9	137.9
39.00	116.6	25.9	142.5
40.00	121.2	25.9	147.1
41.00	125.9	25.9	151.9
42.00	130.7	25.9	156.7
43.00	135.6	25.9	161.5
44.00	140.5	25.9	166.4
45.00	145.5	25.9	171.4
46.00	150.6	25.9	176.5
47.00	155.7	25.9	181.6
48.00	160.9	25.9	186.9
49.00	166.2	25.9	192.1
50.00	171.6	25.9	197.5
51.00	177.0	25.9	202.9
52.00	182.5	25.9	208.4
53.00	188.0	25.9	213.9
54.00	193.6	25.9	219.5
55.00	199.3	25.9	225.2
56.00	205.1	25.9	231.0
57.00	210.9	25.9	236.8
58.00	216.8	25.9	242.7
59.00	222.8	25.9	248.7
60.00	228.8	25.9	254.7
61.00	234.9	25.9	260.9
62.00	241.1	25.9	267.0
63.00	247.4	25.9	273.3
64.00	253.7	25.9	279.6
65.00	260.1	25.9	286.0



NOTES:
- AN ASTERISK IS PLACED IN THE END-BEARING COLUMN
  IF THE TIP RESISTANCE IS CONTROLLED BY THE FRICTION
  OF SOIL PLUG INSIDE AN OPEN-ENDED PIPE PILE.

****
* COMPUTE LOAD-DISTRIBUTION AND LOAD-SETTLEMENT *
* CURVES FOR AXIAL LOADING *

****

T-Z CURVE NO.	NO. OF POINTS	DEPTH TO CURVE FT.	LOAD TRANSFER PSI	PILE MOVEMENT IN.
1	10	0.0000E+00		
			0.0000E+00	0.0000E+00
			0.1554E+01	0.1920E-01
			0.2590E+01	0.3720E-01
			0.3885E+01	0.6840E-01
			0.4662E+01	0.9600E-01
			0.5181E+01	0.1200E+00
			0.4662E+01	0.2400E+00
			0.4662E+01	0.3600E+00
			0.4662E+01	0.6000E+00
			0.4662E+01	0.2400E+01
2	10	0.1003E+02		
			0.0000E+00	0.0000E+00
			0.1554E+01	0.1920E-01
			0.2590E+01	0.3720E-01
			0.3885E+01	0.6840E-01
			0.4662E+01	0.9600E-01
			0.5181E+01	0.1200E+00
			0.4662E+01	0.2400E+00
			0.4662E+01	0.3600E+00
			0.4662E+01	0.6000E+00
			0.4662E+01	0.2400E+01
3	10	0.1996E+02		
			0.0000E+00	0.0000E+00
			0.1554E+01	0.1920E-01
			0.2590E+01	0.3720E-01
			0.3885E+01	0.6840E-01
			0.4662E+01	0.9600E-01
			0.5181E+01	0.1200E+00
			0.4662E+01	0.2400E+00
			0.4662E+01	0.3600E+00
			0.4662E+01	0.6000E+00
			0.4662E+01	0.2400E+01
4	10	0.2000E+02		

		0.0000E+00	0.0000E+00
		0.1554E+01	0.1920E-01
		0.2590E+01	0.3720E-01
		0.3885E+01	0.6840E-01
		0.4662E+01	0.9600E-01
		0.5181E+01	0.1200E+00
		0.5181E+01	0.2400E+00
		0.5181E+01	0.3600E+00
		0.5181E+01	0.6000E+00
		0.5181E+01	0.2400E+01
5	10	0.2653E+02	
		0.0000E+00	0.0000E+00
		0.2212E+01	0.1920E-01
		0.3686E+01	0.3720E-01
		0.5530E+01	0.6840E-01
		0.6636E+01	0.9600E-01
		0.7373E+01	0.1200E+00
		0.7373E+01	0.2400E+00
		0.7373E+01	0.3600E+00
		0.7373E+01	0.6000E+00
		0.7373E+01	0.2400E+01
6	10	0.3296E+02	
		0.0000E+00	0.0000E+00
		0.2781E+01	0.1920E-01
		0.4636E+01	0.3720E-01
		0.6953E+01	0.6840E-01
		0.8344E+01	0.9600E-01
		0.9271E+01	0.1200E+00
		0.9271E+01	0.2400E+00
		0.9271E+01	0.3600E+00
		0.9271E+01	0.6000E+00
		0.9271E+01	0.2400E+01
7	10	0.3300E+02	
		0.0000E+00	0.0000E+00
		0.2785E+01	0.1920E-01
		0.4642E+01	0.3720E-01
		0.6963E+01	0.6840E-01
		0.8355E+01	0.9600E-01
		0.9284E+01	0.1200E+00
		0.9284E+01	0.2400E+00

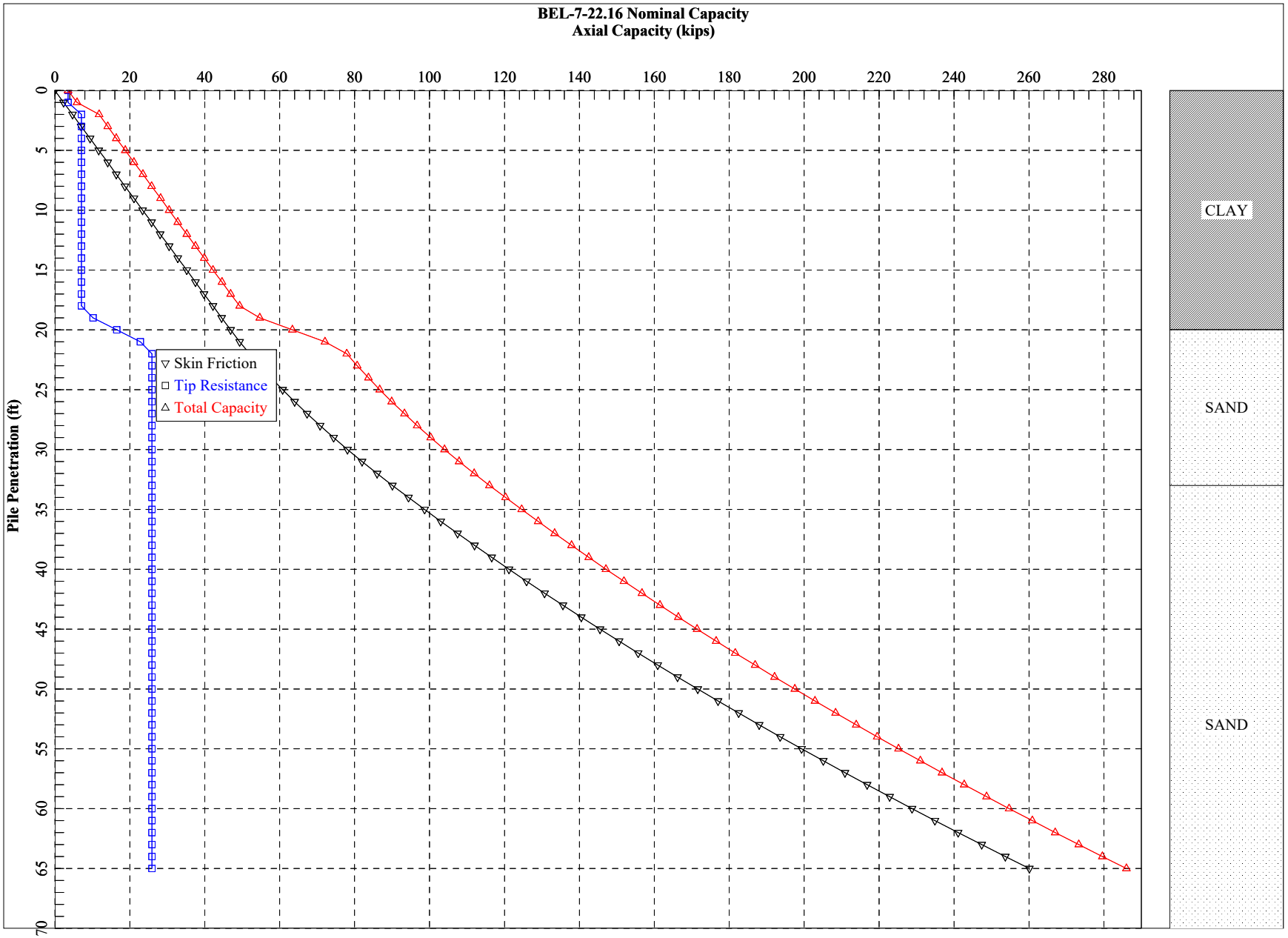
			0.9284E+01	0.3600E+00
			0.9284E+01	0.6000E+00
			0.9284E+01	0.2400E+01
8	10	0.5303E+02		
			0.0000E+00	0.0000E+00
			0.3707E+01	0.1920E-01
			0.6178E+01	0.3720E-01
			0.9267E+01	0.6840E-01
			0.1112E+02	0.9600E-01
			0.1236E+02	0.1200E+00
			0.1236E+02	0.2400E+00
			0.1236E+02	0.3600E+00
			0.1236E+02	0.6000E+00
			0.1236E+02	0.2400E+01
9	10	0.7296E+02		
			0.0000E+00	0.0000E+00
			0.4258E+01	0.1920E-01
			0.7097E+01	0.3720E-01
			0.1065E+02	0.6840E-01
			0.1277E+02	0.9600E-01
			0.1419E+02	0.1200E+00
			0.1419E+02	0.2400E+00
			0.1419E+02	0.3600E+00
			0.1419E+02	0.6000E+00
			0.1419E+02	0.2400E+01

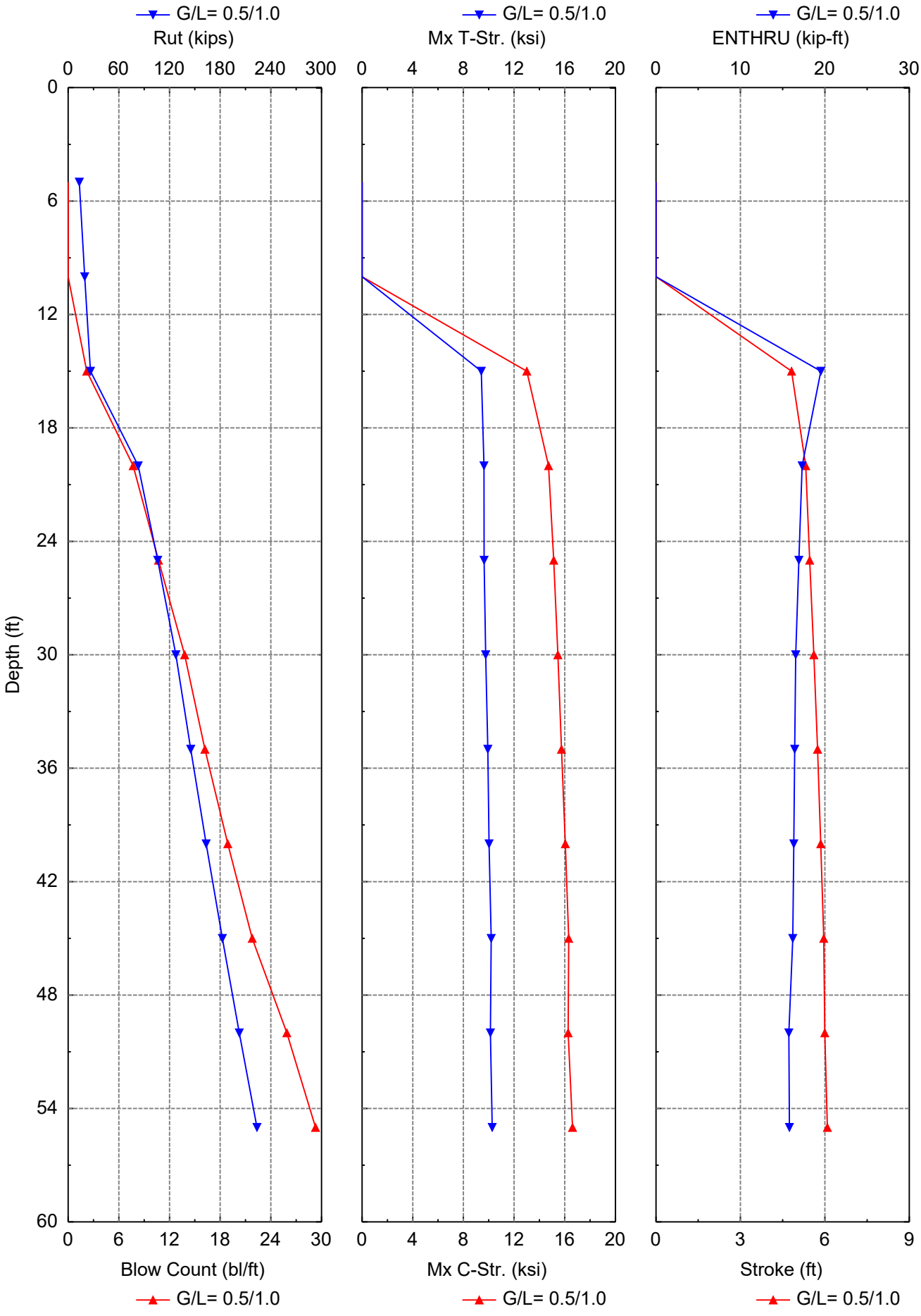
TIP LOAD KIP	TIP MOVEMENT IN.
0.0000E+00	0.0000E+00
0.1620E+01	0.6000E-02
0.3240E+01	0.1200E-01
0.6480E+01	0.2400E-01
0.1296E+02	0.1560E+00
0.1944E+02	0.5040E+00
0.2333E+02	0.8760E+00
0.2592E+02	0.1200E+01
0.2592E+02	0.1800E+01

0.2592E+02 0.2400E+01

LOAD VERSUS SETTLEMENT CURVE
****

TOP LOAD KIP	TOP MOVEMENT IN.	TIP LOAD KIP	TIP MOVEMENT IN.
0.1960E+01	0.2108E-02	0.2700E-01	0.1000E-03
0.2005E+02	0.2138E-01	0.2700E+00	0.1000E-02
0.8096E+02	0.9969E-01	0.1350E+01	0.5000E-02
0.1262E+03	0.1759E+00	0.2700E+01	0.1000E-01
0.1726E+03	0.2808E+00	0.5400E+01	0.2000E-01
0.2277E+03	0.4366E+00	0.7756E+01	0.5000E-01
0.2529E+03	0.5294E+00	0.9228E+01	0.8000E-01
0.2620E+03	0.5734E+00	0.1021E+02	0.1000E+00
0.2690E+03	0.6932E+00	0.1378E+02	0.2000E+00
0.2746E+03	0.1010E+01	0.1936E+02	0.5000E+00
0.2778E+03	0.1319E+01	0.2253E+02	0.8000E+00
0.2795E+03	0.1524E+01	0.2432E+02	0.1000E+01
0.2811E+03	0.2529E+01	0.2592E+02	0.2000E+01

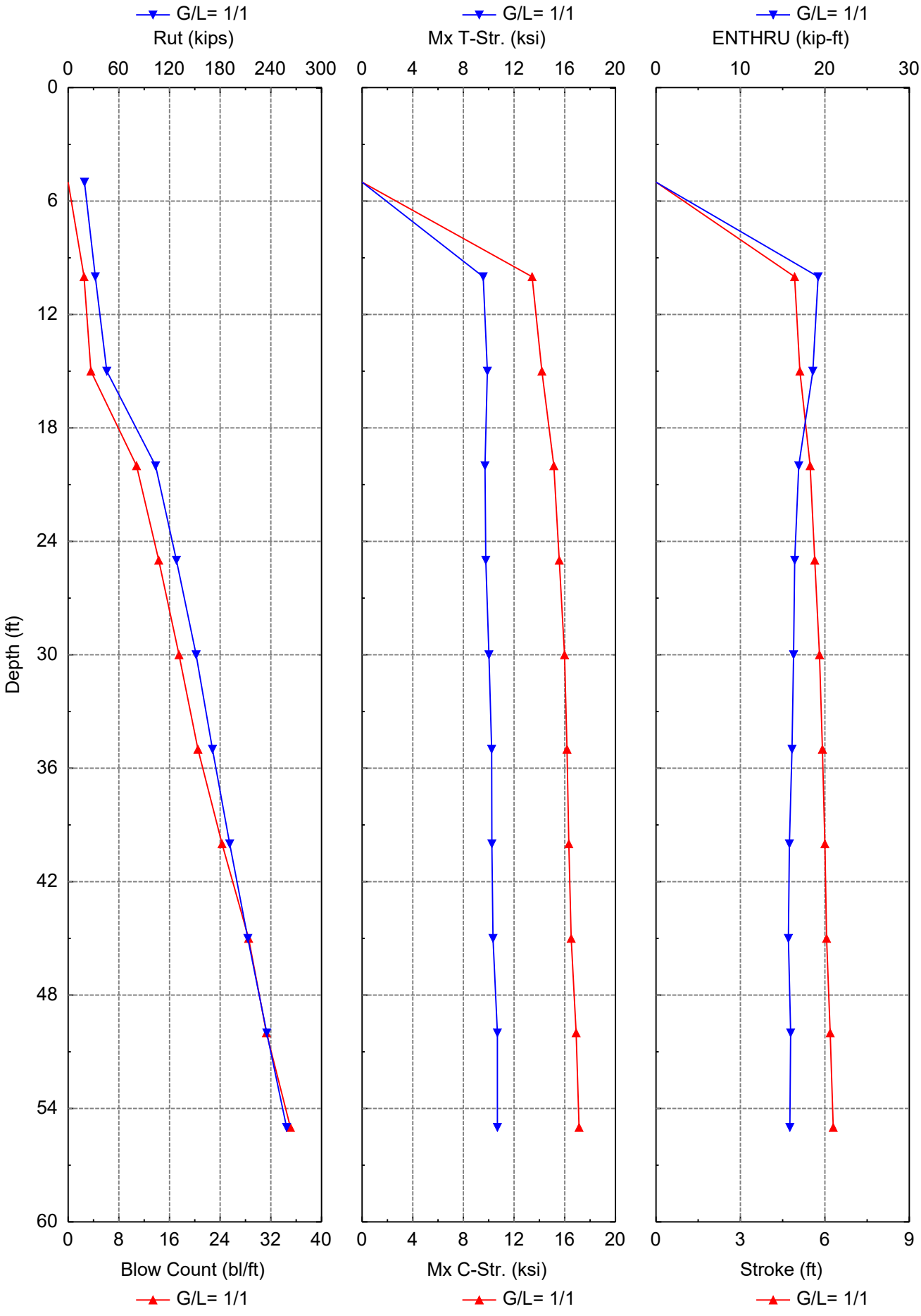

BEL-7-22.16 Nominal Capacity
Axial Capacity (kips)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
Pile Penetration (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
Skin Friction
Tip Resistance
Total Capacity
CLAY
SAND
SAND


G/L= 0.5/1.0
Rut (kips)
0 60 120 180 240 300
Blow Count (bl/ft)
0 6 12 18 24 30
G/L= 0.5/1.0
Mx T-Str. (ksi)
0 4 8 12 16 20
Mx C-Str. (ksi)
0 4 8 12 16 20
G/L= 0.5/1.0
ENTHRU (kip-ft)
0 10 20 30
Stroke (ft)
0 3 6 9
G/L= 0.5/1.0
Depth (ft)
0 6 12 18 24 30 36 42 48 54 60

Driveability Analysis Summary
Gain/Loss Factor at Shaft/Toe = 0.500/1.000

Depth	Rut	Rshaft	Rtoe	Blow Ct	Mx C-Str	Mx T-Str.	Stroke	ENTHRU	Hammer
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft	-
5.0	13.2	6.1	7.1	0.3	0.000	0.000	8.27	0.0	D 22
10.0	19.6	12.6	7.1	0.3	0.000	0.000	8.27	0.0	D 22
15.0	26.4	19.4	7.1	2.2	13.000	9.409	4.82	19.5	D 22
20.0	83.0	25.3	57.7	7.7	14.716	9.628	5.32	17.3	D 22
25.0	106.1	33.1	73.0	10.7	15.130	9.638	5.46	16.9	D 22
30.0	127.6	42.2	85.4	13.8	15.458	9.762	5.61	16.5	D 22
35.0	145.1	51.7	93.4	16.2	15.747	9.926	5.74	16.4	D 22
40.0	163.4	62.1	101.3	18.9	16.050	10.028	5.85	16.3	D 22
45.0	182.6	73.3	109.3	21.8	16.316	10.195	5.96	16.2	D 22
50.0	202.7	85.4	117.2	25.9	16.267	10.132	6.00	15.7	D 22
55.0	223.5	98.4	125.2	29.3	16.616	10.277	6.09	15.8	D 22

Total driving time: 13 minutes; Total Number of Blows: 660 (starting at penetration 5.0 ft)


G/L= 1/1
Rut (kips)
0 60 120 180 240 300
Mx T-Str. (ksi)
0 4 8 12 16 20
ENTHRU (kip-ft)
0 10 20 30
Depth (ft)
0 6 12 18 24 30 36 42 48 54 60
Blow Count (bl/ft)
0 8 16 24 32 40
Mx C-Str. (ksi)
0 4 8 12 16 20
Stroke (ft)
0 3 6 9

Driveability Analysis Summary
Gain/Loss Factor at Shaft/Toe = 1.000/1.000

Depth	Rut	Rshaft	Rtoe	Blow Ct	Mx C-Str	Mx T-Str.	Stroke	ENTHRU	Hammer
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft	-
5.0	19.3	12.2	7.1	0.3	0.000	0.000	8.27	0.0	D 22
10.0	32.2	25.1	7.1	2.5	13.423	9.565	4.93	19.2	D 22
15.0	45.8	38.7	7.1	3.6	14.192	9.892	5.11	18.6	D 22
20.0	103.6	45.8	57.7	10.8	15.137	9.709	5.48	16.9	D 22
25.0	128.2	55.2	73.0	14.3	15.564	9.770	5.64	16.4	D 22
30.0	151.5	66.1	85.4	17.5	15.983	10.013	5.81	16.3	D 22
35.0	170.9	77.6	93.4	20.5	16.179	10.227	5.91	16.1	D 22
40.0	191.3	90.0	101.3	24.3	16.319	10.251	6.00	15.8	D 22
45.0	212.8	103.5	109.3	28.5	16.510	10.339	6.06	15.7	D 22
50.0	235.2	118.0	117.2	31.3	16.900	10.682	6.19	15.9	D 22
55.0	258.7	133.5	125.2	35.1	17.131	10.685	6.30	15.9	D 22

Total driving time: 18 minutes; Total Number of Blows: 854 (starting at penetration 5.0 ft)

APPENDIX C
SEISMIC SITE CLASS EVALUATION

Seismic Site Class Evaluation

Project: BEL-7-22.16 **Structure:** Pedestrian Bridge **Performed by:** J. Samples
Checked by: E. Kistner

SPT Hammer Efficiency	90.0%

Boring: B-001-0-22

SPT Blow Counts			N-value	N60	Range	Range/N	
11	7	5	12	18	1.5	0.08	
3	3	2	5	8	2.5	0.33	
1	2	4	6	9	2.5	0.28	
2	2	5	7	11	2.5	0.24	
2	4	4	8	12	2.5	0.21	
0	2	2	4	6	2.5	0.42	
0	0	0	0	1	2.5	2.50	*
0	0	1	1	2	2.5	1.67	
1	1	2	3	5	2.5	0.56	
0	3	6	9	14	2.5	0.19	
1	2	5	7	11	2.5	0.24	
3	5	8	13	20	2.5	0.13	
5	11	9	20	30	2.5	0.08	
3	6	6	12	18	5	0.28	
20	24	22	46	69	5	0.07	
16	18	23	41	62	5	0.08	
7	16	18	34	51	5	0.10	
14	16	18	34	51	5	0.10	
18	18	16	34	51	5	0.10	
28	19	16	35	53	5	0.10	
15	22	23	45	68	5	0.07	
Assumed Bedrock			100	100	28.5	0.29	
				Σ Range/N		8.09	
				Ñ =		12.4	

Boring: B-002-0-22

SPT Blow Counts			N-value	N60	Range	Range/N
5	8	4	12	18	1.5	0.08
3	8	26	34	51	2.5	0.05
8	3	6	9	14	2.5	0.19
2	3	5	8	12	2.5	0.21
1	3	6	9	14	2.5	0.19
2	3	5	8	12	2.5	0.21
2	2	3	5	8	2.5	0.33
0	0	4	4	6	2.5	0.42
5	11	8	19	29	2.5	0.09
7	7	12	19	29	2.5	0.09
2	3	13	16	24	2.5	0.10
5	7	9	16	24	2.5	0.10
1	5	6	11	17	2.5	0.15
3	3	4	7	11	5	0.48
9	11	12	23	35	5	0.14
22	24	34	58	87	5	0.06
14	13	15	28	42	5	0.12
17	18	18	36	54	5	0.09
18	15	13	28	42	5	0.12
18	17	18	35	53	5	0.10
18	13	23	36	54	5	0.09
15	44	50	100	100	4.8	0.05
Assumed Bedrock			100	100	23.7	0.24
				Σ Range/N	3.69	
				Ñ =	27.1	

Average Ñ = **19.7**

* The split spoon reached required depth by weight of hamer (N = 0). N60 assumed as 1 for calculation.

In accordance with ODOT's Seismic Design Policy (2016) and AASHTO LRFD Section 3.10.3.1 (8th Edition)
The average Ñ for the three borings is 15 < Ñ < 50.
Therefore, based on AASHTO Table 3.10.3.1-1, use Site Class D.

Table 3.10.3.1-1—Site Class Definitions

Site Class	Soil Type and Profile
A	Hard rock with measured shear wave velocity, 5,000 ft/s
B	Rock with 2,500 ft/sec < < 5,000 ft/s
C	Very dense soil and soil rock with 1,200 ft/sec < < 2,500 ft/s, or with either > 50 blows/ft, or > 2.0 ksf
D	Stiff soil with 600 ft/s < vs < 1,200 ft/s, or with either 15 < Ñ < 50 blows/ft, or 1.0 < < 2.0 ksf
E	Soil profile with < 600 ft/s or with either < 15 blows/ft or < 1.0 ksf, or any profile with more than 10.0 ft of soft clay defined as soil with PI > 20, w > 40 percent and < 0.5 ksf

APPENDIX D
GEOTECHNICAL DESIGN CHECKLISTS

I. Geotechnical Design Checklists	
Project: BEL-7-22.16	**PDP Path: N/A**
PID: 114382	**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. Soil Profile VI. D. Geotechnical Reports	✓

II. Reconnaissance and Planning Checklist

C-R-S: BEL-7-22.16	PID: 114382	Reviewer: J. Samples	Date: 8/26/2022

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 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, probes, 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?	Y	

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)		
	Rockfall (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,b,c)		
	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-7-22.16	PID: 114382	Reviewer: J. Samples	Date: 8/26/2022

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

		(Y/N/X)	Notes:
Soil and Bedrock Strength Data			
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	N	
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	Y	
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?		No scour predicted.
15 Has a wave equation drivability analysis been performed as per BDM 305.4.1.2 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	Piles are already driven.
16 If required for design, have sufficient soil parameters been provided and calculations performed to evaluate the:	X	Piles are already driven.
a. Nominal unit tip resistance and maximum settlement of the piles?		
b. Nominal unit side resistance for each contributing soil layer and maximum deflection of the piles?		
c. Downdrag load on piles driven through new embankment or compressible soil layers, as per BDM 305.4.2.2?		
d. Potential for and impact of lateral squeeze from soft foundation soils?		

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 305.4.5.6?	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 305.4.5.7?	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.	N	
21 Have the drilled shaft diameter and embedment length been specified?		
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?		
23 For shafts undergoing lateral loading, have the following been determined:		
a. total factored lateral shear?		
b. total factored bending moment?		
c. maximum deflection?		
d. reinforcement design?		
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 305.5.2?		
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?		
26 If scour is predicted, has shaft resistance in the scour zone been neglected?		
27 Has the site been assessed for groundwater influence?		
a. If yes, and if artesian flow is a potential concern, does the design address control of groundwater flow during construction?		
28 Have all the proper items been included in the plans for integrity testing?		
29 If special construction features (e.g., slurry, casing, load tests) are required, have all the proper items been included in the plans?		
30 If necessary, have wet construction methods been specified?		
General	(Y/N/X)	Notes:
31 Has the need for load testing of the foundations been evaluated?	X	
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-7-22.16	PID:	114382	Reviewer:	E. Kistner	Date:	10/4/2022

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'?	Y	
4	Has the boring data been submitted in a native format that is DIGGS (Data Interchange for Geotechnical and Geoenvironmental) compatable? gINT files may be used for this.	Y	
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 705.1 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 705.2 of the SGE?	Y	
b.	an Introduction as described in Section 705.3 of the SGE?	Y	
c.	a section titled "Geology and Observations of the Project," as described in Section 705.4 of the SGE?	Y	
d.	a section titled "Exploration," as described in Section 705.5 of the SGE?	Y	
e.	a section titled "Findings," as described in Section 705.6 of the SGE?	Y	
f.	a section titled "Analyses and Recommendations," as described in Section 705.7 of the SGE?	Y	
Appendices		(Y/N/X)	Notes:
8	Do all geotechnical reports being submitted contain all applicable Appendices as described in Section 705.8 of the SGE?	Y	
9	Do the Appendices present a site Boring Plan showing all boring locations as described in Section 705.8.1 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 705.8.2 of the SGE?	Y	
11	Do the Appendices include reports of undisturbed test data as described in Section 705.8.3 of the SGE?	X	
12	Do the Appendices include calculations in a logical format to support recommendations as described in Section 705.8.4 of the SGE?	Y	