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Established 1927

August 3, 2026

Arcadis U.S., Inc.

7575 Huntington Park Drive, Suite 130

Columbus, Ohio 43235

Attention: Mr. Josh Conley, PE
Principal

Reference: Geotechnical Exploration Report- FINAL
VAR-STW-Truck Parking SE Ohio
GUE-IR70 EB Rest Area (Site 3B)
PID No. 122882, Agreement No. 41868-3
Guernsey County, Ohio
CTL Project No. 25050075COL

Dear Mr. Conley:

CTL Engineering, Inc. (CTL) has completed the geotechnical exploration for the above referenced project. We are providing an electronic version (PDF file) of the FINAL Report via email.

At the time this report was prepared, CTL was in the process of completing the Soil Profile Sheets. The finalized Soil Profile Sheets will be submitted under separate cover upon completion.

Thank you for the opportunity to be of service to you on this project. If you have any questions, please contact me at our office.

Respectfully Submitted,

A handwritten signature in black ink, appearing to read "H J Hughes", with a horizontal line extending to the right.

CTL ENGINEERING, INC.

H. Jason Hughes, P.E.

Regional Service Line Manager,

Sr. Geotechnical Engineer

GEOTECHNICAL EXPLORATION – FINAL

**VAR-STW-TRUCK PARKING SE OHIO
GUE-IR70 EB REST AREA (SITE 3B)
PID NO. 122882, AGREEMENT NO. 41868-3
GUERNSEY COUNTY, OHIO**

CTL PROJECT NO. 25050075COL

PREPARED FOR:

**ARCADIS U.S., INC.
7575 HUNTINGTON PARK DRIVE, SUITE 130
COLUMBUS, OHIO 43235**

PREPARED BY:

**CTL ENGINEERING, INC.
2860 FISHER ROAD
COLUMBUS, OHIO 43204**

August 3, 2026



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I. EXECUTIVE SUMMARY

The project, designated as GUE-IR70 EB Rest Area (Site 3b), involves the development of construction plans for truck parking planned off Interstate Route 70 Eastbound (IR 70 EB) in Wills Township, Guernsey County, Ohio. The project begins approximately at S.L.M 19.40 and ends approximately at S.L.M 19.60. The total project length is approximately 1,100 feet.

A total of ten (10) soil test borings were drilled for this project. Two of the test borings were drilled on the entrance and exit ramps for the rest area, while the remaining eight borings were distributed across the rest area facility, including paved parking areas as well as adjacent grassy and undeveloped portions of the site. The surficial materials encountered consisted of topsoil, concrete/asphalt, or were absent at some locations. Beneath the surface, subsurface conditions predominantly consisted of fine-grained, cohesive soils described as silts and clays (A-6a), silty clay (A-6b), clay (A-7-6), and elastic clay (A-7-5). Coarse-grained soil layers, consisting of gravel and/or stone fragments with sand, silt, and clay (A-2-6/A-2-7), were encountered at a few locations. Beneath the soil overburden, shale or interbedded shale and limestone bedrock was encountered in the majority of the test borings at varying depths. Free groundwater was encountered during drilling in two test borings at elevations of 934.4 and 935.0 feet

According to ODOT's Transportation Information Mapping System (TIMS), four (4) geotechnical borings were performed by ODOT in 1983 within the project limits. The historic borings encountered predominantly cohesive soils underlain by shale bedrock. Top of bedrock was encountered in three of the four borings while the fourth boring encountered auger refusal on boulders within the overburden. Groundwater was encountered in one boring at an elevation 919.7 ft.

Based upon the preceding considerations as well as the subsurface information obtained from the field and laboratory testing and CTL's experience with these soil types, the site is suitable for the proposed construction provided following recommendations are followed. Consider the following site specific conditions that are addressed in the following sections:

- **Highly plastic clay soils (A-7-5 and A-7-6):** these soils are susceptible to shrink/swell with changes in moisture content. Subgrades comprised of these materials are susceptible to strength loss when exposed to water (i.e. precipitation, surface drainage/ponding, etc.). Note that A-7-5 soils and A-7-6 soils with liquid limit above 65 percent are unsuitable for subgrade within 3 feet below proposed subgrade and require removal or chemical stabilization to a minimum depth of 14 inches. *Proper drainage is essential for mitigation of shrink/swell and strength loss of the highly plastic soils. Global subgrade stabilization will also help to mitigate shrink/swell potential of the subgrade.*
- **Shallow groundwater:** Groundwater and/or moist clay soils with high moisture content indicating saturated soils were encountered near the proposed subgrade elevation in the southern borings (B-002-0-25 through B-006-0-25). *Proper*



drainage is essential for intended performance of the design features (i.e. pavement, retaining wall, light towers and poles, etc.) to avoid shortened design life and/or excessive maintenance/repairs.

- **Conemaugh Shale (and colluvium/fill derived from it):** The shales and claystones of the bedrock formation at this site are often low durability and prone to rapid weathering and gradual loss in shear strength caused by weathering. This formation and the colluvium derived from it are prone to landslides where over-steepened as indicated by the landslide on the north side of IR-70 as well as other slides along the IR-70 corridor in the general vicinity. Borings along the retaining wall indicate relatively shallow groundwater, highly plastic soils, and shallow to variable depth bedrock along the wall. *Given these conditions, it is recommended that drained residual shear strength values of the retained soils be incorporated into the proposed retaining wall design.*

Due to the presence of severely weathered and very weak bedrock at variable depths along the wall alignment, relatively long rock sockets should be anticipated for the drilled shafts compared to similar retaining walls founded on more competent, shallow bedrock.

Presence of Cobbles and Boulders: Cobbles and boulders are commonly encountered within native colluvium in the region. Multiple project borings noted rock fragments which indicate potential for cobbles and one of the historic borings noted refusal on boulders. *It is recommended to specifically note the potential for cobbles and boulders in the drilled shaft plan notes and reference the boring logs included in the plans (i.e., the Geotechnical Profile Sheets).*

- **Sloping and Variable Top of Bedrock Elevations:** Based on conditions encountered in the borings, in general the top of bedrock appears to slope downward from south to north (i.e. roughly 13 feet elevation difference between borings B-004-0-25 and B-003-1-15) and is highly variable from east to west varying roughly 4 to 7 feet or more (up and down) between nearby borings along the retaining wall alignment indicating possible ancient drainage swales/ravines buried beneath the colluvium. *For design purposes, it is recommended that relatively conservative top-of-rock elevations be used between borings when developing the drilled shaft table and estimating pile lengths along the retaining wall.*

II. INTRODUCTION

The project, designated as GUE-IR70 EB Rest Area (Site 3b), involves the development of construction plans for truck parking planned off Interstate Route 70 Eastbound (IR 70 EB) in Wills Township, Guernsey County, Ohio. The project begins approximately at S.L.M 19.40 and ends approximately at S.L.M 19.60. The total project length is approximately 1,100 feet. A new retaining wall is planned along the southern boundary of the proposed truck parking facility. The wall will extend approximately 562 feet in



length and is anticipated to have a maximum exposed height of approximately 10 feet. Based on current design assumptions, the retaining wall will likely consist of a soldier pile and lagging system socketed into the underlying bedrock. At the time of the preparation of the report, a conceptual plan for the selected alternative was provided to us. It is understood that, prior to the commencement of construction for the new truck parking facility, all existing rest area infrastructure including buildings, shelters, and parking spaces will be demolished to prepare the site for redevelopment

This is a FINAL Geotechnical Exploration Report. This exploration was performed in accordance with CTL's proposal dated November 7, 2026 and the ODOT Specifications for Geotechnical Exploration (SGE) dated January 2026.

III. **GEOLOGY AND OBSERVATIONS OF THE PROJECT**

A. **Geology**

According to the Ohio Department of Natural Resources (ODNR) Physiographic Regions of Ohio Map (1998), the project site is located within the Marietta Plateau physiographic region. This physiographic region is described Pennsylvanian- through Permian-age strata of the Upper Conemaugh and Dunkard Groups, composed of cyclic deposits of red and gray shales along with siltstones, sandstones, limestones, and coal seams; additionally, it includes Pleistocene (Teays)-age Minford Clay, areas of red and brown silty-clay loam colluvium, and localized landslide deposits.

According to the United States Department of Agriculture, Natural Resources Conservation Service's Web Soil Survey, the surficial soils mapped at the project site are described below in Table 1.

Table 1. Soil Survey Soil Types and Properties

USDA Soil Unit Name	Soil Unit Symbol	Risk of Corrosion to Concrete	Risk of Corrosion to Steel
Guernsey-Upshur complex, 8 to 15 percent slopes 15 pep	GuC	Moderate	High
Guernsey-Upshur complex, 15 to 25 percent slopes	GuD	Moderate	High
Udorthents-Urban land complex	Ud		

Geologic mapping (Quaternary Geology of Ohio, ODNR Division of Geological Survey, 1999) indicates the overburden soils at the site are Holocene-aged colluvium.

According to the bedrock geology map of Ohio (2006), the surficial soil deposits on the site are underlain by sedimentary bedrock formations identified as the Pennsylvanian -age Conemaugh Group. This is described as thick sequence of shale, siltstone, sandstone, and mudstone with minor limestone and coal, characterized by



multicolored strata (gray, red, green, brown, black), sparse coal beds, and rapid vertical and lateral changes in rock types.

There is a Tier 1 landslide (ID LS00004926) and a Tier 1 rock slope (ID RS00001297) located along north (opposite) side of IR-70 less than 300 feet from the site and no mapped mines, based on information from the ODOT Geohazard Inventory.

According to the mapping of karst features (Karst Interactive Map, *ODNR Division of Geological Survey*, date accessed June 2, 2026), there are no mapped karst features in the general vicinity of the project area. Additionally, karst features were not observed at the ground surface during our field exploration.

According to the mapping of historic and active mines (Mines of Ohio, ODNR Division of Mineral Resources, accessed June 2, 2026), there are no documented active mines within a 2.5-mile radius of the project area; however, regional mapping indicates extensive mining activity in all directions beyond this distance.

B. Observations

Field reconnaissance was completed by CTL personnel on November 6, 2025. Interstate Route 70 is a bi-directional roadway oriented in an east-west direction. The eastbound rest area is located between south of IR-70, and north of Easton Road, with entry and exit ramps providing access between the rest area and IR 70.

The surrounding topography consists of rolling terrain, and the rest area is positioned at a slightly higher elevation than IR-70, with slopes ascending from the interstate toward the rest area in a north-to-south direction. The project area is located in a rural setting, and surrounding land use consists primarily of agricultural fields, and wooded areas along with few scattered residential properties.

Pavement within the parking lots appears to be in fair condition, with longitudinal and transverse cracking observed throughout the existing parking areas as well as along the entry and exit ramps.

IV. SUBSURFACE EXPLORATION

A total of ten (10) soil test borings (identified in *Table 2*) were drilled for this project at the approximate locations shown on the boring location plan in *Appendix A*. Two of the test borings were drilled on the pavement of the entrance and exit ramps for the rest area, while the remaining eight borings were distributed across the rest area facility, including paved parking areas as well as adjacent grassy and undeveloped portions of the site. A summary of approximate test boring locations, ground surface elevations and coordinates along with the depths are presented in *Table 2*.



Table 2. Boring Locations, Depths, Elevations, and Coordinates

Boring No.	Boring Type	Station & Offset	Ground Surface Elevation (feet)	Latitude (degrees)	Longitude (degrees)	Borehole Depth (feet)
B-001-0-25	A	9+95, 5' RT.	926.05	40.03905	-81.3953	7
B-002-0-25	B/E3/E5	13+04, 56' RT.	942.01	40.038783	-81.39422	21.2
B-003-0-25	E3	14+49, 183' RT.	949.41	40.038553	-81.393601	36.3
B-003-1-25	B/E5	14+71, 120' LT.	932.91	40.039367	-81.393808	21.8
B-004-0-25	E3	15+89, 169' RT.	943.51	40.038683	-81.393131	26.3
B-004-1-25	B/E5	15+55, 17' LT.	933.98	40.03915	-81.393422	10
B-005-0-25	E3	17+25, 171' RT	939.71	40.038783	-81.39266	36.3
B-005-1-25	B/E5	17+13, 43' RT.	933.06	40.039117	-81.392821	13.7
B-006-0-25	E3/E5	18+57, 163' RT.	938.96	40.0389	-81.392215	26.3
B-007-0-25	A	21+18, 5' RT.	932.55	40.03975	-81.39184	5.8

The number and locations of the test borings were mutually selected by CTL and Arcadis to provide a general profile of the subsurface conditions at the site. The locations of the test borings were determined in the field by the CTL personnel. The coordinates, ground surface elevations, stations and offsets at the test boring locations were determined by Arcadis and provided to CTL.

The test borings were drilled by CTL on November 26, 2025, December 4, 2025, December 5, 2025 and December 8, 2025 utilizing 3-¼ inch inside diameter hollow-stem augers powered by track-mounted rotary drill rigs powered by Diedrich D-70 track mounted drill rig. Split-barrel (spoon) samples and Standard Penetration Tests (SPTs) were performed in the test borings using a 140-pound automatic hammer falling 30 inches to drive 2-inch O.D. split barrel samplers for 18 inches. The automatic hammers were calibrated on November 8, 2024 and had energy ratios of 80.7 percent. Shelby tube samples were obtained at selected boring locations by pushing thin-walled tubes in offset holes at designated depths. Rock coring was performed in the test borings using wireline casing with an NQ-size, double tube core barrel with a diamond bit.

Soil samples obtained were preserved in glass jars, visually classified in the field and laboratory, and tested for natural moisture content. Representative soil samples were subjected to laboratory testing including grain size distribution, Atterberg limits and unconfined compressive strength .

Rock from the coring operation was visually classified. The Rock Quality Designation (RQD) and percent core loss values were determined. Representative samples of the recovered rock were subjected to compressive strength testing.

Drilling, sampling, field and laboratory testing were performed according to standard geotechnical engineering practices and current ASTM International and/or AASHTO procedures. Results from field and laboratory tests are shown on the test boring records in



Appendix B of this report. The results of the laboratory tests are presented in *Appendix C* of this report.

According to ODOT's Transportation Information Mapping System (TIMS), four (4) geotechnical borings were performed by ODOT in 1983 within the project limits as part of the project GUE-70-19.37 (EB) and the boring data was incorporated into the exploration for this current project. A summary of approximate historic test boring locations, ground surface elevations (converted to the current vertical datum) and coordinates along with the depths are presented in *Table 3*.

Table 3. Historic Boring Locations, Depths, Elevations, and Coordinates

Boring No.	Station & Offset*	Ground Surface Elevation (feet) [#]	Latitude (degrees)	Longitude (degrees)	Borehole Depth (feet)
B-000-A-83	15+70, 63' RT.	939.2	40.038970	-81.393300	15.6
B-000-B-83	16+05, 82' RT.	941.2	40.038950	-81.393162	6.5
B-000-C-83	15+95, 32' RT.	938.0	40.039072	-81.393242	20.0
B-001-A-83	14+75, 58' RT	938.0	40.038918	-81.393643	20.5

* Stations and offsets are based on the superimposed boring locations and are therefore approximate.

[#] Ground surface elevations have been determined from ODNr Interactive data and existing contour maps.

V. FINDINGS

A. Subsurface Conditions

A general description of the soils encountered during our subsurface exploration is presented below. Further details of the subsurface conditions encountered during CTL's geotechnical exploration are presented in the Test Boring Records in Appendix B.

1. Surficial Materials

At the ground surface, five (5) of the ten (10) test borings encountered topsoil ranging in thickness from approximately one (1) to eight (8) inches. Two (2) borings (B-001-0-25 & B-007-0-25) encountered ten (10) inches of concrete. One (1) boring (B-004-1-25) encountered two (2) inches of asphalt followed by five (5) inches of concrete, and the remaining two borings (B-004-0-25 & B-005-1-25) did not encounter any surface material.

2. General Soil Stratigraphy

Below the surficial materials, a majority of the test borings encountered fine-grained, cohesive soils, followed by bedrock prior to reaching the boring termination depth.

The fine-grained cohesive soils were described as medium stiff to hard, brown, brown and red, brown and gray, silt and clay (A-6a), silty clay (A-6b), clay (A-7-6) and elastic clay (A-7-5). SPT N_{60} -values determined within the fine-grained soils ranged



from 7 blows per foot (bpf) to 69 bpf, with natural moisture content values ranging from 7 percent to 35 percent. The N_{60} -value is the SPT blow count corrected for the hammer efficiency delivered by the hammer system utilized, normalized to 60 percent efficiency in bpf.

Where encountered in the test borings, the coarse-grained soils were generally described as medium dense to dense, brown gravel and/or stone fragments with sand, silt and clay (A-2-6/A-2-7). SPT N_{60} -values determined within the coarse-grained soils ranged from 15 bpf to 39 bpf with natural moisture content values ranging from 11 percent to 32 percent.

Beneath the soil overburden, eight (8) of the ten (10) test borings (B-002-0-25, B-003-0-25, B-003-1-25, B-004-0-25, B-005-0-25, B-005-1-25, B-006-0-25, and B-007-0-25) encountered bedrock. The top of bedrock was encountered at depths ranging from 2.5 to 21 feet bgs corresponding to elevations 919.4 to 932.5. The upper bedrock consisted of severely to highly weathered shale that was sampled using split-barrel sampler and exhibited N_{60} values ranging from 69 blows per foot (bpf) to 50 blows per 1 inch of penetration. Borings B-003-1-25 and B-007-0-25 were terminated within the severely weathered bedrock at elevations of 911.7 and 926.9, respectively. Borings B-002-0-25, B-003-0-25, B-004-0-25, B-005-0-25, and B-006-0-25 were advanced by coring an additional 5 to 10 feet into bedrock. The cored bedrock was described as shale and interbedded shale and limestone that ranged from very weak to slightly strong and severely to moderately weathered. The measured RQD values ranged from 0 to 88 percent, and measured recovery values ranged from 48 to 100 percent. Unconfined compressive strength (UCS) test results on intact core samples of the shale ranged from 60 to 2,910 psi. Note that the number of UCS tests on severely weak to weak bedrock was significantly under-represented proportionally due to the lack of suitable representative samples for testing. Photographs of the recovered rock core are presented in Appendix D.

In general the historic borings encountered similar conditions as the project test borings consisting of predominantly cohesive soils underlain by shale bedrock. Top of bedrock was encountered in three of the four borings at elevations approximately ranging from 920.7 to 924.9 feet (NAVD88). The fourth boring encountered auger refusal on boulders within the overburden.

B. Results of Laboratory Tests

Selected soil samples were tested in the laboratory for Atterberg Limits and grain size distribution. The results of the soil laboratory tests are presented on the Test Boring Records in *Appendix A* and *Appendix B* and are summarized in *Table 4*.

Table 4. Soil Laboratory Classification Test Results

Boring No.	Sample No.	Depth (feet)	ODOT	Atterberg Limits (%)		Grain-Size Distribution (%)			
				LL	PI	Gr	Sa	Silt	Clay
B-001-0-25	SS-1	1.0-2.5	A-6a	26	11	32	30	18	20



Boring No.	Sample No.	Depth (feet)	ODOT	Atterberg Limits (%)		Grain-Size Distribution (%)			
				LL	PI	Gr	Sa	Silt	Clay
B-001-0-25	SS-2	2.5-4.0	A-6a	32	14	30	19	26	25
B-002-0-25	SS-2	3.5-5.0	A-7-6	53	28	3	8	25	64
B-002-0-25	SS-4	8.5-10.0	A-7-6	57	30	3	7	34	56
B-002-0-25	SS-5	11.0-12.5	A-7-6	44	18	21	8	36	35
B-003-0-25	SS-1	1.0-2.5	A-7-6	41	17	16	4	47	33
B-003-0-25	SS-3	4.0-5.5	A-6a	38	14	2	3	58	37
B-003-0-25	SS-5	7.0-8.5	A-6b	38	17	2	6	46	46
B-003-0-25	SS-7	11.0-12.5	A-7-6	41	19	7	9	40	44
B-003-1-25	SS-1	1.0-2.5	A-7-6	42	20	21	10	37	32
B-003-1-25	SS-3	4.0-5.5	A-7-6	50	22	9	8	38	45
B-003-1-25	SS-5	7.0-8.5	A-6b	35	16	20	19	38	23
B-004-0-25	SS-1	1.0-2.5	A-7-6	50	23	3	9	36	52
B-004-0-25	SS-2	3.5-5.0	A-7-6	46	21	4	5	42	49
B-004-0-25	SS-4	8.5-10.0	A-2-7	45	19	56	14	13	17
B-004-1-25	SS-1	1.0-2.5	A-7-6	54	30	5	7	34	54
B-004-1-25	SS-3	6.0-7.5	A-6b	36	16	11	40	22	27
B-005-0-25	SS-1	1.0-2.5	A-6b	40	18	4	9	41	46
B-005-0-25	SS-3	6.0-7.5	A-7-6	49	26	3	12	35	50
B-005-0-25	SS-5	11.0-12.5	A-7-5	68	37	11	10	25	54
B-005-1-25	SS-1	1.0-2.5	A-7-6	47	24	21	8	31	40
B-005-1-25	SS-3	4.0-5.5	A-7-6	49	25	20	12	31	37
B-005-1-25	SS-5	7.0-8.5	A-6b	39	17	1	10	47	42
B-005-1-25	SS-6	8.5-10.0	A-7-6	42	19	13	9	40	38
B-006-0-25	SS-1	1.0-2.5	A-7-6	53	28	8	11	25	56
B-006-0-25	SS-3	6.0-7.5	A-7-6	75	46	1	1	19	79
B-006-0-25	SS-5	11.0-12.5	A-6a	36	14	28	25	28	19
B-007-0-25	SS-1	1.0-2.5	A-2-6	30	13	48	20	16	16

SS-#: Split-Spoon Sample Number

LL = Liquid Limit; PI = Plasticity Index

NP = Non-Plastic

Silt Fraction (particle size < 0.075 mm)

Clay Fraction (particle size < 0.005 mm)

Gr = Gravel; Sa = Sand

Samples from the collected Shelby tubes were subjected to unconfined compressive strength test utilizing ASTM D2166. The test results are summarized in Table 5 below:



Table 5. Summary of Soil Unconfined Compressive Strength Test Results

Boring No.	Sample Depth	Sample Type	Total Unit Weight (pcf)	Unconfined Compressive Strength (ksf)
B-003-0-25	1.0-3.0	A-6a	132.3	1.15
B-005-0-25	8.0-10.0	A-7-6	128.8	2.95
B-006-0-25	5.0-7.0	A-7-6	126.6	2.37

Samples of the rock core from borings B-002-0-25, B-003-0-25, B-004-0-25, and B-005-0-25 were tested for uniaxial compressive strength utilizing ASTM D7012, Method C. The test results are summarized in *Table 6* below.

Table 6. Summary of Intact Rock Unconfined Compressive Strength Test Results

Boring No.	Sample No.	Sample Depth (feet)	Sample Description	Unit Weight (pcf)	Uniaxial Compressive Strength (psi) ⁽¹⁾
B-002-0-25	NQ2-1	19.8 – 20.3	Shale	162.2	850
B-003-0-25	NQ2-2	32.3 – 32.8	Shale	159.3	2,810
B-004-0-25	NQ2-1	18.3 – 18.5	Shale	166.2	1,400
B-004-0-25	NQ2-2	21.3 – 21.8	Shale	162.7	2,910
B-005-0-25	NQ2-2	34.0-34.5	Shale	167.7	60

(1) Uniaxial Compressive Strength of Intact Rock Core Testing conducted in accordance with ASTM D7012, Method C.

C. Groundwater

Free groundwater was encountered during drilling in two (2) of the ten (10) test borings (B-003-0-25 and B-004-0-25) at elevations of 934.4 and 935.0 feet corresponding to depths of 15 feet and 8 feet bgs, respectively. Since five of the ten test borings involved rock coring prior to termination, groundwater levels at completion are not reported for those borings. The remaining test borings did not encounter groundwater at completion. However, note that borings B-002-0-25, B-005-0-25, and B-006-0-25 all encountered “moist” clay with relatively high moisture content at elevations of 933.5, 933.7, and 935.5, respectively, which is similar to the elevation of free water encountered in borings B-003-0-25 and B-004-0-25. Borehole cave-in occurred in all ten (10) boreholes and measured from about 3.1 to 19.4 feet bgs.

The historic borings encountered free groundwater in one of the four borings. Boring B-000-C-83 encountered groundwater at a depth of 15.2 feet bgs (elevation 919.7) and rose to a depth of 5.1 feet bgs (elevation 929.8) in 15 minutes.

It should be noted that the groundwater depths encountered during this subsurface exploration may not be a reliable indication of long-term groundwater levels.



Fluctuations in the level of the groundwater table (or saturated soils/perched water levels) will occur due to seasonal variances in rainfall, drainage, types of soils present and other factors. We caution that groundwater can be perched at various elevations above the general static groundwater level after periods of rainfall, especially in the lower elevations and natural drainage paths of the site, and “seeps” encountered at isolated locations within the colluvium and bedrock.

VI. ANALYSES AND RECOMMENDATIONS

Based upon the preceding considerations as well as the subsurface information obtained from the field and laboratory testing and CTL’s experience with these soil types, the site is suitable for the proposed construction provided following recommendations are followed. Consider the following site specific conditions that are addressed in the following sections:

- **Highly plastic clay soils (A-7-5 and A-7-6):** these soils are susceptible to shrink/swell with changes in moisture content. Subgrades comprised of these materials are susceptible to strength loss when exposed to water (i.e. precipitation, surface drainage/ponding, etc.). Note that A-7-5 soils and A-7-6 soils with liquid limit above 65 percent are unsuitable for subgrade within 3 feet below proposed subgrade and require removal or chemical stabilization to a minimum depth of 14 inches. *Proper drainage is essential for mitigation of shrink/swell and strength loss of the highly plastic soils. Global subgrade stabilization will also help to mitigate shrink/swell potential of the subgrade.*
- **Shallow groundwater:** Groundwater and/or moist clay soils with high moisture content indicating saturated soils were encountered near the proposed subgrade elevation in the southern borings (B-002-0-25 through B-006-0-25). *Proper drainage is essential for intended performance of the design features (i.e. pavement, retaining wall, light towers and poles, etc.) to avoid shortened design life and/or excessive maintenance/repairs.*
- **Conemaugh Shale (and colluvium/fill derived from it):** The shales and claystones of the bedrock formation at this site are often low durability and prone to rapid weathering and gradual loss in shear strength caused by weathering. This formation and the colluvium derived from it are prone to landslides where over-steepened as indicated by the landslide on the north side of IR-70 as well as other slides along the IR-70 corridor in the general vicinity. Borings along the retaining wall indicate relatively shallow groundwater, highly plastic soils, and shallow to variable depth bedrock along the wall. *Given these conditions, it is recommended that drained residual shear strength values of the retained soils be incorporated into the proposed retaining wall design.*

Due to the presence of severely weathered and very weak bedrock at variable depths along the wall alignment, relatively long rock sockets should be



anticipated for the drilled shafts compared to similar retaining walls founded on more competent, shallow bedrock.

Presence of Cobbles and Boulders: Cobbles and boulders are commonly encountered within native colluvium in the region. Multiple project borings noted rock fragments which indicates potential for cobbles and one of the historic borings noted refusal on boulders. *It is recommended to specifically note the potential for cobbles and boulders in the drilled shaft plan notes and reference the boring logs included in the plans (i.e., the Geotechnical Profile Sheets).*

- **Sloping and Variable Top of Bedrock Elevations:** Based on conditions encountered in the borings, in general the top of bedrock appears to slope downward from south to north (i.e. roughly 13 feet elevation difference between borings B-004-0-25 and B-003-1-15) and is highly variable from east to west varying roughly 4 to 7 feet or more (up and down) between nearby borings along the retaining wall alignment indicating possible ancient drainage swales/ravines buried beneath the colluvium. *For design purposes, it is recommended that relatively conservative top-of-rock elevations be used between borings when developing the drilled shaft table and estimating pile lengths along the retaining wall.*

A. Pavement Subgrade Recommendations

According to the final plans, construction of the rest area consists of expanding the truck parking facility by reconstructing the existing site. This includes the entry ramp from station 7+23 to 11+93, the truck parking area from station 11+93 to 22+00 (with a maximum left offset of 130 feet and right offset of 167 feet), and the exit ramp from station 22+00 to 28+96.

A subgrade analysis was performed utilizing the subsurface information from the drilled borings within the project limits and ODOT Geotechnical Design Manual (GDM) Section 600, and ODOT's Version 14.81 Subgrade Analysis spreadsheet (dated July 21, 2025). Boring B-001-0-25, B-002-0-25, B-003-1-25, B-004-1-25, B-005-1-25, B-007-0-25, B-003-0-25, B-004-0-25, B-005-0-25 and B-006-0-25 were utilized in subgrade analysis. A copy of the Subgrade Analysis spreadsheet is provided in Appendix E.

According to the final plans, the proposed pavement thickness will be 16 inches for stations 7+23 to 11+93 (entrance ramp), 11+93 to 22+00 (left offset), 22+00 to 28+96 (exit ramp). and 11+93 to 22+00 (right offset). This thicknesses was assumed for estimating cut/fill in the Subgrade Analysis and estimated cut and fill depths ranged from approximately 14.2-feet cut to 0.3-feet of fill to reach proposed subgrade.

It is important to note that boring B-007-0-25 and B-004-0-25 consist of weathered bedrock within 3 feet from the proposed subgrade elevation, N60 corresponding to 30 was assumed for the purpose of subgrade analysis.



The natural moisture content values of the subgrade soil samples ranged from 7 to 35 percent, averaging 20 percent. The estimated optimum moisture content (OMC) values ranged from 0 to 26 percent, averaging 15 percent. On average, the natural moisture content values are 5 percent higher than the optimum moisture content values.

The Plasticity Indices (PI) of the soils within the proposed subgrade ranged from 11 to 46 percent with an average PI of 23 percent.

The lowest SPT N_{60L} -value analyzed for the pavement subgrade was 7 to 30 bpf with an average of 14 bpf. A summary of the analysis results are presented in Table 7 including recommended subgrade stabilization alternatives. For more detailed information see the subgrade analysis provided in Appendix E.

Group Index values were calculated for each of the samples tested. The Group Index values for the soils ranged from 0 to 20, averaging 11. This average Group Index value corresponds to an estimated California Bearing Ratio (CBR) value of 6.0. The pavement for this project may be designed using a CBR value of 6.0, provided the pavement subgrade soils are prepared per ODOT requirements

Table 7. Summary of Pavement Subgrade Analysis Results

Parameter	Result
Average Plasticity Index (PI)	23
Average SPT N_{60L} (bpf)	14
Average Design CBR	6
Recommended Subgrade Stabilization Alternatives	(1) Global Subgrade stabilization*: Item 206 Lime Stabilization, 14" Depth (2) Spot Stabilization*: Excavate and Replace (Item 204)

**Spot stabilization recommended in lieu of global stabilization along the Exit Ramp from Station from Station 20+50 to the end of the project (Station 30+50). Perform subgrade compaction and proof-rolling in this section and include a contingency quantity of excavate-and-replace subgrade stabilization totaling 20% of the area to a depth of 1 foot using fabric and Type C Granular.*

The ODOT Subgrade Analysis identified eight (8) of the ten (10) borings as requiring subgrade improvement due to being unstable/unsuitable soil has been identified through out the parking facility. Recommendations for these two different subgrade stabilization alternatives are presented in Table 7 above. The estimated limits and corresponding depths for subgrade stabilization Alternative 2 are summarized in subgrade analysis spreadsheet in Appendix E

The approximate depth of excavate and replace is measured from the top of the proposed pavement subgrade level (bottom of Item 304 Aggregate Base). It should be noted that the location and depth of subgrade stabilization provided below is only an



estimate. The actual depths and horizontal limits of excavate and replace will be determined by the Project Engineer in the field based upon proofrolling.

According to ODOT GDM Section 605, if 30 percent or more of the subgrade requires stabilization, global stabilization should be considered. The ODOT Subgrade Analysis Spreadsheet indicates that approximately 57 percent of the proposed subgrade is unstable/unsuitable, which significantly exceeds this threshold. Additionally, the transverse extent of the subgrade requiring improvement, based on these eight borings, is not precisely defined, making localized stabilization impractical. Given the overall project width and the proportion of subgrade requiring treatment, global subgrade stabilization (Alternative 1) is likely to be a more cost-effective and efficient method to provide uniform support and meet ODOT design requirements. It is important to note that the bedrock elevation is shallow at boring (B-007-0-25) at Station 21+18, it may be challenging to implement chemical stabilization. Therefore, CTL recommends not performing chemical stabilization from Station 20+50 to the end of the project (Station 30+50) and instead performing subgrade compaction and proof-rolling in this section and including a contingency quantity of excavate-and-replace subgrade stabilization totaling 20% of the area to a depth of 1 foot using fabric and Type C Granular.

B. Structure Foundation Support – Light Tower & Light Pole Foundations

The project includes proposed light poles and high mast light towers with drilled shaft foundations. The proposed light towers are 45-foot tall with high mast LED luminaires and drilled shaft foundations that are 10-feet in length and 36-inches in diameter. CTL performed three borings to explore the subsurface conditions for the proposed light tower foundations (i.e. B-002-0-25, B-003-1-25, and B-005-1-0-25) in addition to retaining wall borings B-004-0-25 and B-006-0-25 and historic boring B-001-A-83 which are located near proposed tower locations. These borings encountered predominantly stiff to hard cohesive overburden soils (A-6a, A-6b, and A-7-6) with lesser amounts of granular soils (A-2-7) underlain by shale bedrock. Groundwater was encountered in boring B-004-0-26 and historic boring B-001-A-83. Boring B-007-0-25 which is in the vicinity of proposed light poles, encountered shallow shale bedrock at a depth of 2.5 feet corresponding to elevation 930.1.

CTL evaluated the estimated average shear strength of the foundation soils for the light towers and light poles using nearby borings based on shear strength correlations from the ODOT GDM and found that the average shear strength values meet or exceed the required minimum shear strength values listed on the Standard Construction Drawing (SCD) HL-20.11 and therefore *a Standard Foundation Design can be used for the project for the light pole foundations*. CTL also performed lateral analysis of the proposed light tower foundations in accordance with section 1202.1 of the ODOT GDM. CTL used an Excel spreadsheet to estimate the design loads on the towers for p-y analysis of the foundations using the software L-Pile by Ensoft, Inc. For design purposes of the



tower foundations it is assumed that groundwater will be 3 feet below the ground surface and **a design undrained shear strength, S_u , of 1,200 psf was assumed for the foundation soils** below the upper three feet. The results of the analysis indicated the proposed tower foundations provide sufficient overturning resistance for the Extreme Limit State and estimated deflections at the top of the tower are within acceptable limits for the Service Limit State (i.e. less than 10% of tower height). A summary of the pole and tower foundation analyses are included in Appendix F.

Additional design and construction considerations for the pole and tower foundations:

1. Drilled shaft foundations should be installed in accordance with ODOT CMS 524. Temporary casing may be necessary for excavation stability of drilled shaft excavations due to the interbedded granular soils and groundwater.
2. The drilled shaft foundation excavations can generally be expected to encounter shale and interbedded shale and limestone bedrock and/or bouldery zones. The contractor should be prepared with rock excavation tooling. See the attached soil borings for specific details. At all sites, the drilled shafts for tower foundations shall be 36-inch diameter and penetrate 10 feet deep into the ground below finished grade (exclusive of any above-grade pedestal height for mounting). Do not lessen the depth due to encountering bedrock. Steel reinforcement for the drilled shaft foundations shall be in accordance with standard construction drawing TC-21.21.

C. Structure Foundation Support – Soldier Pile and Lagging Retaining Wall

The project includes a proposed retaining wall along the southern border of the paved lot to accommodate the proposed pavement and site grading. Based on available plan information, the retaining wall will have a maximum exposed height of roughly 10 feet with a backslope of 4H:1V (cut slopes) or flatter. CTL performed four borings to explore the subsurface conditions for the proposed retaining wall (i.e. B-003-0-25, B-004-0-25, B-005-0-25, and B-006-0-25) in addition to information from light tower boring B-002-0-25. In general, these borings encountered predominantly stiff to hard cohesive soils overlying shale and interbedded shale and limestone bedrock with top of bedrock encountered at elevations ranging from 925.5 to 932.5. Groundwater and/or moist clay indicating possible saturated conditions were encountered in each of the borings at elevations ranging from 933.5 to 935.5 and below.

Recommended design soil parameters for use in retaining wall design are provided in Appendix G. CTL performed lateral pile analysis for the Soldier Pile and Lagging wall using P-Y analysis with the software L-Pile by Ensoft, Inc. Results of the analysis are included in the Appendix G.



Consider the following for design purposes:

1. A minimum rock-socket length of 20 feet into bedrock using a 36-inch drilled shaft with a W24×146 soldier pile section for the lagging walls was considered. Table 8 presents the L-Pile output obtained for both service and strength limit states using this configuration.
2. For p-y analysis of retaining wall consider p-multiplier within the overburden soils only (not in bedrock). Determine the p-multiplier based on the drilled shaft diameter and center-to-center pile spacing in accordance with section 305.1.2 of the ODOT BDM.
3. Soldier pile and lagging wall should be designed in accordance with ODOT BDM sections 305 and 307 and ODOT GDM section 1500.

Table 8. L-Pile Outputs during Strength and Service Limit

Deflection at Top of Wall (Service Limit) (inches)	Maximum Moment (Strength Limit) (in-kips)	Maximum Shear (Strength Limit) (kips)
1.35	7,175	99.0

D. Site Preparation and Earthwork Recommendations

General construction and earthwork recommendations are provided below. Site preparation and earthwork should be performed in accordance with the ODOT Construction and Material Specifications.

1. Embankment construction for the roadway should follow ODOT CMS 203 and related sections.
2. Borrow materials used for embankment fill must comply with ODOT CMS 203.02R unless noted otherwise with the exception that those used within 3 feet below the pavement subgrade shall comply with ODOT CMS 204.02 and shall have a CBR value of 6 or greater.
3. Any pavement not scheduled to remain should be removed per CMS 202.
4. Topsoil within pavement and embankment construction limits should be stripped.
5. Where new embankment will be placed overtop existing ditches, include quantities and details in the plans for an excavation of the ditch bottom to a nominal depth of 2.0 feet for the width of the ditch.
6. During construction, adequate drainage should be provided on the surface of the exposed soils. Absorption of heavy rainfall, accumulations of water



and heavy construction traffic may result in softening these soils, hence, severely weakening the subgrade soils.

7. Compaction of the subgrade materials should be performed in accordance with ODOT CMS 204 including backfill for subgrade stabilization using Excavate and Replace (Item 204). Any soft soils encountered during the compaction operations which will not readily compact should be removed and replaced with engineered fill.
8. Embankment fill should be placed and compacted in accordance with ODOT CMS 203. Where embankment is placed on an existing slope it shall be benched into the slope per CMS 203.05 with the exception that special benching should be used in areas of sliver fills (i.e. less than 8-foot width of new embankment) on existing slopes that are 4H:1V or steeper. Special Benching should be shown on the plans and separate plan quantity provided and plan note G109 from L&D V3 should be included in the plans.
9. In general, embankment and cut slopes along the alignment are relatively short (less than 10 feet in height). Embankment side slopes for the project constructed at a rate of 4:1 Horizontal to Vertical (H:V) or flatter are generally considered safe against sliding and slope failure provided that embankment is benched into existing slopes as described above. However, if soft or unsuitable soils are encountered at the base of embankment, these materials may need to be over excavated and replaced with approved backfill material.
10. The side slopes should be seeded and mulched as soon as possible to allow vegetation growth to develop and minimize or limit erosion, sloughing and potential slope failure.
11. Temporary excavations in excess of 4.0 feet in depth should be sloped, benched or shored in accordance with OSHA regulations.

VII. CHANGED CONDITIONS

The evaluations, conclusions, and recommendations in this report are based on our interpretation of the field and laboratory data obtained during the exploration, our understanding of the project and our experience with similar sites and subsurface conditions using generally accepted geotechnical engineering practices. Although individual test borings are representative of the subsurface conditions at the boring locations on the dates drilled, they are not necessarily representative of the subsurface conditions between boring locations or subsurface conditions during other seasons of the year.

In the event that changes in the project are proposed, additional information becomes available, or if it is apparent that subsurface conditions are different from those provided



in this report, CTL should be notified so that our recommendations can be modified, if required.

VIII. TESTING AND OBSERVATION

During the design process, it is recommended that CTL work with the project designers to confirm that the geotechnical recommendations are properly incorporated into the final plans and specifications, and to assist with establishing criteria for the construction observation and testing.

CTL is not responsible for independent conclusions, opinions and recommendations made by others based on the data and recommendations provided in this report. It is recommended that CTL be retained to provide construction quality control services on this project. If CTL is not retained for these services, CTL shall assume no responsibility for compliance with the design concepts or recommendations provided.

IX. CLOSING

This report has been prepared for the exclusive use by the client for use only on this project. Our services have been performed in accordance with generally accepted Geotechnical Engineering principles and practices. No warranty is either expressed or implied.

CTL Engineering's assignment does not include, nor does this geotechnical report address the environmental aspects of this particular site.

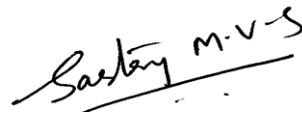
Specific design and construction recommendations have been provided in this report. Therefore, the report should be used in its entirety.

Respectfully Submitted,

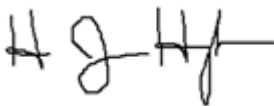
CTL ENGINEERING, INC.



Gaurav Verma, , E.I.T., PhD.
Project Engineer



Sastry Malladi, P.E.
Principal Geotechnical Engineering



H. Jason Hughes, P.E.
Regional Service Line Manager
Sr. Geotechnical Engineer



APPENDIX A
GEOTECHNICAL PROFILE SHEET



PROJECT DESCRIPTION

THE PROJECT, DESIGNATED AS GUE-IR70 EB REST AREA (SITE 3B) INVOLVES THE CONSTRUCTION OF TRUCK PARKING EXPANSION AT THE EXISTING INTERSTATE ROUTE 70 EASTBOUND (IR 70 EB) REST AREA IN WILLS TOWNSHIP, GUERNSEY COUNTY, OHIO.

HISTORIC RECORDS

ACCORDING TO ODOT'S TRANSPORTATION INFORMATION MAPPING SYSTEM (TIMS), FOUR (4) SOIL BORINGS GEOTECHNICAL WERE PERFORMED BY ODOT IN 1983 WITHIN THE EASTBOUND REST AREA PROJECT LIMITS AS PART OF PROJECT GUE-70-19.37 (EB) AND THE DATA WAS INCORPORATED INTO THE EXPLORATION FOR THIS CURRENT PROJECT.

GEOLOGY

ACCORDING TO THE OHIO DEPARTMENT OF NATURAL RESOURCES (ODNR) PHYSIOGRAPHIC REGIONS OF OHIO MAP, THE PROJECT SITE LIES WITHIN THE MARIETTA PLATEAU PHYSIOGRAPHIC REGIONS. THE GEOLOGY OF THIS PHYSIOGRAPHIC SETTING IS DESCRIBED AS PENNSYLVANIAN- THROUGH PERMIAN-AGE STRATA OF THE UPPER CONEMAUGH AND DUNKARD GROUPS, COMPOSED OF CYCLIC DEPOSITS OF RED AND GRAY SHALES ALONG WITH SILTSTONES, SANDSTONES, LIMESTONES, AND COAL SEAMS; ADDITIONALLY, IT INCLUDES PLEISTOCENE (TEAYS)-AGE MINFORD CLAY, AREAS OF RED AND BROWN SILTY-CLAY LOAM COLLUVIUM, AND LOCALIZED LANDSLIDE DEPOSITS.

THE UPPER BEDROCK UNDERLYING THE PROJECT AREA CONSISTS OF PENNSYLVANIAN-AGE CONEMAUGH GROUP WHICH INCLUDES SHALE, SILTSTONE, SANDSTONE, AND MUDSTONE WITH MINOR LIMESTONE AND COAL.

THERE IS A TIER 1 LANDSLIDE AND A TIER 1 ROCK SLOPE LOCATED ALONG THE NORTH (OPPOSITE) SIDE OF IR-70 LESS THAN 300 FEET FROM THE SITE. NO DOCUMENTED MINES WERE IDENTIFIED WITHIN A 2.5 MILE RADIUS OF THE PROJECT AREA.

RECONNAISSANCE

FIELD RECONNAISSANCE WAS COMPLETED BY CTL PERSONNEL ON NOVEMBER 6, 2025. THE TOPOGRAPHY SURROUNDING THE REST AREAS CONSISTS OF ROLLING TERRAIN, AND THE SITE IS SITUATED SLIGHTLY AT A HIGHER ELEVATION THAN IR-70, WITH SLOPES ASCENDING FROM THE IR-70 TO REST AREA FROM NORTH TO SOUTH DIRECTION. THE PROJECT AREA IS LOCATED IN A RURAL SETTING, AND SURROUNDING LAND USE CONSISTS PRIMARILY OF AGRICULTURAL, AND WOODED AREAS WITH FEW SCATTERED RESIDENTIAL PROPERTIES. PAVEMENT IN THE PARKING LOTS APPEARS TO BE IN FAIR CONDITION; HOWEVER, LONGITUDINAL AND TRANSVERSE CRACKING WAS OBSERVED IN THE EXISTING PARKING FACILITY, INCLUDING THE ENTRY AND EXIT RAMP PAVEMENT.

SUBSURFACE EXPLORATION

A TOTAL OF TEN (10) SOIL TEST BORINGS WERE DRILLED FOR THIS PROJECT. TWO (2) OF THE TEST BORINGS WERE DRILLED ON THE PAVEMENT OF THE ENTRANCE AND EXIT RAMPS FOR THE REST AREA, WHILE THE REMAINING EIGHT (8) BORINGS WERE DISTRIBUTED ACROSS THE REST AREA FACILITY, INCLUDING PAVED PARKING AREAS AS WELL AS ADJACENT GRASSY AND UNDEVELOPED PORTIONS OF THE SITE. THE BORINGS WERE DRILLED TO DEPTHS RANGING FROM 5.8 FEET TO 36.3 FEET BELOW THE EXISTING GROUND SURFACE.

THE BORINGS WERE PERFORMED BY CTL ON NOVEMBER 26, 2025 AND BETWEEN DECEMBER 4, 2025 TO DECEMBER 8, 2025, USING 3¼ INCH INSIDE-DIAMETER (I.D.) HOLLOW-STEM AUGERS (HSA) POWERED BY A TRACK-MOUNTED DIEDRICH D-70 ROTARY DRILL RIG. SPLIT-BARREL (SPOON) DISTURBED SOIL SAMPLES AND STANDARD PENETRATION TESTS (SPT) WERE PERFORMED IN ACCORDANCE WITH AASHTO T206. THE AUTOMATIC HAMMER SYSTEM USED WAS CALIBRATED ON NOVEMBER 08, 2024 WITH AN AVERAGE DRILL ROD ENERGY RATIO (ER) OF 80.7%.

EXPLORATION FINDINGS

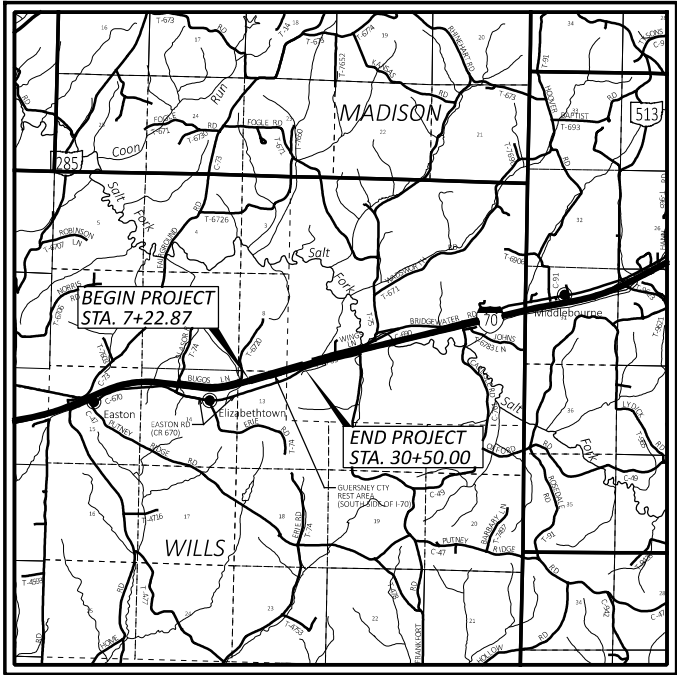
MAJORITY OF SOIL BORINGS PERFORMED AT THE EASTBOUND REST AREA GENERALLY EXHIBITED TOPSOIL OR CONCRETE/ OR ASPHALT PAVEMENT UNDERLAIN BY MEDIUM STIFF TO HARD, FINE GRAINED COHESIVE SOILS. THE PREDOMINANT SOIL MATERIALS ARE SILT AND CLAY (A-6A), SILTY CLAYS (A-6B), CLAYS (A-7-6) AND ELASTIC CLAYS (A-7-5). THE COARSE-GRAINED SOILS ENCOUNTERED IN THE COUPLE OF TEST BORINGS WERE DESCRIBED AS MEDIUM DENSE TO DENSE, BROWN GRAVEL AND/OR STONE FRAGMENTS WITH SAND, SILT AND CLAY (A-2-6, A-2-7).

EIGHT OF TEN BORINGS ENCOUNTERED BEDROCK. TOP OF BEDROCK ELEVATIONS RANGED BETWEEN 919.4 AND 932.5. THE BEDROCK CONSISTED OF SEVERELY TO MODERATELY WEATHERED SHALE AND INTERBEDDED SHALE AND LIMESTONE. GROUNDWATER WAS ENCOUNTERED DURING DRILLING IN BORINGS B-003-0-25 AND B-004-0-25, AT DEPTHS OF 15 FEET AND 8 FEET BELOW GRADE (ELEVATIONS 934.4 AND 935.0), RESPECTIVELY. UNCONFINED COMPRESSIVE STRENGTH TEST (ASTM D7012) RESULTS ON INTACT CORE SAMPLES OF SHALE RANGED FROM 60 TO 2,910 PSI. THE NUMBER OF TESTS ON SCREEN WEAK TO WEAK SHALE WAS SIGNIFICANTLY UNDERREPRESENTED PROPORTIONALLY DUE TO THE LACK OF SUITABLE SAMPLES FOR TESTING.

THE HISTORIC BORINGS ENCOUNTERED PREDOMINANTLY COHESIVE SOILS UNDERLAIN BY SHALE BEDROCK. TOP OF BEDROCK WAS ENCOUNTERED IN THREE OF THE FOUR BORINGS AT ELEVATIONS APPROXIMATELY RANGING FROM 920.7 TO 924.9 FEET (NAVD88). THE FOURTH BORING ENCOUNTERED AUGER REFUSAL ON BOULDERS WITHIN THE OVERBURDEN. GROUNDWATER WAS ENCOUNTERED IN BORING B-000-A-83 AT A DEPTH OF 14.7 FEET (ELEVATION 921.0). B-001-A-83 AT DEPTH OF 14.9 (ELEVATION 921.9) B-000-C-83 AT A DEPTH OF

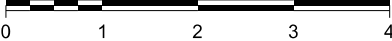
LEGEND

DESCRIPTION	ODOT CLASS	CLASSIFIED MECH./VISUAL	
GRAVEL AND/OR STONE FRAGMENTS W/SAND, SILT & CLAY	A-2-6	1	0
GRAVEL AND/OR STONE FRAGMENTS W/SAND, SILT & CLAY	A-2-7	1	0
SILT AND CLAY	A-6a	6	3
SILTY CLAY	A-6b	5	8
ELASTIC CLAY	A-7-5	1	0
CLAY	A-7-6	20	12
	TOTAL	34	23
SHALE	VISUAL		
INTERBEDDED SHALE AND LIMESTONE	VISUAL		
PAVEMENT OR BASE = X = APPROXIMATE THICKNESS	VISUAL		
SOD AND TOPSOIL = X = APPROXIMATE THICKNESS	VISUAL		
EXPLORATION LOCATION - PLAN VIEW			
HISTORICAL BORING OR CPT LOCATION			
DRIVE SAMPLE AND/OR ROCK CORE BORING PLOTTED TO VERTICAL SCALE ONLY. HORIZONTAL BAR INDICATES A CHANGE IN STRATIGRAPHY.			
WC	INDICATES WATER CONTENT IN PERCENT.		
N ₆₀	INDICATES STANDARD PENETRATION RESISTANCE NORMALIZED TO 60% DRILL ROD ENERGY RATIO.		
X/D"	NUMBER OF BLOWS FOR STANDARD PENETRATION TEST (SPT): X/D" = NUMBER OF BLOWS (UNCORRECTED) FOR D" PENETRATION AT REFUSAL.		
X/Y/D"	NUMBER OF BLOWS FOR STANDARD PENETRATION TEST (SPT): X = NUMBER BLOWS FOR 6 INCHES (UNCORRECTED). Y/D" = NUMBER OF BLOWS (UNCORRECTED) FOR D" PENETRATION AT REFUSAL.		
X/Y/Z/D"	NUMBER OF BLOWS FOR STANDARD PENETRATION TEST (SPT): X = NUMBER OF BLOWS FOR FIRST 6 INCHES (UNCORRECTED). Y = NUMBER OF BLOWS FOR SECOND 6 INCHES (UNCORRECTED). Z/D" = NUMBER OF BLOWS (UNCORRECTED) FOR D" OF PENETRATION AT REFUSAL.		
INDICATES A NON-PLASTIC MATERIAL WITH A MOISTURE CONTENT GREATER THAN 25% OR GREATER THAN 19% WITH A WET APPEARANCE.			
INDICATES A PLASTIC MATERIAL WITH A MOISTURE CONTENT EQUAL TO OR GREATER THAN THE LIQUID LIMIT MINUS 3.			
W	INDICATES FREE WATER ELEVATION.		
Y	INDICATES TOTAL UNIT WEIGHT.		
Qu	INDICATES UNCONFINED COMPRESSION TEST RESULT, ASTM D2166 FOR SOIL, ASTM D7012 FOR BEDROCK.		
SS	INDICATES A SPLIT-SPOON SAMPLE.		
TR	INDICATES THE TOP OF ROCK.		

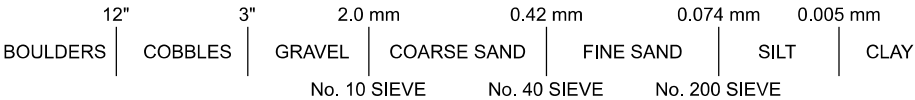


LOCATION MAP

SCALE IN MILES



PARTICLE SIZE DEFINITIONS



INDEX OF SHEETS			
COVER SHEET 1 & 2			
SUMMARY OF SOIL TEST DATA, SHEET, 3			
LAB TEST DATA SHEET, 4 & 5			
ROCK CORE PHOTO SHEET, 6 TO 8			
LOCATION		PLAN VIEW SHEET	PROFILE SHEET
FROM STA.	TO STA.		
US 20			
7+22.87	20+50	9	9
20+50	31+00	10	10
RETAINING WALL			
0+25.00	5+62.24	11	11
BORING LOG SHEET, 12 TO 20			

RECON. -	JH 11/06/2025
DRILLING -	CTL ENGINEERING, INC. 11/26/2025, 12/04/2025-12/08/25
DRAWN -	N.K.S 07/28/2026
REVIEWED -	JH 07/28/26

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DESIGNER

N.K.S

REVIEWER

JH 08-03-26

PROJECT ID

122882

SUBSET TOTAL

1 20

SHEET TOTAL

P.93 112

HISTORICAL SOIL DESCRIPTIONS		ODOT CLASS	CLASSIFIED MECH./VISUAL	
	GRAVEL AND/OR STONE FRAGMENTS W/SAND AND SILT	A-2-4	1	0
	GRAVEL AND/OR STONE FRAGMENTS W/SAND, SILT & CLAY	A-2-6	0	1
	SANDY SILT	A-4a	1	1
	SILT AND CLAY	A-6a	4	0
	SILTY CLAY	A-6b	3	0
	CLAY	A-7-6	3	0
		TOTAL	12	2
	SHALE	VISUAL		
	SOD AND TOPSOIL = X = APPROXIMATE THICKNESS	VISUAL		
	BOULDERS	VISUAL		

15.2 FEET (ELEVATION 919.7) AND ROSE TO A DEPTH OF 5.1 FEET (ELEVATION 929.8) IN 15 MINUTES.

SPECIFICATIONS

THIS GEOTECHNICAL EXPLORATION WAS PERFORMED IN ACCORDANCE WITH THE STATE OF OHIO, DEPARTMENT OF TRANSPORTATION, OFFICE OF GEOTECHNICAL ENGINEERING, SPECIFICATIONS FOR GEOTECHNICAL EXPLORATIONS, DATED JANUARY 2026.

AVAILABLE INFORMATION

THE SOIL, BEDROCK, AND GROUNDWATER INFORMATION COLLECTED FOR THIS SUBSURFACE EXPLORATION THAT CAN BE CONVENIENTLY DISPLAYED ON THE GEOTECHNICAL PROFILE SHEETS HAS BEEN PRESENTED. GEOTECHNICAL REPORTS, IF PREPARED, ARE AVAILABLE FOR REVIEW ON THE OFFICE OF CONTRACT SALES WEBSITE.

BEDROCK TEST SUMMARY				
Boring No.	Sample Elevation	Sample Depth	Uniaxial Compressive Strenght (psi)	Sample Description
B-002-0-25	922.2' – 921.7'	19.8' – 20.3'	850	Shale
B-003-0-25	917.1' – 916.6'	32.3' – 32.8'	2,810	Shale
B-004-0-25	925.2' – 924.7'	18.3' – 18.5'	1,400	Shale
	922.2' – 921.7'	21.3' – 21.8'	2,910	Shale
B-005-0-25	905.7' – 905.2'	34.0' – 34.5'	60	Shale

DESIGN AGENCY



2860 FISHER ROAD
COLUMBUS, OHIO 43204
PHONE: (614) 276-8123
FAX: (614) 276-6377

DESIGNER

N.K.S

REVIEWER

JH 08-03-26

PROJECT ID

122882

SUBSET

2

TOTAL

20

SHEET

P.94

TOTAL

112

GUE-IR 70 REST AREAS TP

MODEL: Sheet PAPER SIZE: 11x17 (in.) DATE: 03-08-2026 TIME: 13:48:07 USER: hp
D:\Drop_Box\CTL_2026\August\Dept_05\COL\Gaurav\25050075COL_ODOT\Mod_03.08.26\122882ID001.dgn

SUMMARY OF SOIL TEST DATA
IR 70 Eastbound Truck Parking

EXPLORATION NO., STATION & OFFSET	FROM TO	SAMPLE ID	N ₆₀	% REC	HP tsf	% GR	% CS	% FS	% SILT	% CLAY	LL	PL	PI	% WC	ODOT CLASS (GI)	ppm SO ₄
B-001-0-25	01.00-02.50	SS-1	11	100	0.5	32	16	14	18	20	26	15	11	29	A-6a (1)	<100
STA. 9+95, 5' RT.	02.50-04.00	SS-2	15	100	0.5	30	10	9	26	25	32	18	14	17	A-6a (5)	-
LATITUDE = 40.039050	04.00-05.50	SS-3	16	100	3.25				Same as SS-2					9	A-6a (VISUAL)	-
LONGITUDE = -81.395300	05.50-07.00	SS-4	19	100	1.5				Same as SS-2					15	A-6a (VISUAL)	-
B-004-1-25	01.00-02.50	SS-1	11	89	1.25	5	3	4	34	54	54	24	30	13	A-7-6 (19)	<100
STA. 15+55, 17' LT.	03.50-05.00	SS-2	19	56	2				Same as SS-3					15	A-6b (VISUAL)	-
LATITUDE = 40.039150	06.00-07.50	SS-3	23	44	2.25	11	18	22	22	27	36	20	16	16	A-6b(5)	-
LONGITUDE = -81.393422	08.50-10.00	SS-4	20	78	2				Same as SS-3					25	A-6b (VISUAL)	-
B-007-0-25	01.00-02.50	SS-1	39	89	-	48	12	8	16	16	30	17	13	11	A-2-6 (1)	<100
STA. 21+18, 5' RT.	02.50-03.33	SS-2	41/50/4"	100					Shale, Gray, Highly Weathered					15	Rock (VISUAL)	-
LATITUDE = 40.039750	04.00-04.25	SS-3	50/3"	100					Same as SS-2					12	Rock (VISUAL)	-
LONGITUDE = -81.391840	05.50-05.75	SS-4	50/3"	100					Same as SS-2					7	Rock (VISUAL)	-

GEOTECHNICAL PROFILE - ROADWAY
SUMMARY OF SOIL TEST DATA

DESIGN AGENCY



CTL
ENGINEERING &
CONSTRUCTION
2080 FISHER ROAD
COLUMBIA, SC 29204
PHONE: 803-726-4120
FAX: 803-726-5377

DESIGNER

N.K.S

REVIEWER

JH 08-03-26

PROJECT ID

122882

SUBSET

3

TOTAL

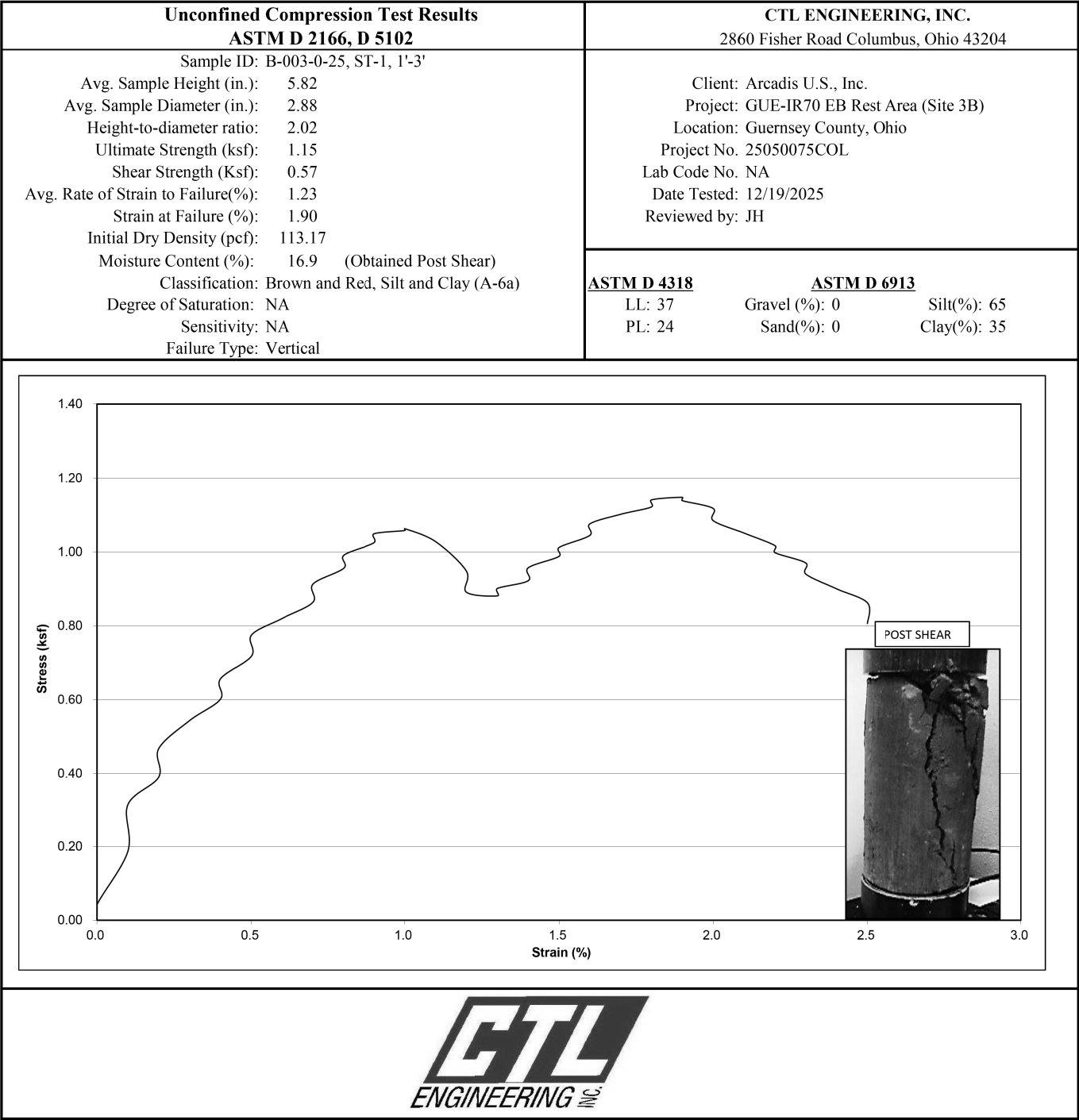
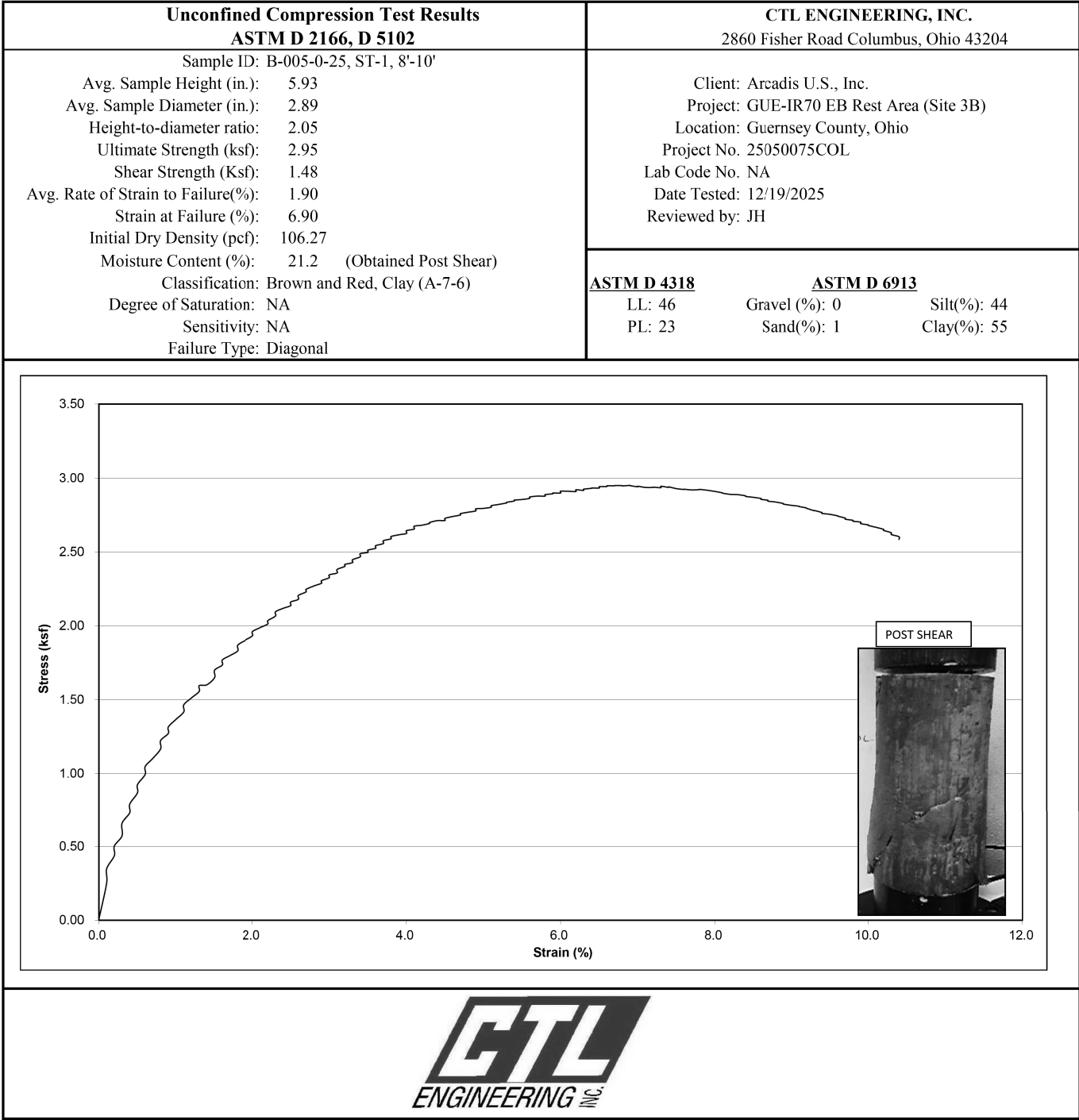
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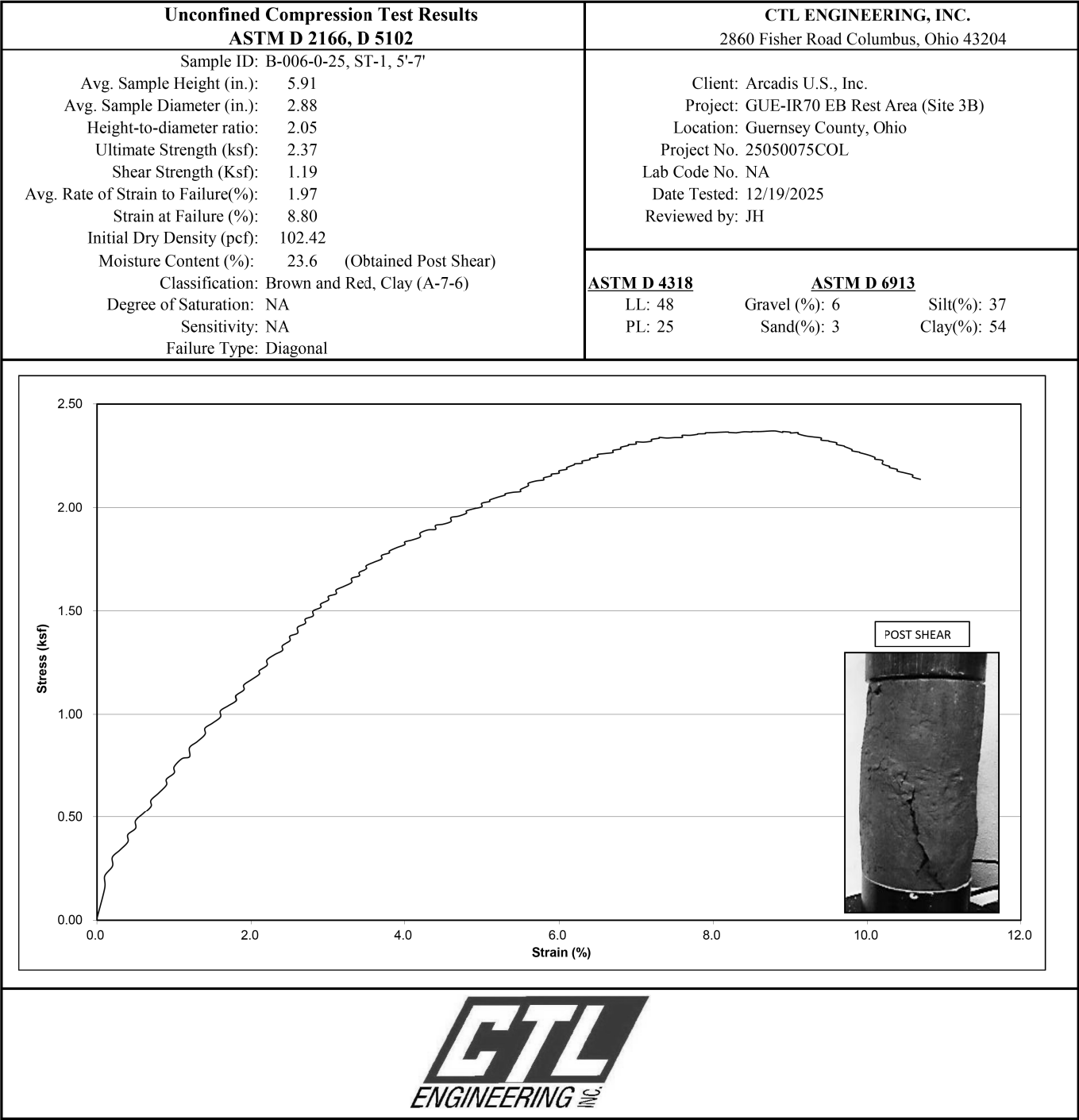
SHEET

P.95

TOTAL

112





DESIGN AGENCY



DESIGNER

N.K.S

REVIEWER

JH 08-03-26

PROJECT ID

122882

SUBSET TOTAL

5 20

SHEET TOTAL

P.97 112



B-002-0-25



Run #:	Depth:	Recovery	RQD
NQ2-1	16.2'	60"/60"	100%
PID No. 122866; GUE-IR70 EB REST AREA (SITE 3B)			
		11.5"/60"	19%



B-003-0-25



Run #:	Depth:	Recovery	RQD
NQ2-1	26.3'	54"/60"	90%
NQ2-2	31.3'	60"/60"	100%
PID No. 122866; GUE-IR70 EB REST AREA (SITE 3B)			
		53"/60"	88%
		30"/60"	50%



B-004-0-25



Run #:	Depth:		Recovery		RQD	
NQ2-1	16.3'	21.3'	57"/60"	95%	37"/60"	62%
NQ2-2	21.3'	26.3'	60"/60"	100%	11"/60"	18%
PID No. 122866; GUE-IR70 EB REST AREA (SITE 3B)						



B-005-0-25



Run #:	Depth:		Recovery		RQD	
NQ2-1	26.3'	31.3'	29"/60"	48%	0"/60"	0%
NQ2-2	31.3'	36.3'	60"/60"	100%	8"/60"	13%
PID No. 122866; GUE-IR70 EB REST AREA (SITE 3B)						

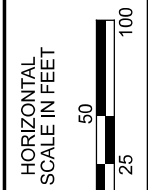


B-006-0-25

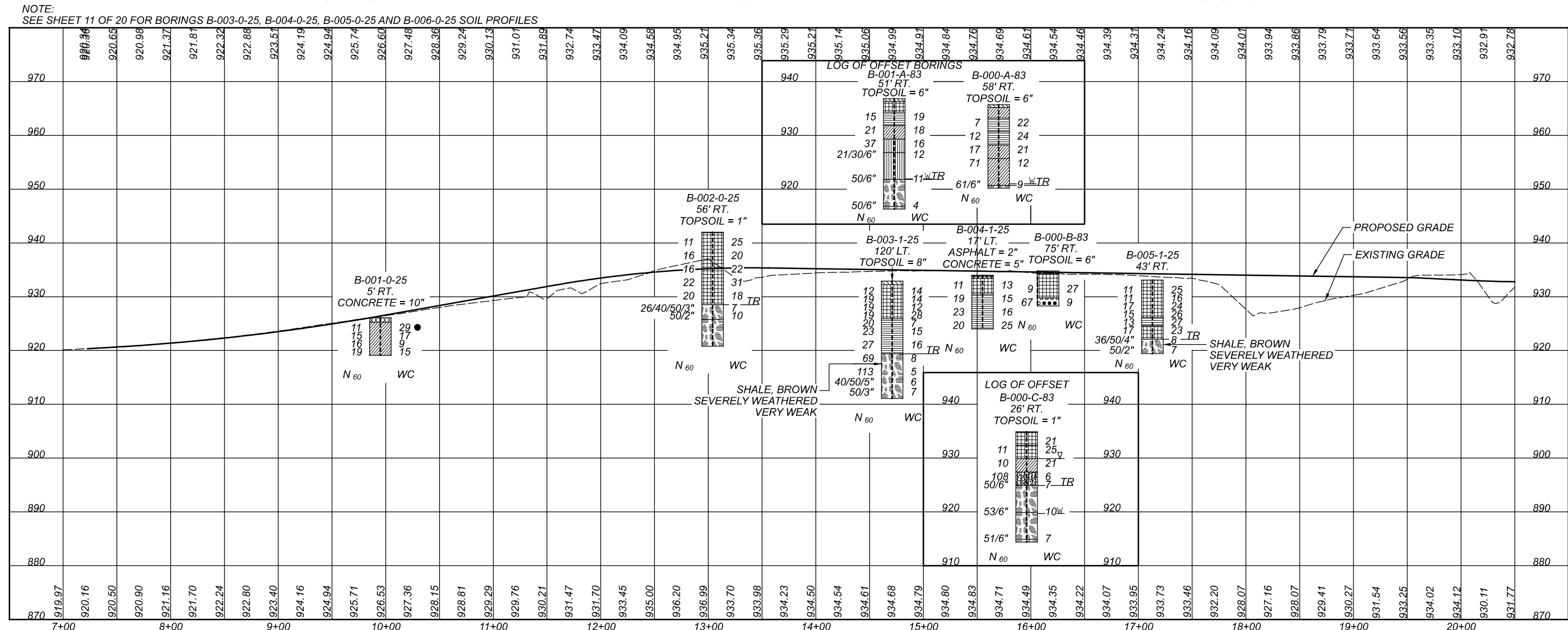


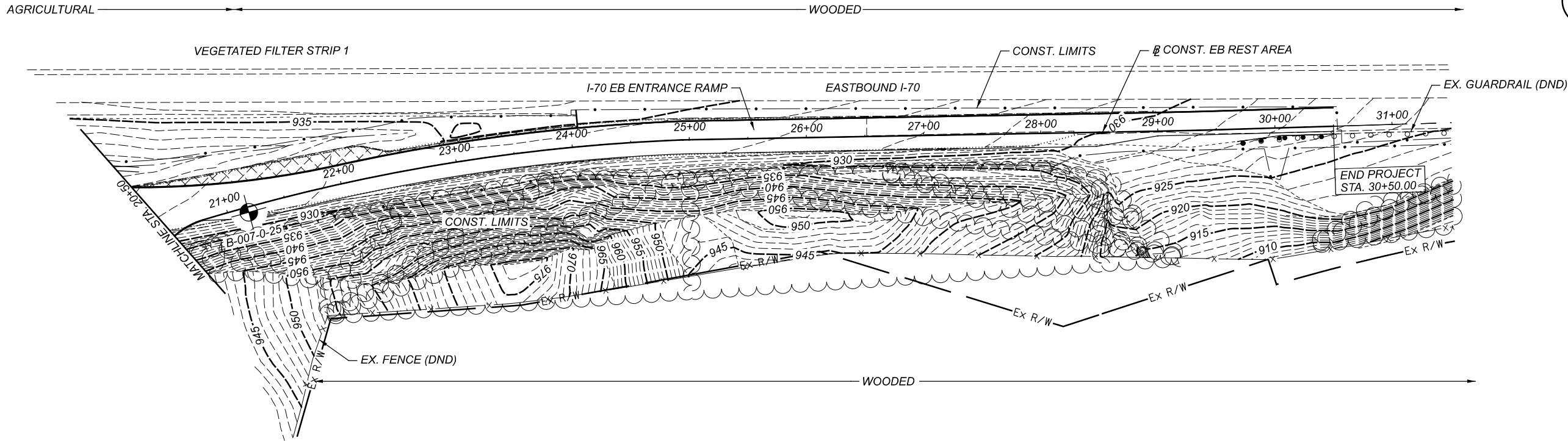
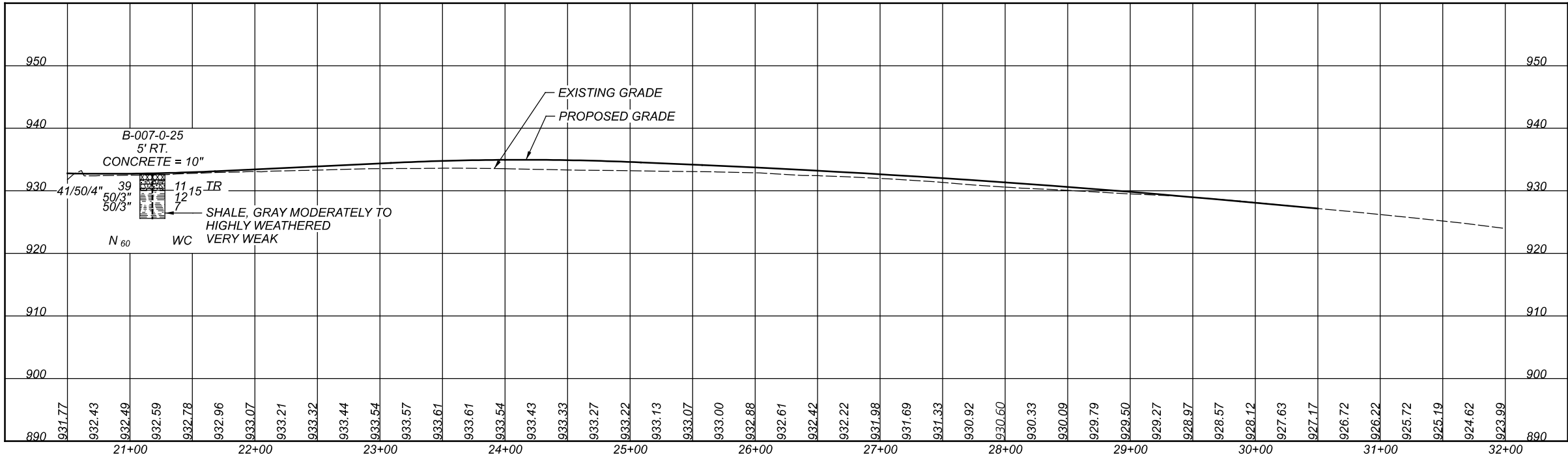
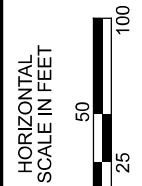
Run #:	Depth:		Recovery		RQD	
NQ2-1	16.3'	21.3'	60"/60"	100%	0"/60"	0%
NQ2-2	21.3'	26.3'	57"/60"	95%	9"/60"	15%
PID No. 122866; GUE-IR70 EB REST AREA (SITE 3B)						

MODEL: Site 3B Plan - Site 3B Plan PAPERSIZE: 17x11 (in.) DATE: 03-08-2026 TIME: 13:28:08 USER: hp
D:\Drop Box\ACTL 2026\August\Dept 05\COL Gaurav\25050075COL_000T Mod_03.08.26\122882GP001.dgn



DESIGN AGENCY	
	
2860 FISHER ROAD COLUMBUS, OHIO 43204 PHONE: (614) 276-8123 FAX: (614) 276-5377	
DESIGNER	
N.K.S	
REVIEWER	
JH 08-03-26	
PROJECT ID	
122882	
SUBSET	TOTAL
9	20
SHEET	TOTAL
P.101	112

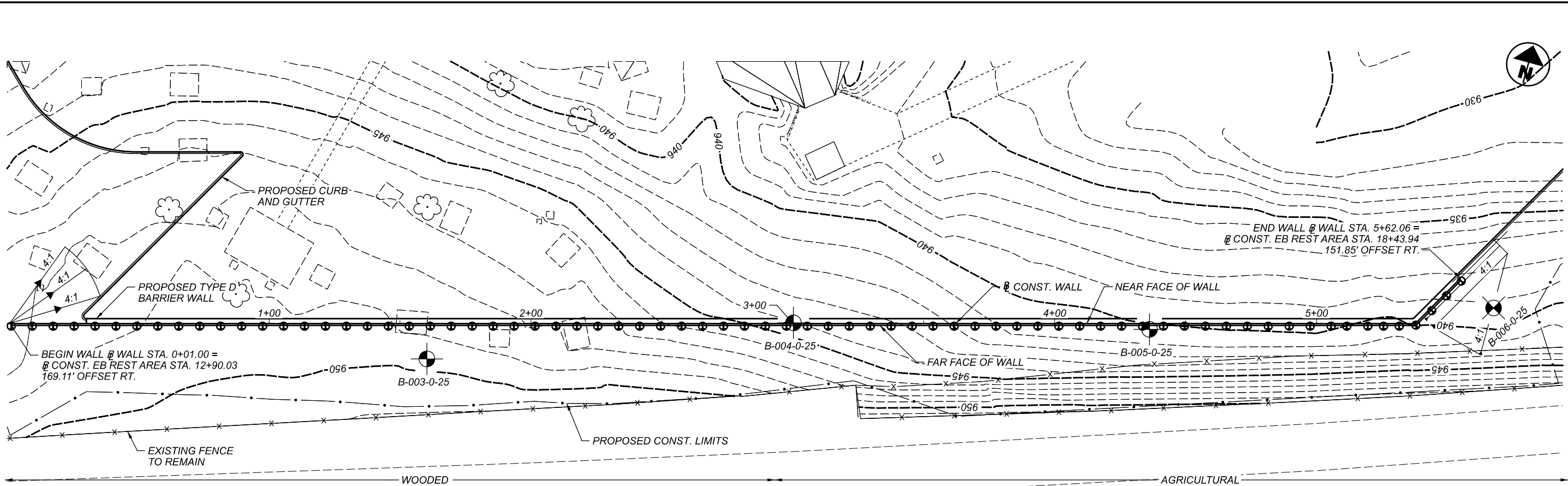
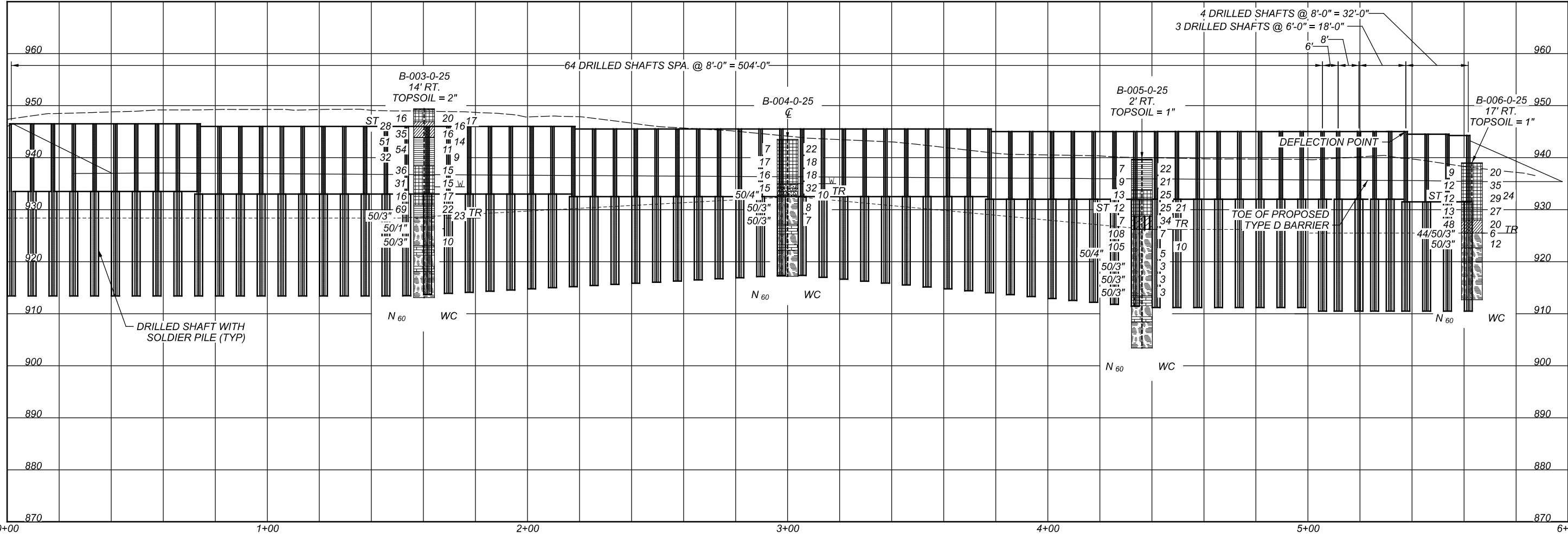




GEOTECHNICAL PROFILE - ROADWAY
STA. 20+50 TO STA. 31+00 US 20

DESIGN AGENCY
GTL
ENGINEERING
2860 FISHER ROAD
COLUMBUS, OHIO 43204
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DESIGNER	N.K.S
REVIEWER	JH 08-03-26
PROJECT ID	122882
SUBSET	TOTAL
10	20
SHEET	TOTAL
P.102	112



GEOTECHNICAL PROFILE - RETAINING WALL
RETAINING WALL STA. 0+25.00 TO STA. 5+62.06

DESIGN AGENCY
CTL
ENGINEERING
2860 FISHER ROAD
COLUMBUS, OHIO 43204
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FAX: (614) 276-8377

DESIGNER
N.K.S
REVIEWER
JH 08-03-26
PROJECT ID
122882
SUBSET TOTAL
11 20
SHEET TOTAL
P.103 112

GUE-IR 70 REST AREAS TP

MODEL: Sheet PAPERSIZE: 11x17 (in.) DATE: 03-08-2026 TIME: 14:02:03 USER: hp
D:\Drop_Box\CTL_2026\August\Dept_05\COL\Gaurav\25050075COL_ODOT\Mod_03.08.26\122882ZL001.dgn

PROJECT: GUE-IR70 EB REST AREA		DRILLING FIRM / OPERATOR: CTL / J.CARTE		DRILL RIG: DIEDRICH D-70		STATION / OFFSET: 13+04, 56' RT.		EXPLORATION ID													
TYPE: LIGHT TOWER		SAMPLING FIRM / LOGGER: CTL / J.CARTE		HAMMER: DIEDRICH AUTOMATIC		ALIGNMENT: IR70		B-002-0-25													
PID: 122866 SFN: N/A		DRILLING METHOD: 3.25" HSA / NQ2		CALIBRATION DATE: 11-8-24		ELEVATION: 942.0 (MSL) EOB: 21.2 ft.		PAGE													
START: 12-4-25 END: 12-4-25		SAMPLING METHOD: SPT / NQ2		ENERGY RATIO (%): 80.7		LAT / LONG: 40.038783, -81.394220		1 OF 1													
MATERIAL DESCRIPTION AND NOTES		ELEV. 942.0	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	SO4 ppm	HOLE SEALED	
TOPSOIL (1") STIFF TO VERY STIFF, BROWN AND RED, CLAY, SOME SILT, TRACE SAND, TRACE GRAVEL, CONTAINS ROOTS AND STONE FRAGMENTS, DAMP		941.9																			
			1	4	4	11	100	SS-1	1.25	-	-	-	-	-	-	-	25	A-7-6 (V)	<100		
			2																		
			3																		
			4	5	5	7	16	100	SS-2	2.25	3	5	3	25	64	53	25	28	20	A-7-6 (18)	-
			5																		
			6																		
			7	7	5	7	16	100	SS-3	3.25	-	-	-	-	-	-	-	22	A-7-6 (V)	-	
			8																		
@8.5'; BROWN, MOIST			9	7	7	9	22	100	SS-4	1.00	3	3	4	34	56	57	27	30	31	A-7-6 (19)	-
			10																		
@11.0'; HARD, "AND" SILT, SOME GRAVEL, DAMP			11																		
		12	8	5	10	20	100	SS-5	4.50	21	4	4	36	35	44	26	18	18	A-7-6 (11)	-	
		13																			
SHALE, BROWN, SEVERELY WEATHERED, VERY WEAK.		928.5	TR	14	26	40	50/3"	-	100	SS-6	-	-	-	-	-	-	-	7	Rock (V)	-	
		925.8	15																		
			16	60/2"			-	100	SS-7	4.50	-	-	-	-	-	-	-	10	Rock (V)	-	
SHALE, GRAY AND RED, HIGHLY TO SEVERELY WEATHERED, VERY WEAK TO WEAK, LAMINATED TO THIN BEDDED; RQD 19%, REC 100%.			17																		
		920.8	18																		
			19																		
@ 19.8' - 20.3' (SHALE); γ = 162.2 pcf, Qu = 850 psi			20																		
			21																		
			EOB																		

NOTES: CAVED AT 14.1'
ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH BENTONITE GROUT

STANDARD ODOT LOG LOG W/ SULFATES (11 X 17) - OH DOT.GDT - 16-6-28 21:14 - D:\DEPT_05\COL\25050075COL\DOWNLOAD\RENAME_4\25050075COL.GPJ

DESIGN AGENCY



CTL
ENGINEERING, INC.
2080 FISHER ROAD
COLUMBUS, OH 43240
PHONE: 614-276-4129
FAX: 614-276-5377

DESIGNER

N.K.S.

REVIEWER

JH 08-03-26

PROJECT ID

122882

SUBSET TOTAL

12 20

SHEET TOTAL

P.104 112

GEOTECHNICAL PROFILE - ROADWAY
BORING LOG FOR B-002-0-25

GUE-IR 70 REST AREAS TP

MODEL: Sheet PAPERSIZE: 1x17 (in.) DATE: 03-08-2026 TIME: 14:03:56 USER: hp
D:\Drop_Box\CTL_2026\August\Dept_05\COL\Gaurav\25050075COL_ODOT\Mod_03.08.26\122882ZL002.dgn

PROJECT: GUE-IR70 EB REST AREA		DRILLING FIRM / OPERATOR: CTL / J.CARTE		DRILL RIG: DIEDRICH D-70		STATION / OFFSET: 14+49, 183' RT.		EXPLORATION ID: B-003-0-25												
TYPE: RETAINING WALL		SAMPLING FIRM / LOGGER: CTL / J.CARTE		HAMMER: DIEDRICH AUTOMATIC		ALIGNMENT: IR70		PAGE 1 OF 1												
PID: 122866 SFN: N/A		DRILLING METHOD: 3.25" HSA / NQ2		CALIBRATION DATE: 11-8-24		ELEVATION: 949.4 (MSL) EOB: 36.3 ft.														
START: 11-26-25 END: 11-26-25		SAMPLING METHOD: SPT / ST / NQ2		ENERGY RATIO (%): 80.7		LAT / LONG: 40.038553, -81.393601														
MATERIAL DESCRIPTION AND NOTES		ELEV.	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	SO ₄ ppm	HOLE SEALED
TOPSOIL (2")		949.4																		
STIFF, BROWN AND RED, CLAY, "AND" SILT, LITTLE GRAVEL, TRACE SAND, DAMP		949.2	1	4	6	16	100	SS-1	1.75	16	1	3	47	33	41	24	17	20	A-7-6 (11)	-
VERY STIFF, BROWN AND RED, SILT AND CLAY, DAMP		946.9	2	6	6		-	ST-1	-	0	0	0	65	35	37	24	13	17	A-6a (9)	-
@4.0'; TRACE SAND, TRACE GRAVEL			3	5	8	28	89	SS-2	2.75	-	-	-	-	-	-	-	-	16	A-6a (V)	-
HARD, BROWN AND RED, SILTY CLAY, TRACE SAND, TRACE GRAVEL, DAMP		943.9	4	8	13															
			5	8	12	35	100	SS-3	3.50	2	0	3	58	37	38	24	14	16	A-6a (10)	-
			6	8	14															
			7	11	24	51	100	SS-4	4.50	-	-	-	-	-	-	-	-	14	A-6b (V)	-
			8	11	14	54	100	SS-5	4.50	2	3	3	46	46	38	21	17	11	A-6b (11)	-
			9	6	16	32	100	SS-6	4.50	-	-	-	-	-	-	-	-	9	A-6b (V)	-
		938.4	10																	
HARD, BROWN AND RED, CLAY, "AND" SILT, TRACE SAND, TRACE GRAVEL, CONTAINS ROCK FRAGMENTS, DAMP			11	11	13	36	100	SS-7	4.25	7	5	4	40	44	41	22	19	15	A-7-6 (12)	-
@13.5'; LITTLE SAND, LITTLE GRAVEL			12		14															
			13																	
@16.0'; MEDIUM STIFF			14	10	11	31	100	SS-8	-	-	-	-	-	-	-	-	-	15	A-7-6 (V)	-
		934.4	15		12															
			16																	
			17	2	8	16	100	SS-9	0.50	-	-	-	-	-	-	-	-	17	A-7-6 (V)	-
		930.9	18		4															
HARD, BROWN, SILTY CLAY, TRACE SAND, CONTAINS ROCK FRAGMENTS, MOIST			19	11	26	69	100	SS-10	-	-	-	-	-	-	-	-	-	22	A-6b (V)	-
			20		25															
SHALE, GRAY, SEVERELY WEATHERED, VERY WEAK.		928.4	21	50/3"		-	100	SS-11	-	-	-	-	-	-	-	-	-	23	Rock (V)	-
			22																	
			23																	
			24	50/1"		-	100	SS-12	-	-	-	-	-	-	-	-	-	-	Rock (V)	-
		923.1	25																	
INTERBEDDED LIMESTONE (60%) AND SHALE (40%), RQD 50%, REC. 90%;			26	50/3"		-	100	SS-13	-	-	-	-	-	-	-	-	-	10	Rock (V)	-
LIMESTONE, GRAY AND LIGHT GRAY, HIGHLY WEATHERED, VERY WEAK TO WEAK, THIN TO MEDIUM BEDDED;			27																	
SHALE, GRAY, MODERATELY WEATHERED, VERY WEAK TO WEAK, LAMINATED TO THIN BEDDED, CALCAREOUS.			28																	
			29	50		90		NQ2-1											CORE	
		918.1	30																	
			31																	
SHALE, GRAY, HIGHLY TO MODERATELY WEATHERED, SLIGHTLY STRONG, THIN TO THICK BEDDED, CALCAREOUS; RQD 88%, REC 100%.			32																	
@ 32.3' - 32.8' (SHALE); γ = 159.3 pcf, Qu = 2,810 psi			33																	
			34	88		100		NQ2-2											CORE	
		913.1	35																	
			36																	
			EOB																	
NOTES: CAVED AT 19.4'																				
ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH BENTONITE GROUT																				

GUE-IR 70 REST AREAS TP

MODEL: Sheet PAPERSIZE: 11x17 (in.) DATE: 03-08-2026 TIME: 14:06:55 USER: hp
D:\Drop_Box\CTL_2026\August\Dept_05\COL\Gaurav\25050075COL_ODOT\Mod_03.08.26\122882ZL003.dgn

PROJECT: GUE-IR70 EB REST AREA		DRILLING FIRM / OPERATOR: CTL / J.CARTE		DRILL RIG: DIEDRICH D-70		STATION / OFFSET: 14+71, 120' LT.		EXPLORATION ID													
TYPE: LIGHT TOWER		SAMPLING FIRM / LOGGER: CTL / J.CARTE		HAMMER: DIEDRICH AUTOMATIC		ALIGNMENT: IR70		B-003-1-25													
PID: 122866 SFN: N/A		DRILLING METHOD: 3.25" HSA / NQ2		CALIBRATION DATE: 11-8-24		ELEVATION: 932.9 (MSL) EOB: 21.8 ft.		PAGE													
START: 12-5-25 END: 12-5-25		SAMPLING METHOD: SPT / NQ2		ENERGY RATIO (%): 80.7		LAT / LONG: 40.039367, -81.393808		1 OF 1													
MATERIAL DESCRIPTION AND NOTES		ELEV.	DEPTHS		SPT/RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	SO4 ppm	BACK FILL
TOPSOIL (8")		932.9								GR	CS	FS	SI	CL	LL	PL	PI	WC			
STIFF TO VERY STIFF, BROWN AND RED, CLAY, "AND" SILT, SOME GRAVEL, TRACE SAND, CONTAINS ROOTS, DAMP @2.5'; CONTAINS ROCK FRAGMENTS @4.0'; TRACE GRAVEL, TRACE SAND		932.2	1	5	12	89	SS-1	-	21	5	5	37	32	42	22	20	14	A-7-6 (11)	<100		
			2	4	5																
			3	6	7	19	100	SS-2	4.00	-	-	-	-	-	-	-	-	14	A-7-6 (V)	-	
			4	7	7																
			5	7	7	19	100	SS-3	2.00	9	3	5	38	45	50	28	22	12	A-7-6 (15)	-	
			6	7	6	19	100	SS-4	1.50	-	-	-	-	-	-	-	-	28	A-7-6 (V)	-	
			7	6	8																
			8	7	8	20	100	SS-5	4.50	20	8	11	38	23	35	19	16	7	A-6b (8)	-	
			9	8	9	23	100	SS-6	4.50	-	-	-	-	-	-	-	-	15	A-6b (V)	-	
			10																		
VERY STIFF TO HARD, BROWN, SILTY CLAY, LITTLE GRAVEL, LITTLE SAND, CONTAINS ROCK FRAGMENTS, DAMP		925.9	11	7																	
			12	8	12	27	100	SS-7	2.00	-	-	-	-	-	-	-	16	A-6b (V)	-		
			13																		
			14	16	25	69	100	SS-8	-	-	-	-	-	-	-	-	8	Rock (V)	-		
			15	26																	
			16	31	36	113	100	SS-9	-	-	-	-	-	-	-	-	5	Rock (V)	-		
			17	48																	
			18																		
			19	40	50/5"	-	91	SS-10	-	-	-	-	-	-	-	-	6	Rock (V)	-		
			20																		
SHALE, BROWN, SEVERELY WEATHERED, VERY WEAK.		919.4	21	50/3"	-	100	SS-11	-	-	-	-	-	-	-	-	7	Rock (V)	-			
		911.1	EOB																		

NOTES: CAVED AT 16.4'
ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH SOIL CUTTINGS

STANDARD ODOT LOG LOG W/ SULFATES (11 X 17) - OH DOT.GDT - 16-6-28 21:14 - D:\DEPT_05\COL\25050075COL\DOWN\LOAD\RENAME_4\25050075COL.GPJ

GUE-IR 70 REST AREAS TP

MODEL: Sheet PAPER SIZE: 11x17 (in.) DATE: 03-08-2026 TIME: 14:08:45 USER: hp
D:\Drop_Box\CTL_2026\August\Dept_05\COL\Gaurav\25050075COL_ODOT\Mod_03.08.26\122882ZL004.dgn

PROJECT: GUE-IR70 EB REST AREA			DRILLING FIRM / OPERATOR: CTL / J.CARTE				DRILL RIG: DIEDRICH D-70				STATION / OFFSET: 15+89, 169' RT.				EXPLORATION ID: B-004-0-25							
TYPE: RETAINING WALL			SAMPLING FIRM / LOGGER: CTL / J.CARTE				HAMMER: DIEDRICH AUTOMATIC				ALIGNMENT: IR70											
PID: 122866 SFN: N/A			DRILLING METHOD: 3.25" HSA / NQ2				CALIBRATION DATE: 11-8-24				ELEVATION: 943.5 (MSL) EOB: 26.3 ft.				PAGE 1 OF 1							
START: 12-4-25 END: 12-4-25			SAMPLING METHOD: SPT / NQ2				ENERGY RATIO (%): 80.7				LAT / LONG: 40.038683, -81.393131											
MATERIAL DESCRIPTION AND NOTES			ELEV.	DEPTHS		SPT/RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	SO4 ppm	HOLE SEALED
MEDIUM STIFF, BROWN, CLAY, "AND" SILT, TRACE SAND, TRACE GRAVEL, DAMP @3.5'; VERY STIFF, BROWN AND RED @6.0'; SOME SAND, SOME GRAVEL, LITTLE SILT			943.5								GR	CS	FS	SI	CL	LL	PL	PI				
					1	3	2	7	100	SS-1	0.75	3	5	4	36	52	50	27	23	22	A-7-6 (15)	-
					2																	
					3																	
					4	5	5	17	100	SS-2	2.50	4	1	4	42	49	46	25	21	18	A-7-6 (14)	-
					5		8															
					6																	
					7	3	5	16	100	SS-3	0.50	-	-	-	-	-	-	-	-	18	A-7-6 (V)	-
MEDIUM DENSE, BROWN, GRAVEL AND/OR STONE FRAGMENTS WITH SAND, SILT, AND CLAY, WET			935.0	W	935.0																	
					9	3	5	15	100	SS-4	-	56	10	4	13	17	45	26	19	32	A-2-7 (1)	-
SHALE, BROWN AND GRAY, SEVERELY WEATHERED, VERY WEAK.			932.5	TR																		
					10																	
					11	50/4"	-	100	SS-5	-	-	-	-	-	-	-	-	-	-	10	Rock (V)	-
					12																	
					13																	
					14	50/3"	-	100	SS-6	-	-	-	-	-	-	-	-	-	-	8	Rock (V)	-
					15																	
					16	50/3"	-	100	SS-7	-	-	-	-	-	-	-	-	-	-	7	Rock (V)	-
INTERBEDDED SHALE (67%) AND LIMESTONE (33%), RQD 62%, REC. 95%; SHALE, GRAY, MODERATELY WEATHERED, WEAK, THIN TO MEDIUM BEDDED; LIMESTONE, GRAY AND LIGHT GRAY, HIGHLY WEATHERED, VERY WEAK, THIN TO MEDIUM BEDDED. @ 18.3' - 18.8' (SHALE); γ = 166.2 pcf, Qu = 1,400 psi			927.2																			
					17																	
					18																	
					19	62		95	NQ2-1											CORE		
					20																	
SHALE, GRAY, HIGHLY TO MODERATELY WEATHERED, WEAK TO SLIGHTLY STRONG, LAMINATED TO THIN BEDDED, CALCAREOUS; RQD 18%, REC 100%. @ 21.3' - 21.8 (SHALE); γ = 162.7 pcf, Qu = 2,910 psi			922.2																			
					21																	
					22																	
					23																	
					24	18		100	NQ2-2											CORE		
					25																	
			917.2	EOB																		

NOTES: CAVED AT 13.1'
ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH BENTONITE GROUT

DESIGN AGENCY



2080 FISHER ROAD
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FAX 636-426-5377

DESIGNER

N.K.S.

REVIEWER

JH 08-03-26

PROJECT ID

122882

SUBSET TOTAL

15

SHEET TOTAL

112

GEOTECHNICAL PROFILE - ROADWAY
BORING LOG FOR B-004-0-25

GUE-IR 70 REST AREAS TP

MODEL: Sheet PAPER SIZE: 11x17 (in.) DATE: 03-08-2026 TIME: 14:10:49 USER: hp
D:\Drop_Box\CTL_2026\August\Dept_05\COL\Gaurav\25050075COL_ODOT\Mod_03.08.26\122882ZL005.dgn

PROJECT: GUE-IR70 EB REST AREA		DRILLING FIRM / OPERATOR: CTL / J.CARTE		DRILL RIG: DIEDRICH D-70		STATION / OFFSET: 17+25, 171' RT.		EXPLORATION ID: B-005-0-25												
TYPE: RETAINING WALL		SAMPLING FIRM / LOGGER: CTL / J.CARTE		HAMMER: DIEDRICH AUTOMATIC		ALIGNMENT: IR70		PAGE 1 OF 1												
PID: 122866 SFN: N/A		DRILLING METHOD: 3.25" HSA / NQ2		CALIBRATION DATE: 11-8-24		ELEVATION: 939.7 (MSL) EOB: 36.3 ft.														
START: 12-4-25 END: 12-4-25		SAMPLING METHOD: SPT / ST / NQ2		ENERGY RATIO (%): 80.7		LAT / LONG: 40.038783, -81.392660														
MATERIAL DESCRIPTION AND NOTES		ELEV.	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	SO4 ppm	HOLE SEALED
TOPSOIL (1")		939.7																		
STIFF, BROWN AND RED, SILTY CLAY, TRACE SAND, TRACE GRAVEL, DAMP		939.6	1	2	7	100	SS-1	1.25	4	5	4	41	46	40	22	18	22	A-6b (11)	-	
			2	3																
			3																	
@3.5'; BROWN, CONTAINS ROCK FRAGMENTS			4	2	9	89	SS-2	1.25	-	-	-	-	-	-	-	-	21	A-6b (V)	-	
			5	3																
			6	4																
STIFF, BROWN AND RED, CLAY, SOME SILT, LITTLE SAND, TRACE GRAVEL, MOIST		933.7	7	3	13	100	SS-3	0.50	3	6	6	35	50	49	23	26	25	A-7-6 (16)	-	
			8	5																
BROWN, "AND" SILT, TRACE SAND, NO GRAVEL @ 8.0' - 10.0'; γ = 106.3 pcf, Qu = 1.48 tsf			9	3	12	100	ST-1 SS-4	0.25	0	0	1	44	55	46	23	23	21 25	A-7-6 (14) A-7-6 (V)	-	
			10	4																
STIFF, BROWN, ELASTIC CLAY, SOME SILT, LITTLE GRAVEL, TRACE SAND, MOIST		928.7	11	2	7	100	SS-5	1.50	11	2	8	25	54	68	31	37	34	A-7-5 (20)	-	
			12	2																
			13	3																
SHALE, BROWN, SEVERELY WEATHERED, VERY WEAK.		926.2	14	24	108	100	SS-6	-	-	-	-	-	-	-	-	-	7	Rock (V)	-	
			15	36																
			16	44																
			17	36	105	100	SS-7	-	-	-	-	-	-	-	-	-	10	Rock (V)	-	
			18	34																
			19	44																
@18.5'; GRAY, HIGHLY WEATHERED.			20	50/4"	-	100	SS-8	-	-	-	-	-	-	-	-	-	5	Rock (V)	-	
			21																	
			22	50/3"	-	100	SS-9	-	-	-	-	-	-	-	-	-	3	Rock (V)	-	
			23																	
			24	50/3"	-	100	SS-10	-	-	-	-	-	-	-	-	-	3	Rock (V)	-	
			25																	
INTERBEDDED SHALE (90%) AND LIMESTONE (10%), RQD 0%, REC. 48%; SHALE, GRAY AND RED, HIGHLY WEATHERED, VERY WEAK, VERY THIN TO THIN BEDDED, CALCAREOUS; LIMESTONE, GRAY AND RED, HIGHLY WEATHERED, VERY WEAK, THIN BEDDED.		913.4	26	50/3"	-	100	SS-11	-	-	-	-	-	-	-	-	-	3	Rock (V)	-	
			27																	
			28																	
			29	0	48		NQ2-1											CORE		
			30																	
SHALE, GRAY, HIGHLY WEATHERED, VERY WEAK, VERY THIN TO THIN BEDDED, CALCAREOUS; RQD 13%, REC 100%. @ 34.0' - 34.5' (SHALE); γ = 167.7 pcf, Qu = 60 psi		908.4	31																	
			32																	
			33																	
			34	13	100		NQ2-2												CORE	
			35																	
		903.4	36																	
			EOB																	
NOTES: CAVED AT 18.1'																				
ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH BENTONITE GROUT																				

GUE-IR 70 REST AREAS TP

MODEL: Sheet PAPERSIZE: 11x17 (in.) DATE: 03-08-2026 TIME: 14:12:56 USER: hp
D:\Drop_Box\CTL_2026\August\Dept_05\COL\Gaurav\25050075COL_ODOT\Mod_03.08.26\122882ZL006.dgn

PROJECT: GUE-IR70 EB REST AREA		DRILLING FIRM / OPERATOR: CTL / J.CARTE		DRILL RIG: DIEDRICH D-70		STATION / OFFSET: 17+13, 43' RT.		EXPLORATION ID												
TYPE: LIGHT TOWER		SAMPLING FIRM / LOGGER: CTL / J.CARTE		HAMMER: DIEDRICH AUTOMATIC		ALIGNMENT: IR70		B-005-1-25												
PID: 122866 SFN: N/A		DRILLING METHOD: 3.25" HSA		CALIBRATION DATE: 11-8-24		ELEVATION: 933.1 (MSL) EOB: 13.7 ft.		PAGE												
START: 12-5-25 END: 12-5-25		SAMPLING METHOD: SPT		ENERGY RATIO (%): 80.7		LAT / LONG: 40.039117, -81.392821		1 OF 1												
MATERIAL DESCRIPTION AND NOTES		ELEV. 933.1	DEPTHS	SPT/RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)				ATTERBERG			WC	ODOT CLASS (GI)	SO4 ppm	BACK FILL	
STIFF TO VERY STIFF, BROWN, CLAY , SOME SILT, SOME GRAVEL, TRACE SAND, CONTAINS ROOTS, MOIST		926.1	1	3	11	100	SS-1	2.25	21	4	4	31	40	47	23	24	25	A-7-6 (14)	<100	L L

NOTES: CAVED AT 11.8'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH SOIL CUTTINGS

STANDARD ODOT LOG LOG W/ SULFATES (11 X 17) - OH DOT.GDT - 16-6-28 21:14 - D:\DEPT_05\COL\25050075COL\DOWNLOAD\RENAME_4\25050075COL.GPJ

DESIGN AGENCY



CTL
ENGINEERING &
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DESIGNER

N.K.S.

REVIEWER

JH 08-03-26

PROJECT ID

122882

SUBSET

17

TOTAL

20

SHEET

P.109

TOTAL

112

GEOTECHNICAL PROFILE - ROADWAY
BORING LOG FOR B-005-1-25

GUE-IR 70 REST AREAS TP

MODEL: Sheet PAPER SIZE: 11x17 (in.) DATE: 03-08-2026 TIME: 14:14:48 USER: hp
D:\Drop_Box\CTL_2026\August\Dept_05\COL\Gaurav\25050075COL_ODOT\Mod_03.08.26\122882ZL007.dgn

PROJECT: GUE-IR70 EB REST AREA			DRILLING FIRM / OPERATOR: CTL / J.CARTE			DRILL RIG: DIEDRICH D-70			STATION / OFFSET: 18+57, 163' RT.			EXPLORATION ID: B-006-0-25											
TYPE: RETAINING WALL			SAMPLING FIRM / LOGGER: CTL / J.CARTE			HAMMER: DIEDRICH AUTOMATIC			ALIGNMENT: IR70														
PID: 122866 SFN: N/A			DRILLING METHOD: 3.25" HSA / NQ2			CALIBRATION DATE: 11-8-24			ELEVATION: 939.0 (MSL) EOB: 26.3 ft.			PAGE 1 OF 1											
START: 12-4-25 END: 12-4-25			SAMPLING METHOD: SPT / ST / NQ2			ENERGY RATIO (%): 80.7			LAT / LONG: 40.038900, -81.392215														
MATERIAL DESCRIPTION AND NOTES			ELEV.	DEPTHS	SPT/RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	SO ₄ ppm	HOLE SEALED		
										GR	CS	FS	SI	CL	LL	PL	PI						
TOPSOIL (1") MEDIUM STIFF TO STIFF, BROWN AND RED, CLAY, SOME SILT, LITTLE SAND, TRACE GRAVEL, CONTAINS ROOTS, DAMP @3.5'; CONTAINS ROCK FRAGMENTS, MOIST "AND" SILT, TRACE GRAVEL, TRACE SAND, DAMP @ 5.0' - 7.0'; γ = 102.4 pcf, Qu = 1.2 tsf @6.0'; LITTLE SILT, TRACE SAND			939.0																				
			938.9	1	3	9	100	SS-1	1.25	8	5	6	25	56	53	25	28	20	A-7-6 (18)	-			
				2																			
				3																			
				4	3	12	100	SS-2	0.75	-	-	-	-	-	-	-	-	35	A-7-6 (V)	-			
				5																			
				6			-	ST-1	-	6	1	2	37	54	48	25	23	24	A-7-6 (15)	-			
				7	4	12	100	SS-3	0.50	1	0	1	19	79	75	29	46	29	A-7-6 (20)	-			
				8																			
				9	4	13	100	SS-4	1.00	-	-	-	-	-	-	-	-	27	A-7-6 (V)	-			
STIFF, BROWN, SILT AND CLAY, SOME GRAVEL, SOME SAND, CONTAINS ROCK FRAGMENTS, DAMP			928.0	10																			
				11	7																		
SHALE, BROWN, SEVERLY WEATHERED, VERY WEAK.			925.5	12	13	48	100	SS-5	1.75	28	16	9	28	19	36	22	14	20	A-6a (4)	-			
				13																			
SHALE, GRAY, MODERATELY TO HIGHLY WEATHERED, WEAK TO SLIGHTLY STRONG, LAMINATED TO THIN BEDDED; RQD 8%, REC 98%.			922.7	14	44	-	100	SS-6	-	-	-	-	-	-	-	6	Rock (V)	-					
				15																			
				16	50/3"	-	100	SS-7	4.50	-	-	-	-	-	-	-	12	Rock (V)	-				
				17																			
				18																			
				19	0	100	NQ2-1												CORE				
				20																			
				21																			
				22																			
				23																			
				24	15	95	NQ2-2												CORE				
				25																			
			912.7	26																			

NOTES: CAVED AT 12.4'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH BENTONITE GROUT

STANDARD ODOT LOG LOG W/ SULFATES (11' X 17') - OH DOT.GDT - 15-6-26 15:07 - G:\2026\JUNE\1025050075COL\25050075COL.GPJ

DESIGN AGENCY



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DESIGNER

N.K.S.

REVIEWER

JH 08-03-26

PROJECT ID

122882

SUBSET TOTAL

18 20

SHEET TOTAL

P.110 112

GEOTECHNICAL PROFILE - ROADWAY
BORING LOG FOR B-006-0-25

GUE-IR 70 REST AREAS TP

MODEL: Sheet PAPER: 11x17 (in.) DATE: 03-08-2026 TIME: 14:16:44 USER: hp
D:\Drop_Box\CTL_2026\August\Dept_05\COL\Gaurav\25050075COL\DOT\Mod_03.08.26\122882ZL008.dgn

B-001-A-83

State of Ohio
Department of Transportation
Division of Highways
Testing Laboratory

NAVD88 ELEV = NGVD29 ELEV -0.686 FEET

5
11

LOG OF BORING
Date Started: 1-10-83 Sampler Type: SS Dia: 1 3/8" Water Elev: 922.6'
Date Completed: 1-10-83 Casing Length: Dia:

Project Identification: GUERNSEY
GUE - 70 - 19.37 (EB)
SUBSURFACE INVESTIGATION
RENOVATION TO MOTORIST FACILITIES

Boring No. Station & Offset TEST LOCATION 1A - (WET AREA) Surface Elev. 937.5'

Boring No.	Station & Offset	TEST DESCRIPTION	TEST DATE	TEST TIME	TESTER	TESTER'S PHONE	TESTER'S ADDRESS	TESTER'S CITY	TESTER'S STATE	TESTER'S ZIP	TESTER'S COUNTRY	TESTER'S ORGANIZATION	TESTER'S TITLE	TESTER'S SIGNATURE	TESTER'S DATE	TESTER'S TIME	TESTER'S LOCATION	TESTER'S COMMENTS	TESTER'S NOTES	TESTER'S REMARKS	TESTER'S OBSERVATIONS	TESTER'S CONCLUSIONS	TESTER'S RECOMMENDATIONS	TESTER'S SUGGESTIONS	TESTER'S ADVICE	TESTER'S COUNSEL	TESTER'S GUIDANCE	TESTER'S ASSISTANCE	TESTER'S SUPPORT	TESTER'S BACKUP	TESTER'S RESOURCES	TESTER'S TOOLS	TESTER'S EQUIPMENT	TESTER'S MATERIALS	TESTER'S SUPPLIES	TESTER'S SERVICES	TESTER'S FACILITIES	TESTER'S INFRASTRUCTURE	TESTER'S UTILITIES	TESTER'S TRANSPORTATION	TESTER'S COMMUNICATIONS	TESTER'S SECURITY	TESTER'S PROTECTION	TESTER'S SAFETY	TESTER'S HEALTH	TESTER'S WELFARE	TESTER'S INTERESTS	TESTER'S RIGHTS	TESTER'S OBLIGATIONS	TESTER'S RESPONSIBILITIES	TESTER'S ACCOUNTABILITIES	TESTER'S LIABILITIES	TESTER'S ASSETS	TESTER'S NET WORTH	TESTER'S CREDIT RATING	TESTER'S CREDIT HISTORY	TESTER'S CREDIT RECORD	TESTER'S CREDIT REPORT	TESTER'S CREDIT REVIEW	TESTER'S CREDIT ANALYSIS	TESTER'S CREDIT EVALUATION	TESTER'S CREDIT ASSESSMENT	TESTER'S CREDIT RISK	TESTER'S CREDIT EXPOSURE	TESTER'S CREDIT VULNERABILITY	TESTER'S CREDIT RESILIENCE	TESTER'S CREDIT STRENGTH	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT SOUNDNESS	TESTER'S CREDIT 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Form TE-153 Particle Sizes: Agg. > 2.00mm, Coarse Sand=200-0.42mm, Fine Sand=0.42-0.074mm, Silt=0.074-0.005mm, Clay=< 0.005mm

B-000-A-83

State of Ohio
Department of Transportation
Division of Highways
Testing Laboratory

NAVD88 ELEV = NGVD29 ELEV -0.686 FEET

6
11

LOG OF BORING
Date Started: 1-7-11-83 Sampler Type: SSS Dia: 1 3/8" Water Elev: 924.7'
Date Completed: 1-7-12-83 Casing Length: Dia:

Project Identification: GUERNSEY
GUE - 70 - 19.37 (EB)
SUBSURFACE INVESTIGATION
RENOVATION TO MOTORIST FACILITIES

Boring No. Station & Offset TEST LOCATION A Surface Elev. 936.4'

Elev.	Depth	Std. Pen. (N)	Description	ALLOW. BRNG. CAP. TSF	Field No	Lab Nos. So.	Physical Characteristics										SMTL Class	
							% Agg.	% C.S.	% F.S.	% Silt	% Clay	L.L.	PI	W.C.				
936.4 936.0	0		SOD AND TOPSOIL															
933.9	2		REDDISH-BROWN CLAY AND SILT															
931.4	4	3/4/3	REDDISH-BROWN SILTY CLAY	0.6	14	31481	13	3	4	40	40	39	17	22			A-6b	
928.9	6	1/5/7	REDDISH-BROWN SILTY CLAY WITH COAL BLOSSOM	1.5	15	31482	9	3	8	34	55	40	13	24			A-6b	
926.4	8	3/4/18	BROWN WITH GRAY SILT AND CLAY	22.1	16	31483	0	6	9	45	39	34	12	21			A-6b	
	10	10/24/47	BROWN WITH GRAY SILT AND CLAY	4.0	17	31484	7	3	6	51	33	32	11	12			A-6a	
921.4 920.0	12		TOP OF ROCK															
	14	51(0.5')	BROWN AND GRAY WEATHERED SHALE CLAY		18	31485	50	13	8	14	15	-	-	-		79	13 VISUAL	
	16		BOTTOM OF BORING															
	18																	
	20																	
	22																	
	24																	
	26																	
	28																	
	30																	
	32																	
	34																	
	36																	

Form TE-153 Particle Sizes: Agg. > 2.00mm, Coarse Sand=200-0.42mm, Fine Sand=0.42-0.074mm, Silt=0.074-0.005mm, Clay=< 0.005mm

MODEL: Sheet PAPERSIZE: 11x17 (in.) DATE: 03-08-2026 TIME: 14:18:36 USER: hp
D:\Drop Box\CTL 2026\August\Dept 05\COL\Gaurav\25050075COL_ODOT\Mod_03.08.26\122882ZL009.dgn

NAVD88 ELEV = NGVD29 ELEV -0.686 FEET

B-000-B-83

LOG OF BORING

Date Started 1-12-83 Sampler Type SS Dia 1 3/8" Water Elev
Date Completed 1-12-83 Casing Length Dia

Project Identification: **GUERNSEY**
602-70-19.37 (EB)
SUBSURFACE INVESTIGATION
RENOVATION TO MOTORIST FACILITIES

Boring No. _____ Station & Offset _____ **TEST LOCATION B** _____ Surface Elev. **935.5'**

Form TE-153 Particle Sizes: Agg.= >2.00mm, Coarse Sand=200-0.42mm, Fine Sand=0.42-0.074mm, Silt=0.074-0.005mm, Clay=< 0.005mm

NAVD88 ELEV = NGVD29 ELEV -0.686 FEET

B-000-C-83

LOG OF BORING

Date Started 1-11-83 Sample Type SS Dia. 1 3/8" Water Elev. 2000
Date Completed 1-11-83 Casing Length Dia.

Project Identification: **GUERNSEY**
GUE - 70 - 19.37 (FD)
SUBSURFACE INVESTIGATION
RENOVATION TO MOTORIST FACILITIES

Boring No. 1 Station & Offset TEST LOCATION C Surface Elev. 935.6'

Form TE-153 Particle Sizes: Agg.= >2.00mm, Coarse Sand=200-0.42mm, Fine Sand=0.42-0.074mm, Silt=0.074-0.005mm, Clay=< 0.005mm

DESIGN AGENCY		 ENGINEERING 2860 FISHER ROAD COLUMBUS, OHIO 43224 FAX:614/276-6377	
DESIGNER		N.K.S	
REVIEWER		JH 08-03-20	
PROJECT ID		122862	
SUBSET	TOTAL		
20	20		
SHEET	TOTAL		
P.112	112		

APPENDIX B

TEST BORING RECORDS
&
ROCK CORE PHOTOSHEETS



[illegible]

NOTES: CAVED AT 3.5'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED ASPHALT PATCH; BACKFILLED WITH SOIL CUTTINGS

[illegible]

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH BENTONITE GROUT

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT GDT - 6/9/26 17:04 - C:\PROJECT\2025\COL-05\25050075COL ARCADIS U.S. INC. GUE-IR70 EB REST AREA (SITE 3B)\DESIGN\DRAWING

PID: 122866	SFN: N/A	PROJECT: GUE-IR70 EB REST AREA	STATION / OFFSET: 14+49, 183' RT.	START: 11/26/25	END: 11/26/25	PG 2 OF 2	B-003-0-25														
MATERIAL DESCRIPTION AND NOTES			ELEV.	DEPTHS		SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	HOLE SEALED
			919.4								GR	CS	FS	SI	CL	LL	PL	PI	WC		
INTERBEDDED LIMESTONE (60%) AND SHALE (40%), RQD 50%, REC. 90%; LIMESTONE , GRAY AND LIGHT GRAY, HIGHLY WEATHERED, VERY WEAK TO WEAK, THIN TO MEDIUM BEDDED; SHALE , GRAY, MODERATELY WEATHERED, VERY WEAK TO WEAK, LAMINATED TO THIN BEDDED, CALCAREOUS. <i>(continued)</i> SHALE , GRAY, HIGHLY TO MODERATELY WEATHERED, SLIGHTLY STRONG, THIN TO THICK BEDDED, CALCAREOUS: RQD 88%. REC 100%.			918.1	31																	CORE
				32																	
				33																	
				34	88	100	NQ2-2														
				35																	
			913.1	36																	

EOB

NOTES: CAVED AT 19.4'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH BENTONITE GROUT

[illegible]

NOTES: CAVED AT 16.4'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH SOIL CUTTINGS

[illegible]

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH BENTONITE GROUT

[illegible]

NOTES: CAVED AT 6.9'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED ASPHALT PATCH; BACKFILLED WITH SOIL CUTTINGS

PROJECT: GUE-IR70 EB REST AREA		DRILLING FIRM / OPERATOR: CTL / J.CARTE		DRILL RIG: DIEDRICH D-70		STATION / OFFSET: 17+25, 171' RT.		EXPLORATION ID											
TYPE: RETAINING WALL		SAMPLING FIRM / LOGGER: CTL / J.CARTE		HAMMER: DIEDRICH AUTOMATIC		ALIGNMENT: IR70		B-005-0-25											
PID: 122866 SFN: N/A		DRILLING METHOD: 3.25" HSA / NQ2		CALIBRATION DATE: 11/8/24		ELEVATION: 939.7 (MSL) EOB: 36.3 ft.		PAGE											
START: 12/4/25 END: 12/4/25		SAMPLING METHOD: SPT / ST / NQ2		ENERGY RATIO (%): 80.7		LAT / LONG: 40.038783, -81.392660		1 OF 2											
MATERIAL DESCRIPTION AND NOTES		ELEV.	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
									GR	CS	FS	SI	CL	LL	PL	PI			
TOPSOIL (1")		939.7	TR	1	2														
STIFF, BROWN AND RED, SILTY CLAY, TRACE SAND, TRACE GRAVEL, DAMP		939.6		2	3	7	100	SS-1	1.25	4	5	4	41	46	40	22	18	22	A-6b (11)
@3.5'; BROWN, CONTAINS ROCK FRAGMENTS				3															
				4	2														
				5	3	9	89	SS-2	1.25	-	-	-	-	-	-	-	-	21	A-6b (V)
		933.7		6	4														
STIFF, BROWN AND RED, CLAY, SOME SILT, LITTLE SAND, TRACE GRAVEL, MOIST				7	3	13	100	SS-3	0.50	3	6	6	35	50	49	23	26	25	A-7-6 (16)
				8	5														
BROWN, "AND" SILT, TRACE SAND, NO GRAVEL @ 8.0' - 10.0'; $\gamma = 106.3$ pcf, $Q_u = 1.48$ tsf				9	3	12	100	ST-1 SS-4	0.25	0	0	1	44	55	46	23	23	21 25	A-7-6 (14) A-7-6 (V)
				10	4														
		928.7		11															
STIFF, BROWN, ELASTIC CLAY, SOME SILT, LITTLE GRAVEL, TRACE SAND, MOIST				12	2	7	100	SS-5	1.50	11	2	8	25	54	68	31	37	34	A-7-5 (20)
		926.2		13	3														
SHALE, BROWN, SEVERELY WEATHERED, VERY WEAK.				14	24	108	100	SS-6	-	-	-	-	-	-	-	-	-	7	Rock (V)
				15	36	44													
				16															
				17	36	105	100	SS-7	-	-	-	-	-	-	-	-	-	10	Rock (V)
				18	34	44													
@18.5'; GRAY, HIGHLY WEATHERED.				19	50/4"	-	100	SS-8	-	-	-	-	-	-	-	-	-	5	Rock (V)
				20															
				21	50/3"	-	100	SS-9	-	-	-	-	-	-	-	-	-	3	Rock (V)
				22															
				23															
				24	50/3"	-	100	SS-10	-	-	-	-	-	-	-	-	-	3	Rock (V)
		913.4		25															
				26	50/3"	-	100	SS-11	-	-	-	-	-	-	-	-	-	3	Rock (V)
				27															
				28															
				29	0		48	NQ2-1											CORE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH BENTONITE GROUT

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT GDT - 6/9/26 17:05 - C:\PROJECT\2025\COL-05\25050075COL-ARCADIS U.S.-INC.-GUE-IR70 EB REST AREA (SITE 3B)DESIGNDRAFT

PROJECT: GUE-IR70 EB REST AREA		DRILLING FIRM / OPERATOR: CTL / J.CARTE		DRILL RIG: DIEDRICH D-70		STATION / OFFSET: 17+13, 43' RT.		EXPLORATION ID												
TYPE: LIGHT TOWER		SAMPLING FIRM / LOGGER: CTL / J.CARTE		HAMMER: DIEDRICH AUTOMATIC		ALIGNMENT: IR70		B-005-1-25												
PID: 122866 SFN: N/A		DRILLING METHOD: 3.25" HSA		CALIBRATION DATE: 11/8/24		ELEVATION: 933.1 (MSL) EOB: 13.7 ft.		PAGE												
START: 12/5/25 END: 12/5/25		SAMPLING METHOD: SPT		ENERGY RATIO (%): 80.7		LAT / LONG: 40.039117, -81.392821		1 OF 1												
MATERIAL DESCRIPTION AND NOTES		ELEV.	DEPTHS		SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	BACK FILL
		933.1								GR	CS	FS	SI	CL	LL	PL	PI	WC		
STIFF TO VERY STIFF, BROWN, CLAY , SOME SILT, SOME GRAVEL, TRACE SAND, CONTAINS ROOTS, MOIST		926.1	1	3	11	100	SS-1	2.25	21	4	4	31	40	47	23	24	25	A-7-6 (14)	<V>	
@2.5'; HARD, NO ROOTS, CONTAINS ROCK FRAGMENTS, DAMP			2	4	11	89	SS-2	4.50	-	-	-	-	-	-	-	-	16	A-7-6 (V)	<V>	
@4.0'; LITTLE GRAVEL, LITTLE SAND			3	6	17	100	SS-3	1.50	20	6	6	31	37	49	24	25	24	A-7-6 (14)	<V>	
@5.5'; TRACE GRAVEL, TRACE SAND, NO ROCK FRAGMENTS, MOIST			4	5	15	100	SS-4	1.25	-	-	-	-	-	-	-	-	26	A-7-6 (V)	<V>	
			5	6	13	100	SS-5	1.75	1	3	7	47	42	39	22	17	27	A-6b (11)	<V>	
STIFF, BROWN, SILTY CLAY , TRACE SAND, TRACE GRAVEL, CONTAINS ROOTS, MOIST		924.6	6	4	13	100	SS-5	1.75	1	3	7	47	42	39	22	17	27	A-6b (11)	<V>	
STIFF, BROWN, CLAY , "AND" SILT, LITTLE GRAVEL, TRACE SAND, CONTAINS ROCK FRAGMENTS, MOIST		922.1	7	6	17	100	SS-6	1.75	13	3	6	40	38	42	23	19	23	A-7-6 (12)	<V>	
			8																<V>	
			9																<V>	
SHALE , BROWN, SEVERELY WEATHERED, VERY WEAK.		919.4	10	36	-	100	SS-7	-	-	-	-	-	-	-	-	-	8	Rock (V)	<V>	
			11	50/4"															<V>	
			12																<V>	
Auger Refusal @ 13.67'			13	50/2"	-	100	SS-8	-	-	-	-	-	-	-	-	-	7	Rock (V)	<V>	
			EOB																<V>	

NOTES: CAVED AT 11.8'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH SOIL CUTTINGS

NOTES: CAVED AT 12.4'
ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH BENTONITE GROUT

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT GDT - 6/9/26 17:05 - C:\PROJECT\2025\COL-05\25050075COL ARCADIS U.S.- INC.- GUE-IR70 EB REST AREA (SITE 3B)\DESIGN\DRAFT

PROJECT: GUE-IR70 EB REST AREA			DRILLING FIRM / OPERATOR: CTL / J.CARTE			DRILL RIG: DIEDRICH D-70			STATION / OFFSET: 21+18, 5' RT.			EXPLORATION ID									
TYPE: SUBGRADE			SAMPLING FIRM / LOGGER: CTL / J.CARTE			HAMMER: DIEDRICH AUTOMATIC			ALIGNMENT: IR70			B-007-0-25									
PID: 122866 SFN: N/A			DRILLING METHOD: 3.25" HSA			CALIBRATION DATE: 11/8/24			ELEVATION: 932.6 (MSL) EOB: 7.0 ft.			PAGE									
START: 12/8/25 END: 12/8/25			SAMPLING METHOD: SPT			ENERGY RATIO (%): 80.7			LAT / LONG: 40.039750, -81.391840			1 OF 1									
MATERIAL DESCRIPTION AND NOTES			ELEV.	DEPTHS		SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL
			932.6								GR	CS	FS	SI	CL	LL	PL	PI			
CONCRETE (10")			931.7																		
DENSE, BROWN, GRAVEL AND/OR STONE FRAGMENTS WITH SAND, SILT, AND CLAY, MOIST			930.1	TR		7	39	89	SS-1	-	48	12	8	16	16	30	17	13	11	A-2-6 (1)	
SHALE, GRAY, MODERATELY TO HIGHLY WEATHERED, VERY WEAK.						41	-	100	SS-2	-	-	-	-	-	-	-	-	-	15	Rock (V)	
						50/4"															
						50/3"	-	100	SS-3	-	-	-	-	-	-	-	-	-	12	Rock (V)	
						50/3"	-	100	SS-4	-	-	-	-	-	-	-	-	-	7	Rock (V)	
			925.6	EOB																	

NOTES: CAVED AT 3.1'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED ASPHALT PATCH; BACKFILLED WITH SOIL CUTTINGS

B-002-0-25



Run #:	Depth:		Recovery		RQD	
NQ2-1	16.2'	21.2'	60"/60"	100%	11.5"/60"	19%
PID No. 122866; GUE-IR70 EB REST AREA (SITE 3B)						

B-003-0-25



Run #:	Depth:		Recovery		RQD	
NQ2-1	26.3'	31.3'	54"/60"	90%	30"/60"	50%
NQ2-2	31.3'	36.3'	60"/60"	100%	53"/60"	88%

PID No. 122866; GUE-IR70 EB REST AREA (SITE 3B)

B-004-0-25



Run #:	Depth:		Recovery		RQD	
NQ2-1	16.3'	21.3'	57"/60"	95%	37"/60"	62%
NQ2-2	21.3'	26.3'	60"/60"	100%	11"/60"	18%
PID No. 122866; GUE-IR70 EB REST AREA (SITE 3B)						

B-005-0-25



Run #:	Depth:		Recovery		RQD	
NQ2-1	26.3'	31.3'	29"/60"	48%	0"/60"	0%
NQ2-2	31.3'	36.3'	60"/60"	100%	8"/60"	13%
PID No. 122866; GUE-IR70 EB REST AREA (SITE 3B)						

B-006-0-25



Run #:	Depth:		Recovery		RQD	
NQ2-1	16.3'	21.3'	60"/60"	100%	0"/60"	0%
NQ2-2	21.3'	26.3'	57"/60"	95%	9"/60"	15%

PID No. 122866; GUE-IR70 EB REST AREA (SITE 3B)

APPENDIX C

LABORATORY TEST RESULTS





OHIO DEPARTMENT OF TRANSPORTATION
DETERMINING SULFATE CONTENT IN SOILS
SUPPLEMENT 1122

Project C-R-S: GUE-IR70 EB Rest Area (Site 3B)

PID No: 122866

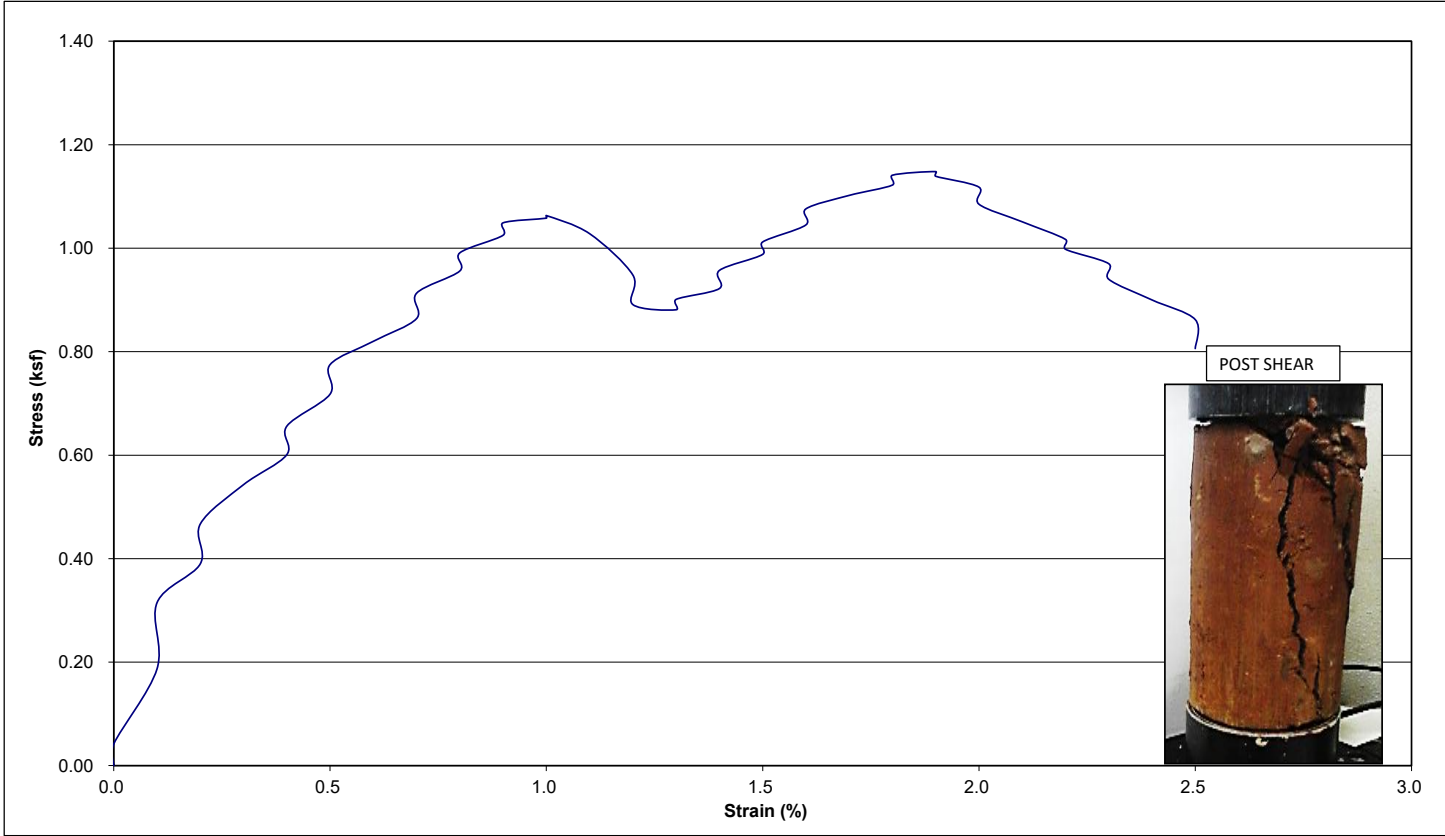
Report Date: 12/30/2025

Consultant: CTL Engineering, Inc.

Technician: RV

Sample or Boring ID	Station	Offset	Latitude & Longitude or State Plane Coordinates		Elevation	Soaking Time (hr)	Replicate Sample Readings						Sulfate Content (ppm)
							1		2		3		
							Dilution	Reading	Dilution	Reading	Dilution	Reading	
B-001-0-25	9+95	5' RT.	40.03905	-81.3953	925.1	20	20	< 5	20	< 5	20	< 5	< 100
B-002-0-25	13+04	56' RT.	40.038783	-81.39422	941	20	20	< 5	20	< 5	20	< 5	< 100
B-003-1-25	14+71	120' LT.	40.039367	-81.393808	931.9	20	20	< 5	20	< 5	20	< 5	< 100
B-004-1-25	15+55	17' LT.	40.03915	-81.393422	933	20	20	< 5	20	< 5	20	< 5	< 100
B-005-1-25	17+13	43' RT.	40.039117	-81.392821	932.1	20	20	< 5	20	< 5	20	< 5	< 100
B-007-0-25	21+18	5' RT.	40.03975	-81.39184	931.6	20	20	< 5	20	< 5	20	< 5	< 100

Unconfined Compression Test Results ASTM D 2166, D 5102		CTL ENGINEERING, INC. 2860 Fisher Road Columbus, Ohio 43204	
Sample ID: B-003-0-25, ST-1, 1'-3' Avg. Sample Height (in.): 5.82 Avg. Sample Diameter (in.): 2.88 Height-to-diameter ratio: 2.02 Ultimate Strength (ksf): 1.15 Shear Strength (Ksf): 0.57 Avg. Rate of Strain to Failure(%): 1.23 Strain at Failure (%): 1.90 Initial Dry Density (pcf): 113.17 Moisture Content (%): 16.9 (Obtained Post Shear) Classification: Brown and Red, Silt and Clay (A-6a) Degree of Saturation: NA Sensitivity: NA Failure Type: Vertical		Client: Arcadis U.S., Inc. Project: GUE-IR70 EB Rest Area (Site 3B) Location: Guernsey County, Ohio Project No. 25050075COL Lab Code No. NA Date Tested: 12/19/2025 Reviewed by: JH	
		ASTM D 4318 LL: 37 PL: 24	ASTM D 6913 Gravel (%): 0 Sand(%): 0 Silt(%): 65 Clay(%): 35



Unconfined Compression Test Results**ASTM D 2166, D 5102**

Sample ID: B-005-0-25, ST-1, 8'-10'

Avg. Sample Height (in.): 5.93
Avg. Sample Diameter (in.): 2.89
Height-to-diameter ratio: 2.05
Ultimate Strength (ksf): 2.95
Shear Strength (Ksf): 1.48
Avg. Rate of Strain to Failure(%): 1.90
Strain at Failure (%): 6.90
Initial Dry Density (pcf): 106.27
Moisture Content (%): 21.2 (Obtained Post Shear)
Classification: Brown and Red, Clay (A-7-6)
Degree of Saturation: NA
Sensitivity: NA
Failure Type: Diagonal

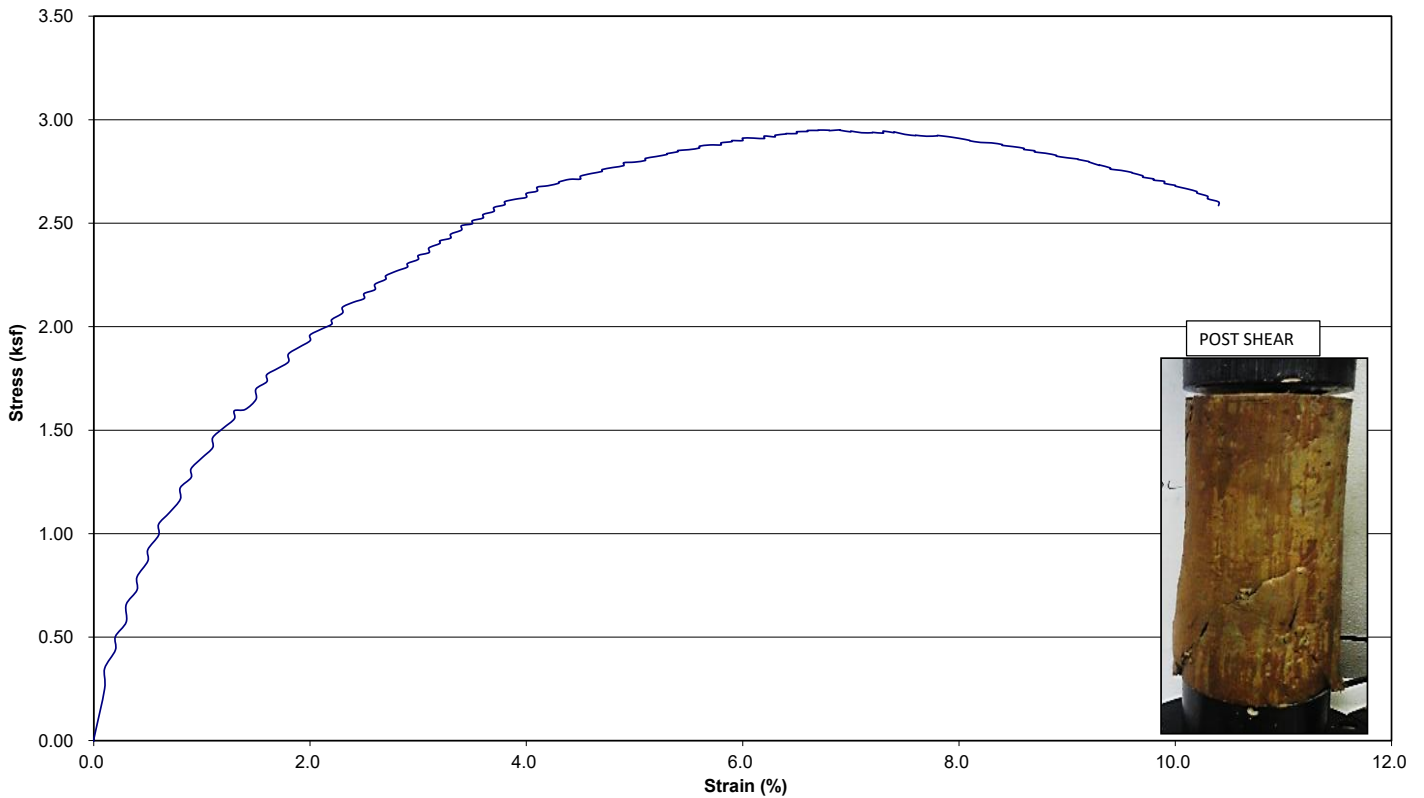
CTL ENGINEERING, INC.

2860 Fisher Road Columbus, Ohio 43204

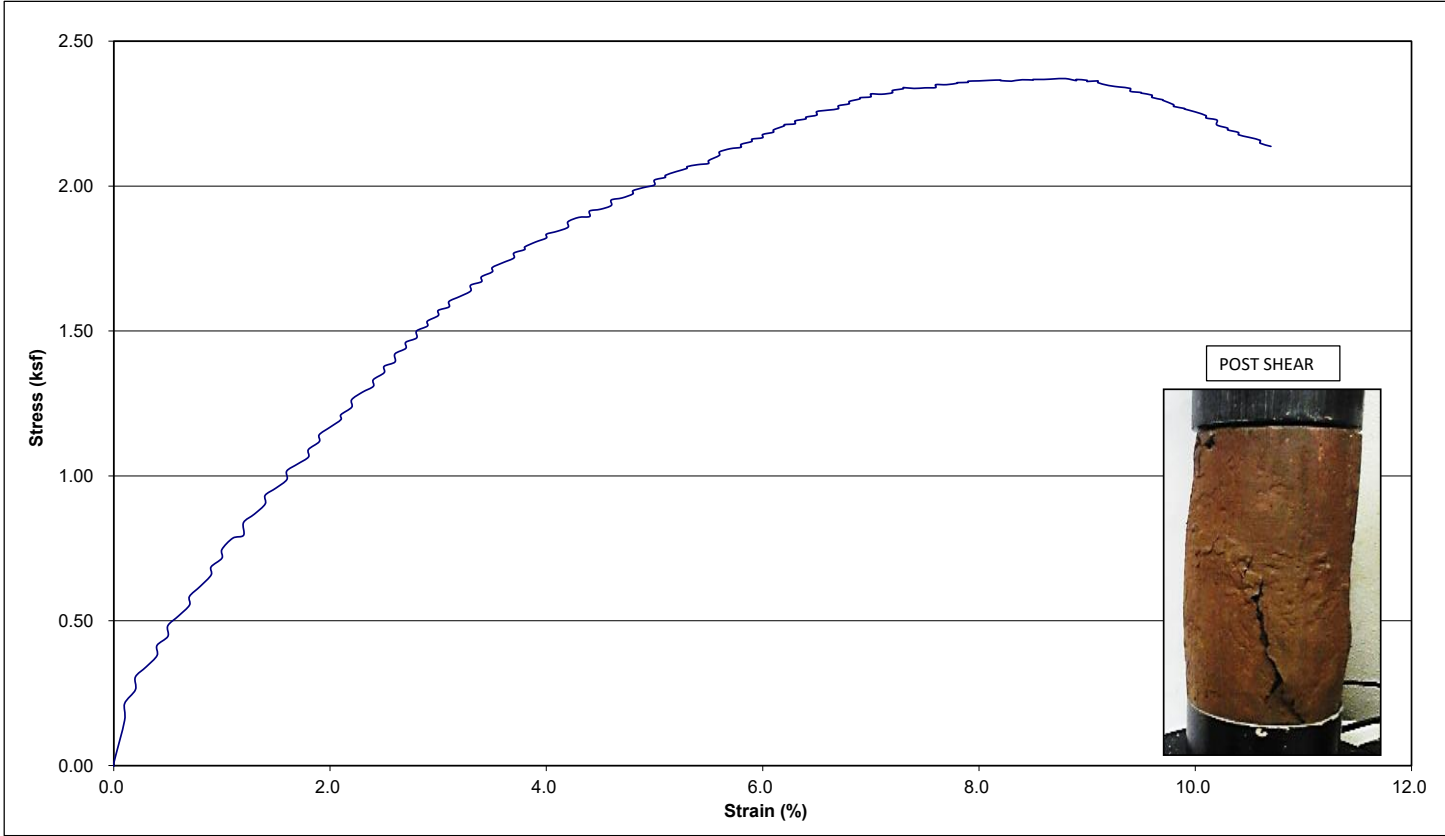
Client: Arcadis U.S., Inc.
Project: GUE-IR70 EB Rest Area (Site 3B)
Location: Guernsey County, Ohio
Project No. 25050075COL
Lab Code No. NA
Date Tested: 12/19/2025
Reviewed by: JH

ASTM D 4318LL: 46
PL: 23**ASTM D 6913**

Gravel (%): 0
Sand(%): 1
Silt(%): 44
Clay(%): 55



Unconfined Compression Test Results ASTM D 2166, D 5102		CTL ENGINEERING, INC. 2860 Fisher Road Columbus, Ohio 43204	
Sample ID: B-006-0-25, ST-1, 5'-7' Avg. Sample Height (in.): 5.91 Avg. Sample Diameter (in.): 2.88 Height-to-diameter ratio: 2.05 Ultimate Strength (ksf): 2.37 Shear Strength (Ksf): 1.19 Avg. Rate of Strain to Failure(%): 1.97 Strain at Failure (%): 8.80 Initial Dry Density (pcf): 102.42 Moisture Content (%): 23.6 (Obtained Post Shear) Classification: Brown and Red, Clay (A-7-6) Degree of Saturation: NA Sensitivity: NA Failure Type: Diagonal		Client: Arcadis U.S., Inc. Project: GUE-IR70 EB Rest Area (Site 3B) Location: Guernsey County, Ohio Project No. 25050075COL Lab Code No. NA Date Tested: 12/19/2025 Reviewed by: JH	
		ASTM D 4318 LL: 48 PL: 25	ASTM D 6913 Gravel (%): 6 Sand(%): 3 Silt(%): 37 Clay(%): 54



PROJECT NO:	25050075COL
DATE:	4/21/2026

UNIAXIAL COMPRESSIVE STRENGTH OF INTACT ROCK CORE - ASTM D 7012



Method C

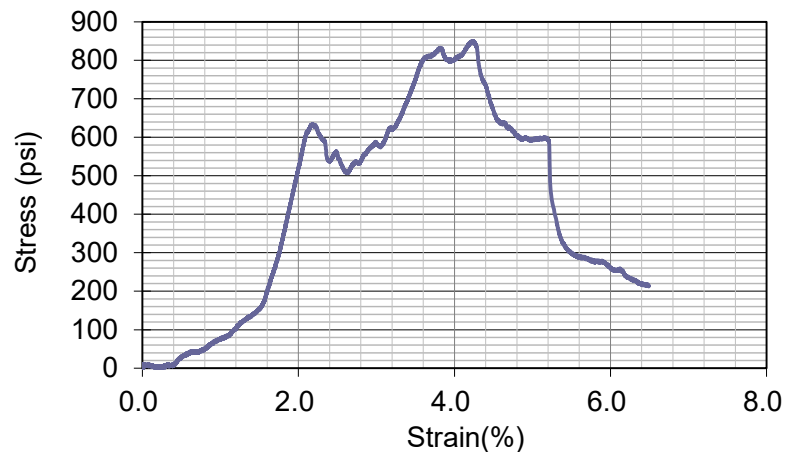
BORING NUMBER	B-002-0-25	TOP DEPTH(FT)	19.8	BOTTOM DEPTH(FT)	20.3
SAMPLE NUMBER	NQ2-1	DISTRICT	5	PID NO.	122866
COUNTY	Guernsey	ROUTE	NA	SECTION	NA

FORMATION	Pennsylvanian age Conemaugh Group
DESCRIPTION	Shale, Gray, Highly Weathered, Weak
MOISTURE CONDITION	As Received

MEASUREMENT	LENGTH(INCHES)	DIAMETER(INCHES)
1	4.047	1.980
2	4.049	1.986
3	4.052	1.985
AVERAGE	4.049	1.984

LENGTH/DIAMETER	2.0
CORRECTION FACTOR	1
AREA(IN ²)	3.1
MASS (GRAMS)	533.0
UNIT WEIGHT(LBS/FT ³)	162.2

RATE OF LOADING (in/min)
0.11
COMPRESSIVE STRENGTH (PSI)
850
Equip. ID - 68897
NON-CONFORMANCES - None
TIME OF TEST (MINUTES)
2.45
LOADING DIRECTION
PERP. TO BEDDING
TECHNICIAN - MW
TEMPERATURE - Room



BEFORE TESTING



AFTER TESTING

Physical Appearance after Test - Sample sheared through top portion - No signs of cracking, spalling or shearing at the platen-specimen interface

PROJECT NO:	25050075COL
DATE:	4/21/2026

UNIAXIAL COMPRESSIVE STRENGTH OF INTACT ROCK CORE - ASTM D 7012



Method C

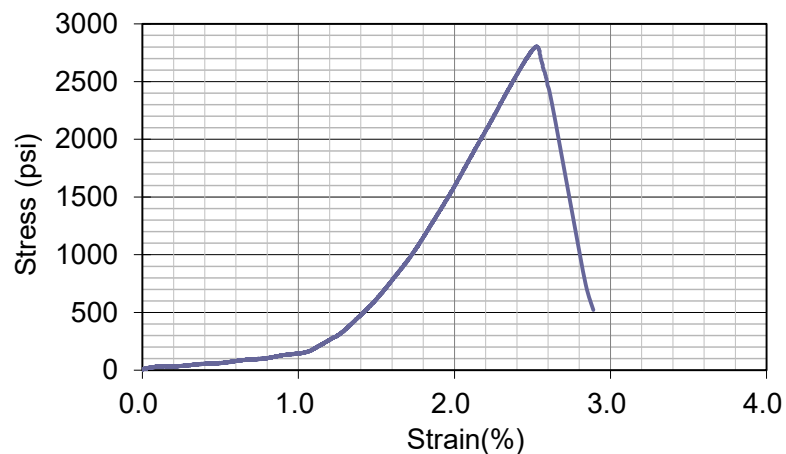
BORING NUMBER	B-003-0-25	TOP DEPTH(FT)	32.3	BOTTOM DEPTH(FT)	32.8
SAMPLE NUMBER	NQ2-2	DISTRICT	5	PID NO.	122866
COUNTY	Guernsey	ROUTE	NA	SECTION	NA

FORMATION	Pennsylvanian age Conemaugh Group
DESCRIPTION	Shale, Gray, Moderately Weathered, Slightly Strong
MOISTURE CONDITION	As Received

MEASUREMENT	LENGTH(INCHES)	DIAMETER(INCHES)
1	4.070	1.991
2	4.074	1.990
3	4.063	1.997
AVERAGE	4.069	1.993

LENGTH/DIAMETER	2.0
CORRECTION FACTOR	1
AREA(IN ²)	3.1
MASS (GRAMS)	530.5
UNIT WEIGHT(LBS/FT ³)	159.3

RATE OF LOADING (in/min)
0.10
COMPRESSIVE STRENGTH (PSI)
2,810
Equip. ID - 68897
NON-CONFORMANCES - None
TIME OF TEST (MINUTES)
1.13
LOADING DIRECTION
PERP. TO BEDDING
TECHNICIAN - MW
TEMPERATURE - Room



		
BEFORE TESTING		AFTER TESTING
Physical Appearance after Test - Sample sheared through middle portion - No signs of cracking, spalling or shearing at the platen-specimen interface		

PROJECT NO:	25050075COL
DATE:	4/21/2026

UNIAXIAL COMPRESSIVE STRENGTH OF INTACT ROCK CORE - ASTM D 7012



Method C

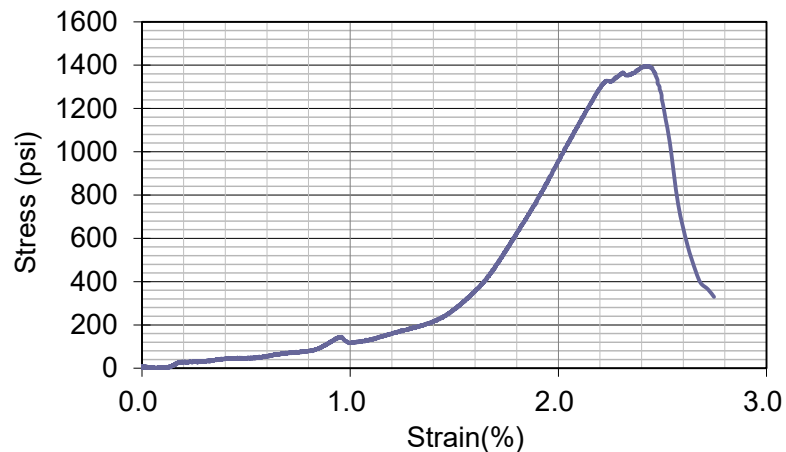
BORING NUMBER	B-004-0-25	TOP DEPTH(FT)	18.3	BOTTOM DEPTH(FT)	18.8
SAMPLE NUMBER	NQ2-1	DISTRICT	5	PID NO.	122866
COUNTY	Guernsey	ROUTE	NA	SECTION	NA

FORMATION	Pennsylvanian age Conemaugh Group
DESCRIPTION	Shale, Gray, Moderately Weathered, Weak
MOISTURE CONDITION	As Received

MEASUREMENT	LENGTH(INCHES)	DIAMETER(INCHES)
1	4.052	1.997
2	4.054	1.994
3	4.056	1.991
AVERAGE	4.054	1.994

LENGTH/DIAMETER	2.0
CORRECTION FACTOR	1
AREA(IN ²)	3.1
MASS (GRAMS)	552.2
UNIT WEIGHT(LBS/FT ³)	166.2

RATE OF LOADING (in/min)	0.09
COMPRESSIVE STRENGTH (PSI)	1,400
Equip. ID - 68897	
NON-CONFORMANCES - None	
TIME OF TEST (MINUTES)	1.27
LOADING DIRECTION	PERP. TO BEDDING
TECHNICIAN - MW	
TEMPERATURE - Room	



BEFORE TESTING



AFTER TESTING

Physical Appearance after Test - Sample sheared through middle portion - No signs of cracking, spalling or shearing at the platen-specimen interface

PROJECT NO:	25050075COL
DATE:	4/21/2026

UNIAXIAL COMPRESSIVE STRENGTH OF INTACT ROCK CORE - ASTM D 7012



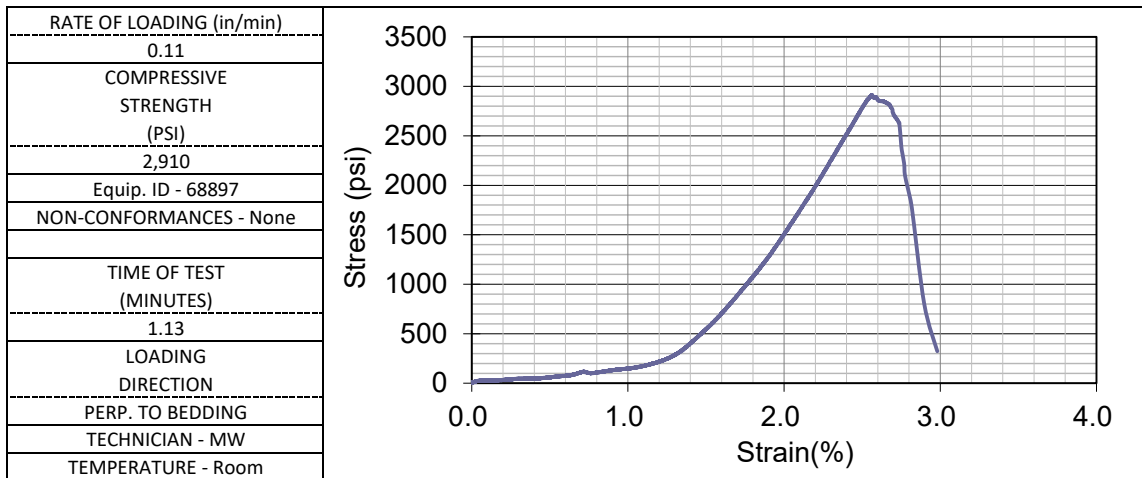
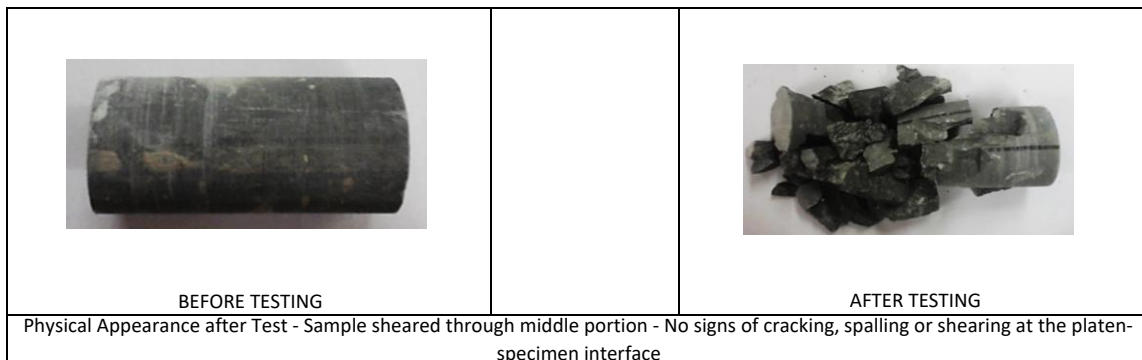
Method C

BORING NUMBER	B-004-0-25	TOP DEPTH(FT)	21.3	BOTTOM DEPTH(FT)	21.8
SAMPLE NUMBER	NQ2-2	DISTRICT	5	PID NO.	122866
COUNTY	Guernsey	ROUTE	NA	SECTION	NA

FORMATION	Pennsylvanian age Conemaugh Group
DESCRIPTION	Shale, Gray, Moderately Weathered, Slightly Strong
MOISTURE CONDITION	As Received

MEASUREMENT	LENGTH(INCHES)	DIAMETER(INCHES)
1	4.044	1.994
2	4.051	1.990
3	4.043	1.992
AVERAGE	4.046	1.992

LENGTH/DIAMETER	2.0
CORRECTION FACTOR	1
AREA(IN ²)	3.1
MASS (GRAMS)	538.4
UNIT WEIGHT(LBS/FT ³)	162.7



PROJECT NO:	25050075COL
DATE:	4/21/2026

UNIAXIAL COMPRESSIVE STRENGTH OF INTACT ROCK CORE - ASTM D 7012



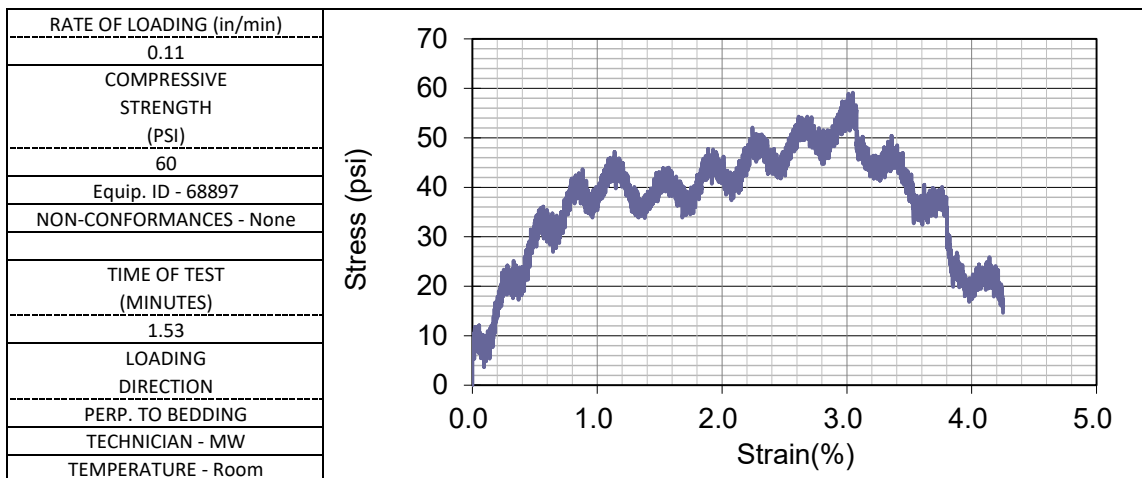
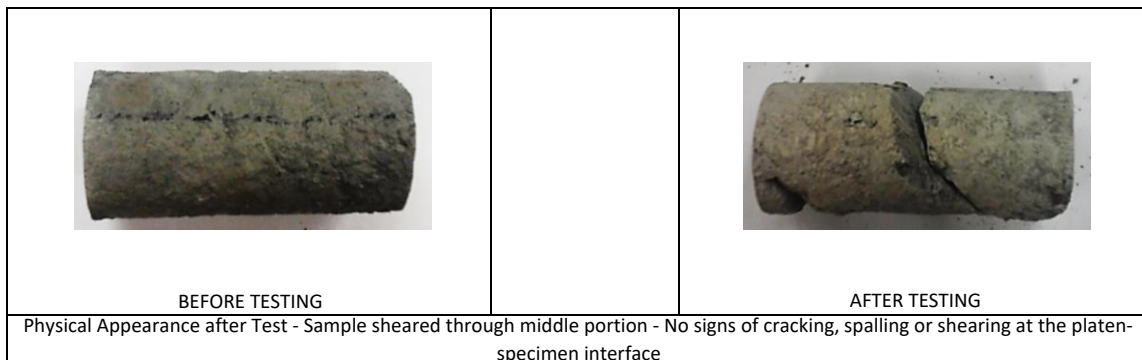
Method C

BORING NUMBER	B-005-0-25	TOP DEPTH(FT)	34.0	BOTTOM DEPTH(FT)	34.5
SAMPLE NUMBER	NQ2-2	DISTRICT	5	PID NO.	122866
COUNTY	Guernsey	ROUTE	NA	SECTION	NA

FORMATION	Pennsylvanian age Conemaugh Group
DESCRIPTION	Shale, Gray, Highly Weathered, Very Weak
MOISTURE CONDITION	As Received

MEASUREMENT	LENGTH(INCHES)	DIAMETER(INCHES)
1	4.039	1.777
2	4.065	1.991
3	4.063	1.986
AVERAGE	4.056	1.918

LENGTH/DIAMETER	2.1
CORRECTION FACTOR	1
AREA(IN ²)	2.9
MASS (GRAMS)	515.9
UNIT WEIGHT(LBS/FT ³)	167.7



APPENDIX D

HISTORICAL TEST BORING RECORDS



B-001-A-83

State of Ohio
Department of Transportation
Division of Highways
Testing Laboratory

NAVD88 ELEV = NGVD29 ELEV -0.686 FEET

5
11

LOG OF BORING

Date Started 1-10-83 Sampler Type SS Dia. 1 3/8" Water Elev. 922.6'
Date Completed 1-10-83 Casing Length _____ Dia. _____

Project Identification: GUERNSEY
GUE - 70 - 19.37 (EB)

SUBSURFACE INVESTIGATION
RENOVATION TO MOTORIST FACILITIES

Boring No. _____ Station & Offset TEST LOCATION 1A - (WET AREA) Surface Elev. 937.5'

Boring No.		Station & Offset		TEST LOCATION 1A - (WE) AREA 1		Surface Elev. 922.19		Physical Characteristics										SHTL
Elev.	Depth	Std. Pen. (N)	Description	ALLOW. BRNG. CAP. TSF		Field No.	Lab. Nos. So.	% Agg.	% Co.	F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	Class		
937.5	0		SOD AND TOPSOIL															
937.0																		
935.0			REDDISH BROWN CLAY															
932.5	4	3/6/9	BROWN WITH GRAY SILTY CLAY	2.0		1	31468	2	4	11	41	42	40	16	19	A-6a		
930.0	6	4/7/14	BROWN WITH GRAY SILT AND CLAY	2.7		2	31469	10	1	6	50	33	38	14	18	A-6a		
930.0	8	10/16/21	BROWN WITH GRAY SANDY GRAVELLY SILT	3.5		3	31470	28	11	14	30	17	32	8	16	A-4a		
927.5	10	21/30	BROWN WITH GRAY STONE FRAGMENTS WITH SAND AND FINES	10.0		4	31471	47	10	8	22	13	-	-	12	VISUAL		
	12		TOP OF ROCK															
922.5	14	50(0.5')	BROWN AND GRAY WEATHERED CLAY SHALE			5	31472	80	10	7	14	9	-	-	11	VISUAL		
	16																	
917.5	18																	
917.0	20	50(0.5')	GRAY CLAY SHALE			6	31473	71	9	5	9	6	-	-	4	VISUAL		
	22		BOTTOM OF BORING															
	24																	
	26																	
	28																	
	30																	
	32																	
	34																	
	36																	

B-000-A-83

State of Ohio
Department of Transportation
Division of Highways
Testing Laboratory

NAVD88 ELEV = NGVD29 ELEV -0.686 FEET

8
11

LOG OF BORING

Date Started: 1-11-83 Sampler Type: SS Dia: 1 7/8" Water Elev: 929.7'
Date Completed: 1-12-83 Casing Length: _____ Dia: _____

Project Identification: 4
SH-20-15-101
SH-20-15-101
SH-20-15-101

Boring No: B-1 Station & Offset: TEST LOCATION A Surface Elev: 936.4'

Elev.	Depth	Std Pen. (N)	Description	Surface Elev	Field No.	Lab Nos.	Physical Characteristics										SMTL Class
							% Agg.	% S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.			
936.4	0		508 AND TOPSOIL	44.1													
933.9	2		REDISH-BROWN CLAY AND SILT														
931.4	4	3/4/43	REDISH-BROWN SILTY CLAY	08.6	14	31481	13	3	4	40	40	58	17	22	A-5		
928.9	6	1/5/7	REDISH-BROWN SILTY CLAY WITH COAL BLOSSOM	1.5	15	31482	0	3	8	34	66	60	53	24	A-5		
926.4	8	3/4/183	BROWN WITH GRAY SILT AND CLAY	22.1	16	31483	0	6	9	45	39	34	12	21	A-5		
	10																
	12	10/24/47	BROWN WITH GRAY SILT AND CLAY	4.0	17	31484	7	3	6	51	33	32	11	12	A-5		
	14		TOP OF ROCK														
921.4	16	BT(0.5')	BROWN AND GRAY WEATHERED SHALE CLAY	78		31485	50	13	8	14	15	-	-	79	A-5		
	18		BOTTOM OF BORING														
	20																
	22																
	24																
	26																
	28																
	30																
	32																
	34																
	36																

Per T-43. Particle Size: Agg. > 2.00mm, Coarse Sand=200-0.42mm, Fine Sand=0.42-0.075mm, Silt=0.075-0.0075mm, Clay < 0.0075mm

State of Ohio
Department of Transportation
Division of Highways
Testing Laboratory

NAVD88 ELEV = NGVD29 ELEV -0.686 FEET

7
11

B-000-B-83

LOG OF BORING

Date Started 1-12-83 Sampler Type SS Dia 1 3/8" Water Elev _____
Date Completed 1-12-83 Casing Length _____ Dia _____

Project Identification: GUERNSEY

GUE-70-19.37 (EB)

SUBSURFACE INVESTIGATION

REMOVAL TO MOTORIST FACILITIES

Boring No. _____ Station & Offset TEST LOCATION B Surface Elev 935.5'

Boring No.	Station & Offset	Depth	Std. Pen. IN.	Description	ALLOW BRNG CAP TSE	Field No	Lab. Nos. So.	Physical Characteristics										SHTL Class
Elev								% Agg	% C	% F	% Silt	% Clay	LL	PI	WC			
935.5		0		SOD AND TOPSOIL														
935.0		2																
933.0		4	3/4/5	REDDISH-BROWN CLAY	0.5	19	31486	0	2	5	32	61	46	22	27	A-7-6		
930.5		6		BROWN AND GRAY STONE FRAGMENTS														
929.0		8	29/31/36	WITH SAND, FINES AND BOULDERS	-	20	31487	33	9	12	22	24	-	-	9	VISUAL		
		10		BOTTOM OF BORING - BOULDERS IMPENETRABLE														
		12																
		14																
		16																
		18																
		20																
		22																
		24																
		26																
		28																
		30																
		32																
		34																
		36																

State of Ohio
Department of Transportation
Division of Highways
Testing Laboratory

NAVD88 ELEV = NGVD29 ELEV -0.686 FEET

B-000-C-83

LOG OF BORING

Date Started: 1-11-83 Sample Type: SS Dia: 1 3/8" Water Elev:
Date Completed: 1-11-83 Casing Length: Dia:

Project Identification: GUERNSEY

GUE - 70 - 18.37 (FB)

SUBSURFACE INVESTIGATION
RENOVATION TO HIGHWAY FACILITIES

Boring No. Station B Offset TEST LOCATION C Surface Elev. 935.6'

Elev	Depth	Std Pen (N)	Description	ALLON BRNG CAP TSP	Field No	Lab Nos. So	% Agg	% CS	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	SHTL Class
935.8 935.5	0		SOD AND TOPSOIL												
933.1	2	P.S.	REDDISH-BROWN SILT AND CLAY **		7	31550	3	4	11	36	46	49	15	21	A-7-6
930.6	4	4/5/6	REDDISH BROWN GRAVELLY CLAY	4.5	8	31475	25	7	5	27	36	46	20	25	A-7-6
928.1	6	2/4/6	REDDISH BROWN SILT AND CLAY	1.1	9	31476	9	3	4	41	43	49	15	21	A-6a
925.6	10	23/50/58	BROWN SILTY GRAVELLY SAND	9.0	10	31477	28	25	16	17	14	28	7	6	A-2-4
	12	50(0.5')	BROWN WEATHERED ARENACEOUS SHALE		11	31478	37	20	12	19	12	-	-	7	VISUAL
	14		TOP OF ROCK												
920.6	16	53(0.5')	BROWN WEATHERED CLAY SHALE	-	12	31479	69	14	5	6	6	-	-	10	VISUAL
915.6	20	51(0.5')	GRAY CLAY SHALE	-	13	31480	26	12	16	38	16	-	-	7	VISUAL
	22		BOTTOM OF BORING												
	24														
	26		WATER WAS ENCOUNTERED AT 15:2' FEET, ELEVATION 920.4' AND ROSE TO 5.1 FEET ELEVATION 930.5' IN 15 MINUTES.												
	28														
	30														
	32														
	34		AVERAGE GRABING TRIAXIAL TEST												
	36														



B-000-C-83

State of Ohio
Department of Transportation
Division of Highways
Testing Laboratory

TRIAXIAL COMPRESSION TEST

Station & Offset TEST BORING - CProject Ident. GUE-70-19.37 (E.B.)Sample No. 7 Lab. No. 31560-A & BREST AREADepth 0.3' - 1.2' Rate of Strain 0.52%/MIN.

Type of Test _____

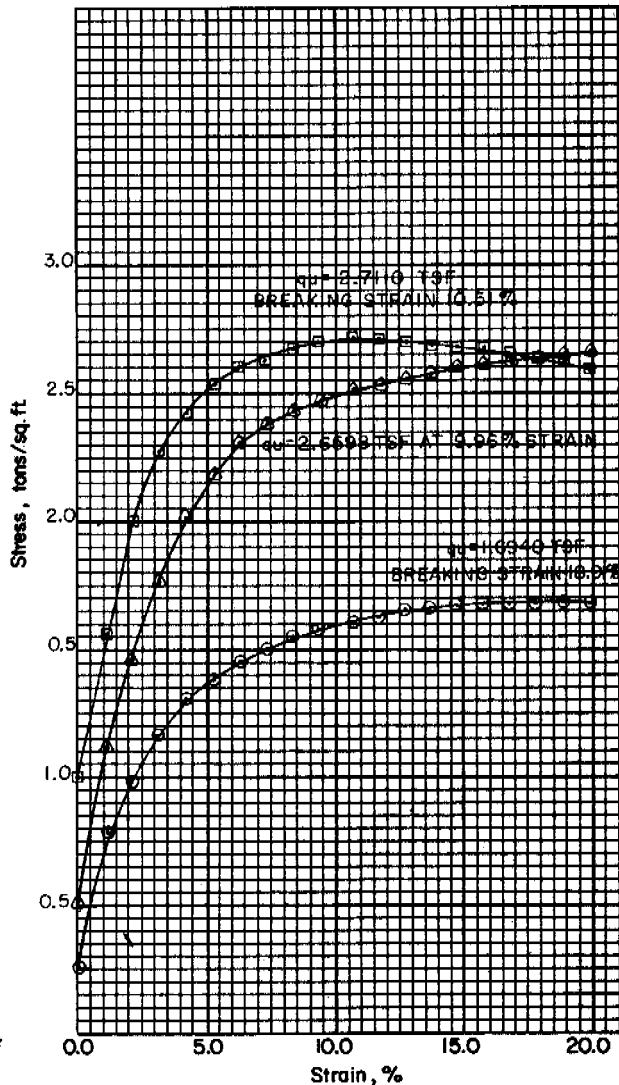


Diagram of Failure



Diagram of Failure

Penetrometer 2.25 TSFTorvane 1.00 TSFChamber Pressure 1.00 kg./cm²

Diagram of Failure



Diagram of Failure

Penetrometer 3.25 TSFTorvane 1.00 TSFChamber Pressure 0.50 kg./cm²

Diagram of Failure



Diagram of Failure

Penetrometer 1.75 TSFTorvane 0.87 TSFChamber Pressure 0.25 kg./cm²

Remarks _____



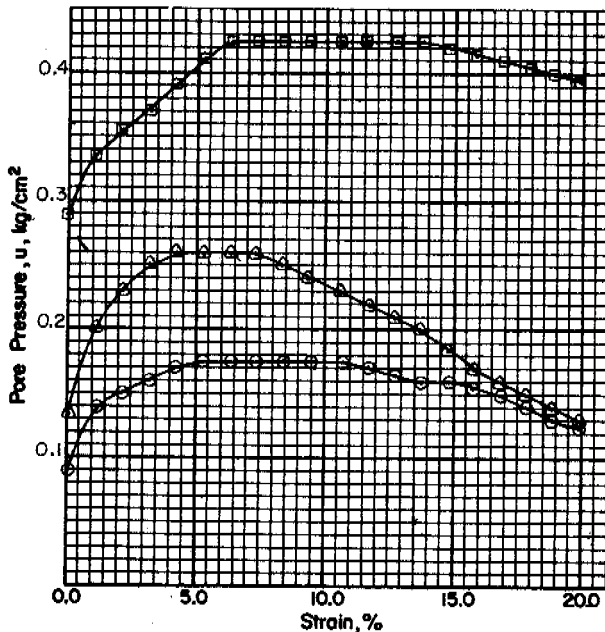
B-000-C-83

State of Ohio
Department of Transportation
Division of Highways
Testing Laboratory

TRIAXIAL COMPRESSION TEST

Station & Offset TEST BORING - CSample No. 7 Lab. No. 31560 - A & BDepth 0.3' - 1.2'Project Ident. GUE-70-19.37 (E.B.)

REST AREA

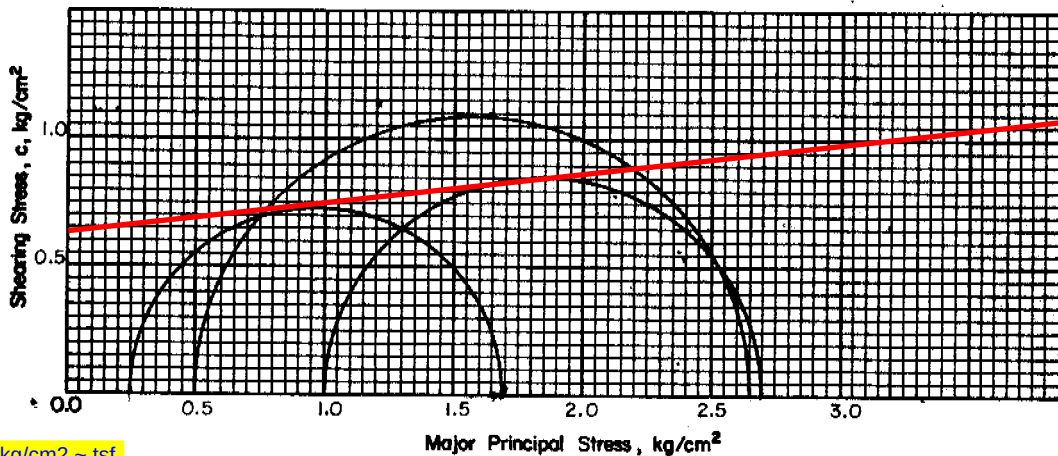


Physical Characteristics								Applied Load kg/cm ²
% Agg.	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	
4	4	9	36	47	40	15	21	0.25
5	3	14	38	40	37	13	21	0.50
0	4	6	35	55	45	17	21	1.00

Visual Description

REDDISH-BROWN SILT AND CLAY

Wet Density (lbs./cu. ft.)	Dry Density (lbs./cu. ft.)	Applied Load kg/cm ²
130.38	107.89	0.25
131.32	113.65	0.50
130.69	103.49	1.00

kg/cm² - tsf

Form TE-21

APPENDIX E

SUBGRADE ANALYSIS



OHIO DEPARTMENT OF TRANSPORTATION**OFFICE OF GEOTECHNICAL ENGINEERING****PLAN SUBGRADES****Geotechnical Design Manual Section 600**

**Arcadis U-S- Inc
VAR-STW-Truck Parking SE Ohio
GUE-IR70 EB Rest Area (Site 3B)**

CTL ENGINEERING, INC

Prepared By: Gaurav Verma
Date prepared: Monday, July 27, 2026

**CTL Engineering, Inc.
2860 Fisher Road
Columbus
Ohio 43204
773-575-0956
gverma@ctleng.com**

NO. OF BORINGS: 10

NO. OF DCPS:



#	Boring ID	Alignment	Station	Add DCP Test Data Worksheets				Boring EL.	Proposed Subgrade EL	Cut Fill
				Offset	Dir	Drill Rig	ER			
1	B-001-0-25	Site 3B	9+95	5'	RT.	Diedrich D-70	81	926.1	925.7	0.4 C
2	B-002-0-25	Site 3B	13+04	56'	RT.	Diedrich D-70	81	942.0	935.4	6.6 C
3	B-003-1-25	Site 3B	14+71	120'	LT.	Diedrich D-70	81	932.9	932.7	0.2 C
4	B-004-1-25	Site 3B	15+55	17'	LT.	Diedrich D-70	81	934.0	933.4	0.6 C
5	B-005-1-25	Site 3B	17+13	43'	RT.	Diedrich D-70	81	933.1	933.4	0.3 F
6	B-007-0-26	Site 3B	21+18	5'	RT.	Diedrich D-70	81	932.6	931.7	0.9 C
7	B-003-0-25	Site 3B	14+49	183'	RT.	Diedrich D-71	81	949.4	935.2	14.2 C
8	B-004-0-25	Site 3B	15+89	169'	RT.	Diedrich D-72	81	943.5	935.2	8.3 C
9	B-005-0-25	Site 3B	17+25	171'	RT.	Diedrich D-73	81	939.7	934.7	5.0 C
10	B-006-0-25	Site 3B	18+57	163'	RT.	Diedrich D-74	81	939.0	934.2	4.8 C



#	Boring	Sample	Sample Depth		Subgrade Depth		Standard Penetration		HP (tsf)	Physical Characteristics					Moisture		Ohio DOT		Sulfate Content (ppm)	Problem		Excavate and Replace (Item 204)		Recommendation (Enter depth in inches)	
			From	To	From	To	N ₆₀	N _{60L}		LL	PL	PI	% Silt	% Clay	P200	M _C	M _{OPT}	Class		GI	Unsuitable	Unstable	Unsuitable		Unstable
1	B 001-0 25	SS-1	1.0	2.5	0.6	2.1	11	11	0.5	26	15	11	18	20	38	29	14	A-6a	1	99		HP & Mc		24"	18" 204 Geogrid
		SS-2	2.5	4.0	2.1	3.6	15		0.5	32	18	14	26	25	51	17	14	A-6a	5						
		SS-3	4.0	5.5	3.6	5.1	16		3.25							9	14	A-6a	10						
		SS-4	5.5	7.0	5.1	6.6	19		1.5							15	14	A-6a							
2	B 002-0 25	SS-2	3.5	5.0	-3.1	-1.6	16	16	2.25	53	25	28	25	64	89	20	22	A-7-6	18	99					12" 204 Geotextile
		SS-3	6.0	7.5	-0.6	0.9	16		3.25							22	18	A-7-6	16			Mc			
		SS-4	8.5	10.0	1.9	3.4	22		1	57	27	30	34	56	90	31	24	A-7-6	19			HP & Mc			
		SS-5	11.0	12.5	4.4	5.9	20		4.5	44	26	18	36	35	71	18	23	A-7-6	11						
3	B 003-1 25	SS-1	1.0	2.5	0.8	2.3	12	12		42	22	20	37	32	69	14	19	A-7-6	11	99					
		SS-2	2.5	4.0	2.3	3.8	19		4							14	18	A-7-6	16						
		SS-3	4.0	5.5	3.8	5.3	19		2	50	28	22	38	45	83	12	25	A-7-6	15						
		SS-4	5.5	7.0	5.3	6.8	19		1.5							28	18	A-7-6							
4	B 004-1 25	SS-1	1.0	2.5	0.4	1.9	11	11	1.25	54	24	30	34	54	88	13	21	A-7-6	19	99		HP		12"	12" 204 Geotextile
		SS-2	3.5	5.0	2.9	4.4	19		2							15	16	A-6b	16						
		SS-3	6.0	7.5	5.4	6.9	23		2.25	36	20	16	22	27	49	16	16	A-6b							
		SS-4	8.5	10.0	7.9	9.4	20		2							25	16	A-6b							
5	B 005-1 25	SS-1	1.0	2.5	1.3	2.8	11	11	2.25	47	23	24	31	40	71	25	20	A-7-6	14	99		N ₆₀ & Mc			12" 204 Geotextile
		SS-2	2.5	4.0	2.8	4.3	11		4.5							16	18	A-7-6	16						
		SS-3	4.0	5.5	4.3	5.8	17		1.5	49	24	25	31	37	68	24	21	A-7-6	14						
		SS-4	5.5	7.0	5.8	7.3	15		1.25							26	18	A-7-6							
6	B 007-0 26	SS-1	1.0	2.5	0.1	1.6	39	30		30	17	13	16	16	32	11	10	A-2-6	1	99					
			2.5	4.0	1.6	3.1	30									15	0	Rock	0						
			4.0	5.5	3.1	4.6	30									12	0	Rock	0						
			5.5	7.0	4.6	6.1	30									7	0	Rock	0						
7	B 003-0 25	SS-7	11.0	12.5	-3.2	-1.7	36	16	4.25	41	22	19	40	44	84	15	19	A-7-6	12						12" 204 Geogrid
		SS-8	13.5	15.0	-0.7	0.8	31									15	18	A-7-6	16						
		SS-9	16.0	17.5	1.8	3.3	16		0.5							17	18	A-7-6	16			HP			
		SS-10	18.5	20.0	4.3	5.8	69									22	16	A-6b	16						
8	B 004-0 25	SS-3	6.0	7.5	-2.3	-0.8	16	15	0.5							18	18	A-7-6	16						12" 204 Geogrid
		SS-4	8.5	10.0	0.2	1.7	15			45	26	19	13	17	30	32	10	A-2-7	1			Mc			
		SS-5	11.0	11.3	2.7	3.0	30									10	0	Rock	0						
		SS-6	13.5	13.8	5.2	5.4	30									8	0	Rock							
9	B 005-0 25	SS-2	3.5	5.0	-1.5	0.0	9	7	1.25							21	16	A-6b	16						12" 204 Geogrid
		SS-3	6.0	7.5	1.0	2.5	13		0.5	49	23	26	35	50	85	25	20	A-7-6	16			HP & Mc		24"	
		SS-4	8.5	10.0	3.5	5.0	12		0.25							25	18	A-7-6	16						
		SS-5	11.0	12.5	6.0	7.5	7		1.5	68	31	37	25	54	79	34		A-7-5			High LL		36"		



V. 14.81

7/21/2025

[illegible]

PID: Arcadis U-S-

County-Route-Section: 0

No. of Borings: 10

Geotechnical Consultant: CTL ENGINEERING, INC

Prepared By: Gaurav Verma

Date prepared: 7/27/2026

Chemical Stabilization Options		
320	Rubblize & Roll	Option
206	Cement Stabilization	No
	Lime Stabilization	Option
206	Depth	12"

Excavate and Replace Stabilization Options	
Global Geotextile Average(N60L):	12"
Average(HP):	12"
Global Geogrid Average(N60L):	0"
Average(HP):	0"

Design CBR	6
------------	---

% Samples within 3 feet of subgrade			
$N_{60} \leq 5$	0%	$HP \leq 0.5$	15%
$N_{60} < 12$	12%	$0.5 < HP \leq 1$	6%
$12 \leq N_{60} < 15$	12%	$1 < HP \leq 2$	6%
$N_{60} \geq 20$	18%	$HP > 2$	12%
M+	24%		
Rock	10%		
Unsuitable Soil	5%		

Excavate and Replace at Surface	
Average	0"
Maximum	0"
Minimum	0"

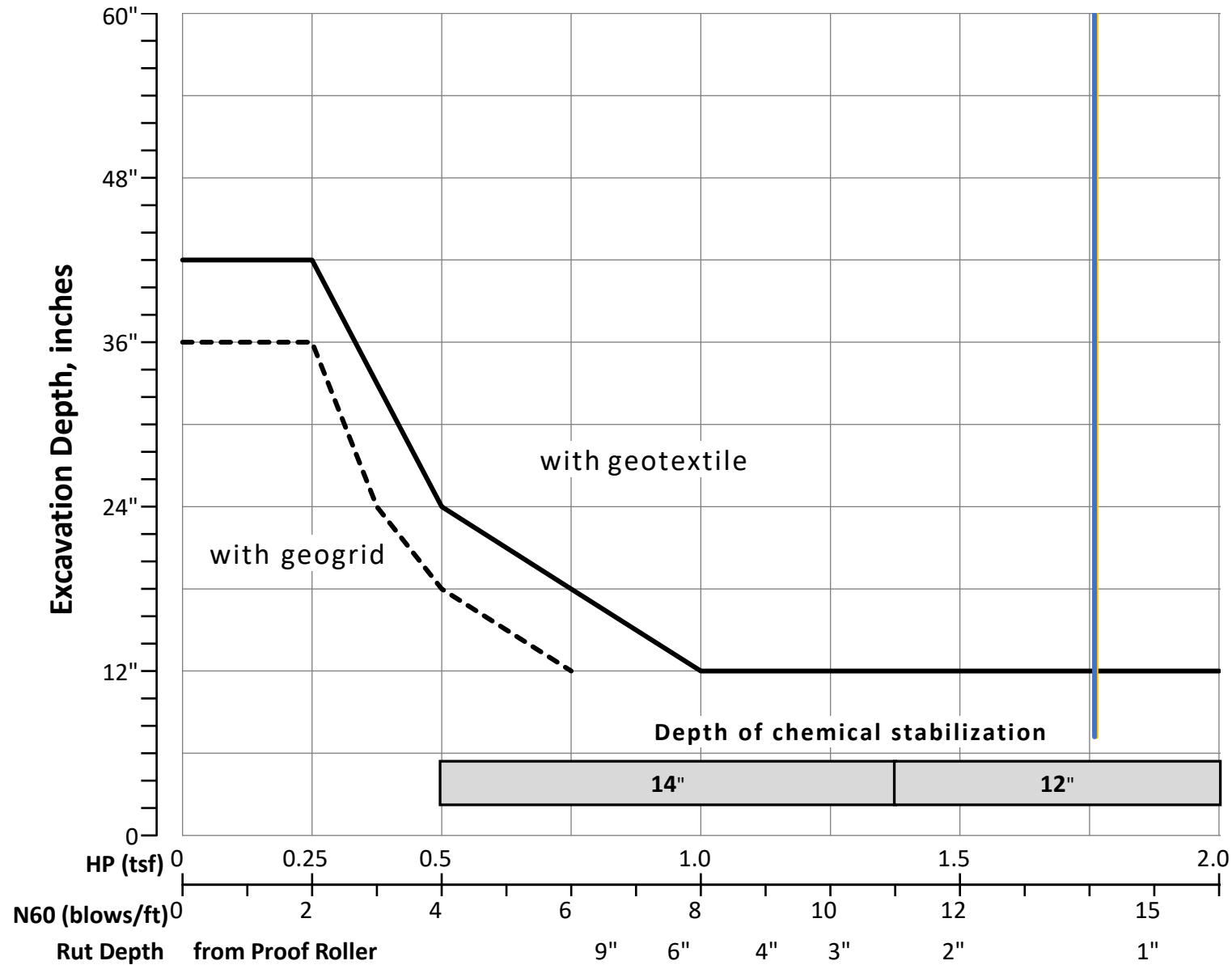
% Proposed Subgrade Surface	
Unstable & Unsuitable	57%
Unstable	48%
Unsuitable (Soil & Rock)	10%

	N_{60}	N_{60L}	HP	LL	PL	PI	Silt	Clay	P 200	M_C	M_{OPT}	GI
Average	21	14	1.76	46	23	23	28	38	66	20	15	11
Maximum	69	30	4.50	75	31	46	40	79	98	35	26	20
Minimum	7	7	0.25	26	15	11	13	16	30	7	0	0

Classification Counts by Sample																					
ODOT Class	UCF	Rock	A-1-a	A-1-b	A-2-4	A-2-5	A-2-6	A-2-7	A-3	A-3a	A-4a	A-4b	A-5	A-6a	A-6b	A-7-5	A-7-6	A-8a	A-8b	Totals	
Count	0	5	0	0	0	0	1	1	0	0	0	0	0	5	4	1	19	0	0	36	
Percent	0%	14%	0%	0%	0%	0%	3%	3%	0%	0%	0%	0%	0%	14%	11%	3%	53%	0%	0%	100%	
% Rock Granular Cohesive	0%	14%	6%									81%									100%
Surface Class Count	0	2	0	0	0	0	1	1	0	0	0	0	0	2	1	0	14	0	0	21	
Surface Class Percent	0%	10%	0%	0%	0%	0%	5%	5%	0%	0%	0%	0%	0%	10%	5%	0%	67%	0%	0%	100%	



Fig. 600-1 – Subgrade Stabilization



OVERRIDE TABLE

Calculated Average	New Values	Check to Override
1.76	0.50	☐ HP
14.10	6.00	☐ N60L

Average HP



Average N_{60L}



APPENDIX F

LIGHT TOWER ANALYSIS



Soil and Bedrock Parameters

Project Arcadis U-S- Inc-_GUE-IR70 EB Rest Area (Site 3B)
 Location Guernsey County, Ohio
 Light Tower Foundation 10' Deep and 36" Dia

Light Tower	Station	Nearest Boring	Proposed Top Elev	Propsoed Bottom Elev	Thickness (feet)	Soil Layer	Lpile Soil/Rock Model	Type	Effective Unit Weight (pcf)	Undrained Shear Strength (psf)	Friction Angle (degrees)	Unconfined Compressive Strength (psi)	Reference
AA-1	18+62.7	B-006-0-25	937	927	3	Frost Zone	Soft Clay Matlock	A-7-6, A-6a	108	250	0		1, 2, 3
					8.5	Clay Foundation	Stiff Clay w/ Free Water Reese		62.6	1200	0		
					3	Weak Augerable Rock	Weak Rock Reese	Shale	77.6			60	
					10.0	Coreable Rock*	Massive Rock	Shale	87.6			500	

*Poisson's Ratio- 0.25; GSI-40; Intact Rock Modulus- 30,000psi

Reference Key

- 1 Undrained shear strength of cohesive soils estimated according to ODOT GDM Section 404.1
- 2 Total stress friction angle of cohesive soils estimated to be 0
- 3 Unconfined compressive test results of sample collected in Shelby tube

GUE-IR70 EB Rest Area (Site 3B)

								LPILE Inputs			LPILE Outputs				M and V	Flexural (Moment) Resistance				Shear Resistance				Deflection									
								Axial	Shear	Bending	Shear	Bending	Axial	Deflect	Slope	Bending	Shear	Resist.	Bending	Flexure	Flexure	Flexure	Shear	Shear	Shear	Shear	Deflect	Slope	Pole	Deflect	Δ _{max}	Pole	Deflect
Tower Number	Boring Number	D (feet)	W (in)	Long Bars	Hoop Bars	Clear Cover	Limit State	Fz (lb)	Fv (lb)	Mu (ft-lb)	Fv (lb)	Mu (in-lb)	Fz (lb)	Δy (in)	S (rad)	M _{max} (in-lb)	V _{max} (lb)	Factor φ _{f, v}	M _{max} (in-kip)	M _n (in-kip)	M _r (in-kip)	CDF _r (M _r /M _{max})	F _{max} (kip)	V _n (kip)	V _r (kip)	CDR _v (V _r /V _{max})	Δy (in)	S (rad)	Height H (ft)	Top Δ (in)	Criterion %H	Δ _{max} (in)	CDR _Δ (Δ _{max} /Top Δ)
AA-1	B-006-0-25	10	36	16 - #9	#4 12" c/c	2.5"	Extreme	1827.12	1929.50	73239.89	1929.50	878878.68	1827.12	2.2862	0.02852	896964	15748	0.9	896.96	12356	11120	12.40	15.75	752.04	676.83	42.98	2.2862	0.028520	45	17.687	NA*	NA*	NA*
	Average Su (psf)						Service	2030.13	909.28	33754.38	909.28	405052.56	2030.13	0.7054	0.0091	411026	6549	1.00	411.03	12359	12359	30.07	6.55	752.04	752.04	114.83	0.7054	0.009100	45	5.619	10.00	54.000	9.61
	1200																																

36-inch Drilled Shaft			Nominal Shear Resistance (kips)																																
1.125	in	Cage Long Bars	Hoop Spacing, s (in):	4.5																															
0.500	in	Cage Spiral/Hoop	Spiral Angle, α (deg.):	90																															
2.50	in	Concrete Cover	Shear Width, b_v (in):	36.00	=D																														
36.00	in	Drilled Shaft Diameter, D	Shear Depth, d_v (in):	24.47	=0.9(D/2+D _r /π) (per AASHTO LRFD Equation 5.7.2.8-2)																														
3.5625	in	Edge to CL of Long Bars	Shear Area, A_v (in ²):	1.963	Area of a transverse reinforcement within distance s																														
28.875	in	Effective Diameter of Reinforcing Steel, D _r	Stress Angle, θ (deg.):	45	(5.7.3.4.1)																														
0.196	in ²	Area of Spiral/Hoop Bar, A _{sh}	Shear Resistance, V _s (kip):	640.68	=(A _v f _y d _v (cot θ + cot α) sin α)/s (per AASHTO LRFD Equation 5.7.3.3-4)																														
60	ksi	Steel Yield Stress, f _y	Diagonal Shear Factor (β):	2	(5.7.3.4.1)																														
4	ksi	Concrete Comp. Strength, f' _c	Density Mod. Factor (λ):	1	(for normal-weight concrete)																														
			Shear Resistance, V _c (kip):	111.36	=0.0316 β λ (f' _c) ^{0.5} b _v d _v (per AASHTO LRFD Equation 5.7.3.3-3)																														
			Shear Resistance, V _n (kip):	752.04	=V _s + V _c (per AASHTO LRFD Equation 5.7.3.3-1)																														
			Shear Resistance, V _n (kip):	880.99	=0.25 f' _c b _v d _v (per AASHTO LRFD Equation 5.7.3.3-2)																														
			Nominal Shear Resistance, V _n (kip):	752.04	(lesser of 5.7.3.3-1 or 5.7.3.3-2)																														

*Solution just needs to converge (deflections at top of shaft not excessive indicating pushover, e.g. 10 to 20 inches)

=====

LFile for Version 2022-12.012

License ID : 224802699
License Type : (Network License)

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method
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All Rights Reserved

This software is licensed for exclusive use by:
CTL ENGINEERING INC
Columbus, OH

=====

This model was prepared by:
gverma

Files Used for Analysis

Path to file locations:
\PROJECT\2025\C0L-05\25050075C0L_Arcadis U-S- Inc-_GUE-IR70 EB Rest Area (Site
3B)\Design\Light Towers\L-Pile Analysis\

Name of input data file:
Eastbound US 35 Light Tower AA-1_Service.lp12d

Name of output report file:
Eastbound US 35 Light Tower AA-1_Service.lp12o

Name of plot output file:
Eastbound US 35 Light Tower AA-1_Service.lp12p

Name of runtime message file:
Eastbound US 35 Light Tower AA-1_Service.lp12r

Date and Time of Analysis

Date: June 10, 2026

Time: 21:02:29

Problem Title

Project Name: GUE-IR70 EB Rest Area (Site 3B)

Job Number: PID 122866

Client:

Engineer: GV

Description: Eastbound IR-70 Light Tower AA-1 Service Load

Program Options and Settings

Computational Options:

- Conventional Analysis

Engineering Units Used for Data Input and Computations:

- US Customary System Units (pounds, feet, inches)

Analysis Control Options:

- | | | |
|--|---|---------------|
| - Maximum number of iterations allowed | = | 500 |
| - Deflection tolerance for convergence | = | 1.0000E-05 in |
| - Maximum allowable deflection | = | 100.0000 in |
| - Number of pile increments | = | 100 |

Loading Type and Number of Cycles of Loading:

- | | | |
|-------------------------------|---|------------|
| - Cyclic loading specified | | |
| - Number of cycles of loading | = | 100 cycles |

- Use of p-y modification factors for p-y curves not selected
- Analysis uses layering correction (Method of Georgiadis)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:

- Output files use decimal points to denote decimal symbols.
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

Pile Structural Properties and Geometry

Number of pile sections defined	=	1
Total length of pile	=	10.000 ft
Depth of ground surface below top of pile	=	0.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	36.0000
2	10.000	36.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a round drilled shaft, bored pile, or CIDH pile	
Length of section	= 10.000000 ft
Shaft Diameter	= 36.000000 in

Soil and Rock Layering Information

The soil profile is modelled using 4 layers

Layer 1 is soft clay, p-y criteria by Matlock, 1970

Distance from top of pile to top of layer	=	0.0000 ft
Distance from top of pile to bottom of layer	=	3.000000 ft
Effective unit weight at top of layer	=	108.000000 pcf
Effective unit weight at bottom of layer	=	108.000000 pcf
Undrained cohesion at top of layer	=	250.000000 psf
Undrained cohesion at bottom of layer	=	250.000000 psf
Epsilon-50 at top of layer	=	0.020000
Epsilon-50 at bottom of layer	=	0.020000

Layer 2 is stiff clay with water-induced erosion

Distance from top of pile to top of layer	=	3.000000 ft
Distance from top of pile to bottom of layer	=	11.500000 ft
Effective unit weight at top of layer	=	62.600000 pcf
Effective unit weight at bottom of layer	=	62.600000 pcf
Undrained cohesion at top of layer	=	1200. psf
Undrained cohesion at bottom of layer	=	1200. psf
Epsilon-50 at top of layer	=	0.070000
Epsilon-50 at bottom of layer	=	0.070000
Subgrade k at top of layer	=	0.0000 pci
Subgrade k at bottom of layer	=	0.0000 pci

NOTE: Default values for subgrade k will be computed for this layer.

Layer 3 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	11.500000 ft
Distance from top of pile to bottom of layer	=	14.500000 ft
Effective unit weight at top of layer	=	77.600000 pcf
Effective unit weight at bottom of layer	=	77.600000 pcf
Uniaxial compressive strength at top of layer	=	60.000000 psi
Uniaxial compressive strength at bottom of layer	=	60.000000 psi
Initial modulus of rock at top of layer	=	5400. psi
Initial modulus of rock at bottom of layer	=	5400. psi
RQD of rock at top of layer	=	0.0000 %
RQD of rock at bottom of layer	=	0.0000 %
k _{rm} of rock at top of layer	=	0.0005000
k _{rm} of rock at bottom of layer	=	0.0005000

Layer 4 is massive rock, p-y criteria by Liang et al., 2009

Distance from top of pile to top of layer = 14.500000 ft
Distance from top of pile to bottom of layer = 24.300000 ft
Effective unit weight at top of layer = 87.600000 pcf
Effective unit weight at bottom of layer = 87.600000 pcf
Uniaxial compressive strength at top of layer = 500.000000 psi
Uniaxial compressive strength at bottom of layer = 500.000000 psi
Poisson's ratio at top of layer = 0.250000
Poisson's ratio at bottom of layer = 0.250000
Option 1: Intact rock modulus at top of layer = 30000. psi
Intact rock modulus at bottom of layer = 30000. psi
Option 1: Geologic Strength Index for layer = 40.000000
Option 2: Rock mass modulus at top of layer = 0.0000 psi
Rock mass modulus at bottom of layer = 0.0000 psi
Option 1 will be used to compute values of rock mass modulus for the p-y curve
in massive rock.
The rock type is (sedimentary) shales, Hoek-Brown Material Constant mi = 6

(Depth of the lowest soil layer extends 14.300 ft below the pile tip)

Summary of Input Soil Properties

Layer	Soil Type	Layer	Effective	Cohesion	Uniaxial
	E50	Rock Mass	Geologic	Int. Rock	
Hoek-Brown					
Num.	Name	Depth	Unit Wt.		qu
RQD %	or	Modulus	Strength	Modulus	Material
Poisson's					
(p-y Curve Type)		ft	pcf	psf	psi
krm	pci	psi	Index	psi	Index,
mi	Ratio				
1	Soft	0.00	108.0000	250.0000	--
--	0.02000	--	--	--	0.00
0.00	0.00				
	Clay	3.0000	108.0000	250.0000	--
--	0.02000	--	--	--	0.00
0.00	0.00				
2	Stiff Clay	3.0000	62.6000	1200.	--
--	0.07000	default	--	--	0.00

0.00	0.00					
	with Free Water		11.5000	62.6000	1200.	--
--	0.07000	default	--	--		0.00
0.00	0.00					
3	Weak		11.5000	77.6000	--	60.0000
0.00	5.00E-04	--	5400.	--		0.00
0.00	0.00					
	Rock		14.5000	77.6000	--	60.0000
0.00	5.00E-04	--	5400.	--		0.00
0.00	0.00					
4	Massive		14.5000	87.6000	--	500.0000
--	--	--	Internally	40.0000		30000.
6.0000	0.2500					
	Rock		24.3000	87.6000	--	500.0000
--	--	--	Computed	40.0000		30000.
6.0000	0.2500					

Cyclic Loading Type

Cyclic loading criteria were used for computation of p-y curves for all analyses.

Number of cycles of loading = 100

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load Compute No.	Load Top y Type	Condition Run Analysis 1	Condition 2	Axial Thrust Force, lbs
vs. Pile Length				
-----	-----	-----	-----	-----
1	1	V = 910.000000 lbs	M = 405053. in-lbs	2030.
Yes		Yes		

V = shear force applied normal to pile axis

M = bending moment applied to pile head

y = lateral deflection normal to pile axis

S = pile slope relative to original pile batter angle

R = rotational stiffness applied to pile head

Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).

Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Drilled Shaft (Bored Pile):

Length of Section	=	10.000000 ft
Shaft Diameter	=	36.000000 in
Concrete Cover Thickness (to edge of trans. reinf.)	=	3.000000 in
Number of Reinforcing Bars	=	16 bars
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Shaft	=	1018. sq. in.
Total Area of Reinforcing Steel	=	16.000000 sq. in.
Area Ratio of Steel Reinforcement	=	1.57 percent
Edge-to-Edge Bar Spacing	=	4.309557 in
Maximum Concrete Aggregate Size	=	0.750000 in
Ratio of Bar Spacing to Aggregate Size	=	5.75
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in
Transverse Reinforcement		
Type: Spiral		
Number of Transverse Reinf. (per spacing)	=	1
Spacing of Transverse Reinf.	=	4.500000 in
Yield Stress of Transverse Reinf.	=	60000. psi
Diameter of Transverse Reinf.	=	0.500000 in

Axial Structural Capacities:

Nom. Axial Structural Capacity = $0.85 F_c A_c + F_y A_s$	=	4366.378 kips
Tensile Load for Cracking of Concrete	=	-470.222 kips
Nominal Axial Tensile Capacity	=	-960.000 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
-----	-----	-----	-----	-----

1	1.128000	1.000000	13.936000	0.000000
2	1.128000	1.000000	12.875185	5.333076
3	1.128000	1.000000	9.854240	9.854240
4	1.128000	1.000000	5.333076	12.875185
5	1.128000	1.000000	0.000000	13.936000
6	1.128000	1.000000	-5.33308	12.875185
7	1.128000	1.000000	-9.85424	9.854240
8	1.128000	1.000000	-12.87519	5.333076
9	1.128000	1.000000	-13.93600	0.000000
10	1.128000	1.000000	-12.87519	-5.33308
11	1.128000	1.000000	-9.85424	-9.85424
12	1.128000	1.000000	-5.33308	-12.87519
13	1.128000	1.000000	0.000000	-13.93600
14	1.128000	1.000000	5.333076	-12.87519
15	1.128000	1.000000	9.854240	-9.85424
16	1.128000	1.000000	12.875185	-5.33308

NOTE: The positions of the above rebars were computed by LPile

Minimum spacing between any two bars not equal to zero = 4.310 inches
between bars 15 and 16.

Ratio of bar spacing to maximum aggregate size = 5.75

Concrete Properties:

Compressive Strength of Concrete	=	4000. psi
Modulus of Elasticity of Concrete	=	3604997. psi
Modulus of Rupture of Concrete	=	-474.34165 psi
Compression Strain at Peak Stress	=	0.001886
Tensile Strain at Fracture of Concrete	=	-0.0001154
Maximum Coarse Aggregate Size	=	0.750000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
-----	-----
1	2.030

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.

T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318-14, Section 21.2.3.

Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.

Position of neutral axis is measured from edge of compression side of pile.

Compressive stresses and strains are positive in sign.

Tensile stresses and strains are negative in sign.

Axial Thrust Force = 2.030 kips

Bending Max Conc Curvature Stress rad/in. ksi	Bending Max Steel Moment Stress in-kip ksi	Bending Run Stiffness Msg kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in
-----	-----	-----	-----	-----	-----
6.25000E-07	242.1978621	387516579.	18.6907284	0.00001168	-0.00001082
0.0489165	0.2767820				
0.00000125	483.5282081	386822567.	18.3461618	0.00002293	-0.00002207
0.0957276	0.5410734				
0.00000188	723.9894145	386127688.	18.2313088	0.00003418	-0.00003332
0.1422597	0.8053649				
0.00000250	963.5814810	385432592.	18.1738842	0.00004543	-0.00004457
0.1885129	1.0696566				
0.00000313	1202.	384737410.	18.1394310	0.00005669	-0.00005581
0.2344872	1.3339484				
0.00000375	1440.	384042185.	18.1164634	0.00006794	-0.00006706
0.2801825	1.5982404				
0.00000438	1677.	383346935.	18.1000591	0.00007919	-0.00007831
0.3255989	1.8625325				
0.00000500	1913.	382651670.	18.0877568	0.00009044	-0.00008956
0.3707363	2.1268247				
0.00000563	2149.	381956394.	18.0781892	0.0001017	-0.000101
0.4155948	2.3911171				
0.00000625	2383.	381261111.	18.0705358	0.0001129	-0.000112
0.4601744	2.6554096				
0.00000688	2383.	346601010.	10.0740800	0.00006926	-0.000178
0.2832908	-4.487116 C				
0.00000750	2383.	317717592.	10.0594623	0.00007545	-0.000195
0.3080819	-4.898214 C				
0.00000813	2383.	293277777.	10.0474929	0.00008164	-0.000211
0.3328034	-5.309219 C				
0.00000875	2383.	272329365.	10.0376053	0.00008783	-0.000227
0.3574549	-5.720129 C				

0.00000938	2383.	254174074.	10.0293842	0.00009403	-0.000243
0.3820365	-6.130944 C				
0.00001000	2383.	238288194.	10.0225179	0.0001002	-0.000260
0.4065480	-6.541664 C				
0.00001063	2383.	224271242.	10.0167682	0.0001064	-0.000276
0.4309893	-6.952290 C				
0.00001125	2383.	211811728.	10.0119497	0.0001126	-0.000292
0.4553604	-7.362820 C				
0.00001188	2383.	200663742.	10.0079163	0.0001188	-0.000309
0.4796611	-7.773254 C				
0.00001250	2383.	190630555.	10.0045509	0.0001251	-0.000325
0.5038914	-8.183592 C				
0.00001313	2383.	181552910.	10.0017587	0.0001313	-0.000341
0.5280511	-8.593834 C				
0.00001375	2383.	173300505.	9.9994623	0.0001375	-0.000358
0.5521401	-9.003979 C				
0.00001438	2383.	165765700.	9.9975976	0.0001437	-0.000374
0.5761584	-9.414028 C				
0.00001500	2383.	158858796.	9.9961113	0.0001499	-0.000390
0.6001058	-9.823979 C				
0.00001563	2383.	152504444.	9.9949586	0.0001562	-0.000406
0.6239822	-10.233833 C				
0.00001625	2383.	146638889.	9.9941015	0.0001624	-0.000423
0.6477875	-10.643590 C				
0.00001688	2383.	141207819.	9.9935078	0.0001686	-0.000439
0.6715217	-11.053249 C				
0.00001750	2383.	136164682.	9.9931497	0.0001749	-0.000455
0.6951846	-11.462809 C				
0.00001813	2383.	131469349.	9.9930036	0.0001811	-0.000471
0.7187762	-11.872272 C				
0.00001875	2383.	127087037.	9.9930485	0.0001874	-0.000488
0.7422962	-12.281635 C				
0.00001938	2383.	122987455.	9.9932666	0.0001936	-0.000504
0.7657447	-12.690900 C				
0.00002000	2383.	119144097.	9.9936421	0.0001999	-0.000520
0.7891215	-13.100065 C				
0.00002063	2383.	115533670.	9.9941612	0.0002061	-0.000536
0.8124264	-13.509131 C				
0.00002125	2383.	112135621.	9.9948117	0.0002124	-0.000553
0.8356595	-13.918097 C				
0.00002188	2383.	108931746.	9.9955826	0.0002187	-0.000569
0.8588206	-14.326963 C				
0.00002250	2383.	105905864.	9.9964645	0.0002249	-0.000585
0.8819095	-14.735729 C				
0.00002313	2383.	103043543.	9.9974488	0.0002312	-0.000601
0.9049262	-15.144394 C				
0.00002375	2383.	100331871.	9.9985543	0.0002375	-0.000618
0.9278706	-15.552958 C				
0.00002438	2383.	97759259.	9.9997218	0.0002437	-0.000634
0.9507426	-15.961421 C				

0.00002563	2494.	97344794.	10.0022961	0.0002563	-0.000666
0.9962688	-16.778042 C				
0.00002688	2614.	97263554.	10.0051549	0.0002689	-0.000699
1.0415039	-17.594254 C				
0.00002813	2733.	97184819.	10.0082632	0.0002815	-0.000731
1.0864471	-18.410056 C				
0.00002938	2853.	97108247.	10.0115920	0.0002941	-0.000763
1.1310975	-19.225444 C				
0.00003063	2972.	97033550.	10.0151170	0.0003067	-0.000796
1.1754542	-20.040417 C				
0.00003188	3091.	96960487.	10.0188177	0.0003193	-0.000828
1.2195162	-20.854972 C				
0.00003313	3209.	96888852.	10.0226769	0.0003320	-0.000860
1.2632828	-21.669106 C				
0.00003438	3328.	96818469.	10.0266797	0.0003447	-0.000893
1.3067529	-22.482818 C				
0.00003563	3447.	96749187.	10.0308135	0.0003573	-0.000925
1.3499257	-23.296103 C				
0.00003688	3565.	96680875.	10.0350674	0.0003700	-0.000957
1.3928002	-24.108961 C				
0.00003813	3683.	96613418.	10.0394318	0.0003828	-0.000990
1.4353754	-24.921388 C				
0.00003938	3802.	96546717.	10.0438985	0.0003955	-0.001022
1.4776505	-25.733382 C				
0.00004063	3920.	96480684.	10.0484604	0.0004082	-0.001054
1.5196244	-26.544940 C				
0.00004188	4037.	96415241.	10.0531110	0.0004210	-0.001087
1.5612963	-27.356059 C				
0.00004313	4155.	96350321.	10.0578449	0.0004337	-0.001119
1.6026651	-28.166737 C				
0.00004438	4273.	96285862.	10.0626571	0.0004465	-0.001151
1.6437298	-28.976971 C				
0.00004563	4390.	96221809.	10.0675433	0.0004593	-0.001183
1.6844895	-29.786759 C				
0.00004688	4507.	96158114.	10.0724995	0.0004721	-0.001215
1.7249431	-30.596096 C				
0.00004813	4625.	96094733.	10.0775224	0.0004850	-0.001248
1.7650897	-31.404982 C				
0.00004938	4742.	96031626.	10.0826089	0.0004978	-0.001280
1.8049283	-32.213412 C				
0.00005063	4858.	95968757.	10.0877562	0.0005107	-0.001312
1.8444577	-33.021384 C				
0.00005188	4975.	95906093.	10.0929618	0.0005236	-0.001344
1.8836770	-33.828896 C				
0.00005313	5092.	95843606.	10.0982236	0.0005365	-0.001376
1.9225851	-34.635943 C				
0.00005438	5208.	95781267.	10.1035396	0.0005494	-0.001408
1.9611810	-35.442523 C				
0.00005563	5324.	95719052.	10.1089080	0.0005623	-0.001440
1.9994636	-36.248634 C				

0.00005688	5440.	95656938.	10.1143272	0.0005753	-0.001472
2.0374318	-37.054272 C				
0.00005813	5556.	95594904.	10.1197957	0.0005882	-0.001504
2.0750846	-37.859433 C				
0.00005938	5672.	95532930.	10.1253123	0.0006012	-0.001536
2.1124208	-38.664115 C				
0.00006063	5788.	95471000.	10.1308757	0.0006142	-0.001568
2.1494393	-39.468315 C				
0.00006188	5903.	95409095.	10.1364849	0.0006272	-0.001600
2.1861390	-40.272030 C				
0.00006313	6019.	95347201.	10.1421390	0.0006402	-0.001632
2.2225188	-41.075256 C				
0.00006438	6134.	95285303.	10.1478370	0.0006533	-0.001664
2.2585776	-41.877989 C				
0.00006563	6249.	95223387.	10.1535783	0.0006663	-0.001696
2.2943142	-42.680228 C				
0.00006688	6364.	95161442.	10.1593621	0.0006794	-0.001728
2.3297274	-43.481967 C				
0.00006813	6479.	95099454.	10.1651878	0.0006925	-0.001760
2.3648160	-44.283205 C				
0.00006938	6593.	95037414.	10.1710548	0.0007056	-0.001792
2.3995790	-45.083937 C				
0.00007063	6708.	94975309.	10.1769627	0.0007187	-0.001824
2.4340150	-45.884160 C				
0.00007188	6822.	94913132.	10.1829109	0.0007319	-0.001856
2.4681229	-46.683871 C				
0.00007313	6936.	94850871.	10.1888992	0.0007451	-0.001887
2.5019014	-47.483065 C				
0.00007438	7050.	94788519.	10.1949271	0.0007582	-0.001919
2.5353493	-48.281740 C				
0.00007938	7504.	94538026.	10.2194594	0.0008112	-0.002046
2.6658100	-51.471169 C				
0.00008438	7955.	94285450.	10.2445791	0.0008644	-0.002173
2.7908792	-54.651983 C				
0.00008938	8404.	94030610.	10.2698813	0.0009179	-0.002300
2.9103924	-57.824961 C				
0.00009438	8849.	93762849.	10.2948413	0.0009716	-0.002426
3.0241390	-60.000000 CY				
0.00009938	9240.	92979362.	10.3010599	0.0010237	-0.002554
3.1284320	-60.000000 CY				
0.0001044	9520.	91210251.	10.2682836	0.0010718	-0.002686
3.2193444	-60.000000 CY				
0.0001094	9765.	89278487.	10.2266085	0.0011185	-0.002819
3.3029448	-60.000000 CY				
0.0001144	10008.	87501786.	10.1901604	0.0011655	-0.002952
3.3821156	-60.000000 CY				
0.0001194	10199.	85435786.	10.1376100	0.0012102	-0.003087
3.4529400	-60.000000 CY				
0.0001244	10337.	83108225.	10.0696372	0.0012524	-0.003225
3.5158514	-60.000000 CY				

0.0001294	10472.	80945613.	10.0078626	0.0012948	-0.003363
3.5750870	-60.000000 CY				
0.0001344	10607.	78936564.	9.9519532	0.0013373	-0.003500
3.6306816	-60.000000 CY				
0.0001394	10741.	77064417.	9.9013208	0.0013800	-0.003638
3.6825907	-60.000000 CY				
0.0001444	10873.	75311812.	9.8531964	0.0014226	-0.003775
3.7304014	-60.000000 CY				
0.0001494	11002.	73652258.	9.8082025	0.0014651	-0.003912
3.7743088	-60.000000 CY				
0.0001544	11104.	71927853.	9.7554540	0.0015060	-0.004052
3.8128121	-60.000000 CY				
0.0001594	11174.	70109484.	9.6926426	0.0015448	-0.004193
3.8459368	-60.000000 CY				
0.0001644	11235.	68352343.	9.6311076	0.0015831	-0.004334
3.8755272	-60.000000 CY				
0.0001694	11297.	66695214.	9.5721405	0.0016213	-0.004476
3.9020630	-60.000000 CY				
0.0001744	11357.	65127693.	9.5180531	0.0016597	-0.004618
3.9253941	-60.000000 CY				
0.0001794	11416.	63641111.	9.4667705	0.0016981	-0.004759
3.9454614	-60.000000 CY				
0.0001844	11474.	62231745.	9.4189921	0.0017366	-0.004901
3.9624554	-60.000000 CY				
0.0001894	11532.	60893418.	9.3737598	0.0017752	-0.005042
3.9763376	-60.000000 CY				
0.0001944	11589.	59620587.	9.3320886	0.0018139	-0.005184
3.9870687	-60.000000 CY				
0.0001994	11645.	58408260.	9.2931861	0.0018528	-0.005325
3.9946079	-60.000000 CY				
0.0002044	11701.	57251933.	9.2573168	0.0018920	-0.005466
3.9989131	-60.000000 CY				
0.0002094	11756.	56147389.	9.2236590	0.0019312	-0.005606
3.9977284	-60.000000 CY				
0.0002144	11810.	55090606.	9.1924644	0.0019706	-0.005747
3.9988916	-60.000000 CY				
0.0002194	11863.	54077689.	9.1623904	0.0020100	-0.005888
3.9983486	-60.000000 CY				
0.0002244	11912.	53091123.	9.1319220	0.0020490	-0.006029
3.9982698	-60.000000 CY				
0.0002294	11957.	52127818.	9.1011457	0.0020876	-0.006170
3.9999704	-60.000000 CY				
0.0002344	11992.	51163911.	9.0671728	0.0021251	-0.006312
3.9964157	-60.000000 CY				
0.0002394	12018.	50205524.	9.0300735	0.0021616	-0.006456
3.9992267	-60.000000 CY				
0.0002444	12040.	49268171.	8.9932828	0.0021977	-0.006600
3.9988869	-60.000000 CY				
0.0002494	12058.	48351189.	8.9560280	0.0022334	-0.006744
3.9963667	-60.000000 CY				

0.0002544	12075.	47469217.	8.9206318	0.0022692	-0.006888
3.9990439	-60.000000 CY				
0.0002594	12092.	46620212.	8.8870382	0.0023051	-0.007032
3.9999979	-60.000000 CY				
0.0002644	12109.	45801429.	8.8554793	0.0023412	-0.007176
3.9947150	-60.000000 CY				
0.0002694	12125.	45012148.	8.8252250	0.0023773	-0.007320
3.9979900	-60.000000 CY				
0.0002744	12141.	44248950.	8.7948994	0.0024131	-0.007464
3.9996964	-60.000000 CY				
0.0003044	12228.	40175669.	8.6382745	0.0026293	-0.008328
3.9930440	-60.000000 CY				
0.0003344	12309.	36810756.	8.5218556	0.0028495	-0.009188
3.9959588	-60.000000 CY				
0.0003644	12382.	33982309.	8.4306947	0.0030719	-0.010046
3.9958852	-60.000000 CYT				
0.0003944	12451.	31570270.	8.3560564	0.0032954	-0.010902
3.9925164	-60.000000 CYT				
0.0004244	12515.	29490915.	8.2979832	0.0035215	-0.011756
3.9902656	60.0000000 CYT				
0.0004544	12567.	27658105.	8.2447152	0.0037462	-0.012611
3.9994973	60.0000000 CYT				
0.0004844	12567.	25945086.	8.2188567	0.0039810	-0.013456
3.9919212	60.0000000 CYT				

Summary of Results for Nominal Moment Capacity for Section 1

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

Load Tens. No. Strain	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain	Max.
----- -----	----- -----	----- -----	----- -----	
1 -0.00976824	2.030	12358.468	0.00300000	

Note that the values of moment capacity in the table above are not
factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether
the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction
factor to compute ultimate moment capacity according to ACI 318,

or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding bending stiffnesses computed for common resistance factor values used for reinforced concrete sections.

Axial Stiff. Load Ult Mom No. kip-in ²	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. at
1 94241332.	0.65	2.030000	12358.	1.319500	8033.	
1 92796124.	0.75	2.030000	12358.	1.522500	9269.	
1 71439423.	0.90	2.030000	12358.	1.827000	11123.	

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	1021.
2	3.0000	3.5864	No	No	1021.	8834.
3	11.5000	11.5000	No	Yes	N.A.	N.A.
4	14.5000	14.5000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 910.0 lbs
Applied moment at pile head = 405053.0 in-lbs
Axial thrust load on pile head = 2030.0 lbs

Depth Res.	Soil X	Deflect. Spr. y	Distrib. Lat. Load	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil p
	Es*H feet lb/inch		inches lb/inch						
	0.00	0.7054	405053.	910.0000	-0.00910	0.00	3.87E+11		
-68.606	58.3560		0.00						
	0.10000	0.6945	406118.	827.0525	-0.00910	0.00	3.87E+11		
-69.612	120.2860		0.00						
	0.2000	0.6835	407082.	742.9432	-0.00910	0.00	3.87E+11		
-70.599	123.9422		0.00						
	0.3000	0.6726	407945.	657.6422	-0.00910	0.00	3.87E+11		
-71.569	127.6842		0.00						
	0.4000	0.6617	408705.	571.1889	-0.00910	0.00	3.87E+11		
-72.520	131.5153		0.00						
	0.5000	0.6508	409360.	483.6060	-0.00910	0.00	3.87E+11		
-73.452	135.4395		0.00						
	0.6000	0.6399	409910.	394.9167	-0.00910	0.00	3.87E+11		
-74.364	139.4609		0.00						
	0.7000	0.6290	410352.	305.1446	-0.00909	0.00	3.87E+11		
-75.256	143.5836		0.00						
	0.8000	0.6180	410687.	214.3135	-0.00909	0.00	3.87E+11		
-76.129	147.8124		0.00						
	0.9000	0.6071	410911.	122.4480	-0.00909	0.00	3.87E+11		
-76.980	152.1520		0.00						
	1.0000	0.5962	411025.	29.5732	-0.00909	0.00	3.87E+11		
-77.811	156.6076		0.00						
	1.1000	0.5853	411026.	-64.285	-0.00909	0.00	3.87E+11		
-78.620	161.1847		0.00						
	1.2000	0.5744	410915.	-159.102	-0.00909	0.00	3.87E+11		
-79.407	165.8894		0.00						
	1.3000	0.5635	410689.	-254.849	-0.00909	0.00	3.87E+11		
-80.172	170.7278		0.00						
	1.4000	0.5526	410347.	-351.500	-0.00909	0.00	3.87E+11		
-80.913	175.7068		0.00						
	1.5000	0.5417	409889.	-449.027	-0.00908	0.00	3.87E+11		
-81.632	180.8336		0.00						

1.6000	0.5308	409314.	-547.402	-0.00908	0.00	3.87E+11
-82.326	186.1160	0.00				
1.7000	0.5199	408620.	-646.594	-0.00908	0.00	3.87E+11
-82.995	191.5623	0.00				
1.8000	0.5090	407806.	-746.575	-0.00908	0.00	3.87E+11
-83.639	197.1816	0.00				
1.9000	0.4981	406872.	-847.312	-0.00908	0.00	3.87E+11
-84.257	202.9836	0.00				
2.0000	0.4872	405817.	-948.775	-0.00908	0.00	3.87E+11
-84.848	208.9788	0.00				
2.1000	0.4763	404640.	-1051.	-0.00908	0.00	3.87E+11
-85.413	215.1786	0.00				
2.2000	0.4654	403339.	-1154.	-0.00908	0.00	3.87E+11
-85.948	221.5953	0.00				
2.3000	0.4545	401915.	-1257.	-0.00907	0.00	3.87E+11
-86.455	228.2422	0.00				
2.4000	0.4437	400366.	-1361.	-0.00907	0.00	3.87E+11
-86.933	235.1340	0.00				
2.5000	0.4328	398692.	-1466.	-0.00907	0.00	3.87E+11
-87.379	242.2866	0.00				
2.6000	0.4219	396892.	-1571.	-0.00907	0.00	3.87E+11
-87.794	249.7172	0.00				
2.7000	0.4110	394966.	-1676.	-0.00907	0.00	3.87E+11
-88.176	257.4449	0.00				
2.8000	0.4001	392913.	-1783.	-0.00907	0.00	3.87E+11
-88.524	265.4906	0.00				
2.9000	0.3892	390732.	-1889.	-0.00907	0.00	3.87E+11
-88.837	273.8772	0.00				
3.0000	0.3784	388424.	-2043.	-0.00907	0.00	3.87E+11
-167.743	532.0087	0.00				
3.1000	0.3675	385873.	-2233.	-0.00906	0.00	3.87E+11
-148.992	486.5253	0.00				
3.2000	0.3566	383109.	-2431.	-0.00906	0.00	3.87E+11
-180.514	607.4359	0.00				
3.3000	0.3457	380084.	-2646.	-0.00906	0.00	3.87E+11
-177.638	616.5586	0.00				
3.4000	0.3349	376804.	-2857.	-0.00906	0.00	3.87E+11
-174.581	625.6249	0.00				
3.5000	0.3240	373272.	-3064.	-0.00906	0.00	3.87E+11
-171.346	634.6380	0.00				
3.6000	0.3131	369493.	-3268.	-0.00906	0.00	3.87E+11
-167.936	643.6011	0.00				
3.7000	0.3022	365473.	-3467.	-0.00906	0.00	3.87E+11
-164.351	652.5111	0.00				
3.8000	0.2914	361216.	-3662.	-0.00906	0.00	3.87E+11
-160.424	660.6760	0.00				
3.9000	0.2805	356728.	-3852.	-0.00905	0.00	3.87E+11
-156.364	668.9018	0.00				
4.0000	0.2697	352014.	-4037.	-0.00905	0.00	3.87E+11
-152.171	677.1908	0.00				

4.1000	0.2588	347082.	-4217.	-0.00905	0.00	3.87E+11
-147.842	685.5449	0.00				
4.2000	0.2479	341937.	-4392.	-0.00905	0.00	3.87E+11
-143.376	693.9665	0.00				
4.3000	0.2371	336585.	-4561.	-0.00905	0.00	3.87E+11
-138.772	702.4574	0.00				
4.4000	0.2262	331033.	-4725.	-0.00905	0.00	3.87E+11
-134.029	711.0197	0.00				
4.5000	0.2153	325289.	-4883.	-0.00905	0.00	3.87E+11
-129.145	719.6553	0.00				
4.6000	0.2045	319358.	-5035.	-0.00905	0.00	3.87E+11
-124.118	728.3662	0.00				
4.7000	0.1936	313249.	-5181.	-0.00905	0.00	3.87E+11
-118.947	737.1543	0.00				
4.8000	0.1828	306968.	-5320.	-0.00905	0.00	3.87E+11
-113.629	746.0213	0.00				
4.9000	0.1719	300524.	-5453.	-0.00904	0.00	3.87E+11
-108.163	754.9690	0.00				
5.0000	0.1611	293924.	-5580.	-0.00904	0.00	3.87E+11
-102.547	763.9992	0.00				
5.1000	0.1502	287176.	-5699.	-0.00904	0.00	3.87E+11
-96.779	773.1136	0.00				
5.2000	0.1394	280289.	-5812.	-0.00904	0.00	3.87E+11
-90.857	782.3139	0.00				
5.3000	0.1285	273272.	-5917.	-0.00904	0.00	3.87E+11
-84.779	791.6017	0.00				
5.4000	0.1177	266132.	-6015.	-0.00904	0.00	3.87E+11
-78.542	800.9786	0.00				
5.5000	0.1068	258879.	-6106.	-0.00904	0.00	3.87E+11
-72.144	810.4462	0.00				
5.6000	0.09597	251522.	-6188.	-0.00904	0.00	3.87E+11
-65.583	820.0059	0.00				
5.7000	0.08513	244070.	-6263.	-0.00904	0.00	3.88E+11
-58.856	829.6594	0.00				
5.8000	0.07428	236534.	-6330.	-0.00904	0.00	3.88E+11
-51.962	839.4080	0.00				
5.9000	0.06344	228923.	-6388.	-0.00904	0.00	3.88E+11
-44.897	849.2532	0.00				
6.0000	0.05260	221248.	-6437.	-0.00904	0.00	3.88E+11
-37.659	859.1962	0.00				
6.1000	0.04175	213518.	-6478.	-0.00903	0.00	3.88E+11
-30.245	869.2386	0.00				
6.2000	0.03091	205745.	-6510.	-0.00903	0.00	3.88E+11
-22.653	879.3815	0.00				
6.3000	0.02007	197939.	-6532.	-0.00903	0.00	3.88E+11
-14.880	889.6263	0.00				
6.4000	0.00923	190111.	-6545.	-0.00903	0.00	3.88E+11
-6.924	899.9740	0.00				
6.5000	-0.00161	182274.	-6549.	-0.00903	0.00	3.88E+11
1.2184	909.6197	0.00				

6.6000	-0.01245	174438.	-6542.	-0.00903	0.00	3.88E+11
9.4869	914.7044	0.00				
6.7000	-0.02328	166616.	-6526.	-0.00903	0.00	3.88E+11
17.8476	919.8248	0.00				
6.8000	-0.03412	158820.	-6499.	-0.00903	0.00	3.88E+11
26.3012	924.9796	0.00				
6.9000	-0.04496	151062.	-6463.	-0.00903	0.00	3.88E+11
34.8487	930.1672	0.00				
7.0000	-0.05579	143353.	-6416.	-0.00903	0.00	3.88E+11
43.4909	935.3861	0.00				
7.1000	-0.06663	135708.	-6358.	-0.00903	0.00	3.88E+11
52.2286	940.6348	0.00				
7.2000	-0.07746	128137.	-6290.	-0.00903	0.00	3.88E+11
61.0625	945.9117	0.00				
7.3000	-0.08830	120655.	-6212.	-0.00903	0.00	3.88E+11
69.9932	951.2153	0.00				
7.4000	-0.09913	113273.	-6122.	-0.00903	0.00	3.88E+11
79.0215	956.5440	0.00				
7.5000	-0.110	106005.	-6022.	-0.00903	0.00	3.88E+11
88.1478	961.8961	0.00				
7.6000	-0.121	98864.	-5911.	-0.00903	0.00	3.88E+11
97.3726	967.2701	0.00				
7.7000	-0.132	91864.	-5788.	-0.00903	0.00	3.88E+11
106.6964	972.6643	0.00				
7.8000	-0.142	85016.	-5655.	-0.00903	0.00	3.88E+11
116.1195	978.0770	0.00				
7.9000	-0.153	78337.	-5510.	-0.00903	0.00	3.88E+11
125.6422	983.5066	0.00				
8.0000	-0.164	71838.	-5353.	-0.00903	0.00	3.88E+11
135.2648	988.9512	0.00				
8.1000	-0.175	65533.	-5185.	-0.00903	0.00	3.88E+11
144.9873	994.4092	0.00				
8.2000	-0.186	59438.	-5005.	-0.00903	0.00	3.88E+11
154.8238	999.9680	0.00				
8.3000	-0.197	53566.	-4813.	-0.00903	0.00	3.88E+11
164.8542	1006.	0.00				
8.4000	-0.207	47931.	-4610.	-0.00903	0.00	3.88E+11
173.9209	1006.	0.00				
8.5000	-0.218	42546.	-4396.	-0.00903	0.00	3.88E+11
182.4516	1003.	0.00				
8.6000	-0.229	37424.	-4172.	-0.00903	0.00	3.88E+11
190.9285	999.9794	0.00				
8.7000	-0.240	32577.	-3938.	-0.00903	0.00	3.88E+11
199.3516	996.9676	0.00				
8.8000	-0.251	28017.	-3694.	-0.00903	0.00	3.88E+11
207.7212	993.9600	0.00				
8.9000	-0.262	23756.	-3439.	-0.00903	0.00	3.88E+11
216.0373	990.9566	0.00				
9.0000	-0.272	19807.	-3175.	-0.00903	0.00	3.88E+11
224.3000	987.9574	0.00				

9.1000	-0.283	16180.	-2901.	-0.00903	0.00	3.88E+11
232.5096	984.9624	0.00				
9.2000	-0.294	12888.	-2617.	-0.00903	0.00	3.88E+11
240.6660	981.9715	0.00				
9.3000	-0.305	9943.	-2323.	-0.00903	0.00	3.88E+11
248.7696	978.9848	0.00				
9.4000	-0.316	7356.	-2020.	-0.00903	0.00	3.88E+11
256.8202	976.0024	0.00				
9.5000	-0.327	5139.	-1707.	-0.00903	0.00	3.88E+11
264.8182	973.0241	0.00				
9.6000	-0.337	3303.	-1385.	-0.00903	0.00	3.88E+11
272.7635	970.0501	0.00				
9.7000	-0.348	1859.	-1053.	-0.00903	0.00	3.88E+11
280.6564	967.0802	0.00				
9.8000	-0.359	820.4717	-711.053	-0.00903	0.00	3.88E+11
288.4970	964.1146	0.00				
9.9000	-0.370	196.9104	-360.184	-0.00903	0.00	3.88E+11
296.2853	961.1532	0.00				
10.0000	-0.381	0.00	0.00	-0.00903	0.00	3.88E+11
304.0215	479.0980	0.00				

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

Pile-head deflection	=	0.70538292 inches
Computed slope at pile head	=	-0.0091029 radians
Maximum bending moment	=	411026. inch-lbs
Maximum shear force	=	-6549. lbs
Depth of maximum bending moment	=	1.10000000 feet below pile head
Depth of maximum shear force	=	6.50000000 feet below pile head
Number of iterations	=	14
Number of zero deflection points	=	1

Pile-head Deflection vs. Pile Length for Load Case 1

Boundary Condition Type 1, Shear and Moment

Shear	=	910. lbs
Moment	=	405053. in-lbs

Axial Load = 2030. lbs

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
10.00000	0.70538292	411026.	-6549.
9.50000	0.85099979	410739.	-6985.
9.00000	1.05667152	410441.	-7497.
8.50000	1.34509243	410150.	-8096.
8.00000	1.76848310	409875.	-8815.
7.50000	2.45254031	409623.	-9698.
7.00000	3.58998177	409457.	-10786.
6.50000	6.79438423	410032.	-12516.

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
 Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
 Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
 Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
 Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case	Load Type	Load 1	Load 2	Axial Loading	Pile-head Deflection	Pile-head Rotation	Max in lbs	
Pile No.	1	Pile Load 1	2	Load 2	lbs	inches	radians	lbs
1	V, lb	910.0000	M, in-lb	405053.	2030.	0.7054	-0.00910	
-6549.		411026.						

Maximum pile-head deflection = 0.7053829179 inches
 Maximum pile-head rotation = -0.0091028991 radians = -0.521558 deg.

The analysis ended normally.

=====

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Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method
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=====

This model was prepared by:
gverma

Files Used for Analysis

Path to file locations:
\PROJECT\2025\COL-05\25050075COL_Arcadis U-S- Inc-_GUE-IR70 EB Rest Area (Site
3B)\Design\Soil Parameters\L-Pile Analysis\

Name of input data file:
Eastbound US 35 Light Tower AA-1 Extreme I Max.lp12d

Name of output report file:
Eastbound US 35 Light Tower AA-1 Extreme I Max.lp12o

Name of plot output file:
Eastbound US 35 Light Tower AA-1 Extreme I Max.lp12p

Name of runtime message file:
Eastbound US 35 Light Tower AA-1 Extreme I Max.lp12r

Date and Time of Analysis

Date: June 8, 2026

Time: 12:15:20

Problem Title

Project Name: GUE-IR70 EB Rest Area (Site 3B)

Job Number: PID 122866

Client:

Engineer: GV

Description: Eastbound IR-70 Light Tower AA-1 Extreme I Max

Program Options and Settings

Computational Options:

- Conventional Analysis

Engineering Units Used for Data Input and Computations:

- US Customary System Units (pounds, feet, inches)

Analysis Control Options:

- | | | |
|--|---|---------------|
| - Maximum number of iterations allowed | = | 500 |
| - Deflection tolerance for convergence | = | 1.0000E-05 in |
| - Maximum allowable deflection | = | 100.0000 in |
| - Number of pile increments | = | 100 |

Loading Type and Number of Cycles of Loading:

- | | | |
|-------------------------------|---|------------|
| - Cyclic loading specified | | |
| - Number of cycles of loading | = | 100 cycles |

- Use of p-y modification factors for p-y curves not selected
- Analysis uses layering correction (Method of Georgiadis)
- No distributed lateral loads are entered
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:

- Output files use decimal points to denote decimal symbols.
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1
- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

Pile Structural Properties and Geometry

Number of pile sections defined	=	1
Total length of pile	=	10.000 ft
Depth of ground surface below top of pile	=	0.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	36.0000
2	10.000	36.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a round drilled shaft, bored pile, or CIDH pile	
Length of section	= 10.000000 ft
Shaft Diameter	= 36.000000 in

Soil and Rock Layering Information

The soil profile is modelled using 4 layers

Layer 1 is soft clay, p-y criteria by Matlock, 1970

Distance from top of pile to top of layer	=	0.0000 ft
Distance from top of pile to bottom of layer	=	3.000000 ft
Effective unit weight at top of layer	=	108.000000 pcf
Effective unit weight at bottom of layer	=	108.000000 pcf
Undrained cohesion at top of layer	=	250.000000 psf
Undrained cohesion at bottom of layer	=	250.000000 psf
Epsilon-50 at top of layer	=	0.020000
Epsilon-50 at bottom of layer	=	0.020000

Layer 2 is stiff clay with water-induced erosion

Distance from top of pile to top of layer	=	3.000000 ft
Distance from top of pile to bottom of layer	=	11.500000 ft
Effective unit weight at top of layer	=	62.600000 pcf
Effective unit weight at bottom of layer	=	62.600000 pcf
Undrained cohesion at top of layer	=	1200. psf
Undrained cohesion at bottom of layer	=	1200. psf
Epsilon-50 at top of layer	=	0.070000
Epsilon-50 at bottom of layer	=	0.070000
Subgrade k at top of layer	=	0.0000 pci
Subgrade k at bottom of layer	=	0.0000 pci

NOTE: Default values for subgrade k will be computed for this layer.

Layer 3 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	11.500000 ft
Distance from top of pile to bottom of layer	=	14.500000 ft
Effective unit weight at top of layer	=	77.600000 pcf
Effective unit weight at bottom of layer	=	77.600000 pcf
Uniaxial compressive strength at top of layer	=	60.000000 psi
Uniaxial compressive strength at bottom of layer	=	60.000000 psi
Initial modulus of rock at top of layer	=	5400. psi
Initial modulus of rock at bottom of layer	=	5400. psi
RQD of rock at top of layer	=	0.0000 %
RQD of rock at bottom of layer	=	0.0000 %
k _{rm} of rock at top of layer	=	0.0005000
k _{rm} of rock at bottom of layer	=	0.0005000

Layer 4 is massive rock, p-y criteria by Liang et al., 2009

Distance from top of pile to top of layer = 14.500000 ft
Distance from top of pile to bottom of layer = 24.300000 ft
Effective unit weight at top of layer = 87.600000 pcf
Effective unit weight at bottom of layer = 87.600000 pcf
Uniaxial compressive strength at top of layer = 500.000000 psi
Uniaxial compressive strength at bottom of layer = 500.000000 psi
Poisson's ratio at top of layer = 0.250000
Poisson's ratio at bottom of layer = 0.250000
Option 1: Intact rock modulus at top of layer = 7000. psi
Intact rock modulus at bottom of layer = 7000. psi
Option 1: Geologic Strength Index for layer = 40.000000
Option 2: Rock mass modulus at top of layer = 0.0000 psi
Rock mass modulus at bottom of layer = 0.0000 psi
Option 1 will be used to compute values of rock mass modulus for the p-y curve
in massive rock.
The rock type is (sedimentary) shales, Hoek-Brown Material Constant mi = 6

(Depth of the lowest soil layer extends 14.300 ft below the pile tip)

Summary of Input Soil Properties

Layer	Soil Type	Layer	Effective	Cohesion	Uniaxial
	E50	Rock Mass	Geologic	Int. Rock	
Hoek-Brown					
Num.	Name	Depth	Unit Wt.		qu
RQD %	or	Modulus	Strength	Modulus	Material
Poisson's	(p-y Curve Type)	ft	pcf	psf	psi
mi	Ratio	pci	psi	Index	psi
	krm				Index,
1	Soft	0.00	108.0000	250.0000	--
--	0.02000	--	--	--	0.00
0.00	0.00				
	Clay	3.0000	108.0000	250.0000	--
--	0.02000	--	--	--	0.00
0.00	0.00				
2	Stiff Clay	3.0000	62.6000	1200.	--
--	0.07000	default	--	--	0.00

0.00	0.00					
	with Free Water		11.5000	62.6000	1200.	--
--	0.07000	default	--	--		0.00
0.00	0.00					
3	Weak		11.5000	77.6000	--	60.0000
0.00	5.00E-04	--	5400.	--		0.00
0.00	0.00					
	Rock		14.5000	77.6000	--	60.0000
0.00	5.00E-04	--	5400.	--		0.00
0.00	0.00					
4	Massive		14.5000	87.6000	--	500.0000
--	--	--	Internally	40.0000		7000.
6.0000	0.2500					
	Rock		24.3000	87.6000	--	500.0000
--	--	--	Computed	40.0000		7000.
6.0000	0.2500					

Cyclic Loading Type

Cyclic loading criteria were used for computation of p-y curves for all analyses.

Number of cycles of loading = 100

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load Compute No.	Load Top y Type	Condition Run Analysis 1	Condition 2	Axial Thrust Force, lbs
vs. Pile Length				
-----	-----	-----	-----	-----
1	1	V = 1930. lbs	M = 878879. in-lbs	1827.
Yes		Yes		

V = shear force applied normal to pile axis

M = bending moment applied to pile head

y = lateral deflection normal to pile axis

S = pile slope relative to original pile batter angle

R = rotational stiffness applied to pile head

Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).

Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Drilled Shaft (Bored Pile):

Length of Section	=	10.000000 ft
Shaft Diameter	=	36.000000 in
Concrete Cover Thickness (to edge of trans. reinf.)	=	3.000000 in
Number of Reinforcing Bars	=	16 bars
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Shaft	=	1018. sq. in.
Total Area of Reinforcing Steel	=	16.000000 sq. in.
Area Ratio of Steel Reinforcement	=	1.57 percent
Edge-to-Edge Bar Spacing	=	4.309557 in
Maximum Concrete Aggregate Size	=	0.750000 in
Ratio of Bar Spacing to Aggregate Size	=	5.75
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in
Transverse Reinforcement		
Type: Spiral		
Number of Transverse Reinf. (per spacing)	=	1
Spacing of Transverse Reinf.	=	4.500000 in
Yield Stress of Transverse Reinf.	=	60000. psi
Diameter of Transverse Reinf.	=	0.500000 in

Axial Structural Capacities:

Nom. Axial Structural Capacity = $0.85 F_c A_c + F_y A_s$	=	4366.378 kips
Tensile Load for Cracking of Concrete	=	-470.222 kips
Nominal Axial Tensile Capacity	=	-960.000 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
-----	-----	-----	-----	-----

1	1.128000	1.000000	13.936000	0.000000
2	1.128000	1.000000	12.875185	5.333076
3	1.128000	1.000000	9.854240	9.854240
4	1.128000	1.000000	5.333076	12.875185
5	1.128000	1.000000	0.000000	13.936000
6	1.128000	1.000000	-5.33308	12.875185
7	1.128000	1.000000	-9.85424	9.854240
8	1.128000	1.000000	-12.87519	5.333076
9	1.128000	1.000000	-13.93600	0.000000
10	1.128000	1.000000	-12.87519	-5.33308
11	1.128000	1.000000	-9.85424	-9.85424
12	1.128000	1.000000	-5.33308	-12.87519
13	1.128000	1.000000	0.000000	-13.93600
14	1.128000	1.000000	5.333076	-12.87519
15	1.128000	1.000000	9.854240	-9.85424
16	1.128000	1.000000	12.875185	-5.33308

NOTE: The positions of the above rebars were computed by LPile

Minimum spacing between any two bars not equal to zero = 4.310 inches
between bars 15 and 16.

Ratio of bar spacing to maximum aggregate size = 5.75

Concrete Properties:

Compressive Strength of Concrete	=	4000. psi
Modulus of Elasticity of Concrete	=	3604997. psi
Modulus of Rupture of Concrete	=	-474.34165 psi
Compression Strain at Peak Stress	=	0.001886
Tensile Strain at Fracture of Concrete	=	-0.0001154
Maximum Coarse Aggregate Size	=	0.750000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
-----	-----
1	1.827

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.

T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318-14, Section 21.2.3.

Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.

Position of neutral axis is measured from edge of compression side of pile.

Compressive stresses and strains are positive in sign.

Tensile stresses and strains are negative in sign.

Axial Thrust Force = 1.827 kips

Bending Max Conc Curvature Stress rad/in. ksi	Bending Max Steel Moment Stress in-kip ksi	Bending Run Stiffness Msg kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in
-----	-----	-----	-----	-----	-----
6.25000E-07	242.1981691	387517071.	18.6216570	0.00001164	-0.00001086
0.0487346	0.2755300				
0.00000125	483.5285167	386822813.	18.3115472	0.00002289	-0.00002211
0.0955463	0.5398186				
0.00000188	723.9897245	386127853.	18.2081795	0.00003414	-0.00003336
0.1420791	0.8041073				
0.00000250	963.5817924	385432717.	18.1564974	0.00004539	-0.00004461
0.1883330	1.0683961				
0.00000313	1202.	384737511.	18.1254895	0.00005664	-0.00005586
0.2343079	1.3326850				
0.00000375	1440.	384042269.	18.1048187	0.00006789	-0.00006711
0.2800039	1.5969740				
0.00000438	1677.	383347007.	18.0900548	0.00007914	-0.00007836
0.3254210	1.8612632				
0.00000500	1913.	382651733.	18.0789827	0.00009039	-0.00008961
0.3705591	2.1255525				
0.00000563	2149.	381956450.	18.0703719	0.0001016	-0.000101
0.4154183	2.3898419				
0.00000625	2383.	381261162.	18.0634839	0.0001129	-0.000112
0.4599985	2.6541315				
0.00000688	2383.	346601056.	10.0532516	0.00006912	-0.000178
0.2827053	-4.491268 C				
0.00000750	2383.	317717635.	10.0403524	0.00007530	-0.000195
0.3074980	-4.902370 C				
0.00000813	2383.	293277817.	10.0298370	0.00008149	-0.000211
0.3322208	-5.313379 C				
0.00000875	2383.	272329401.	10.0211958	0.00008769	-0.000227
0.3568738	-5.724292 C				

0.00000938	2383.	254174108.	10.0140547	0.00009388	-0.000244
0.3814568	-6.135112 C				
0.00001000	2383.	238288226.	10.0081333	0.0001001	-0.000260
0.4059697	-6.545836 C				
0.00001063	2383.	224271272.	10.0032174	0.0001063	-0.000276
0.4304125	-6.956465 C				
0.00001125	2383.	211811757.	9.9991401	0.0001125	-0.000293
0.4547851	-7.366998 C				
0.00001188	2383.	200663769.	9.9957698	0.0001187	-0.000309
0.4790872	-7.777436 C				
0.00001250	2383.	190630581.	9.9930011	0.0001249	-0.000325
0.5033189	-8.187778 C				
0.00001313	2383.	181552934.	9.9907488	0.0001311	-0.000341
0.5274801	-8.598024 C				
0.00001375	2383.	173300528.	9.9889431	0.0001373	-0.000358
0.5515706	-9.008173 C				
0.00001438	2383.	165765723.	9.9875265	0.0001436	-0.000374
0.5755903	-9.418226 C				
0.00001500	2383.	158858817.	9.9864509	0.0001498	-0.000390
0.5995392	-9.828181 C				
0.00001563	2383.	152504465.	9.9856759	0.0001560	-0.000406
0.6234171	-10.238039 C				
0.00001625	2383.	146638908.	9.9851676	0.0001623	-0.000423
0.6472239	-10.647800 C				
0.00001688	2383.	141207838.	9.9848967	0.0001685	-0.000439
0.6709596	-11.057462 C				
0.00001750	2383.	136164701.	9.9848385	0.0001747	-0.000455
0.6946239	-11.467027 C				
0.00001813	2383.	131469366.	9.9849713	0.0001810	-0.000472
0.7182170	-11.876493 C				
0.00001875	2383.	127087054.	9.9852767	0.0001872	-0.000488
0.7417385	-12.285861 C				
0.00001938	2383.	122987472.	9.9857385	0.0001935	-0.000504
0.7651885	-12.695129 C				
0.00002000	2383.	119144113.	9.9863424	0.0001997	-0.000520
0.7885667	-13.104299 C				
0.00002063	2383.	115533685.	9.9870760	0.0002060	-0.000537
0.8118732	-13.513369 C				
0.00002125	2383.	112135636.	9.9879283	0.0002122	-0.000553
0.8351078	-13.922339 C				
0.00002188	2383.	108931761.	9.9888895	0.0002185	-0.000569
0.8582703	-14.331209 C				
0.00002250	2383.	105905878.	9.9899512	0.0002248	-0.000585
0.8813608	-14.739979 C				
0.00002313	2383.	103043557.	9.9911315	0.0002310	-0.000601
0.9043790	-15.148648 C				
0.00002375	2383.	100331885.	9.9923722	0.0002373	-0.000618
0.9273249	-15.557216 C				
0.00002438	2383.	97759272.	9.9936925	0.0002436	-0.000634
0.9501984	-15.965683 C				

0.00002563	2493.	97281878.	9.9965499	0.0002562	-0.000666
0.9957276	-16.782312 C				
0.00002688	2612.	97203650.	9.9996654	0.0002687	-0.000699
1.0409658	-17.598532 C				
0.00002813	2732.	97127660.	10.0030075	0.0002813	-0.000731
1.0859121	-18.414342 C				
0.00002938	2851.	97053598.	10.0065501	0.0002939	-0.000764
1.1305655	-19.229739 C				
0.00003063	2970.	96981208.	10.0102714	0.0003066	-0.000796
1.1749253	-20.044720 C				
0.00003188	3089.	96910272.	10.0141530	0.0003192	-0.000828
1.2189905	-20.859284 C				
0.00003313	3208.	96840603.	10.0181793	0.0003319	-0.000861
1.2627602	-21.673427 C				
0.00003438	3327.	96772044.	10.0223371	0.0003445	-0.000893
1.3062334	-22.487146 C				
0.00003563	3445.	96704458.	10.0266149	0.0003572	-0.000925
1.3494093	-23.300441 C				
0.00003688	3564.	96637727.	10.0310029	0.0003699	-0.000958
1.3922870	-24.113307 C				
0.00003813	3682.	96571748.	10.0354927	0.0003826	-0.000990
1.4348654	-24.925743 C				
0.00003938	3800.	96506431.	10.0400768	0.0003953	-0.001022
1.4771437	-25.737746 C				
0.00004063	3918.	96441698.	10.0447487	0.0004081	-0.001054
1.5191209	-26.549312 C				
0.00004188	4036.	96377478.	10.0495028	0.0004208	-0.001087
1.5607959	-27.360441 C				
0.00004313	4154.	96313710.	10.0543340	0.0004336	-0.001119
1.6021680	-28.171128 C				
0.00004438	4271.	96250338.	10.0592381	0.0004464	-0.001151
1.6432359	-28.981371 C				
0.00004563	4389.	96187314.	10.0642110	0.0004592	-0.001183
1.6839989	-29.791167 C				
0.00004688	4506.	96124593.	10.0692494	0.0004720	-0.001216
1.7244559	-30.600514 C				
0.00004813	4623.	96062135.	10.0743500	0.0004848	-0.001248
1.7646058	-31.409409 C				
0.00004938	4740.	95999905.	10.0795103	0.0004977	-0.001280
1.8044476	-32.217849 C				
0.00005063	4857.	95937870.	10.0847277	0.0005105	-0.001312
1.8439804	-33.025830 C				
0.00005188	4974.	95876001.	10.0900000	0.0005234	-0.001344
1.8832030	-33.833351 C				
0.00005313	5090.	95814270.	10.0953254	0.0005363	-0.001376
1.9221145	-34.640408 C				
0.00005438	5207.	95752654.	10.1007019	0.0005492	-0.001408
1.9607138	-35.446998 C				
0.00005563	5323.	95691129.	10.1061281	0.0005622	-0.001440
1.9989998	-36.253118 C				

0.00005688	5439.	95629676.	10.1116024	0.0005751	-0.001472
2.0369715	-37.058765 C				
0.00005813	5555.	95568274.	10.1171237	0.0005881	-0.001504
2.0746277	-37.863937 C				
0.00005938	5671.	95506907.	10.1226908	0.0006010	-0.001536
2.1119673	-38.668629 C				
0.00006063	5786.	95445557.	10.1283026	0.0006140	-0.001568
2.1489893	-39.472839 C				
0.00006188	5902.	95384211.	10.1339582	0.0006270	-0.001600
2.1856925	-40.276563 C				
0.00006313	6017.	95322853.	10.1396568	0.0006401	-0.001632
2.2220759	-41.079799 C				
0.00006438	6132.	95261470.	10.1453976	0.0006531	-0.001664
2.2581382	-41.882543 C				
0.00006563	6248.	95200051.	10.1511800	0.0006662	-0.001696
2.2938783	-42.684791 C				
0.00006688	6362.	95138584.	10.1570033	0.0006792	-0.001728
2.3292951	-43.486541 C				
0.00006813	6477.	95077057.	10.1628670	0.0006923	-0.001760
2.3643873	-44.287789 C				
0.00006938	6592.	95015461.	10.1687706	0.0007055	-0.001792
2.3991539	-45.088532 C				
0.00007063	6706.	94953786.	10.1747137	0.0007186	-0.001824
2.4335935	-45.888766 C				
0.00007188	6820.	94892022.	10.1806960	0.0007317	-0.001856
2.4677051	-46.688487 C				
0.00007313	6934.	94830162.	10.1867170	0.0007449	-0.001888
2.5014873	-47.487692 C				
0.00007438	7048.	94768197.	10.1927766	0.0007581	-0.001919
2.5349389	-48.286378 C				
0.00007938	7502.	94519134.	10.2174255	0.0008110	-0.002046
2.6654146	-51.475851 C				
0.00008438	7954.	94267823.	10.2426471	0.0008642	-0.002173
2.7904990	-54.656710 C				
0.00008938	8403.	94014068.	10.2681103	0.0009177	-0.002300
2.9100420	-57.829551 C				
0.00009438	8847.	93746907.	10.2931329	0.0009714	-0.002426
3.0238012	-60.000000 CY				
0.00009938	9238.	92962884.	10.2993663	0.0010235	-0.002554
3.1280988	-60.000000 CY				
0.0001044	9518.	91193460.	10.2666101	0.0010716	-0.002686
3.2190171	-60.000000 CY				
0.0001094	9763.	89262471.	10.2249271	0.0011184	-0.002819
3.3026191	-60.000000 CY				
0.0001144	10006.	87486549.	10.1885394	0.0011653	-0.002952
3.3818065	-60.000000 CY				
0.0001194	10197.	85419541.	10.1359598	0.0012100	-0.003088
3.4526310	-60.000000 CY				
0.0001244	10335.	83092644.	10.0680411	0.0012522	-0.003225
3.5155586	-60.000000 CY				

0.0001294	10470.	80930688.	10.0063184	0.0012946	-0.003363
3.5748108	-60.000000 CY				
0.0001344	10605.	78922247.	9.9504566	0.0013371	-0.003500
3.6304224	-60.000000 CY				
0.0001394	10739.	77050661.	9.8998663	0.0013798	-0.003638
3.6823482	-60.000000 CY				
0.0001444	10871.	75298492.	9.8517118	0.0014223	-0.003775
3.7301653	-60.000000 CY				
0.0001494	11000.	73639344.	9.8067507	0.0014649	-0.003913
3.7740903	-60.000000 CY				
0.0001544	11102.	71914452.	9.7539708	0.0015058	-0.004052
3.8126020	-60.000000 CY				
0.0001594	11172.	70096306.	9.6911804	0.0015445	-0.004193
3.8457429	-60.000000 CY				
0.0001644	11233.	68339602.	9.6296824	0.0015829	-0.004335
3.8753518	-60.000000 CY				
0.0001694	11294.	66682885.	9.5707463	0.0016210	-0.004476
3.9019066	-60.000000 CY				
0.0001744	11355.	65115627.	9.5166501	0.0016595	-0.004618
3.9252486	-60.000000 CY				
0.0001794	11414.	63629416.	9.4653983	0.0016979	-0.004760
3.9453362	-60.000000 CY				
0.0001844	11472.	62220402.	9.4176489	0.0017364	-0.004901
3.9623508	-60.000000 CY				
0.0001894	11530.	60882409.	9.3724437	0.0017749	-0.005043
3.9762541	-60.000000 CY				
0.0001944	11587.	59609895.	9.3307983	0.0018137	-0.005184
3.9870065	-60.000000 CY				
0.0001994	11643.	58397870.	9.2919197	0.0018526	-0.005325
3.9945674	-60.000000 CY				
0.0002044	11699.	57241831.	9.2560390	0.0018917	-0.005466
3.9988948	-60.000000 CY				
0.0002094	11754.	56137566.	9.2224023	0.0019309	-0.005607
3.9978109	-60.000000 CY				
0.0002144	11808.	55081045.	9.1912284	0.0019704	-0.005747
3.9988729	-60.000000 CY				
0.0002194	11861.	54068309.	9.1610905	0.0020097	-0.005888
3.9984380	-60.000000 CY				
0.0002244	11910.	53081884.	9.1306289	0.0020487	-0.006029
3.9982441	-60.000000 CY				
0.0002294	11955.	52118511.	9.0998304	0.0020873	-0.006170
3.9999668	-60.000000 CY				
0.0002344	11989.	51154838.	9.0658751	0.0021248	-0.006313
3.9963770	-60.000000 CY				
0.0002394	12016.	50196366.	9.0287515	0.0021613	-0.006456
3.9992080	-60.000000 CY				
0.0002444	12038.	49259137.	8.9919646	0.0021974	-0.006600
3.9989880	-60.000000 CY				
0.0002494	12055.	48342353.	8.9547288	0.0022331	-0.006744
3.9963252	-60.000000 CY				

0.0002544	12073.	47460573.	8.9193514	0.0022689	-0.006889
3.9990224	-60.000000 CY				
0.0002594	12090.	46611752.	8.8857742	0.0023047	-0.007033
3.9999968	-60.000000 CY				
0.0002644	12107.	45793157.	8.8542321	0.0023408	-0.007177
3.9946640	-60.000000 CY				
0.0002694	12123.	45004044.	8.8239937	0.0023770	-0.007321
3.9979584	-60.000000 CY				
0.0002744	12139.	44240912.	8.7935848	0.0024127	-0.007465
3.9996829	-60.000000 CY				
0.0003044	12226.	40168519.	8.6370401	0.0026289	-0.008329
3.9929777	-60.000000 CY				
0.0003344	12306.	36804316.	8.5206996	0.0028491	-0.009188
3.9959066	-60.000000 CY				
0.0003644	12380.	33976405.	8.4295005	0.0030715	-0.010046
3.9958258	-60.000000 CYT				
0.0003944	12448.	31564863.	8.3549177	0.0032950	-0.010903
3.9924338	-60.000000 CYT				
0.0004244	12513.	29485937.	8.2968890	0.0035210	-0.011757
3.9904112	60.0000000 CYT				
0.0004544	12565.	27653417.	8.2436444	0.0037457	-0.012612
3.9994739	60.0000000 CYT				
0.0004844	12565.	25940689.	8.2177293	0.0039805	-0.013457
3.9918169	60.0000000 CYT				

Summary of Results for Nominal Moment Capacity for Section 1

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

Load Tens. No. Strain	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain	Max.
----- -----	----- -----	----- -----	----- -----	
1 -0.00977028	1.827	12356.455	0.00300000	

Note that the values of moment capacity in the table above are not
factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether
the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction
factor to compute ultimate moment capacity according to ACI 318,

or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding bending stiffnesses computed for common resistance factor values used for reinforced concrete sections.

Axial Stiff. Load Ult Mom No. kip-in ²	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. at
1 94223793.	0.65	1.827000	12356.	1.187550	8032.	
1 92778733.	0.75	1.827000	12356.	1.370250	9267.	
1 71419169.	0.90	1.827000	12356.	1.644300	11121.	

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	1021.
2	3.0000	3.5864	No	No	1021.	8834.
3	11.5000	11.5000	No	Yes	N.A.	N.A.
4	14.5000	14.5000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 1930.0 lbs
Applied moment at pile head = 878879.0 in-lbs
Axial thrust load on pile head = 1827.0 lbs

Depth Res.	Soil X	Deflect. Spr.	Distrib. y	Bending Moment	Shear Force	Slope S	Total Stress	Bending Stiffness	Soil p
	Es*H		Lat. Load						
feet		inches		in-lbs	lbs	radians	psi*	lb-in^2	
lb/inch		lb/inch		lb/inch					
0.00		2.2862		878879.	1930.	-0.02852	0.00	3.86E+11	
-101.528		26.6457		0.00					
0.10000		2.2520		881185.	1807.	-0.02852	0.00	3.86E+11	
-103.034		54.9041		0.00					
0.2000		2.2177		883342.	1683.	-0.02851	0.00	3.86E+11	
-104.516		56.5526		0.00					
0.3000		2.1835		885348.	1556.	-0.02851	0.00	3.86E+11	
-105.971		58.2384		0.00					
0.4000		2.1493		887202.	1428.	-0.02851	0.00	3.86E+11	
-107.399		59.9630		0.00					
0.5000		2.1151		888901.	1299.	-0.02851	0.00	3.86E+11	
-108.800		61.7279		0.00					
0.6000		2.0809		890444.	1167.	-0.02850	0.00	3.86E+11	
-110.174		63.5348		0.00					
0.7000		2.0467		891828.	1034.	-0.02850	0.00	3.86E+11	
-111.520		65.3855		0.00					
0.8000		2.0125		893051.	899.6855	-0.02850	0.00	3.86E+11	
-112.837		67.2820		0.00					
0.9000		1.9783		894112.	763.5084	-0.02850	0.00	3.86E+11	
-114.125		69.2262		0.00					
1.0000		1.9441		895009.	625.8036	-0.02849	0.00	3.86E+11	
-115.383		71.2204		0.00					
1.1000		1.9099		895739.	486.6075	-0.02849	0.00	3.86E+11	
-116.611		73.2667		0.00					
1.2000		1.8757		896301.	345.9567	-0.02849	0.00	3.86E+11	
-117.807		75.3677		0.00					
1.3000		1.8415		896694.	203.8889	-0.02848	0.00	3.86E+11	
-118.973		77.5258		0.00					
1.4000		1.8074		896916.	60.4423	-0.02848	0.00	3.86E+11	
-120.105		79.7440		0.00					
1.5000		1.7732		896964.	-84.344	-0.02848	0.00	3.86E+11	
-121.205		82.0252		0.00					

1.6000	1.7390	896838.	-230.430	-0.02848	0.00	3.86E+11
-122.271	84.3724	0.00				
1.7000	1.7048	896536.	-377.773	-0.02847	0.00	3.86E+11
-123.302	86.7893	0.00				
1.8000	1.6707	896056.	-526.333	-0.02847	0.00	3.86E+11
-124.298	89.2793	0.00				
1.9000	1.6365	895398.	-676.065	-0.02847	0.00	3.86E+11
-125.257	91.8465	0.00				
2.0000	1.6024	894558.	-826.927	-0.02846	0.00	3.86E+11
-126.179	94.4950	0.00				
2.1000	1.5682	893538.	-978.872	-0.02846	0.00	3.86E+11
-127.063	97.2294	0.00				
2.2000	1.5341	892334.	-1132.	-0.02846	0.00	3.86E+11
-127.907	100.0547	0.00				
2.3000	1.4999	890946.	-1286.	-0.02846	0.00	3.86E+11
-128.712	102.9761	0.00				
2.4000	1.4658	889373.	-1441.	-0.02845	0.00	3.86E+11
-129.474	105.9995	0.00				
2.5000	1.4316	887613.	-1597.	-0.02845	0.00	3.86E+11
-130.195	109.1311	0.00				
2.6000	1.3975	885666.	-1753.	-0.02845	0.00	3.86E+11
-130.871	112.3778	0.00				
2.7000	1.3633	883530.	-1911.	-0.02845	0.00	3.86E+11
-131.502	115.7469	0.00				
2.8000	1.3292	881205.	-2069.	-0.02844	0.00	3.86E+11
-132.086	119.2466	0.00				
2.9000	1.2951	878690.	-2228.	-0.02844	0.00	3.86E+11
-132.622	122.8859	0.00				
3.0000	1.2610	875984.	-2496.	-0.02844	0.00	3.86E+11
-315.405	300.1595	0.00				
3.1000	1.2268	872823.	-2901.	-0.02843	0.00	3.86E+11
-358.750	350.9045	0.00				
3.2000	1.1927	869146.	-3381.	-0.02843	0.00	3.86E+11
-441.309	444.0072	0.00				
3.3000	1.1586	864834.	-3910.	-0.02843	0.00	3.86E+11
-440.786	456.5394	0.00				
3.4000	1.1245	859886.	-4438.	-0.02843	0.00	3.86E+11
-439.564	469.0855	0.00				
3.5000	1.0904	854306.	-4965.	-0.02842	0.00	3.86E+11
-437.644	481.6463	0.00				
3.6000	1.0563	848096.	-5488.	-0.02842	0.00	3.86E+11
-435.025	494.2231	0.00				
3.7000	1.0222	841259.	-6008.	-0.02842	0.00	3.86E+11
-431.703	506.8129	0.00				
3.8000	0.9881	833800.	-6524.	-0.02842	0.00	3.86E+11
-427.230	518.8714	0.00				
3.9000	0.9540	825727.	-7033.	-0.02841	0.00	3.86E+11
-422.144	531.0199	0.00				
4.0000	0.9199	817045.	-7536.	-0.02841	0.00	3.86E+11
-416.442	543.2631	0.00				

4.1000	0.8858	807764.	-8032.	-0.02841	0.00	3.86E+11
-410.119	555.6052	0.00				
4.2000	0.8517	797892.	-8520.	-0.02841	0.00	3.86E+11
-403.169	568.0506	0.00				
4.3000	0.8176	787439.	-9000.	-0.02840	0.00	3.86E+11
-395.587	580.6039	0.00				
4.4000	0.7835	776417.	-9469.	-0.02840	0.00	3.86E+11
-387.367	593.2694	0.00				
4.5000	0.7494	764837.	-9929.	-0.02840	0.00	3.86E+11
-378.501	606.0516	0.00				
4.6000	0.7154	752712.	-10377.	-0.02840	0.00	3.86E+11
-368.984	618.9549	0.00				
4.7000	0.6813	740056.	-10814.	-0.02839	0.00	3.86E+11
-358.806	631.9837	0.00				
4.8000	0.6472	726883.	-11238.	-0.02839	0.00	3.86E+11
-347.960	645.1425	0.00				
4.9000	0.6132	713209.	-11649.	-0.02839	0.00	3.86E+11
-336.436	658.4357	0.00				
5.0000	0.5791	699050.	-12045.	-0.02839	0.00	3.86E+11
-324.227	671.8676	0.00				
5.1000	0.5450	684425.	-12427.	-0.02838	0.00	3.86E+11
-311.321	685.4428	0.00				
5.2000	0.5110	669351.	-12792.	-0.02838	0.00	3.86E+11
-297.709	699.1655	0.00				
5.3000	0.4769	653848.	-13141.	-0.02838	0.00	3.86E+11
-283.380	713.0401	0.00				
5.4000	0.4429	637938.	-13472.	-0.02838	0.00	3.86E+11
-268.322	727.0710	0.00				
5.5000	0.4088	621641.	-13784.	-0.02838	0.00	3.86E+11
-252.524	741.2625	0.00				
5.6000	0.3748	604980.	-14077.	-0.02837	0.00	3.86E+11
-235.974	755.6190	0.00				
5.7000	0.3407	587980.	-14350.	-0.02837	0.00	3.86E+11
-218.659	770.1447	0.00				
5.8000	0.3067	570665.	-14602.	-0.02837	0.00	3.87E+11
-200.565	784.8440	0.00				
5.9000	0.2726	553061.	-14831.	-0.02837	0.00	3.87E+11
-181.679	799.7211	0.00				
6.0000	0.2386	535195.	-15037.	-0.02837	0.00	3.87E+11
-161.986	814.7802	0.00				
6.1000	0.2045	517096.	-15219.	-0.02837	0.00	3.87E+11
-141.472	830.0257	0.00				
6.2000	0.1705	498793.	-15376.	-0.02836	0.00	3.87E+11
-120.121	845.4617	0.00				
6.3000	0.1365	480318.	-15507.	-0.02836	0.00	3.87E+11
-97.918	861.0923	0.00				
6.4000	0.1024	461701.	-15611.	-0.02836	0.00	3.87E+11
-74.847	876.9217	0.00				
6.5000	0.06839	442976.	-15686.	-0.02836	0.00	3.87E+11
-50.891	892.9541	0.00				

6.6000	0.03436	424179.	-15732.	-0.02836	0.00	3.87E+11
-26.032	909.1936	0.00				
6.7000	3.30E-04	405344.	-15748.	-0.02836	0.00	3.87E+11
-0.254	925.6441	0.00				
6.8000	-0.03370	386508.	-15733.	-0.02836	0.00	3.87E+11
25.9782	925.0872	0.00				
6.9000	-0.06772	367710.	-15686.	-0.02835	0.00	3.87E+11
52.1679	924.3508	0.00				
7.0000	-0.102	348987.	-15607.	-0.02835	0.00	3.87E+11
78.3133	923.5982	0.00				
7.1000	-0.136	330376.	-15498.	-0.02835	0.00	3.87E+11
104.4129	922.8260	0.00				
7.2000	-0.170	311916.	-15357.	-0.02835	0.00	3.87E+11
130.4644	922.0308	0.00				
7.3000	-0.204	293644.	-15185.	-0.02835	0.00	3.87E+11
156.4655	921.2094	0.00				
7.4000	-0.238	275598.	-14981.	-0.02835	0.00	3.87E+11
182.4134	920.3584	0.00				
7.5000	-0.272	257814.	-14747.	-0.02835	0.00	3.87E+11
208.3048	919.4749	0.00				
7.6000	-0.306	240329.	-14481.	-0.02835	0.00	3.88E+11
234.1363	918.5556	0.00				
7.7000	-0.340	223182.	-14185.	-0.02835	0.00	3.88E+11
259.9041	917.5977	0.00				
7.8000	-0.374	206410.	-13858.	-0.02835	0.00	3.88E+11
285.6039	916.5980	0.00				
7.9000	-0.408	190048.	-13500.	-0.02835	0.00	3.88E+11
311.2313	915.5539	0.00				
8.0000	-0.442	174135.	-13111.	-0.02835	0.00	3.88E+11
336.7816	914.4625	0.00				
8.1000	-0.476	158707.	-12691.	-0.02835	0.00	3.88E+11
362.2497	913.3211	0.00				
8.2000	-0.510	143800.	-12241.	-0.02834	0.00	3.88E+11
387.6613	912.2001	0.00				
8.3000	-0.544	129452.	-11761.	-0.02834	0.00	3.88E+11
413.1882	911.4746	0.00				
8.4000	-0.578	115698.	-11251.	-0.02834	0.00	3.88E+11
435.9446	905.0831	0.00				
8.5000	-0.612	102572.	-10716.	-0.02834	0.00	3.88E+11
457.0013	896.0701	0.00				
8.6000	-0.646	90105.	-10155.	-0.02834	0.00	3.88E+11
477.5702	887.1006	0.00				
8.7000	-0.680	78325.	-9570.	-0.02834	0.00	3.88E+11
497.6552	878.1747	0.00				
8.8000	-0.714	67262.	-8961.	-0.02834	0.00	3.88E+11
517.2601	869.2927	0.00				
8.9000	-0.748	56943.	-8329.	-0.02834	0.00	3.88E+11
536.3888	860.4549	0.00				
9.0000	-0.782	47397.	-7674.	-0.02834	0.00	3.88E+11
555.0453	851.6614	0.00				

9.1000	-0.816	38650.	-6997.	-0.02834	0.00	3.88E+11
573.2337	842.9126	0.00				
9.2000	-0.850	30729.	-6298.	-0.02834	0.00	3.88E+11
590.9578	834.2087	0.00				
9.3000	-0.884	23659.	-5579.	-0.02834	0.00	3.88E+11
608.2217	825.5499	0.00				
9.4000	-0.918	17464.	-4839.	-0.02834	0.00	3.88E+11
625.0295	816.9366	0.00				
9.5000	-0.952	12170.	-4079.	-0.02834	0.00	3.88E+11
641.3853	808.3690	0.00				
9.6000	-0.986	7799.	-3300.	-0.02834	0.00	3.88E+11
657.2932	799.8474	0.00				
9.7000	-1.020	4375.	-2502.	-0.02834	0.00	3.88E+11
672.7575	791.3721	0.00				
9.8000	-1.054	1919.	-1685.	-0.02834	0.00	3.88E+11
687.7822	782.9434	0.00				
9.9000	-1.088	453.7651	-851.341	-0.02834	0.00	3.88E+11
702.3717	774.5616	0.00				
10.0000	-1.122	0.00	0.00	-0.02834	0.00	3.88E+11
716.5303	383.1135	0.00				

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

Pile-head deflection	=	2.28617425 inches
Computed slope at pile head	=	-0.0285200 radians
Maximum bending moment	=	896964. inch-lbs
Maximum shear force	=	-15748. lbs
Depth of maximum bending moment	=	1.50000000 feet below pile head
Depth of maximum shear force	=	6.70000000 feet below pile head
Number of iterations	=	17
Number of zero deflection points	=	1

Pile-head Deflection vs. Pile Length for Load Case 1

Boundary Condition Type 1, Shear and Moment

Shear	=	1930. lbs
Moment	=	878879. in-lbs

Axial Load = 1827. lbs

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
10.00000	2.28617425	896964.	-15748.
9.50000	2.89470811	895951.	-16897.
9.00000	3.95898646	894807.	-18363.
8.50000	6.62463670	894514.	-20569.

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case	Load Type	Load 1	Load 2	Axial Load	Pile-head Deflection	Pile-head Rotation	Max in lbs
No.		in-lbs	in-lb	lbs	inches	radians	
1	V, lb	1930.	M, in-lb	878879.	1827.	2.2862	-0.02852
		-15748.					

Maximum pile-head deflection = 2.2861742498 inches

Maximum pile-head rotation = -0.0285200138 radians = -1.634076 deg.

The analysis ended normally.

APPENDIX G

**RETAINING WALL L-PILE
PARAMETER & ANALYSIS**



Soldier Pile and Lagging Wall
Lateral Analysis (P-Y Method)
For Estimated Drilled Shaft/Rock Socket Configuration

Calc By GV 7/30/2026
Check By HJH 7/30/2026

Analysis considers proposed grading and cross sections provided by
Arcadis on 05/12/2026

Utilized cross section @ STA 14+50 with adjacent boring B-003-0-25
for approx 10' max exposed wall height, 4H:1V slope, 8' depth to
bedrock (top 3' below grade excluded per ODOTGDM requirements
resulting in 13' design wall height).

For L-Pile Analysis we used a W24x104 pile with 33-ft length founded
in 36" Drilled Shaft socketed 15 feet into bedrock (TR@18'). Results
of analysis indicate 15-foot rock socket is acceptable

L-PILE Soil Parameters

**Site 3B_Retaining Wall
Exposed Wall**

Top of Drilled Shaft Elevation	946.5	feet	
Ground Surface Elevation	933.5	feet	
Grade in front of wall	0	degrees	
Depth of Shear surface below existing grade	0	feet	
Depth of Shear surface from top of wall	13	feet	
Anticipated Loss of Passive Resistance	0.0	feet	GDM 903.3
Passive Resistance depth to be Ignored	13.0	feet	GDM 903.3

From 13 to 18 feet

Use Soil Type-	Stiff Clay w Free Water (Reese)		
Effective Unit Weight =	62.6	pcf	GDM Table 400-4
Undrained Cohesion	1200	psf	GDM 405.1
Strain Factor ϵ_{50} =	0.007	pci	From L-pile Table 3.3

From 18 to 23.3 feet

Use Soil Type-	Massive Bedrock		GDM Section 1306.5.2
Effective Unit Weight =	87.6	pcf	GDM Table 400-5
Hoek-Brown Material Index, mi	6	dim	Shale
			Calculated based on Avg N60 =50/3", ERI =80.7 using Stark Eq. from
Qu	114.00	psi	GDM 405.3
Poisson's Ratio	0.25	dim	
GSI	20	dim	AASHTO LRFD Bridge Design Specification Figure 10.4.6.4-1
Intact Rock Modulus	10000	psi	GDM Table 400-6, Considering Very Weak Strength

From 23.3 to 60.0 feet

Use Soil Type-	Massive Bedrock		GDM Section 1306.5.2
Effective Unit Weight =	97.6	pcf	GDM Table 400-5
Hoek-Brown Material Index, mi	6	dim	Shale
Qu	500.00	psi	Average (Compressive Strength)-Stdev (Compressive Strength)
Poisson's Ratio	0.25	dim	
GSI	40	dim	AASHTO LRFD Bridge Design Specification Figure 10.4.6.4-1
Intact Rock Modulus	45000	psi	GDM Table 400-6, Considering Very Weak to Weak Strength

P-y Modification Factors

P- modification factor $\beta_a = 0.64(S/D)0.34$

S= Center to Center Spacing between the Piles= 8 feet

D= Diameter of the Pile= 3 feet

$\beta_a = 0.89$

Applied for Soil

	Equivalent Steel Pipe Section				Drilled Shaft			Comments
	Sxx in3	OD in	T in	ID in	Sxx in3	Diagonal in	Dia. (min) in	
W24x104	258	36	0.259	35.482	258	27.3	36	Acceptable

Site 3B_Retaining Wall

From AASHTO 3.11.5.3, Active Earth Pressure

$$K_a = \frac{\sin^2(\Theta + \phi'_f)}{\Gamma [\sin^2(\Theta) \sin(\Theta - \delta)]}$$

in which $\Gamma = [1 + \nu \{ (\sin(\phi'_f + \delta) \sin(\phi'_f - \beta)) / (\sin(\Theta - \delta) \sin(\Theta + \beta)) \}]^2$

Where

Angle of back face of the wall to the horizontal (Degrees), $\Theta =$

90

Effective angle of internal friction (degrees), $\phi'_f =$

28 (Assumed)

Friction angle between fill and wall (degrees), $\delta =$

0 (0 ϕ'_f)

Angle of fill to the horizontal, $\beta =$

14 (Assumed)

Calculation

$$\sin(\Theta - \delta) = 1.00$$

$$\sin^2(\Theta) = 1.00$$

$$\sin(\Theta + \phi'_f) = 0.88$$

$$\sin^2(\Theta + \phi'_f) = 0.78$$

$$\sin(\phi'_f - \beta) = 0.24$$

$$\sin(\Theta + \beta) = 0.97$$

$$\sin(\phi'_f + \delta) = 0.47$$

$$\Gamma = 1.80$$

$$K_a = 0.43$$

$$\gamma_{LS} = \text{NA} \quad \text{pcf}$$

Case 1

$$\text{Diameter of Shaft} = 36 \text{ inches}$$

$$\text{C/C Spacing (CC)} = 8 \text{ feet}$$

Therefore for a 36-inch Shaft placed at 8 feet center to center

$$\text{Surcharge Load } q_{LS} = 0.0 \text{ lb/in} \quad \gamma_{LS} * 2 * K_a * CC / 12$$

Project

Location

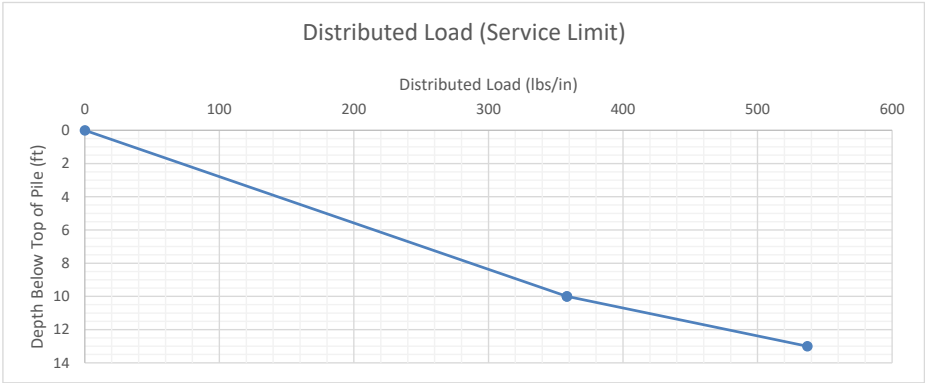
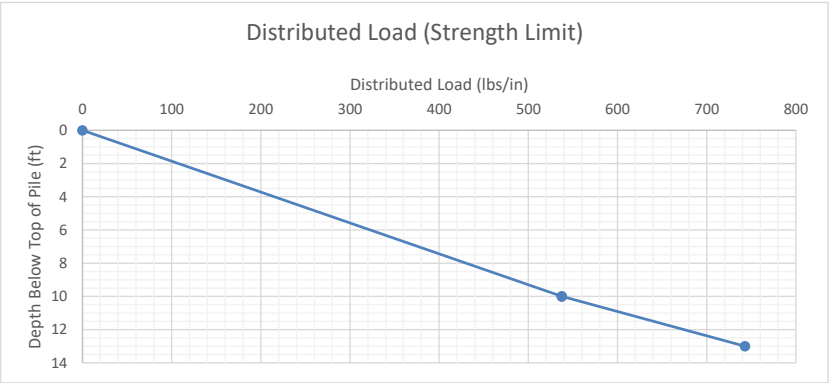
Structure Type

Analysis

Arcadis U-S- Inc-_GUE-IR70 EB Rest Area (Site 3B)
Guernsey County, Ohio
Retaining Wall_Soldier Pile and Lagging Wall
Distributed Lateral Load Summary (using Coulomb Active Earth Pressure)

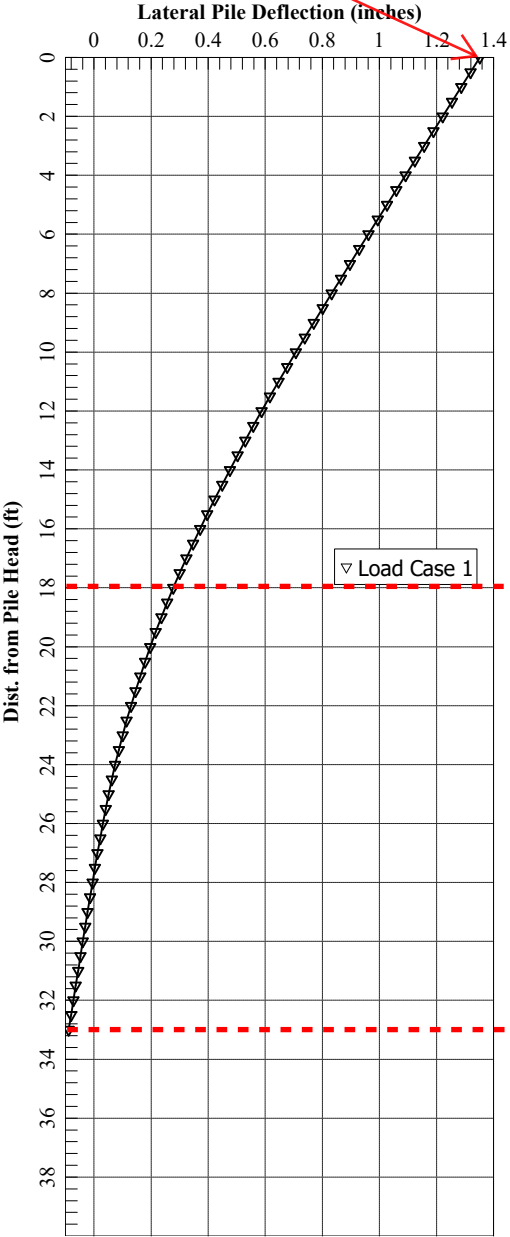
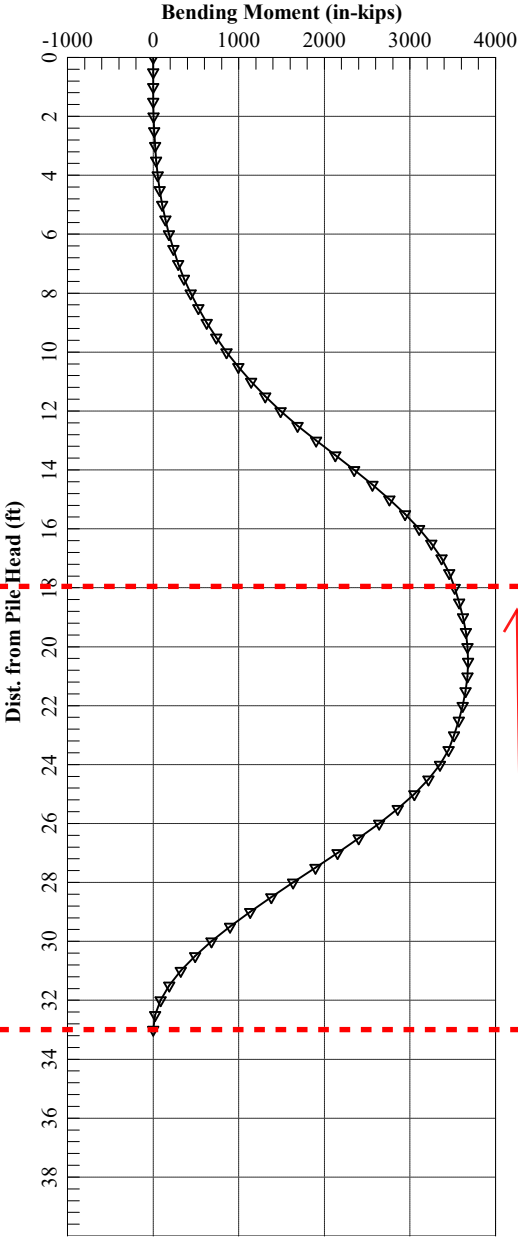
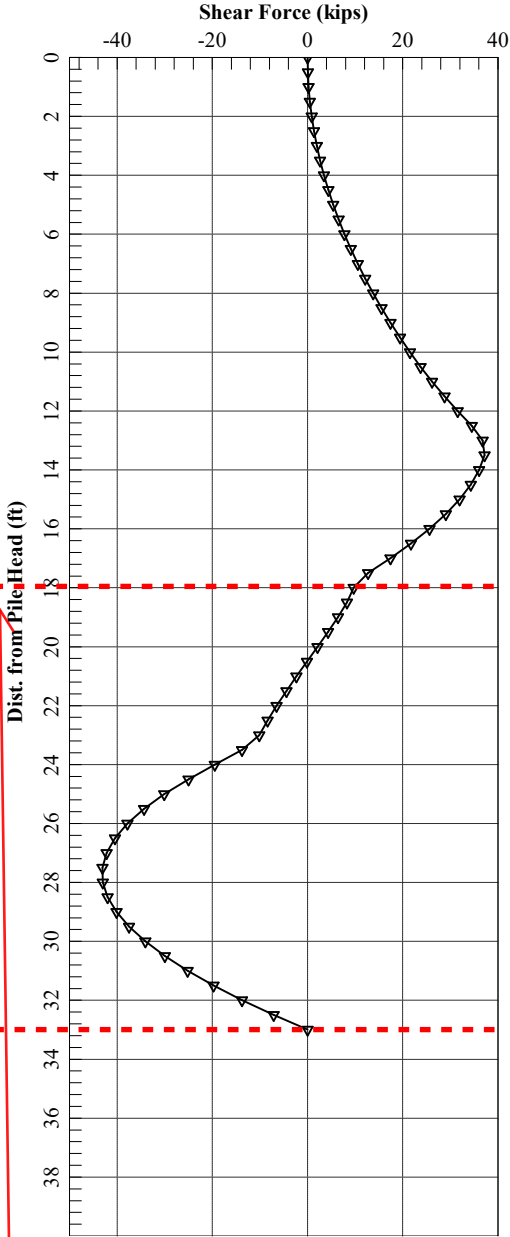
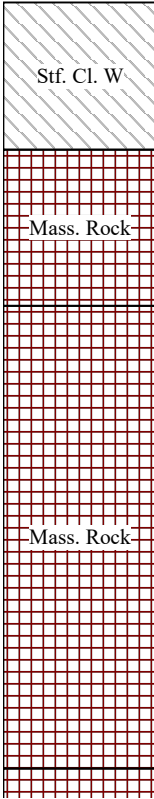
Terms & Definition			
γ	Total Unit Weight (pcf)	σ_v'	Effective Vertical Stress (psf)
K_a	Coefficient of Active Earth Pressure	σ_h	Total Horizontal Stress (Earth & Hydrostatic)
σ_v	Total Vertical Stress (psf)	W	Lateral Load due to Water (Hydrostatic)
u	Pore Water Pressure (psf)	EH	Lateral Load due to Soil

	Service I	Strength I														
Y _w	1.00	1.00														
Y _{EH}	1.00	1.50														
Water Table		10	ft													
Pile Spacing		8	ft						Service Limit				Strength Limit			
Depth	Thickness of layer	γ (pcf)	K _a	σ _v	u	σ _v '	σ _h '	σ _h	W	EH	Total		W	EH	Total	
											lb/ft	lb/in			lb/ft	lb/in
0	0	125		0	0	0	0	0	0	0	0	0	0	0	0	0
10	10	125	0.43	1250	0	1250	537.5	537.5	0	4300	4300	358	0	6450	6450	538
10	3	125	0.43	1250	0E+00	1250	537.5	537.5	0	4300	4300	358	0	6450	6450	538
13	3	125	0.43	1625	187.2	1437.8	618.3	805	1497.6	4946	6444	537	1497.6	7419.048	8917	743
									Total Load/Pile (lbs)		37,615		Total Load/Pile (lbs)		55,300	



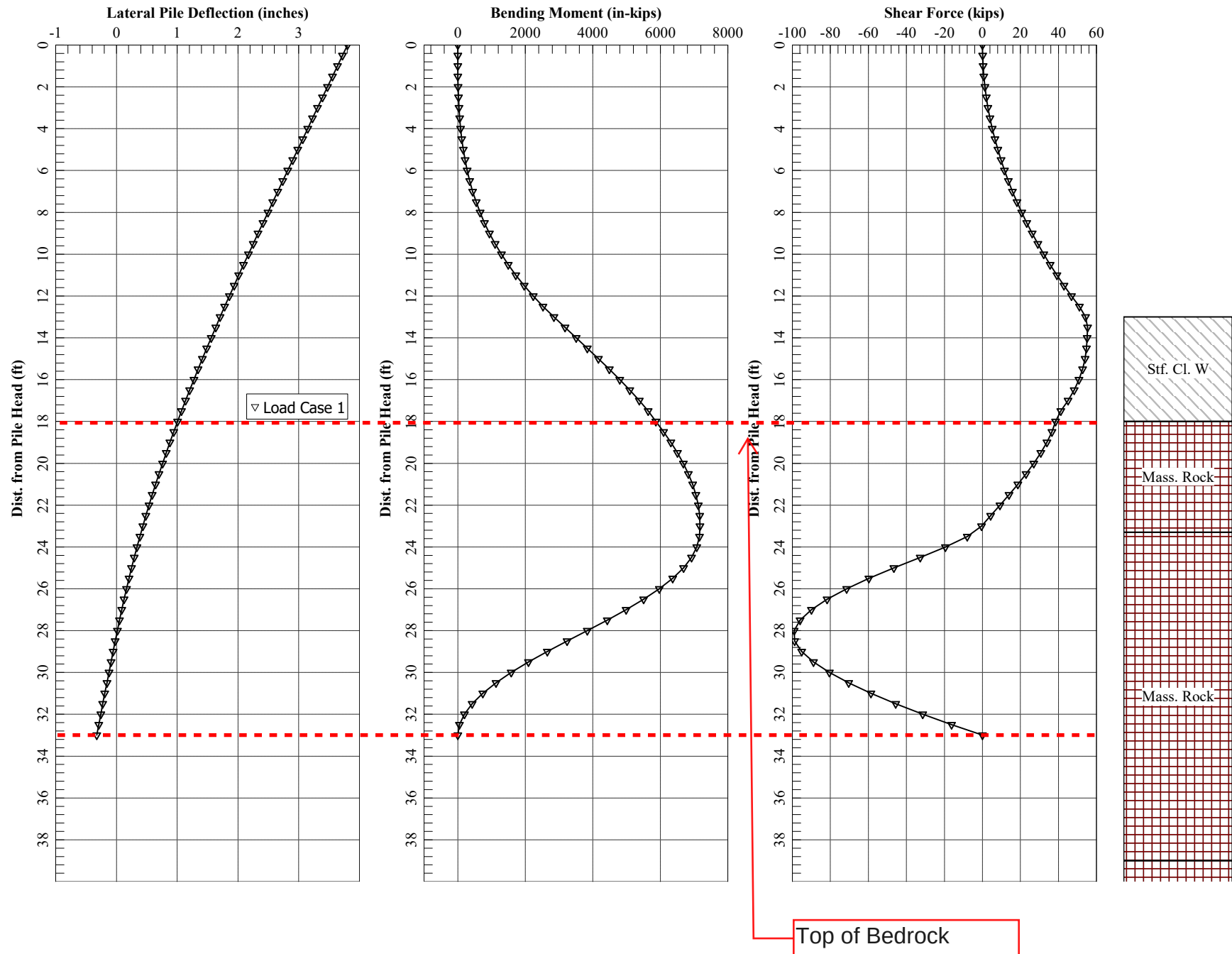
L-Pile Analysis Results - Service Limit

Deflection = 1.35



Top of Bedrock

L-Pile Analysis Results - Strength Limit



Site 3B_Retaining Wall

f) *L-pile Analysis*

Applied for Soil

Note: It is assumed that 50 Ksi steel will be used.

Section Used=

W 24x104

Case: 36 inch diameter Shafts with 8 feet center to center spacing

Checks:

Structural Strength Limit State Checks (W 24x104 Section)

Calculated Factored Moment(in-lbs)	Factored Nominal Moment Resistance(in-lbs)	Acceptable Or Unacceptable
7,174,594	12,900,000	Acceptable

Calculated Factored Shear (Kips)	Factored Nominal Shear resistance (Kips)	Acceptable Or Unacceptable
99.1	327.7	Acceptable

and for nominal shear resistance calculation Per AASHTO 6.10.9

Service Limit State Checks (W 24x104 Section)

Drilled Shaft retained height=

13 feet

For the unfactored Service Limit State analysis, the maximum Pilehead deflection must be limited to 1% of Retained Height or less

Calculated Deflection(in)	Allowable Deflection (in)	Acceptable Or Unacceptable
1.35	1.6	Acceptable

Site 3B_Retaining Wall

W 24x104

Thickness of Flange (t_f) =	0.75 in
Depth (d) =	24.10 in
Yield Strength of Steel (F_y) =	50 Ksi
$D = d - 2t_f =$	22.6 in
thickness of Web (t_w) =	0.5 in

$$V_p = 0.58 F_y D t_w = 327.7 \text{ Kips}$$

$$\text{Young's Modulus (E)} = 29000 \text{ Ksi}$$

Assume Unstiffened Web

$$\text{Shear Buckling Coefficient (K)} = 5.0$$

$$\text{Sqrt}(EK/F_y) = 53.9 \text{ Equation 1}$$

$$1.12 * \text{Sqrt}(EK/F_y) = 60.3 \text{ Equation 2}$$

$$1.4 * \text{Sqrt}(EK/F_y) = 75.4 \text{ Equation 3}$$

$$D/t_w = 45.2$$

$$\text{Since, } D/t_w \leq \text{Equation 1, } C = 1.0$$

Therefore,

$$\text{Nominal Shear Resistance (V}_n\text{)} = C V_p = 327.7 \text{ Kips}$$

$$\phi_v = 1.0$$

$$\text{Factored Shear Resistance (V}_u\text{)} = \phi_v V_n = 327.7 \text{ Kips}$$

Site 3B_Retaining Wall

W 24x104

Per AASHTO, 6.10.8

For Continuously Braced Flanges in Tension or Compression

$$f_{bu} \leq \phi_f R_h F_{yf} \quad \text{Equation 1}$$

Where f_{bu} = Factored Bending Moment Obtained in Strength Limit State

ϕ_f = Flexural Resistance Factor

R_h = Hybrid Factor

F_{yf} = $f_y * S_{x-x}$

f_y = Yield Strength of Steel

S_{x-x} = Section Modulus of Steel Section

ϕ_f = 1.0 Per AASHTO 6.5.4.2

R_h = 1.0 Per AASHTO 6.10.1.10.1

S_{x-x} = 258.0 in^3

f_y = 50.0 ksi

F_{yf} = 12,900,000 lb-in

=====

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Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method
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CTL ENGINEERING INC
Columbus, OH

=====

This model was prepared by:
gverma

Files Used for Analysis

Path to file locations on this computer:
\\PROJECT\\2025\\COL-05\\25050075COL_Arcadis U-S- Inc-_GUE-IR70 EB Rest Area (Site 3 B)\\Design\\RW\\

Name of the input data file:
SPL 8ft CTC W24x104 Service Limit_07.30.2026.lp12d

Name of the output report file:
SPL 8ft CTC W24x104 Service Limit_07.30.2026.lp12o

Name of the plot output file:
SPL 8ft CTC W24x104 Service Limit_07.30.2026.lp12p

Name of the runtime message file:
SPL 8ft CTC W24x104 Service Limit_07.30.2026.lp12r

Date and Time of Analysis

Date: July 30, 2026

Time: 16:53:15

Problem Title

Project Name: GUE-IR70 EB Rest Area (Site 3B)_RW

Job Number: 25050075COL

Client: Arcadis U.S., Inc.

Engineer: CTL Engineering, Inc.

Description:

Program Options and Settings

Computational Options:

- Conventional Analysis

Engineering Units Used for Data Input and Computations:

- US Customary System Units (pounds, feet, inches)

Analysis Control Options:

- | | | |
|--|---|---------------|
| - Maximum number of iterations allowed | = | 500 |
| - Deflection tolerance for convergence | = | 1.0000E-05 in |
| - Maximum allowable deflection | = | 100.0000 in |
| - Number of pile increments | = | 66 |

Loading Type and Number of Cycles of Loading:

- Static loading specified
- Analysis uses p-y modification factors for p-y curves
- Analysis uses layering correction (Method of Georgiadis)

- Analysis includes loading by one distributed lateral load acting on pile
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:

- Output files use decimal points to denote decimal symbols.
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1
- No p-y curves to be computed and reported for user-specified depths
- Print using narrow report formats
(Note: Some output information is omitted from the narrow report formats)

Pile Structural Properties and Geometry

Number of pile sections defined	=	2
Total length of pile	=	33.000 ft
Depth of ground surface below top of pile	=	13.0000 ft

Pile diameters used for p-y curve computations are defined using 4 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	12.8000
2	13.000	12.8000
3	13.000	36.0000
4	33.000	36.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a AISC strong axis steel pile	
Length of section	= 13.000000 ft

AISC Section Type = W

AISC Section Name = W24X104

Pile width = 12.800000 in

Pile Section No. 2:

Section 2 is a drilled shaft with casing and AISC section core/insert

Length of section = 20.000000 ft

Section Diameter = 36.000000 in

Core/Insert AISC Section Type = W

Core/Insert AISC Section Name = W24X104

Soil and Rock Layering Information

The soil profile is modelled using 3 layers

Layer 1 is stiff clay with water-induced erosion

Distance from top of pile to top of layer = 13.000000 ft

Distance from top of pile to bottom of layer = 18.000000 ft

Effective unit weight at top of layer = 62.600000 pcf

Effective unit weight at bottom of layer = 62.600000 pcf

Undrained cohesion at top of layer = 1200. psf

Undrained cohesion at bottom of layer = 1200. psf

Epsilon-50 at top of layer = 0.007000

Epsilon-50 at bottom of layer = 0.007000

Subgrade k at top of layer = 0.0000 pci

Subgrade k at bottom of layer = 0.0000 pci

NOTE: Default values for subgrade k will be computed for this layer.

Layer 2 is massive rock, p-y criteria by Liang et al., 2009

Distance from top of pile to top of layer = 18.000000 ft

Distance from top of pile to bottom of layer = 23.300000 ft
 Effective unit weight at top of layer = 87.600000 pcf
 Effective unit weight at bottom of layer = 87.600000 pcf
 Uniaxial compressive strength at top of layer = 114.000000 psi
 Uniaxial compressive strength at bottom of layer = 114.000000 psi
 Poisson's ratio at top of layer = 0.250000
 Poisson's ratio at bottom of layer = 0.250000
 Option 1: Intact rock modulus at top of layer = 10000. psi
 Intact rock modulus at bottom of layer = 10000. psi
 Option 1: Geologic Strength Index for layer = 20.000000
 Option 2: Rock mass modulus at top of layer = 0.0000 psi
 Rock mass modulus at bottom of layer = 0.0000 psi
 Option 1 will be used to compute values of rock mass modulus for the p-y curve
 in massive rock.
 The rock type is (sedimentary) shales, Hoek-Brown Material Constant $m_i = 6$

Layer 3 is massive rock, p-y criteria by Liang et al., 2009

Distance from top of pile to top of layer = 23.300000 ft
 Distance from top of pile to bottom of layer = 60.000000 ft
 Effective unit weight at top of layer = 97.600000 pcf
 Effective unit weight at bottom of layer = 97.600000 pcf
 Uniaxial compressive strength at top of layer = 500.000000 psi
 Uniaxial compressive strength at bottom of layer = 500.000000 psi
 Poisson's ratio at top of layer = 0.250000
 Poisson's ratio at bottom of layer = 0.250000
 Option 1: Intact rock modulus at top of layer = 45000. psi
 Intact rock modulus at bottom of layer = 45000. psi
 Option 1: Geologic Strength Index for layer = 40.000000
 Option 2: Rock mass modulus at top of layer = 0.0000 psi
 Rock mass modulus at bottom of layer = 0.0000 psi
 Option 1 will be used to compute values of rock mass modulus for the p-y curve
 in massive rock.
 The rock type is (sedimentary) shales, Hoek-Brown Material Constant $m_i = 6$

(Depth of the lowest soil layer extends 27.000 ft below the pile tip)

Modification Factors for p-y Curves

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
-----	-----	-----	-----

1	13.000	0.8900	1.0000
2	18.000	0.8900	1.0000

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Distributed Lateral Loading Used For All Load Cases

Distributed lateral load intensity defined using 3 points

Point No.	Depth X ft	Dist. Load lb/in
1	0.000	0.000
2	10.000	358.000
3	13.000	537.000

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs
1	1	V = 0.0000 lbs	M = 0.0000 in-lbs	0.0000000

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

 Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 2

Pile Section No. 1:

Dimensions and Properties of Steel AISC Strong Axis:

Length of Section	=	13.000000 ft
Flange Width	=	12.800000 in
Section Depth	=	24.100000 in
Flange Thickness	=	0.750000 in
Web Thickness	=	0.500000 in
Yield Stress of Pipe	=	50.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	30.700000 sq. in.
Moment of Inertia	=	3100. in^4
Elastic Bending Stiffness	=	89900000. kip-in^2
Plastic Modulus, Z	=	289.000000 in^3
Plastic Moment Capacity = Fy Z	=	14450. in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As	=	1535.000 kips
Nominal Axial Tensile Capacity	=	-1535.000 kips

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
-----	-----
1	0.000

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 0.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Run Msg
-----	-----	-----	-----	---
0.0000057247	514.1817236952	89818473.	12.0500000000	
0.0000114494	1028.	89818473.	12.0500000000	
0.0000171740	1543.	89818473.	12.0500000000	
0.0000228987	2057.	89818473.	12.0500000000	
0.0000286234	2571.	89818473.	12.0500000000	
0.0000343481	3085.	89818473.	12.0500000000	
0.0000400727	3599.	89818473.	12.0500000000	
0.0000457974	4113.	89818473.	12.0500000000	
0.0000515221	4628.	89818473.	12.0500000000	
0.0000572468	5142.	89818473.	12.0500000000	
0.0000629714	5656.	89818473.	12.0500000000	
0.0000686961	6170.	89818473.	12.0500000000	
0.0000744208	6684.	89818473.	12.0500000000	
0.0000801455	7199.	89818473.	12.0500000000	
0.0000858702	7713.	89818473.	12.0500000000	
0.0000915948	8227.	89818473.	12.0500000000	
0.0000973195	8741.	89818473.	12.0500000000	
0.0001030442	9255.	89818473.	12.0500000000	
0.0001087689	9769.	89818473.	12.0500000000	
0.0001144935	10284.	89818473.	12.0500000000	
0.0001202182	10798.	89818473.	12.0500000000	
0.0001259429	11312.	89818473.	12.0500000000	
0.0001316676	11826.	89818473.	12.0500000000	
0.0001373922	12340.	89818473.	12.0500000000	
0.0001431169	12855.	89818473.	12.0500000000	
0.0001488416	13226.	88861272.	12.0500000000	Y
0.0001545663	13360.	86433359.	12.0500000000	Y
0.0001602909	13432.	83800739.	12.0500000000	Y
0.0001660156	13498.	81303575.	12.0500000000	Y
0.0001717403	13557.	78937457.	12.0500000000	Y
0.0001774650	13610.	76691343.	12.0500000000	Y
0.0001831897	13658.	74558147.	12.0500000000	Y
0.0001889143	13702.	72532141.	12.0500000000	Y
0.0001946390	13743.	70605849.	12.0500000000	Y
0.0002003637	13780.	68772556.	12.0500000000	Y
0.0002060884	13813.	67026205.	12.0500000000	Y
0.0002118130	13844.	65361302.	12.0500000000	Y
0.0002175377	13873.	63772850.	12.0500000000	Y
0.0002232624	13899.	62256280.	12.0500000000	Y
0.0002289871	13947.	59422338.	12.0500000000	Y
0.0002347117	13988.	56823148.	12.0500000000	Y
0.0002404364	14023.	54435866.	12.0500000000	Y
0.0002461611	14055.	52235636.	12.0500000000	Y
0.0002518858	14082.	50201523.	12.0500000000	Y

0.0002919585	14106.	48315753.	12.0500000000	Y
0.0003034079	14128.	46563108.	12.0500000000	Y
0.0003148572	14147.	44930469.	12.0500000000	Y
0.0003263066	14164.	43406443.	12.0500000000	Y
0.0003377559	14179.	41981071.	12.0500000000	Y
0.0003492053	14194.	40645595.	12.0500000000	Y
0.0003606546	14206.	39389601.	12.0500000000	Y
0.0003721040	14218.	38208731.	12.0500000000	Y
0.0003835533	14228.	37095857.	12.0500000000	Y
0.0003950027	14238.	36044580.	12.0500000000	Y
0.0004064520	14247.	35051451.	12.0500000000	Y
0.0004179014	14255.	34110035.	12.0500000000	Y
0.0004293508	14262.	33218146.	12.0500000000	Y
0.0004408001	14269.	32370779.	12.0500000000	Y
0.0004522495	14275.	31565283.	12.0500000000	Y
0.0004636988	14282.	30799114.	12.0500000000	Y
0.0004751482	14287.	30067958.	12.0500000000	Y
0.0004865975	14292.	29371210.	12.0500000000	Y
0.0004980469	14297.	28705698.	12.0500000000	Y
0.0005094962	14301.	28068959.	12.0500000000	Y
0.0005209456	14305.	27460208.	12.0500000000	Y
0.0005323949	14309.	26877299.	12.0500000000	Y
0.0005438443	14313.	26317710.	12.0500000000	Y
0.0005552936	14316.	25781197.	12.0500000000	Y
0.0005667430	14320.	25266362.	12.0500000000	Y
0.0005781923	14323.	24771272.	12.0500000000	Y
0.0005896417	14325.	24294809.	12.0500000000	Y
0.0006010911	14328.	23836496.	12.0500000000	Y
0.0006125404	14331.	23395317.	12.0500000000	Y
0.0006239898	14333.	22970165.	12.0500000000	Y
0.0006354391	14335.	22559527.	12.0500000000	Y
0.0006468885	14337.	22163424.	12.0500000000	Y
0.0006583378	14339.	21781099.	12.0500000000	Y
0.0006697872	14341.	21411844.	12.0500000000	Y
0.0006812365	14343.	21055002.	12.0500000000	Y
0.0007270339	14350.	19737211.	12.0500000000	Y

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	0.00000000	14350.

Note that the values in the above table are not factored by a strength

reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Pile Section No. 2:

Dimensions and Properties of Drilled Shaft (Bored Pile) with Casing and AISC Strong Axis Core/Insert:

Length of Section	=	20.000000 ft
Outside Diameter of Casing	=	36.000000 in
Casing Wall Thickness	=	0.0000 in
Moment of Inertia of Steel Casing	=	0.0000 in^4
Width Flange of Core/Insert	=	12.800000 in
Depth of Core/Insert	=	24.100000 in
Flange Thickness of Core/Insert	=	0.750000 in
Web Thickness of Core/Insert	=	0.500000 in
Moment of Inertia of Steel Core/Insert	=	3100. in^4
Yield Stress of Casing	=	50000. psi
Elastic Modulus of Casing	=	29000000. psi
Yield Stress of Core/Insert	=	50000. psi
Elastic Modulus of Core/Insert	=	29000000. psi
Number of Reinforcing Bars	=	0 bars
Gross Area of Pile	=	1018. sq. in.
Area of Concrete	=	987.376020 sq. in.
Cross-sectional Area of Steel Casing	=	0.0000 sq. in.
Cross-sectional Area of Steel Core/Insert	=	30.700000 sq. in.
Area of All Steel (Casing, Core/Insert, and Bars)	=	30.500000 sq. in.
Area Ratio of All Steel to Gross Area	=	3.00 percent

Note that the core is assumed to be void of concrete.

Axial Structural Capacities:

Nom. Axial Structural Capacity = $0.85 F_c A_c + F_y A_s$	=	4891.398 kips
Tensile Load for Cracking of Concrete	=	-513.290 kips
Nominal Axial Tensile Capacity	=	-1535.000 kips

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
-----	-----
1	0.000

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 0.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Run Msg
-----	-----	-----	-----	---
0.0000057247	2406.	420205918.	18.0000000000	
0.0000114494	2406.	210102959.	11.7228426511	C
0.0000171740	2789.	162415986.	11.7521600616	C
0.0000228987	3708.	161927833.	11.7819896335	C
0.0000286234	4621.	161432224.	11.8123480620	C
0.0000343481	5528.	160928906.	11.8432548210	C
0.0000400727	6428.	160417611.	11.8747327250	C
0.0000457974	7323.	159898057.	11.9068009122	C
0.0000515221	8211.	159369944.	11.9394845421	C
0.0000572468	9093.	158832948.	11.9728079083	C
0.0000629714	9968.	158286752.	12.0067961383	C
0.0000686961	10836.	157730991.	12.0414774442	C
0.0000744208	11696.	157165689.	12.0764238564	C
0.0000801455	12550.	156590718.	12.1115873404	C
0.0000858702	13396.	156005303.	12.1474960677	C
0.0000915948	14235.	155409013.	12.1841833485	C
0.0000973195	15052.	154664148.	12.2172576561	CY
0.0001030442	15494.	150358616.	12.1326377484	CY
0.0001087689	15754.	144842116.	12.0023172884	CY
0.0001144935	15985.	139611572.	11.8757466805	CY
0.0001202182	16191.	134680765.	11.7558690500	CY
0.0001259429	16375.	130021242.	11.6399004804	CY
0.0001316676	16541.	125626514.	11.5281739225	CY
0.0001373922	16691.	121485581.	11.4224646661	CY
0.0001431169	16827.	117577872.	11.3216603291	CY
0.0001488416	16951.	113885579.	11.2232772740	CY
0.0001545663	17064.	110396645.	11.1299950753	CY
0.0001602909	17168.	107103480.	11.0419486901	CY
0.0001660156	17263.	103981919.	10.9574574015	CY
0.0001717403	17349.	101019022.	10.8748206361	CY

0.0001774650	17429.	98210681.	10.7965612235	CY
0.0001831897	17503.	95544473.	10.7224724390	CY
0.0001889143	17571.	93010513.	10.6523701801	CY
0.0001946390	17634.	90596301.	10.5842120822	CY
0.0002003637	17691.	88293206.	10.5181443005	CY
0.0002060884	17744.	86099167.	10.4553114127	CY
0.0002118130	17794.	84006591.	10.3957927895	CY
0.0002175377	17839.	82005958.	10.3387963412	CY
0.0002232624	17882.	80094735.	10.2846718048	CY
0.0002347117	17958.	76511946.	10.1798233717	CY
0.0002461611	18025.	73222599.	10.0827673090	CY
0.0002576105	18083.	70193954.	9.9935173998	CY
0.0002690598	18134.	67398823.	9.9116913660	CY
0.0002805092	18179.	64807090.	9.8321132806	CY
0.0002919585	18219.	62401359.	9.7578505280	CY
0.0003034079	18254.	60162452.	9.6884129101	CY
0.0003148572	18285.	58075363.	9.6239033323	CY
0.0003263066	18315.	56127037.	9.5635697961	CY

Summary of Results for Nominal Moment Capacity for Section 2

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
-----	-----	-----
1	0.00000000	18315.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Layering Correction Equivalent Depths of Soil & Rock Layers

Top of	Equivalent
--------	------------

Layer No.	Layer Below Pile Head ft	Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	13.0000	0.00	N.A.	No	0.00	5532.
2	18.0000	5.0000	No	Yes	N.A.	N.A.
3	23.3000	10.3000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 0.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Soil Res. p lb/inch	Bending Stiffness lb-in^2
0.000	1.35232	-1.219E-05	4.617E-08	0.000	8.982E+10
0.50000	1.31973	80.55001	67.12500	0.000	8.982E+10
1.00000	1.28713	805.50001	228.22500	0.000	8.982E+10
1.50000	1.25454	2819.	496.72500	0.000	8.982E+10
2.00000	1.22195	6766.	872.62500	0.000	8.982E+10
2.50000	1.18936	13291.	1356.	0.000	8.982E+10
3.00000	1.15677	23037.	1947.	0.000	8.982E+10
3.50000	1.12420	36650.	2645.	0.000	8.982E+10
4.00000	1.09164	54774.	3450.	0.000	8.982E+10
4.50000	1.05910	78053.	4363.	0.000	8.982E+10
5.00000	1.02660	107131.	5383.	0.000	8.982E+10
5.50000	0.99413	142654.	6511.	0.000	8.982E+10
6.00000	0.96172	185265.	7746.	0.000	8.982E+10
6.50000	0.92939	235609.	9089.	0.000	8.982E+10
7.00000	0.89715	294330.	10539.	0.000	8.982E+10
7.50000	0.86503	362072.	12096.	0.000	8.982E+10
8.00000	0.83306	439481.	13761.	0.000	8.982E+10

8.50000	0.80126	527200.	15533.	0.000	8.982E+10
9.00000	0.76967	625873.	17412.	0.000	8.982E+10
9.50000	0.73834	736146.	19399.	0.000	8.982E+10
10.00000	0.70730	858663.	21498.	0.000	8.982E+10
10.50000	0.67660	994121.	23740.	0.000	8.982E+10
11.00000	0.64630	1143541.	26156.	0.000	8.982E+10
11.50000	0.61646	1307998.	28752.	0.000	8.982E+10
12.00000	0.58714	1488564.	31526.	0.000	8.982E+10
12.50000	0.55842	1686314.	34480.	0.000	8.982E+10
13.00000	0.53038	1902322.	36796.	0.000	8.982E+10
13.50000	0.50310	2127862.	37150.	-146.6132	4.202E+11
14.00000	0.47600	2348124.	36004.	-235.5918	4.202E+11
14.50000	0.44910	2559905.	34273.	-341.3518	1.862E+11
15.00000	0.42270	2759397.	31933.	-438.6786	1.650E+11
15.50000	0.39690	2943097.	29032.	-528.2542	1.623E+11
16.00000	0.37175	3107779.	25615.	-610.5294	1.622E+11
16.50000	0.34729	3250482.	21726.	-685.8026	1.621E+11
17.00000	0.32355	3368497.	17406.	-754.2722	1.621E+11
17.50000	0.30057	3459357.	12695.	-816.0655	1.620E+11
18.00000	0.27835	3520840.	9700.	-182.4087	1.620E+11
18.50000	0.25691	3575755.	8266.	-295.4762	1.620E+11
19.00000	0.23627	3620033.	6377.	-334.2409	1.620E+11
19.50000	0.21643	3652279.	4298.	-358.6209	1.620E+11
20.00000	0.19740	3671615.	2111.	-370.4223	1.619E+11
20.50000	0.17919	3677615.	-114.5752	-371.5349	1.619E+11
21.00000	0.16180	3670240.	-2321.	-363.8182	1.619E+11
21.50000	0.14522	3649767.	-4459.	-349.0199	1.620E+11
22.00000	0.12946	3616730.	-6492.	-328.7243	1.620E+11
22.50000	0.11450	3571859.	-8392.	-304.3275	1.620E+11
23.00000	0.10033	3516031.	-10135.	-276.7795	1.620E+11
23.50000	0.08694	3450240.	-13776.	-936.8557	1.620E+11
24.00000	0.07432	3350722.	-19457.	-956.8833	1.621E+11
24.50000	0.06245	3216757.	-25025.	-899.0202	1.622E+11
25.00000	0.05129	3050426.	-30071.	-783.0671	1.622E+11
25.50000	0.04080	2855905.	-34360.	-646.5972	1.624E+11
26.00000	0.03095	2638107.	-37825.	-508.2888	1.769E+11
26.50000	0.02164	2402010.	-40453.	-367.7445	4.202E+11
27.00000	0.01253	2152674.	-42217.	-220.3448	4.202E+11
27.50000	0.003606	1895406.	-43075.	-65.6119	4.202E+11
28.00000	-0.005155	1635776.	-42992.	93.25513	4.202E+11
28.50000	-0.0138	1379503.	-41988.	241.44128	4.202E+11
29.00000	-0.0223	1131922.	-40127.	378.99400	4.202E+11
29.50000	-0.0307	897985.	-37467.	507.47959	4.202E+11
30.00000	-0.0390	682317.	-34060.	628.18623	4.202E+11
30.50000	-0.0473	489264.	-29949.	742.17611	4.202E+11
31.00000	-0.0555	322929.	-25172.	850.32553	4.202E+11
31.50000	-0.0637	187206.	-19760.	953.35609	4.202E+11
32.00000	-0.0719	85803.	-13745.	1052.	4.202E+11
32.50000	-0.0801	22268.	-7150.	1146.	4.202E+11
33.00000	-0.0883	0.000	0.000	1237.	4.202E+11

Output Summary for Load Case No. 1:

Pile-head deflection = 1.35231975 inches
 Computed slope at pile head = -0.0054322 radians
 Maximum bending moment = 3677615. inch-lbs
 Maximum shear force = -43075. lbs
 Depth of maximum bending moment = 20.50000000 feet below pile head
 Depth of maximum shear force = 27.50000000 feet below pile head
 Number of iterations = 30
 Number of zero deflection points = 1
 Pile deflection at ground = 0.53037873 inches

Pile-head Deflection vs. Pile Length for Load Case 1

Boundary Condition Type 1, Shear and Moment

Shear = 0. lbs
 Moment = 0. in-lbs
 Axial Load = 0. lbs

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs	On reducing the depth of drilled shaft socketed into bedrock, the deflection is increasing significantly specifically from shaft length of 31.35 to 29.7
33.00000	1.35231975	3677615.	-43075.	
31.35000	1.69534629	3675971.	-50167.	
29.70000	7.09069911	4915750.	-98199.	

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
 Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
 Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
 Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
 Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
---------------	-----------	-----------------------------	----------------------------	-----------------------	---------------------------

----	----	-----	-----	-----	-----
1	1	1.352320	-0.00543	-43075.	3677615.

Maximum pile-head deflection = 1.3523197502 inches

Maximum pile-head rotation = -0.0054322417 radians = -0.311245 deg.

The analysis ended normally.

=====

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Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method
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Columbus, OH

=====

This model was prepared by:
gverma

Files Used for Analysis

Path to file locations on this computer:
\PROJECT\2025\COL-05\25050075COL_Arcadis U-S- Inc-_GUE-IR70 EB Rest Area (Site 3 B)\Design\RW\

Name of the input data file:
SPL 8ft CTC W24x104 Strength Limit_07.30.2026.lp12d

Name of the output report file:
SPL 8ft CTC W24x104 Strength Limit_07.30.2026.lp12o

Name of the plot output file:
SPL 8ft CTC W24x104 Strength Limit_07.30.2026.lp12p

Name of the runtime message file:
SPL 8ft CTC W24x104 Strength Limit_07.30.2026.lp12r

Date and Time of Analysis

Date: July 30, 2026

Time: 16:55:54

Problem Title

Project Name: GUE-IR70 EB Rest Area (Site 3B)_RW

Job Number: 25050075COL

Client: Arcadis U.S., Inc.

Engineer: CTL Engineering, Inc.

Description:

Program Options and Settings

Computational Options:

- Conventional Analysis

Engineering Units Used for Data Input and Computations:

- US Customary System Units (pounds, feet, inches)

Analysis Control Options:

- | | | |
|--|---|---------------|
| - Maximum number of iterations allowed | = | 500 |
| - Deflection tolerance for convergence | = | 1.0000E-05 in |
| - Maximum allowable deflection | = | 100.0000 in |
| - Number of pile increments | = | 66 |

Loading Type and Number of Cycles of Loading:

- Static loading specified
- Analysis uses p-y modification factors for p-y curves
- Analysis uses layering correction (Method of Georgiadis)

- Analysis includes loading by one distributed lateral load acting on pile
- Loading by lateral soil movements acting on pile not selected
- Input of shear resistance at the pile tip not selected
- Input of moment resistance at the pile tip not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

Output Options:

- Output files use decimal points to denote decimal symbols.
- Values of pile-head deflection, bending moment, shear force, and soil reaction are printed for full length of pile.
- Printing Increment (nodal spacing of output points) = 1
- No p-y curves to be computed and reported for user-specified depths
- Print using narrow report formats
(Note: Some output information is omitted from the narrow report formats)

Pile Structural Properties and Geometry

Number of pile sections defined	=	2
Total length of pile	=	33.000 ft
Depth of ground surface below top of pile	=	13.0000 ft

Pile diameters used for p-y curve computations are defined using 4 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	12.8000
2	13.000	12.8000
3	13.000	36.0000
4	33.000	36.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a AISC strong axis steel pile	
Length of section	= 13.000000 ft

AISC Section Type = W

AISC Section Name = W24X104

Pile width = 12.800000 in

Pile Section No. 2:

Section 2 is a drilled shaft with casing and AISC section core/insert

Length of section = 20.000000 ft

Section Diameter = 36.000000 in

Core/Insert AISC Section Type = W

Core/Insert AISC Section Name = W24X104

Soil and Rock Layering Information

The soil profile is modelled using 3 layers

Layer 1 is stiff clay with water-induced erosion

Distance from top of pile to top of layer = 13.000000 ft

Distance from top of pile to bottom of layer = 18.000000 ft

Effective unit weight at top of layer = 62.600000 pcf

Effective unit weight at bottom of layer = 62.600000 pcf

Undrained cohesion at top of layer = 1200. psf

Undrained cohesion at bottom of layer = 1200. psf

Epsilon-50 at top of layer = 0.007000

Epsilon-50 at bottom of layer = 0.007000

Subgrade k at top of layer = 0.0000 pci

Subgrade k at bottom of layer = 0.0000 pci

NOTE: Default values for subgrade k will be computed for this layer.

Layer 2 is massive rock, p-y criteria by Liang et al., 2009

Distance from top of pile to top of layer = 18.000000 ft

Distance from top of pile to bottom of layer = 23.300000 ft
 Effective unit weight at top of layer = 87.600000 pcf
 Effective unit weight at bottom of layer = 87.600000 pcf
 Uniaxial compressive strength at top of layer = 114.000000 psi
 Uniaxial compressive strength at bottom of layer = 114.000000 psi
 Poisson's ratio at top of layer = 0.250000
 Poisson's ratio at bottom of layer = 0.250000
 Option 1: Intact rock modulus at top of layer = 10000. psi
 Intact rock modulus at bottom of layer = 10000. psi
 Option 1: Geologic Strength Index for layer = 20.000000
 Option 2: Rock mass modulus at top of layer = 0.0000 psi
 Rock mass modulus at bottom of layer = 0.0000 psi
 Option 1 will be used to compute values of rock mass modulus for the p-y curve
 in massive rock.
 The rock type is (sedimentary) shales, Hoek-Brown Material Constant $m_i = 6$

Layer 3 is massive rock, p-y criteria by Liang et al., 2009

Distance from top of pile to top of layer = 23.300000 ft
 Distance from top of pile to bottom of layer = 60.000000 ft
 Effective unit weight at top of layer = 97.600000 pcf
 Effective unit weight at bottom of layer = 97.600000 pcf
 Uniaxial compressive strength at top of layer = 500.000000 psi
 Uniaxial compressive strength at bottom of layer = 500.000000 psi
 Poisson's ratio at top of layer = 0.250000
 Poisson's ratio at bottom of layer = 0.250000
 Option 1: Intact rock modulus at top of layer = 45000. psi
 Intact rock modulus at bottom of layer = 45000. psi
 Option 1: Geologic Strength Index for layer = 40.000000
 Option 2: Rock mass modulus at top of layer = 0.0000 psi
 Rock mass modulus at bottom of layer = 0.0000 psi
 Option 1 will be used to compute values of rock mass modulus for the p-y curve
 in massive rock.
 The rock type is (sedimentary) shales, Hoek-Brown Material Constant $m_i = 6$

(Depth of the lowest soil layer extends 27.000 ft below the pile tip)

Modification Factors for p-y Curves

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
-----	-----	-----	-----

1	13.000	0.8900	1.0000
2	18.000	0.8900	1.0000

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Distributed Lateral Loading Used For All Load Cases

Distributed lateral load intensity defined using 3 points

Point No.	Depth X ft	Dist. Load lb/in
1	0.000	0.000
2	10.000	538.000
3	13.000	743.000

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs
1	1	V = 0.0000 lbs	M = 0.0000 in-lbs	0.0000000

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 2

Pile Section No. 1:

Dimensions and Properties of Steel AISC Strong Axis:

Length of Section	=	13.000000 ft
Flange Width	=	12.800000 in
Section Depth	=	24.100000 in
Flange Thickness	=	0.750000 in
Web Thickness	=	0.500000 in
Yield Stress of Pipe	=	50.000000 ksi
Elastic Modulus	=	29000. ksi
Cross-sectional Area	=	30.700000 sq. in.
Moment of Inertia	=	3100. in^4
Elastic Bending Stiffness	=	89900000. kip-in^2
Plastic Modulus, Z	=	289.000000 in^3
Plastic Moment Capacity = $F_y Z$	=	14450. in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = $F_y A_s$	=	1535.000 kips
Nominal Axial Tensile Capacity	=	-1535.000 kips

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
-----	-----
1	0.000

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 0.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Run Msg
-----	-----	-----	-----	---
0.0000057247	514.1817236952	89818473.	12.0500000000	
0.0000114494	1028.	89818473.	12.0500000000	
0.0000171740	1543.	89818473.	12.0500000000	
0.0000228987	2057.	89818473.	12.0500000000	
0.0000286234	2571.	89818473.	12.0500000000	
0.0000343481	3085.	89818473.	12.0500000000	
0.0000400727	3599.	89818473.	12.0500000000	
0.0000457974	4113.	89818473.	12.0500000000	
0.0000515221	4628.	89818473.	12.0500000000	
0.0000572468	5142.	89818473.	12.0500000000	
0.0000629714	5656.	89818473.	12.0500000000	
0.0000686961	6170.	89818473.	12.0500000000	
0.0000744208	6684.	89818473.	12.0500000000	
0.0000801455	7199.	89818473.	12.0500000000	
0.0000858702	7713.	89818473.	12.0500000000	
0.0000915948	8227.	89818473.	12.0500000000	
0.0000973195	8741.	89818473.	12.0500000000	
0.0001030442	9255.	89818473.	12.0500000000	
0.0001087689	9769.	89818473.	12.0500000000	
0.0001144935	10284.	89818473.	12.0500000000	
0.0001202182	10798.	89818473.	12.0500000000	
0.0001259429	11312.	89818473.	12.0500000000	
0.0001316676	11826.	89818473.	12.0500000000	
0.0001373922	12340.	89818473.	12.0500000000	
0.0001431169	12855.	89818473.	12.0500000000	
0.0001488416	13226.	88861272.	12.0500000000	Y
0.0001545663	13360.	86433359.	12.0500000000	Y
0.0001602909	13432.	83800739.	12.0500000000	Y
0.0001660156	13498.	81303575.	12.0500000000	Y
0.0001717403	13557.	78937457.	12.0500000000	Y
0.0001774650	13610.	76691343.	12.0500000000	Y
0.0001831897	13658.	74558147.	12.0500000000	Y
0.0001889143	13702.	72532141.	12.0500000000	Y
0.0001946390	13743.	70605849.	12.0500000000	Y
0.0002003637	13780.	68772556.	12.0500000000	Y
0.0002060884	13813.	67026205.	12.0500000000	Y
0.0002118130	13844.	65361302.	12.0500000000	Y
0.0002175377	13873.	63772850.	12.0500000000	Y
0.0002232624	13899.	62256280.	12.0500000000	Y
0.0002289871	13947.	59422338.	12.0500000000	Y
0.0002347117	13988.	56823148.	12.0500000000	Y
0.0002404364	14023.	54435866.	12.0500000000	Y
0.0002461611	14055.	52235636.	12.0500000000	Y
0.0002518858	14082.	50201523.	12.0500000000	Y

0.0002919585	14106.	48315753.	12.0500000000	Y
0.0003034079	14128.	46563108.	12.0500000000	Y
0.0003148572	14147.	44930469.	12.0500000000	Y
0.0003263066	14164.	43406443.	12.0500000000	Y
0.0003377559	14179.	41981071.	12.0500000000	Y
0.0003492053	14194.	40645595.	12.0500000000	Y
0.0003606546	14206.	39389601.	12.0500000000	Y
0.0003721040	14218.	38208731.	12.0500000000	Y
0.0003835533	14228.	37095857.	12.0500000000	Y
0.0003950027	14238.	36044580.	12.0500000000	Y
0.0004064520	14247.	35051451.	12.0500000000	Y
0.0004179014	14255.	34110035.	12.0500000000	Y
0.0004293508	14262.	33218146.	12.0500000000	Y
0.0004408001	14269.	32370779.	12.0500000000	Y
0.0004522495	14275.	31565283.	12.0500000000	Y
0.0004636988	14282.	30799114.	12.0500000000	Y
0.0004751482	14287.	30067958.	12.0500000000	Y
0.0004865975	14292.	29371210.	12.0500000000	Y
0.0004980469	14297.	28705698.	12.0500000000	Y
0.0005094962	14301.	28068959.	12.0500000000	Y
0.0005209456	14305.	27460208.	12.0500000000	Y
0.0005323949	14309.	26877299.	12.0500000000	Y
0.0005438443	14313.	26317710.	12.0500000000	Y
0.0005552936	14316.	25781197.	12.0500000000	Y
0.0005667430	14320.	25266362.	12.0500000000	Y
0.0005781923	14323.	24771272.	12.0500000000	Y
0.0005896417	14325.	24294809.	12.0500000000	Y
0.0006010911	14328.	23836496.	12.0500000000	Y
0.0006125404	14331.	23395317.	12.0500000000	Y
0.0006239898	14333.	22970165.	12.0500000000	Y
0.0006354391	14335.	22559527.	12.0500000000	Y
0.0006468885	14337.	22163424.	12.0500000000	Y
0.0006583378	14339.	21781099.	12.0500000000	Y
0.0006697872	14341.	21411844.	12.0500000000	Y
0.0006812365	14343.	21055002.	12.0500000000	Y
0.0007270339	14350.	19737211.	12.0500000000	Y

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	0.00000000	14350.

Note that the values in the above table are not factored by a strength

reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Pile Section No. 2:

Dimensions and Properties of Drilled Shaft (Bored Pile) with Casing and AISC Strong Axis Core/Insert:

Length of Section	=	20.000000 ft
Outside Diameter of Casing	=	36.000000 in
Casing Wall Thickness	=	0.0000 in
Moment of Inertia of Steel Casing	=	0.0000 in ⁴
Width Flange of Core/Insert	=	12.800000 in
Depth of Core/Insert	=	24.100000 in
Flange Thickness of Core/Insert	=	0.750000 in
Web Thickness of Core/Insert	=	0.500000 in
Moment of Inertia of Steel Core/Insert	=	3100. in ⁴
Yield Stress of Casing	=	50000. psi
Elastic Modulus of Casing	=	29000000. psi
Yield Stress of Core/Insert	=	50000. psi
Elastic Modulus of Core/Insert	=	29000000. psi
Number of Reinforcing Bars	=	0 bars
Gross Area of Pile	=	1018. sq. in.
Area of Concrete	=	987.376020 sq. in.
Cross-sectional Area of Steel Casing	=	0.0000 sq. in.
Cross-sectional Area of Steel Core/Insert	=	30.700000 sq. in.
Area of All Steel (Casing, Core/Insert, and Bars)	=	30.500000 sq. in.
Area Ratio of All Steel to Gross Area	=	3.00 percent

Note that the core is assumed to be void of concrete.

Axial Structural Capacities:

Nom. Axial Structural Capacity = $0.85 F_c A_c + F_y A_s$	=	4891.398 kips
Tensile Load for Cracking of Concrete	=	-513.290 kips
Nominal Axial Tensile Capacity	=	-1535.000 kips

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
-----	-----
1	0.000

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 0.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Run Msg
-----	-----	-----	-----	---
0.0000057247	2406.	420205918.	18.0000000000	
0.0000114494	2406.	210102959.	11.7228426511	C
0.0000171740	2789.	162415986.	11.7521600616	C
0.0000228987	3708.	161927833.	11.7819896335	C
0.0000286234	4621.	161432224.	11.8123480620	C
0.0000343481	5528.	160928906.	11.8432548210	C
0.0000400727	6428.	160417611.	11.8747327250	C
0.0000457974	7323.	159898057.	11.9068009122	C
0.0000515221	8211.	159369944.	11.9394845421	C
0.0000572468	9093.	158832948.	11.9728079083	C
0.0000629714	9968.	158286752.	12.0067961383	C
0.0000686961	10836.	157730991.	12.0414774442	C
0.0000744208	11696.	157165689.	12.0764238564	C
0.0000801455	12550.	156590718.	12.1115873404	C
0.0000858702	13396.	156005303.	12.1474960677	C
0.0000915948	14235.	155409013.	12.1841833485	C
0.0000973195	15052.	154664148.	12.2172576561	CY
0.0001030442	15494.	150358616.	12.1326377484	CY
0.0001087689	15754.	144842116.	12.0023172884	CY
0.0001144935	15985.	139611572.	11.8757466805	CY
0.0001202182	16191.	134680765.	11.7558690500	CY
0.0001259429	16375.	130021242.	11.6399004804	CY
0.0001316676	16541.	125626514.	11.5281739225	CY
0.0001373922	16691.	121485581.	11.4224646661	CY
0.0001431169	16827.	117577872.	11.3216603291	CY
0.0001488416	16951.	113885579.	11.2232772740	CY
0.0001545663	17064.	110396645.	11.1299950753	CY
0.0001602909	17168.	107103480.	11.0419486901	CY
0.0001660156	17263.	103981919.	10.9574574015	CY
0.0001717403	17349.	101019022.	10.8748206361	CY

0.0001774650	17429.	98210681.	10.7965612235	CY
0.0001831897	17503.	95544473.	10.7224724390	CY
0.0001889143	17571.	93010513.	10.6523701801	CY
0.0001946390	17634.	90596301.	10.5842120822	CY
0.0002003637	17691.	88293206.	10.5181443005	CY
0.0002060884	17744.	86099167.	10.4553114127	CY
0.0002118130	17794.	84006591.	10.3957927895	CY
0.0002175377	17839.	82005958.	10.3387963412	CY
0.0002232624	17882.	80094735.	10.2846718048	CY
0.0002347117	17958.	76511946.	10.1798233717	CY
0.0002461611	18025.	73222599.	10.0827673090	CY
0.0002576105	18083.	70193954.	9.9935173998	CY
0.0002690598	18134.	67398823.	9.9116913660	CY
0.0002805092	18179.	64807090.	9.8321132806	CY
0.0002919585	18219.	62401359.	9.7578505280	CY
0.0003034079	18254.	60162452.	9.6884129101	CY
0.0003148572	18285.	58075363.	9.6239033323	CY
0.0003263066	18315.	56127037.	9.5635697961	CY

Summary of Results for Nominal Moment Capacity for Section 2

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	0.00000000	18315.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Layering Correction Equivalent Depths of Soil & Rock Layers

Top of	Equivalent
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Layer No.	Layer Below Pile Head ft	Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	13.0000	0.00	N.A.	No	0.00	5532.
2	18.0000	5.0000	No	Yes	N.A.	N.A.
3	23.3000	10.3000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 0.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Soil Res. p lb/inch	Bending Stiffness lb-in^2
0.000	3.80266	-2.881E-05	0.000	0.000	8.982E+10
0.50000	3.72058	121.05000	100.87500	0.000	8.982E+10
1.00000	3.63850	1210.	342.97500	0.000	8.982E+10
1.50000	3.55642	4237.	746.47500	0.000	8.982E+10
2.00000	3.47434	10168.	1311.	0.000	8.982E+10
2.50000	3.39227	19973.	2038.	0.000	8.982E+10
3.00000	3.31020	34620.	2925.	0.000	8.982E+10
3.50000	3.22815	55078.	3974.	0.000	8.982E+10
4.00000	3.14612	82314.	5185.	0.000	8.982E+10
4.50000	3.06412	117297.	6557.	0.000	8.982E+10
5.00000	2.98217	160997.	8090.	0.000	8.982E+10
5.50000	2.90029	214380.	9785.	0.000	8.982E+10
6.00000	2.81849	278415.	11641.	0.000	8.982E+10
6.50000	2.73680	354071.	13658.	0.000	8.982E+10
7.00000	2.65525	442317.	15837.	0.000	8.982E+10
7.50000	2.57388	544120.	18178.	0.000	8.982E+10
8.00000	2.49273	660449.	20679.	0.000	8.982E+10

8.50000	2.41184	792272.	23342.	0.000	8.982E+10
9.00000	2.33128	940559.	26167.	0.000	8.982E+10
9.50000	2.25108	1106276.	29153.	0.000	8.982E+10
10.00000	2.17134	1290393.	32303.	0.000	8.982E+10
10.50000	2.09210	1493911.	35636.	0.000	8.982E+10
11.00000	2.01347	1718027.	39172.	0.000	8.982E+10
11.50000	1.93553	1963970.	42912.	0.000	8.982E+10
12.00000	1.85837	2232972.	46858.	0.000	8.982E+10
12.50000	1.78211	2526262.	51008.	0.000	8.982E+10
13.00000	1.70686	2845070.	54236.	0.000	8.982E+10
13.50000	1.63275	3177098.	55282.	-18.5051	1.622E+11
14.00000	1.55935	3508459.	55123.	-34.6695	1.620E+11
14.50000	1.48673	3838573.	54753.	-88.7932	1.618E+11
15.00000	1.41496	4165490.	53971.	-171.7028	1.617E+11
15.50000	1.34411	4486226.	52663.	-264.4130	1.615E+11
16.00000	1.27427	4797443.	50773.	-365.3615	1.613E+11
16.50000	1.20550	5095507.	48258.	-473.1632	1.611E+11
17.00000	1.13787	5376537.	45079.	-586.5854	1.610E+11
17.50000	1.07143	5636450.	41205.	-704.5308	1.609E+11
18.00000	1.00626	5871000.	38437.	-218.1840	1.607E+11
18.50000	0.94241	6097695.	36589.	-397.9657	1.606E+11
19.00000	0.87992	6310064.	33923.	-490.4917	1.605E+11
19.50000	0.81885	6504775.	30730.	-574.0395	1.604E+11
20.00000	0.75924	6678820.	27067.	-646.9865	1.603E+11
20.50000	0.70113	6829574.	23002.	-707.8774	1.602E+11
21.00000	0.64455	6954844.	18612.	-755.4941	1.601E+11
21.50000	0.58954	7052917.	13979.	-788.9073	1.600E+11
22.00000	0.53611	7122589.	9189.	-807.5126	1.600E+11
22.50000	0.48429	7163190.	4334.	-811.0485	1.600E+11
23.00000	0.43408	7174594.	-491.9270	-797.5124	1.600E+11
23.50000	0.38548	7157287.	-8016.	-1711.	1.600E+11
24.00000	0.33849	7078398.	-19452.	-2101.	1.600E+11
24.50000	0.29310	6923864.	-32744.	-2329.	1.601E+11
25.00000	0.24926	6685470.	-46587.	-2285.	1.603E+11
25.50000	0.20693	6364816.	-59691.	-2083.	1.604E+11
26.00000	0.16602	5969179.	-71467.	-1843.	1.607E+11
26.50000	0.12645	5507207.	-81661.	-1555.	1.609E+11
27.00000	0.08811	4989245.	-89952.	-1208.	1.612E+11
27.50000	0.05089	4427787.	-95928.	-783.7527	1.615E+11
28.00000	0.01465	3838114.	-99046.	-255.8131	1.618E+11
28.50000	-0.0207	3239232.	-98750.	354.40746	1.621E+11
29.00000	-0.0554	2653109.	-95154.	844.48345	1.752E+11
29.50000	-0.0895	2097387.	-88915.	1235.	4.202E+11
30.00000	-0.1235	1586129.	-80534.	1558.	4.202E+11
30.50000	-0.1573	1130976.	-70362.	1832.	4.202E+11
31.00000	-0.1910	741784.	-58660.	2068.	4.202E+11
31.50000	-0.2246	427052.	-45630.	2275.	4.202E+11
32.00000	-0.2582	194222.	-31430.	2458.	4.202E+11
32.50000	-0.2918	49897.	-16185.	2623.	4.202E+11
33.00000	-0.3254	0.000	0.000	2772.	4.202E+11

Output Summary for Load Case No. 1:

Pile-head deflection = 3.80266141 inches
Computed slope at pile head = -0.0136801 radians
Maximum bending moment = 7174594. inch-lbs
Maximum shear force = -99046. lbs
Depth of maximum bending moment = 23.00000000 feet below pile head
Depth of maximum shear force = 28.00000000 feet below pile head
Number of iterations = 51
Number of zero deflection points = 1
Pile deflection at ground = 1.70686108 inches

Pile-head Deflection vs. Pile Length for Load Case 1

Boundary Condition Type 1, Shear and Moment

Shear = 0. lbs
Moment = 0. in-lbs
Axial Load = 0. lbs

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
33.00000	3.80266141	7174594.	-99046.
31.35000	10.48789043	7807528.	-139888.

On reducing the depth of drilled shaft socketed into bedrock, the deflection is increasing significantly specifically from shaft length of 33.0 to 31.35

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
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1	1	3.802661	-0.01368	-99046.	7174594.
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Maximum pile-head deflection = 3.8026614109 inches

Maximum pile-head rotation = -0.0136800978 radians = -0.783812 deg.

The analysis ended normally.