FINAL REPORT
STRUCTURE FOUNDATION EXPLORATION
BRIDGE SCI-125-6.26 OVER TURKEY CREEK
PID: 119955
SCIOTO COUNTY, OHIO

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NEAS PROJECT 24-0002

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EXECUTIVE SUMMARY

The Ohio Department of Transportation (ODOT) District 9 has proposed a bridge replacement project (SCI-125-6.26, PID# 119955) to replace the existing bridge carrying SR-125 over Turkey Creek, Scioto County, Ohio. The report presents a summary of the surficial and subsurface conditions during the investigation, along with our recommendations for the design and construction of the bridge foundation.

National Engineering and Architectural Services Inc. (NEAS) has been contracted to perform geotechnical engineering services for the project. The purpose of the geotechnical engineering services is to perform geotechnical explorations within the project limits to obtain information concerning the subsurface soil and groundwater conditions relevant to the design and construction of the project. As part of the referenced explorations, NEAS advanced two project borings and conducted laboratory testing to evaluate and characterize the soils for engineering purposes. The report provides a summary of the surficial and subsurface conditions encountered and presents our recommendations for the design and construction of the bridge foundation.

The subsurface profile at the bridge site is generally consistent with the geological model for the project in regard to the materials encountered. The subsurface profile generally consists of both soft to hard cohesive fine-grained materials and medium dense to very dense coarse-grained granular materials. Bedrock was encountered in both project borings, ranging from depths of 10.0 ft to 16.0 ft below ground surface (with elevations between 642.1 ft and 645.4 ft above mean sea level).

According to our subgrade analysis, subgrade stabilization is not required per ODOT GDM Section 600.

A foundation review was conducted for the deep foundation system for the referenced replacement bridge, based on the following design information: 1) the Site Plan for the Bridge prepared by American StructurePoint; 2) historical plans and subsurface exploration data; and 3) load and scour information provided by American StructurePoint. Based on this information, NEAS suggests supporting both abutments on HP 14x73 piles installed in prebored holes.

Our analyses of laterally and axially loaded piles indicate that the estimated pile lengths will be governed by ODOT GDM Section 1305.4, which addresses pile scour considerations at both abutment locations. The estimated pile length is 15 ft for both abutments, with pile tip elevations of 632.7 ft at the rear abutment and 631.1 ft at the forward abutment.

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1. INTRODUCTION

1.1. General

National Engineering and Architectural Services Inc. (NEAS) presents our Structure Foundation Exploration Report for the planned replacement of the existing bridge carrying SR-125 over Turkey Creek in Scioto County, Ohio. The report presents a summary of the encountered surficial and subsurface conditions and our recommendations for bridge foundation design and construction. Our recommendations are in accordance with ODOT's 2020 LRFD Bridge Design Manual (BDM) (ODOT, 2024), ODOT's 2024 Geotechnical Design Manual (GDM) (ODOT, 2024).

The exploration was conducted in general accordance with NEAS, Inc.'s proposal to American StructurePoint dated December 08, 2023, and with the provisions of ODOT's *Specifications for Geotechnical Explorations* (SGE) (ODOT, 2024).

The scope of work performed included: 1) a review of published geotechnical information; 2) performing 2 total test borings; 3) laboratory testing of soil samples in accordance with the SGE; 4) performing geotechnical engineering analysis to assess foundation design and construction considerations; and 5) development of this summary report.

1.2. Proposed Construction

The existing SCI-125-6.26 bridge is a three-span, non-composite, prestressed concrete box beam superstructure supported on reinforced concrete substructure with spread footings. The roadway of the existing bridge is 32 feet wide.

It is our understanding that the proposed structure will be a single-span, composite, prestressed box beam superstructure supported on wall abutments with a pre-bored H-pile foundation. The roadway for the proposed bridge will be 36 feet wide.

2. GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1. Geology and Physiography

The project site is located within the Shawnee-Mississippian Plateau physiographic region part of the Allegheny Plateaus. This area is characterized as a highly dissected plateau of coarse- and fine-grained rock sequences of high-relief (400 to 800 ft) with extensive remnants of ancient lacustrine clay-filled Teays drainage systems present in lowlands and absent in uplands. The geology in this region is characterized as Pleistocene-age sandy outwash in the Scioto River, Teays-age Minford Clay, as well as silt-loam and channery colluvium all atop Devonian- and Mississippian-age shales, siltstones, and locally thick sandstones (ODGS, 1998).

Based on the Quaternary geology map of Ohio, the geology at the project site is mapped as Alluvium and alluvial terraces, deposited in present and former floodplains; ranges from silty clay in areas of fine-grained deposits to coarse sand, gravel, or cobbles in areas of shallow bedrock (Pavey, et al 1999).

Based on the Bedrock Geologic Units Map of Ohio (USGS & ODGS, 2006), bedrock within the project area consists of a combination of, shale, and siltstone, of the Sunbury Shale, Berea Sandstone and Bedford Shale formation. The formation is comprised of Devonian and/or Mississippian-age. This

formation is described as upper 10 to 50 feet shale; black to brown, weathers light brown; carbonaceous; thin, planar bedding. Underlain by 10 to 50 feet sandstone; brown, weathers light brown to reddish brown; thin to thick bedded, planar to lenticular bedding; minor shale interbeds. Basal 80 to 100 feet shale and interbedded sandstone; gray to brown, weathers light gray to light brown; thin to medium bedded, planar to lenticular bedding; thick. Interval thickness ranges from 100 to 200 feet.

The bedrock appears to follow the natural topography of the site which slopes upward from east to west. The bedrock is relatively level throughout the project (ODGS, 2003). Based on the ODNR bedrock topography map of Ohio, bedrock elevations at the project site can be expected to be between 666 ft amsl to 674 ft amsl, putting bedrock at depths of between 10 and 16 ft below ground surface (bgs).

The soils at the project site have been mapped (Web Soil Survey) by the Natural Resources Conservation Service (USDA, 2024) as a Skidmore silt loam. Skidmore silt loam series is comprised of both coarse-grained and fine-grained soils and classified as A-1-a, A-2-4, A-2-6, A-2-7, A-4, and A-6 type soils according to the AASHTO method of soil classification.

2.2. Hydrology/Hydrogeology

Groundwater at the project site is expected at an elevation consistent with that of the nearby Turkey Creek as it is the most dominant hydraulic influence in the vicinity of the project's boundaries. The water level of the Roosevelt Lake may also have influence the local groundwater table. However, it should be noted that perched groundwater systems may be existent in areas due to the presence of fine-grained soils making it difficult for groundwater to permeate to the phreatic surface.

The project site is located within a special flood hazard area (Zone A) based on available mapping by the Federal Emergency Management Agency's (FEMA) National Flood Hazard mapping program (FEMA, 2024).

2.3. Mining and Oil/Gas Production

No mines were noted on ODNR's Abandoned Underground Mine Locator in the vicinity of the project site. (ODNR [1], 2024).

No oil or gas wells were noted on ODNR's Oil and Gas Well Locator in the vicinity of the project site (ODNR [1], 2024).

2.4. Historical Records and Previous Phases of Project Exploration

The original bridge site plan, dated November 1931, was available for review and evaluation for this report. Four soundings were conducted during the exploration, with rock elevations ranging from 641.08 feet to 642.59 feet (NGVD 29). Two of the test holes were used for evaluation purposes; test hole # 2 and # 4 and summarized in Table1 below. According to the current exploration, the bedrock elevation is increasing from ease to west. However, these soundings were not utilized in the report or analysis.

Table 1: Historical and Current Bedrock Elevation Summary

Historical Rock Elevation			
Test ID/ Boring ID	**NGVD 1929**	**NAVD 88**	**Difference**
Test Hole 1	642.59	641.968	0.622
Test Hole 2	641.08	640.458	0.622
Test Hole 3	641.68	641.057	0.623
Test Hole 4	641.75	641.127	0.623
B-001-0-23	-	642.1	-
B-002-0-23	-	645.4	-

2.5. Field Reconnaissance

A field reconnaissance visit for the bridge carrying SR-125 over Turkey Creek in Scioto County, Ohio, was conducted on January 31st, 2024. During our field reconnaissance, site conditions were noted and photographed.

Land use at the project site can be described as primarily forested.

The existing bridge is a three-span prestressed concrete box beam bridge with a cast-in-place concrete deck and bituminous wearing surface, supported by concrete gravity-type spread footing abutments and piers.

The roadway embankment slopes at the site generally appeared to be stable, with no signs of instability observed during our site visit. The existing roadway embankments were estimated to have slopes of approximately 2 Horizontal to 1 Vertical (2H:1V) on the north side of bridge and 3H:1V on the south side, and they were vegetated with grass, shrubs, and trees. Overall, the bridge appeared to be in fair condition, with wear and degradation observed on both the superstructure and substructure. Spalling and exposed reinforcing steel were observed on one of the inner box beams (Photograph 1) and on the outer box beams (Photograph 2). Spalling was also observed on both abutments (Photograph 3), and both spalling and exposed reinforcing steel were noted on the piers (Photograph 4). No apparent signs of structural distress related to geotechnical concerns were observed during our field reconnaissance visit.

In general, the existing bridge structure appeared to be well drained, with no signs of significant erosion at the bridge site. The asphalt wearing course was observed to be in good condition, with minor surface wear, including occasional transverse and longitudinal cracking (Photograph 5). No signs of standing water was observed on the bridge.

Photograph 1: Spalling and exposed steel on inner box beam

Photograph 2: Spalling and exposed steel on outer box beam

Photograph 3: Spalling on abutment

Photograph 2: Spalling and exposed reinforcing steel on pier

Photograph 5: Pavement condition

3. GEOTECHNICAL EXPLORATION

3.1. Field Exploration Program

The project subsurface exploration was conducted by NEAS on February 09, 2024, and included 2 borings drilled to depths range between 25.3 ft to 31.5 ft below ground surface. The boring locations were selected by NEAS in general accordance with the guidelines contained in the SGE with the intent to evaluate subsurface soil and groundwater conditions. Borings were typically located within the planned project construction areas that were not restricted by underground utilities or dictated by terrain (e.g. steep embankment slopes). Project boring locations were in the field after drilling by project surveyor. Each individual project boring log (included within Appendix B) includes the recorded boring latitude and longitude location and the corresponding ground surface elevation (surveyed by the project surveyors). The boring locations are depicted on the Site Plan provided in Appendix A. Latitude/Longitude, elevations and stationing and offsets of the borings are shown on Table 1 below.

Table 2: Project Boring Summary

Boring Number	Location (Sta/offset)	Latitude	Longitude	Elevation (NAVD 88) (ft)	Depth (ft)	Structure
B-001-0-23	108+87, 18' RT.	38.726340	-83.171250	658.1	31.5	Rear Abutment
B-002-0-23	110+69, 16' LT.	38.726270	-83.170610	655.4	25.3	Forward Abutment

Notes:
1. Stationing and Offset are in reference to centerline of Proposed SR-125.

Project borings were drilled using a D50 SN481 drilling rig utilizing 3.25-inch (inner diameter) hollow stem auger. In general, soil samples were recovered continuously to end of boring, using an 18-inch split spoon sampler (AASHTO T-206 “Standard Method for Penetration Test and Split Barrel Sampling of Soils.”). The soil samples obtained from the exploration program were visually observed in the field by the NEAS field representative and preserved for review by a Geologist for possible laboratory testing. Standard penetration tests (SPT) were conducted using a CME auto hammer calibrated to be 86.8% efficient on March 14, 2022, as indicated on the boring logs.

Field /boring logs were prepared by drilling personnel, and included lithological description, SPT results recorded as blows per 6-inch increment of penetration and estimated unconfined shear strength values on specimens exhibiting cohesion (using a hand-penetrometer). Groundwater level observations were recorded both during and after the completion of drilling. These groundwater level observations are included on the individual boring logs. After completing the borings, the boreholes were backfilled with bentonite grout and patched with cold patch asphalt and/or quickset concrete where necessary and appropriate.

3.2. Laboratory Testing Program

The laboratory testing program consisted of classification testing, moisture content determinations, slake durability index testing, and unconfined compressive strength testing. Data from the laboratory testing program was incorporated onto the boring logs (Appendix B).

3.2.1. Classification Testing

Representative soil samples were selected for index properties (Atterberg Limits) and gradation testing for classification purposes on approximately 33% of the samples. At each boring location, samples were selected for testing with the intent of identification and classification of all significant soil units. Soils not selected for testing were compared to laboratory tested samples/strata and classified visually. Moisture content testing was conducted on all samples. The laboratory testing was performed in general accordance with applicable AASHTO specifications.

A final classification of the soil strata was made in accordance with AASHTO M-145 “Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes,” as modified by ODOT “Classification of Soils” once laboratory test results became available. The results of the soil classification are presented on the boring logs provided in Appendix B.

3.2.2. Standard Penetration Test Results

Standard Penetration Tests (SPT) and split-barrel (commonly known as split-spoon) sampling of soils were performed at varying intervals (i.e., continuous, 2.5-ft, or 5.0-ft intervals) in the project borings performed. To account for the high efficiency (automatic) hammers used during SPT sampling, field SPT N-values were converted based on the calibrated efficiency (energy ratio) of the specific drill rig's hammer. Field N-values were converted to an equivalent rod energy of 60% (N_{60}) for use in analysis or for correlation purposes. The resulting N_{60} values are shown on the boring logs provided in Appendix B.

3.2.3. D_{50} Values for Scour Evaluation

Grain size distribution testing was performed on the obtained streambed samples to develop D_{50} values (i.e., the diameter in the particle-size distribution curve corresponding to 50 % finer). The calculated D_{50} values are shown in Table 2 below and the developed particle-size distribution curves are included with the associated boring log within Appendix B.

Table 3: D_{50} Values for Scour Evaluation

Boring Number	Specimen ID	Specimen Elevation (ft)	ODOT (Modified AASHTO) ~ USCS Classification	D_{50} (mm)	Scour Critical Shear Stress, τ_c (psf)	$D_{50, equiv}$ (mm)	Erosion Category (EC)
B-001-0-23	SS-1	657.2' - 655.7'	A-6a ~ LEAN CLAY with SAND (CL)	0.017	0.809	38.713	3.255
	SS-5	651.1' - 649.6'	A-6a ~ LEAN CLAY(CL)	0.012	0.445	21.325	3.255
	SS-6	649.6' - 648.1'	A-4b ~ SANDY LEAN CLAY(CL)	0.045	0.078	3.731	2.754
	SS-7	648.1' - 646.6'	A-2-4 ~ SSILTY SAND with GRAVEL (SM)	0.953	0.020	0.953	2.175
	SS-8	646.6' - 645.1'	A-2-4 ~ SSILTY SAND with GRAVEL (SM)	0.767	0.016	0.767	2.062
	SS-10	643.6' - 642.1'	A-4a ~ SANDY SILT with GRAVEL(ML)	0.112	0.048	2.296	2.211
B-002-0-23	SS-2	653.9' - 652.4'	A-2-4 ~ SILTY SAND with GRAVEL(SM)	1.102	0.023	1.102	2.251
	SS-3	652.4 - 650.9'	A-4a ~ CLAYEY SAND with GRAVEL(SC)	0.120	0.093	4.450	2.501
	SS-4	650.9' - 649.4'	A-4a ~ CLAYEY SAND with GRAVEL(SC)	0.206	0.004	0.206	1.377
	SS-5	649.4' - 647.9'	A-4a ~ CLAYEY SAND with GRAVEL(SC)	0.077	0.040	1.909	2.211
	SS-6	647.9' - 646.4'	A-4a ~ SANDY LEAN CLAY(CL)	0.044	0.031	1.501	2.211

Based on our lab testing results, the equivalent D_{50} (mm) values of bedrock were estimated using the methods described in ODOT's BDM Section 305.2.1.2.b and ODOT's GDM Section 1302.1.3. The estimated equivalent D_{50} (mm) and Erodibility Index K for different layers of bedrock for both abutments are listed in Table 3 below. The lab testing results, and the equivalent D_{50} (mm) calculation process are attached in Appendix B.

Table 4: Bedrock Equivalent D_{50} Values and Erodibility K

Boring Number	Rock Layer	Rock Layer Elevation (ft)	Rock Type	RQD (%)	Equivalent D_{50} (mm)	Erodibility Index K
B-001-0-23	Layer 1	641.6' - 639.1'	Interbedded Shale and Sandstone	75	518.5	4.20
	Layer 2	639.1' - 631.6'	Interbedded Shale and Sandstone	48	414.8	2.69
	Layer 3	631.6' - 626.6'	Interbedded Shale and Sandstone	53	435.9	2.97
B-002-0-23	Layer 1	645.1' - 640.1'	Interbedded Shale and Sandstone	33	395.4	2.44
	Layer 2	640.1' - 637.1'	Interbedded Shale and Sandstone	0	26.7	0.01
	Layer 3	637.1' - 630.1'	Interbedded Shale and Sandstone	18	292.0	1.33

3.2.4. Slake Durability Test of Rock Core

Slake Durability Index Test of rock core samples was conducted in accordance with ASTM D4644 "Standard Test Method for Slake Durability of Shales and Other Similar Weak Rocks". The tests were performed on two rock core samples obtained during the exploration program. The results are summarized in Table 4 below and provided in Appendix B.

Table 5: Slake Durability Index Test Results

Boring ID	Sample Number	Depth (ft)	Moisture Content (%)	Retained Material	Slake Durability Index (%)
B-001-0-23	NQ2-2	19.0 - 20.1	5.65	T2	49.8
B-002-0-23	NQ2-2 & NQ2-3	15.4 - 19.4	4.98	T2	47.0

3.2.5. Unconfined Compressive Strength of Rock Core

Unconfined Compressive Strength of rock core samples was conducted in accordance with ASTM D7012 "Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying Sates of Stress and Temperatures". The tests were performed on two rock core samples

obtained during the exploration program. The results are summarized in Table 5 below and provided in Appendix B.

Table 6: Unconfined Compressive Strength of Rock Core Results

Boring ID	Depth (ft)	Elevation (ft)	Unconfined Compressive Strength (psi)	Stain at Failure (%)
B-001-0-23	17.5 - 17.8	642.1 - 626.6	15,386	1.0
B-002-0-23	10.5 - 10.9	645.4 - 630.1	9,869	1.0

4. GEOTECHNICAL FINDINGS

The subsurface conditions encountered during NEAS's explorations are described in the following subsections and/or on each boring log presented in Appendix B. The boring logs represent NEAS's interpretation of the subsurface conditions encountered at each boring location based on our site observations, field logs, visual review of the soil samples by NEAS's geologist, and laboratory test results. The lines designating the interfaces between various soil strata on the boring logs represent the approximate interface location; the actual transition between strata may be gradual and indistinct. The subsurface soil and groundwater characterizations included herein, including summary test data, are based on the subsurface findings from the geotechnical explorations performed by NEAS as part of the referenced project, and consideration of the geological history of the site.

4.1. Subsurface Conditions

The subsurface profile at the referenced site is generally consistent with the geological model for the project in regard to the materials encountered. The subsurface profile at the proposed bridge site generally consists of primarily very stiff to hard cohesive fine materials and some medium dense to very dense granular materials. Bedrock was encountered in both project borings and historic borings, ranging from depths of 10 ft to 31.5 ft below ground surface (with elevations between 642.1 ft and 645.4 ft above mean sea level).

4.1.1. Overburden Soil

At the site of the proposed bridge over Turkey Creek, natural soils were encountered below the surficial pavement.

At the rear abutment location, cohesive soils were encountered, followed by granular soils. The cohesive soils extend from an elevation of 658.1 ft to 648.1 ft amsl, corresponding to a depth from top of the boring to 10 ft below ground surface. The granular soils extend from an elevation of 648.1 ft to 642.1 ft, corresponding to a depth of 10 ft to 16 ft bgs. The cohesive soils are classified as Silt and Clay (A-6a), Silt (A-4b) while the granular materials are classified as Gravel and Stone Fragments with Sand and Silt (A-2-4) and non-cohesive Sandy Silt (A-4a). The cohesive soils can be described as stiff to hard consistency based on N_{60} values between 6 to 14 blow per feet (bpf) and unconfined compressive strengths (estimated by means of hand penetrometer) between approximately 0.5 and 4.50 tons per square foot (tsf). Based on Atterberg Limits test performed on a representative sample of the cohesive materials, the liquid and plastic limits ranged from 28 to 33 percent and from 17 to 20 percent, respectively. Natural moisture contents of the cohesive soils ranged from 15 to 22 percent. The granular soils have a relative compactness of medium dense to very dense based on N_{60} values between 22 to 69 bpf. The natural

moisture content of the non-cohesive soils ranged from 11 to 14 percent. Rock was encountered at an elevation of 642.1 ft amsl to the end of boring (EOD), corresponding to a depth from 16 ft to 31.5 ft bgs. The rock was classified as Shale and Sandstone. Shale bedrock can be described as slightly to moderately weathered, very weak to weak while the Sandstone can be described as very strong, very fine to fine grained.

At the forward abutment location, the soils encountered are primarily granular material classified as Gravel with Sand (A-1-b), non-cohesive Sandy Silt (A-4a). The granular materials can be described having a relative compactness of medium dense to very dense base on N_{60} values between 16 bpf to refusal. The natural moisture content of the non-cohesive soils ranged from 3 to 114 percent. A thin layer of cohesive soil was encountered between elevations 652.4 ft and 650.9 ft amsl, corresponding to depths of 3 ft to 4.5 ft bgs. This layer was classified as cohesive sandy silt (A-4a). The material consistency can be described as stiff to very stiff base on N_{60} value of 6 bpf and unconfined compressive strengths (estimated by means of hand penetrometer) of 2.0 tons per square foot (tsf). Based on Atterberg Limits test performed on a representative sample of the cohesive material, the liquid and plastic limits were 25 percent and 19 percent, respectively. The natural moisture content of the cohesive soil was 17 percent. Rock was encountered at an elevation of 645.4 ft amsl to the end of boring, corresponding to depths from 10 ft to 23.5 ft bgs). The rock was classified as Shale and Sandstone. Shale bedrock can be described as slightly to moderately weathered, very weak to weak while Sandstone can be described as strong and fine grained.

4.1.2. Groundwater

Groundwater measurements were taken during the drilling procedures and/or immediately following the completion of each borehole. Groundwater was not encountered in any of the project borings during drilling.

It should be noted that groundwater is affected by many hydrologic characteristics in the area and may vary from those measured at the time of the exploration.

4.1.3. Bedrock

Bedrock was encountered in both project borings. At the rear abutment, bedrock was encountered at a depth of 16 feet below ground surface, corresponding to an elevation of 642.1 feet amsl. At the forward abutment, it was found at a depth of 10 feet below ground surface, corresponding to an elevation of 645.4 feet amsl.

Based on the exploration and testing conducted, bedrock encountered at both abutments was primarily classified as Interbedded Shale and Sandstone. The bedrock was described as slightly to moderately weathered, weak to very weak, highly fractured to slightly fractured, with open to narrow, slightly rough fractures and fair to poor surface condition. An exception was observed at B-002-0-23, where a 2.9-foot thick layer of sandstone was encountered above the Interbedded Shale and Sandstone. The recovery of the bedrock cores ranged from 56 to 100 percent, while the Rock Quality Designation (RQD) values varied from 0 to 75 percent.

5. ANALYSES AND RECOMMENDATIONS

5.1. Soil Profile for Analysis

For analysis purposes, each boring log was reviewed, and a generalized material profile was developed for analysis. Utilizing the generalized soil profile, engineering properties for each soil strata were estimated based on their field (i.e., SPT N_{60} Values, hand penetrometer values, etc.) and laboratory (i.e., Atterberg Limits, grain size, etc.) test results using correlations provided in published engineering manuals, research reports and guidance documents. The developed soil profile and estimated engineering soil and rock properties (with cited correlation/reference material) used in our evaluation is summarized per boring within Tables 6 and 7 below.

Table 7: B-001-0-23 Soil Profile

SCI-125-6.26 Over Turkey Creek: Soil Profile B-001-0-23							
Soil Description	**Unit Weight[1] (pcf)**	**Moist Unit Weight[1] (pcf)**	**Saturated Unit Weight[1] (pcf)**	**Undrained Shear Strength[2] (psf)**	**Effective Cohesion[3] (psf)**	**Effective Friction Angle[3] (degrees)**	**Setup Factor (f_{su})**
Silt and Clay Depth (658.1 ft - 654.1 ft)	110	110	120	1500	150	23	1.50
Silt and Clay Depth (654.1 ft - 649.6 ft)	105	105	115	750	75	21	1.50
Silt Depth (649.6 ft - 648.1 ft)	105	105	115	750	75	22	1.50
Gravel with Sand and Silt Depth (648.1 ft - 643.6 ft)	120	120	130	-	-	40	1.20
Sandy Silt Depth (643.6 ft - 642.1 ft)	130	130	140	-	-	40	1.20

Notes:
1. *Values interpreted from ODOT Geotechnical Design Manual (GDM) Section 405.*
2. *Values calculated from Terzaghi and Peck (1967) if N160<52, else Stroud and Butler (1975) was used.*
3. *Values interpreted from LRFD BDS Table 10.4.6.2.4-1 and ODOT GDM Table 400-3.*

Table 8: B-002-0-23 Soil Profile

SCI-125-6.26 Over Turkey Creek: Soil Profile B-002-0-23							
Soil Description	**Unit Weight[1] (pcf)**	**Moist Unit Weight[1] (pcf)**	**Saturated Unit Weight[1] (pcf)**	**Undrained Shear Strength[2] (psf)**	**Effective Cohesion[3] (psf)**	**Effective Friction Angle[3] (degrees)**	**Setup Factor (f_{su})**
Gravel with Sand Depth (655.4 ft - 653.9 ft)	115	115	125	-	-	40	1.00
Sandy Silt Depth (653.9 ft - 652.4 ft)	115	115	125	-	-	32	1.20
Sandy Silt Depth (652.4 ft - 650.9 ft)	105	105	115	750	75	22	1.50
Sandy Silt Depth (650.9 ft - 645.4 ft)	115	115	125	-	-	32	1.20

Notes:
1. *Values interpreted from ODOT Geotechnical Design Manual (GDM) Section 405.*
2. *Values calculated from Terzaghi and Peck (1967) if N160<52, else Stroud and Butler (1975) was used.*
3. *Values interpreted from LRFD BDS Table 10.4.6.2.4-1 and ODOT GDM Table 400-3.*

Deep foundation element subjected to horizontal loads and/or moments should be analyzed for maximum bending moment, maximum shear force, and lateral deflection. In our design, reactions were calculated by a p-y analysis method. For the purpose of evaluating the lateral resistance, the pile was analyzed by using the software entitled *LPile v2016* by Ensoft, Inc. The generalized soil/rock parameters used to analyze the laterally loaded deep foundation by the p-y curve method are shown in Tables 8 and 9 below.

Table 9: LPILE Soil Parameters – B-001-0-23

SCI-125-6.26 Bridge Rear Abutment B-001-0-23							
Soil Layer Number (No.)	Top Elev. (ft)	Bottom Elev. (ft)	Layer Depth (ft)	Soil Class	LPILE p-y Model	Soil Strain Parameter ε50	Soil Modulus Parameter p-y k (pci)
1	658.1	654.1	4	A-6a	Stiff Clay w/o Water	0.0073	500
2	654.1	649.6	8.5	A-6a	Soft Clay	0.0111	139
3	649.6	648.1	10	A-4b	Soft Clay	0.0115	125
4	648.1	643.6	14.5	A-2-4	Sand (Reese)	-	437
5	643.6	642.1	16	A-4a	Sand (Reese)	-	437
Rock Layer Number (No.)	Top Elev. (ft)	Bottom Elev. (ft)	Layer Depth (ft)	Rock Type	LPILE p-y Model	krm	Rock Initial Modulus Ei (psi)
1	642.1	626.6	31.5	Shale	Weak Rock	0.00005	1400000

Table 10: LPILE Soil Parameters – B-002-0-23

SCI-125-6.26 Bridge Forward Abutment B-002-0-23							
Soil Layer Number (No.)	Top Elev. (ft)	Bottom Elev. (ft)	Layer Depth (ft)	Soil Class	LPILE p-y Model	Soil Strain Parameter ε50	Soil Modulus Parameter p-y k (pci)
1	655.4	653.9	1.5	A-1-b	Sand (Reese)	-	656
2	653.9	652.4	3	A-4a	Sand (Reese)	-	140
3	652.4	650.9	4.5	A-4a	Soft Clay	0.0115	125
4	650.9	645.4	10	A-4a	Sand (Reese)	-	140
Rock Layer Number (No.)	Top Elev. (ft)	Bottom Elev. (ft)	Layer Depth (ft)	Rock Type	LPILE p-y Model	krm	Rock Initial Modulus Ei (psi)
1	645.4	630.1	25.3	Sandstone	Weak Rock	0.00005	890000

5.2. Pavement Design and Recommendations

The subgrade analysis was performed in accordance with ODOT's GDM criteria utilizing the ODOT provided*: Subgrade Analysis Spreadsheet* (SubgradeAnalysis.xls, Version 14.7 dated November 6, 2024). Input information for the spreadsheet was based on the soil characteristics gathered during NEAS's subgrade exploration (i.e., SPT results, laboratory test results, etc.), and our geotechnical experience. For analysis purposes, the proposed roadway elevations were assumed to be the same as the existing roadway elevations.

A subgrade analysis was performed to identify the method, location, and dimensions (including depth) of recommended subgrade stabilization in the referenced project plan. Appropriate stabilization of the subgrade will ensure a constructible pavement buildup, enhance pavement performance over its life, and help reduce costly extra work change orders (ODOT SGE, 2024). In addition to identifying stabilization recommendations, pavement design parameters are also determined to aid in pavement section design. The subsections below present the results of our subgrade analysis including pavement design parameters and unsuitable/unstable subgrade conditions if any identified within the project limits. Subgrade analysis spreadsheet for the referenced roadway segment is provided in Appendix C.

5.2.1. Pavement Design Recommendations

It is our understanding that pavement analysis and design is to be performed to determine the proposed pavement sections for the segments within the project limits to undergo full depth replacement. A

subgrade analysis was performed using the subgrade soil data obtained during our field exploration program to evaluate the soil characteristics and develop pavement parameters for use in pavement design. The subgrade analysis parameters recommended for use in pavement design are presented in Table 10 below. Provided in the table are ranges of maximum, minimum and average N_{60L} values for the indicated segments as well as the design CBR value recommended for use in pavement design.

Table 11: Pavement Design Values

Segment	Maximum N_{60L}	Minimum N_{60L}	Average N_{60L}	Average PI Value	Design CBR
SR-125	6	6	6	10	7

5.2.2. Unsuitable/Unstable Subgrade

Per ODOT's GDM, the presence of select subgrade conditions may require some form of subgrade stabilization within the subgrade zone for new pavement construction. These unsuitable and unstable subgrade conditions generally include the presence of rock, specific soil types, weak soil conditions, and overly moist soil conditions. With respect to the planned roadways, these subgrade conditions are further discussed in the following subsections.

5.2.2.1. Rock

Rock was not encountered within the top 6 inches of the proposed grade in either of the borings performed; therefore, no specialized remediation efforts are necessary.

5.2.2.2. Prohibited Soils

Prohibited soil types, per the GDM, include A-4b, A-2-5, A-5, A-7-5, A-8a, A-8b, and soils with liquid limits greater than 65. No prohibited soils were encountered within the subgrade of the referenced project roadway.

5.2.2.3. Weak Soils

The GDM recommends subgrade stabilization for soils considered unstable in which the N_{60} value of a particular soil sample (SS) at a referenced boring location is less than 12 bpf and in some cases less than 15 bpf (i.e., where moisture content is greater than optimum plus 3 percent). Based on the specific N_{60} value at the subject boring, *Figure 600-1 - Subgrade Stabilization* within the GDM recommends a depth of subgrade stabilization for ODOT standard stabilization methods. It should be noted that although a soil sample's N_{60} value may meet the criteria to be considered an unstable soil, the depth in which the unstable soil is encountered in relation to the proposed subgrade is considered when each individual subgrade boring is analyzed. For example, if the GDM recommends an excavate and replace of 12 inches within a weak soil underlying 18 inches of stable material, it would be unreasonable to recommend the removal of both the stable and unstable material for a total of 30 inches of excavate and replace.

A summary of the boring locations where unstable soils were encountered and determined to have a potential impact on subgrade performance are shown in Table 11 below, per the roadway segment for which they were encountered.

Table 12: Unstable Soil Location Summary

Boring ID	N_{60L}	Subgrade Depth (ft)
B-001-0-23	10	1.7 - 3.2

It should be noted that *Figure B - Subgrade Stabilization* does not apply to soil types A-1-a, A-1-b, A-3, or A-3a, nor to soils with N_{60L} values of 15 or more. Per GB1 guidance, *these soils should be reworked to stabilize the subgrade.*

5.2.2.4. High Moisture Content Soils

High moisture content soils are defined by the GDM as soils that exceed the estimated optimum moisture content (per Table 600-1 - Optimum Moisture Content within the ODOT GDM) for a given classification by 3 percent or more. Per the GDM, soils determined to be above the identified moisture content levels are a likely indication of the presence of an unstable subgrade and may require some form of subgrade stabilization. Similar to our analysis of unstable soils, although a soil sample's moisture content may meet the criteria to be considered high, the depth in which the high moisture soil is encountered in relation to the proposed subgrade is considered when each individual subgrade boring is analyzed for stabilization recommendations. Summaries of the boring locations where high moisture content conditions were encountered within the limits of each proposed alignment are shown in Table 12 below.

Table 13: High Moisture Content Soils Summary

Boring ID	Soil Type	Moisture Content (%)	Optimum Moisture Content (%)	Depth Below Subgrade (ft)
B-002-0-23	A-4a	14	11	0.8 - 2.3

5.2.3. Stabilization Recommendations

According to our subgrade analysis, subgrade stabilization is not required per ODOT GDM Section 600 (ODOT, 2024). Detailed results of the subgrade analysis are provided in Appendix C.

5.3. Bridge Foundation Analysis and Recommendations

A foundation review was completed for a deep foundation system for the referenced replacement bridge based on the following design information: 1) the Site Plan for the Bridge conducted by American StructurePoint; 2) historical plans and subsurface exploration; and 3) load and scour information provided by American StructurePoint.

5.3.1. Pile Scour Consideration

Based on our lab testing results, the equivalent D_{50} (mm) values were estimated using the methods described in ODOT's BDM Section 305.2.1.2.b and ODOT's GDM Section 1302.1.3. At the rear abutment, the equivalent D_{50} (mm) is estimated to be 440 mm and at the forward abutment, the equivalent D_{50} (mm) is estimated to be 300 mm. Scour analysis was then carried out by American StructurePoint. The lab testing results, and the equivalent D_{50} (mm) calculation process are attached in Appendix C.

According to the scour information provided by American StructurePoint via email on August 2, 2024, the 2% AEP scour is at the elevation of 637.69 ft and 636.06 ft at the rear and forward abutments,

respectively. The results indicate that during the 2% AEP scour event, 4.16 ft piles at the rear abutment and 6.19 ft piles at the forward abutment will become unsupported.

5.3.2. Axially Loaded Pile Analysis

Deep foundations will be used to support the substructures of the proposed SCI-125-06260 bridge over Turkey Creek. According to the site plan provided by American Structurepoint via email on January 7, 2025, the bottom of footing is approximately at the elevations of 641.85 ft and 642.25 ft for the rear and forward abutments, respectively. At the project site, bedrock was encountered in both structural borings at the elevation of 642.1 ft and 645.4 ft at the rear and forward abutments, respectively. HP-piles are usually used as end-bearing piles bearing on bedrock and can provide high axial working capacity. Both abutments will be supported on HP 14x73 piles in prebored holes.

Based on the email from American Structurepoint on January 23, 2025, the Service I and the Strength I axial loads for the abutment piles are 185 kips and 256 kips, respectively. For end-bearing HP-piles, the axial resistance of these foundation elements will be dictated by structural considerations and the maximum factored structural resistances for commonly used HP-piles are provided by the Bridge Design Manual (BDM) (ODOT, 2024) Section 305.3.3. The maximum factored structural resistance of HP 14x73 is 530 kips, which is much larger than the axial load. However, the laterally loaded condition controls the size of HP pile at the proposed project site.

Per CMS 507.11, the prebored holes shall have a diameter from 6 inches less to 2 inches more than the pile's diagonal dimension but shall be such as to produce satisfactory pile driving results. Place Class QC Misc. concrete in the prebored holes to the top of bedrock. Above the top of bedrock, backfill voids between the pile and prebored hole with a granular material satisfactory to the Engineer.

Based on ODOT GDM Section 1305.4, piles placed in prebored holes must extend a minimum of 5 feet below the maximum estimated scour depth when the bedrock unconfined compressive strength is greater than 1,500 psi. Therefore, the bottom of piles should be at the elevation of 632.69 ft and 631.06 ft at the rear and forward abutment, respectively.

According to the pile loads provided by American Structurepoint on January 9, 2025, the Strength I maximum uplift load per pile is 36 kips. Since the proposed bottom of footing is expected to be below top of bedrock, the piles will be installed in prebored holes surrounding by concrete. The uplift analyses were conducted using software entitled Shaft. In these analyses, the prebored hole was assumed to have a diameter of 2 ft. An uplift resistance factor of 0.4, based on the 2020 LRFD Table 10.5.5.2.4-1, was applied in our calculations. The results of the analysis are summarized in Table 13 below. As shown, the uplift capacity significantly exceeds the maximum uplift load when the piles are extended 5 ft below the bottom of the scour zone. The detailed output can be found in Appendix D.

Table 14: Axially Loaded Pile Analysis Summary

Substructure	Bottom of Footing Elevation (ft amsl)	Bottom of Scour Elevation - 2% AEP Scour (ft amsl)	Estimated Top of Bedrock Elevation (ft amsl)	Nearby Boring	Geotechnical Pile Tip Elevation - 5 ft below Bottom of Scour (ft amsl)	Geotechnial Pile Length (ft)	Max Uplift (Strength I) (kips)	Uplift Capacity (kips)
Bridge SCI-125-06260 SR-125 over Turkey Creek								
Rear Abutment	641.9	637.7	642.1	B-001-0-23	632.7	9.2	36.0	238.0
Forward Abutment	642.3	636.1	645.4	B-002-0-23	631.1	11.2	36.0	297.0

5.3.3. Laterally Loaded Pile Analysis

The lateral loads were provided by American Structurepoint via email on January 9, 2025. The Service I and Strength I shear forces for the abutment piles are 24 kips and 35 kips, respectively, while the corresponding moments are 63 kips-ft and 93 kips-ft.

For laterally loaded conditions, the piles should extend to the specified depth (Second Fixity Point) indicated in Table 14 to limit the pile head lateral deflection. The results of lateral load analyses using LPILE are summarized in Table 14. The LPILE analyses output can be found in Appendix E.

Based on our laterally loaded and axially loaded pile analyses, as can be seen, the estimated pile lengths under the lateral loading condition are shorter than scour condition (5 feet below the maximum estimated scour depth) at both abutment locations. The scour condition will control the pile length design.

Table 15: Laterally Loaded Pile Analysis Summary

Location	Pile Size	Maximum Moment in Pile - Strength Limit State (in-lbs)	Depth of Maximum Bending Moment below Pile Head (ft)	Maximum Shear in Pile- Strength Limit State (lbs)	Depth of Maximum Shear Force below Pile Head (ft)	Pile Head Deflection - Service Limit State (in)	First Fixity Point below Pile Head (ft)	Second Fixity Point below Pile Head (ft)
Rear Abutment @ B-001-0-23								
Rear Abutment	HP 14X73	1,116,000	0.0	154,393	0.4	0.00	0.4	1.5
Forward Abutment @ B-002-0-23								
Forward Abutment	HP 14X73	1,121,544	0.0	139,073	0.4	0.00	0.4	1.7

5.3.4. Pile Foundation Recommendations

Pile lengths based on: 1) the "Estimated Length" and "Order Length" definitions and formulas presented in Section 305.3.5.2 "Estimated Pile Length" of the BDM, are shown in Table 15. It is assumed that the piles will be supported from the elevations at the bottom of footing as shown in the site plan provided by American Structurepoint via email on January 7, 2025. The calculated 'estimated' length assumes penetration through a 1 ft embedment into the concrete footing for the abutments, and rounding up to the nearest 5 ft.

Table 16: Estimated Pile Lengths Summary

Substructure	Pile Type	Bottom of Footing Elevation (ft amsl)	Assumed Pile Cutoff Elevation (ft amsl)	Bottom of Scour Elevation - 2% AEP Scour (ft amsl)	Estimated Top of Bedrock Elevation (ft amsl)	Nearby Boring	Geotechnical Pile Tip Elevation - 5 ft below Bottom of Scour (ft amsl)	Geotechnial Pile Length (ft)	Estimated Pile Length (ft)	Order Length (ft)
Bridge SCI-125-06260 SR-125 over Turkey Creek										
Rear Abutment	HP 14X73	641.9	643.9	637.7	642.1	B-001-0-23	632.7	9.2	15	20
Forward Abutment	HP 14X73	642.3	644.3	636.1	645.4	B-002-0-23	631.1	11.2	15	20

5.4. Global Stability Analysis

Global stability should not be a concern due to shallow bedrock.

6. QUALIFICATIONS

This investigation was performed in accordance with accepted geotechnical engineering practice for the purpose of characterizing the subsurface conditions at the site of the proposed SCI-125-6.26 (PID# 119955) project. This report has been prepared for American StructurePoint, ODOT and their design consultants to be used solely in evaluating the soils underlying the indicated structures and presenting geotechnical engineering recommendations specific to this project. The assessment of general site environmental conditions or the presence of pollutants in the soil, rock and groundwater of the site was beyond the scope of this geotechnical exploration. Our recommendations are based on the results of our

field explorations, laboratory test results from representative soil samples, and geotechnical engineering analyses. The results of the field explorations and laboratory tests, which form the basis of our recommendations, are presented in the appendices as noted. This design memo does not reflect any variations that may occur between the borings or elsewhere on the site, or variations whose nature and extent may not become evident until a later stage of construction. In the event that any changes occur in the nature, design or location of the proposed structural work, the conclusions and recommendations contained in this memo should not be considered valid until they are reviewed and have been modified or verified in writing by a geotechnical engineer.

It has been a pleasure to be of service to American StructurePoint in performing this geotechnical exploration for the SCI-125-6.26 (PID# 119955) project. Please call if there are any questions, or if we can be of further service.

Respectfully Submitted,

Chunmei (Melinda) He, Ph.D., P.E.
Project Manager

Derar Tarawneh, Ph.D., P.E.
Geotechnical Staff Engineer

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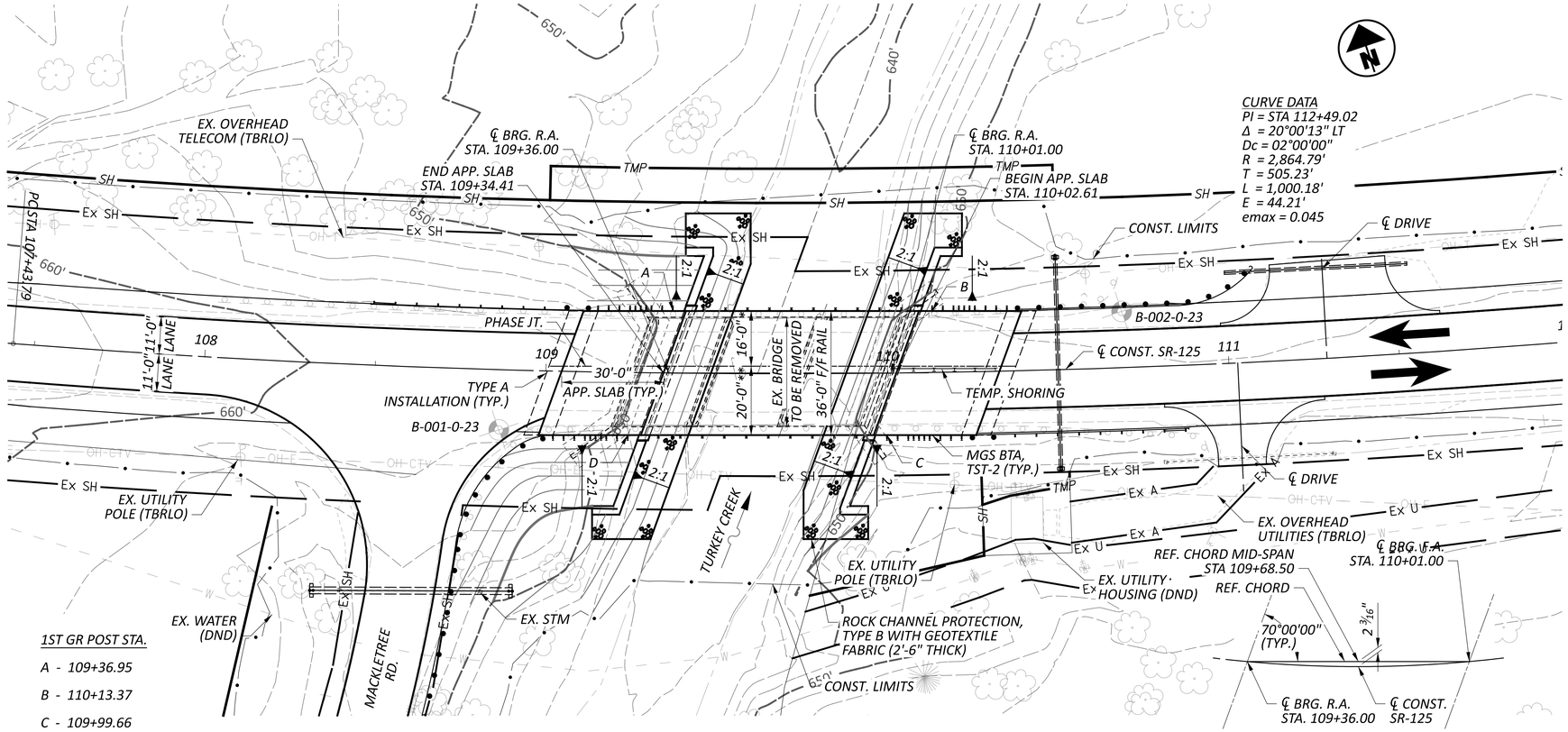
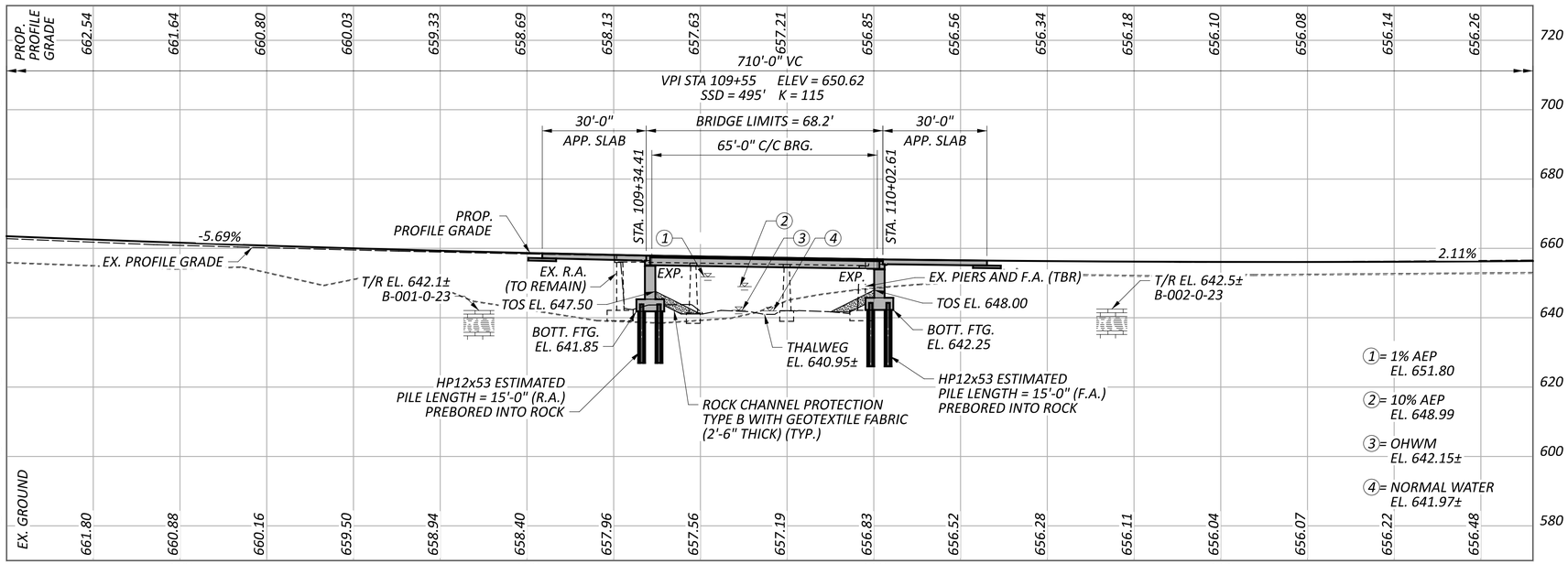
APPENDIX A

SITE PLAN & BORING LOCATION PLAN



PLAN

REFERENCE CHORD DIAGRAM



PROFILE

ALONG ℄ CONST. SR-125

BENCHMARK DATA

BM #1 STA.	108+12.16	ELEV.	658.38	OFFSET	27.79 RT.
BM #2 STA.	110+58.91	ELEV.	660.53	OFFSET	27.21 LT.

FOR ADDITIONAL BENCHMARK INFORMATION. SEE ROADWAY PLAN SHEET XX/XX.

NOTES

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

DESIGN TRAFFIC:

2024 ADT = 1355 2024 ADTT = 109
2044 ADT = 1910 2044 ADTT = 153
DIRECTIONAL DISTRIBUTION = 50%

LEGEND

BORING LOCATION
* - PHASE 1 CONSTRUCTION
** - PHASE 2 CONSTRUCTION
BTA - BRIDGE TERMINAL ASSEMBLY
DND - DO NOT DISTURB
TBR - TO BE REMOVED
TBRLO - TO BE RELOCATED BY OTHERS

HYDRAULIC DATA

DRAINAGE AREA = 16.5 SQ. MILES
Q (10% AEP) = 3560 CFS V (10% AEP) = 8.37 FT/S
Q (1% AEP) = 6650 CFS V (1% AEP) = 11.37 FT/S
STRUCTURE CLEARS THE 10 YEAR (10% AEP) DESIGN HW BY 4.11 FEET.

EXISTING STRUCTURE

TYPE: THREE-SPAN NON-COMPOSITE PRESTRESSED CONCRETE BOX BEAM SUPERSTRUCTURE REINFORCED CONCRETE WALL ABUTMENTS AND PIERS WITH SPREAD FOOTING FOUNDATIONS

SPANS: 21'-2⅞"±, 25'-0"±, 21'-4⅞"± C/C BRGS.
ROADWAY: 32'-0"± F/F RAILING
VEHICULAR LIVE LOADING: HS20-44 & ALTERNATIVE MILITARY
SKEW: 20°00'00"± L.F.
WEARING SURFACE: 2½"± BITUMINOUS
APPROACH SLABS: 15'-0"± LONG (AS-1-81)
ALIGNMENT: TANGENT
SUPERELEVATION: 0.027± FT/FT MAX.
STRUCTURE FILE NUMBER: 7303394
DATE BUILT: 1931
DISPOSITION: TO BE REPLACED

PROPOSED STRUCTURE

TYPE: SINGLE SPAN COMPOSITE PRESTRESSED BOX BEAM SUPERSTUCTURE ON WALL ABUTMENTS WITH PRE-BORED H-PILE FOUNDATION

SPANS: 65'-0" C/C BRGS
ROADWAY: 36'-0" F/F RAILING
VEHICULAR LIVE LOAD: HL-93
FUTURE WEARING SURFACE: 0.060 KSF
SKEW: 20°00'00" L.F. TO REFERENCE CHORD
APPROACH SLABS: 30'-0" LONG (AS-1-15, AS-2-15 TYPE A)
ALIGNMENT: TANGENT
SUPERELEVATION: 0.045 FT/FT
DECK AREA: 2455 SF

COORDINATES: LATITUDE 38°43'34.56" N
LONGITUDE 83°10'15.73" W

SITE PLAN
BRIDGE NO. SCI-125-06260
SR-125 OVER TURKEY CREEK

SFN	7303394
DESIGN AGENCY	STRUCTUREPOINT LLC
DESIGNER	BWJ
CHECKER	SJF
REVIEWER	CLB 08-09-24
PROJECT ID	119955
SUBSET	1
TOTAL	5
SHEET	P.30
TOTAL	37

CTY-RTE-SECTION

MODEL: CLP_SR_125 - Plan 1 [Sheet] PAPERSIZE: 34x22 (in.) DATE: 8/9/2024 TIME: 4:15:18 PM USER: awills
O:\2023\03013\C_Design\119955-SCI-125-6.26\400-Engineering\Structures\SFN_7303394\Sheets\119955_SFN_7303394_SP001.dgn


SCI-125-6.26
Boring Location Plan
Legend
Feature 1
125
125
125
B-001-0-23
B-002-0-23
Mackenzie Rd
Google Earth
N
100 ft

APPENDIX B

BORING LOGS & LABORATORY TEST RESULTS

PROJECT: SCI-125-6.26	DRILLING FIRM / OPERATOR: CS / TS	DRILL RIG: D50 SN481	STATION / OFFSET: 108+87, 18' RT.	EXPLORATION ID B-001-0-23
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: NEAS / LR	HAMMER: CME AUTOMATIC	ALIGNMENT: SR-125	
PID: 119955 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 3/14/22	ELEVATION: 658.1 (MSL) EOB: 31.5 ft.	PAGE 1 OF 2
START: 2/9/24 END: 2/9/24	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 86.8	LAT / LONG: 38.726340, -83.171250	

MATERIAL DESCRIPTION AND NOTES	ELEV. 658.1	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
11.0" ASPHALT	657.2																	
STIFF TO HARD, BROWN MOTTLED WITH ORANGISH BROWN AND GRAY, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, IRON STAINING, DAMP TO MOIST		1	10 6 4	14	89	SS-1	4.50	10	3	4	52	31	30	17	13	15	A-6a (9)	
		2																
		3	3 4 3	10	78	SS-2	3.50	-	-	-	-	-	-	-	-	16	A-6a (V)	
		4																
		5	2 1 3	6	56	SS-3	3.00	-	-	-	-	-	-	-	-	20	A-6a (V)	
		6	3 2 2	6	89	SS-4	2.00	-	-	-	-	-	-	-	-	20	A-6a (V)	
		7	2 2 3	7	17	SS-5	2.50	0	1	2	64	33	33	20	13	21	A-6a (9)	
	649.6	8																
SOFT TO MEDIUM STIFF, BROWN, **SILT**, LITTLE SAND, LITTLE CLAY, LITTLE GRAVEL, MOIST	648.1	9	2 2 2	6	89	SS-6	0.50	13	9	8	54	16	28	20	8	22	A-4b (7)	
MEDIUM DENSE TO VERY DENSE, BROWN AND GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, DAMP		10	6 7 8	22	78	SS-7	-	42	18	10	21	9	NP	NP	NP	13	A-2-4 (0)	
		11	6 30 11	59	78	SS-8	-	42	14	10	26	8	NP	NP	NP	11	A-2-4 (0)	
	643.6	12	9 11 10	30	89	SS-9	-	-	-	-	-	-	-	-	-	16	A-2-4 (V)	
		13																
VERY DENSE, BROWN AND ORANGISH BROWN, **SANDY SILT**, SOME STONE FRAGMENTS, TRACE CLAY, IRON STAINING, RESIDUAL ROCK, DAMP	642.1	14	14 25 23	69	89	SS-10	-	26	12	15	40	7	NP	NP	NP	12	A-4a (2)	
	TR	15	50/5"	-	100	SS-11	-	-	-	-	-	-	-	-	-	14	Rock (V)	
INTERBEDDED SHALE (69%) AND SANDSTONE (31%), RQD 54%, REC. 98%; **SHALE**, GRAY AND LIGHT GRAY, SLIGHTLY TO MODERATELY WEATHERED, VERY WEAK TO WEAK, LAMINATED TO THIN BEDDED, THICK BEDDED FROM 24.3-26.5', CONTAINS INTERBEDDED CLAY SEAMS, FISSILE, BEDDING DISCONTINUITIES: LOW ANGLE, HIGHLY FRACTURED TO SLIGHTLY FRACTURED, OPEN TO NARROW, SLIGHTLY ROUGH, LAMINATED, INTACT FROM 24.3-26.5', FAIR TO POOR SURFACE CONDITION; **SANDSTONE**, BROWN AND GRAY, STRONG, VERY FINE TO FINE GRAINED. @17.5'-17.8'; Qu = 15386 PSI @ 1.0% STRAIN (SANDSTONE)		16	75		100	NQ2-1												CORE	
		17																
		18																
		19																
		20																
		21																
		22	48		98	NQ2-2											CORE	
		23																
		24																
		25																
		26																
		27																
		28																
		29	53		97	NQ2-3											CORE	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 12/12/24 12:44 - X:\1ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\SCI-125-6.26\GINT FILES\SCI-125-6.26.GPJ

PID: 119955	SFN:	PROJECT: SCI-125-6.26	STATION / OFFSET: 108+87, 18' RT.	START: 2/9/24	END: 2/9/24	PG 2 OF 2	B-001-0-23

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL
								GR	CS	FS	SI	CL	LL	PL	PI			
	628.1																	
	626.6	31 EOB																

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. HOLE DID NOT CAVE. DRILLED AS STAKED.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; POURED 3 BAGS HOLE PLUG; SHOVELED SOIL CUTTINGS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 12/12/24 12:44 - X:\1ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\SCI-125-6.26\GINT FILES\SCI-125-6.26.GPJ

OHIO DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING

Office of Geotechnical Engineering

B-001-0-23

Run #:	Depth		Recovery		RQD	
NQ2-1	16.5'	19.0'	30"	100%	22.5"	75%
NQ2-2	19.0'	26.5'	88"	98%	43"	48%

SCI-125-6.26

OHIO DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING

Office of Geotechnical Engineering

B-001-0-23

Run #:	Depth		Recovery		RQD	
NQ2-3	26.5'	31.5'	58"	97%	31.75"	53%

SCI-125-6.26

Objective: **To estimate depth of rock scour for foundations (shallow foundations/drilled shafts) in rock per direction of ODOT.**

Method: **In accordance with FHWA Publication No. FHWA-HIF-12-003, Hydraulic Engineering Circular No. 18 (HEC-18) and ODOT's BDM Section 305.2.1.2.b**

Erodibility Index (K):

Givens:

$RQD := 75$ — Rock Quality Designation, Unit: Percentage

$J_n := 1.22$ — Rock Joint Set Number (Boring Logs, HEC-18 Table 4.23)

Per ODOT BDM: If Jn, cannot be determined from observation or bore hole data, then assume Jn = 5.

$J_r := 1.0$ — Joint Roughness Number (Boring Logs, HEC-18 Table 4.24)

Per ODOT BDM: If Jr, cannot be determined from observation or bore hole data, then assume Jn = 1.

$J_a := 13.0$ — Joint Alteration Number (Boring Logs, HEC-18 Table 4.25)

Per ODOT BDM: If Ja, cannot be determined from observation or bore hole data, then assume Jn = 5.

$J_s := 1.02$ — Relative Joint Orientation Parameter (Boring Logs, HEC-18 Table 4.26)

Per ODOT BDM: If Js, cannot be determined from observation or bore hole data, then assume Jn = 0.4.

$M_s := 0.87$ — Intact Rock Mass Strength Parameter (ODOT BDM, Sect. 305.2.1.2.b.B.6.b)

Analysis:

$K_b := \text{if}\left(RQD = 0\,,\,0.1\,,\,\frac{RQD}{J_n}\right) = 61.48$ — Block Size Parameter (HEC-18, Eq. 4.18)

$K_d := \frac{J_r}{J_a} = 0.08$ — Shear Strength Parameter (HEC-18, Eq. 4.19)

$K := M_s \cdot K_b \cdot K_d \cdot J_s = 4.2$ — Erodibility Index (HEC-18, Eq. 4.17)

Approach Flow Stream Power (Pa):

Givens:

$\rho := 1000$ Mass Density of Water (kg/m^3)

Analysis:

$\tau c\_Pa := \rho \cdot \left(\frac{1000 \cdot K^{0.75}}{7.853 \cdot \rho} \right)^{\frac{2}{3}}$ $\tau c\_Pa = 518.5$ Critical shear stress (Pa)

$\tau c\_psf := \tau c\_Pa \cdot \frac{1}{47.88}\ psf$ $\tau c\_psf = 10.8\ psf$ Critical shear stress (Psf)

$D_{50\_equivalent} := \tau c\_Pa$ $D_{50\_equivalent} = 518.5$ Equivalent D50 (mm)

Objective: **To estimate depth of rock scour for foundations (shallow foundations/drilled shafts) in rock per direction of ODOT.**

Method: **In accordance with FHWA Publication No. FHWA-HIF-12-003, Hydraulic Engineering Circular No. 18 (HEC-18) and ODOT's BDM Section 305.2.1.2.b**

Erodibility Index (K):

Givens:

$RQD := 48$ — Rock Quality Designation, Unit: Percentage

$J_n := 1.22$ — Rock Joint Set Number (Boring Logs, HEC-18 Table 4.23)

Per ODOT BDM: If Jn, cannot be determined from observation or bore hole data, then assume Jn = 5.

$J_r := 1.0$ — Joint Roughness Number (Boring Logs, HEC-18 Table 4.24)

Per ODOT BDM: If Jr, cannot be determined from observation or bore hole data, then assume Jn = 1.

$J_a := 13.0$ — Joint Alteration Number (Boring Logs, HEC-18 Table 4.25)

Per ODOT BDM: If Ja, cannot be determined from observation or bore hole data, then assume Jn = 5.

$J_s := 1.02$ — Relative Joint Orientation Parameter (Boring Logs, HEC-18 Table 4.26)

Per ODOT BDM: If Js, cannot be determined from observation or bore hole data, then assume Jn = 0.4.

$M_s := 0.87$ — Intact Rock Mass Strength Parameter (ODOT BDM, Sect. 305.2.1.2.b.B.6.b)

Analysis:

$K_b := \text{if}\left(RQD = 0\,,\,0.1\,,\,\frac{RQD}{J_n}\right) = 39.34$ — Block Size Parameter (HEC-18, Eq. 4.18)

$K_d := \frac{J_r}{J_a} = 0.08$ — Shear Strength Parameter (HEC-18, Eq. 4.19)

$K := M_s \cdot K_b \cdot K_d \cdot J_s = 2.69$ — Erodibility Index (HEC-18, Eq. 4.17)

Approach Flow Stream Power (Pa):

Givens:

$\rho := 1000$ Mass Density of Water (kg/m^3)

Analysis:

$\tau c\_Pa := \rho \cdot \left(\frac{1000 \cdot K^{0.75}}{7.853 \cdot \rho} \right)^{\frac{2}{3}}$ $\tau c\_Pa = 414.8$ Critical shear stress (Pa)

$\tau c\_psf := \tau c\_Pa \cdot \frac{1}{47.88}\ psf$ $\tau c\_psf = 8.7\ psf$ Critical shear stress (Psf)

$D_{50\_equivalent} := \tau c\_Pa$ $D_{50\_equivalent} = 414.8$ Equivalent D50 (mm)

Objective: **To estimate depth of rock scour for foundations (shallow foundations/drilled shafts) in rock per direction of ODOT.**

Method: **In accordance with FHWA Publication No. FHWA-HIF-12-003, Hydraulic Engineering Circular No. 18 (HEC-18) and ODOT's BDM Section 305.2.1.2.b**

Erodibility Index (K):

Givens:

$RQD := 53$ — Rock Quality Designation, Unit: Percentage

$J_n := 1.22$ — Rock Joint Set Number (Boring Logs, HEC-18 Table 4.23)

Per ODOT BDM: If Jn, cannot be determined from observation or bore hole data, then assume Jn = 5.

$J_r := 1.0$ — Joint Roughness Number (Boring Logs, HEC-18 Table 4.24)

Per ODOT BDM: If Jr, cannot be determined from observation or bore hole data, then assume Jn = 1.

$J_a := 13.0$ — Joint Alteration Number (Boring Logs, HEC-18 Table 4.25)

Per ODOT BDM: If Ja, cannot be determined from observation or bore hole data, then assume Jn = 5.

$J_s := 1.02$ — Relative Joint Orientation Parameter (Boring Logs, HEC-18 Table 4.26)

Per ODOT BDM: If Js, cannot be determined from observation or bore hole data, then assume Jn = 0.4.

$M_s := 0.87$ — Intact Rock Mass Strength Parameter (ODOT BDM, Sect. 305.2.1.2.b.B.6.b)

Analysis:

$K_b := \text{if}\left(RQD = 0\,,\,0.1\,,\,\frac{RQD}{J_n}\right) = 43.44$ — Block Size Parameter (HEC-18, Eq. 4.18)

$K_d := \frac{J_r}{J_a} = 0.08$ — Shear Strength Parameter (HEC-18, Eq. 4.19)

$K := M_s \cdot K_b \cdot K_d \cdot J_s = 2.97$ — Erodibility Index (HEC-18, Eq. 4.17)

Approach Flow Stream Power (Pa):

Givens:

$\rho := 1000$ Mass Density of Water (kg/m^3)

Analysis:

$\tau c\_Pa := \rho \cdot \left(\frac{1000 \cdot K^{0.75}}{7.853 \cdot \rho} \right)^{\frac{2}{3}}$ $\tau c\_Pa = 435.9$ Critical shear stress (Pa)

$\tau c\_psf := \tau c\_Pa \cdot \frac{1}{47.88}\ psf$ $\tau c\_psf = 9.1\ psf$ Critical shear stress (Psf)

$D_{50\_equivalent} := \tau c\_Pa$ $D_{50\_equivalent} = 435.9$ Equivalent D50 (mm)

PROJECT: SCI-125-6.26	DRILLING FIRM / OPERATOR: CS / TS	DRILL RIG: D50 SN481	STATION / OFFSET: 110+69, 16' LT.	EXPLORATION ID B-002-0-23
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: NEAS / LR	HAMMER: CME AUTOMATIC	ALIGNMENT: SR-125	
PID: 119955 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 3/14/22	ELEVATION: 655.4 (MSL) EOB: 25.3 ft.	PAGE 1 OF 1
START: 2/9/24 END: 2/9/24	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 86.8	LAT / LONG: 38.726270, -83.170610	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
8.0" ASPHALT	654.7																	
MEDIUM DENSE, DARK BROWN AND BLACK, **GRAVEL WITH SAND**, TRACE SILT, TRACE CLAY, DAMP	653.9		27 5 11	23	44	SS-1	-	-	-	-	-	-	-	-	-	3	A-1-b (V)	
MEDIUM DENSE, BROWN, **SANDY SILT**, SOME STONE FRAGMENTS, TRACE CLAY, DAMP	652.4		6 7 4	16	72	SS-2	-	35	9	11	36	9	NP	NP	NP	14	A-4a (2)	
STIFF TO VERY STIFF, BROWN, **SANDY SILT**, LITTLE CLAY, LITTLE GRAVEL, DAMP	650.9		2 2 2	6	33	SS-3	2.00	13	14	11	46	16	25	19	6	17	A-4a (5)	
MEDIUM DENSE TO VERY DENSE, BROWN, **SANDY SILT**, SOME TO "AND" STONE FRAGMENTS, TRACE CLAY, DAMP			5 4 5	13	56	SS-4	-	38	9	15	34	4	NP	NP	NP	10	A-4a (1)	
			4 5 9	20	67	SS-5	-	30	8	12	40	10	NP	NP	NP	14	A-4a (3)	
			6 11 10	30	56	SS-6	-	43	7	12	31	7	NP	NP	NP	12	A-4a (1)	
	645.4	TR	8 29 50/3"	-	60	SS-7	-	-	-	-	-	-	-	-	-	10	A-4a (V)	
SANDSTONE, BROWN AND ORANGISH BROWN, SLIGHTLY TO MODERATELY WEATHERED, STRONG, FINE GRAINED, THIN TO MEDIUM BEDDED, BEDDING DISCONTINUITIES: LOW ANGLE, HIGHLY FRACTURED TO MODERATELY FRACTURED, NARROW, SLIGHTLY ROUGH, BLOCKY/DISTURBED/SEAMY, FAIR SURFACE CONDITION; RQD 63%, REC 100%. @10.5'-10.9'; Qu = 9869 PSI @ 1.0% STRAIN (SANDSTONE)	642.5		33		56	NQ2-1											CORE	
INTERBEDDED SHALE (73%) AND SANDSTONE (27%), RQD 10%, REC. 78%; **SHALE**, GRAY AND LIGHT GRAY, SLIGHTLY TO MODERATELY WEATHERED, VERY WEAK TO WEAK, LAMINATED TO THIN BEDDED, FISSILE, CONTAINS INTERBEDDED CLAY SEAMS, BEDDING DISCONTINUITIES: LOW ANGLE, HIGHLY FRACTURED TO MODERATELY FRACTURED, OPEN TO NARROW, SLIGHTLY ROUGH, LAMINATED TO THIN BEDDED, FAIR TO POOR SURFACE CONDITION; **SANDSTONE**, GRAY, STRONG, FINE GRAINED.			0		92	NQ2-2											CORE	
			18		96	NQ2-3											CORE	
	630.1	EOB																

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. HOLE DID NOT CAVE. DRILLED AS STAKED.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; POURED 3 BAGS HOLE PLUG; SHOVELED SOIL CUTTINGS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 12/12/24 12:44 - X:\1ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\SCI-125-6.26\GINT FILES\SCI-125-6.26.GPJ

OHIO DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING

Office of Geotechnical Engineering

B-002-0-23

Run #:	Depth		Recovery		RQD	
NQ2-1	10.3'	15.3'	33.5"	56%	20"	33%
NQ2-2	15.3'	18.3'	33"	92%	0"	0%

SCI-125-6.26

OHIO DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING

Office of Geotechnical Engineering

B-002-0-23

Run #:	Depth		Recovery		RQD	
NQ2-3	18.3'	25.3'	81"	96%	15"	18%

SCI-125-6.26

Objective: **To estimate depth of rock scour for foundations (shallow foundations/drilled shafts) in rock per direction of ODOT.**

Method: **In accordance with FHWA Publication No. FHWA-HIF-12-003, Hydraulic Engineering Circular No. 18 (HEC-18) and ODOT's BDM Section 305.2.1.2.b**

Erodibility Index (K):

Givens:

$RQD := 33$ — Rock Quality Designation, Unit: Percentage

$J_n := 1.50$ — Rock Joint Set Number (Boring Logs, HEC-18 Table 4.23)

Per ODOT BDM: If Jn, cannot be determined from observation or bore hole data, then assume Jn = 5.

$J_r := 1.0$ — Joint Roughness Number (Boring Logs, HEC-18 Table 4.24)

Per ODOT BDM: If Jr, cannot be determined from observation or bore hole data, then assume Jn = 1.

$J_a := 8.0$ — Joint Alteration Number (Boring Logs, HEC-18 Table 4.25)

Per ODOT BDM: If Ja, cannot be determined from observation or bore hole data, then assume Jn = 5.

$J_s := 1.02$ — Relative Joint Orientation Parameter (Boring Logs, HEC-18 Table 4.26)

Per ODOT BDM: If Js, cannot be determined from observation or bore hole data, then assume Jn = 0.4.

$M_s := 0.87$ — Intact Rock Mass Strength Parameter (ODOT BDM, Sect. 305.2.1.2.b.B.6.b)

Analysis:

$K_b := \text{if}\left(RQD = 0\,,\,0.1\,,\,\frac{RQD}{J_n}\right) = 22$ — Block Size Parameter (HEC-18, Eq. 4.18)

$K_d := \frac{J_r}{J_a} = 0.13$ — Shear Strength Parameter (HEC-18, Eq. 4.19)

$K := M_s \cdot K_b \cdot K_d \cdot J_s = 2.44$ — Erodibility Index (HEC-18, Eq. 4.17)

Approach Flow Stream Power (Pa):

Givens:

$\rho := 1000$ Mass Density of Water (kg/m^3)

Analysis:

$\tau c\_Pa := \rho \cdot \left(\frac{1000 \cdot K^{0.75}}{7.853 \cdot \rho} \right)^{\frac{2}{3}}$ $\tau c\_Pa = 395.4$ Critical shear stress (Pa)

$\tau c\_psf := \tau c\_Pa \cdot \frac{1}{47.88}\ psf$ $\tau c\_psf = 8.3\ psf$ Critical shear stress (Psf)

$D_{50\_equivalent} := \tau c\_Pa$ $D_{50\_equivalent} = 395.4$ Equivalent D50 (mm)

Objective: **To estimate depth of rock scour for foundations (shallow foundations/drilled shafts) in rock per direction of ODOT.**

Method: **In accordance with FHWA Publication No. FHWA-HIF-12-003, Hydraulic Engineering Circular No. 18 (HEC-18) and ODOT's BDM Section 305.2.1.2.b**

Erodibility Index (K):

Givens:

$RQD := 0$ — Rock Quality Designation, Unit: Percentage

$J_n := 1.50$ — Rock Joint Set Number (Boring Logs, HEC-18 Table 4.23)

Per ODOT BDM: If Jn, cannot be determined from observation or bore hole data, then assume Jn = 5.

$J_r := 1.0$ — Joint Roughness Number (Boring Logs, HEC-18 Table 4.24)

Per ODOT BDM: If Jr, cannot be determined from observation or bore hole data, then assume Jn = 1.

$J_a := 8.0$ — Joint Alteration Number (Boring Logs, HEC-18 Table 4.25)

Per ODOT BDM: If Ja, cannot be determined from observation or bore hole data, then assume Jn = 5.

$J_s := 1.02$ — Relative Joint Orientation Parameter (Boring Logs, HEC-18 Table 4.26)

Per ODOT BDM: If Js, cannot be determined from observation or bore hole data, then assume Jn = 0.4.

$M_s := 0.87$ — Intact Rock Mass Strength Parameter (ODOT BDM, Sect. 305.2.1.2.b.B.6.b)

Analysis:

$K_b := \text{if}\left(RQD = 0 , 0.1 , \frac{RQD}{J_n}\right) = 0.1$ — Block Size Parameter (HEC-18, Eq. 4.18)

$K_d := \frac{J_r}{J_a} = 0.13$ — Shear Strength Parameter (HEC-18, Eq. 4.19)

$K := M_s \cdot K_b \cdot K_d \cdot J_s = 0.01$ — Erodibility Index (HEC-18, Eq. 4.17)

Approach Flow Stream Power (Pa):

Givens:

$\rho := 1000$ Mass Density of Water (kg/m^3)

Analysis:

$\tau c\_Pa := \rho \cdot \left(\frac{1000 \cdot K^{0.75}}{7.853 \cdot \rho} \right)^{\frac{2}{3}}$ $\tau c\_Pa = 26.7$ Critical shear stress (Pa)

$\tau c\_psf := \tau c\_Pa \cdot \frac{1}{47.88}\ psf$ $\tau c\_psf = 0.6\ psf$ Critical shear stress (Psf)

$D_{50\_equivalent} := \tau c\_Pa$ $D_{50\_equivalent} = 26.7$ Equivalent D50 (mm)

Objective: **To estimate depth of rock scour for foundations (shallow foundations/drilled shafts) in rock per direction of ODOT.**

Method: **In accordance with FHWA Publication No. FHWA-HIF-12-003, Hydraulic Engineering Circular No. 18 (HEC-18) and ODOT's BDM Section 305.2.1.2.b**

Erodibility Index (K):

Givens:

$RQD := 18$ — Rock Quality Designation, Unit: Percentage

$J_n := 1.50$ — Rock Joint Set Number (Boring Logs, HEC-18 Table 4.23)

Per ODOT BDM: If Jn, cannot be determined from observation or bore hole data, then assume Jn = 5.

$J_r := 1.0$ — Joint Roughness Number (Boring Logs, HEC-18 Table 4.24)

Per ODOT BDM: If Jr, cannot be determined from observation or bore hole data, then assume Jn = 1.

$J_a := 8.0$ — Joint Alteration Number (Boring Logs, HEC-18 Table 4.25)

Per ODOT BDM: If Ja, cannot be determined from observation or bore hole data, then assume Jn = 5.

$J_s := 1.02$ — Relative Joint Orientation Parameter (Boring Logs, HEC-18 Table 4.26)

Per ODOT BDM: If Js, cannot be determined from observation or bore hole data, then assume Jn = 0.4.

$M_s := 0.87$ — Intact Rock Mass Strength Parameter (ODOT BDM, Sect. 305.2.1.2.b.B.6.b)

Analysis:

$K_b := \text{if}\left(RQD = 0\,,\,0.1\,,\,\frac{RQD}{J_n}\right) = 12$ — Block Size Parameter (HEC-18, Eq. 4.18)

$K_d := \frac{J_r}{J_a} = 0.13$ — Shear Strength Parameter (HEC-18, Eq. 4.19)

$K := M_s \cdot K_b \cdot K_d \cdot J_s = 1.33$ — Erodibility Index (HEC-18, Eq. 4.17)

Approach Flow Stream Power (Pa):

Givens:

$\rho := 1000$ Mass Density of Water (kg/m^3)

Analysis:

$\tau c\_Pa := \rho \cdot \left(\frac{1000 \cdot K^{0.75}}{7.853 \cdot \rho} \right)^{\frac{2}{3}}$ $\tau c\_Pa = 292$ Critical shear stress (Pa)

$\tau c\_psf := \tau c\_Pa \cdot \frac{1}{47.88}\ psf$ $\tau c\_psf = 6.1\ psf$ Critical shear stress (Psf)

$D_{50\_equivalent} := \tau c\_Pa$ $D_{50\_equivalent} = 292$ Equivalent D50 (mm)

National Engineering & Architectural Services Inc.
5710 Westbourne Avenue
Columbus, OH 43213
614-892-0162

Unconfined Compressive Strength of Rock Core (ASTM D7012 Method C)

(Project: SCI-125-6.26, Boring Location: B-001-0-23, NQ2-1, Depth: 17.5-17.8ft)

Tested Date: 4/19/2024

Specimen Properties

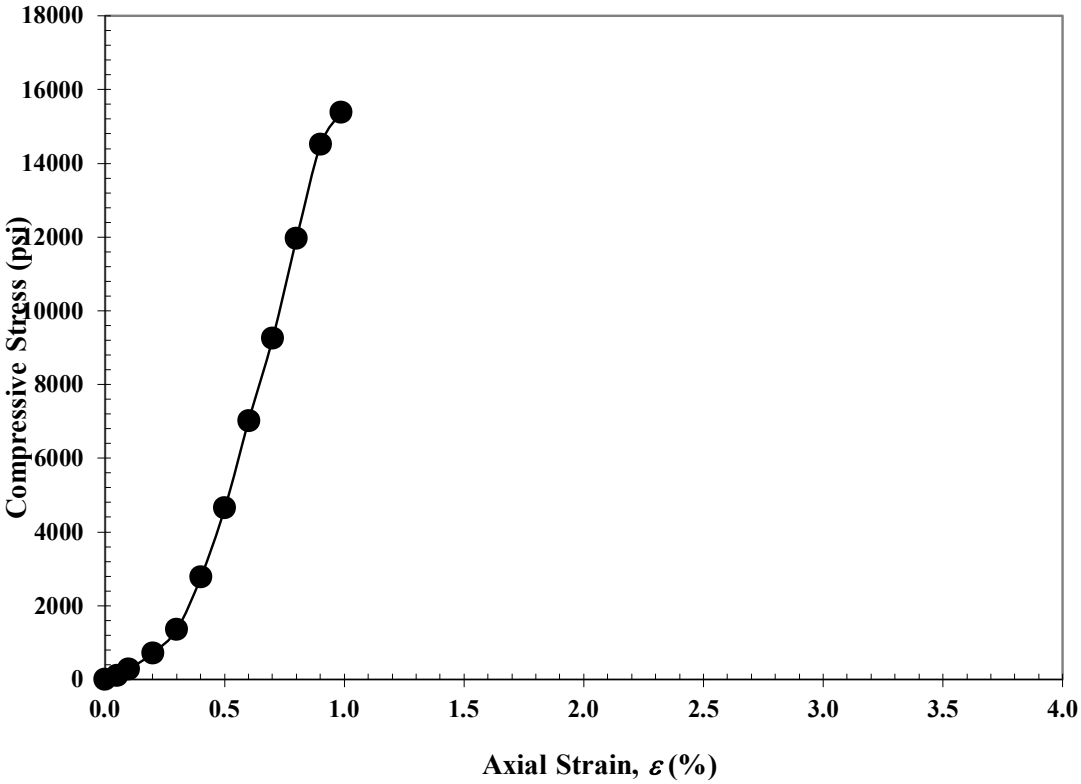
Average Dia., D_{avg} (in):	1.99
Average Height, H_{avg} (in):	4.16
Length to Diameter Ratio:	2.09
Area, A (in^2):	3.10
Volume, V (in^3):	12.91
Wet Mass of Specimen (lb):	1.2
Moisture Content (%):	1.4
Dry Mass of Specimen (lb):	1.2
Wet Unit Weight, γ (lb/ft^3):	165.7
Dry Unit Weight, γ_d (lb/ft^3):	163.3

Final Specimen Figure

Results

Unconfined Compressive Strength (psi): **15386** **106** (MPa)

Strain (%): **1.0**



Notes: Sandstone, gray and light brown, slightly weathered, very strong, very fine to fine grained.

Sample trimming procedure does not conform to ASTM D4543 and the results reported may differ from the results obtained from a test specimen that meets the requirements of Practice D4543.

National Engineering & Architectural Services Inc.
5710 Westbourne Avenue
Columbus, OH 43213
614-892-0162

Unconfined Compressive Strength of Rock Core (ASTM D7012 Method C)

(Project: SCI-125-6.26, Boring Location: B-002-0-23, NQ2-1, Depth: 10.5-10.9ft)

Tested Date: 4/19/2024

Specimen Properties

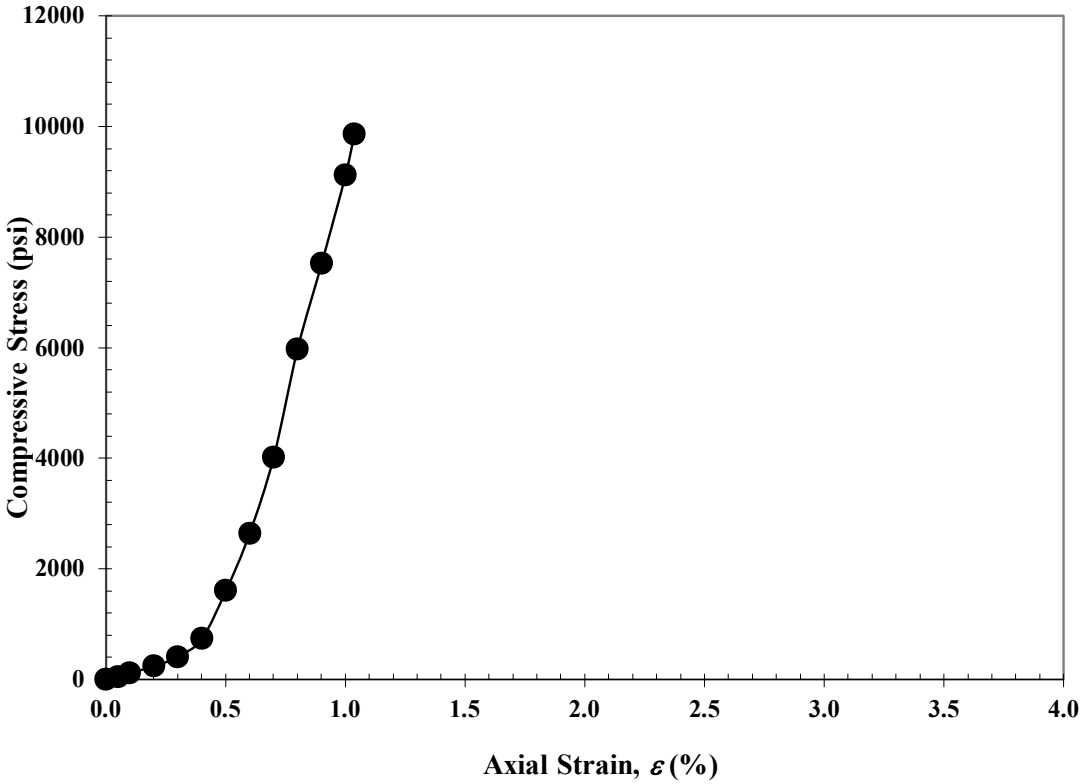
Average Dia., D_{avg} (in):	1.99
Average Height, H_{avg} (in):	4.34
Length to Diameter Ratio:	2.18
Area, A (in^2):	3.10
Volume, V (in^3):	13.44
Wet Mass of Specimen (lb):	1.1
Moisture Content (%):	5.9
Dry Mass of Specimen (lb):	1.1
Wet Unit Weight, γ (lb/ft^3):	145.1
Dry Unit Weight, γ_d (lb/ft^3):	137.0

Final Specimen Figure

Results

Unconfined Compressive Strength (psi): **9869** **68** (MPa)

Strain (%): **1.0**



Notes: Sandstone, brown and orangish brown, slightly weathered, strong, fine grained.

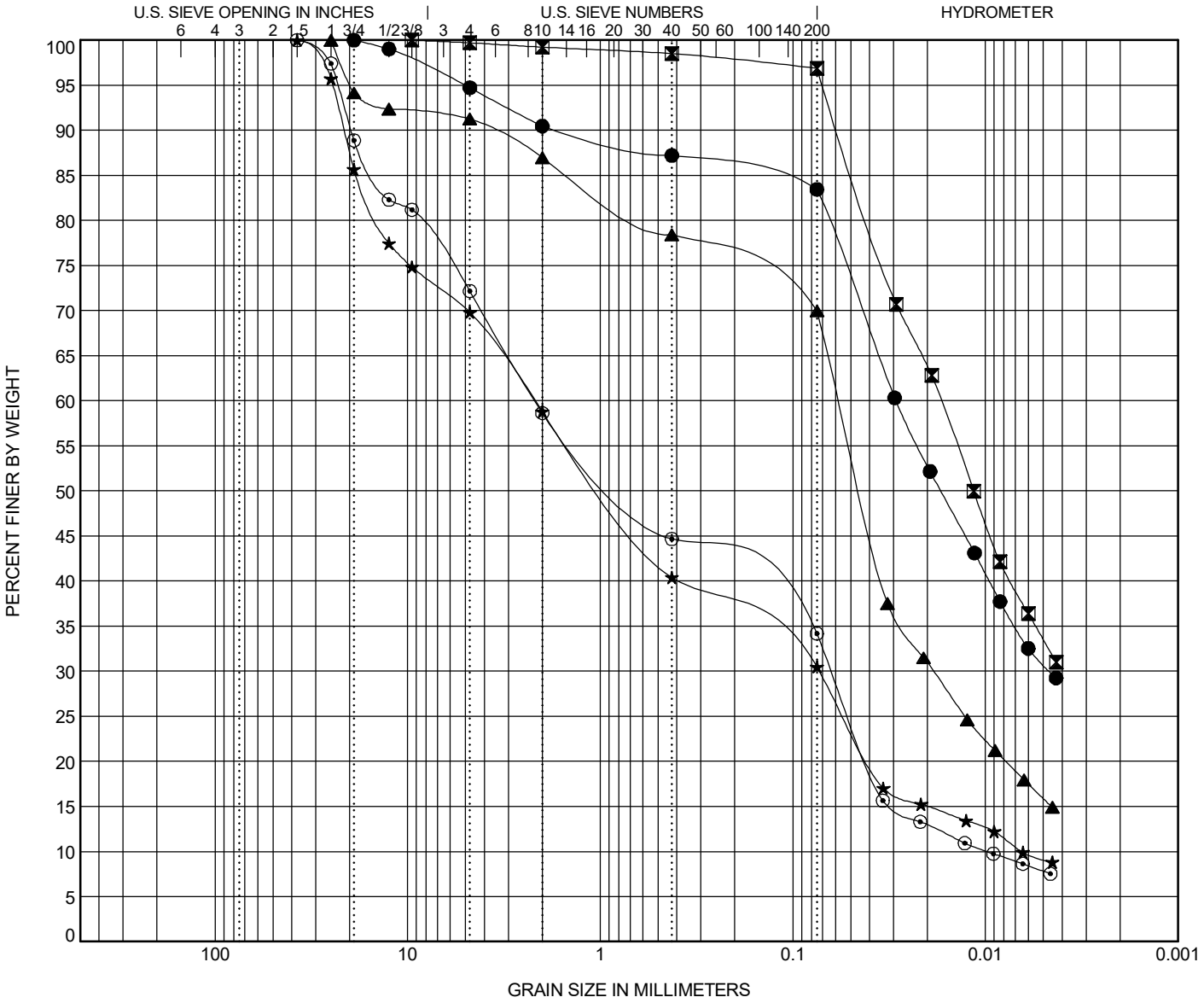
Sample trimming procedure does not conform to ASTM D4543 and the results reported may differ from the results obtained from a test specimen that meets the requirements of Practice D4543.

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT SCI-125-6.26 **PID**

OGE NUMBER 0 **PROJECT TYPE**



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

Specimen Identification			ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
●	B-001-0-23	1.0	**A-6a ~ LEAN CLAY with SAND(CL)**	**30**	**17**	**13**
⊠	B-001-0-23	7.0	**A-6a ~ LEAN CLAY(CL)**	**33**	**20**	**13**
▲	B-001-0-23	8.5	**A-4b ~ SANDY LEAN CLAY(CL)**	**28**	**20**	**8**
★	B-001-0-23	10.0	**A-2-4 ~ SILTY SAND with GRAVEL(SM)**	**NP**	**NP**	**NP**
⊙	B-001-0-23	11.5	**A-2-4 ~ SILTY SAND with GRAVEL(SM)**	**NP**	**NP**	**NP**

Specimen Identification			D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
●	B-001-0-23	1.0	**1.597**	**0.017**	**0.005**		**10**	**3**	**4**	**52**	**31**		
⊠	B-001-0-23	7.0	**0.058**	**0.012**			**0**	**1**	**2**	**64**	**33**		
▲	B-001-0-23	8.5	**3.669**	**0.045**	**0.019**		**13**	**9**	**8**	**54**	**16**		
★	B-001-0-23	10.0	**21.383**	**0.953**	**0.073**	**0.006**	**42**	**18**	**10**	**21**	**9**	**0.37**	**338.61**
⊙	B-001-0-23	11.5	**19.693**	**0.767**	**0.063**	**0.01**	**42**	**14**	**10**	**26**	**8**	**0.18**	**222.88**

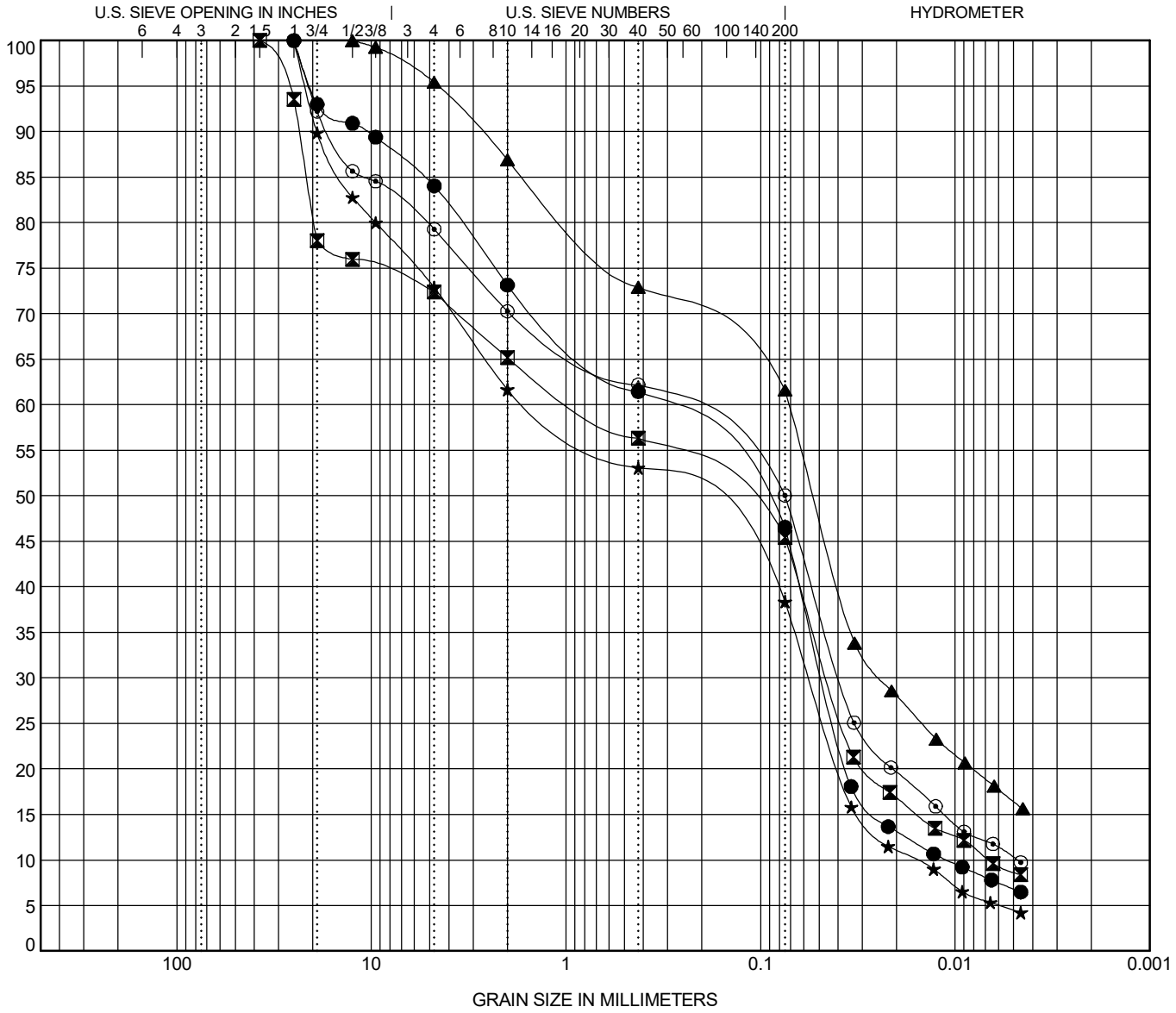
GRAIN SIZE - OH DOT.GDT - 4/3/24 16:08 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\SCI-125-6.26\GINT FILES\SCI-125-6.26.GPJ

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT SCI-125-6.26 **PID**

OGE NUMBER 0 **PROJECT TYPE**



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

Specimen Identification			ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
●	B-001-0-23	14.5	A-4a ~ SILTY SAND with GRAVEL(SM)	NP	NP	NP
⊠	B-002-0-23	1.5	A-4a ~ SILTY GRAVEL with SAND(GM)	NP	NP	NP
▲	B-002-0-23	3.0	A-4a ~ SANDY SILTY CLAY(CL-ML)	25	19	6
★	B-002-0-23	4.5	A-4a ~ SILTY SAND with GRAVEL(SM)	NP	NP	NP
⊙	B-002-0-23	6.0	A-4a ~ SANDY SILT with GRAVEL(ML)	NP	NP	NP

Specimen Identification			D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
●	B-001-0-23	14.5	10.588	0.112	0.048	0.011	26	12	15	40	7	0.57	32.49
⊠	B-002-0-23	1.5	23.472	0.155	0.045	0.007	35	9	11	36	9	0.37	120.38
▲	B-002-0-23	3.0	2.736	0.053	0.024		13	14	11	46	16		
★	B-002-0-23	4.5	19.059	0.296	0.056	0.016	38	9	15	34	4	0.13	92.64
⊙	B-002-0-23	6.0	16.485	0.075	0.039	0.005	30	8	12	40	10	1.02	64.56

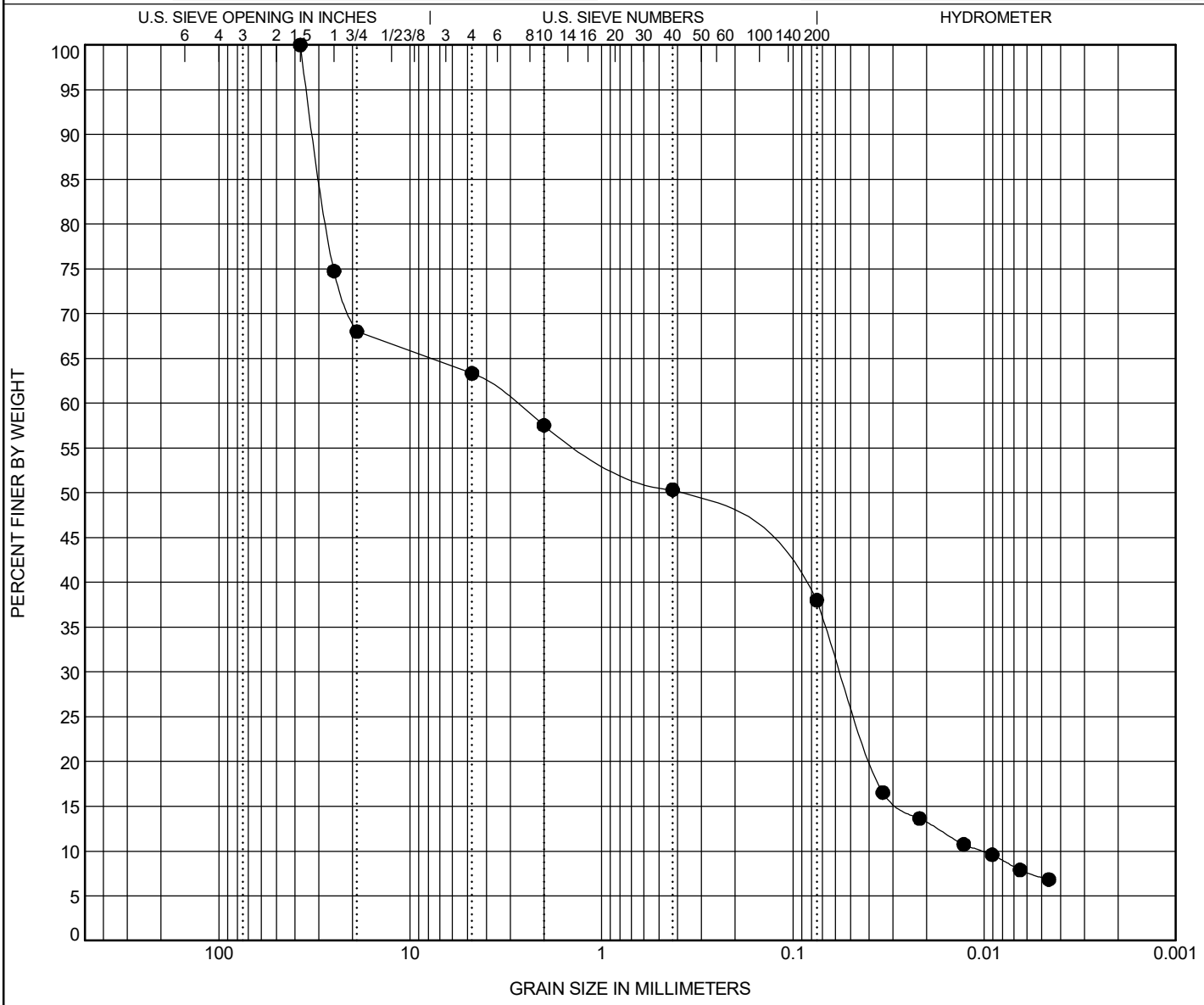
GRAIN SIZE - OH DOT.GDT - 4/3/24 16:08 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\SCI-125-6.26\GINT FILES\SCI-125-6.26.GPJ

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT SCI-125-6.26 **PID**

OGE NUMBER 0 **PROJECT TYPE**



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

Specimen Identification		ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
● **B-002-0-23**	**7.5**	**A-4a ~ SILTY GRAVEL with SAND(GM)**	**NP**	**NP**	**NP**

Specimen Identification		D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
● **B-002-0-23**	**7.5**	**31.934**	**0.405**	**0.056**	**0.01**	**43**	**7**	**12**	**31**	**7**	**0.11**	**281.24**

GRAIN SIZE - OH DOT.GDT - 4/3/24 16:08 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\SCI-125-6.26\GINT FILES\SCI-125-6.26.GPJ

ROCK CORE ID

Job Name: SCI-125-6.26 By: LR Date: 4/17/2024

Boring	Sample	Depth	Description	Cored	Recovery	RQD
B-001-0-23	NQ2-1	16.5-19.0'	Shale interbedded with Sandstone	30"	30"	22.5"
					100%	75%
	NQ2-2	19.0-26.5'		90"	88"	43"
					98%	48%
	NQ2-3	26.5-31.5'		60"	58"	31.75"
					97%	53%
				180"	***176"***	***97.25"***
					98%	***54%***

Erodability Index (K) K=(Ms)(RQD/Jn)(Jr/Ja)(Js)	
	Strength (Ms) = 0.87
	Joint Set # (Jn) = 1.22
	Joint Roughness (Jr) = 1.0
	Joint Alteration (Ja) = 13.0
	Joint Orientation (Js) = 1.02

ROCK CORE ID

Job Name: SCI-125-6.26 By: LR Date: 4/17/2024

Boring	Sample	Depth	Description	Cored	Recovery	RQD
B-002-0-23	NQ2-1	10.3-15.3'	Shale interbedded with Sandstone	60"	33.5"	20"
					56%	33%
	NQ2-2	15.3-18.3'		36"	33"	0"
					92%	0%
	NQ2-3	18.3-25.3'		84"	81"	15"
					96%	18%
				180"	***147.5"***	***35"***
					82%	***19%***

Erodability Index (K) K=(Ms)(RQD/Jn)(Jr/Ja)(Js)	
	Strength (Ms) = 0.87
	Joint Set # (Jn) = 1.50
	Joint Roughness (Jr) = 1.0
	Joint Alteration (Ja) = 8.0
	Joint Orientation (Js) = 1.02

APPENDIX C

ROADWAY SUNGRADE ANALYSIS

OHIO DEPARTMENT OF TRANSPORTATION

OFFICE OF GEOTECHNICAL ENGINEERING

PLAN SUBGRADES
Geotechnical Design Manual Section 600

Instructions: Enter data in the shaded cells only.
(Enter state route number, project description,county, consultant's name, prepared by name, and date prepared. This information will be transferred to all other sheets. The date prepared must be entered in the appropriate cell on this sheet to remove these instructions prior to printing.)

SCI-125-6.26
119955

Replacement of the bridge carrying SR-125 over Turkey Creek

NEAS,Inc.

Prepared By: Derar Tarawneh, Ph.D., P.E.
Date prepared: Thursday, December 12, 2024

Chunmei (Melinda) He, Ph.D., P.E.
2800 Corporate Exchange Drive
Suite 240
Columbus, OH 43231
614.714.0299 Ext 111
che@neasinc.com

NO. OF BORINGS: 2

#	Boring ID	Alignment	Station	Offset	Dir	Drill Rig	ER	Boring EL.	Proposed Subgrade EL	Cut Fill
1	B-001-0-23	SR-125	108+87	18	RT	D50 SN481	87	658.1	657.3	0.8 C
2	B-002-0-23	SR-125	110+69	16	LT	D50 SN481	87	655.4	654.6	0.8 C

OHIO DEPARTMENT OF TRANSPORTATION

Subgrade Analysis

V. 14.7 11/6/2024

#	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	SS-1	1.0	2.5	0.2	1.7	14		4.5	30	17	13	52	31	83	15	14	A-6a	9						
	001-0	SS-2	2.5	4.0	1.7	3.2	10		3.5							16	14	A-6a	10			N_{60}			
	23	SS-3	4.0	5.5	3.2	4.7	6		3							20	14	A-6a	10						
		SS-4	5.5	7.0	4.7	6.2	6	6	2							20	14	A-6a	10						
2	B	SS-1	0.0	1.5	-0.8	0.8	23									3	6	A-1-b	0						
	002-0	SS-2	1.5	3.0	0.8	2.3	16			NP	NP	NP	36	9	45	14	11	A-4a	2			Mc			
	23	SS-3	3.0	4.5	2.3	3.8	6		2	25	19	6	46	16	62	17	14	A-4a	5						
		SS-4	4.5	6.0	3.8	5.3	13	6		NP	NP	NP	34	4	38	10	11	A-4a	1						

OHIO DEPARTMENT OF TRANSPORTATION

Subgrade Analysis

V. 14.7 11/6/2024

PID: 119955

County-Route-Section: SCI-125-6.26
No. of Borings: 2

Geotechnical Consultant: NEAS,Inc.
Prepared By: Derar Tarawneh, Ph.D., P.E.
Date prepared: 12/12/2024

Chemical Stabilization Options		
320	Rubblize & Roll	No
206	Cement Stabilization	Option
	Lime Stabilization	No
206	Depth	14''

Excavate and Replace Stabilization Options	
Global Geotextile Average(N60L):	18''
Average(HP):	0''
Global Geogrid Average(N60L):	12''
Average(HP):	0''

Design CBR	7

% Samples within 3 feet of subgrade			
$N_{60} \leq 5$	0%	HP ≤ 0.5	0%
$N_{60} < 12$	25%	0.5 < HP ≤ 1	0%
$12 \leq N_{60} < 15$	13%	1 < HP ≤ 2	13%
$N_{60} \geq 20$	13%	HP > 2	25%
M+	13%		
Rock	0%		
Unsuitable Soil	0%		

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

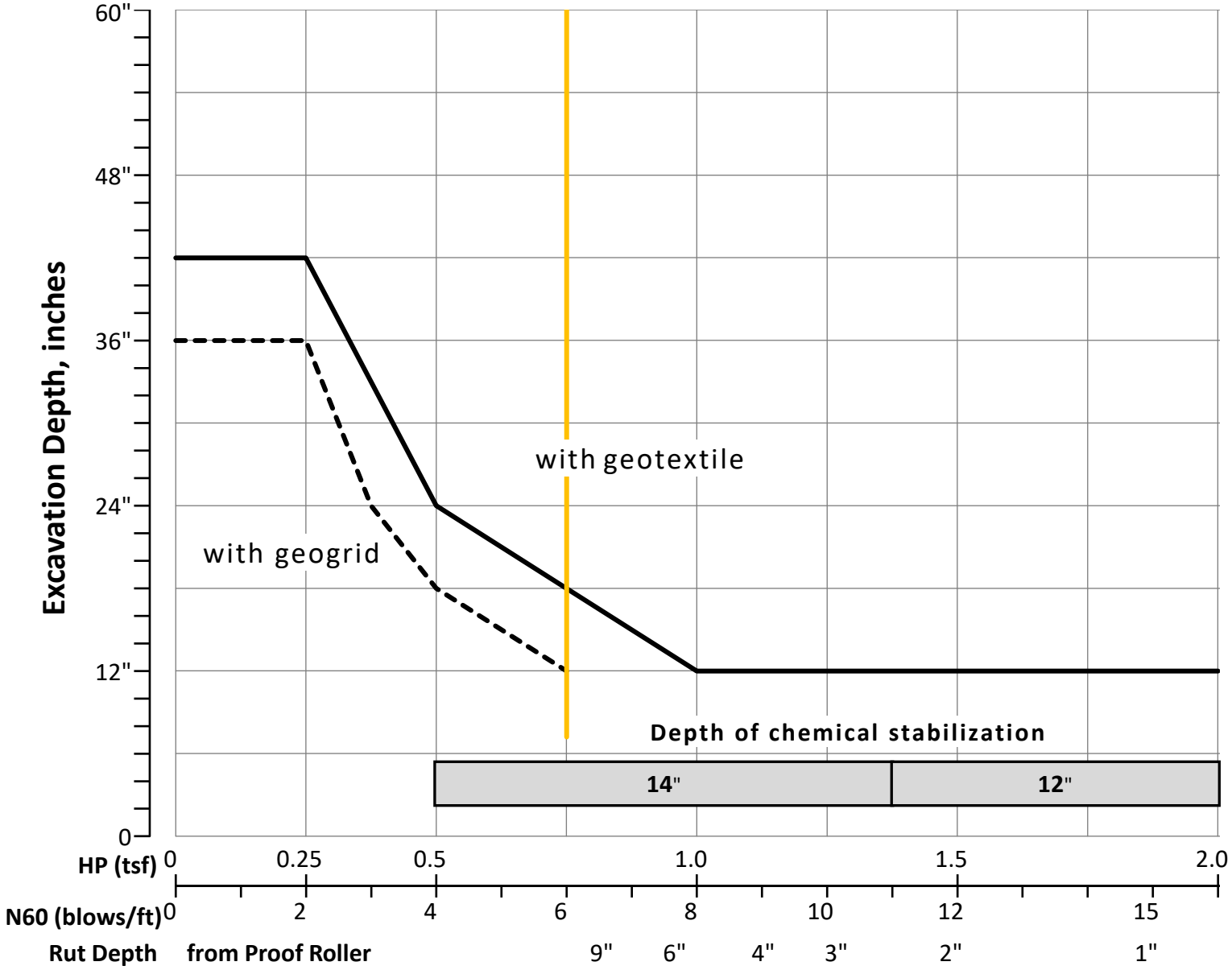
% Proposed Subgrade Surface	
Unstable & Unsuitable	40%
Unstable	40%
Unsuitable (Soil & Rock)	0%

	N_{60}	N_{60L}	HP	LL	PL	PI	Silt	Clay	P 200	M_C	M_{OPT}	GI
Average	12	6	3.00	28	18	10	42	15	57	14	12	6
Maximum	23	6	4.50	30	19	13	52	31	83	20	14	10
Minimum	6	6	2.00	25	17	6	34	4	38	3	6	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	0	0	1	0	0	0	0	0	0	3	0	0	4	0	0	0	0	0	8
Percent	0%	0%	0%	13%	0%	0%	0%	0%	0%	0%	38%	0%	0%	50%	0%	0%	0%	0%	0%	100%
% Rock|Granular|Cohesive	0%	0%	50%									50%								100%
Surface Class Count	0	0	0	1	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	5
Surface Class Percent	0%	0%	0%	20%	0%	0%	0%	0%	0%	0%	40%	0%	0%	40%	0%	0%	0%	0%	0%	100%

Fig. 600-1 – Subgrade Stabilization



OVERRIDE TABLE

Calculated Average	New Values	Check to Override
3.00	0.50	☐ HP
6.00	6.00	☐ N60L

Average HP
Average N_{60L}

APPENDIX D

UPLIFT ANALYSIS

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

                  SHAFT for Windows, Version 2017.8.12

                   Serial Number :  156012233

                VERTICALLY LOADED DRILLED SHAFT ANALYSIS
                 (c) Copyright ENSOFT, Inc., 1987-2017
                       All Rights Reserved

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

     Path to file locations      : P:\24-0002 SCI-125-6.26 LAW-378-4.84 PID
119955\119955\geotechnical\bridges\SCI-125-6.26\Analysis\Uplift in Prebored
Rock\Shaft Files\
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     Name of output file         : SCI-125_Rear Abut_DS=2ft_B-001_Uplift.sf8o
     Name of plot output file    : SCI-125_Rear Abut_DS=2ft_B-001_Uplift.sf8p
     Name of runtime file        : SCI-125_Rear Abut_DS=2ft_B-001_Uplift.sf8r


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

               Date:  January 28, 2025     Time:  14:31:27

     SCI-125_Rear Abut_B001


     PROPOSED DEPTH =       9.2 FT
     ----------------


     REDUCTION FACTOR APPLIED FOR UPLIFT FRICTION = 1.000
     ---------------------------------------------


     NUMBER OF LAYERS =    1
     ------------------


     WATER TABLE DEPTH =       0.0 FT.
     -------------------



     SOIL INFORMATION
```

LAYER NO 1----STRONG ROCK

AT THE TOP

DIAMETER OF SOCKET, FT	= 0.200E+01
SPACING OF DISCONTINUITIES,FT	= 0.000E+00
THICKNESS OF INDIVIDUAL DISCONTINUITIES,FT	= 0.000E+00
UNIAXIAL COMPRESSION STRENGTH OF ROCK,LB/SQ FT	= 0.222E+07
UNIAXIAL COMPRESSION STRENGTH OF CONCRETE,LB/SQ FT	= 0.576E+06
ELASTIC MODULUS FOR THE INTACT ROCK, LB/SQ IN.	= 0.257E+07
ROCK QUALITY DESIGNATION (RQD) %	= 0.540E+02
DEPTH, FT	= 0.000E+00

AT THE BOTTOM

DIAMETER OF SOCKET, FT	= 0.200E+01
SPACING OF DISCONTINUITIES,FT	= 0.000E+00
THICKNESS OF INDIVIDUAL DISCONTINUITIES,FT	= 0.000E+00
UNIAXIAL COMPRESSION STRENGTH OF ROCK,LB/SQ FT	= 0.222E+07
UNIAXIAL COMPRESSION STRENGTH OF CONCRETE,LB/SQ FT	= 0.576E+06
ELASTIC MODULUS FOR THE INTACT ROCK, LB/SQ IN.	= 0.257E+07
ROCK QUALITY DESIGNATION (RQD) %	= 0.540E+02
DEPTH, FT	= 0.150E+02

LRFD RESISTANCE FACTOR (SIDE FRICTION)	= 0.400E+00
LRFD RESISTANCE FACTOR (TIP RESISTANCE)	= 0.500E+00

INPUT DRILLED SHAFT INFORMATION

MINIMUM SHAFT DIAMETER	= 2.000	FT.
MAXIMUM SHAFT DIAMETER	= 2.000	FT.
RATIO BASE/SHAFT DIAMETER	= 0.000	FT.
ANGLE OF BELL	= 0.000	DEG.
IGNORED TOP PORTION	= 5.000	FT.
IGNORED BOTTOM PORTION	= 0.000	FT.
ELASTIC MODULUS, Ec	= 0.290E+08	LB/SQ IN

COMPUTATION RESULTS

- CASE ANALYZED : 1
  VARIATION LENGTH : 1
  VARIATION DIAMETER : 1

DRILLED SHAFT INFORMATION

DIAMETER OF STEM	= 2.000	FT.
DIAMETER OF BASE	= 2.000	FT.
END OF STEM TO BASE	= 0.000	FT.
ANGLE OF BELL	= 0.000	DEG.
IGNORED TOP PORTION	= 5.000	FT.
IGNORED BOTTOM PORTION	= 0.000	FT.
AREA OF ONE PERCENT STEEL	= 4.524	SQ.IN.
ELASTIC MODULUS, Ec	= 0.290E+08	LB/SQ IN
VOLUME OF UNDERREAM	= 0.000	CU.YDS.
SHAFT LENGTH	= 9.160	FT.

PREDICTED RESULTS

QS = ULTIMATE SIDE RESISTANCE;
QB = ULTIMATE BASE RESISTANCE;
WT = WEIGHT OF DRILLED SHAFT (UPLIFT CAPACITY ONLY);
QU = TOTAL ULTIMATE RESISTANCE;
LRFD QS = TOTAL SIDE FRICTION USING LRFD RESISTANCE FACTOR
TO THE ULTIMATE SIDE RESISTANCE;
LRFD QB = TOTAL BASE BEARING USING LRFD RESISTANCE FACTOR
TO THE ULTIMATE BASE RESISTANCE
LRFD QU = TOTAL CAPACITY WITH LRFD RESISTANCE FACTOR.

LENGTH (FT)	VOLUME (CU.YDS)	QS (TONS)	WT (TONS)	QU (TONS)	LRFD QS (TONS)	WT (TONS)	LRFD QU (TONS)
6.0	0.70	71.54	0.83	72.36	28.62	0.83	29.44
7.0	0.81	143.08	0.96	144.04	57.23	0.96	58.19
8.0	0.93	214.61	1.10	215.72	85.85	1.10	86.95
9.0	1.05	286.15	1.24	287.39	114.46	1.24	115.70
10.0	1.16	357.69	1.38	359.07	143.08	1.38	144.45

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

                  SHAFT for Windows, Version 2017.8.12

                   Serial Number :  156012233

                VERTICALLY LOADED DRILLED SHAFT ANALYSIS
                 (c) Copyright ENSOFT, Inc., 1987-2017
                       All Rights Reserved

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

     Path to file locations      : P:\24-0002 SCI-125-6.26 LAW-378-4.84 PID
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Rock\Shaft Files\
     Name of input data file     : SCI-125_Forw Abut_DS=2ft_B-002_Uplift.sf8d
     Name of output file         : SCI-125_Forw Abut_DS=2ft_B-002_Uplift.sf8o
     Name of plot output file    : SCI-125_Forw Abut_DS=2ft_B-002_Uplift.sf8p
     Name of runtime file        : SCI-125_Forw Abut_DS=2ft_B-002_Uplift.sf8r


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

               Date:  January 28, 2025     Time:  14:12:44

     SCI-125_Forw Abut_B002


     PROPOSED DEPTH =      11.2 FT
     ----------------


     REDUCTION FACTOR APPLIED FOR UPLIFT FRICTION = 1.000
     ------------------------------------------------


     NUMBER OF LAYERS =    1
     ------------------


     WATER TABLE DEPTH =       0.0 FT.
     -------------------



     SOIL INFORMATION
```

LAYER NO 1----STRONG ROCK

AT THE TOP

DIAMETER OF SOCKET, FT	= 0.200E+01
SPACING OF DISCONTINUITIES,FT	= 0.000E+00
THICKNESS OF INDIVIDUAL DISCONTINUITIES,FT	= 0.000E+00
UNIAXIAL COMPRESSION STRENGTH OF ROCK,LB/SQ FT	= 0.142E+07
UNIAXIAL COMPRESSION STRENGTH OF CONCRETE,LB/SQ FT	= 0.576E+06
ELASTIC MODULUS FOR THE INTACT ROCK, LB/SQ IN.	= 0.257E+07
ROCK QUALITY DESIGNATION (RQD) %	= 0.630E+02
DEPTH, FT	= 0.000E+00

AT THE BOTTOM

DIAMETER OF SOCKET, FT	= 0.200E+01
SPACING OF DISCONTINUITIES,FT	= 0.000E+00
THICKNESS OF INDIVIDUAL DISCONTINUITIES,FT	= 0.000E+00
UNIAXIAL COMPRESSION STRENGTH OF ROCK,LB/SQ FT	= 0.142E+07
UNIAXIAL COMPRESSION STRENGTH OF CONCRETE,LB/SQ FT	= 0.576E+06
ELASTIC MODULUS FOR THE INTACT ROCK, LB/SQ IN.	= 0.257E+07
ROCK QUALITY DESIGNATION (RQD) %	= 0.630E+02
DEPTH, FT	= 0.160E+02

LRFD RESISTANCE FACTOR (SIDE FRICTION)	= 0.400E+00
LRFD RESISTANCE FACTOR (TIP RESISTANCE)	= 0.500E+00

INPUT DRILLED SHAFT INFORMATION

MINIMUM SHAFT DIAMETER	= 2.000	FT.
MAXIMUM SHAFT DIAMETER	= 2.000	FT.
RATIO BASE/SHAFT DIAMETER	= 0.000	FT.
ANGLE OF BELL	= 0.000	DEG.
IGNORED TOP PORTION	= 6.190	FT.
IGNORED BOTTOM PORTION	= 0.000	FT.
ELASTIC MODULUS, Ec	= 0.290E+08	LB/SQ IN

COMPUTATION RESULTS

- CASE ANALYZED : 1
  VARIATION LENGTH : 1
  VARIATION DIAMETER : 1

DRILLED SHAFT INFORMATION

DIAMETER OF STEM	= 2.000	FT.
DIAMETER OF BASE	= 2.000	FT.
END OF STEM TO BASE	= 0.000	FT.
ANGLE OF BELL	= 0.000	DEG.
IGNORED TOP PORTION	= 6.190	FT.
IGNORED BOTTOM PORTION	= 0.000	FT.
AREA OF ONE PERCENT STEEL	= 4.524	SQ.IN.
ELASTIC MODULUS, Ec	= 0.290E+08	LB/SQ IN
VOLUME OF UNDERREAM	= 0.000	CU.YDS.
SHAFT LENGTH	= 11.190	FT.

PREDICTED RESULTS

QS = ULTIMATE SIDE RESISTANCE;
QB = ULTIMATE BASE RESISTANCE;
WT = WEIGHT OF DRILLED SHAFT (UPLIFT CAPACITY ONLY);
QU = TOTAL ULTIMATE RESISTANCE;
LRFD QS = TOTAL SIDE FRICTION USING LRFD RESISTANCE FACTOR
TO THE ULTIMATE SIDE RESISTANCE;
LRFD QB = TOTAL BASE BEARING USING LRFD RESISTANCE FACTOR
TO THE ULTIMATE BASE RESISTANCE
LRFD QU = TOTAL CAPACITY WITH LRFD RESISTANCE FACTOR.

LENGTH (FT)	VOLUME (CU.YDS)	QS (TONS)	WT (TONS)	QU (TONS)	LRFD QS (TONS)	WT (TONS)	LRFD QU (TONS)
7.0	0.81	71.54	0.96	72.50	28.62	0.96	29.58
8.0	0.93	143.08	1.10	144.18	57.23	1.10	58.33
9.0	1.05	214.61	1.24	215.85	85.85	1.24	87.08
10.0	1.16	286.15	1.38	287.53	114.46	1.38	115.84
11.0	1.28	357.69	1.51	359.21	143.08	1.51	144.59

APPENDIX E

LPILE ANALYSIS

==========

LPile for Windows, Version 2016-09.003

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method
© 1985-2015 by Ensoft, Inc.
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==========

This copy of LPile is being used by:

NEAS
Columbus

Serial Number of Security Device: 136151274

This copy of LPile is licensed for exclusive use by:

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Use of this program by any entity other than Barr Engineering, Inc., Cincinna
is a violation of the software license agreement.

Files Used for Analysis

Path to file locations:
\24-0002 SCI-125-6.26 LAW-378-4.84 PID
119955\119955\geotechnical\bridges\SCI-125-6.26\Analysis\Lpile\Files\14x73 new
01242025\

Name of input data file:
SCI-125-6.26_Rear Abutment_Service_B-001_HP14X73.lp9d

Name of output report file:
SCI-125-6.26_Rear Abutment_Service_B-001_HP14X73.lp9o

Name of plot output file:
SCI-125-6.26_Rear Abutment_Service_B-001_HP14X73.lp9p

Name of runtime message file:
SCI-125-6.26_Rear Abutment_Service_B-001_HP14X73.lp9r

Date and Time of Analysis

Date: January 28, 2025 Time: 13:19:33

Problem Title

Project Name: SCI-125-6.26

Job Number:

Client: American Structurepoint / ODOT

Engineer: ZM

Description: Rear Abutment - B-001-0-23

Program Options and Settings

Computational Options:
- Use unfactored loads in computations (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:
- Static loading specified

- Use of p-y modification factors for p-y curves not selected
- 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
- 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 = 9.160 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	14.6000
2	9.160	14.6000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile
Cross-sectional Shape = Strong H-Pile
Length of section = 9.160000 ft
Flange Width = 14.600000 in

Section Depth	=	13.600000	in
Flange Thickness	=	0.505000	in
Web Thickness	=	0.505000	in
Section Area	=	21.400000	sq. in
Moment of Inertia	=	729.000000	in^4
Elastic Modulus	=	29000000.	psi

Ground Slope and Pile Batter Angles

Ground Slope Angle	=	0.000	degrees
	=	0.000	radians
Pile Batter Angle	=	0.000	degrees
	=	0.000	radians

Soil and Rock Layering Information

The soil profile is modelled using 1 layers

Layer 1 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	0.0000	ft
Distance from top of pile to bottom of layer	=	14.160000	ft
Effective unit weight at top of layer	=	103.700000	pcf
Effective unit weight at bottom of layer	=	103.700000	pcf
Uniaxial compressive strength at top of layer	=	15386.	psi
Uniaxial compressive strength at bottom of layer	=	15386.	psi
Initial modulus of rock at top of layer	=	1400000.	psi
Initial modulus of rock at bottom of layer	=	1400000.	psi
RQD of rock at top of layer	=	54.000000	%
RQD of rock at bottom of layer	=	54.000000	%
k rm of rock at top of layer	=	0.0000500	
k rm of rock at bottom of layer	=	0.0000500	

(Depth of the lowest soil layer extends 5.000 ft below the pile tip)

Summary of Input Soil Properties

Layer or Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Uniaxial qu psi	RQD %	E50 Rock Mass Modulus krm psi
1	Weak	0.00	103.7000	15386.	54.0000	5.00E-05 1400000.
	Rock	14.1600	103.7000	15386.	54.0000	5.00E-05 1400000.

Static Loading Type

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

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	Compute Top y vs. Pile Length
1	1	V = 24000. lbs	M = 756000. in-lbs	185000.	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

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

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Moment-curvature properties were derived from elastic section properties

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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 = 24000.0 lbs
Applied moment at pile head = 756000.0 in-lbs
Axial thrust load on pile head = 185000.0 lbs

Depth X	Deflect. y	Bending Moment	Shear Force	Slope S	Total Stress	Bending Stiffness	Soil Res. Es*h	Soil Spr. Lat. Load	Distrib. p
feet	inches	in-lbs	lbs	radians	psi*	in-lb^2	lb/inch	lb/inch	lb/inch
0.00	4.76E-04	756000.	24000.	-1.82E-04	16215.	2.11E+10	-64594.	7.46E+07	0.00
0.09160	2.97E-04	743391.	-36660.	-1.43E-04	16089.	2.11E+10	-45777.	1.69E+08	0.00
0.1832	1.61E-04	675465.	-76677.	-1.06E-04	15409.	2.11E+10	-27034.	1.85E+08	0.00
0.2748	6.31E-05	574868.	-97850.	-7.40E-05	14401.	2.11E+10	-11491.	2.00E+08	0.00
0.3664	-1.80E-06	460381.	-103971.	-4.71E-05	13255.	2.11E+10	353.0100	2.16E+08	0.00
0.4580	-4.04E-05	346316.	-99113.	-2.61E-05	12113.	2.11E+10	8488.	2.31E+08	0.00
0.5496	-5.91E-05	242502.	-87156.	-1.08E-05	11073.	2.11E+10	13267.	2.47E+08	0.00
0.6412	-6.41E-05	154716.	-71473.	-4.50E-07	10194.	2.11E+10	15270.	2.62E+08	0.00
0.7328	-6.01E-05	85377.	-54738.	5.79E-06	9500.	2.11E+10			

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15179.   2.77E+08       0.00
    0.8244  -5.13E-05     34377.    -38879.   8.91E-06      8989.   2.11E+10
13677.   2.93E+08       0.00
    0.9160  -4.06E-05   -98.5823    -25110.   9.80E-06      8646.   2.11E+10
11377.   3.08E+08       0.00
    1.0076  -2.98E-05    -20828.    -14034.   9.25E-06      8853.   2.11E+10
8775.   3.24E+08       0.00
    1.0992  -2.02E-05    -30955.     -5782.   7.91E-06      8955.   2.11E+10
6239.   3.39E+08       0.00
    1.1908  -1.24E-05    -33544.  -153.1423   6.23E-06      8981.   2.11E+10
4004.   3.55E+08       0.00
    1.2824  -6.52E-06    -31294.      3254.   4.54E-06      8958.   2.11E+10
2195.   3.70E+08       0.00
    1.3740  -2.42E-06    -26392.      4927.   3.04E-06      8909.   2.11E+10
848.5199   3.86E+08       0.00
    1.4656   1.73E-07    -20464.      5358.   1.83E-06      8850.   2.11E+10
-63.1189   4.01E+08       0.00
    1.5572   1.60E-06    -14613.      4992.   9.14E-07      8791.   2.11E+10
-604.4377   4.17E+08       0.00
    1.6488   2.18E-06     -9491.      4188.   2.87E-07      8740.   2.11E+10
-857.5445   4.32E+08       0.00
    1.7404   2.23E-06     -5406.      3219.  -1.00E-07      8699.   2.11E+10
-906.3620   4.47E+08       0.00
    1.8320   1.96E-06     -2416.      2266.  -3.03E-07      8669.   2.11E+10
-826.3353   4.63E+08       0.00
    1.9236   1.56E-06  -423.7550      1439.  -3.77E-07      8649.   2.11E+10
-678.8029   4.78E+08       0.00
    2.0152   1.13E-06   748.0645   786.2033  -3.69E-07      8652.   2.11E+10
-509.0805   4.94E+08       0.00
    2.1068   7.49E-07      1305.   315.6076  -3.15E-07      8658.   2.11E+10
-347.1707   5.09E+08       0.00
    2.1984   4.40E-07      1442.     9.3526  -2.44E-07      8659.   2.11E+10
-210.0619   5.25E+08       0.00
    2.2900   2.13E-07      1325.  -163.6691  -1.72E-07      8658.   2.11E+10
-104.7521   5.40E+08       0.00
    2.3816   6.20E-08      1082.  -238.4700  -1.09E-07      8656.   2.11E+10
-31.3485   5.56E+08       0.00
    2.4732  -2.73E-08   801.2363  -247.9091  -6.04E-08      8653.   2.11E+10
14.1739   5.71E+08       0.00
    2.5648  -7.08E-08   537.3054  -219.3571  -2.56E-08      8650.   2.11E+10
37.7766   5.86E+08       0.00
    2.6564  -8.36E-08   319.0121  -173.4299  -3.36E-09      8648.   2.11E+10
45.7882   6.02E+08       0.00
    2.7480  -7.82E-08   156.0384  -124.1259   8.99E-09      8646.   2.11E+10
43.9207   6.17E+08       0.00
    2.8396  -6.39E-08    46.1299   -79.7799   1.42E-08      8645.   2.11E+10
36.7672   6.33E+08       0.00
    2.9312  -4.69E-08   -19.3554   -44.3728   1.49E-08      8645.   2.11E+10
27.6561   6.48E+08       0.00
    3.0228  -3.10E-08   -51.4254   -18.8759   1.31E-08      8645.   2.11E+10
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18.7358   6.64E+08       0.00
    3.1144  -1.81E-08   -60.8574    -2.4312   1.02E-08      8645.   2.11E+10
11.1854   6.79E+08       0.00
    3.2060  -8.66E-09   -56.7743     6.7222   7.12E-09      8645.   2.11E+10
5.4693   6.95E+08       0.00
    3.2976  -2.45E-09   -46.0822    10.5985   4.45E-09      8645.   2.11E+10
1.5836   7.10E+08       0.00
    3.3892   1.12E-09   -33.4764    11.0631   2.38E-09      8645.   2.11E+10
-0.7383   7.25E+08       0.00
    3.4808   2.78E-09   -21.7622     9.6290   9.42E-10      8645.   2.11E+10
-1.8710   7.41E+08       0.00
    3.5724   3.19E-09   -12.3084     7.3946   5.61E-11      8645.   2.11E+10
-2.1944   7.56E+08       0.00
    3.6640   2.90E-09    -5.5058     5.0733  -4.07E-10      8645.   2.11E+10
-2.0293   7.69E+08       0.00
    3.7556   2.29E-09    -1.1552     3.0753  -5.80E-10      8645.   2.11E+10
-1.6060   7.69E+08       0.00
    3.8472   1.62E-09     1.2551     1.5680  -5.78E-10      8645.   2.11E+10
-1.1365   7.69E+08       0.00
    3.9388   1.02E-09     2.2921     0.5492  -4.85E-10      8645.   2.11E+10
-0.7172   7.69E+08       0.00
    4.0304   5.56E-10     2.4626   -0.05903  -3.62E-10      8645.   2.11E+10
-0.3895   7.69E+08       0.00
    4.1220   2.29E-10     2.1625    -0.3613  -2.42E-10      8645.   2.11E+10
-0.1604   7.69E+08       0.00
    4.2136   2.55E-11     1.6685    -0.4593  -1.42E-10      8645.   2.11E+10
-0.01783   7.69E+08       0.00
    4.3052  -8.29E-11     1.1529    -0.4372  -6.86E-11      8645.   2.11E+10
0.05801   7.69E+08       0.00
    4.3968  -1.25E-10     0.7074    -0.3571  -2.02E-11      8645.   2.11E+10
0.08773   7.69E+08       0.00
    4.4884  -1.27E-10     0.3679    -0.2599   7.72E-12      8645.   2.11E+10
0.08915   7.69E+08       0.00
    4.5800  -1.08E-10     0.1361    -0.1692   2.08E-11      8645.   2.11E+10
0.07585   7.69E+08       0.00
    4.6716  -8.16E-11   -0.00400   -0.09611   2.43E-11      8645.   2.11E+10
0.05710   7.69E+08       0.00
    4.7632  -5.50E-11   -0.07516   -0.04356   2.22E-11      8645.   2.11E+10
0.03851   7.69E+08       0.00
    4.8548  -3.28E-11   -0.09978   -0.00979   1.77E-11      8645.   2.11E+10
0.02293   7.69E+08       0.00
    4.9464  -1.62E-11   -0.09669    0.00905   1.25E-11      8645.   2.11E+10
0.01134   7.69E+08       0.00
    5.0380  -5.18E-12   -0.07989    0.01727   7.96E-12      8645.   2.11E+10
0.00362   7.69E+08       0.00
    5.1296   1.29E-12   -0.05872    0.01877   4.35E-12      8645.   2.11E+10
-9.02E-04   7.69E+08       0.00
    5.2212   4.40E-12   -0.03863    0.01658   1.82E-12      8645.   2.11E+10
-0.00308   7.69E+08       0.00
    5.3128   5.30E-12   -0.02227    0.01285       0.00      8645.   2.11E+10
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-0.00371   7.69E+08       0.00
    5.4044   4.92E-12   -0.01038    0.00892       0.00      8645.   2.11E+10
-0.00345   7.69E+08       0.00
    5.4960   3.96E-12   -0.00266    0.00550       0.00      8645.   2.11E+10
-0.00277   7.69E+08       0.00
    5.5876   2.84E-12    0.00172    0.00289       0.00      8645.   2.11E+10
-0.00199   7.69E+08       0.00
    5.6792   1.82E-12    0.00369    0.00109       0.00      8645.   2.11E+10
-0.00128   7.69E+08       0.00
    5.7708   1.01E-12    0.00411   6.58E-07       0.00      8645.   2.11E+10
-7.09E-04   7.69E+08       0.00
    5.8624       0.00    0.00369  -5.58E-04       0.00      8645.   2.11E+10
-3.08E-04   7.69E+08       0.00
    5.9540       0.00    0.00289  -7.56E-04       0.00      8645.   2.11E+10
-5.34E-05   7.69E+08       0.00
    6.0456       0.00    0.00202  -7.39E-04       0.00      8645.   2.11E+10
8.51E-05   7.69E+08       0.00
    6.1372       0.00    0.00126  -6.14E-04       0.00      8645.   2.11E+10
1.43E-04   7.69E+08       0.00
    6.2288       0.00   6.75E-04  -4.53E-04       0.00      8645.   2.11E+10
1.50E-04   7.69E+08       0.00
    6.3204       0.00   2.67E-04  -3.00E-04       0.00      8645.   2.11E+10
1.30E-04   7.69E+08       0.00
    6.4120       0.00   1.63E-05  -1.74E-04       0.00      8645.   2.11E+10
9.91E-05   7.69E+08       0.00
    6.5036       0.00  -1.15E-04  -8.19E-05       0.00      8645.   2.11E+10
6.78E-05   7.69E+08       0.00
    6.5952       0.00  -1.64E-04  -2.20E-05       0.00      8645.   2.11E+10
4.11E-05   7.69E+08       0.00
    6.6868       0.00  -1.63E-04   1.21E-05       0.00      8645.   2.11E+10
2.10E-05   7.69E+08       0.00
    6.7784       0.00  -1.37E-04   2.77E-05       0.00      8645.   2.11E+10
7.36E-06   7.69E+08       0.00
    6.8700       0.00  -1.02E-04   3.13E-05       0.00      8645.   2.11E+10
-7.74E-07   7.69E+08       0.00
    6.9616       0.00  -6.83E-05   2.83E-05       0.00      8645.   2.11E+10
-4.82E-06   7.69E+08       0.00
    7.0532       0.00  -4.01E-05   2.22E-05       0.00      8645.   2.11E+10
-6.13E-06   7.69E+08       0.00
    7.1448       0.00  -1.94E-05   1.57E-05       0.00      8645.   2.11E+10
-5.84E-06   7.69E+08       0.00
    7.2364       0.00  -5.74E-06   9.82E-06       0.00      8645.   2.11E+10
-4.77E-06   7.69E+08       0.00
    7.3280       0.00   2.17E-06   5.28E-06       0.00      8645.   2.11E+10
-3.47E-06   7.69E+08       0.00
    7.4196       0.00   5.88E-06   2.13E-06       0.00      8645.   2.11E+10
-2.26E-06   7.69E+08       0.00
    7.5112       0.00   6.85E-06   1.80E-07       0.00      8645.   2.11E+10
-1.29E-06   7.69E+08       0.00
    7.6028       0.00   6.27E-06  -8.47E-07       0.00      8645.   2.11E+10
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-5.83E-07   7.69E+08       0.00
    7.6944       0.00   4.99E-06  -1.24E-06       0.00      8645.   2.11E+10
-1.32E-07   7.69E+08       0.00
    7.7860       0.00   3.55E-06  -1.25E-06       0.00      8645.   2.11E+10
1.20E-07   7.69E+08       0.00
    7.8776       0.00   2.25E-06  -1.05E-06       0.00      8645.   2.11E+10
2.31E-07   7.69E+08       0.00
    7.9692       0.00   1.23E-06  -7.89E-07       0.00      8645.   2.11E+10
2.51E-07   7.69E+08       0.00
    8.0608       0.00   5.16E-07  -5.29E-07       0.00      8645.   2.11E+10
2.22E-07   7.69E+08       0.00
    8.1524       0.00   6.88E-08  -3.13E-07       0.00      8645.   2.11E+10
1.72E-07   7.69E+08       0.00
    8.2440       0.00  -1.71E-07  -1.53E-07       0.00      8645.   2.11E+10
1.19E-07   7.69E+08       0.00
    8.3356       0.00  -2.67E-07  -4.67E-08       0.00      8645.   2.11E+10
7.36E-08   7.69E+08       0.00
    8.4272       0.00  -2.74E-07   1.50E-08       0.00      8645.   2.11E+10
3.86E-08   7.69E+08       0.00
    8.5188       0.00  -2.34E-07   4.42E-08       0.00      8645.   2.11E+10
1.46E-08   7.69E+08       0.00
    8.6104       0.00  -1.77E-07   5.21E-08       0.00      8645.   2.11E+10
-1.31E-10   7.69E+08       0.00
    8.7020       0.00  -1.20E-07   4.78E-08       0.00      8645.   2.11E+10
-7.75E-09   7.69E+08       0.00
    8.7936       0.00  -7.17E-08   3.77E-08       0.00      8645.   2.11E+10
-1.06E-08   7.69E+08       0.00
    8.8852       0.00  -3.66E-08   2.61E-08       0.00      8645.   2.11E+10
-1.06E-08   7.69E+08       0.00
    8.9768       0.00  -1.43E-08   1.53E-08       0.00      8645.   2.11E+10
-9.06E-09   7.69E+08       0.00
    9.0684       0.00  -2.91E-09   6.49E-09       0.00      8645.   2.11E+10
-7.00E-09   7.69E+08       0.00
    9.1600       0.00       0.00       0.00       0.00      8645.   2.11E+10
-4.82E-09   3.85E+08       0.00

* The above values of total stress are combined axial and bending stresses.


Output Summary for Load Case No. 1:

Pile-head deflection             =     0.00047597 inches
Computed slope at pile head      =    -0.00018234 radians
Maximum bending moment           =        756000. inch-lbs
Maximum shear force              =       -103971. lbs
Depth of maximum bending moment  =       0.000000 feet below pile head
Depth of maximum shear force     =     0.36640000 feet below pile head
Number of iterations             =              6
Number of zero deflection points =             10
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Pile-head Deflection vs. Pile Length for Load Case 1

Boundary Condition Type 1, Shear and Moment

Shear = 24000. lbs
Moment = 756000. in-lbs
Axial Load = 185000. lbs

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
9.16000	0.00047597	756000.	-103971.
8.70200	0.00047677	756000.	-103976.
8.24400	0.00047750	756000.	-103499.
7.78600	0.00047817	756000.	-104246.
7.32800	0.00047878	756000.	-104783.
6.87000	0.00047934	756000.	-104622.
6.41200	0.00047983	756000.	-104885.
5.95400	0.00048028	756646.	-105226.
5.49600	0.00048066	757767.	-105171.
5.03800	0.00048100	758693.	-105432.
4.58000	0.00048128	759425.	-105656.
4.12200	0.00048152	759962.	-105740.
3.66400	0.00048170	760304.	-105855.
3.20600	0.00048184	760451.	-105835.
2.74800	0.00048193	760402.	-105968.
2.29000	0.00048197	760158.	-106063.
1.83200	0.00048206	760380.	-106142.
1.37400	0.00048258	760414.	-105823.
0.91600	0.00049654	760377.	-111962.
0.91600	0.000000	905005069.	-4116653332.

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 Pile-head	Load Type	Load Pile-head	Axial Loading	Pile-head Deflection	Pile-head Rotation	Max Shear in Pile	Max Moment in Pile
No.	1	Load 1	2	Load 2	lbs	inches	radians	lbs	in-lbs
1	V, lb	24000.	M, in-lb	756000.	185000.	4.76E-04	-1.82E-04	-103971.	756000.

Maximum pile-head deflection = 0.0004759737 inches
Maximum pile-head rotation = -0.0001823385 radians = -0.010447 deg.

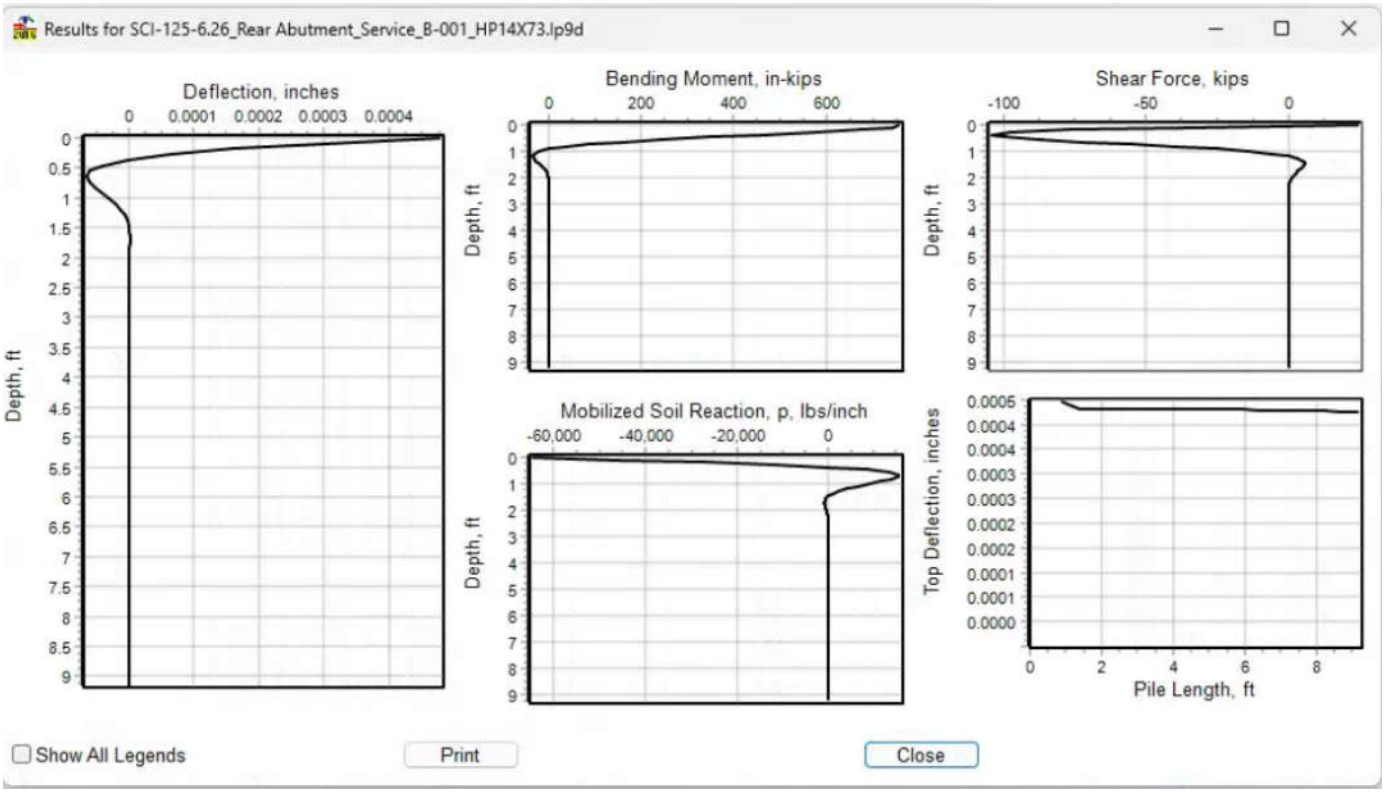
Summary of Warning Messages

The following warning was reported 10000 times

**** Warning ****

An unreasonable input value for unconfined compressive strength has been specified for a soil defined using the weak rock criteria. The input value is greater than 1000 psi. Please check your input data for correctness.

The analysis ended normally.



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LPile for Windows, Version 2016-09.003

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

Path to file locations:
\24-0002 SCI-125-6.26 LAW-378-4.84 PID
119955\119955\geotechnical\bridges\SCI-125-6.26\Analysis\Lpile\Files\14x73 new
01242025\

Name of input data file:
SCI-125-6.26_Rear Abutment_Strength_B-001_HP 14X73.lp9d

Name of output report file:
SCI-125-6.26_Rear Abutment_Strength_B-001_HP 14X73.lp9o

Name of plot output file:
SCI-125-6.26_Rear Abutment_Strength_B-001_HP 14X73.lp9p

Name of runtime message file:
SCI-125-6.26_Rear Abutment_Strength_B-001_HP 14X73.lp9r

Date and Time of Analysis

Date: January 28, 2025 Time: 13:26:28

Problem Title

Project Name: SCI-125-6.26

Job Number:

Client: American Structurepoint / ODOT

Engineer: ZM

Description: Rear Abutment - B-001-0-23

Program Options and Settings

Computational Options:
- Use unfactored loads in computations (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:
- Static loading specified

- Use of p-y modification factors for p-y curves not selected
- 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
- 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 = 9.160 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	14.6000
2	9.160	14.6000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile
Cross-sectional Shape = Strong H-Pile
Length of section = 9.160000 ft
Flange Width = 14.600000 in

Section Depth	=	13.600000	in
Flange Thickness	=	0.505000	in
Web Thickness	=	0.505000	in
Section Area	=	21.400000	sq. in
Moment of Inertia	=	729.000000	in^4
Elastic Modulus	=	29000000.	psi

Ground Slope and Pile Batter Angles

Ground Slope Angle	=	0.000	degrees
	=	0.000	radians
Pile Batter Angle	=	0.000	degrees
	=	0.000	radians

Soil and Rock Layering Information

The soil profile is modelled using 1 layers

Layer 1 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	0.0000	ft
Distance from top of pile to bottom of layer	=	14.160000	ft
Effective unit weight at top of layer	=	103.700000	pcf
Effective unit weight at bottom of layer	=	103.700000	pcf
Uniaxial compressive strength at top of layer	=	15386.	psi
Uniaxial compressive strength at bottom of layer	=	15386.	psi
Initial modulus of rock at top of layer	=	1400000.	psi
Initial modulus of rock at bottom of layer	=	1400000.	psi
RQD of rock at top of layer	=	54.000000	%
RQD of rock at bottom of layer	=	54.000000	%
k rm of rock at top of layer	=	0.0000500	
k rm of rock at bottom of layer	=	0.0000500	

(Depth of the lowest soil layer extends 5.000 ft below the pile tip)

Summary of Input Soil Properties

Layer or Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Uniaxial qu psi	RQD %	E50 Rock Mass Modulus krm psi
1	Weak	0.00	103.7000	15386.	54.0000	5.00E-05 1400000.
	Rock	14.1600	103.7000	15386.	54.0000	5.00E-05 1400000.

Static Loading Type

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

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	Compute Top y vs. Pile Length
1	1	V = 35000. lbs	M = 1116000. in-lbs	256000.	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

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

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Moment-curvature properties were derived from elastic section properties

---

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 = 35000.0 lbs
Applied moment at pile head = 1116000.0 in-lbs
Axial thrust load on pile head = 256000.0 lbs

Depth X	Deflect. y	Bending Moment	Shear Force	Slope S	Total Stress	Bending Stiffness	Soil Res. Es*h	Soil Spr. Lat. Load	Distrib. p
feet	inches	in-lbs	lbs	radians	psi*	in-lb^2	lb/inch	lb/inch	lb/inch
0.00	7.46E-04	1116000.	35000.	-2.78E-04	23138.	2.11E+10	-72300.	5.32E+07	0.00
0.09160	4.73E-04	1110864.	-43918.	-2.20E-04	23086.	2.11E+10	-71292.	1.66E+08	0.00
0.1832	2.62E-04	1019574.	-107317.	-1.65E-04	22172.	2.11E+10	-44062.	1.85E+08	0.00
0.2748	1.10E-04	875032.	-142541.	-1.16E-04	20725.	2.11E+10	-20030.	2.00E+08	0.00
0.3664	7.82E-06	706277.	-154393.	-7.46E-05	19035.	2.11E+10	-1535.	2.16E+08	0.00
0.4580	-5.40E-05	535657.	-149002.	-4.23E-05	17327.	2.11E+10	11344.	2.31E+08	0.00
0.5496	-8.51E-05	378735.	-132274.	-1.85E-05	15755.	2.11E+10	19092.	2.47E+08	0.00
0.6412	-9.46E-05	244876.	-109384.	-2.29E-06	14415.	2.11E+10	22556.	2.62E+08	0.00
0.7328	-9.01E-05	138266.	-84482.	7.67E-06	13347.	2.11E+10			

```
22754.   2.77E+08       0.00
    0.8244  -7.78E-05     59146.    -60588.   1.28E-05     12555.   2.11E+10
20721.   2.93E+08       0.00
    0.9160  -6.20E-05      5062.    -39642.   1.45E-05     12013.   2.11E+10
17391.   3.08E+08       0.00
    1.0076  -4.59E-05    -28010.    -22645.   1.39E-05     12243.   2.11E+10
13533.   3.24E+08       0.00
    1.0992  -3.15E-05    -44730.     -9867.   1.20E-05     12411.   2.11E+10
9718.   3.39E+08       0.00
    1.1908  -1.96E-05    -49708.     -1051.   9.53E-06     12460.   2.11E+10
6322.   3.55E+08       0.00
    1.2824  -1.05E-05    -47046.      4373.   7.02E-06     12434.   2.11E+10
3548.   3.70E+08       0.00
    1.3740  -4.17E-06    -40097.      7127.   4.75E-06     12364.   2.11E+10
1462.   3.86E+08       0.00
    1.4656  -9.31E-08    -31382.      7949.   2.89E-06     12277.   2.11E+10
33.9611   4.01E+08       0.00
    1.5572   2.19E-06    -22624.      7512.   1.49E-06     12189.   2.11E+10
-829.2396   4.17E+08       0.00
    1.6488   3.18E-06    -14868.      6370.   5.13E-07     12112.   2.11E+10
-1248.   4.32E+08       0.00
    1.7404   3.32E-06     -8621.      4942.  -9.79E-08     12049.   2.11E+10
-1350.   4.47E+08       0.00
    1.8320   2.96E-06     -4004.      3515.  -4.26E-07     12003.   2.11E+10
-1247.   4.63E+08       0.00
    1.9236   2.38E-06  -893.6705      2260.  -5.53E-07     11972.   2.11E+10
-1035.   4.78E+08       0.00
    2.0152   1.75E-06   965.7209      1261.  -5.52E-07     11972.   2.11E+10
-783.9786   4.94E+08       0.00
    2.1068   1.17E-06      1878.   532.6462  -4.78E-07     11981.   2.11E+10
-540.4714   5.09E+08       0.00
    2.1984   6.95E-07      2137.    53.1773  -3.73E-07     11984.   2.11E+10
-331.9247   5.25E+08       0.00
    2.2900   3.46E-07      1995.  -222.7569  -2.66E-07     11983.   2.11E+10
-170.1390   5.40E+08       0.00
    2.3816   1.11E-07      1647.  -347.1323  -1.71E-07     11979.   2.11E+10
-56.1626   5.56E+08       0.00
    2.4732  -2.99E-08      1232.  -369.4715  -9.62E-08     11975.   2.11E+10
15.5163   5.71E+08       0.00
    2.5648  -1.00E-07   835.2078  -331.4876  -4.25E-08     11971.   2.11E+10
53.5957   5.86E+08       0.00
    2.6564  -1.23E-07   503.2208  -264.9210  -7.71E-09     11968.   2.11E+10
67.5224   6.02E+08       0.00
    2.7480  -1.17E-07   252.8097  -191.5702   1.19E-08     11965.   2.11E+10
65.9398   6.17E+08       0.00
    2.8396  -9.71E-08    82.0661  -124.6216   2.06E-08     11963.   2.11E+10
55.8737   6.33E+08       0.00
    2.9312  -7.20E-08   -21.1699   -70.5721   2.22E-08     11963.   2.11E+10
42.4696   6.48E+08       0.00
    3.0228  -4.82E-08   -73.0922   -31.2418   1.98E-08     11963.   2.11E+10
```

29.0922   6.64E+08   0.00
    3.1144 -2.85E-08   -89.8630   -5.5656   1.55E-08   11964.   2.11E+10
17.6257   6.79E+08   0.00
    3.2060 -1.40E-08   -85.3364   8.9865   1.10E-08   11963.   2.11E+10
8.8520   6.95E+08   0.00
    3.2976 -4.37E-09   -70.1131   15.4017   6.95E-09   11963.   2.11E+10
2.8205   7.10E+08   0.00
    3.3892   1.27E-09   -51.4811   16.4916   3.79E-09   11963.   2.11E+10
-0.8375   7.25E+08   0.00
    3.4808   3.96E-09   -33.8601   14.5636   1.57E-09   11963.   2.11E+10
-2.6706   7.41E+08   0.00
    3.5724   4.72E-09   -19.4653   11.3108   1.84E-10   11963.   2.11E+10
-3.2479   7.56E+08   0.00
    3.6640   4.37E-09   -8.9946   7.8462 -5.56E-10   11963.   2.11E+10
-3.0560   7.69E+08   0.00
    3.7556   3.50E-09   -2.2160   4.8211 -8.48E-10   11963.   2.11E+10
-2.4481   7.69E+08   0.00
    3.8472   2.50E-09   1.6047   2.5131 -8.64E-10   11963.   2.11E+10
-1.7515   7.69E+08   0.00
    3.9388   1.60E-09   3.3092   0.9354 -7.36E-10   11963.   2.11E+10
-1.1191   7.69E+08   0.00
    4.0304   8.84E-10   3.6616   -0.01984 -5.55E-10   11963.   2.11E+10
-0.6191   7.69E+08   0.00
    4.1220   3.79E-10   3.2659   -0.5060 -3.75E-10   11963.   2.11E+10
-0.2655   7.69E+08   0.00
    4.2136   6.10E-11   2.5494   -0.6754 -2.23E-10   11963.   2.11E+10
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    4.3052 -1.12E-10   1.7812   -0.6559 -1.11E-10   11963.   2.11E+10
0.07818   7.69E+08   0.00
    4.3968 -1.83E-10   1.1075   -0.5427 -3.57E-11   11963.   2.11E+10
0.1278   7.69E+08   0.00
    4.4884 -1.90E-10   0.5881   -0.3993   8.40E-12   11963.   2.11E+10
0.1331   7.69E+08   0.00
    4.5800 -1.64E-10   0.2296   -0.2631   2.97E-11   11963.   2.11E+10
0.1149   7.69E+08   0.00
    4.6716 -1.25E-10   0.00978   -0.1519   3.59E-11   11963.   2.11E+10
0.08746   7.69E+08   0.00
    4.7632 -8.52E-11   -0.1043   -0.07102   3.34E-11   11963.   2.11E+10
0.05966   7.69E+08   0.00
    4.8548 -5.15E-11   -0.1464   -0.01843   2.69E-11   11963.   2.11E+10
0.03603   7.69E+08   0.00
    4.9464 -2.61E-11   -0.1449   0.01141   1.93E-11   11963.   2.11E+10
0.01826   7.69E+08   0.00
    5.0380 -8.98E-12   -0.1213   0.02489   1.24E-11   11963.   2.11E+10
0.00628   7.69E+08   0.00
    5.1296   1.20E-12   -0.09015   0.02789   6.91E-12   11963.   2.11E+10
-8.40E-04   7.69E+08   0.00
    5.2212   6.22E-12   -0.06000   0.02503   3.01E-12   11963.   2.11E+10
-0.00436   7.69E+08   0.00
    5.3128   7.82E-12   -0.03512   0.01963   0.00   11963.   2.11E+10

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-0.00547   7.69E+08       0.00
    5.4044   7.40E-12   -0.01685    0.01377       0.00     11963.   2.11E+10
-0.00518   7.69E+08       0.00
    5.4960   6.03E-12   -0.00484    0.00861  -1.38E-12     11963.   2.11E+10
-0.00422   7.69E+08       0.00
    5.5876   4.37E-12    0.00207    0.00461  -1.45E-12     11963.   2.11E+10
-0.00306   7.69E+08       0.00
    5.6792   2.84E-12    0.00529    0.00183  -1.26E-12     11963.   2.11E+10
-0.00199   7.69E+08       0.00
    5.7708   1.61E-12    0.00610   1.24E-04       0.00     11963.   2.11E+10
-0.00112   7.69E+08       0.00
    5.8624       0.00    0.00556  -7.71E-04       0.00     11963.   2.11E+10
-5.05E-04   7.69E+08       0.00
    5.9540       0.00    0.00441   -0.00111       0.00     11963.   2.11E+10
-1.08E-04   7.69E+08       0.00
    6.0456       0.00    0.00312   -0.00111       0.00     11963.   2.11E+10
1.12E-04   7.69E+08       0.00
    6.1372       0.00    0.00197  -9.32E-04       0.00     11963.   2.11E+10
2.07E-04   7.69E+08       0.00
    6.2288       0.00    0.00107  -6.95E-04       0.00     11963.   2.11E+10
2.23E-04   7.69E+08       0.00
    6.3204       0.00   4.45E-04  -4.65E-04       0.00     11963.   2.11E+10
1.96E-04   7.69E+08       0.00
    6.4120       0.00   5.25E-05  -2.74E-04       0.00     11963.   2.11E+10
1.52E-04   7.69E+08       0.00
    6.5036       0.00  -1.57E-04  -1.33E-04       0.00     11963.   2.11E+10
1.05E-04   7.69E+08       0.00
    6.5952       0.00  -2.39E-04  -3.96E-05       0.00     11963.   2.11E+10
6.45E-05   7.69E+08       0.00
    6.6868       0.00  -2.44E-04   1.43E-05       0.00     11963.   2.11E+10
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    6.7784       0.00  -2.08E-04   3.97E-05       0.00     11963.   2.11E+10
1.25E-05   7.69E+08       0.00
    6.8700       0.00  -1.57E-04   4.64E-05       0.00     11963.   2.11E+10
-2.43E-07   7.69E+08       0.00
    6.9616       0.00  -1.06E-04   4.26E-05       0.00     11963.   2.11E+10
-6.75E-06   7.69E+08       0.00
    7.0532       0.00  -6.32E-05   3.39E-05       0.00     11963.   2.11E+10
-9.02E-06   7.69E+08       0.00
    7.1448       0.00  -3.13E-05   2.41E-05       0.00     11963.   2.11E+10
-8.77E-06   7.69E+08       0.00
    7.2364       0.00  -1.01E-05   1.53E-05       0.00     11963.   2.11E+10
-7.25E-06   7.69E+08       0.00
    7.3280       0.00   2.35E-06   8.41E-06       0.00     11963.   2.11E+10
-5.34E-06   7.69E+08       0.00
    7.4196       0.00   8.37E-06   3.54E-06       0.00     11963.   2.11E+10
-3.52E-06   7.69E+08       0.00
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    7.6028       0.00   9.44E-06  -1.15E-06       0.00     11963.   2.11E+10
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-9.51E-07   7.69E+08       0.00
    7.6944       0.00   7.60E-06  -1.81E-06       0.00     11963.   2.11E+10
-2.47E-07   7.69E+08       0.00
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1.52E-07   7.69E+08       0.00
    7.8776       0.00   3.51E-06  -1.60E-06       0.00     11963.   2.11E+10
3.32E-07   7.69E+08       0.00
    7.9692       0.00   1.96E-06  -1.21E-06       0.00     11963.   2.11E+10
3.73E-07   7.69E+08       0.00
    8.0608       0.00   8.52E-07  -8.20E-07       0.00     11963.   2.11E+10
3.35E-07   7.69E+08       0.00
    8.1524       0.00   1.53E-07  -4.92E-07       0.00     11963.   2.11E+10
2.62E-07   7.69E+08       0.00
    8.2440       0.00  -2.29E-07  -2.46E-07       0.00     11963.   2.11E+10
1.84E-07   7.69E+08       0.00
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    8.4272       0.00  -4.09E-07   1.55E-08       0.00     11963.   2.11E+10
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    8.5188       0.00  -3.54E-07   6.29E-08       0.00     11963.   2.11E+10
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1.48E-09   7.69E+08       0.00
    8.7020       0.00  -1.85E-07   7.21E-08       0.00     11963.   2.11E+10
-1.07E-08   7.69E+08       0.00
    8.7936       0.00  -1.12E-07   5.77E-08       0.00     11963.   2.11E+10
-1.55E-08   7.69E+08       0.00
    8.8852       0.00  -5.77E-08   4.04E-08       0.00     11963.   2.11E+10
-1.59E-08   7.69E+08       0.00
    8.9768       0.00  -2.29E-08   2.41E-08       0.00     11963.   2.11E+10
-1.39E-08   7.69E+08       0.00
    9.0684       0.00  -4.79E-09   1.04E-08       0.00     11963.   2.11E+10
-1.10E-08   7.69E+08       0.00
    9.1600       0.00       0.00       0.00       0.00     11963.   2.11E+10
-7.93E-09   3.85E+08       0.00

* The above values of total stress are combined axial and bending stresses.


Output Summary for Load Case No. 1:

Pile-head deflection             =     0.00074642 inches
Computed slope at pile head      =    -0.00027820 radians
Maximum bending moment           =       1116000. inch-lbs
Maximum shear force              =       -154393. lbs
Depth of maximum bending moment  =       0.000000 feet below pile head
Depth of maximum shear force     =     0.36640000 feet below pile head
Number of iterations             =              6
Number of zero deflection points =             10
```

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

Boundary Condition Type 1, Shear and Moment

Shear = 35000. lbs
Moment = 1116000. in-lbs
Axial Load = 256000. lbs

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
9.16000	0.00074642	1116000.	-154393.
8.70200	0.00074930	1116000.	-153753.
8.24400	0.00075164	1116000.	-153948.
7.78600	0.00075347	1117130.	-155087.
7.32800	0.00075477	1118804.	-155221.
6.87000	0.00075552	1120267.	-154649.
6.41200	0.00075574	1121515.	-155837.
5.95400	0.00075544	1122548.	-155585.
5.49600	0.00075462	1123363.	-156250.
5.03800	0.00075330	1123960.	-155878.
4.58000	0.00075473	1124324.	-156433.
4.12200	0.00075597	1124474.	-156638.
3.66400	0.00075583	1124410.	-156688.
3.20600	0.00075528	1124126.	-156908.
2.74800	0.00075614	1123621.	-156991.
2.29000	0.00075614	1124320.	-156987.
1.83200	0.00075642	1124408.	-157183.
1.37400	0.00075744	1124470.	-156695.
0.91600	0.00078923	1124331.	-167365.
0.91600	0.000000	1436436182.	-6534007378.

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	Load Pile-head	Load Type	Load Pile-head	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	35000.	M, in-lb	1116000.	256000.	7.46E-04	-2.78E-04	-154393.	1116000.

Maximum pile-head deflection = 0.0007464247 inches
Maximum pile-head rotation = -0.0002781975 radians = -0.015940 deg.

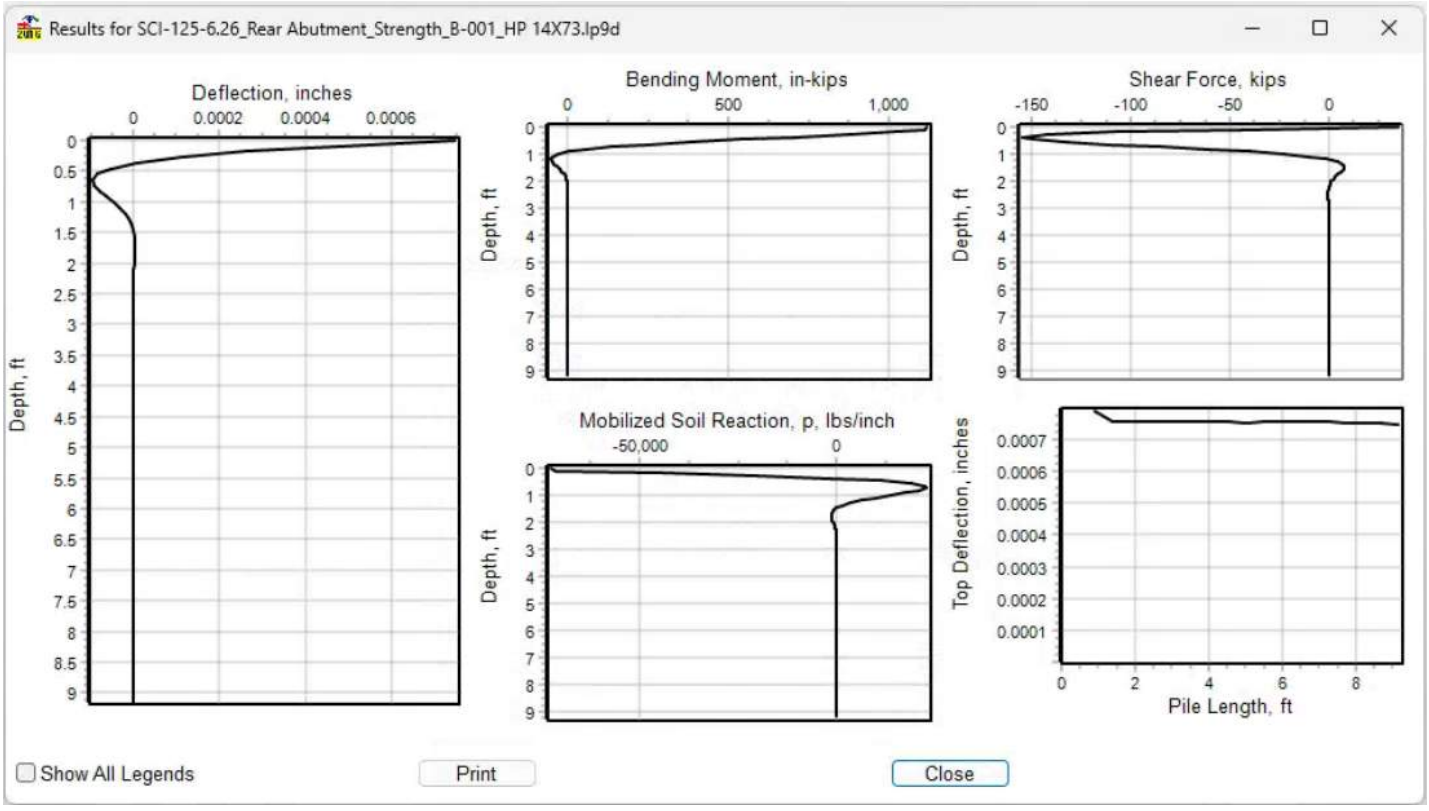
Summary of Warning Messages

The following warning was reported 10000 times

**** Warning ****

An unreasonable input value for unconfined compressive strength has been specified for a soil defined using the weak rock criteria. The input value is greater than 1000 psi. Please check your input data for correctness.

The analysis ended normally.



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LPile for Windows, Version 2016-09.003

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

Path to file locations:
\24-0002 SCI-125-6.26 LAW-378-4.84 PID
119955\119955\geotechnical\bridges\SCI-125-6.26\Analysis\Lpile\Files\14x73 new
01242025\

Name of input data file:
SCI-125-6.26_Forward Abutment_Service_B-002_HP 14X73.lp9d

Name of output report file:
SCI-125-6.26_Forward Abutment_Service_B-002_HP 14X73.lp9o

Name of plot output file:
SCI-125-6.26_Forward Abutment_Service_B-002_HP 14X73.lp9p

Name of runtime message file:
SCI-125-6.26_Forward Abutment_Service_B-002_HP 14X73.lp9r

Date and Time of Analysis

Date: January 28, 2025 Time: 13:28:58

Problem Title

Project Name: SCI-125-6.26

Job Number:

Client: American Structurepoint / ODOT

Engineer: DT

Description: Forward Abutment - B-002-0-23

Program Options and Settings

Computational Options:
- Use unfactored loads in computations (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:
- Static loading specified

- Use of p-y modification factors for p-y curves not selected
- 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
- 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 = 11.190 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	14.6000
2	11.190	14.6000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile
Cross-sectional Shape = Strong H-Pile
Length of section = 11.190000 ft
Flange Width = 14.600000 in

Section Depth	=	13.600000	in
Flange Thickness	=	0.505000	in
Web Thickness	=	0.505000	in
Section Area	=	21.400000	sq. in
Moment of Inertia	=	729.000000	in^4
Elastic Modulus	=	29000000.	psi

Ground Slope and Pile Batter Angles

Ground Slope Angle	=	0.000	degrees
	=	0.000	radians
Pile Batter Angle	=	0.000	degrees
	=	0.000	radians

Soil and Rock Layering Information

The soil profile is modelled using 1 layers

Layer 1 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	0.0000	ft
Distance from top of pile to bottom of layer	=	11.190000	ft
Effective unit weight at top of layer	=	96.500000	pcf
Effective unit weight at bottom of layer	=	96.500000	pcf
Uniaxial compressive strength at top of layer	=	9869.	psi
Uniaxial compressive strength at bottom of layer	=	9869.	psi
Initial modulus of rock at top of layer	=	890000.	psi
Initial modulus of rock at bottom of layer	=	890000.	psi
RQD of rock at top of layer	=	63.000000	%
RQD of rock at bottom of layer	=	63.000000	%
k rm of rock at top of layer	=	0.0000500	
k rm of rock at bottom of layer	=	0.0000500	

(Depth of the lowest soil layer extends 0.000 ft below the pile tip)

Summary of Input Soil Properties

Layer or Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Uniaxial qu psi	RQD %	E50 Rock Mass Modulus krm psi
1	Weak Rock	0.00 11.1900	96.5000 96.5000	9869. 9869.	63.0000 63.0000	5.00E-05 890000. 5.00E-05 890000.

Static Loading Type

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

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	Compute Top y vs. Pile Length
1	1	V = 24000. lbs	M = 756000. in-lbs	185000.	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:

Moment-curvature properties were derived from elastic section properties

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 = 24000.0 lbs
Applied moment at pile head = 756000.0 in-lbs
Axial thrust load on pile head = 185000.0 lbs

Depth X	Deflect. y	Bending Moment	Shear Force	Slope S	Total Stress	Bending Stiffness	Soil Res. Es*h	Soil Spr. Lat. Load	Distrib. p
feet	inches	in-lbs	lbs	radians	psi*	in-lb^2	lb/inch	lb/inch	lb/inch
0.00	6.37E-04	756000.	24000.	-2.12E-04	16215.	2.11E+10	-40386.	4.26E+07	0.00
0.1119	3.85E-04	751864.	-28946.	-1.64E-04	16174.	2.11E+10	-38473.	1.34E+08	0.00
0.2238	1.97E-04	678344.	-69457.	-1.18E-04	15438.	2.11E+10	-21865.	1.49E+08	0.00
0.3357	6.74E-05	565388.	-89644.	-7.88E-05	14306.	2.11E+10	-8202.	1.63E+08	0.00
0.4476	-1.43E-05	437635.	-93875.	-4.69E-05	13027.	2.11E+10	1901.	1.78E+08	0.00
0.5595	-5.87E-05	313302.	-86940.	-2.31E-05	11782.	2.11E+10	8428.	1.93E+08	0.00
0.6714	-7.64E-05	204160.	-73362.	-6.66E-06	10689.	2.11E+10	11795.	2.07E+08	0.00
0.7833	-7.66E-05	116284.	-56937.	3.52E-06	9809.	2.11E+10	12668.	2.22E+08	0.00
0.8952	-6.69E-05	51248.	-40511.	8.84E-06	9158.	2.11E+10			

```
11797.   2.37E+08       0.00
    1.0071  -5.29E-05      7484.    -25945.   1.07E-05      8720.   2.11E+10
9897.   2.51E+08       0.00
    1.1190  -3.82E-05    -18435.    -14222.   1.04E-05      8829.   2.11E+10
7564.   2.66E+08       0.00
    1.2309  -2.51E-05    -30716.     -5627.   8.79E-06      8952.   2.11E+10
5238.   2.81E+08       0.00
    1.3428  -1.46E-05    -33551.    40.3644   6.75E-06      8981.   2.11E+10
3203.   2.95E+08       0.00
    1.4547  -6.92E-06    -30611.      3264.   4.71E-06      8951.   2.11E+10
1599.   3.10E+08       0.00
    1.5666  -1.90E-06    -24787.      4646.   2.95E-06      8893.   2.11E+10
459.5837   3.25E+08       0.00
    1.6785   1.01E-06    -18135.      4783.   1.59E-06      8826.   2.11E+10
-255.0912   3.39E+08       0.00
    1.7904   2.37E-06    -11942.      4192.   6.36E-07      8764.   2.11E+10
-625.5381   3.54E+08       0.00
    1.9023   2.72E-06     -6876.      3271.   3.85E-08      8714.   2.11E+10
-746.1266   3.69E+08       0.00
    2.0142   2.48E-06     -3156.      2296.  -2.80E-07      8676.   2.11E+10
-706.8298   3.83E+08       0.00
    2.1261   1.97E-06  -710.7032      1430.  -4.03E-07      8652.   2.11E+10
-582.4772   3.98E+08       0.00
    2.2380   1.39E-06   684.6500   751.4647  -4.04E-07      8652.   2.11E+10
-428.3491   4.13E+08       0.00
    2.3499   8.81E-07      1308.   275.6580  -3.41E-07      8658.   2.11E+10
-280.3293   4.27E+08       0.00
    2.4618   4.80E-07      1425.   -18.5130  -2.54E-07      8659.   2.11E+10
-157.8164   4.42E+08       0.00
    2.5737   2.00E-07      1258.  -170.0387  -1.69E-07      8657.   2.11E+10
-67.8697   4.57E+08       0.00
    2.6856   2.70E-08   968.5541  -221.9629  -9.78E-08      8655.   2.11E+10
-9.4676   4.71E+08       0.00
    2.7975  -6.30E-08   661.9833  -213.0044  -4.60E-08      8651.   2.11E+10
22.8107   4.86E+08       0.00
    2.9094  -9.66E-08   396.5324  -173.5139  -1.24E-08      8649.   2.11E+10
36.0074   5.01E+08       0.00
    3.0213  -9.63E-08   196.0007  -124.5232   6.42E-09      8647.   2.11E+10
36.9605   5.15E+08       0.00
    3.1332  -7.94E-08    62.1097   -78.6855   1.46E-08      8645.   2.11E+10
31.3114   5.30E+08       0.00
    3.2451  -5.71E-08   -15.3243   -42.1244   1.61E-08      8645.   2.11E+10
23.1435   5.45E+08       0.00
    3.3570  -3.61E-08   -51.0277   -16.4923   1.40E-08      8645.   2.11E+10
15.0337   5.59E+08       0.00
    3.4689  -1.95E-08   -59.6228    -0.8087   1.05E-08      8645.   2.11E+10
8.3259   5.74E+08       0.00
    3.5808  -7.95E-09   -53.2046     7.1204   6.90E-09      8645.   2.11E+10
3.4839   5.88E+08       0.00
    3.6927  -9.54E-10   -40.5037     9.7445   3.92E-09      8645.   2.11E+10
```

```
0.4244   5.98E+08       0.00
    3.8046   2.59E-09   -27.0369     9.2564   1.78E-09      8645.   2.11E+10
-1.1514   5.98E+08       0.00
    3.9165   3.82E-09   -15.6457     7.3412   4.23E-10      8645.   2.11E+10
-1.7011   5.98E+08       0.00
    4.0284   3.72E-09    -7.3215     5.0866  -3.06E-10      8645.   2.11E+10
-1.6570   5.98E+08       0.00
    4.1403   3.00E-09    -1.9849     3.0779  -6.02E-10      8645.   2.11E+10
-1.3349   5.98E+08       0.00
    4.2522   2.11E-09     0.9447     1.5521  -6.35E-10      8645.   2.11E+10
-0.9376   5.98E+08       0.00
    4.3641   1.29E-09     2.1836     0.5358  -5.36E-10      8645.   2.11E+10
-0.5761   5.98E+08       0.00
    4.4760   6.69E-10     2.3838   -0.05079  -3.91E-10      8645.   2.11E+10
-0.2975   5.98E+08       0.00
    4.5879   2.46E-10     2.0474    -0.3240  -2.50E-10      8645.   2.11E+10
-0.1094   5.98E+08       0.00
    4.6998  -2.39E-12     1.5139    -0.3967  -1.37E-10      8645.   2.11E+10
0.00106   5.98E+08       0.00
    4.8117  -1.21E-10     0.9822    -0.3597  -5.75E-11      8645.   2.11E+10
0.05404   5.98E+08       0.00
    4.9236  -1.57E-10     0.5479    -0.2766  -8.86E-12      8645.   2.11E+10
0.06973   5.98E+08       0.00
    5.0355  -1.45E-10     0.2394    -0.1864   1.61E-11      8645.   2.11E+10
0.06463   5.98E+08       0.00
    5.1474  -1.13E-10    0.04741    -0.1091   2.52E-11      8645.   2.11E+10
0.05044   5.98E+08       0.00
    5.2593  -7.74E-11   -0.05363   -0.05211   2.51E-11      8645.   2.11E+10
0.03446   5.98E+08       0.00
    5.3712  -4.61E-11   -0.09254   -0.01521   2.04E-11      8645.   2.11E+10
0.02051   5.98E+08       0.00
    5.4831  -2.26E-11   -0.09448    0.00532   1.45E-11      8645.   2.11E+10
0.01007   5.98E+08       0.00
    5.5950  -7.22E-12   -0.07826    0.01424   8.98E-12      8645.   2.11E+10
0.00321   5.98E+08       0.00
    5.7069   1.50E-12   -0.05625    0.01595   4.71E-12      8645.   2.11E+10
-6.69E-04   5.98E+08       0.00
    5.8188   5.43E-12   -0.03544    0.01387   1.80E-12      8645.   2.11E+10
-0.00242   5.98E+08       0.00
    5.9307   6.34E-12   -0.01899    0.01036       0.00      8645.   2.11E+10
-0.00282   5.98E+08       0.00
    6.0426   5.62E-12   -0.00762    0.00679       0.00      8645.   2.11E+10
-0.00250   5.98E+08       0.00
    6.1545   4.26E-12  -7.66E-04    0.00383  -1.04E-12      8645.   2.11E+10
-0.00189   5.98E+08       0.00
    6.2664   2.83E-12    0.00267    0.00172       0.00      8645.   2.11E+10
-0.00126   5.98E+08       0.00
    6.3783   1.63E-12    0.00384   3.86E-04       0.00      8645.   2.11E+10
-7.24E-04   5.98E+08       0.00
    6.4902       0.00    0.00371  -3.25E-04       0.00      8645.   2.11E+10
```

-3.35E-04 5.98E+08 0.00
6.6021 0.00 0.00297 -6.08E-04 0.00 8645. 2.11E+10
-8.69E-05 5.98E+08 0.00
6.7140 0.00 0.00208 -6.34E-04 0.00 8645. 2.11E+10
4.83E-05 5.98E+08 0.00
6.8259 0.00 0.00127 -5.31E-04 0.00 8645. 2.11E+10
1.05E-04 5.98E+08 0.00
6.9378 0.00 6.50E-04 -3.86E-04 0.00 8645. 2.11E+10
1.13E-04 5.98E+08 0.00
7.0497 0.00 2.34E-04 -2.45E-04 0.00 8645. 2.11E+10
9.62E-05 5.98E+08 0.00
7.1616 0.00 -8.97E-06 -1.33E-04 0.00 8645. 2.11E+10
7.07E-05 5.98E+08 0.00
7.2735 0.00 -1.24E-04 -5.52E-05 0.00 8645. 2.11E+10
4.57E-05 5.98E+08 0.00
7.3854 0.00 -1.57E-04 -7.55E-06 0.00 8645. 2.11E+10
2.53E-05 5.98E+08 0.00
7.4973 0.00 -1.45E-04 1.68E-05 0.00 8645. 2.11E+10
1.09E-05 5.98E+08 0.00
7.6092 0.00 -1.12E-04 2.54E-05 0.00 8645. 2.11E+10
1.99E-06 5.98E+08 0.00
7.7211 0.00 -7.63E-05 2.50E-05 0.00 8645. 2.11E+10
-2.66E-06 5.98E+08 0.00
7.8330 0.00 -4.51E-05 2.02E-05 0.00 8645. 2.11E+10
-4.41E-06 5.98E+08 0.00
7.9449 0.00 -2.19E-05 1.43E-05 0.00 8645. 2.11E+10
-4.46E-06 5.98E+08 0.00
8.0568 0.00 -6.79E-06 8.81E-06 0.00 8645. 2.11E+10
-3.67E-06 5.98E+08 0.00
8.1687 0.00 1.73E-06 4.58E-06 0.00 8645. 2.11E+10
-2.63E-06 5.98E+08 0.00
8.2806 0.00 5.52E-06 1.72E-06 0.00 8645. 2.11E+10
-1.65E-06 5.98E+08 0.00
8.3925 0.00 6.34E-06 2.48E-08 0.00 8645. 2.11E+10
-8.75E-07 5.98E+08 0.00
8.5044 0.00 5.59E-06 -7.94E-07 0.00 8645. 2.11E+10
-3.45E-07 5.98E+08 0.00
8.6163 0.00 4.21E-06 -1.04E-06 0.00 8645. 2.11E+10
-2.75E-08 5.98E+08 0.00
8.7282 0.00 2.78E-06 -9.75E-07 0.00 8645. 2.11E+10
1.30E-07 5.98E+08 0.00
8.8401 0.00 1.59E-06 -7.65E-07 0.00 8645. 2.11E+10
1.83E-07 5.98E+08 0.00
8.9520 0.00 7.27E-07 -5.25E-07 0.00 8645. 2.11E+10
1.75E-07 5.98E+08 0.00
9.0639 0.00 1.80E-07 -3.14E-07 0.00 8645. 2.11E+10
1.39E-07 5.98E+08 0.00
9.1758 0.00 -1.16E-07 -1.56E-07 0.00 8645. 2.11E+10
9.69E-08 5.98E+08 0.00
9.2877 0.00 -2.38E-07 -5.09E-08 0.00 8645. 2.11E+10

```
5.89E-08   5.98E+08       0.00
    9.3996       0.00  -2.53E-07   8.64E-09       0.00      8645.   2.11E+10
2.99E-08   5.98E+08       0.00
    9.5115       0.00  -2.14E-07   3.58E-08       0.00      8645.   2.11E+10
1.05E-08   5.98E+08       0.00
    9.6234       0.00  -1.57E-07   4.23E-08       0.00      8645.   2.11E+10
-7.29E-10   5.98E+08       0.00
    9.7353       0.00  -1.01E-07   3.78E-08       0.00      8645.   2.11E+10
-6.01E-09   5.98E+08       0.00
    9.8472       0.00  -5.55E-08   2.88E-08       0.00      8645.   2.11E+10
-7.46E-09   5.98E+08       0.00
    9.9591       0.00  -2.36E-08   1.92E-08       0.00      8645.   2.11E+10
-6.80E-09   5.98E+08       0.00
   10.0710       0.00  -3.94E-09   1.11E-08       0.00      8645.   2.11E+10
-5.25E-09   5.98E+08       0.00
   10.1829       0.00   6.22E-09   5.18E-09       0.00      8645.   2.11E+10
-3.55E-09   5.98E+08       0.00
   10.2948       0.00   9.98E-09   1.39E-09       0.00      8645.   2.11E+10
-2.09E-09   5.98E+08       0.00
   10.4067       0.00   9.96E-09  -6.87E-10       0.00      8645.   2.11E+10
-1.01E-09   5.98E+08       0.00
   10.5186       0.00   8.13E-09  -1.56E-09       0.00      8645.   2.11E+10
-3.00E-10   5.98E+08       0.00
   10.6305       0.00   5.76E-09  -1.70E-09       0.00      8645.   2.11E+10
9.76E-11   5.98E+08       0.00
   10.7424       0.00   3.56E-09  -1.45E-09       0.00      8645.   2.11E+10
2.77E-10   5.98E+08       0.00
   10.8543       0.00   1.87E-09  -1.05E-09       0.00      8645.   2.11E+10
3.21E-10   5.98E+08       0.00
   10.9662       0.00   7.49E-10  -6.36E-10       0.00      8645.   2.11E+10
2.94E-10   5.98E+08       0.00
   11.0781       0.00   1.59E-10  -2.79E-10       0.00      8645.   2.11E+10
2.38E-10   5.98E+08       0.00
   11.1900       0.00     0.00       0.00       0.00      8645.   2.11E+10
1.77E-10   2.99E+08       0.00

* The above values of total stress are combined axial and bending stresses.


Output Summary for Load Case No. 1:

Pile-head deflection             =     0.00063697 inches
Computed slope at pile head      =    -0.00021160 radians
Maximum bending moment           =        756000. inch-lbs
Maximum shear force              =        -93875. lbs
Depth of maximum bending moment  =       0.000000 feet below pile head
Depth of maximum shear force     =     0.44760000 feet below pile head
Number of iterations             =              6
Number of zero deflection points =             11
```

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

Boundary Condition Type 1, Shear and Moment

Shear = 24000. lbs
Moment = 756000. in-lbs
Axial Load = 185000. lbs

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
11.19000	0.00063697	756000.	-93875.
10.63050	0.00063607	756000.	-94273.
10.07100	0.00063511	756000.	-94211.
9.51150	0.00063720	757121.	-93549.
8.95200	0.00063960	758489.	-94522.
8.39250	0.00064147	759686.	-94853.
7.83300	0.00064279	760709.	-94390.
7.27350	0.00064357	761555.	-95132.
6.71400	0.00064382	762222.	-95027.
6.15450	0.00064354	762709.	-95441.
5.59500	0.00064274	763015.	-95347.
5.03550	0.00064201	763137.	-95422.
4.47600	0.00064366	763070.	-95518.
3.91650	0.00064391	762825.	-95816.
3.35700	0.00064327	762398.	-95844.
2.79750	0.00064394	762996.	-95941.
2.23800	0.00064404	763061.	-96007.
1.67850	0.00064494	763115.	-96016.
1.11900	0.00065217	763040.	-97665.
1.11900	0.000000	798740293.	-2974159565.

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	Pile-head Load 1	Load Type	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	24000.	M, in-lb	756000.	185000.	6.37E-04	-2.12E-04	-93875.	756000.

Maximum pile-head deflection = 0.0006369677 inches
Maximum pile-head rotation = -0.0002116041 radians = -0.012124 deg.

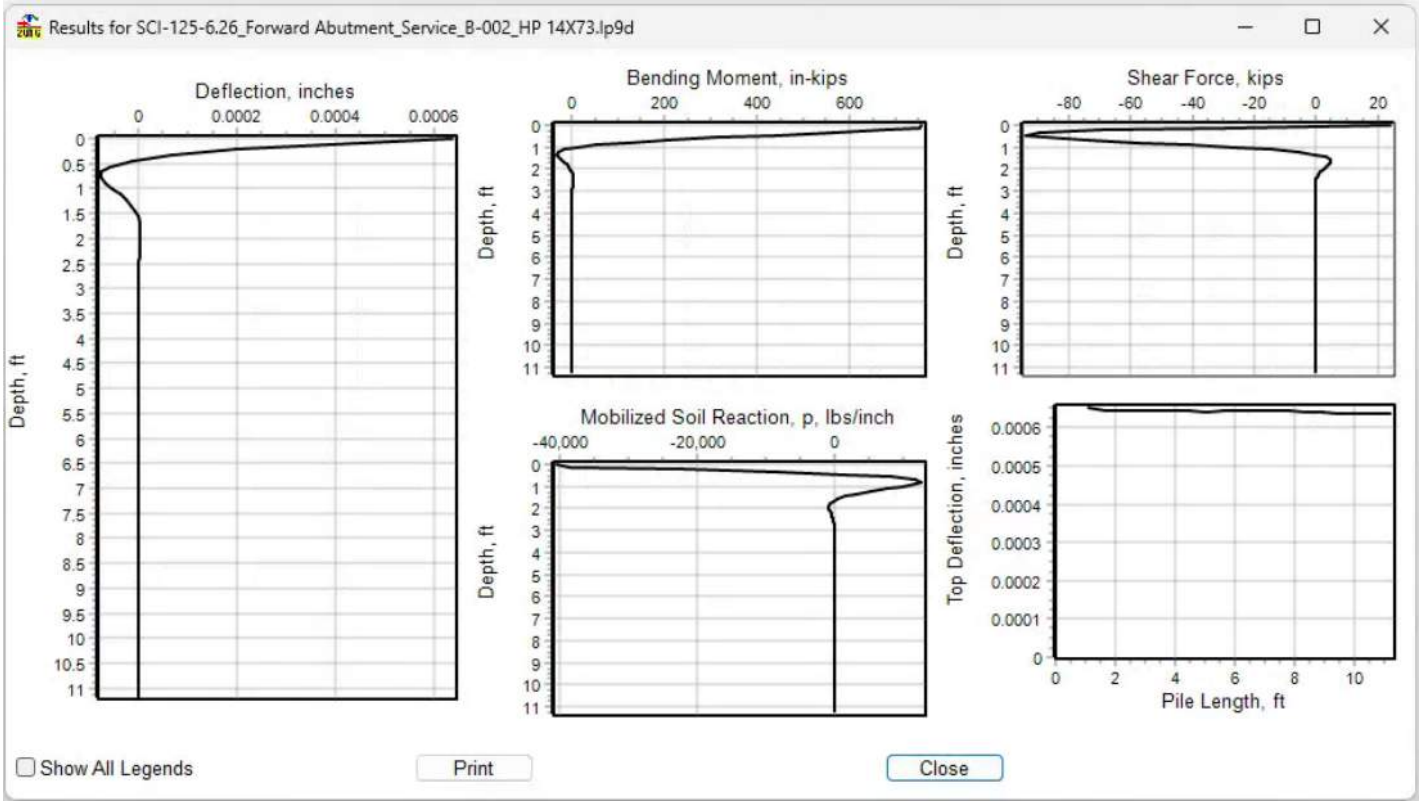
Summary of Warning Messages

The following warning was reported 10000 times

**** Warning ****

An unreasonable input value for unconfined compressive strength has been specified for a soil defined using the weak rock criteria. The input value is greater than 1000 psi. Please check your input data for correctness.

The analysis ended normally.



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LPile for Windows, Version 2016-09.003

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

Path to file locations:
\24-0002 SCI-125-6.26 LAW-378-4.84 PID
119955\119955\geotechnical\bridges\SCI-125-6.26\Analysis\Lpile\Files\14x73 new
01242025\

Name of input data file:
SCI-125-6.26_Forward Abutment_Strength_B-002_HP 14X73.lp9d

Name of output report file:
SCI-125-6.26_Forward Abutment_Strength_B-002_HP 14X73.lp9o

Name of plot output file:
SCI-125-6.26_Forward Abutment_Strength_B-002_HP 14X73.lp9p

Name of runtime message file:
SCI-125-6.26_Forward Abutment_Strength_B-002_HP 14X73.lp9r

Date and Time of Analysis

Date: January 28, 2025 Time: 13:30:40

Problem Title

Project Name: SCI-125-6.26

Job Number:

Client: American Structurepoint / ODOT

Engineer: DT

Description: Forward Abutment - B-002-0-23

Program Options and Settings

Computational Options:
- Use unfactored loads in computations (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:
- Static loading specified

- Use of p-y modification factors for p-y curves not selected
- 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
- 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 = 11.190 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	14.6000
2	11.190	14.6000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile
Cross-sectional Shape = Strong H-Pile
Length of section = 11.190000 ft
Flange Width = 14.600000 in

Section Depth	=	13.600000	in
Flange Thickness	=	0.505000	in
Web Thickness	=	0.505000	in
Section Area	=	21.400000	sq. in
Moment of Inertia	=	729.000000	in^4
Elastic Modulus	=	29000000.	psi

Ground Slope and Pile Batter Angles

Ground Slope Angle	=	0.000	degrees
	=	0.000	radians
Pile Batter Angle	=	0.000	degrees
	=	0.000	radians

Soil and Rock Layering Information

The soil profile is modelled using 1 layers

Layer 1 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	0.0000	ft
Distance from top of pile to bottom of layer	=	11.190000	ft
Effective unit weight at top of layer	=	96.500000	pcf
Effective unit weight at bottom of layer	=	96.500000	pcf
Uniaxial compressive strength at top of layer	=	9869.	psi
Uniaxial compressive strength at bottom of layer	=	9869.	psi
Initial modulus of rock at top of layer	=	890000.	psi
Initial modulus of rock at bottom of layer	=	890000.	psi
RQD of rock at top of layer	=	63.000000	%
RQD of rock at bottom of layer	=	63.000000	%
k rm of rock at top of layer	=	0.0000500	
k rm of rock at bottom of layer	=	0.0000500	

(Depth of the lowest soil layer extends 0.000 ft below the pile tip)

Summary of Input Soil Properties

Layer or Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Uniaxial qu psi	RQD %	E50 Rock Mass Modulus krm psi
1	Weak	0.00	96.5000	9869.	63.0000	5.00E-05 890000.
	Rock	11.1900	96.5000	9869.	63.0000	5.00E-05 890000.

Static Loading Type

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

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	Compute Top y vs. Pile Length
1	1	V = 35000. lbs	M = 1116000. in-lbs	256000.	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:

Moment-curvature properties were derived from elastic section properties

---

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 = 35000.0 lbs
Applied moment at pile head = 1116000.0 in-lbs
Axial thrust load on pile head = 256000.0 lbs

Depth X	Deflect. y	Bending Moment	Shear Force	Slope S	Total Stress	Bending Stiffness	Soil Res. Es*h	Soil Spr. Lat. Load	Distrib. p
feet	inches	in-lbs	lbs	radians	psi*	in-lb^2	lb/inch	lb/inch	lb/inch
0.00	0.00108	1116000.	35000.	-3.35E-04	23138.	2.11E+10	-46095.	2.87E+07	0.00
0.1119	6.76E-04	1121544.	-27040.	-2.64E-04	23193.	2.11E+10	-46310.	9.20E+07	0.00
0.2238	3.70E-04	1043562.	-85642.	-1.95E-04	22413.	2.11E+10	-40973.	1.49E+08	0.00
0.3357	1.52E-04	891678.	-125612.	-1.33E-04	20892.	2.11E+10	-18559.	1.63E+08	0.00
0.4476	1.12E-05	706310.	-139073.	-8.27E-05	19035.	2.11E+10	-1491.	1.78E+08	0.00
0.5595	-6.97E-05	518240.	-133353.	-4.38E-05	17152.	2.11E+10	10011.	1.93E+08	0.00
0.6714	-1.06E-04	348209.	-115585.	-1.63E-05	15449.	2.11E+10	16452.	2.07E+08	0.00
0.7833	-1.14E-04	207835.	-91929.	1.34E-06	14044.	2.11E+10	18783.	2.22E+08	0.00
0.8952	-1.03E-04	101325.	-67136.	1.12E-05	12977.	2.11E+10			

```
18143.   2.37E+08       0.00
    1.0071  -8.36E-05     27526.    -44446.   1.52E-05     12238.   2.11E+10
15653.   2.51E+08       0.00
    1.1190  -6.20E-05    -18049.    -25695.   1.55E-05     12143.   2.11E+10
12275.   2.66E+08       0.00
    1.2309  -4.18E-05    -41490.    -11580.   1.37E-05     12378.   2.11E+10
8748.   2.81E+08       0.00
    1.3428  -2.53E-05    -49158.     -1974.   1.08E-05     12455.   2.11E+10
5559.   2.95E+08       0.00
    1.4547  -1.29E-05    -46800.      3757.   7.73E-06     12431.   2.11E+10
2977.   3.10E+08       0.00
    1.5666  -4.51E-06    -39072.      6488.   5.00E-06     12354.   2.11E+10
1090.   3.25E+08       0.00
    1.6785   5.45E-07    -29379.      7128.   2.83E-06     12257.   2.11E+10
-137.8208   3.39E+08       0.00
    1.7904   3.09E-06    -19932.      6487.   1.26E-06     12162.   2.11E+10
-815.5814   3.54E+08       0.00
    1.9023   3.94E-06    -11957.      5213.   2.52E-07     12082.   2.11E+10
-1082.   3.69E+08       0.00
    2.0142   3.77E-06     -5932.      3764.  -3.16E-07     12022.   2.11E+10
-1076.   3.83E+08       0.00
    2.1261   3.09E-06     -1848.      2426.  -5.63E-07     11981.   2.11E+10
-916.7118   3.98E+08       0.00
    2.2380   2.26E-06   583.5731      1345.  -6.03E-07     11968.   2.11E+10
-693.8954   4.13E+08       0.00
    2.3499   1.47E-06      1764.   563.9927  -5.29E-07     11980.   2.11E+10
-468.6904   4.27E+08       0.00
    2.4618   8.38E-07      2099.    64.1076  -4.06E-07     11984.   2.11E+10
-275.8510   4.42E+08       0.00
    2.5737   3.82E-07      1936.  -208.3912  -2.78E-07     11982.   2.11E+10
-130.0157   4.57E+08       0.00
    2.6856   9.17E-08      1539.  -317.2903  -1.68E-07     11978.   2.11E+10
-32.1813   4.71E+08       0.00
    2.7975  -6.77E-08      1084.  -322.4498  -8.43E-08     11973.   2.11E+10
24.4967   4.86E+08       0.00
    2.9094  -1.35E-07   673.2181  -272.3071  -2.85E-08     11969.   2.11E+10
50.1871   5.01E+08       0.00
    3.0213  -1.44E-07   352.8130  -201.4776   4.12E-09     11966.   2.11E+10
55.3082   5.15E+08       0.00
    3.1332  -1.24E-07   132.1271  -131.6041   1.95E-08     11964.   2.11E+10
48.7632   5.30E+08       0.00
    3.2451  -9.17E-08    -0.6363   -73.8889   2.37E-08     11963.   2.11E+10
37.1993   5.45E+08       0.00
    3.3570  -5.99E-08   -66.3251   -32.1531   2.16E-08     11963.   2.11E+10
24.9630   5.59E+08       0.00
    3.4689  -3.38E-08   -87.0014    -5.6910   1.67E-08     11963.   2.11E+10
14.4502   5.74E+08       0.00
    3.5808  -1.51E-08   -81.6203     8.4549   1.13E-08     11963.   2.11E+10
6.6190   5.88E+08       0.00
    3.6927  -3.35E-09   -64.3027    13.9007   6.71E-09     11963.   2.11E+10
```

```
1.4921   5.98E+08       0.00
    3.8046   2.91E-09   -44.2932    14.0323   3.26E-09     11963.   2.11E+10
-1.2961   5.98E+08       0.00
    3.9165   5.40E-09   -26.6198    11.5486   1.01E-09     11963.   2.11E+10
-2.4032   5.98E+08       0.00
    4.0284   5.62E-09   -13.2790     8.2566  -2.60E-10     11963.   2.11E+10
-2.5000   5.98E+08       0.00
    4.1403   4.70E-09    -4.4458     5.1729  -8.23E-10     11963.   2.11E+10
-2.0928   5.98E+08       0.00
    4.2522   3.41E-09     0.6140     2.7493  -9.44E-10     11963.   2.11E+10
-1.5169   5.98E+08       0.00
    4.3641   2.17E-09     2.9385     1.0835  -8.31E-10     11963.   2.11E+10
-0.9643   5.98E+08       0.00
    4.4760   1.18E-09     3.5243    0.08476  -6.26E-10     11963.   2.11E+10
-0.5232   5.98E+08       0.00
    4.5879   4.85E-10     3.1666    -0.4114  -4.14E-10     11963.   2.11E+10
-0.2159   5.98E+08       0.00
    4.6998   6.45E-11     2.4196    -0.5757  -2.36E-10     11963.   2.11E+10
-0.02872   5.98E+08       0.00
    4.8117  -1.50E-10     1.6208    -0.5502  -1.08E-10     11963.   2.11E+10
0.06660   5.98E+08       0.00
    4.9236  -2.26E-10     0.9420    -0.4381  -2.67E-11     11963.   2.11E+10
0.1004   5.98E+08       0.00
    5.0355  -2.21E-10     0.4442    -0.3046   1.74E-11     11963.   2.11E+10
0.09845   5.98E+08       0.00
    5.1474  -1.79E-10     0.1239    -0.1850   3.54E-11     11963.   2.11E+10
0.07964   5.98E+08       0.00
    5.2593  -1.26E-10   -0.05279   -0.09389   3.77E-11     11963.   2.11E+10
0.05613   5.98E+08       0.00
    5.3712  -7.78E-11    -0.1283   -0.03296   3.19E-11     11963.   2.11E+10
0.03462   5.98E+08       0.00
    5.4831  -4.04E-11    -0.1413    0.00236   2.34E-11     11963.   2.11E+10
0.01798   5.98E+08       0.00
    5.5950  -1.51E-11    -0.1220    0.01893   1.50E-11     11963.   2.11E+10
0.00671   5.98E+08       0.00
    5.7069       0.00   -0.09050    0.02347   8.25E-12     11963.   2.11E+10
6.12E-05   5.98E+08       0.00
    5.8188   7.08E-12   -0.05893    0.02140   3.50E-12     11963.   2.11E+10
-0.00315   5.98E+08       0.00
    5.9307   9.27E-12   -0.03303    0.01652       0.00     11963.   2.11E+10
-0.00412   5.98E+08       0.00
    6.0426   8.64E-12   -0.01456    0.01117       0.00     11963.   2.11E+10
-0.00384   5.98E+08       0.00
    6.1545   6.77E-12   -0.00303    0.00657  -1.49E-12     11963.   2.11E+10
-0.00301   5.98E+08       0.00
    6.2664   4.64E-12    0.00307    0.00316  -1.49E-12     11963.   2.11E+10
-0.00206   5.98E+08       0.00
    6.3783   2.77E-12    0.00545   9.44E-04  -1.22E-12     11963.   2.11E+10
-0.00123   5.98E+08       0.00
    6.4902   1.37E-12    0.00561  -2.93E-04       0.00     11963.   2.11E+10
```

-6.10E-04 5.98E+08 0.00
6.6021 0.00 0.00467 -8.35E-04 0.00 11963. 2.11E+10
-1.99E-04 5.98E+08 0.00
6.7140 0.00 0.00337 -9.45E-04 0.00 11963. 2.11E+10
3.54E-05 5.98E+08 0.00
6.8259 0.00 0.00213 -8.26E-04 0.00 11963. 2.11E+10
1.42E-04 5.98E+08 0.00
6.9378 0.00 0.00115 -6.19E-04 0.00 11963. 2.11E+10
1.67E-04 5.98E+08 0.00
7.0497 0.00 4.65E-04 -4.07E-04 0.00 11963. 2.11E+10
1.49E-04 5.98E+08 0.00
7.1616 0.00 5.32E-05 -2.31E-04 0.00 11963. 2.11E+10
1.13E-04 5.98E+08 0.00
7.2735 0.00 -1.55E-04 -1.04E-04 0.00 11963. 2.11E+10
7.54E-05 5.98E+08 0.00
7.3854 0.00 -2.27E-04 -2.44E-05 0.00 11963. 2.11E+10
4.36E-05 5.98E+08 0.00
7.4973 0.00 -2.21E-04 1.85E-05 0.00 11963. 2.11E+10
2.03E-05 5.98E+08 0.00
7.6092 0.00 -1.77E-04 3.58E-05 0.00 11963. 2.11E+10
5.44E-06 5.98E+08 0.00
7.7211 0.00 -1.24E-04 3.76E-05 0.00 11963. 2.11E+10
-2.71E-06 5.98E+08 0.00
7.8330 0.00 -7.63E-05 3.17E-05 0.00 11963. 2.11E+10
-6.15E-06 5.98E+08 0.00
7.9449 0.00 -3.93E-05 2.31E-05 0.00 11963. 2.11E+10
-6.68E-06 5.98E+08 0.00
8.0568 0.00 -1.44E-05 1.47E-05 0.00 11963. 2.11E+10
-5.73E-06 5.98E+08 0.00
8.1687 0.00 2.60E-07 8.04E-06 0.00 11963. 2.11E+10
-4.23E-06 5.98E+08 0.00
8.2806 0.00 7.25E-06 3.37E-06 0.00 11963. 2.11E+10
-2.74E-06 5.98E+08 0.00
8.3925 0.00 9.30E-06 5.02E-07 0.00 11963. 2.11E+10
-1.53E-06 5.98E+08 0.00
8.5044 0.00 8.60E-06 -9.68E-07 0.00 11963. 2.11E+10
-6.64E-07 5.98E+08 0.00
8.6163 0.00 6.70E-06 -1.50E-06 0.00 11963. 2.11E+10
-1.28E-07 5.98E+08 0.00
8.7282 0.00 4.57E-06 -1.48E-06 0.00 11963. 2.11E+10
1.53E-07 5.98E+08 0.00
8.8401 0.00 2.71E-06 -1.21E-06 0.00 11963. 2.11E+10
2.60E-07 5.98E+08 0.00
8.9520 0.00 1.33E-06 -8.54E-07 0.00 11963. 2.11E+10
2.65E-07 5.98E+08 0.00
9.0639 0.00 4.20E-07 -5.29E-07 0.00 11963. 2.11E+10
2.19E-07 5.98E+08 0.00
9.1758 0.00 -9.32E-08 -2.77E-07 0.00 11963. 2.11E+10
1.57E-07 5.98E+08 0.00
9.2877 0.00 -3.24E-07 -1.05E-07 0.00 11963. 2.11E+10

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9.88E-08   5.98E+08       0.00
    9.3996       0.00  -3.76E-07  -3.36E-09       0.00     11963.   2.11E+10
5.28E-08   5.98E+08       0.00
    9.5115       0.00  -3.33E-07   4.63E-08       0.00     11963.   2.11E+10
2.11E-08   5.98E+08       0.00
    9.6234       0.00  -2.52E-07   6.18E-08       0.00     11963.   2.11E+10
1.99E-09   5.98E+08       0.00
    9.7353       0.00  -1.67E-07   5.80E-08       0.00     11963.   2.11E+10
-7.57E-09   5.98E+08       0.00
    9.8472       0.00  -9.58E-08   4.57E-08       0.00     11963.   2.11E+10
-1.08E-08   5.98E+08       0.00
    9.9591       0.00  -4.42E-08   3.14E-08       0.00     11963.   2.11E+10
-1.04E-08   5.98E+08       0.00
   10.0710       0.00  -1.13E-08   1.89E-08       0.00     11963.   2.11E+10
-8.32E-09   5.98E+08       0.00
   10.1829       0.00   6.56E-09   9.40E-09       0.00     11963.   2.11E+10
-5.81E-09   5.98E+08       0.00
   10.2948       0.00   1.40E-08   3.12E-09       0.00     11963.   2.11E+10
-3.54E-09   5.98E+08       0.00
   10.4067       0.00   1.50E-08  -4.71E-10       0.00     11963.   2.11E+10
-1.81E-09   5.98E+08       0.00
   10.5186       0.00   1.27E-08  -2.12E-09       0.00     11963.   2.11E+10
-6.48E-10   5.98E+08       0.00
   10.6305       0.00   9.25E-09  -2.53E-09       0.00     11963.   2.11E+10
3.49E-11   5.98E+08       0.00
   10.7424       0.00   5.88E-09  -2.26E-09       0.00     11963.   2.11E+10
3.67E-10   5.98E+08       0.00
   10.8543       0.00   3.17E-09  -1.70E-09       0.00     11963.   2.11E+10
4.75E-10   5.98E+08       0.00
   10.9662       0.00   1.32E-09  -1.07E-09       0.00     11963.   2.11E+10
4.63E-10   5.98E+08       0.00
   11.0781       0.00   2.96E-10  -4.90E-10       0.00     11963.   2.11E+10
4.01E-10   5.98E+08       0.00
   11.1900       0.00       0.00       0.00       0.00     11963.   2.11E+10
3.28E-10   2.99E+08       0.00

* The above values of total stress are combined axial and bending stresses.


Output Summary for Load Case No. 1:

Pile-head deflection             =     0.00107789 inches
Computed slope at pile head      =    -0.00033476 radians
Maximum bending moment           =       1121544. inch-lbs
Maximum shear force              =       -139073. lbs
Depth of maximum bending moment  =     0.11190000 feet below pile head
Depth of maximum shear force     =     0.44760000 feet below pile head
Number of iterations             =              6
Number of zero deflection points =             11
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Pile-head Deflection vs. Pile Length for Load Case 1

Boundary Condition Type 1, Shear and Moment

Shear = 35000. lbs
Moment = 1116000. in-lbs
Axial Load = 256000. lbs

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
11.19000	0.00107789	1121544.	-139073.
10.63050	0.00107456	1123275.	-138634.
10.07100	0.00107325	1124749.	-138655.
9.51150	0.00107832	1125981.	-139775.
8.95200	0.00108203	1127039.	-139825.
8.39250	0.00108380	1127904.	-139109.
7.83300	0.00108360	1128574.	-140455.
7.27350	0.00108145	1129043.	-140306.
6.71400	0.00108027	1129286.	-140936.
6.15450	0.00108375	1129313.	-140383.
5.59500	0.00108372	1129146.	-141061.
5.03550	0.00108245	1128769.	-141340.
4.47600	0.00108418	1128182.	-141316.
3.91650	0.00108398	1128503.	-141525.
3.35700	0.00108382	1129231.	-141633.
2.79750	0.00108436	1129117.	-141611.
2.23800	0.00108434	1129221.	-141777.
1.67850	0.00108635	1129212.	-141756.
1.11900	0.00110741	1129130.	-145902.
1.11900	0.000000	1352318590.	-5035443067.

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	Pile-head Load 1	Load Type	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	35000.	M, in-lb	1116000.	256000.	0.00108	-3.35E-04	-139073.	1121544.

Maximum pile-head deflection = 0.0010778857 inches
Maximum pile-head rotation = -0.0003347569 radians = -0.019180 deg.

Summary of Warning Messages

The following warning was reported 10000 times

**** Warning ****

An unreasonable input value for unconfined compressive strength has been specified for a soil defined using the weak rock criteria. The input value is greater than 1000 psi. Please check your input data for correctness.

The analysis ended normally.