FINAL REPORT
STRUCTURE FOUNDATION EXPLORATION
BRIDGE LAW-378-4.84 OVER VENISONHAM CREEK
PID: 119953
LAWERENCE 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 (LAW-378-4.84 PID# 119953) for the planned replacement of the existing bridge carrying SR-378 over Venisonham Creek in Lawerence County, Ohio. The report presents a summary of the encountered surficial and subsurface conditions and our recommendations for bridge foundation design and construction.

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 2 project borings and conducted laboratory testing to characterize the soils for engineering purposes. The report presents a summary of the encountered surficial and subsurface conditions and our recommendations for bridge foundation design and construction.

At the site of the proposed bridge over Venisonham Creek, natural soil was encountered below the surficial pavement, which had a thickness ranging from 5 to 6 inches. The subsurface profile consists of primarily very stiff to hard cohesive fine materials, with some loose to very dense granular materials. Bedrock was encountered in both the project borings and historical borings. In the project borings, bedrock was encountered at a depth of 10.5 feet below ground surface (561.9 feet above mean sea level) at the rear abutment and at a depth of 12.5 feet below ground surface (559.2 feet above mean sea level) at the forward abutment.

Based on our subgrade analysis, unstable and high moisture content soils were encountered in more than 30% of the proposed subgrade surface. These soils exhibited an N_{60} value below 12 bpf and a moisture content exceeding the optimum level by more than 3 percent within 3 feet of subgrade. According to ODOT GDM Section 605, “for all other roadways, if it is determined that 30 percent or more of the subgrade area must be stabilized, consider stabilizing the entire project (global stabilization)”. Therefore, NEAS recommends global stabilization using one of the following methods: Item 204 Excavate and Replace with Geotextile to a depth of 21 inches, Item 204 Excavate and Replace with Geogrid to a depth of 15 inches, or Item 206 Cement Stabilization to a depth of 14 inches.

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.

Based on our shaft scour evaluation and the analyses of laterally and axially loaded piles, the estimated shaft lengths are 8 ft for the rear abutment and 7 ft for the forward abutment. It is recommended that each drilled shaft be socketed to a minimum depth of 1.5 times the shaft diameter below the lower of the scour elevation or the top of rock elevation. The corresponding estimated shaft tip elevations are 554.8 ft at the rear abutment and 554.7 ft at the forward abutment.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

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 OH-378 over Venisonham Creek in Lawrence County, Ohio. The report presents a summary of the encountered surficial and subsurface conditions and our recommendations for bridge foundation design and construction in accordance with Load and Resistance Factor Design (LRFD) method as set forth in AASHTO's Publication LRFD Bridge Design Specifications, 9th Edition (BDS) (AASHTO, 2020), ODOT's 2024 Bridge Design Manual (BDM) (ODOT, 2024) and 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 November 16, 2023, and with the provisions of ODOT's *Specifications for Geotechnical Explorations* (SGE) (ODOT[2], 2024).

The scope of work performed included: 1) a review of published geotechnical information; 2) performing 2 test borings as part of the referenced structure foundation exploration; 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

It is our understanding that the bridge LAW-378-04840 carrying SR-378 over Venisonham Creek is proposed to be replaced. The existing structure is a single span non-composite prestressed concrete box beam bridge with wall abutments on spread footing foundations. The roadway for the existing bridge is 32'-0" wide.

The proposed replacement structure is a single span composite prestressed box beam bridge with semi-integral stub abutments on drilled shaft foundations. The roadway for the proposed bridge is 36'-0" wide.

2. GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1. Geology and Physiography

The project site is located within the Marietta Plateau physiographic region. This area is characterized as a dissected plateau of high relief (350 to 600 ft near the Ohio River) comprised of mostly fine-grained rocks with red shales and soils common. Remnants of ancient lacustrine clay-filled Teays drainage systems are common as well as landslides. The geology in this region is described as Pleistoscene-age Minford Clay or red and brown silty-clay loam colluvium with landslide deposits over Pennsylvanian-age to Permian-age red and gray shales, and siltstones, sandstones, limestones, and coals (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), the bedrock within the project area consists of a combination of shale, siltstone and sandstone from the Conemaugh formation.

The formation is comprised of Pennsylvanian-age. This formation is described as; Shale, siltstone, and mudstone: Shale, black, gray, green and red; clayey to silty; locally contains marine fossils in lower half of unit; calcareous in part. Siltstone, gray, green and red, locally variegated; clayed to sandy; thin bedded to nonbedded. Mudstone, black, gray, green, red, and yellow, variegated in part; clayey to silty; locally calcareous; commonly nonbedded. Sandstone, green-gray weathers to shades of yellow-brown; mostly very fine to medium grained, locally conglomeratic; thin to massive to cross bedded; locally calcareous. Limestone and coal; thin and discontinuous. Limestone, black, gray and green; micritic to coarse grained; thin bedded to concretionary with marine fossils common in lower half of interval; thin to medium bedded, nonmarine limestone common in upper half of unit. Coal, thin, bituminous, impure; very locally thick enough for economic development. Lateral and vertical lithic variability and gradation are common.

The bedrock appears to follow the natural topography of the site. 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 560 ft amsl, putting bedrock at depths of between 10 and 15 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 mix of Cuba silt loam, and Omulga silt loam. Cuba silt loam series is comprised of fine-grained soils and classified as A-4, and A-6 type soils according to the AASHTO method of soil classification. Omulga silt loam series is comprised of fine-grained soils and classified as A-4, A-6 and A-7 type soils according to the AASHTO method of soil classification.

2.2. Hydrology/Hydrogeology

Groundwater at the project site can be expected at an elevation consistent with that of the nearby Venisonham creek as it is the most dominant hydraulic influence in the vicinity of the project's boundaries. The water level of the Venisonham creek may be generally representative of 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 following report/plans were available for review and evaluation for this report:

• Project plan, profile and soil boring logs data for LAW-378-04.84, Dated April 12, 1974

Historical soil borings, B-002-0-73 and B-003-0-73 were reviewed and have been included in Appendix B of the report.

2.5. Field Reconnaissance

A field reconnaissance visits for the bridge carrying SR-378 over Venisonham Creek was conducted on January 31st, 2024, in Lawrence County, Ohio. During this visist, site conditions were noted and photographed.

Land use at the project site is primarily agricultural and forested.

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

The roadway embankment slopes at the site generally appeared stable, with no signs of instability observed during the site visit. The slopes, approximately 2 Horizontal to 1 Vertical (2H:1V), were vegetated with grass and small shrubs.

Overall, the bridge appeared to be in fair condition, with some wear and degradation observed on both the superstructure and substructure. Spalling and exposed reinforcing steel were observed on one of the outside box beams (Photograph 1). Minor spalling and evidence of moisture intrusion at the bridge expansion joints were noted on the beam seats of both abutments (Photograph 2). However, no apparent signs of structural distress related to geotechnical concerns were identified during the reconnaissance.

In general, the existing bridge structure appeared to be well-drained, with no significant erosion noted at the bridge site. Some erosion of the creek banks was observed east of the existing bridge. (Photograph 3). The asphalt wearing course was in good condition, showing minimal signs of surface wear (Photograph 4). No standing water was observed on the bridge.

Evidence of slope movement, such as curving trees, was observed along the slopes leading down to Venisonham Creek in the immediate vicinity of the bridge (Photograph 5).

Photograph 1: Spalling and exposed steel on box beam

Photograph 2: Spalling and moisture intrusion around beam seat

Photograph 3: Creek bank erosion

Photograph 4: Asphalt wearing course

Photograph 5: Evidence of slope movement

3. GEOTECHNICAL EXPLORATION

3.1. Field Exploration Program

The project subsurface exploration was conducted by NEAS on February 14, 2024, and included 2 borings B-001-0-23 and B-002-0-23 drilled to depths between 23.3 ft and 23.5 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 located 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 (based on the surveyed Ohio State Plane North, NAD83, location) and the corresponding ground surface elevation. 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 1: Project Boring Summary

Boring Number	Location (Sta/offset)	Latitude	Longitude	Elevation (NAVD 88) (ft)	Depth (ft)	Structure
B-001-0-23	255+12, 11' LT	38.552360	-82.462870	572.4	23.5	Rear Abutment
B-002-0-23	255+75, 11' RT	38.552540	-82.462810	571.7	23.3	Forward Abutment

Notes:
1. Stationing and Offset are in reference to centerline of Proposed SR-378

Project borings were drilled using a CME D50 SN481 drilling rig utilizing 3.25-inch (inner diameter) hollow stem auger. In general, soil samples were recovered continuously to a depth of 13.5 ft bgs, then at 2.5-ft interval to end of boring depth (EOB), thereafter 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 either auger cuttings 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 and moisture content determinations. 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 2: 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	571.9' - 570.4'	A-2-6 ~ CLAYEY SAND with GRAVEL(SC)	0.482	0.010	0.482	1.820
	SS-3	567.4' - 565.9'	A-6b ~ LEAN CLAY with SAND(CL)	0.010	0.319	15.273	3.484
	SS-6	563.9' - 562.4'	A-6a ~ SANDY LEAN CLAY(CL)	0.057	0.241	11.515	3.337
B-002-0-23	SS-2	569.2' - 567.7'	A-6a ~ SANDY LEAN CLAY with GRAVEL (CL)	0.033	0.268	12.816	3.413
	SS-4	566.2' - 564.7'	A-6a ~ CLAYEY SAND(SC)	0.091	0.162	7.772	3.168
	SS-7	561.7' - 560.2'	A-2-4 ~ CLAYEY GRAVEL with SAND(GC)	1.375	0.029	1.375	2.366

Based on our lab testing results, the equivalent D_{50} (mm) values of bedrock were estimated using the methods outlined 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 3,851.3 mm based on the boring B-001-0-23, and at the forward abutment, the equivalent D_{50} (mm) is estimated to be 19,440.6 mm based on the boring B-002-0-23. The lab testing results and the equivalent D_{50} (mm) calculation process are provided in Appendix B.

3.2.4. 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 3 below and provided in Appendix B.

Table 3: Unconfined Compressive Strength of Rock Core Results

Boring ID	Depth (ft)	Elevation (ft)	Unconfined Compressive Strength (psi)	Stain at Failure (%)
B-001-0-23	14.4 - 14.8	558.0 - 557.6	5,903	1.4
B-002-0-23	13.6 - 14.0	558.1 -557.7	4,629	1.3

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

4.1.1. Overburden Soil

At the site of the proposed bridge over Venisonham Creek, natural soil was encountered below the surficial pavement, which had a thickness ranging from 5 to 6 inches.

At the rear abutment location, the encountered soils consisted of 1.5 ft of granular soils, followed by 8.5 ft of cohesive soils. The granular soil extends from an elevation of 571.9 ft to 570.4 ft amsl, while the cohesive materials extend from 570.4 ft to 561.9 ft amsl. The cohesive soils are classified as Silt and Clay (A-6a) and Silty Clay (A-6b) while the granular soils are classified as gravel with sand, silt and clay (A-2-6). For the cohesive soils, the material consistency can be described as stiff to very stiff based on N_{60} values between 3 bpf to 17 bpf and unconfined compressive strengths (estimated by means of hand penetrometer) between approximately 2.00 and 4.00 tons per square foot (tsf). Based on Atterberg Limits test performed on a representative sample of the cohesive materials, the liquid limits ranged from 33 to 35 percent and the plastic limit was 19 percent. Natural moisture contents of the cohesive soils ranged from 18 to 23 percent. For granular soil it can be described as having a relative compactness of medium dense based on N_{60} value of 12 bpf. The natural moisture content of the non-cohesive soil was 13 percent.

At the forward abutment location, the encountered soils consisted of 9.6 ft of cohesive soils, underlain by 2.5 ft of granular soils. The cohesive materials extend from an elevation of 571.3 ft to 561.7 ft amsl, while the granular materials extend from 561.7 ft to 559.2 ft amsl. The cohesive soils are classified as Silt and Clay (A-6a) while the granular soils are classified as Stone Fragments with Sand and Silt (A-2-4). For the cohesive soils, the material consistency can be described as stiff to very stiff based on N_{60} values between 7 bpf to 13 bpf and unconfined compressive strengths (estimated by means of hand penetrometer) between approximately 1.75 and 3.50 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 35 to 37 percent and 22 to 23 percent, respectively. Natural moisture contents of the cohesive soils ranged from 15 to 22 percent. For granular soil it can be described as having a relative compactness of loose to very dense

based on N_{60} values ranging between 10 to 65 bpf. The natural moisture content of the non-cohesive soil ranged was 18 percent.

4.1.2. Groundwater

Groundwater measurements were taken during the drilling procedures and/or immediately following the completion of each borehole. Groundwater was encountered in one project boring B-002-0-23 at an elevation of 561.7 ft amsl (10 ft bgs) 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 performed at the bridge site. At the rear abutment (B-001-0-23), bedrock was encountered at an elevation of 561.9 ft amsl, extending to the end of boring (EOB) (10.5 ft bgs to 23.5 ft bgs), and was classified as Shale and Sandstone. The Shale bedrock layer extends from 551.9 ft to 550.4 ft amsl, with a depth of 1.5 ft, and can be described as highly weathered, very weak to weak. The Sandstone layer extends from 550.4 to EOB and can be described as slightly weathered, moderately strong, and very fine to medium grained. At the forward abutment (B-002-0-23), rock was encountered at an elevation of 559.2 ft amsl, extending to the end of boring (EOB) (12.5 ft bgs to 23.3 ft bgs), and was classified as Sandstone. This layer can be described as slightly weathered, moderately strong, and very fine to medium grained.

5. ANALYSES AND RECOMMENDATIONS

We understand that this project entails replacing the existing bridge with a single span composite prestressed box beam bridge with semi-integral stub abutments on drilled shaft foundations and the roadway width of 36 ft. The summary and results of our evaluation as well as recommendations presented in subsequent sections.

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 4 and 5 below.

Table 4: Soil Profile and Estimated Soil Parameters – B-001-0-23

LAW-378-4.84 Bridge: Rear Abutment 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})
Gravel with Sand, Silt and Clay Depth (572.4 ft - 570.4 ft)	112	112	122	-	-	34	1.20
Silty Clay Depth (570.4 ft - 563.9 ft)	108	108	118	900	100	22	1.75
Silt and Clay Depth (563.9 ft - 561.9 ft)	112	112	122	2100	200	24	1.50
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 5: Soil Profile and Estimated Soil Parameters – B-002-0-23

LAW-378-4.84 Bridge: Forward Abutment 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})
Silt and Clay Depth (571.7 ft - 561.7 ft)	110	110	120	1250	150	23	1.50
Gravel with Sand and Silt Depth (561.7 ft - 559.2 ft)	122	112	122	-	-	33	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 6 -7 below.

Table 6: LPILE Soil Parameters - B-001-0-23

LAW-378-4.84 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	572.4	570.4	2	A-2-6	Sand (Reese)	-	179
2	570.4	563.9	8.5	A-6b	Stiff Clay w/o Water	0.0101	183
3	563.9	561.9	10.5	A-6a	Stiff Clay w/o Water	0.0060	708
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	561.9	548.9	23.5	Shale	Weak Rock	0.00005	530000

Table 7: LPILE Soil Parameters - B-002-0-22

LAW-378-4.84 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	571.7	561.7	10	A-6a	Stiff Clay w/o Water	0.0081	359
2	561.7	559.2	12.5	A-2-4	Sand (Reese)	-	69
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	559.2	548.4	23.3	Sandstone	Weak Rock	0.00005	420000

5.2. Pavement Design and Recommendations

The subgrade analysis was performed in accordance with ODOT's GDM Section 600 criteria utilizing the ODOT provided*: Roadway Subgrade Analysis Spreadsheet* (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 roadway 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 roadway subgrade analysis including pavement design parameters and unsuitable subgrade conditions if any identified within the project limits. Roadway 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 roadway 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 8 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 8: Pavement Design Values

Segment	Maximum N_{60L}	Minimum N_{60L}	Average N_{60L}	Average PI Value	Design CBR
SR-378	7	3	5	14	6

5.2.2. Unsuitable/Unstable Subgrade

Per ODOT's GDM Section 600, 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 both borings performed; therefore, no specialized remediation efforts are required.

5.2.2.2. Prohibited Soils

Prohibited soil types, per the GDM Section 600, 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 Section 600 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, *GDM Figure 600-1 - Subgrade Stabilization* within the GDM Section 600 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 Section 600 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.

Information on the boring location where weak soils were encountered and determined to have a potential impact on subgrade performance is shown in Table 9 below.

Table 9: Unstable Soil Locations Summary

Boring ID	N_{60L}	Subgrade Depth (ft)
B-001-0-23	12	0.0 - 1.5
B-002-0-23	10	0.0 - 1.5

It should be noted that *GDM Figure 600-1 - 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 GDM Section 600 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 Section 600 as soils that exceed the estimated optimum moisture content (per GDM Table 600-1 - Optimum Moisture Content within the GDM Section 600) for a given classification by 3 percent or more. Per the GDM Section 600, 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 10 below.

Table 10: High Moisture Content Soils Summary

Boring ID	Soil Type	Moisture Content (%)	Optimum Moisture Content (%)	Depth Below Subgrade (ft)
B-001-0-23	A-2-6	13	10	0.0 - 1.5

5.2.3. Stabilization Recommendations

According to our subgrade analysis, unstable and high moisture content soils were encountered in 100% of the proposed subgrade surface. These soils exhibited an N_{60} value below 12 bpf and a moisture content exceeding the optimum level by more than 3 percent within 3 feet of subgrade. According to ODOT GDM Section 605, "for all other roadways, if it is determined that 30 percent or more of the subgrade area must be stabilized, consider stabilizing the entire project (global stabilization)". Therefore, NEAS recommends global stabilization using one of the following methods: Item 204 Excavate and Replace with Geotextile to a depth of 21 inches, Item 204 Excavate and Replace with Geogrid to a depth of 15 inches, or Item 206 Cement Stabilization to a depth of 14 inches.

Stabilization limits should extend 18-inches beyond the edge of the proposed paved roadway, shoulder or median and it is recommended removing any topsoil, existing pavement materials or abandoned structure foundation materials. The mix design should be conducted in accordance with ODOT's CMS Supplement 1120 (Mixture Design for Chemically Stabilized Soils). For design purposes it may be assumed that the cement addition will be 5% using the following formula.

$$\text{Cement: } C = 0.75 \times T \times 115 \times 0.05$$

Where:

C = amount of chemical in pounds / square yard and

T = thickness of the treatment zone in inches

A dry density of 115-pounds per cubic foot (pcf) is assumed.

It should be noted that per ODOT's GDM, *typical chemical stabilization equipment cannot stabilize areas less than 8 ft in width.* If it is anticipated that the project will require multiple maintenance of traffic phases, it is recommended that the roadway work is coordinated with the maintenance of traffic schemes in such a way that an 8-ft minimum width for chemical stabilization exists. If areas of less than 8 ft in width are anticipated, subgrade soils may be excavated out, mixed with stabilization chemical, and compacted in place, though this method is not practical for large areas.

NEAS's opinion that the subgrade soils will provide adequate pavement support assuming it is designed and constructed in accordance with the recommendations provided within this report, as well as all applicable ODOT standards and specifications.

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. Shaft Scour Consideration

Bedrock was encountered at the project site in both structural borings, at elevations of 561.9 ft and 559.2 ft at the rear and forward abutments, respectively. The Rock Quality Designation (RQD) of the sandstone ranged from 98% to 100%. Unconfined compressive strength tests conducted on rock cores at the bridge site indicate that the unconfined compressive strength of the sandstone ranges from 4,629 psi to 5,903 psi. The estimated Erodibility Index K for the sandstone falls between 231.53 and 5899.28.

According to ODOT BDM Section 305.2.1.2.b, the top 1.5 ft of shale encountered at the rear abutment is classified as non-scour resistant rock. The sandstone bedrock encountered at the forward abutment and below elevation 560.4 ft at the rear abutment is classified as scour-resistant rock. The evaluation process is detailed in Appendix C.

Based on scour information provided by American Structurepoint via email on January 23, 2024, the design and check flood scour elevations are 559.32 ft at the rear abutment and 560.82 ft at the forward abutment.

5.3.2. Axially Loaded Pile Analysis

Deep foundations will be used to support the substructures of the proposed LAW-378-04840 bridge over Venisonham Creek. According to the site plan provided by American Structurepoint via email on August 2, 2024, the bottom of footing is approximately at the elevation of 562.00 ft and 561.00 ft for the rear and forward abutments, respectively. At the project site, bedrock was encountered in both structural borings at the elevation of 561.9 ft and 559.2 ft at the rear and forward abutments, respectively. Both abutments will be supported on a 3'-0" diameter drilled shaft with 3'-0" diameter rock socket.

Based on the email from American Structurepoint dated December 17, 2024, the Service I and the Strength I axial loads for the abutment shafts are 237.0 kips and 325.8 kips, respectively. A drilled shaft foundation analysis was performed at the proposed bridge location in accordance with the LRFD BDS. Specifically, the procedures in Section 10.8.3.5.4 of the LRFD BDS were used to calculate the nominal and factored unit tip resistance (per LRFD BDS Section 10.8.3.5.4c) in rock for drilled shaft foundations at each substructure.

Design based solely on end-bearing should be sufficient to support the drilled shaft loads at the referenced bridge site. As no voids, karst features, clay-filled seams, or adverse jointing conditions were identified within the site bedrock, LRFD BDS Equation 10.8.3.5.4c-1 was utilized for calculating drilled shaft tip resistance. The tip resistance was determined based on: 1) bedrock properties obtained from lab testing, and 2) an assumed compressive strength of 4,000 pounds per square inch (psi) for the concrete used in shaft construction.

The nominal and factored unit tip resistances for a drilled shaft foundation socketed in rock are summarized in Table 11 below. In accordance with LRFD BDS Table 10.5.5.2.4-1, the nominal resistance was multiplied by a resistance factor of 0.50 to obtain the factored unit tip resistance. Drilled shaft tip resistance calculations for each substructure are provided in Appendix D.

Table 11: Rock Socket Resistance Summary

Substructure	Drilled Shaft Diameter (in)	Rock Socket Diameter (in)	Nominal Unit Tip Resistance (kips)	Factored Unit Tip Resistance (kips)
Rear Abutment	36	36	15,021	7,511
Forward Abutment	36	36	11,779	5,890

Notes:
1. *Compressive strength of rock exceeded the drilled shaft concrete compressive strength. Unit resistance limited based on 4,000 psi drilled shaft concrete.*

Since only tip resistance is utilized in the rock socket design, ODOT's BDM plan note 606.8-1 should be revised as follows: 'The maximum factored load at each substructure is fully supported by the drilled shafts in tip resistance, ignoring any contribution from side resistance.'

5.3.3. Laterally Loaded Pile Analysis

For the drilled shaft under laterally loaded condition, it is important to ensure that the shafts extend to the specified depth (Second Fixity Point) outlined in Table 12 to limit the pile head lateral deflection. The results of the laterally loaded shaft analyses performed using LPILE are summarized in Table 12, with the detailed LPILE analyses output included in Appendix E. ODOT's BDM plan note 606.8-3 can be incorporated into the structure General Notes.

Based on our laterally loaded analyses for single shaft, as can be seen, the Second Fixity Point is at 5.5 ft and 5.3 ft below shaft head for the rear and forward abutment, respectively.

Table 12: Laterally Loaded Shaft Analysis Summary

Location	Maximum Moment in Shaft - Strength Limit State (in-lbs)	Depth of Maximum Bending Moment below Shaft Head (ft)	Maximum Shear in Shaft- Strength Limit State (lbs)	Depth of Maximum Shear Force below Shaft Head (ft)	Shaft Head Deflection - Service Limit State (in)	First Fixity Point below Shaft Head (ft)	Second Fixity Point below Shaft Head (ft)
Rear Abutment @ B-001-0-23							
Rear Abutment	5,683,521	1.8	308,623	2.7	0.01	2.7	5.5
Forward Abutment @ B-002-0-23							
Forward Abutment	5,393,590	1.4	276,590	2.4	0.00	2.5	5.4

5.3.4. Pile Foundation Recommendations

It is recommended that each drilled shaft be socketed to a minimum depth of 1.5 times the shaft diameter below the lower of the scour elevation or the top of rock elevation. The estimated lengths of the shaft and socket are summarized in Table 13 below.

Table 13: Estimated Drilled Shaft Length Summary

Substructure	Bottom of Footing (ft)	Estimated Top of Rock Elevation (ft)	Estimated Shaft Tip Elevation (ft)	Drilled Shaft Diameter (in)	Rock Socket Diameter (in)	Min. Rocket Socket Length [1] (ft)	Estimated Shaft Length [2] (ft)
Rear Abutment	562.0	561.9	554.8	36	36	7.1	8.0
Forward Abutment	561.0	559.2	554.7	36	36	4.5	7.0

Notes:

1. Each drilled shaft should be socketed to a minimum depth of 1.5 times the shaft diameter below the lower of the scour elevation or the top of rock elevation.
2. *Estimated Shaft Length rounded up to the nearest 1.0 ft.*

5.3.5. Global Stability

Global stability is not expected to be a concern due to the presence of 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 LAW-378-4.84 (PID# 119953) 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 LAW-378-4.84 (PID# 119953) 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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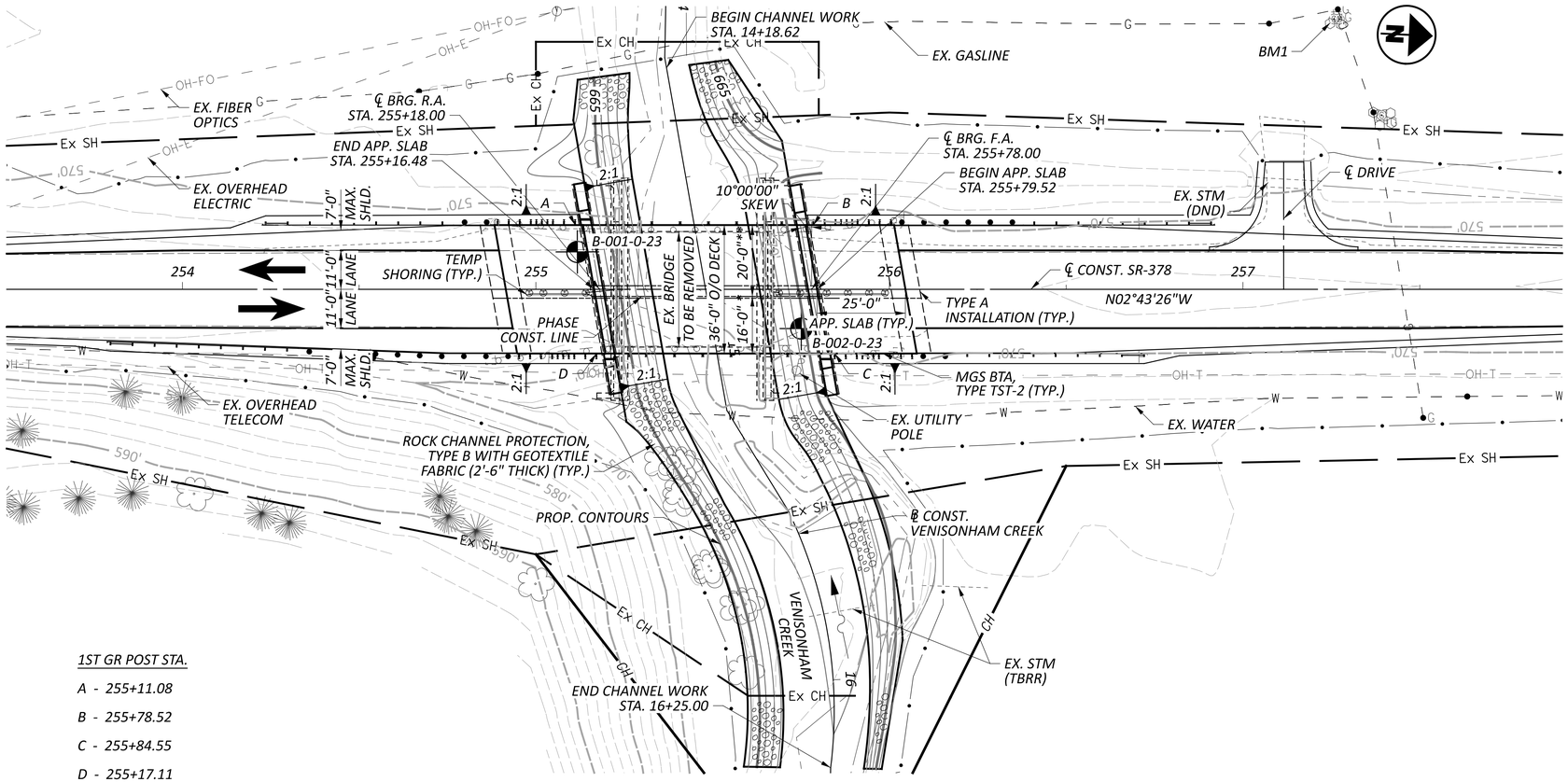
APPENDIX A

SITE PLAN & BORING LOCATION PLAN



1ST GR POST STA.

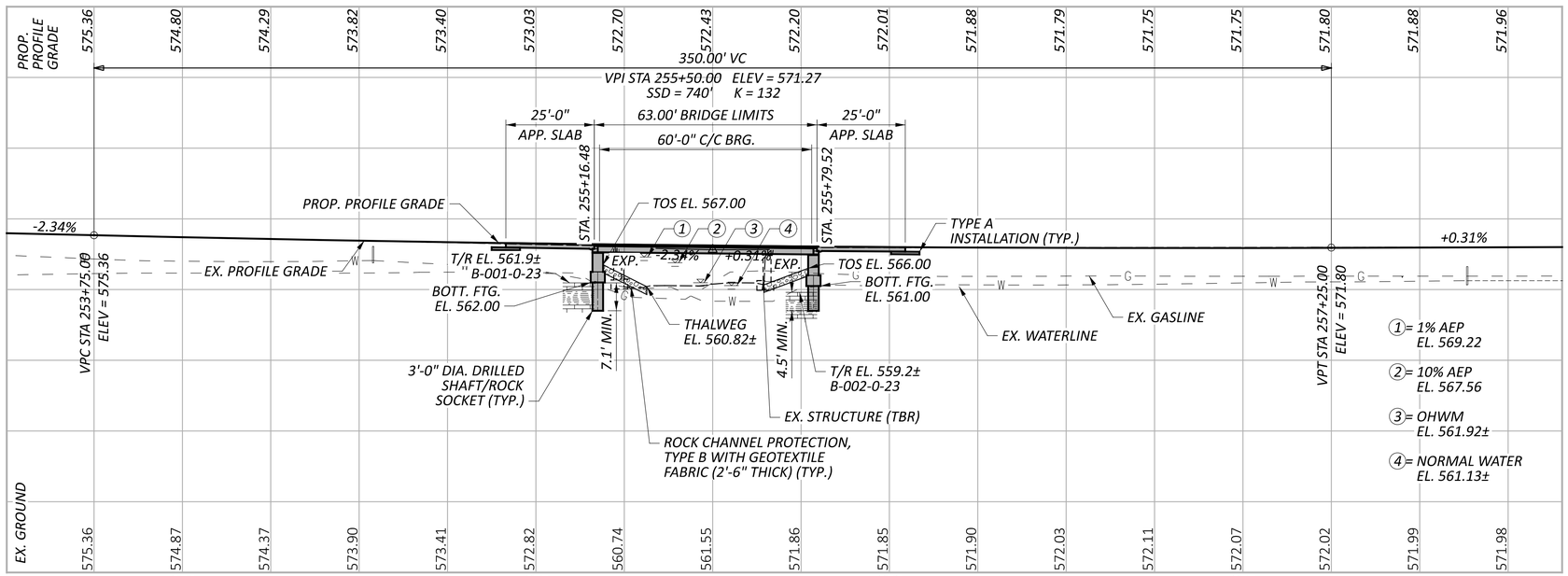
A - 255+11.08

B - 255+78.52

C - 255+84.55

D - 255+17.11

PLAN



PROFILE

ALONG ℄ CONST. SR-378

BENCHMARK DATA

BM1 STA. 257+25.74, ELEV. 566.699, OFFSET 76.45' LT., CENTER BOLT ON GAS VALVE

FOR ADDITIONAL BENCHMARK INFORMATION. SEE ROADWAY PLAN SHEET 11 & 12/56.

NOTES

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

SEE SHEET XX/XX FOR ℄ CONST. VENISONHAM CREEK COORDINATES.

DESIGN TRAFFIC:

2024 ADT = 1005 *2024 ADTT = 31*

2044 ADT = 1248 *2044 ADTT = 38*

DIRECTIONAL DISTRIBUTION = 51%

LEGEND

BORING LOCATION

** - PHASE 1 CONSTRUCTION*
*** - PHASE 2 CONSTRUCTION*
BTA - BRIDGE TERMINAL ASSEMBLY
DND - DO NOT DISTURB
TBR - TO BE REMOVED
TBRR - TO BE REMOVED AND REPLACED

HYDRAULIC DATA

DRAINAGE AREA = 5.92 SQ. MILES

Q (10% AEP) = 1090 CFS *V (10% AEP) = 3.70 FT/S*

Q (1% AEP) = 2210 CFS *V (1% AEP) = 5.51 FT/S*

STRUCTURE CLEARS THE 10% AEP STORM DESIGN HW BY 1.83 FEET

EXISTING STRUCTURE

TYPE: SINGLE SPAN NON-COMPOSITE PRESTRESSED CONCRETE BOX BEAMS WITH WALL ABUTMENTS ON SPREAD FOOTING FOUNDATIONS

SPANS: 41'-6"± C/C BRG.
ROADWAY: 32'-0"± F/F RAIL
VEHICULAR LIVE LOAD: HS20-44
SKEW: NONE
WEARING SURFACE: 2½"± ASPHALT CONCRETE
APPROACH SLABS: NONE
ALIGNMENT: TANGENT
CROWN: 0.016± FT/FT
STRUCTURE FILE NUMBER: 4403746
DATE BUILT: 1979
DISPOSITION: TO BE REPLACED

PROPOSED STRUCTURE

TYPE: SINGLE SPAN COMPOSITE PRESTRESSED CONCRETE BOX BEAMS WITH SEMI-INTEGRAL STUB ABUTMENTS ON DRILLED SHAFT FOUNDATIONS

SPANS: 60'-0" C/C BRG.
ROADWAY: 36'-0"± F/F RAIL
VEHICULAR LIVE LOAD: HL-93
FUTURE WEARING SURFACE: 0.06 KSF
SKEW: 10°00'00" RIGHT FORWARD
APPROACH SLABS: 25'-0" LONG (AS-1-15, AS-2-15 TYPE A)
ALIGNMENT: TANGENT
CROWN: 0.016 FT/FT
DECK AREA: 2291 SF

COORDINATES: LATITUDE 38°33'08.82" N
LONGITUDE 82°27'46.18" W

SITE PLAN
BRIDGE NO. LAW-378-04840
SR 378 OVER VENISONHAM CREEK

SFN	4403747
DESIGN AGENCY	STRUCTUREPOINT
DESIGNER	BMK
CHECKER	SJF
REVIEWER	CLB 01-29-25
PROJECT ID	119953
SUBSET	1
TOTAL	22
SHEET	P.30
TOTAL	56

LAW-378-4.84

MODEL: CLP_6 - Plan 3 [Sheet] PAPERSIZE: 34x22 (in.) DATE: 1/30/2025 TIME: 9:29:45 AM USER: SFlannagan
O:\2023\03013\C. Design\119953-LAW-378-4.84\400-Engineering\Structures\SFN_4403746\Sheets\119953_SFN_4403746_SP001.dgn


LAW-378-4.84
Boring Location Plan
Legend
Feature 1
378
B-002-0-23
B-001-0-23
Google Earth
N
100 ft

APPENDIX B

BORING LOGS

PROJECT: LAW-378-4.84	DRILLING FIRM / OPERATOR: CS / TS	DRILL RIG: D50 SN481	STATION / OFFSET: 255+12, 11' LT.	EXPLORATION ID B-001-0-23
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: NEAS / LR	HAMMER: CME AUTOMATIC	ALIGNMENT: SR-378	
PID: 119953 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 3/14/22	ELEVATION: 572.4 (MSL) EOB: 23.5 ft.	PAGE 1 OF 1
START: 2/14/24 END: 2/14/24	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 86.8	LAT / LONG: 38.552360, -82.462870	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
6.0" ASPHALT	572.4 / 571.9																	
MEDIUM DENSE, BROWN, **GRAVEL WITH SAND, SILT, AND CLAY**, DAMP	570.4		5 5 3	12	50	SS-1	-	29	23	18	16	14	30	18	12	13	A-2-6 (0)	
STIFF TO VERY STIFF, BROWN AND ORANGISH BROWN, **SILTY CLAY**, SOME SAND, TRACE GRAVEL, IRON STAINING, DAMP TO MOIST			4 2 2	6	50	SS-2	2.25	-	-	-	-	-	-	-	-	18	A-6b (V)	
			2 2 3	7	67	SS-3	2.00	2	8	15	39	36	35	19	16	21	A-6b (10)	
			2 1 1	3	61	SS-4	2.00	-	-	-	-	-	-	-	-	21	A-6b (V)	
	563.9		2 4 5	13	94	SS-5	3.25	-	-	-	-	-	-	-	-	23	A-6b (V)	
VERY STIFF, ORANGISH BROWN, **SILT AND CLAY**, "AND" SAND, TRACE GRAVEL, IRON STAINING, DAMP	561.9		3 4 8	17	100	SS-6	4.00	10	11	26	28	25	33	19	14	18	A-6a (5)	
SHALE, LIGHT BROWN AND ORANGISH BROWN, HIGHLY WEATHERED, VERY WEAK, FISSILE, ARENACEOUS.	560.4	TR	5 27 50/5"	-	100	SS-7	-	-	-	-	-	-	-	-	-	10	Rock (V)	
			50/4"	-	100	SS-8	-	-	-	-	-	-	-	-	-	6	Rock (V)	
SANDSTONE, BROWN AND GRAY, SLIGHTLY WEATHERED, MODERATELY STRONG, VERY FINE TO MEDIUM GRAINED, THIN TO VERY THICK BEDDED, FRIABLE, 1/2" CLAY SEAM AT 13.8', BEDDING DISCONTINUITIES: LOW ANGLE, INTACT, OPEN TO NARROW, SLIGHTLY ROUGH, INTACT, GOOD SURFACE CONDITION, POOR SURFACE CONDITION AT 13.8'; RQD 100%, REC 100%. **@14.4'-14.8'; Qu = 5903 PSI @ 1.4%**			50/2"	-	100	SS-9	-	-	-	-	-	-	-	-	-	4	Rock (V)	
			100		100	NQ2-1											CORE	
	548.9	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 2 BAGS HOLE PLUG; SHOVELED SOIL CUTTINGS

OHIO DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING

Office of Geotechnical Engineering

B-001-0-23

Run #:	Depth		Recovery		RQD	
NQ2-1	13.5'	23.5'	120"	100%	120"	100%

LAW-378-4.84

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: LAW-378-4.84, Boring Location: B-001-0-23, NQ2-1, Depth: 14.4 - 14.8ft)

Tested Date: 3/22/2024

Specimen Properties

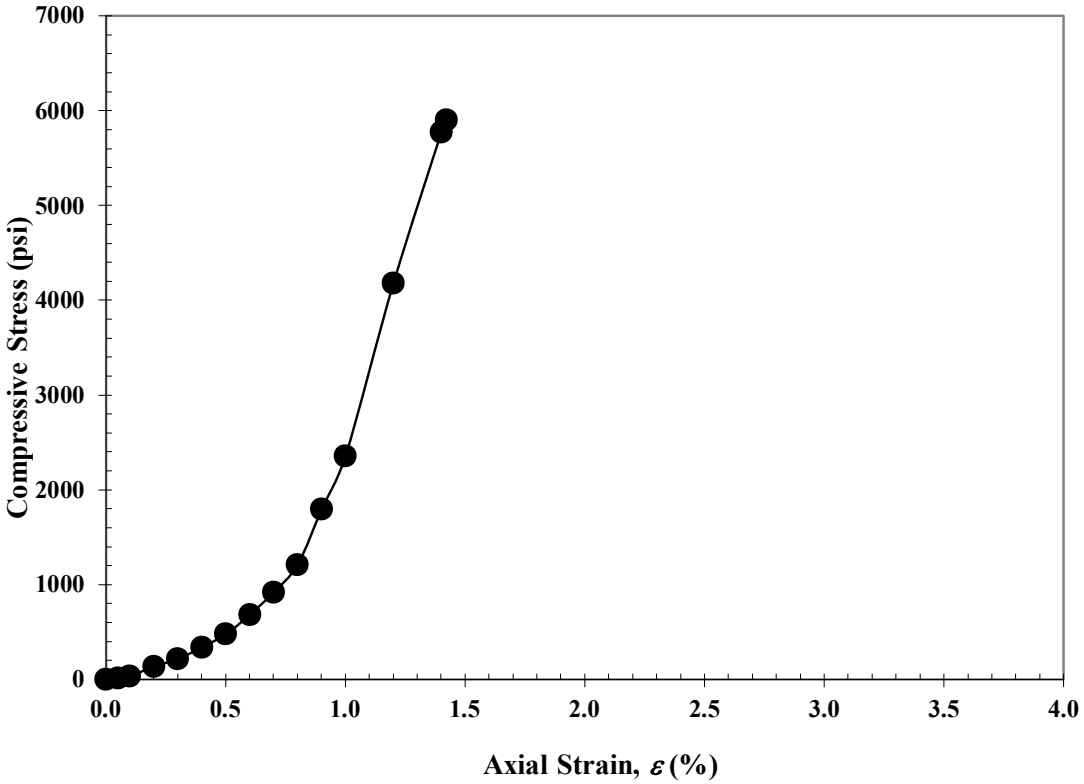
Average Dia., D_{avg} (in):	1.99
Average Height, H_{avg} (in):	4.43
Length to Diameter Ratio:	2.23
Area, A (in^2):	3.11
Volume, V (in^3):	13.78
Wet Mass of Specimen (lb):	1.2
Moisture Content (%):	1.9
Dry Mass of Specimen (lb):	1.2
Wet Unit Weight, γ (lb/ft^3):	154.5
Dry Unit Weight, γ_d (lb/ft^3):	151.6

Final Specimen Figure

Results

Unconfined Compressive Strength (psi): **5903** **41** (MPa)

Strain (%): **1.4**



Notes: Sandstone, gray, slightly weathered, moderately strong, very fine to medium grained, friable.

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.

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:

$q_u := 5903\ psi$ $\quad q_u = 40.7\ MPa$ — Uniaxial Compressive Strength of Rock Core

$RQD := 100$ — 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.

$J_r := 1$ — 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.

$J_a := 13$ — 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.

$M_s := 36$ — Intact Rock Mass Strength Parameter (ODOT BDM, Sect. 305.2.1.2.b.B.6.b)

Analysis:

$K_b := \frac{RQD}{J_n} = 81.97$ — 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)

$K := M_s \cdot K_b \cdot K_d \cdot J_s = 231.53$ — Erodibility Index (HEC-18, Eq. 4.17)

Approach Flow Stream Power (Pa):

Givens:

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

Analysis:

$\tau c\_Pa := \rho \cdot \left(\frac{1000 \cdot K^{0.75}}{7.853 \cdot \rho} \right)^{\frac{2}{3}}$ $\tau c\_Pa = 3851.3$ Critical shear stress (Pa)

$\tau c\_psf := \tau c\_Pa \cdot \frac{1}{47.88}\ psf$ $\tau c\_psf = 80.4\ psf$ Critical shear stress (Psf)

$D_{50\_equivalent} := \tau c\_Pa$ $D_{50\_equivalent} = 3851.3$ Equivalent D50 (mm)

PROJECT: LAW-378-4.84	DRILLING FIRM / OPERATOR: CS / TS	DRILL RIG: D50 SN481	STATION / OFFSET: 255+75, 11' RT.	EXPLORATION ID B-002-0-23
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: NEAS / LR	HAMMER: CME AUTOMATIC	ALIGNMENT: SR-378	
PID: 119953 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 3/14/22	ELEVATION: 571.7 (MSL) EOB: 23.3 ft.	PAGE 1 OF 1
START: 2/14/24 END: 2/14/24	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 86.8	LAT / LONG: 38.552540, -82.462810	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
5.0" ASPHALT	571.7																	
STIFF TO VERY STIFF, BROWN BECOMING GRAY AND ORANGISH BROWN, **SILT AND CLAY**, LITTLE TO SOME SAND, LITTLE TO SOME GRAVEL, DAMP	571.3		4 3 4	10	39	SS-1	3.50	-	-	-	-	-	-	-	-	15	A-6a (V)	
			3 2 3	7	44	SS-2	2.00	23	8	11	30	28	37	22	15	17	A-6a (7)	
			2 5 4	13	100	SS-3	1.75	-	-	-	-	-	-	-	-	22	A-6a (V)	
			4 3 5	12	100	SS-4	2.25	21	15	16	29	19	35	23	12	16	A-6a (3)	
			12 3 3	9	78	SS-5	3.00	-	-	-	-	-	-	-	-	19	A-6a (V)	
	561.7	W 561.7	3 3 4	10	94	SS-6	2.50	-	-	-	-	-	-	-	-	19	A-6a (V)	
LOOSE TO VERY DENSE, GRAY, **STONE FRAGMENTS WITH SAND AND SILT**, LITTLE CLAY, RESIDUAL SHALE, DAMP			9 5 2	10	67	SS-7	-	47	14	12	16	11	30	20	10	18	A-2-4 (0)	
	559.2	TR	2 1 44	65	61	SS-8	-	-	-	-	-	-	-	-	-	18	A-2-4 (V)	
SANDSTONE, GRAY AND LIGHT BROWN, SLIGHTLY WEATHERED, MODERATELY STRONG, FINE TO MEDIUM GRAINED, VERY THICK BEDDED, FRIABLE, BEDDING DISCONTINUITIES: LOW ANGLE, INTACT, NARROW, SLIGHTLY ROUGH, INTACT, GOOD SURFACE CONDITION; RQD 98%, REC 100%. **@13.6' - 14.0'; Qu = 4629 PSI @ 1.3%**			50/3"	-	100	SS-9	-	-	-	-	-	-	-	-	-	5	Rock (V)	
			98		100	NQ2-1											CORE	
	548.4	EOB																

NOTES: GROUNDWATER ENCOUNTERED AT 10.0' DURING DRILLING. HOLE DID NOT CAVE. DRILLED AS STAKED.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; POURED 2 BAGS HOLE PLUG; SHOVELED SOIL CUTTINGS

OHIO DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING

Office of Geotechnical Engineering

B-002-0-23

Run #:	Depth		Recovery		RQD	
NQ2-1	13.3'	23.3'	120"	100%	118"	98%

LAW-378-4.84

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: LAW-378-4.84, Boring Location: B-002-0-23, NQ2-1, Depth: 13.6 - 14.0ft)

Tested Date: 3/22/2024

Specimen Properties

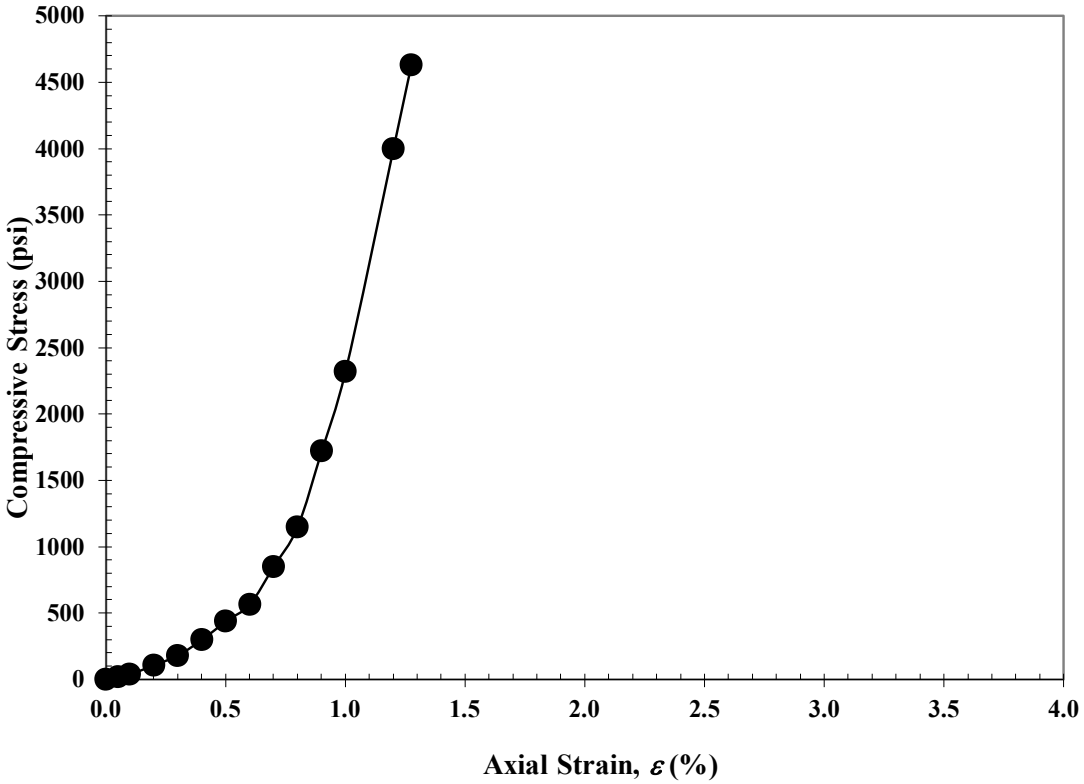
Average Dia., D_{avg} (in):	1.99
Average Height, H_{avg} (in):	4.39
Length to Diameter Ratio:	2.21
Area, A (in^2):	3.10
Volume, V (in^3):	13.62
Wet Mass of Specimen (lb):	1.2
Moisture Content (%):	1.7
Dry Mass of Specimen (lb):	1.2
Wet Unit Weight, γ (lb/ft^3):	149.6
Dry Unit Weight, γ_d (lb/ft^3):	147.1

Final Specimen Figure

Results

Unconfined Compressive Strength (psi): **4629** **32** (MPa)

Strain (%): **1.3**



Notes: Sandstone, gray, slightly weathered, moderately strong, fine to medium grained, friable.

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.

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:

$q_u := 4629\ psi$ $\quad q_u = 31.92\ MPa$ — Uniaxial Compressive Strength of Rock Core

$RQD := 98$ — 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.

$J_r := 2$ — 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.

$J_a := 1$ — 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.

$M_s := 36$ — Intact Rock Mass Strength Parameter (ODOT BDM, Sect. 305.2.1.2.b.B.6.b)

Analysis:

$K_b := \frac{RQD}{J_n} = 80.33$ — Block Size Parameter (HEC-18, Eq. 4.18)

$K_d := \frac{J_r}{J_a} = 2$ — Shear Strength Parameter (HEC-18, Eq. 4.19)

$K := M_s \cdot K_b \cdot K_d \cdot J_s = 5899.28$ — Erodibility Index (HEC-18, Eq. 4.17)

Approach Flow Stream Power (Pa):

Givens:

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

Analysis:

$\tau c\_Pa := \rho \cdot \left(\frac{1000 \cdot K^{0.75}}{7.853 \cdot \rho} \right)^{\frac{2}{3}}$ $\tau c\_Pa = 19440.6$ Critical shear stress (Pa)

$\tau c\_psf := \tau c\_Pa \cdot \frac{1}{47.88}\ psf$ $\tau c\_psf = 406\ psf$ Critical shear stress (Psf)

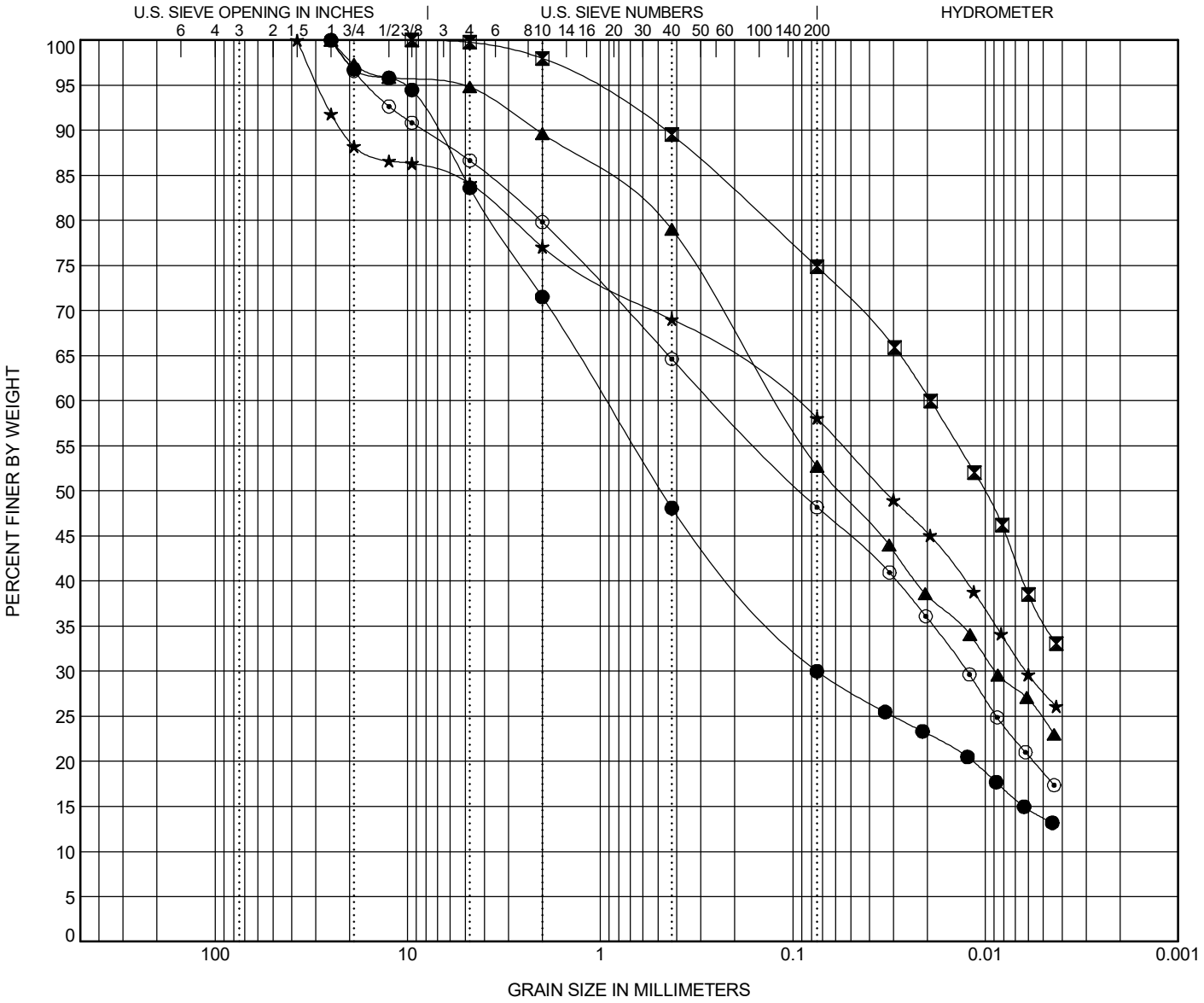
$D_{50\_equivalent} := \tau c\_Pa$ $D_{50\_equivalent} = 19440.6$ Equivalent D50 (mm)

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT LAW-378-4.84 **PID** 119953

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-2-6 ~ CLAYEY SAND with GRAVEL(SC)	30	18	12
⊠	B-001-0-23	4.0	A-6b ~ LEAN CLAY with SAND(CL)	35	19	16
▲	B-001-0-23	8.5	A-6a ~ SANDY LEAN CLAY(CL)	33	19	14
★	B-002-0-23	2.5	A-6a ~ SANDY LEAN CLAY with GRAVEL(CL)	37	22	15
⊙	B-002-0-23	5.5	A-6a ~ CLAYEY SAND(SC)	35	23	12

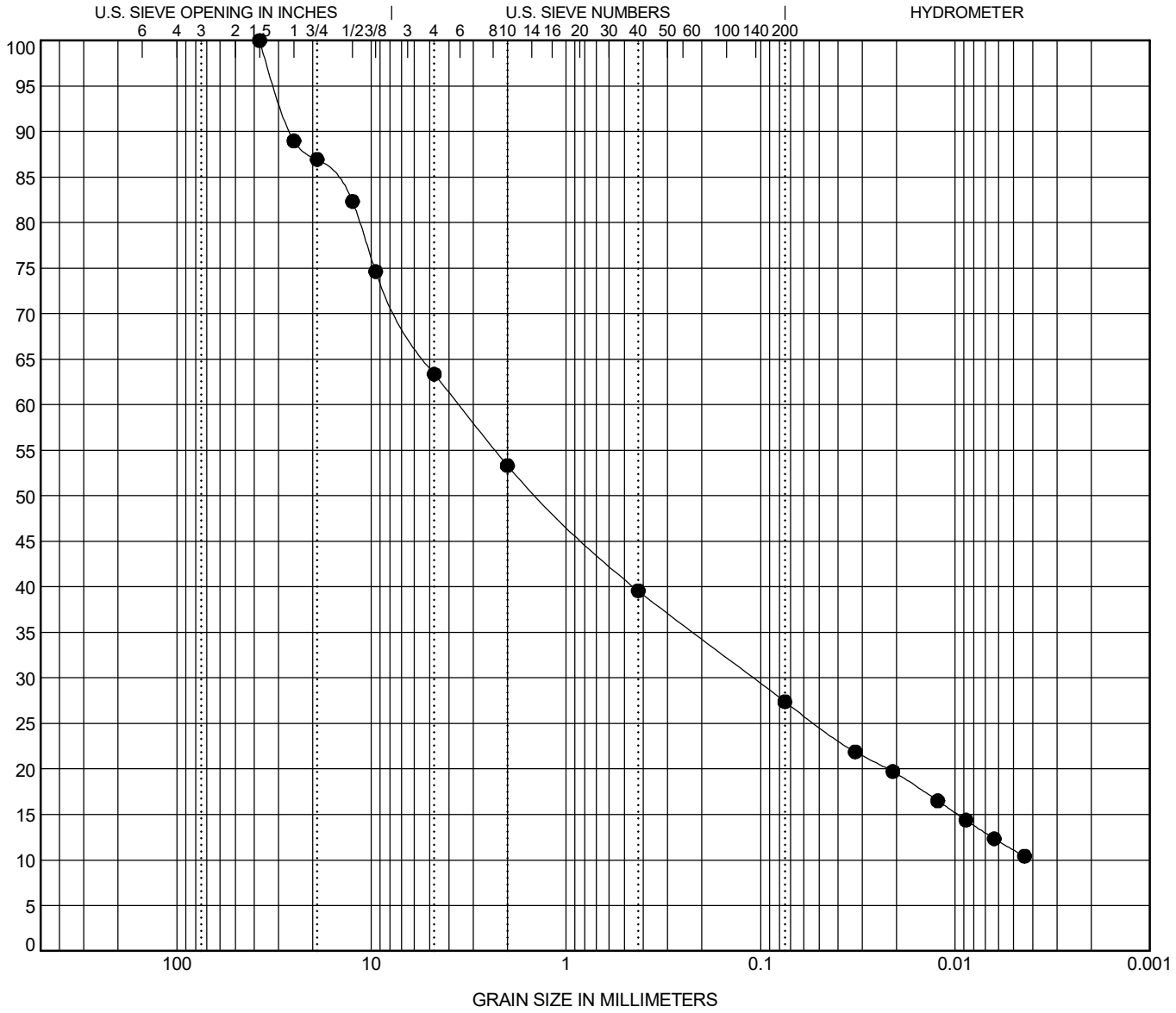
Specimen Identification			D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
●	B-001-0-23	1.0	7.136	0.482	0.075		29	23	18	16	14		
⊠	B-001-0-23	4.0	0.463	0.01			2	8	15	39	36		
▲	B-001-0-23	8.5	2.128	0.057	0.009		10	11	26	28	25		
★	B-002-0-23	2.5	21.749	0.033	0.006		23	8	11	30	28		
⊙	B-002-0-23	5.5	8.258	0.091	0.012		21	15	16	29	19		

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT LAW-378-4.84 **PID** 119953

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**	**10.0**	**A-2-4 ~ CLAYEY GRAVEL with SAND(GC)**	**30**	**20**	**10**

Specimen Identification		D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
● **B-002-0-23**	**10.0**	**25.952**	**1.375**	**0.109**		**47**	**14**	**12**	**16**	**11**		

GRAIN SIZE - OH DOT.GDT - 8/8/24 11:02 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\LAW-378-4.84\GINT FILES\LAW-378-4.84.GPJ

ROCK CORE ID

Job Name: LAW-378-4.84 By: LR Date: 4/17/2024

Boring	Sample	Depth	Description	Cored	Recovery	RQD
B-001-0-23	NQ2-1	13.5-23.5'	Sandstone	120"	120"	120"
					100%	100%

Erodability Index (K) K=(Ms)(RQD/Jn)(Jr/Ja)(Js)	
	Strength (Ms) = 36.0
	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: LAW-378-4.84 By: LR Date: 4/17/2024

Boring	Sample	Depth	Description	Cored	Recovery	RQD
B-002-0-23	NQ2-1	13.3'-23.3'	Sandstone	120"	120"	118"
					100%	98%

Erodability Index (K) K=(Ms)(RQD/Jn)(Jr/Ja)(Js)	
	Strength (Ms) = 36.0
	Joint Set # (Jn) = 1.22
	Joint Roughness (Jr) = 2.0
	Joint Alteration (Ja) = 1.0
	Joint Orientation (Js) = 1.02

APPENDIX C

ROADWAY SUBGRADE 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.)

LAW-378-4.84
119953

Replacement of the bridge carrying SR-378 over Vensonham Creek

NEAS,Inc.

Prepared By: Derar Tarawneh, Ph.D., P.E.
Date prepared: Tuesday, December 10, 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-378	255+12	11	LT	D50 SN481	87	572.4	571.4	1.0 C
2	B-002-0-23	SR-378	255+75	11	RT	D50 SN481	87	571.7	570.7	1.0 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	0.0	1.5	12			30	18	12	16	14	30	13	10	A-2-6	0			N_{60} & Mc		**12"**	
	001-0	SS-2	2.5	4.0	1.5	3.0	6		2.25							18	16	A-6b	16			N_{60}			
	23	SS-3	4.0	5.5	3.0	4.5	7		2	35	19	16	39	36	75	21	16	A-6b	10						
		SS-4	5.5	7.0	4.5	6.0	3	3	2							21	16	A-6b	16						
2	B	SS-1	1.0	2.5	0.0	1.5	10		3.5							15	14	A-6a	10			N_{60}		**12"**	
	002-0	SS-2	2.5	4.0	1.5	3.0	7		2	37	22	15	30	28	58	17	17	A-6a	7			N_{60}			
	23	SS-3	4.0	5.5	3.0	4.5	13		1.75							22	14	A-6a	10						
		SS-4	5.5	7.0	4.5	6.0	12	7	2.25	35	23	12	29	19	48	16	18	A-6a	3						

OHIO DEPARTMENT OF TRANSPORTATION

Subgrade Analysis

V. 14.7 11/6/2024

PID: 119953

County-Route-Section: LAW-378-4.84

No. of Borings: 2

Geotechnical Consultant: NEAS,Inc.

Prepared By: Derar Tarawneh, Ph.D., P.E.

Date prepared: 12/10/2024

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):	21''
Average(HP):	0''
Global Geogrid Average(N60L):	15''
Average(HP):	0''

Design CBR	6

% Samples within 3 feet of subgrade			
$N_{60} \leq 5$	0%	HP ≤ 0.5	0%
$N_{60} < 12$	50%	0.5 < HP ≤ 1	0%
$12 \leq N_{60} < 15$	25%	1 < HP ≤ 2	38%
$N_{60} \geq 20$	0%	HP > 2	25%
M+	13%		
Rock	0%		
Unsuitable Soil	0%		

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

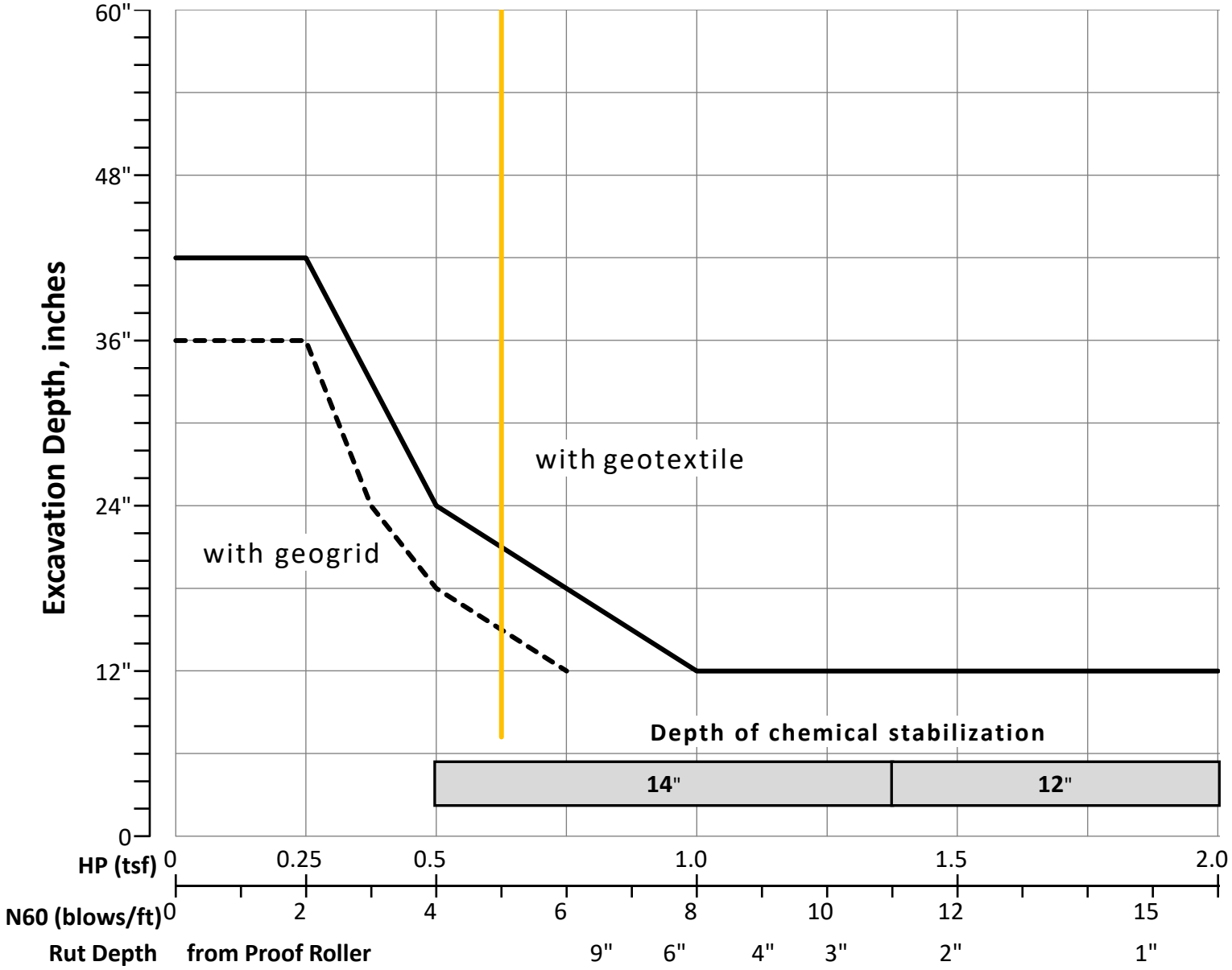
% Proposed Subgrade Surface	
Unstable & Unsuitable	100%
Unstable	100%
Unsuitable (Soil & Rock)	0%

	N_{60}	N_{60L}	HP	LL	PL	PI	Silt	Clay	P 200	M_C	M_{OPT}	GI
Average	9	5	2.25	34	21	14	29	24	53	18	15	9
Maximum	13	7	3.50	37	23	16	39	36	75	22	18	16
Minimum	3	3	1.75	30	18	12	16	14	30	13	10	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	0	0	0	1	0	0	0	0	0	0	4	3	0	0	0	0	8
Percent	0%	0%	0%	0%	0%	0%	13%	0%	0%	0%	0%	0%	0%	50%	38%	0%	0%	0%	0%	100%
% Rock|Granular|Cohesive	0%	0%	13%									88%								100%
Surface Class Count	0	0	0	0	0	0	1	0	0	0	0	0	0	2	1	0	0	0	0	4
Surface Class Percent	0%	0%	0%	0%	0%	0%	25%	0%	0%	0%	0%	0%	0%	50%	25%	0%	0%	0%	0%	100%

Fig. 600-1 – Subgrade Stabilization



OVERRIDE TABLE

Calculated Average	New Values	Check to Override
2.25	0.50	☐ HP
5.00	6.00	☐ N60L

Average HP
Average N_{60L}

APPENDIX D

DEEP FOUNDATION ANALYSIS

Objective: **To estimate Drilled Shaft Tip Resistance in Rock. Assume rock below the base of shaft to a depth of 2D is intact or tightly jointed, and the socket length is 1.5D or longer (D is diameter of socket).**

Method: **In accordance with ODOT GDM, 2024, [Sect. 1306.4.2] and LRFD Bridge Design Specifications, 9th Ed., 2020, [Sect. 10.8.3.5.4 and 10.4.6.4].**

Givens:

Rock Parameters:

$q_u := 5903\ psi$ — Uniaxial Compressive Strength of Rock Core

Geometry:

$D := 3\ ft$ — Diameter of Drilled Shaft

$D_R := D = 3\ ft$ — Diameter of Rock Socket = Diameter of Drilled Shaft

Tip Resistance Calculation:

$q_p := 2.5 \cdot q_u$ $\quad q_p = 14757.5\ psi$ — Unfactored unit tip resistance, LRFD [Equ. 10.8.3.5.4c-1]

$q_b := \pi \cdot \left(\frac{D_R}{2}\right)^2 \cdot q_p$ $\quad q_b = 15021305.4\ lbf$ — Nominal Tip Resistance

$\phi_{st} := 0.50$ — Tip Resistance Factor in Rock LRFD [Sect. 10.5.5.2.4-1]

$q_{b\_F} := \phi_{st} \cdot q_b$ $\quad q_{b\_F} = 7510.7\ kip$ — Factored Tip Resistance

Objective: **To estimate Drilled Shaft Tip Resistance in Rock. Assume rock below the base of shaft to a depth of 2D is intact or tightly jointed, and the socket length is 1.5D or longer (D is diameter of socket).**

Method: **In accordance with ODOT GDM, 2024, [Sect. 1306.4.2] and LRFD Bridge Design Specifications, 9th Ed., 2020, [Sect. 10.8.3.5.4 and 10.4.6.4].**

Givens:

Rock Parameters:

$q_u := 4629\ psi$ — Uniaxial Compressive Strength of Rock Core

Geometry:

$D := 3\ ft$ — Diameter of Drilled Shaft

$D_R := D = 3\ ft$ — Diameter of Rock Socket = Diameter of Drilled Shaft

Tip Resistance Calculation:

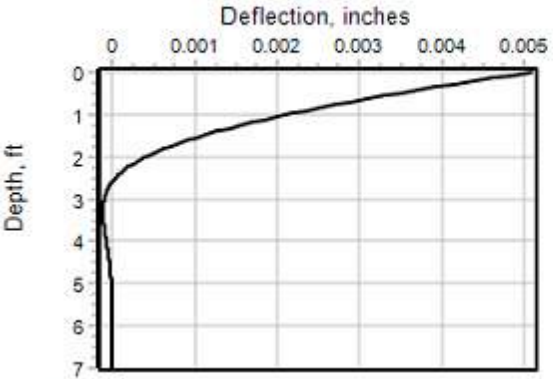
$q_p := 2.5 \cdot q_u$ $\quad q_p = 11572.5\ psi$ — Unfactored unit tip resistance, LRFD [Equ. 10.8.3.5.4c-1]

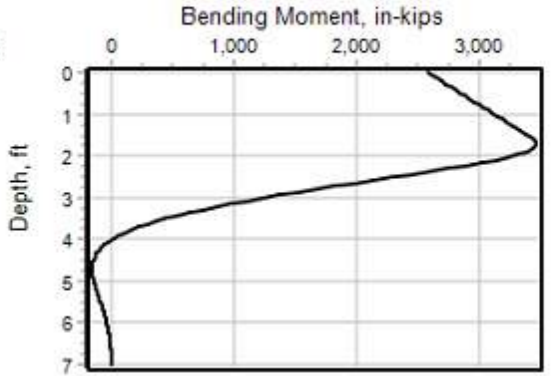
$q_b := \pi \cdot \left(\frac{D_R}{2}\right)^2 \cdot q_p$ $\quad q_b = 11779370.2\ lbf$ — Nominal Tip Resistance

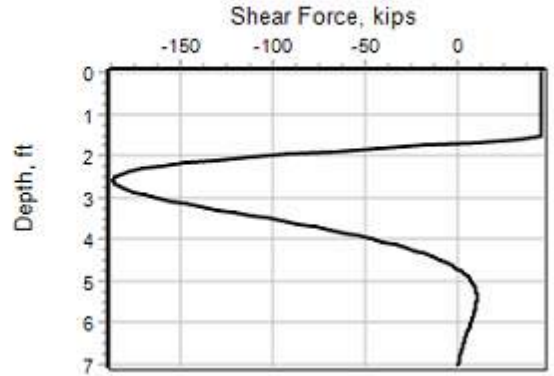
$\phi_{st} := 0.50$ — Tip Resistance Factor in Rock LRFD [Sect. 10.5.5.2.4-1]

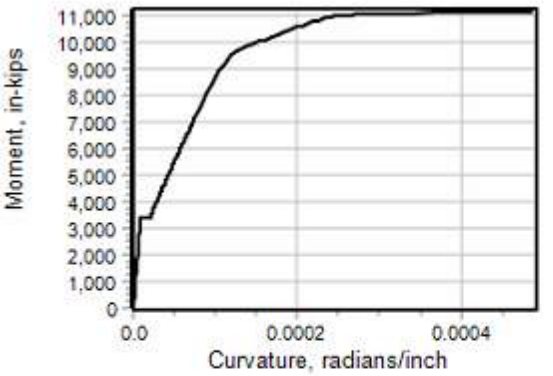
$q_{b\_F} := \phi_{st} \cdot q_b$ $\quad q_{b\_F} = 5889.7\ kip$ — Factored Tip Resistance

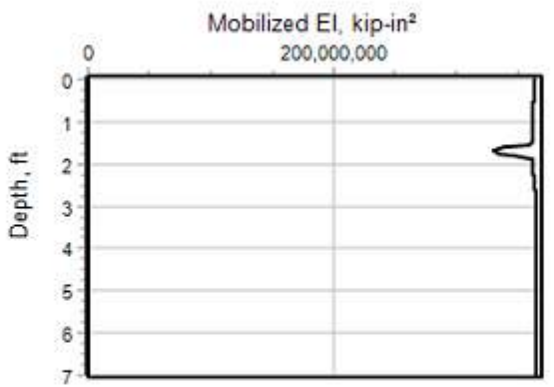
Results for LAW-378-4.84_Rear Abutment_Service_B-001.lp9d

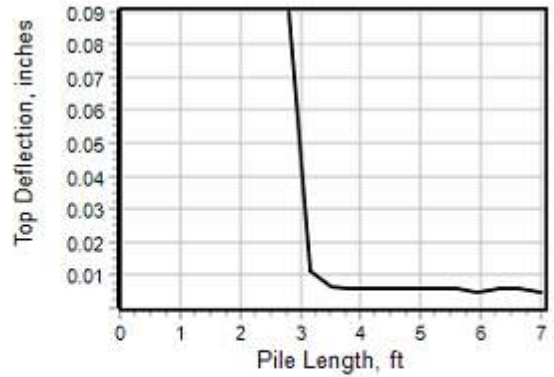












Show All Legends

Print

Close

==

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\LAW-378-4.84\Analysis\Lpile\Files\New analysis 01272025\

Name of input data file:
LAW-378-4.84_Rear Abutment_Service_B-001.lp9d

Name of output report file:
LAW-378-4.84_Rear Abutment_Service_B-001.lp9o

Name of plot output file:
LAW-378-4.84_Rear Abutment_Service_B-001.lp9p

Name of runtime message file:
LAW-378-4.84_Rear Abutment_Service_B-001.lp9r

Date and Time of Analysis

Date: January 27, 2025 Time: 16:01:55

Problem Title

Project Name: LAW-378-4.84

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 = 7.000 ft
Depth of ground surface below top of pile = 1.6000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	36.0000
2	7.000	36.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a round drilled shaft, bored pile, or CIDH pile
Length of section = 7.000000 ft
Shaft Diameter = 36.000000 in
Shear capacity of section = 0.0000 lbs

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	=	1.600000 ft
Distance from top of pile to bottom of layer	=	10.000000 ft
Effective unit weight at top of layer	=	95.800000 pcf
Effective unit weight at bottom of layer	=	95.800000 pcf
Uniaxial compressive strength at top of layer	=	5903. psi
Uniaxial compressive strength at bottom of layer	=	5903. psi
Initial modulus of rock at top of layer	=	530000. psi
Initial modulus of rock at bottom of layer	=	530000. psi
RQD of rock at top of layer	=	100.000000 %
RQD of rock at bottom of layer	=	100.000000 %
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 3.000 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Uniaxial qu psi	RQD % or E50 Rock Mass Modulus

krm	psi					
1	Weak	1.6000	95.8000	5903.	100.0000	5.00E-05	530000.
	Rock	10.0000	95.8000	5903.	100.0000	5.00E-05	530000.

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 = 44800. lbs	M = 2575200. in-lbs	237000.	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:

Dimensions and Properties of Drilled Shaft (Bored Pile):

Length of Section	=	7.000000 ft
Shaft Diameter	=	36.000000 in
Concrete Cover Thickness	=	3.000000 in
Number of Reinforcing Bars	=	8 bars
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Shaft	=	1018. sq. in.
Total Area of Reinforcing Steel	=	10.160000 sq. in.
Area Ratio of Steel Reinforcement	=	1.00 percent
Edge-to-Edge Bar Spacing	=	9.724495 in
Maximum Concrete Aggregate Size	=	0.750000 in
Ratio of Bar Spacing to Aggregate Size	=	12.97
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	4035.834 kips
Tensile Load for Cracking of Concrete	=	-453.111 kips
Nominal Axial Tensile Capacity	=	-609.600 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
1	1.270000	1.270000	14.365000	0.00000
2	1.270000	1.270000	10.157589	10.157589
3	1.270000	1.270000	0.00000	14.365000
4	1.270000	1.270000	-10.157589	10.157589
5	1.270000	1.270000	-14.365000	0.00000
6	1.270000	1.270000	-10.157589	-10.157589
7	1.270000	1.270000	0.00000	-14.365000
8	1.270000	1.270000	10.157589	-10.157589

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

Minimum spacing between any two bars not equal to zero = 9.724 inches
between bars 1 and 2.

Ratio of bar spacing to maximum aggregate size = 12.97

Concrete Properties:

Compressive Strength of Concrete	=	4000. psi
Modulus of Elasticity of Concrete	=	3604997. psi
Modulus of Rupture of Concrete	=	-474.341649 psi
Compression Strain at Peak Stress	=	0.001886
Tensile Strain at Fracture of Concrete	=	-0.0001154
Maximum Coarse Aggregate Size	=	0.750000 in

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

Number	Axial Thrust Force kips
1	237.000

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318, Section 10.3.4.
Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.

Axial Thrust Force = 237.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Run Msg
6.25000E-07	228.7841320	366054611.	102.1115467	0.00006382	0.00004132	0.2656305	1.8475093	

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0.00000125   457.5729045    366058324.    60.0750789    0.00007509    0.00003009
0.3112300     2.1711966
0.00000188   686.3506349    366053672.    46.0714939    0.00008638    0.00001888
0.3566145     2.4953500
0.00000250   915.1118071    366044723.    39.0761300    0.00009769    0.00000769
0.4017827     2.8199694
0.00000313        1144.     366031953.    34.8840507     0.0001090   -0.00000349
0.4467334     3.1450546
0.00000375        1372.     365987065.    32.0932234     0.0001203   -0.00001465
0.4914595     3.4705630
0.00000438        1601.     365860347.    30.1021893     0.0001317   -0.00002580
0.5359439     3.7963778
0.00000500        1828.     365644396.    28.6103845     0.0001431   -0.00003695
0.5801735     4.1224058
0.00000563        2055.     365350179.    27.4510342     0.0001544   -0.00004809
0.6241395     4.4485875
0.00000625        2281.     364991950.    26.5241986     0.0001658   -0.00005922
0.6678366     4.7748860
0.00000688        2507.     364582029.    25.7663376     0.0001771   -0.00007036
0.7112613     5.1012761
0.00000750        2731.     364130373.    25.1351265     0.0001885   -0.00008149
0.7544108     5.4277400
0.00000813        2955.     363644864.    24.6012864     0.0001999   -0.00009261
0.7972835     5.7542656
0.00000875        3177.     363131657.    24.1439165     0.0002113    -0.0001037
0.8398779     6.0808438
0.00000938        3399.     362595602.    23.7476988     0.0002226    -0.0001149
0.8821932     6.4074681
0.00001000        3399.     339933377.    21.0742302     0.0002107    -0.0001493
0.8370803     6.0593268 C
0.00001063        3399.     319937296.    20.5802070     0.0002187    -0.0001638
0.8664658     6.2858137 C
0.00001125        3399.     302163001.    20.1303521     0.0002265    -0.0001785
0.8952634     6.5088024 C
0.00001188        3399.     286259686.    19.7184330     0.0002342    -0.0001933
0.9235122     6.7285479 C
0.00001250        3399.     271946701.    19.3392935     0.0002417    -0.0002083
0.9512425     6.9452439 C
0.00001313        3399.     258996858.    18.9888169     0.0002492    -0.0002233
0.9784870     7.1591059 C
0.00001375        3399.     247224274.    18.6636936     0.0002566    -0.0002384
1.0052809     7.3703728 C
0.00001438        3399.     236475392.    18.3613821     0.0002639    -0.0002536
1.0316687     7.5793637 C
0.00001500        3399.     226622251.    18.0798319     0.0002712    -0.0002688
1.0576980     7.7864269 C
0.00001563        3399.     217557361.    17.8173234     0.0002784    -0.0002841
1.0834155    -8.1574628 C
0.00001625        3399.     209189770.    17.5698172     0.0002855    -0.0002995
1.1087161    -8.6003986 C
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0.00001688         3399.    201442001.    17.3380176     0.0002926    -0.0003149
1.1337473    -9.0446201 C
0.00001750         3399.    194247644.    17.1205491     0.0002996    -0.0003304
1.1585304    -9.4899713 C
0.00001813         3399.    187549449.    16.9136450     0.0003066    -0.0003459
1.1829199    -9.9376528 C
0.00001875         3399.    181297801.    16.7197443     0.0003135    -0.0003615
1.2071518   -10.3857640 C
0.00001938         3399.    175449485.    16.5342873     0.0003204    -0.0003771
1.2310010   -10.8361597 C
0.00002000         3399.    169966688.    16.3600991     0.0003272    -0.0003928
1.2547253   -11.2867425 C
0.00002063         3410.    165331318.    16.1927432     0.0003340    -0.0004085
1.2780788   -11.7395529 C
0.00002125         3460.    162801780.    16.0354156     0.0003408    -0.0004242
1.3013461   -12.1922501 C
0.00002188         3508.    160376420.    15.8835681     0.0003475    -0.0004400
1.3242473   -12.6471739 C
0.00002250         3557.    158079870.    15.7399207     0.0003541    -0.0004559
1.3470325   -13.1022517 C
0.00002313         3605.    155890340.    15.6026103     0.0003608    -0.0004717
1.3696067   -13.5582869 C
0.00002375         3653.    153793518.    15.4705242     0.0003674    -0.0004876
1.3919216   -14.0157014 C
0.00002438         3700.    151802702.    15.3453626     0.0003740    -0.0005035
1.4141540   -14.4730092 C
0.00002563         3794.    148059061.    15.1083191     0.0003872    -0.0005353
1.4578969   -15.3913679 C
0.00002688         3887.    144635706.    14.8912256     0.0004002    -0.0005673
1.5010774   -16.3113635 C
0.00002813         3979.    141473497.    14.6893119     0.0004131    -0.0005994
1.5435032   -17.2347174 C
0.00002938         4070.    138558093.    14.5027306     0.0004260    -0.0006315
1.5853865   -18.1596488 C
0.00003063         4160.    135852731.    14.3287157     0.0004388    -0.0006637
1.6266431   -19.0869468 C
0.00003188         4250.    133344065.    14.1671394     0.0004516    -0.0006959
1.6674193   -20.0153629 C
0.00003313         4339.    130998690.    14.0149544     0.0004642    -0.0007283
1.7075441   -20.9464718 C
0.00003438         4428.    128820101.    13.8742264     0.0004769    -0.0007606
1.7473633   -21.8771929 C
0.00003563         4516.    126766931.    13.7399131     0.0004895    -0.0007930
1.7864446   -22.8114898 C
0.00003688         4604.    124846830.    13.6146254     0.0005020    -0.0008255
1.8251748   -23.7458723 C
0.00003813         4691.    123048917.    13.4978280     0.0005146    -0.0008579
1.8635955   -24.6799513 C
0.00003938         4778.    121341704.    13.3851339     0.0005270    -0.0008905
1.9012732   -25.6178126 C
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0.00004188        4951.    118224259.    13.1808636     0.0005519    -0.0009556
1.9757409   -27.4924011 C
0.00004313        5036.    116787796.    13.0862366     0.0005643    -0.0009882
2.0122933   -28.4314127 C
0.00004438        5122.    115422891.    12.9958779     0.0005767    -0.0010208
2.0483730   -29.3717920 C
0.00004563        5207.    114130150.    12.9107554     0.0005891    -0.0010534
2.0841604   -30.3117941 C
0.00004688        5292.    112903786.    12.8304514     0.0006014    -0.0010861
2.1196546   -31.2514174 C
0.00004813        5377.    111734645.    12.7536648     0.0006138    -0.0011187
2.1547262   -32.1919539 C
0.00004938        5462.    110614835.    12.6792869     0.0006260    -0.0011515
2.1892592   -33.1346085 C
0.00005063        5546.    109548008.    12.6088400     0.0006383    -0.0011842
2.2235030   -34.0768841 C
0.00005188        5630.    108530322.    12.5420411     0.0006506    -0.0012169
2.2574566   -35.0187792 C
0.00005313        5714.    107558298.    12.4786340     0.0006629    -0.0012496
2.2911192   -35.9602919 C
0.00005438        5798.    106628551.    12.4183245     0.0006752    -0.0012823
2.3244807   -36.9015170 C
0.00005563        5881.    105730732.    12.3588470     0.0006875    -0.0013150
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0.00005688        5965.    104870346.    12.3022173     0.0006997    -0.0013478
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0.00005813        6048.    104044967.    12.2482527     0.0007119    -0.0013806
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2.4853398   -41.6189254 C
0.00006188        6296.    101757560.    12.1007455     0.0007487    -0.0014788
2.5166419   -42.5612371 C
0.00006313        6379.    101051250.    12.0557384     0.0007610    -0.0015115
2.5476257   -43.5034512 C
0.00006438        6461.    100365881.    12.0111465     0.0007732    -0.0015443
2.5780656   -44.4481532 C
0.00006563        6543.     99704861.    11.9684626     0.0007854    -0.0015771
2.6082175   -45.3924569 C
0.00006688        6625.     99066817.    11.9275808     0.0007977    -0.0016098
2.6380804   -46.3363602 C
0.00006813        6707.     98450476.    11.8884031     0.0008099    -0.0016426
2.6676535   -47.2798610 C
0.00006938        6789.     97854654.    11.8508383     0.0008222    -0.0016753
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0.00007188        6952.     96720257.    11.7802150     0.0008467    -0.0017408
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0.00007313        7033.     96179706.    11.7470046     0.0008590    -0.0017735
2.7830278   -51.0497957 C
0.00007438        7114.     95655716.    11.7151022     0.0008713    -0.0018062
2.8111371   -51.9912513 C
0.00007938        7437.     93699806.    11.5951352     0.0009204    -0.0019371
2.9198690   -55.7626112 C
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3.0237854   -59.5284629 C
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3.1229281   -60.0000000 CY
0.00009438        8394.     88948114.    11.3246480     0.0010688    -0.0023287
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0.00009938        8681.     87352340.    11.2437794     0.0011174    -0.0024601
3.3040321   -60.0000000 CY
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3.3820399   -60.0000000 CY
 0.0001094        9117.     83356080.    11.0633234     0.0012101    -0.0027274
3.4555541   -60.0000000 CY
 0.0001144        9331.     81586684.    10.9872744     0.0012567    -0.0028608
3.5247404   -60.0000000 CY
 0.0001194        9528.     79816056.    10.9098132     0.0013024    -0.0029951
3.5879633   -60.0000000 CY
 0.0001244        9630.     77424063.    10.8007487     0.0013433    -0.0031342
3.6407198   -60.0000000 CY
 0.0001294        9699.     74968621.    10.6884478     0.0013828    -0.0032747
3.6880786   -60.0000000 CY
 0.0001344        9767.     72685864.    10.5837531     0.0014222    -0.0034153
3.7319808   -60.0000000 CY
 0.0001394        9833.     70553089.    10.4841314     0.0014612    -0.0035563
3.7722110   -60.0000000 CY
 0.0001444        9899.     68563394.    10.3925301     0.0015004    -0.0036971
3.8093213   -60.0000000 CY
 0.0001494        9964.     66702317.    10.3081611     0.0015398    -0.0038377
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 0.0001544       10027.     64953613.    10.2285295     0.0015790    -0.0039785
3.8738123   -60.0000000 CY
 0.0001594       10089.     63304858.    10.1522135     0.0016180    -0.0041195
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3.9628932   -60.0000000 CY
 0.0001794       10330.     57590427.     9.8990947     0.0017757    -0.0046818
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 0.0001844       10388.     56340543.     9.8433478     0.0018149    -0.0048226
3.9877018   -60.0000000 CY
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 0.0001894        10445.     55152954.     9.7915313     0.0018543    -0.0049632
3.9950900   -60.0000000 CY
 0.0001944        10501.     54022771.     9.7433631     0.0018939    -0.0051036
3.9991565   -60.0000000 CY
 0.0001994        10556.     52945360.     9.6986320     0.0019337    -0.0052438
3.9963925   -60.0000000 CY
 0.0002044        10610.     51916590.     9.6571397     0.0019737    -0.0053838
3.9994076   -60.0000000 CY
 0.0002094        10664.     50933013.     9.6186598     0.0020139    -0.0055236
3.9958440   -60.0000000 CY
 0.0002144        10717.     49991343.     9.5830126     0.0020544    -0.0056631
3.9993058   -60.0000000 CY
 0.0002194        10769.     49089026.     9.5499579     0.0020950    -0.0058025
3.9964529   -60.0000000 CY
 0.0002244        10820.     48221618.     9.5178404     0.0021356    -0.0059419
3.9987445    60.0000000 CY
 0.0002294        10869.     47384609.     9.4866182     0.0021760    -0.0060815
3.9997775    60.0000000 CY
 0.0002344        10912.     46555832.     9.4542146     0.0022158    -0.0062217
3.9971752    60.0000000 CY
 0.0002394        10947.     45729698.     9.4190479     0.0022547    -0.0063628
3.9995780    60.0000000 CY
 0.0002444        10975.     44909465.     9.3819069     0.0022927    -0.0065048
3.9966938    60.0000000 CY
 0.0002494        10991.     44073121.     9.3390587     0.0023289    -0.0066486
3.9970638    60.0000000 CY
 0.0002544        11004.     43257962.     9.2964902     0.0023648    -0.0067927
3.9992895    60.0000000 CY
 0.0002594        11011.     42452770.     9.2523360     0.0023998    -0.0069377
4.0000000    60.0000000 CY
 0.0002644        11018.     41676524.     9.2105701     0.0024350    -0.0070825
3.9945127    60.0000000 CY
 0.0002694        11025.     40927517.     9.1697949     0.0024701    -0.0072274
3.9975697    60.0000000 CY
 0.0002744        11030.     40202061.     9.1279498     0.0025045    -0.0073730
3.9993617    60.0000000 CY
 0.0003044        11061.     36338428.     8.9133683     0.0027130    -0.0082445
3.9984565    60.0000000 CY
 0.0003344        11084.     33146996.     8.7394173     0.0029222    -0.0091153
3.9959918    60.0000000 CY
 0.0003644        11101.     30465375.     8.5931153     0.0031311    -0.0099864
3.9999981    60.0000000 CYT
 0.0003944        11114.     28181749.     8.4777220     0.0033434    -0.0108541
3.9987303    60.0000000 CYT
 0.0004244        11121.     26205011.     8.3782854     0.0035555    -0.0117220
3.9913634    60.0000000 CYT
 0.0004544        11122.     24477478.     8.3005297     0.0037716    -0.0125859
3.9986927    60.0000000 CYT
 0.0004844        11122.     22961454.     8.2871262     0.0040141    -0.0134234
3.9969739    60.0000000 CYT
```

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

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

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain
1	237.000	11089.965	0.00300000

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

In ACI 318, the value of the strength reduction factor depends on whether
the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.70).

The above values should be multiplied by the appropriate strength reduction
factor to compute ultimate moment capacity according to ACI 318, Section
9.3.2.2 or the value required by the design standard being followed.

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

Axial Load No.	Resist. Factor for Moment	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	11090.	154.050000	7208.	95086049.
1	0.70	11090.	165.900000	7763.	91929430.
1	0.75	11090.	177.750000	8317.	89295399.

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 = 44800.0 lbs
Applied moment at pile head = 2575200.0 in-lbs

Axial thrust load on pile head = 237000.0 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	0.00508	2575200.	44800.	-2.92E-04	0.00	3.64E+11	0.00	0.00	0.00
0.07000	0.00484	2612890.	44800.	-2.86E-04	0.00	3.64E+11	0.00	0.00	0.00
0.1400	0.00460	2650578.	44800.	-2.80E-04	0.00	3.64E+11	0.00	0.00	0.00
0.2100	0.00437	2688265.	44800.	-2.74E-04	0.00	3.64E+11	0.00	0.00	0.00
0.2800	0.00414	2725951.	44800.	-2.67E-04	0.00	3.64E+11	0.00	0.00	0.00
0.3500	0.00392	2763635.	44800.	-2.61E-04	0.00	3.64E+11	0.00	0.00	0.00
0.4200	0.00370	2801319.	44800.	-2.55E-04	0.00	3.64E+11	0.00	0.00	0.00
0.4900	0.00349	2839001.	44800.	-2.48E-04	0.00	3.64E+11	0.00	0.00	0.00
0.5600	0.00328	2876682.	44800.	-2.42E-04	0.00	3.64E+11	0.00	0.00	0.00
0.6300	0.00308	2914361.	44800.	-2.35E-04	0.00	3.64E+11	0.00	0.00	0.00
0.7000	0.00289	2952039.	44800.	-2.28E-04	0.00	3.64E+11	0.00	0.00	0.00
0.7700	0.00270	2989716.	44800.	-2.21E-04	0.00	3.64E+11	0.00	0.00	0.00
0.8400	0.00252	3027391.	44800.	-2.14E-04	0.00	3.63E+11	0.00	0.00	0.00
0.9100	0.00234	3065065.	44800.	-2.07E-04	0.00	3.63E+11	0.00	0.00	0.00
0.9800	0.00217	3102738.	44800.	-2.00E-04	0.00	3.63E+11	0.00	0.00	0.00
1.0500	0.00201	3140409.	44800.	-1.93E-04	0.00	3.63E+11	0.00	0.00	0.00
1.1200	0.00185	3178078.	44800.	-1.86E-04	0.00	3.63E+11	0.00	0.00	0.00
1.1900	0.00169	3215747.	44800.	-1.78E-04	0.00	3.63E+11	0.00	0.00	0.00
1.2600	0.00155	3253413.	44800.	-1.71E-04	0.00	3.63E+11	0.00	0.00	0.00
1.3300	0.00141	3291079.	44800.	-1.63E-04	0.00	3.63E+11	0.00	0.00	0.00

```
    1.4000    0.00127   3328742.     44800.  -1.55E-04       0.00   3.63E+11
0.00       0.00       0.00
    1.4700    0.00115   3366404.     44800.  -1.48E-04       0.00   3.63E+11
0.00       0.00       0.00
    1.5400    0.00102   3404065.     44800.  -1.40E-04       0.00   3.60E+11
0.00       0.00       0.00
    1.6100   9.11E-04   3441724.     32189.  -1.32E-04       0.00   3.40E+11
-30025.   2.77E+07       0.00
    1.6800   8.04E-04   3458196.      6961.  -1.23E-04       0.00   3.31E+11
-30042.   3.14E+07       0.00
    1.7500   7.04E-04   3453468.    -18246.  -1.14E-04       0.00   3.36E+11
-29975.   3.58E+07       0.00
    1.8200   6.12E-04   3427588.    -43360.  -1.06E-04       0.00   3.49E+11
-29822.   4.10E+07       0.00
    1.8900   5.26E-04   3380664.    -68306.  -9.78E-05       0.00   3.63E+11
-29572.   4.72E+07       0.00
    1.9600   4.47E-04   3312873.    -92280.  -9.00E-05       0.00   3.63E+11
-27509.   5.16E+07       0.00
    2.0300   3.75E-04   3225670.   -113778.  -8.24E-05       0.00   3.63E+11
-23677.   5.30E+07       0.00
    2.1000   3.09E-04   3121758.   -132127.  -7.51E-05       0.00   3.63E+11
-20012.   5.44E+07       0.00
    2.1700   2.49E-04   3003725.   -147476.  -6.80E-05       0.00   3.64E+11
-16532.   5.58E+07       0.00
    2.2400   1.95E-04   2874026.   -159985.  -6.12E-05       0.00   3.64E+11
-13251.   5.72E+07       0.00
    2.3100   1.46E-04   2734975.   -169826.  -5.48E-05       0.00   3.64E+11
-10180.   5.86E+07       0.00
    2.3800   1.03E-04   2588741.   -177178.  -4.86E-05       0.00   3.64E+11
-7326.   6.00E+07       0.00
    2.4500   6.43E-05   2437336.   -182227.  -4.28E-05       0.00   3.65E+11
-4696.   6.13E+07       0.00
    2.5200   3.07E-05   2282616.   -185161.  -3.74E-05       0.00   3.65E+11
-2291.   6.27E+07       0.00
    2.5900   1.47E-06   2126279.   -186171.  -3.23E-05       0.00   3.65E+11
-111.9537   6.41E+07       0.00
    2.6600  -2.36E-05   1969862.   -185444.  -2.76E-05       0.00   3.65E+11
1843.   6.55E+07       0.00
    2.7300  -4.49E-05   1814745.   -183167.  -2.33E-05       0.00   3.66E+11
3578.   6.69E+07       0.00
    2.8000  -6.27E-05   1662152.   -179523.  -1.93E-05       0.00   3.66E+11
5098.   6.83E+07       0.00
    2.8700  -7.73E-05   1513155.   -174688.  -1.56E-05       0.00   3.66E+11
6412.   6.96E+07       0.00
    2.9400  -8.90E-05   1368681.   -168834.  -1.23E-05       0.00   3.66E+11
7527.   7.10E+07       0.00
    3.0100  -9.80E-05   1229518.   -162123.  -9.35E-06       0.00   3.66E+11
8452.   7.24E+07       0.00
    3.0800  -1.05E-04   1096318.   -154709.  -6.68E-06       0.00   3.66E+11
9200.   7.38E+07       0.00
```

```
    3.1500  -1.09E-04    969609.   -146738.  -4.31E-06       0.00   3.66E+11
9780.   7.52E+07       0.00
    3.2200  -1.12E-04    849801.   -138344.  -2.22E-06       0.00   3.66E+11
10205.   7.66E+07       0.00
    3.2900  -1.13E-04    737192.   -129654.  -3.99E-07       0.00   3.66E+11
10486.   7.80E+07       0.00
    3.3600  -1.13E-04    631982.   -120782.   1.17E-06       0.00   3.66E+11
10637.   7.93E+07       0.00
    3.4300  -1.11E-04    534278.   -111833.   2.51E-06       0.00   3.66E+11
10670.   8.07E+07       0.00
    3.5000  -1.08E-04    444102.   -102902.   3.63E-06       0.00   3.66E+11
10596.   8.21E+07       0.00
    3.5700  -1.05E-04    361402.    -94071.   4.56E-06       0.00   3.66E+11
10429.   8.35E+07       0.00
    3.6400  -1.01E-04    286060.    -85415.   5.30E-06       0.00   3.66E+11
10180.   8.49E+07       0.00
    3.7100  -9.60E-05    217902.    -76998.   5.88E-06       0.00   3.66E+11
9861.   8.63E+07       0.00
    3.7800  -9.09E-05    156701.    -68875.   6.31E-06       0.00   3.66E+11
9482.   8.77E+07       0.00
    3.8500  -8.54E-05    102190.    -61090.   6.61E-06       0.00   3.66E+11
9054.   8.90E+07       0.00
    3.9200  -7.98E-05     54068.    -53681.   6.78E-06       0.00   3.66E+11
8587.   9.04E+07       0.00
    3.9900  -7.40E-05     12004.    -46677.   6.86E-06       0.00   3.66E+11
8090.   9.18E+07       0.00
    4.0600  -6.82E-05    -24352.    -40099.   6.85E-06       0.00   3.66E+11
7571.   9.32E+07       0.00
    4.1300  -6.25E-05    -55365.    -33963.   6.75E-06       0.00   3.66E+11
7039.   9.46E+07       0.00
    4.2000  -5.69E-05    -81412.    -28277.   6.60E-06       0.00   3.66E+11
6500.   9.60E+07       0.00
    4.2700  -5.14E-05   -102872.    -23043.   6.39E-06       0.00   3.66E+11
5960.   9.74E+07       0.00
    4.3400  -4.62E-05   -120127.    -18261.   6.13E-06       0.00   3.66E+11
5426.   9.87E+07       0.00
    4.4100  -4.11E-05   -133554.    -13923.   5.84E-06       0.00   3.66E+11
4902.   1.00E+08       0.00
    4.4800  -3.64E-05   -143520.    -10019.   5.52E-06       0.00   3.66E+11
4393.   1.02E+08       0.00
    4.5500  -3.19E-05   -150388.     -6535.   5.18E-06       0.00   3.66E+11
3902.   1.03E+08       0.00
    4.6200  -2.76E-05   -154502.     -3455.   4.83E-06       0.00   3.66E+11
3432.   1.04E+08       0.00
    4.6900  -2.37E-05   -156194.  -759.9848   4.48E-06       0.00   3.66E+11
2985.   1.06E+08       0.00
    4.7600  -2.01E-05   -155780.      1571.   4.12E-06       0.00   3.66E+11
2564.   1.07E+08       0.00
    4.8300  -1.68E-05   -153557.      3559.   3.77E-06       0.00   3.66E+11
2170.   1.08E+08       0.00
```

```
    4.9000  -1.38E-05   -149802.      5228.   3.42E-06       0.00   3.66E+11
1804.   1.10E+08       0.00
    4.9700  -1.11E-05   -144775.      6601.   3.08E-06       0.00   3.66E+11
1466.   1.11E+08       0.00
    5.0400  -8.62E-06   -138714.      7702.   2.75E-06       0.00   3.66E+11
1156.   1.13E+08       0.00
    5.1100  -6.44E-06   -131837.      8555.   2.44E-06       0.00   3.66E+11
874.3510   1.14E+08       0.00
    5.1800  -4.52E-06   -124342.      9183.   2.15E-06       0.00   3.66E+11
620.5757   1.15E+08       0.00
    5.2500  -2.83E-06   -116410.      9609.   1.87E-06       0.00   3.66E+11
393.7613   1.17E+08       0.00
    5.3200  -1.37E-06   -108201.      9855.   1.62E-06       0.00   3.66E+11
192.9434   1.18E+08       0.00
    5.3900  -1.19E-07    -99854.      9943.   1.38E-06       0.00   3.66E+11
16.9803   1.20E+08       0.00
    5.4600   9.41E-07    -91496.      9894.   1.16E-06       0.00   3.66E+11
-135.4115   1.21E+08       0.00
    5.5300   1.82E-06    -83234.      9725.   9.57E-07       0.00   3.66E+11
-265.6254   1.22E+08       0.00
    5.6000   2.55E-06    -75159.      9456.   7.75E-07       0.00   3.66E+11
-375.1336   1.24E+08       0.00
    5.6700   3.13E-06    -67348.      9103.   6.11E-07       0.00   3.66E+11
-465.4599   1.25E+08       0.00
    5.7400   3.58E-06    -59866.      8681.   4.65E-07       0.00   3.66E+11
-538.1537   1.26E+08       0.00
    5.8100   3.91E-06    -52763.      8206.   3.36E-07       0.00   3.66E+11
-594.7674   1.28E+08       0.00
    5.8800   4.14E-06    -46081.      7688.   2.23E-07       0.00   3.66E+11
-636.8363   1.29E+08       0.00
    5.9500   4.28E-06    -39847.      7141.   1.24E-07       0.00   3.66E+11
-665.8597   1.31E+08       0.00
    6.0200   4.35E-06    -34083.      6575.   3.94E-08       0.00   3.66E+11
-683.2862   1.32E+08       0.00
    6.0900   4.35E-06    -28802.      5998.  -3.27E-08       0.00   3.66E+11
-690.4996   1.33E+08       0.00
    6.1600   4.29E-06    -24007.      5418.  -9.33E-08       0.00   3.66E+11
-688.8082   1.35E+08       0.00
    6.2300   4.19E-06    -19699.      4844.  -1.43E-07       0.00   3.66E+11
-679.4349   1.36E+08       0.00
    6.3000   4.05E-06    -15870.      4280.  -1.84E-07       0.00   3.66E+11
-663.5105   1.38E+08       0.00
    6.3700   3.88E-06    -12509.      3731.  -2.17E-07       0.00   3.66E+11
-642.0675   1.39E+08       0.00
    6.4400   3.69E-06     -9602.      3203.  -2.42E-07       0.00   3.66E+11
-616.0366   1.40E+08       0.00
    6.5100   3.48E-06     -7128.      2698.  -2.61E-07       0.00   3.66E+11
-586.2438   1.42E+08       0.00
    6.5800   3.25E-06     -5069.      2219.  -2.75E-07       0.00   3.66E+11
-553.4094   1.43E+08       0.00
```

```
    6.6500   3.01E-06     -3400.      1769.  -2.85E-07       0.00   3.66E+11
-518.1481   1.44E+08       0.00
    6.7200   2.77E-06     -2097.      1350.  -2.91E-07       0.00   3.66E+11
-480.9699   1.46E+08       0.00
    6.7900   2.52E-06     -1133.   961.7588  -2.95E-07       0.00   3.66E+11
-442.2829   1.47E+08       0.00
    6.8600   2.27E-06  -480.8481   606.9938  -2.97E-07       0.00   3.66E+11
-402.3956   1.49E+08       0.00
    6.9300   2.02E-06  -112.8792   286.1486  -2.98E-07       0.00   3.66E+11
-361.5217   1.50E+08       0.00
    7.0000   1.77E-06       0.00       0.00  -2.98E-07       0.00   3.66E+11
-319.7844   7.57E+07       0.00
```

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

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     0.00507993 inches
Computed slope at pile head      =    -0.00029184 radians
Maximum bending moment           =       3458196. inch-lbs
Maximum shear force              =       -186171. lbs
Depth of maximum bending moment  =     1.68000000 feet below pile head
Depth of maximum shear force     =     2.59000000 feet below pile head
Number of iterations             =              7
Number of zero deflection points =              2
```

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

Boundary Condition Type 1, Shear and Moment

```
Shear      =          44800. lbs
Moment     =        2575200. in-lbs
Axial Load =         237000. lbs
```

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
7.00000	0.00507993	3458196.	-186171.

```
    6.65000    0.00612707      3486162.      -188382.
    6.30000    0.00596986      3473291.      -187472.
    5.95000    0.00508815      3457891.      -186313.
    5.60000    0.00585233      3468268.      -187014.
    5.25000    0.00586795      3471312.      -186818.
    4.90000    0.00579808      3466721.      -185679.
    4.55000    0.00601097      3478337.      -186731.
    4.20000    0.00603756      3478548.      -192411.
    3.85000    0.00601247      3467852.      -208994.
    3.50000    0.00654574      3463838.      -248055.
    3.15000    0.01146381      3457447.      -338347.
    2.80000    0.08974615      3471075.      -458258.
    2.45000  -20.48385259      2575208.       440789.
    2.10000  -15.83182499      2575215.       246986.
    2.10000      0.000000 -9.188786E+13  1.823172E+14
    2.10000      0.000000 -9.188786E+13  1.823172E+14
    2.10000      0.000000 -9.188786E+13  1.823172E+14
    2.10000      0.000000 -9.188786E+13  1.823172E+14
    2.10000      0.000000 -9.188786E+13  1.823172E+14

--------------------------------------------------------------------------------
            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 Load                Load                   Axial    Pile-head  Pile-head  Max
Shear Max Moment
Case Type   Pile-head    Type     Pile-head   Loading  Deflection  Rotation    in
Pile    in Pile
 No.  1      Load 1       2        Load 2       lbs      inches     radians      lbs
     in-lbs
---- ----- ---------- ---------- ---------- ---------- ---------- ----------
---------- ----------
  1  V, lb     44800.  M, in-lb    2575200.    237000.    0.00508  -2.92E-04
-186171.   3458196.


Maximum pile-head deflection = 0.0050799278 inches
Maximum pile-head rotation   = -0.0002918424 radians = -0.016721 deg.

--------------------------------------------------------------------------------
                           Summary of Warning Messages
```

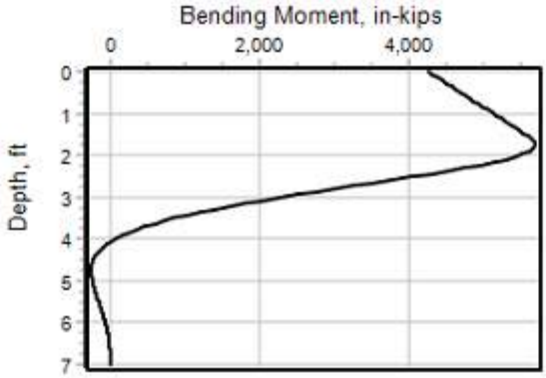
The following warning was reported 10000 times

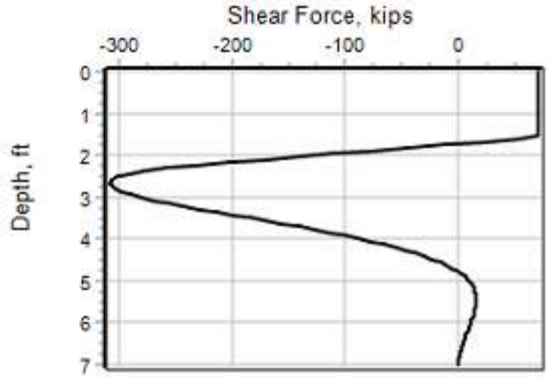
**** Warning ****

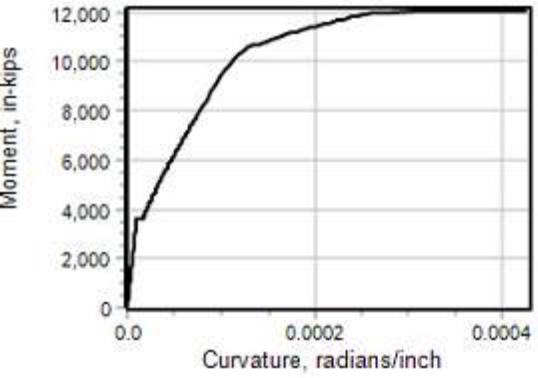
An unreasonable input value for unconfined compressive strength has been specified for a soil defined using the weak rock criteria. The input value is greater than 1000 psi. Please check your input data for correctness.

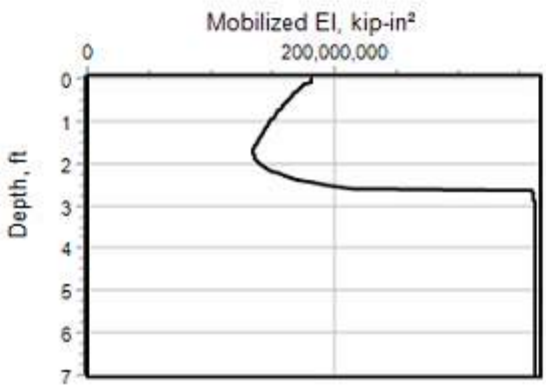
The analysis ended normally.

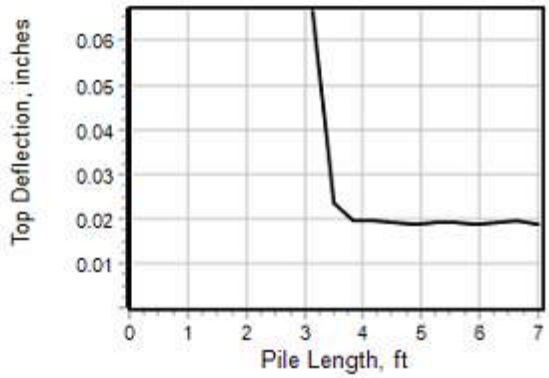
Results for LAW-378-4.84_Rear Abutment_Strength_B-001.lp9d











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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\LAW-378-4.84\Analysis\Lpile\Files\New analysis 01272025\

Name of input data file:
LAW-378-4.84_Rear Abutment_Strength_B-001.lp9d

Name of output report file:
LAW-378-4.84_Rear Abutment_Strength_B-001.lp9o

Name of plot output file:
LAW-378-4.84_Rear Abutment_Strength_B-001.lp9p

Name of runtime message file:
LAW-378-4.84_Rear Abutment_Strength_B-001.lp9r

Date and Time of Analysis

Date: January 27, 2025 Time: 16:04:05

Problem Title

Project Name: LAW-378-4.84

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 = 7.000 ft
Depth of ground surface below top of pile = 1.6000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	36.0000
2	7.000	36.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a round drilled shaft, bored pile, or CIDH pile
Length of section = 7.000000 ft
Shaft Diameter = 36.000000 in
Shear capacity of section = 0.0000 lbs

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	=	1.600000 ft
Distance from top of pile to bottom of layer	=	11.600000 ft
Effective unit weight at top of layer	=	95.800000 pcf
Effective unit weight at bottom of layer	=	95.800000 pcf
Uniaxial compressive strength at top of layer	=	5903. psi
Uniaxial compressive strength at bottom of layer	=	5903. psi
Initial modulus of rock at top of layer	=	530000. psi
Initial modulus of rock at bottom of layer	=	530000. psi
RQD of rock at top of layer	=	100.000000 %
RQD of rock at bottom of layer	=	100.000000 %
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 4.600 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Uniaxial qu psi	RQD % or E50 Rock Mass Modulus

krm	psi					
1	Weak	1.6000	95.8000	5903.	100.0000	5.00E-05	530000.
	Rock	11.6000	95.8000	5903.	100.0000	5.00E-05	530000.

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 = 71800. lbs	M = 4255200. in-lbs	325800.	Yes

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

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

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

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Drilled Shaft (Bored Pile):

Length of Section	=	7.000000 ft
Shaft Diameter	=	36.000000 in
Concrete Cover Thickness	=	3.000000 in
Number of Reinforcing Bars	=	8 bars
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Shaft	=	1018. sq. in.
Total Area of Reinforcing Steel	=	10.160000 sq. in.
Area Ratio of Steel Reinforcement	=	1.00 percent
Edge-to-Edge Bar Spacing	=	9.724495 in
Maximum Concrete Aggregate Size	=	0.750000 in
Ratio of Bar Spacing to Aggregate Size	=	12.97
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	4035.834 kips
Tensile Load for Cracking of Concrete	=	-453.111 kips
Nominal Axial Tensile Capacity	=	-609.600 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
1	1.270000	1.270000	14.365000	0.00000
2	1.270000	1.270000	10.157589	10.157589
3	1.270000	1.270000	0.00000	14.365000
4	1.270000	1.270000	-10.157589	10.157589
5	1.270000	1.270000	-14.365000	0.00000
6	1.270000	1.270000	-10.157589	-10.157589
7	1.270000	1.270000	0.00000	-14.365000
8	1.270000	1.270000	10.157589	-10.157589

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

Minimum spacing between any two bars not equal to zero = 9.724 inches
between bars 1 and 2.

Ratio of bar spacing to maximum aggregate size = 12.97

Concrete Properties:

Compressive Strength of Concrete	=	4000. psi
Modulus of Elasticity of Concrete	=	3604997. psi
Modulus of Rupture of Concrete	=	-474.341649 psi
Compression Strain at Peak Stress	=	0.001886
Tensile Strain at Fracture of Concrete	=	-0.0001154
Maximum Coarse Aggregate Size	=	0.750000 in

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

Number	Axial Thrust Force kips
1	325.800

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318, Section 10.3.4.
Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.

Axial Thrust Force = 325.800 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Run Msg
6.25000E-07	226.4853303	362376528.	134.2076956	0.00008388	0.00006138	0.3473830	2.4292520	

```
0.00000125   452.9791372    362383310.    76.1233527    0.00009515    0.00005015
0.3924801     2.7529465
0.00000188   679.4617879    362379620.    56.7705644     0.0001064    0.00003894
0.4373620     3.0771119
0.00000250   905.9277095    362371084.    47.1006652     0.0001178    0.00002775
0.4820276     3.4017482
0.00000313        1132.    362358825.    41.3039222     0.0001291    0.00001657
0.5264757     3.7268555
0.00000375        1359.    362343219.    37.4437576     0.0001404    0.00000541
0.5707049     4.0524336
0.00000438        1585.    362323613.    34.6901993     0.0001518   -0.00000573
0.6147139     4.3784815
0.00000500        1811.    362278687.    32.6279736     0.0001631   -0.00001686
0.6584957     4.7049562
0.00000563        2037.    362177889.    31.0260746     0.0001745   -0.00002798
0.7020371     5.0317659
0.00000625        2263.    362011865.    29.7459812     0.0001859   -0.00003909
0.7453271     5.3588341
0.00000688        2487.    361782635.    28.6996428     0.0001973   -0.00005019
0.7883574     5.6861038
0.00000750        2711.    361496682.    27.8284343     0.0002087   -0.00006129
0.8311223     6.0135345
0.00000813        2934.    361161651.    27.0918225     0.0002201   -0.00007238
0.8736179     6.3410982
0.00000875        3157.    360784542.    26.4608816     0.0002315   -0.00008347
0.9158409     6.6687737
0.00000938        3378.    360371427.    25.9144174     0.0002429   -0.00009455
0.9577890     6.9965448
0.00001000        3599.    359927480.    25.4365475     0.0002544    -0.0001056
0.9994604     7.3243988
0.00001063        3599.    338755275.    23.4743739     0.0002494    -0.0001331
0.9808346     7.1775790 C
0.00001125        3599.    319935538.    22.9361397     0.0002580    -0.0001470
1.0120872     7.4241906 C
0.00001188        3599.    303096825.    22.4428797     0.0002665    -0.0001610
1.0426714     7.6667792 C
0.00001250        3599.    287941984.    21.9882943     0.0002749    -0.0001751
1.0726152     7.9055067 C
0.00001313        3599.    274230461.    21.5684013     0.0002831    -0.0001894
1.1019991     8.1409603 C
0.00001375        3599.    261765440.    21.1788737     0.0002912    -0.0002038
1.1308492     8.3733009 C
0.00001438        3599.    250384334.    20.8161820     0.0002992    -0.0002183
1.1591935     8.6027084 C
0.00001500        3599.    239951653.    20.4774310     0.0003072    -0.0002328
1.1870618     8.8293825 C
0.00001563        3599.    230353587.    20.1602368     0.0003150    -0.0002475
1.2144863     9.0535448 C
0.00001625        3599.    221493834.    19.8626316     0.0003228    -0.0002622
1.2415011     9.2754402 C
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1.2943698     9.7128615 C
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1.3202209     9.9283024 C
0.00001875         3837.    204646717.    18.8326618     0.0003531    -0.0003219
1.3457861    10.1423849 C
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1.4205729    10.7746387 C
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1.4448661    10.9819820 C
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1.4690350   -11.4198790 C
0.00002250         4171.    185365945.    17.6421396     0.0003969    -0.0004131
1.4928039   -11.8610539 C
0.00002313         4224.    182663267.    17.4757761     0.0004041    -0.0004284
1.5164760   -12.3020951 C
0.00002375         4276.    180054677.    17.3148366     0.0004112    -0.0004438
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0.00002438         4328.    177573066.    17.1619616     0.0004183    -0.0004592
1.5629442   -13.1889008 C
0.00002563         4430.    172896057.    16.8732749     0.0004324    -0.0004901
1.6085124   -14.0797852 C
0.00002688         4531.    168589003.    16.6071022     0.0004463    -0.0005212
1.6532716   -14.9740522 C
0.00002813         4630.    164615453.    16.3614030     0.0004602    -0.0005523
1.6973196   -15.8709181 C
0.00002938         4727.    160912499.    16.1314077     0.0004739    -0.0005836
1.7404628   -16.7722195 C
0.00003063         4823.    157478089.    15.9178803     0.0004875    -0.0006150
1.7829749   -17.6755700 C
0.00003188         4918.    154278737.    15.7186681     0.0005010    -0.0006465
1.8248408   -18.5811686 C
0.00003313         5011.    151282115.    15.5312883     0.0005145    -0.0006780
1.8659791   -19.4898437 C
0.00003438         5104.    148484103.    15.3563886     0.0005279    -0.0007096
1.9066036   -20.3996625 C
0.00003563         5196.    145850895.    15.1909899     0.0005412    -0.0007413
1.9465375   -21.3123460 C
0.00003688         5287.    143378574.    15.0356253     0.0005544    -0.0007731
1.9859560   -22.2262906 C
0.00003813         5378.    141052445.    14.8893120     0.0005677    -0.0008048
2.0248633   -23.1414918 C
0.00003938         5467.    138848594.    14.7498757     0.0005808    -0.0008367
2.0631108   -24.0594481 C
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2.1750756   -26.8187225 C
0.00004438        5821.    131171762.    14.2641328     0.0006330    -0.0009645
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2.6761636   -40.7191247 C
0.00006313        7091.    112339511.    13.0677360     0.0008249    -0.0014476
2.7062964   -41.6508632 C
0.00006438        7174.    111438303.    13.0106651     0.0008376    -0.0014799
2.7361173   -42.5821770 C
0.00006563        7256.    110569369.    12.9559926     0.0008502    -0.0015123
2.7656251   -43.5130639 C
0.00006688        7338.    109730890.    12.9035851     0.0008629    -0.0015446
2.7948188   -44.4435220 C
0.00006813        7420.    108921177.    12.8533190     0.0008756    -0.0015769
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0.00006938        7502.    108138664.    12.8050796     0.0008884    -0.0016091
2.8522596   -46.3031427 C
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3.1665726   -57.4740451 C
0.00008938        8784.     98283903.    12.2100668     0.0010913    -0.0021262
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 0.0001694       11094.     65502012.    10.6671453     0.0018067    -0.0042908
3.9863943   -60.0000000 CY
 0.0001744       11153.     63960729.    10.5989562     0.0018482    -0.0044293
3.9945751   -60.0000000 CY
 0.0001794       11210.     62495195.    10.5329000     0.0018893    -0.0045682
3.9990402   -60.0000000 CY
 0.0001844       11266.     61104193.    10.4716098     0.0019307    -0.0047068
3.9965831   -60.0000000 CY
```

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 0.0001894        11321.     59781473.    10.4147710     0.0019723    -0.0048452
3.9997036   -60.0000000 CY
 0.0001944        11375.     58521553.    10.3620888     0.0020141    -0.0049834
3.9975084   -60.0000000 CY
 0.0001994        11428.     57320159.    10.3131826     0.0020562    -0.0051213
3.9998982   -60.0000000 CY
 0.0002044        11480.     56172354.    10.2679008     0.0020985    -0.0052590
3.9976949   -60.0000000 CY
 0.0002094        11531.     55072202.    10.2233471     0.0021405    -0.0053970
3.9998970    60.0000000 CY
 0.0002144        11580.     54018159.    10.1815241     0.0021827    -0.0055348
3.9970880    60.0000000 CY
 0.0002194        11629.     53008789.    10.1425674     0.0022250    -0.0056725
3.9996890    60.0000000 CY
 0.0002244        11677.     52040644.    10.1063964     0.0022676    -0.0058099
3.9955506    60.0000000 CY
 0.0002294        11724.     51111328.    10.0727723     0.0023104    -0.0059471
3.9989888    60.0000000 CY
 0.0002344        11770.     50219011.    10.0414000     0.0023535    -0.0060840
3.9990219    60.0000000 CY
 0.0002394        11816.     49360154.    10.0124222     0.0023967    -0.0062208
3.9972248    60.0000000 CY
 0.0002444        11858.     48523864.     9.9836955     0.0024398    -0.0063577
3.9996217    60.0000000 CY
 0.0002494        11897.     47705434.     9.9548943     0.0024825    -0.0064950
3.9960203    60.0000000 CY
 0.0002544        11927.     46887047.     9.9231277     0.0025242    -0.0066333
3.9973131    60.0000000 CY
 0.0002594        11952.     46080939.     9.8893832     0.0025651    -0.0067724
3.9994791    60.0000000 CY
 0.0002644        11967.     45266757.     9.8488605     0.0026038    -0.0069137
3.9988371    60.0000000 CY
 0.0002694        11979.     44470017.     9.8084272     0.0026421    -0.0070554
3.9947382    60.0000000 CY
 0.0002744        11986.     43684250.     9.7663519     0.0026796    -0.0071979
3.9975988    60.0000000 CY
 0.0003044        12018.     39482986.     9.5467072     0.0029058    -0.0080517
3.9994825    60.0000000 CY
 0.0003344        12038.     36002228.     9.3596705     0.0031296    -0.0089079
3.9995244    60.0000000 CYT
 0.0003644        12051.     33073136.     9.2174469     0.0033586    -0.0097589
3.9985287    60.0000000 CYT
 0.0003944        12053.     30561841.     9.1036166     0.0035902    -0.0106073
3.9943775    60.0000000 CYT
 0.0004244        12053.     28401357.     9.0156958     0.0038260    -0.0114515
3.9905700    60.0000000 CYT


--------------------------------------------------------------------------------
   Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1
```

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

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain
1	325.800	12026.309	0.00300000

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

In ACI 318, the value of the strength reduction factor depends on whether
the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.70).

The above values should be multiplied by the appropriate strength reduction
factor to compute ultimate moment capacity according to ACI 318, Section
9.3.2.2 or the value required by the design standard being followed.

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

Axial Load No.	Resist. Factor for Moment	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	12026.	211.770000	7817.	105313775.
1	0.70	12026.	228.060000	8418.	100714759.
1	0.75	12026.	244.350000	9020.	96874891.

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 = 71800.0 lbs
Applied moment at pile head = 4255200.0 in-lbs
Axial thrust load on pile head = 325800.0 lbs

Depth	Deflect.	Bending	Shear	Slope	Total	Bending	Soil Res.	Soil Spr.	Distrib.

X	y	Moment	Force	S	Stress	Stiffness	p Es*h	Lat. Load
feet	inches	in-lbs	lbs	radians	psi*	in-lb^2	lb/inch	lb/inch	lb/inch
0.00	0.01861	4255200.	71800.	-0.00110	0.00	1.81E+11	0.00	0.00	0.00
0.07000	0.01769	4315809.	71800.	-0.00108	0.00	1.81E+11	0.00	0.00	0.00
0.1400	0.01680	4376413.	71800.	-0.00106	0.00	1.75E+11	0.00	0.00	0.00
0.2100	0.01592	4437011.	71800.	-0.00103	0.00	1.73E+11	0.00	0.00	0.00
0.2800	0.01506	4497604.	71800.	-0.00101	0.00	1.70E+11	0.00	0.00	0.00
0.3500	0.01422	4558190.	71800.	-9.90E-04	0.00	1.67E+11	0.00	0.00	0.00
0.4200	0.01340	4618770.	71800.	-9.67E-04	0.00	1.65E+11	0.00	0.00	0.00
0.4900	0.01259	4679343.	71800.	-9.43E-04	0.00	1.63E+11	0.00	0.00	0.00
0.5600	0.01181	4739910.	71800.	-9.19E-04	0.00	1.60E+11	0.00	0.00	0.00
0.6300	0.01105	4800470.	71800.	-8.94E-04	0.00	1.58E+11	0.00	0.00	0.00
0.7000	0.01031	4861023.	71800.	-8.68E-04	0.00	1.56E+11	0.00	0.00	0.00
0.7700	0.00959	4921569.	71800.	-8.41E-04	0.00	1.54E+11	0.00	0.00	0.00
0.8400	0.00890	4982108.	71800.	-8.14E-04	0.00	1.52E+11	0.00	0.00	0.00
0.9100	0.00822	5042639.	71800.	-7.86E-04	0.00	1.50E+11	0.00	0.00	0.00
0.9800	0.00758	5103162.	71800.	-7.58E-04	0.00	1.49E+11	0.00	0.00	0.00
1.0500	0.00695	5163678.	71800.	-7.29E-04	0.00	1.47E+11	0.00	0.00	0.00
1.1200	0.00635	5224185.	71800.	-6.99E-04	0.00	1.45E+11	0.00	0.00	0.00
1.1900	0.00578	5284684.	71800.	-6.68E-04	0.00	1.43E+11	0.00	0.00	0.00
1.2600	0.00523	5345175.	71800.	-6.37E-04	0.00	1.42E+11	0.00	0.00	0.00
1.3300	0.00471	5405657.	71800.	-6.05E-04	0.00	1.40E+11	0.00	0.00	0.00
1.4000	0.00421	5466130.	71800.	-5.72E-04	0.00	1.39E+11	0.00	0.00	0.00
1.4700	0.00375	5526594.	71800.	-5.39E-04	0.00	1.37E+11	0.00	0.00	0.00

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    1.5400    0.00331   5587049.     71800.  -5.05E-04       0.00   1.36E+11
0.00       0.00       0.00
    1.6100    0.00290   5647494.     54950.  -4.70E-04       0.00   1.35E+11
-40118.   1.16E+07       0.00
    1.6800    0.00252   5679622.     21303.  -4.34E-04       0.00   1.34E+11
-39995.   1.33E+07       0.00
    1.7500    0.00217   5683521.    -12187.  -3.99E-04       0.00   1.34E+11
-39743.   1.54E+07       0.00
    1.8200    0.00185   5659367.    -45409.  -3.63E-04       0.00   1.34E+11
-39356.   1.79E+07       0.00
    1.8900    0.00156   5607433.    -78247.  -3.28E-04       0.00   1.36E+11
-38831.   2.09E+07       0.00
    1.9600    0.00130   5528091.   -110584.  -2.94E-04       0.00   1.37E+11
-38161.   2.47E+07       0.00
    2.0300    0.00106   5421813.   -142294.  -2.61E-04       0.00   1.40E+11
-37340.   2.95E+07       0.00
    2.1000   8.59E-04   5289179.   -173247.  -2.29E-04       0.00   1.43E+11
-36357.   3.55E+07       0.00
    2.1700   6.80E-04   5130883.   -203302.  -1.99E-04       0.00   1.48E+11
-35201.   4.35E+07       0.00
    2.2400   5.25E-04   4947741.   -232304.  -1.71E-04       0.00   1.53E+11
-33852.   5.42E+07       0.00
    2.3100   3.93E-04   4740706.   -258025.  -1.45E-04       0.00   1.60E+11
-27388.   5.86E+07       0.00
    2.3800   2.82E-04   4514339.   -277968.  -1.21E-04       0.00   1.69E+11
-20097.   6.00E+07       0.00
    2.4500   1.89E-04   4273785.   -292211.  -1.00E-04       0.00   1.80E+11
-13813.   6.13E+07       0.00
    2.5200   1.13E-04   4023479.   -301572.  -8.14E-05       0.00   1.93E+11
-8474.   6.27E+07       0.00
    2.5900   5.25E-05   3767190.   -306813.  -6.52E-05       0.00   2.14E+11
-4006.   6.41E+07       0.00
    2.6600   3.90E-06   3508069.   -308623.  -5.37E-05       0.00   3.60E+11
-304.0971   6.55E+07       0.00
    2.7300  -3.78E-05   3248732.   -307487.  -4.59E-05       0.00   3.61E+11
3010.   6.69E+07       0.00
    2.8000  -7.32E-05   2991517.   -303725.  -3.86E-05       0.00   3.61E+11
5946.   6.83E+07       0.00
    2.8700  -1.03E-04   2738495.   -297652.  -3.19E-05       0.00   3.61E+11
8513.   6.96E+07       0.00
    2.9400  -1.27E-04   2491479.   -289572.  -2.59E-05       0.00   3.62E+11
10726.   7.10E+07       0.00
    3.0100  -1.46E-04   2252028.   -279776.  -2.04E-05       0.00   3.62E+11
12599.   7.24E+07       0.00
    3.0800  -1.61E-04   2021467.   -268541.  -1.54E-05       0.00   3.62E+11
14150.   7.38E+07       0.00
    3.1500  -1.72E-04   1800888.   -256131.  -1.10E-05       0.00   3.62E+11
15398.   7.52E+07       0.00
    3.2200  -1.79E-04   1591173.   -242792.  -7.05E-06       0.00   3.62E+11
16362.   7.66E+07       0.00
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    3.2900  -1.84E-04   1393002.   -228753.  -3.59E-06       0.00   3.62E+11
17064.   7.80E+07       0.00
    3.3600  -1.86E-04   1206870.   -214226.  -5.73E-07       0.00   3.62E+11
17523.   7.93E+07       0.00
    3.4300  -1.85E-04   1033103.   -199406.   2.02E-06       0.00   3.62E+11
17763.   8.07E+07       0.00
    3.5000  -1.82E-04    871867.   -184468.   4.23E-06       0.00   3.62E+11
17803.   8.21E+07       0.00
    3.5700  -1.78E-04    723193.   -169572.   6.08E-06       0.00   3.62E+11
17665.   8.35E+07       0.00
    3.6400  -1.72E-04    586983.   -154856.   7.60E-06       0.00   3.62E+11
17371.   8.49E+07       0.00
    3.7100  -1.65E-04    463030.   -140446.   8.82E-06       0.00   3.62E+11
16940.   8.63E+07       0.00
    3.7800  -1.57E-04    351030.   -126446.   9.76E-06       0.00   3.62E+11
16392.   8.77E+07       0.00
    3.8500  -1.49E-04    250596.   -112948.   1.05E-05       0.00   3.62E+11
15746.   8.90E+07       0.00
    3.9200  -1.40E-04    161272.   -100026.   1.09E-05       0.00   3.62E+11
15019.   9.04E+07       0.00
    3.9900  -1.30E-04     82546.    -87742.   1.12E-05       0.00   3.62E+11
14228.   9.18E+07       0.00
    4.0600  -1.21E-04     13860.    -76143.   1.13E-05       0.00   3.62E+11
13389.   9.32E+07       0.00
    4.1300  -1.11E-04    -45379.    -65263.   1.13E-05       0.00   3.62E+11
12515.   9.46E+07       0.00
    4.2000  -1.02E-04    -95788.    -55127.   1.11E-05       0.00   3.62E+11
11620.   9.60E+07       0.00
    4.2700  -9.25E-05   -137998.    -45746.   1.09E-05       0.00   3.62E+11
10715.   9.74E+07       0.00
    4.3400  -8.35E-05   -172648.    -37125.   1.05E-05       0.00   3.62E+11
9811.   9.87E+07       0.00
    4.4100  -7.48E-05   -200374.    -29259.   1.01E-05       0.00   3.62E+11
8918.   1.00E+08       0.00
    4.4800  -6.66E-05   -221809.    -22136.   9.58E-06       0.00   3.62E+11
8043.   1.02E+08       0.00
    4.5500  -5.87E-05   -237568.    -15736.   9.04E-06       0.00   3.62E+11
7194.   1.03E+08       0.00
    4.6200  -5.14E-05   -248250.    -10037.   8.48E-06       0.00   3.62E+11
6377.   1.04E+08       0.00
    4.6900  -4.45E-05   -254434.     -5008.   7.90E-06       0.00   3.62E+11
5596.   1.06E+08       0.00
    4.7600  -3.81E-05   -256669.  -619.0374   7.31E-06       0.00   3.62E+11
4855.   1.07E+08       0.00
    4.8300  -3.22E-05   -255478.      3167.   6.71E-06       0.00   3.62E+11
4158.   1.08E+08       0.00
    4.9000  -2.68E-05   -251353.      6386.   6.12E-06       0.00   3.62E+11
3507.   1.10E+08       0.00
    4.9700  -2.19E-05   -244753.      9078.   5.55E-06       0.00   3.62E+11
2902.   1.11E+08       0.00
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    5.0400  -1.75E-05   -236105.     11282.   4.99E-06       0.00   3.62E+11
2346.   1.13E+08       0.00
    5.1100  -1.35E-05   -225803.     13038.   4.46E-06       0.00   3.62E+11
1837.   1.14E+08       0.00
    5.1800  -1.00E-05   -214203.     14387.   3.95E-06       0.00   3.62E+11
1375.   1.15E+08       0.00
    5.2500  -6.91E-06   -201634.     15368.   3.46E-06       0.00   3.62E+11
960.0095   1.17E+08       0.00
    5.3200  -4.19E-06   -188387.     16019.   3.01E-06       0.00   3.62E+11
589.7590   1.18E+08       0.00
    5.3900  -1.85E-06   -174724.     16377.   2.59E-06       0.00   3.62E+11
262.7478   1.20E+08       0.00
    5.4600   1.60E-07   -160875.     16478.   2.20E-06       0.00   3.62E+11
-23.0386   1.21E+08       0.00
    5.5300   1.85E-06   -147042.     16355.   1.85E-06       0.00   3.62E+11
-269.8427   1.22E+08       0.00
    5.6000   3.26E-06   -133400.     16040.   1.52E-06       0.00   3.62E+11
-480.0803   1.24E+08       0.00
    5.6700   4.41E-06   -120096.     15563.   1.23E-06       0.00   3.62E+11
-656.2897   1.25E+08       0.00
    5.7400   5.32E-06   -107255.     14950.   9.63E-07       0.00   3.62E+11
-801.0851   1.26E+08       0.00
    5.8100   6.03E-06    -94980.     14229.   7.29E-07       0.00   3.62E+11
-917.1145   1.28E+08       0.00
    5.8800   6.55E-06    -83351.     13421.   5.22E-07       0.00   3.62E+11
-1007.   1.29E+08       0.00
    5.9500   6.90E-06    -72433.     12547.   3.42E-07       0.00   3.62E+11
-1073.   1.31E+08       0.00
    6.0200   7.12E-06    -62273.     11626.   1.86E-07       0.00   3.62E+11
-1119.   1.32E+08       0.00
    6.0900   7.22E-06    -52901.     10675.   5.21E-08       0.00   3.62E+11
-1146.   1.33E+08       0.00
    6.1600   7.21E-06    -44339.      9708.  -6.06E-08       0.00   3.62E+11
-1156.   1.35E+08       0.00
    6.2300   7.11E-06    -36592.      8738.  -1.54E-07       0.00   3.62E+11
-1153.   1.36E+08       0.00
    6.3000   6.95E-06    -29658.      7776.  -2.31E-07       0.00   3.62E+11
-1138.   1.38E+08       0.00
    6.3700   6.73E-06    -23527.      6831.  -2.93E-07       0.00   3.62E+11
-1112.   1.39E+08       0.00
    6.4400   6.46E-06    -18182.      5911.  -3.41E-07       0.00   3.62E+11
-1078.   1.40E+08       0.00
    6.5100   6.15E-06    -13597.      5022.  -3.78E-07       0.00   3.62E+11
-1038.   1.42E+08       0.00
    6.5800   5.82E-06     -9744.      4170.  -4.05E-07       0.00   3.62E+11
-991.6008   1.43E+08       0.00
    6.6500   5.47E-06     -6591.      3358.  -4.24E-07       0.00   3.62E+11
-941.0695   1.44E+08       0.00
    6.7200   5.11E-06     -4102.      2590.  -4.36E-07       0.00   3.62E+11
-887.1571   1.46E+08       0.00
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    6.7900   4.74E-06     -2239.      1869.  -4.44E-07       0.00   3.62E+11
-830.6495   1.47E+08       0.00
    6.8600   4.36E-06  -961.8095      1196.  -4.47E-07       0.00   3.62E+11
-772.1488   1.49E+08       0.00
    6.9300   3.99E-06  -229.6839   572.3595  -4.49E-07       0.00   3.62E+11
-712.0775   1.50E+08       0.00
    7.0000   3.61E-06       0.00       0.00  -4.49E-07       0.00   3.62E+11
-650.6831   7.57E+07       0.00
```

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

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     0.01860706 inches
Computed slope at pile head      =    -0.00109642 radians
Maximum bending moment           =       5683521. inch-lbs
Maximum shear force              =       -308623. lbs
Depth of maximum bending moment  =     1.75000000 feet below pile head
Depth of maximum shear force     =     2.66000000 feet below pile head
Number of iterations             =             16
Number of zero deflection points =              2
```

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

Boundary Condition Type 1, Shear and Moment

```
Shear      =          71800. lbs
Moment     =        4255200. in-lbs
Axial Load =         325800. lbs
```

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
7.00000	0.01860706	5683521.	-308623.
6.65000	0.01949873	5729427.	-312391.
6.30000	0.01909843	5710913.	-310633.
5.95000	0.01860428	5685908.	-308693.
5.60000	0.01893195	5701546.	-309819.

```
    5.25000    0.01904757      5705028.      -309678.
    4.90000    0.01887926      5696791.      -307374.
    4.55000    0.01927328      5716675.      -310374.
    4.20000    0.01936448      5718156.      -321636.
    3.85000    0.01943102      5700550.      -354819.
    3.50000    0.02364332      5690451.      -461351.
    3.15000    0.06654994      5681461.      -583288.
    2.80000  -26.45088889      4255200.       669029.
    2.45000  -20.85485431      4255199.       454289.
    2.10000  -17.46075733      4255198.       260574.
    2.10000      0.000000 -5.036463E+13  9.992981E+13
    2.10000      0.000000 -5.036463E+13  9.992981E+13
    2.10000      0.000000 -5.036463E+13  9.992981E+13
    2.10000      0.000000 -5.036463E+13  9.992981E+13
    2.10000      0.000000 -5.036463E+13  9.992981E+13

--------------------------------------------------------------------------------
            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 Load                Load                   Axial    Pile-head  Pile-head  Max
Shear Max Moment
Case Type   Pile-head    Type     Pile-head   Loading  Deflection  Rotation    in
Pile    in Pile
 No.  1      Load 1       2        Load 2       lbs      inches     radians      lbs
     in-lbs
---- ----- ---------- ---------- ---------- ---------- ---------- ----------
---------- ----------
  1  V, lb     71800.  M, in-lb    4255200.    325800.    0.01861   -0.00110
-308623.   5683521.


Maximum pile-head deflection = 0.0186070631 inches
Maximum pile-head rotation   = -0.0010964243 radians = -0.062820 deg.

--------------------------------------------------------------------------------
                           Summary of Warning Messages
--------------------------------------------------------------------------------

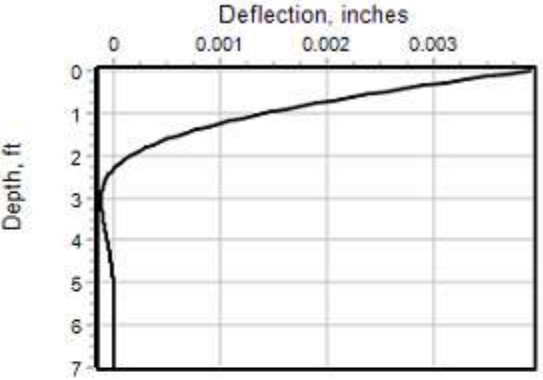
The following warning was reported 10000 times
```

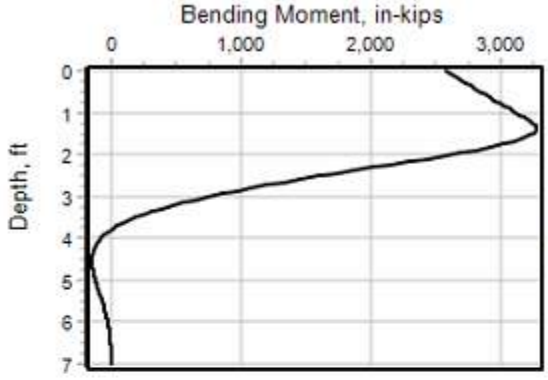
**** Warning ****

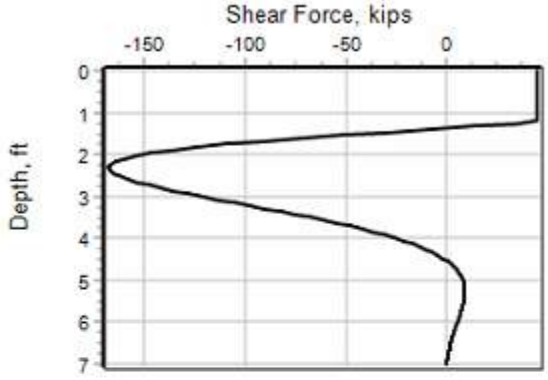
An unreasonable input value for unconfined compressive strength has been specified for a soil defined using the weak rock criteria. The input value is greater than 1000 psi. Please check your input data for correctness.

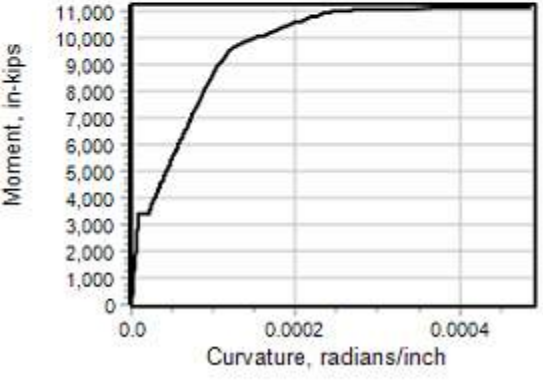
The analysis ended normally.

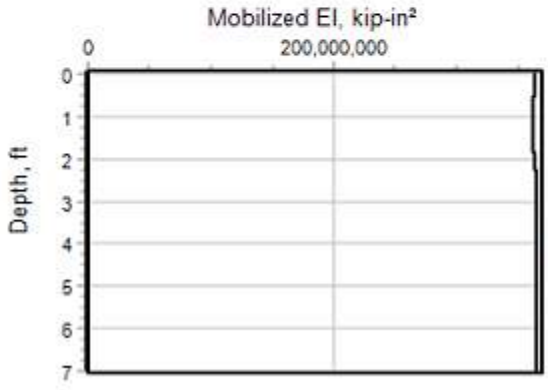
Results for LAW-378-4.84_Forward Abutment_Service_B-002.lp9d

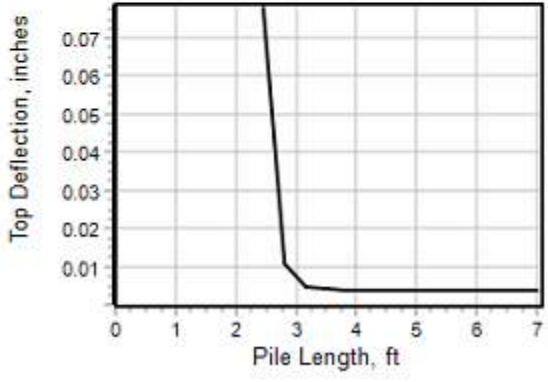












Show All Legends

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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

==

This copy of LPile is being used by:

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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\LAW-378-4.84\Analysis\Lpile\Files\New analysis 01272025\

Name of input data file:
LAW-378-4.84_Forward Abutment_Service_B-002.lp9d

Name of output report file:
LAW-378-4.84_Forward Abutment_Service_B-002.lp9o

Name of plot output file:
LAW-378-4.84_Forward Abutment_Service_B-002.lp9p

Name of runtime message file:
LAW-378-4.84_Forward Abutment_Service_B-002.lp9r

Date and Time of Analysis

Date: January 27, 2025 Time: 16:05:30

Problem Title

Project Name: LAW-378-4.84

Job Number:

Client: American Structurepoint / ODOT

Engineer: ZM

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 = 7.000 ft
Depth of ground surface below top of pile = 0.6000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	36.0000
2	7.000	36.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a round drilled shaft, bored pile, or CIDH pile
Length of section = 7.000000 ft
Shaft Diameter = 36.000000 in
Shear capacity of section = 0.0000 lbs

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 2 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	0.600000 ft
Distance from top of pile to bottom of layer	=	1.200000 ft
Effective unit weight at top of layer	=	73.800000 pcf
Effective unit weight at bottom of layer	=	73.800000 pcf
Friction angle at top of layer	=	33.000000 deg.
Friction angle at bottom of layer	=	33.000000 deg.
Subgrade k at top of layer	=	69.000000 pci
Subgrade k at bottom of layer	=	69.000000 pci

Layer 2 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	1.200000 ft
Distance from top of pile to bottom of layer	=	11.800000 ft
Effective unit weight at top of layer	=	87.200000 pcf
Effective unit weight at bottom of layer	=	87.200000 pcf
Uniaxial compressive strength at top of layer	=	4629. psi
Uniaxial compressive strength at bottom of layer	=	4629. psi
Initial modulus of rock at top of layer	=	420000. psi
Initial modulus of rock at bottom of layer	=	420000. psi
RQD of rock at top of layer	=	98.000000 %
RQD of rock at bottom of layer	=	98.000000 %
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 4.800 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name or (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 kpy	Rock Mass Modulus pci	krm psi
1	Sand (Reese, et al.)	0.6000 69.0000 1.2000 69.0000	73.8000 -- 73.8000 --	33.0000	--	--	--	--	--
2	Weak Rock	1.2000 11.8000	87.2000 87.2000	--	4629. 4629.	98.0000 98.0000	5.00E-05 5.00E-05	-- --	420000. 420000.

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 = 44800. lbs	M = 2575200. in-lbs	237000.	Yes

V = shear force applied normal to pile axis
M = bending moment applied to pile head

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

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

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

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Drilled Shaft (Bored Pile):

Length of Section	=	7.000000 ft
Shaft Diameter	=	36.000000 in
Concrete Cover Thickness	=	3.000000 in
Number of Reinforcing Bars	=	8 bars
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Shaft	=	1018. sq. in.
Total Area of Reinforcing Steel	=	10.160000 sq. in.
Area Ratio of Steel Reinforcement	=	1.00 percent
Edge-to-Edge Bar Spacing	=	9.724495 in
Maximum Concrete Aggregate Size	=	0.750000 in
Ratio of Bar Spacing to Aggregate Size	=	12.97
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	4035.834 kips
Tensile Load for Cracking of Concrete	=	-453.111 kips
Nominal Axial Tensile Capacity	=	-609.600 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

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

1	1.270000	1.270000	14.365000	0.00000
2	1.270000	1.270000	10.157589	10.157589
3	1.270000	1.270000	0.00000	14.365000
4	1.270000	1.270000	-10.157589	10.157589
5	1.270000	1.270000	-14.365000	0.00000
6	1.270000	1.270000	-10.157589	-10.157589
7	1.270000	1.270000	0.00000	-14.365000
8	1.270000	1.270000	10.157589	-10.157589

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

Minimum spacing between any two bars not equal to zero = 9.724 inches
between bars 1 and 2.

Ratio of bar spacing to maximum aggregate size = 12.97

Concrete Properties:

Compressive Strength of Concrete	=	4000. psi
Modulus of Elasticity of Concrete	=	3604997. psi
Modulus of Rupture of Concrete	=	-474.341649 psi
Compression Strain at Peak Stress	=	0.001886
Tensile Strain at Fracture of Concrete	=	-0.0001154
Maximum Coarse Aggregate Size	=	0.750000 in

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

Number	Axial Thrust Force kips
1	237.000

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318, Section 10.3.4.
Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.

Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.

Axial Thrust Force = 237.000 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Max Conc Stress ksi	Max Steel Stress ksi	Run Msg
6.25000E-07	228.7841320	366054611.	102.1115467	0.00006382	0.00004132	0.2656305	1.8475093	
0.00000125	457.5729045	366058324.	60.0750789	0.00007509	0.00003009	0.3112300	2.1711966	
0.00000188	686.3506349	366053672.	46.0714939	0.00008638	0.00001888	0.3566145	2.4953500	
0.00000250	915.1118071	366044723.	39.0761300	0.00009769	0.00000769	0.4017827	2.8199694	
0.00000313	1144.	366031953.	34.8840507	0.0001090	-0.00000349	0.4467334	3.1450546	
0.00000375	1372.	365987065.	32.0932234	0.0001203	-0.00001465	0.4914595	3.4705630	
0.00000438	1601.	365860347.	30.1021893	0.0001317	-0.00002580	0.5359439	3.7963778	
0.00000500	1828.	365644396.	28.6103845	0.0001431	-0.00003695	0.5801735	4.1224058	
0.00000563	2055.	365350179.	27.4510342	0.0001544	-0.00004809	0.6241395	4.4485875	
0.00000625	2281.	364991950.	26.5241986	0.0001658	-0.00005922	0.6678366	4.7748860	
0.00000688	2507.	364582029.	25.7663376	0.0001771	-0.00007036	0.7112613	5.1012761	
0.00000750	2731.	364130373.	25.1351265	0.0001885	-0.00008149	0.7544108	5.4277400	
0.00000813	2955.	363644864.	24.6012864	0.0001999	-0.00009261	0.7972835	5.7542656	
0.00000875	3177.	363131657.	24.1439165	0.0002113	-0.0001037	0.8398779	6.0808438	
0.00000938	3399.	362595602.	23.7476988	0.0002226	-0.0001149	0.8821932	6.4074681	
0.00001000	3399.	339933377.	21.0742302	0.0002107	-0.0001493	0.8370803	6.0593268	C
0.00001063	3399.	319937296.	20.5802070	0.0002187	-0.0001638	0.8664658	6.2858137	C
0.00001125	3399.	302163001.	20.1303521	0.0002265	-0.0001785	0.8952634	6.5088024	C

```
0.00001188         3399.    286259686.    19.7184330     0.0002342    -0.0001933
0.9235122     6.7285479 C
0.00001250         3399.    271946701.    19.3392935     0.0002417    -0.0002083
0.9512425     6.9452439 C
0.00001313         3399.    258996858.    18.9888169     0.0002492    -0.0002233
0.9784870     7.1591059 C
0.00001375         3399.    247224274.    18.6636936     0.0002566    -0.0002384
1.0052809     7.3703728 C
0.00001438         3399.    236475392.    18.3613821     0.0002639    -0.0002536
1.0316687     7.5793637 C
0.00001500         3399.    226622251.    18.0798319     0.0002712    -0.0002688
1.0576980     7.7864269 C
0.00001563         3399.    217557361.    17.8173234     0.0002784    -0.0002841
1.0834155    -8.1574628 C
0.00001625         3399.    209189770.    17.5698172     0.0002855    -0.0002995
1.1087161    -8.6003986 C
0.00001688         3399.    201442001.    17.3380176     0.0002926    -0.0003149
1.1337473    -9.0446201 C
0.00001750         3399.    194247644.    17.1205491     0.0002996    -0.0003304
1.1585304    -9.4899713 C
0.00001813         3399.    187549449.    16.9136450     0.0003066    -0.0003459
1.1829199    -9.9376528 C
0.00001875         3399.    181297801.    16.7197443     0.0003135    -0.0003615
1.2071518   -10.3857640 C
0.00001938         3399.    175449485.    16.5342873     0.0003204    -0.0003771
1.2310010   -10.8361597 C
0.00002000         3399.    169966688.    16.3600991     0.0003272    -0.0003928
1.2547253   -11.2867425 C
0.00002063         3410.    165331318.    16.1927432     0.0003340    -0.0004085
1.2780788   -11.7395529 C
0.00002125         3460.    162801780.    16.0354156     0.0003408    -0.0004242
1.3013461   -12.1922501 C
0.00002188         3508.    160376420.    15.8835681     0.0003475    -0.0004400
1.3242473   -12.6471739 C
0.00002250         3557.    158079870.    15.7399207     0.0003541    -0.0004559
1.3470325   -13.1022517 C
0.00002313         3605.    155890340.    15.6026103     0.0003608    -0.0004717
1.3696067   -13.5582869 C
0.00002375         3653.    153793518.    15.4705242     0.0003674    -0.0004876
1.3919216   -14.0157014 C
0.00002438         3700.    151802702.    15.3453626     0.0003740    -0.0005035
1.4141540   -14.4730092 C
0.00002563         3794.    148059061.    15.1083191     0.0003872    -0.0005353
1.4578969   -15.3913679 C
0.00002688         3887.    144635706.    14.8912256     0.0004002    -0.0005673
1.5010774   -16.3113635 C
0.00002813         3979.    141473497.    14.6893119     0.0004131    -0.0005994
1.5435032   -17.2347174 C
0.00002938         4070.    138558093.    14.5027306     0.0004260    -0.0006315
1.5853865   -18.1596488 C
```

```
0.00003063        4160.    135852731.    14.3287157     0.0004388    -0.0006637
1.6266431   -19.0869468 C
0.00003188        4250.    133344065.    14.1671394     0.0004516    -0.0006959
1.6674193   -20.0153629 C
0.00003313        4339.    130998690.    14.0149544     0.0004642    -0.0007283
1.7075441   -20.9464718 C
0.00003438        4428.    128820101.    13.8742264     0.0004769    -0.0007606
1.7473633   -21.8771929 C
0.00003563        4516.    126766931.    13.7399131     0.0004895    -0.0007930
1.7864446   -22.8114898 C
0.00003688        4604.    124846830.    13.6146254     0.0005020    -0.0008255
1.8251748   -23.7458723 C
0.00003813        4691.    123048917.    13.4978280     0.0005146    -0.0008579
1.8635955   -24.6799513 C
0.00003938        4778.    121341704.    13.3851339     0.0005270    -0.0008905
1.9012732   -25.6178126 C
0.00004063        4864.    119736536.    13.2796953     0.0005395    -0.0009230
1.9386553   -26.5552964 C
0.00004188        4951.    118224259.    13.1808636     0.0005519    -0.0009556
1.9757409   -27.4924011 C
0.00004313        5036.    116787796.    13.0862366     0.0005643    -0.0009882
2.0122933   -28.4314127 C
0.00004438        5122.    115422891.    12.9958779     0.0005767    -0.0010208
2.0483730   -29.3717920 C
0.00004563        5207.    114130150.    12.9107554     0.0005891    -0.0010534
2.0841604   -30.3117941 C
0.00004688        5292.    112903786.    12.8304514     0.0006014    -0.0010861
2.1196546   -31.2514174 C
0.00004813        5377.    111734645.    12.7536648     0.0006138    -0.0011187
2.1547262   -32.1919539 C
0.00004938        5462.    110614835.    12.6792869     0.0006260    -0.0011515
2.1892592   -33.1346085 C
0.00005063        5546.    109548008.    12.6088400     0.0006383    -0.0011842
2.2235030   -34.0768841 C
0.00005188        5630.    108530322.    12.5420411     0.0006506    -0.0012169
2.2574566   -35.0187792 C
0.00005313        5714.    107558298.    12.4786340     0.0006629    -0.0012496
2.2911192   -35.9602919 C
0.00005438        5798.    106628551.    12.4183245     0.0006752    -0.0012823
2.3244807   -36.9015170 C
0.00005563        5881.    105730732.    12.3588470     0.0006875    -0.0013150
2.3572293   -37.8457723 C
0.00005688        5965.    104870346.    12.3022173     0.0006997    -0.0013478
2.3896904   -38.7896427 C
0.00005813        6048.    104044967.    12.2482527     0.0007119    -0.0013806
2.4218631   -39.7331263 C
0.00005938        6131.    103252374.    12.1967862     0.0007242    -0.0014133
2.4537466   -40.6762212 C
0.00006063        6213.    102490529.    12.1476641     0.0007365    -0.0014460
2.4853398   -41.6189254 C
```

```
0.00006188        6296.    101757560.    12.1007455     0.0007487    -0.0014788
2.5166419   -42.5612371 C
0.00006313        6379.    101051250.    12.0557384     0.0007610    -0.0015115
2.5476257   -43.5034512 C
0.00006438        6461.    100365881.    12.0111465     0.0007732    -0.0015443
2.5780656   -44.4481532 C
0.00006563        6543.     99704861.    11.9684626     0.0007854    -0.0015771
2.6082175   -45.3924569 C
0.00006688        6625.     99066817.    11.9275808     0.0007977    -0.0016098
2.6380804   -46.3363602 C
0.00006813        6707.     98450476.    11.8884031     0.0008099    -0.0016426
2.6676535   -47.2798610 C
0.00006938        6789.     97854654.    11.8508383     0.0008222    -0.0016753
2.6969357   -48.2229570 C
0.00007063        6870.     97278256.    11.8148018     0.0008344    -0.0017081
2.7259261   -49.1656463 C
0.00007188        6952.     96720257.    11.7802150     0.0008467    -0.0017408
2.7546238   -50.1079266 C
0.00007313        7033.     96179706.    11.7470046     0.0008590    -0.0017735
2.7830278   -51.0497957 C
0.00007438        7114.     95655716.    11.7151022     0.0008713    -0.0018062
2.8111371   -51.9912513 C
0.00007938        7437.     93699806.    11.5951352     0.0009204    -0.0019371
2.9198690   -55.7626112 C
0.00008438        7758.     91951829.    11.4916370     0.0009696    -0.0020679
3.0237854   -59.5284629 C
0.00008938        8078.     90377651.    11.4024285     0.0010191    -0.0021984
3.1229281   -60.0000000 CY
0.00009438        8394.     88948114.    11.3246480     0.0010688    -0.0023287
3.2171131   -60.0000000 CY
0.00009938        8681.     87352340.    11.2437794     0.0011174    -0.0024601
3.3040321   -60.0000000 CY
 0.0001044        8901.     85280725.    11.1487947     0.0011637    -0.0025938
3.3820399   -60.0000000 CY
 0.0001094        9117.     83356080.    11.0633234     0.0012101    -0.0027274
3.4555541   -60.0000000 CY
 0.0001144        9331.     81586684.    10.9872744     0.0012567    -0.0028608
3.5247404   -60.0000000 CY
 0.0001194        9528.     79816056.    10.9098132     0.0013024    -0.0029951
3.5879633   -60.0000000 CY
 0.0001244        9630.     77424063.    10.8007487     0.0013433    -0.0031342
3.6407198   -60.0000000 CY
 0.0001294        9699.     74968621.    10.6884478     0.0013828    -0.0032747
3.6880786   -60.0000000 CY
 0.0001344        9767.     72685864.    10.5837531     0.0014222    -0.0034153
3.7319808   -60.0000000 CY
 0.0001394        9833.     70553089.    10.4841314     0.0014612    -0.0035563
3.7722110   -60.0000000 CY
 0.0001444        9899.     68563394.    10.3925301     0.0015004    -0.0036971
3.8093213   -60.0000000 CY
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 0.0001494        9964.     66702317.    10.3081611     0.0015398    -0.0038377
3.8432720   -60.0000000 CY
 0.0001544       10027.     64953613.    10.2285295     0.0015790    -0.0039785
3.8738123   -60.0000000 CY
 0.0001594       10089.     63304858.    10.1522135     0.0016180    -0.0041195
3.9008674   -60.0000000 CY
 0.0001644       10151.     61752295.    10.0815745     0.0016572    -0.0042603
3.9247610   -60.0000000 CY
 0.0001694       10211.     60287321.    10.0161282     0.0016965    -0.0044010
3.9454508   -60.0000000 CY
 0.0001744       10271.     58902318.     9.9554469     0.0017360    -0.0045415
3.9628932   -60.0000000 CY
 0.0001794       10330.     57590427.     9.8990947     0.0017757    -0.0046818
3.9770403   -60.0000000 CY
 0.0001844       10388.     56340543.     9.8433478     0.0018149    -0.0048226
3.9877018   -60.0000000 CY
 0.0001894       10445.     55152954.     9.7915313     0.0018543    -0.0049632
3.9950900   -60.0000000 CY
 0.0001944       10501.     54022771.     9.7433631     0.0018939    -0.0051036
3.9991565   -60.0000000 CY
 0.0001994       10556.     52945360.     9.6986320     0.0019337    -0.0052438
3.9963925   -60.0000000 CY
 0.0002044       10610.     51916590.     9.6571397     0.0019737    -0.0053838
3.9994076   -60.0000000 CY
 0.0002094       10664.     50933013.     9.6186598     0.0020139    -0.0055236
3.9958440   -60.0000000 CY
 0.0002144       10717.     49991343.     9.5830126     0.0020544    -0.0056631
3.9993058   -60.0000000 CY
 0.0002194       10769.     49089026.     9.5499579     0.0020950    -0.0058025
3.9964529   -60.0000000 CY
 0.0002244       10820.     48221618.     9.5178404     0.0021356    -0.0059419
3.9987445    60.0000000 CY
 0.0002294       10869.     47384609.     9.4866182     0.0021760    -0.0060815
3.9997775    60.0000000 CY
 0.0002344       10912.     46555832.     9.4542146     0.0022158    -0.0062217
3.9971752    60.0000000 CY
 0.0002394       10947.     45729698.     9.4190479     0.0022547    -0.0063628
3.9995780    60.0000000 CY
 0.0002444       10975.     44909465.     9.3819069     0.0022927    -0.0065048
3.9966938    60.0000000 CY
 0.0002494       10991.     44073121.     9.3390587     0.0023289    -0.0066486
3.9970638    60.0000000 CY
 0.0002544       11004.     43257962.     9.2964902     0.0023648    -0.0067927
3.9992895    60.0000000 CY
 0.0002594       11011.     42452770.     9.2523360     0.0023998    -0.0069377
4.0000000    60.0000000 CY
 0.0002644       11018.     41676524.     9.2105701     0.0024350    -0.0070825
3.9945127    60.0000000 CY
 0.0002694       11025.     40927517.     9.1697949     0.0024701    -0.0072274
3.9975697    60.0000000 CY
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0.0002744	11030.	40202061.	9.1279498	0.0025045	-0.0073730
3.9993617	60.0000000 CY				
0.0003044	11061.	36338428.	8.9133683	0.0027130	-0.0082445
3.9984565	60.0000000 CY				
0.0003344	11084.	33146996.	8.7394173	0.0029222	-0.0091153
3.9959918	60.0000000 CY				
0.0003644	11101.	30465375.	8.5931153	0.0031311	-0.0099864
3.9999981	60.0000000 CYT				
0.0003944	11114.	28181749.	8.4777220	0.0033434	-0.0108541
3.9987303	60.0000000 CYT				
0.0004244	11121.	26205011.	8.3782854	0.0035555	-0.0117220
3.9913634	60.0000000 CYT				
0.0004544	11122.	24477478.	8.3005297	0.0037716	-0.0125859
3.9986927	60.0000000 CYT				
0.0004844	11122.	22961454.	8.2871262	0.0040141	-0.0134234
3.9969739	60.0000000 CYT				

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

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

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain
1	237.000	11089.965	0.00300000

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

In ACI 318, the value of the strength reduction factor depends on whether
the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.70).

The above values should be multiplied by the appropriate strength reduction
factor to compute ultimate moment capacity according to ACI 318, Section
9.3.2.2 or the value required by the design standard being followed.

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

Axial Load No.	Resist. Factor for Moment	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	11090.	154.050000	7208.	95086049.

1	0.70	11090.	165.900000	7763.	91929430.
1	0.75	11090.	177.750000	8317.	89295399.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.6000	0.00	N.A.	No	0.00	375.6026
2	1.2000	0.6000	No	Yes	N.A.	N.A.

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

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

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

Shear force at pile head = 44800.0 lbs
Applied moment at pile head = 2575200.0 in-lbs
Axial thrust load on pile head = 237000.0 lbs

Depth X	Deflect. y	Bending Moment	Shear Force	Slope S	Total Stress	Bending Stiffness	Soil Res. Es*h	Soil Spr. Distrib. p Lat. Load
feet	inches	in-lbs	lbs	radians	psi*	in-lb^2	lb/inch	lb/inch
0.00	0.00391	2575200.	44800.	-2.52E-04	0.00	3.64E+11	0.00	0.00
0.07000	0.00370	2612882.	44800.	-2.46E-04	0.00	3.64E+11		

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0.00       0.00       0.00
    0.1400    0.00350   2650562.     44800.  -2.40E-04       0.00   3.64E+11
0.00       0.00       0.00
    0.2100    0.00330   2688241.     44800.  -2.34E-04       0.00   3.64E+11
0.00       0.00       0.00
    0.2800    0.00310   2725919.     44800.  -2.28E-04       0.00   3.64E+11
0.00       0.00       0.00
    0.3500    0.00291   2763596.     44800.  -2.21E-04       0.00   3.64E+11
0.00       0.00       0.00
    0.4200    0.00273   2801271.     44800.  -2.15E-04       0.00   3.64E+11
0.00       0.00       0.00
    0.4900    0.00255   2838945.     44800.  -2.08E-04       0.00   3.64E+11
0.00       0.00       0.00
    0.5600    0.00238   2876618.     44800.  -2.02E-04       0.00   3.64E+11
0.00       0.00       0.00
    0.6300    0.00221   2914290.     44800.  -1.95E-04       0.00   3.64E+11
-0.05500    20.8656       0.00
    0.7000    0.00205   2951960.     44800.  -1.88E-04       0.00   3.64E+11
-0.1700    69.5520       0.00
    0.7700    0.00190   2989628.     44800.  -1.81E-04       0.00   3.64E+11
-0.2671   118.2384       0.00
    0.8400    0.00175   3027295.     44799.  -1.74E-04       0.00   3.63E+11
-0.3474   166.9248       0.00
    0.9100    0.00160   3064961.     44799.  -1.67E-04       0.00   3.63E+11
-0.4119   215.6112       0.00
    0.9800    0.00147   3102625.     44799.  -1.60E-04       0.00   3.63E+11
-0.4616   264.2976       0.00
    1.0500    0.00134   3140287.     44798.  -1.53E-04       0.00   3.63E+11
-0.4976   312.9840       0.00
    1.1200    0.00121   3177947.     44798.  -1.46E-04       0.00   3.63E+11
-0.5210   361.6704       0.00
    1.1900    0.00109   3215605.     44797.  -1.38E-04       0.00   3.63E+11
-0.5328   410.3568       0.00
    1.2600   9.78E-04   3253262.     34086.  -1.31E-04       0.00   3.63E+11
-25502.   2.19E+07       0.00
    1.3300   8.71E-04   3272922.     12639.  -1.23E-04       0.00   3.63E+11
-25563.   2.47E+07       0.00
    1.4000   7.70E-04   3274544.     -8832.  -1.16E-04       0.00   3.63E+11
-25557.   2.79E+07       0.00
    1.4700   6.76E-04   3258131.    -30267.  -1.08E-04       0.00   3.63E+11
-25479.   3.16E+07       0.00
    1.5400   5.89E-04   3223739.    -51604.  -1.01E-04       0.00   3.63E+11
-25324.   3.61E+07       0.00
    1.6100   5.07E-04   3171476.    -72777.  -9.33E-05       0.00   3.63E+11
-25088.   4.15E+07       0.00
    1.6800   4.32E-04   3101510.    -92561.  -8.60E-05       0.00   3.63E+11
-22017.   4.28E+07       0.00
    1.7500   3.63E-04   3016008.   -109773.  -7.89E-05       0.00   3.63E+11
-18963.   4.39E+07       0.00
    1.8200   2.99E-04   2917123.   -124474.  -7.21E-05       0.00   3.64E+11
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-16041.   4.50E+07       0.00
    1.8900   2.42E-04   2806919.   -136783.  -6.55E-05       0.00   3.64E+11
-13265.   4.61E+07       0.00
    1.9600   1.89E-04   2687354.   -146824.  -5.91E-05       0.00   3.64E+11
-10643.   4.72E+07       0.00
    2.0300   1.42E-04   2560278.   -154732.  -5.31E-05       0.00   3.64E+11
-8184.   4.83E+07       0.00
    2.1000   1.00E-04   2427426.   -160644.  -4.73E-05       0.00   3.65E+11
-5894.   4.94E+07       0.00
    2.1700   6.28E-05   2290415.   -164705.  -4.19E-05       0.00   3.65E+11
-3775.   5.05E+07       0.00
    2.2400   2.98E-05   2150738.   -167060.  -3.68E-05       0.00   3.65E+11
-1831.   5.16E+07       0.00
    2.3100   9.81E-07   2009768.   -167855.  -3.20E-05       0.00   3.65E+11
-61.5194   5.27E+07       0.00
    2.3800  -2.40E-05   1868754.   -167236.  -2.76E-05       0.00   3.66E+11
1535.   5.38E+07       0.00
    2.4500  -4.53E-05   1728823.   -165348.  -2.34E-05       0.00   3.66E+11
2961.   5.49E+07       0.00
    2.5200  -6.33E-05   1590980.   -162331.  -1.96E-05       0.00   3.66E+11
4221.   5.60E+07       0.00
    2.5900  -7.83E-05   1456114.   -158324.  -1.61E-05       0.00   3.66E+11
5319.   5.71E+07       0.00
    2.6600  -9.04E-05   1325002.   -153460.  -1.29E-05       0.00   3.66E+11
6262.   5.82E+07       0.00
    2.7300  -1.00E-04   1198307.   -147866.  -1.00E-05       0.00   3.66E+11
7057.   5.93E+07       0.00
    2.8000  -1.07E-04   1076590.   -141664.  -7.42E-06       0.00   3.66E+11
7710.   6.04E+07       0.00
    2.8700  -1.12E-04    960314.   -134969.  -5.09E-06       0.00   3.66E+11
8231.   6.15E+07       0.00
    2.9400  -1.16E-04    849844.   -127889.  -3.01E-06       0.00   3.66E+11
8627.   6.26E+07       0.00
    3.0100  -1.18E-04    745462.   -120524.  -1.18E-06       0.00   3.66E+11
8908.   6.37E+07       0.00
    3.0800  -1.18E-04    647364.   -112969.   4.19E-07       0.00   3.66E+11
9082.   6.48E+07       0.00
    3.1500  -1.17E-04    555674.   -105307.   1.80E-06       0.00   3.66E+11
9160.   6.59E+07       0.00
    3.2200  -1.15E-04    470448.    -97617.   2.98E-06       0.00   3.66E+11
9149.   6.70E+07       0.00
    3.2900  -1.12E-04    391676.    -89969.   3.97E-06       0.00   3.66E+11
9060.   6.81E+07       0.00
    3.3600  -1.08E-04    319298.    -82426.   4.78E-06       0.00   3.66E+11
8901.   6.91E+07       0.00
    3.4300  -1.04E-04    253200.    -75041.   5.44E-06       0.00   3.66E+11
8681.   7.02E+07       0.00
    3.5000  -9.90E-05    193226.    -67864.   5.95E-06       0.00   3.66E+11
8407.   7.13E+07       0.00
    3.5700  -9.38E-05    139185.    -60936.   6.33E-06       0.00   3.66E+11
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8090.   7.24E+07       0.00
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7350.   7.46E+07       0.00
    3.7800  -7.70E-05     10287.    -41950.   6.82E-06       0.00   3.66E+11
6943.   7.57E+07       0.00
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6518.   7.68E+07       0.00
    3.9200  -6.56E-05    -50694.    -31004.   6.72E-06       0.00   3.66E+11
6083.   7.79E+07       0.00
    3.9900  -6.00E-05    -74593.    -26080.   6.58E-06       0.00   3.66E+11
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    4.0600  -5.45E-05    -94511.    -21527.   6.39E-06       0.00   3.66E+11
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4761.   8.12E+07       0.00
    4.2000  -4.42E-05   -123650.    -13525.   5.88E-06       0.00   3.66E+11
4330.   8.23E+07       0.00
    4.2700  -3.94E-05   -133484.    -10065.   5.59E-06       0.00   3.66E+11
3909.   8.34E+07       0.00
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3501.   8.45E+07       0.00
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3109.   8.56E+07       0.00
    4.4800  -2.65E-05   -147581.     -1723.   4.61E-06       0.00   3.66E+11
2734.   8.67E+07       0.00
    4.5500  -2.28E-05   -148064.   424.5219   4.27E-06       0.00   3.66E+11
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1731.   9.00E+07       0.00
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1440.   9.11E+07       0.00
    4.8300  -1.07E-05   -135497.      6296.   2.95E-06       0.00   3.66E+11
1170.   9.22E+07       0.00
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    4.9700  -6.21E-06   -123445.      7856.   2.36E-06       0.00   3.66E+11
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    5.0400  -4.35E-06   -116600.      8357.   2.08E-06       0.00   3.66E+11
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311.7192   9.66E+07       0.00
    5.1800  -1.28E-06   -101993.      8889.   1.58E-06       0.00   3.66E+11
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    5.2500  -5.41E-08    -94474.      8954.   1.36E-06       0.00   3.66E+11
6.3672   9.88E+07       0.00
    5.3200   9.94E-07    -86951.      8907.   1.15E-06       0.00   3.66E+11
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-118.1739   9.99E+07       0.00
    5.3900   1.87E-06    -79510.      8763.   9.57E-07       0.00   3.66E+11
-225.3054   1.01E+08       0.00
    5.4600   2.60E-06    -72229.      8535.   7.83E-07       0.00   3.66E+11
-316.1132   1.02E+08       0.00
    5.5300   3.19E-06    -65171.      8238.   6.25E-07       0.00   3.66E+11
-391.7203   1.03E+08       0.00
    5.6000   3.65E-06    -58389.      7883.   4.83E-07       0.00   3.66E+11
-453.2697   1.04E+08       0.00
    5.6700   4.00E-06    -51927.      7482.   3.57E-07       0.00   3.66E+11
-501.9089   1.05E+08       0.00
    5.7400   4.25E-06    -45820.      7045.   2.45E-07       0.00   3.66E+11
-538.7753   1.06E+08       0.00
    5.8100   4.41E-06    -40092.      6581.   1.46E-07       0.00   3.66E+11
-564.9844   1.08E+08       0.00
    5.8800   4.50E-06    -34763.      6100.   6.01E-08       0.00   3.66E+11
-581.6180   1.09E+08       0.00
    5.9500   4.51E-06    -29844.      5608.  -1.40E-08       0.00   3.66E+11
-589.7154   1.10E+08       0.00
    6.0200   4.47E-06    -25341.      5112.  -7.73E-08       0.00   3.66E+11
-590.2653   1.11E+08       0.00
    6.0900   4.38E-06    -21255.      4619.  -1.31E-07       0.00   3.66E+11
-584.1989   1.12E+08       0.00
    6.1600   4.25E-06    -17581.      4133.  -1.75E-07       0.00   3.66E+11
-572.3847   1.13E+08       0.00
    6.2300   4.09E-06    -14311.      3660.  -2.12E-07       0.00   3.66E+11
-555.6246   1.14E+08       0.00
    6.3000   3.90E-06    -11433.      3202.  -2.41E-07       0.00   3.66E+11
-534.6506   1.15E+08       0.00
    6.3700   3.68E-06     -8932.      2763.  -2.65E-07       0.00   3.66E+11
-510.1228   1.16E+08       0.00
    6.4400   3.45E-06     -6792.      2346.  -2.83E-07       0.00   3.66E+11
-482.6288   1.17E+08       0.00
    6.5100   3.21E-06     -4991.      1953.  -2.96E-07       0.00   3.66E+11
-452.6835   1.19E+08       0.00
    6.5800   2.95E-06     -3510.      1586.  -3.06E-07       0.00   3.66E+11
-420.7298   1.20E+08       0.00
    6.6500   2.69E-06     -2326.      1247.  -3.13E-07       0.00   3.66E+11
-387.1404   1.21E+08       0.00
    6.7200   2.43E-06     -1415.   936.3598  -3.17E-07       0.00   3.66E+11
-352.2197   1.22E+08       0.00
    6.7900   2.16E-06  -753.1168   655.6205  -3.20E-07       0.00   3.66E+11
-316.2071   1.23E+08       0.00
    6.8600   1.89E-06  -313.8896   405.5158  -3.21E-07       0.00   3.66E+11
-279.2803   1.24E+08       0.00
    6.9300   1.62E-06   -71.7225   186.7629  -3.21E-07       0.00   3.66E+11
-241.5599   1.25E+08       0.00
    7.0000   1.35E-06       0.00       0.00  -3.21E-07       0.00   3.66E+11
-203.1137   6.31E+07       0.00
```

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

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     0.00390838 inches
Computed slope at pile head      =    -0.00025201 radians
Maximum bending moment           =       3274544. inch-lbs
Maximum shear force              =       -167855. lbs
Depth of maximum bending moment  =     1.40000000 feet below pile head
Depth of maximum shear force     =     2.31000000 feet below pile head
Number of iterations             =              6
Number of zero deflection points =              2
```

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

Boundary Condition Type 1, Shear and Moment

```
Shear      =          44800. lbs
Moment     =        2575200. in-lbs
Axial Load =         237000. lbs
```

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
7.00000	0.00390838	3274544.	-167855.
6.65000	0.00392623	3277816.	-168045.
6.30000	0.00392099	3277213.	-168008.
5.95000	0.00389291	3272682.	-167757.
5.60000	0.00384613	3264169.	-167150.
5.25000	0.00377654	3251667.	-166059.
4.90000	0.00383854	3261082.	-166166.
4.55000	0.00385366	3264462.	-165801.
4.20000	0.00383107	3259979.	-166556.
3.85000	0.00392699	3267580.	-174617.
3.50000	0.00410492	3263663.	-194049.
3.15000	0.00487772	3264177.	-235715.
2.80000	0.01073922	3245282.	-314231.
2.45000	0.07791439	3243988.	-408319.

```
    2.10000  -18.24784214      2575232.       388627.

--------------------------------------------------------------------------------
            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 Load                Load                   Axial    Pile-head  Pile-head  Max
Shear Max Moment
Case Type   Pile-head    Type     Pile-head   Loading  Deflection  Rotation    in
Pile    in Pile
 No.  1      Load 1       2        Load 2       lbs      inches     radians      lbs
     in-lbs
---- ----- ---------- ---------- ---------- ---------- ---------- ----------
---------- ----------
  1  V, lb     44800.  M, in-lb    2575200.    237000.    0.00391  -2.52E-04
-167855.   3274544.


Maximum pile-head deflection = 0.0039083772 inches
Maximum pile-head rotation   = -0.0002520094 radians = -0.014439 deg.

--------------------------------------------------------------------------------
                           Summary of Warning Messages
--------------------------------------------------------------------------------

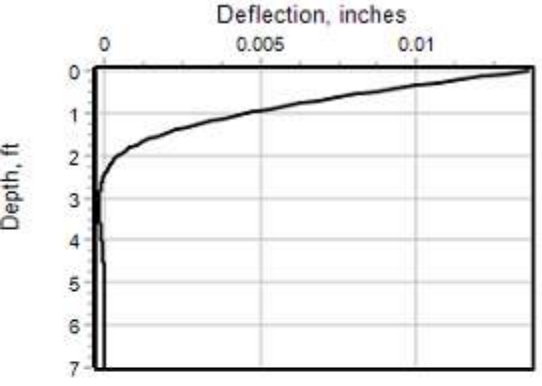
The following warning was reported 10000 times

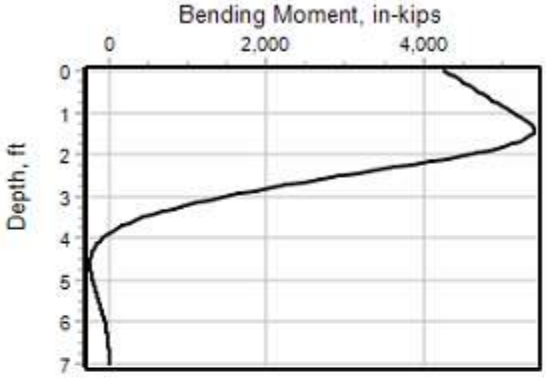

**** Warning ****

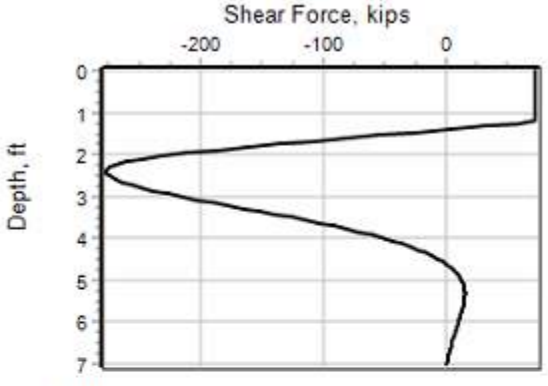
An unreasonable input value for unconfined compressive strength has been
specified for a soil defined using the weak rock criteria. The input value
is greater than 1000 psi. Please check your input data for correctness.

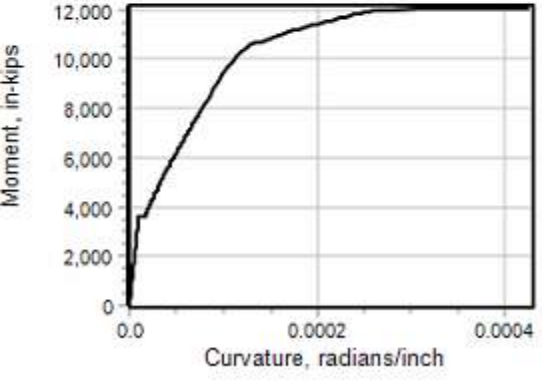

The analysis ended normally.
```

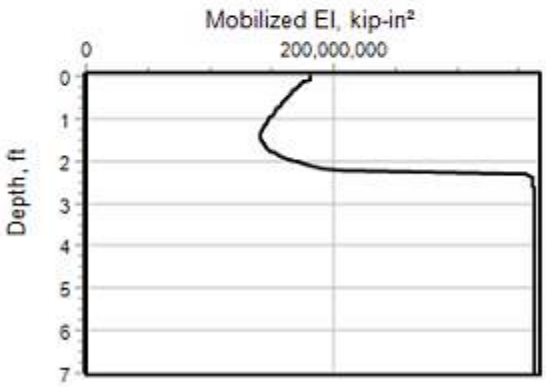
Results for LAW-378-4.84_Forward Abutment_Strength_B-002.lp9d

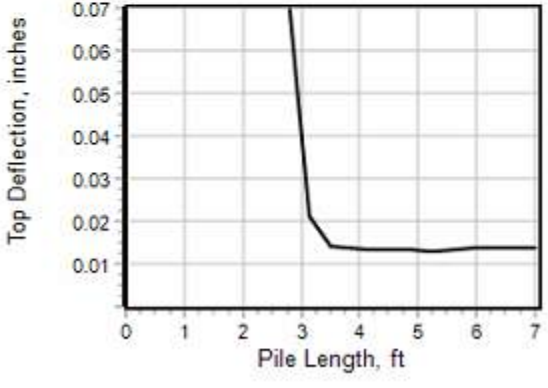












Show All Legends

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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\LAW-378-4.84\Analysis\Lpile\Files\New analysis 01272025\

Name of input data file:
LAW-378-4.84_Forward Abutment_Strength_B-002.lp9d

Name of output report file:
LAW-378-4.84_Forward Abutment_Strength_B-002.lp9o

Name of plot output file:
LAW-378-4.84_Forward Abutment_Strength_B-002.lp9p

Name of runtime message file:
LAW-378-4.84_Forward Abutment_Strength_B-002.lp9r

Date and Time of Analysis

Date: January 27, 2025 Time: 16:06:49

Problem Title

Project Name: LAW-378-4.84

Job Number:

Client: American Structurepoint / ODOT

Engineer: ZM

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 = 7.000 ft
Depth of ground surface below top of pile = 0.6000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	36.0000
2	7.000	36.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a round drilled shaft, bored pile, or CIDH pile
Length of section = 7.000000 ft
Shaft Diameter = 36.000000 in
Shear capacity of section = 0.0000 lbs

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 2 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	=	0.600000 ft
Distance from top of pile to bottom of layer	=	1.200000 ft
Effective unit weight at top of layer	=	73.800000 pcf
Effective unit weight at bottom of layer	=	73.800000 pcf
Friction angle at top of layer	=	33.000000 deg.
Friction angle at bottom of layer	=	33.000000 deg.
Subgrade k at top of layer	=	69.000000 pci
Subgrade k at bottom of layer	=	69.000000 pci

Layer 2 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	1.200000 ft
Distance from top of pile to bottom of layer	=	11.800000 ft
Effective unit weight at top of layer	=	87.200000 pcf
Effective unit weight at bottom of layer	=	87.200000 pcf
Uniaxial compressive strength at top of layer	=	4629. psi
Uniaxial compressive strength at bottom of layer	=	4629. psi
Initial modulus of rock at top of layer	=	420000. psi
Initial modulus of rock at bottom of layer	=	420000. psi
RQD of rock at top of layer	=	98.000000 %
RQD of rock at bottom of layer	=	98.000000 %
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 4.800 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name or (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Angle of Friction deg.	Uniaxial qu psi	RQD %	E50 kpy	Rock Mass Modulus pci	krm psi
1	Sand (Reese, et al.)	0.6000 69.0000 1.2000 69.0000	73.8000 -- 73.8000 --	33.0000	--	--	--	--	--
2	Weak Rock	1.2000 11.8000	87.2000 87.2000	--	4629. 4629.	98.0000 98.0000	5.00E-05 5.00E-05	-- --	420000. 420000.

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 = 71800. lbs	M = 4255200. in-lbs	325800.	Yes

V = shear force applied normal to pile axis
M = bending moment applied to pile head

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

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

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

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Drilled Shaft (Bored Pile):

Length of Section	=	7.000000 ft
Shaft Diameter	=	36.000000 in
Concrete Cover Thickness	=	3.000000 in
Number of Reinforcing Bars	=	8 bars
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Shaft	=	1018. sq. in.
Total Area of Reinforcing Steel	=	10.160000 sq. in.
Area Ratio of Steel Reinforcement	=	1.00 percent
Edge-to-Edge Bar Spacing	=	9.724495 in
Maximum Concrete Aggregate Size	=	0.750000 in
Ratio of Bar Spacing to Aggregate Size	=	12.97
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	4035.834 kips
Tensile Load for Cracking of Concrete	=	-453.111 kips
Nominal Axial Tensile Capacity	=	-609.600 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

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

1	1.270000	1.270000	14.365000	0.00000
2	1.270000	1.270000	10.157589	10.157589
3	1.270000	1.270000	0.00000	14.365000
4	1.270000	1.270000	-10.157589	10.157589
5	1.270000	1.270000	-14.365000	0.00000
6	1.270000	1.270000	-10.157589	-10.157589
7	1.270000	1.270000	0.00000	-14.365000
8	1.270000	1.270000	10.157589	-10.157589

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

Minimum spacing between any two bars not equal to zero = 9.724 inches
between bars 1 and 2.

Ratio of bar spacing to maximum aggregate size = 12.97

Concrete Properties:

Compressive Strength of Concrete	=	4000. psi
Modulus of Elasticity of Concrete	=	3604997. psi
Modulus of Rupture of Concrete	=	-474.341649 psi
Compression Strain at Peak Stress	=	0.001886
Tensile Strain at Fracture of Concrete	=	-0.0001154
Maximum Coarse Aggregate Size	=	0.750000 in

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

Number	Axial Thrust Force kips
1	325.800

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318, Section 10.3.4.
Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.

Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.

Axial Thrust Force = 325.800 kips

Bending Curvature rad/in.	Bending Max Conc Stress ksi	Bending Max Steel Stress in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Comp Strain in/in	Max Tens Strain in/in	Run Msg
6.25000E-07	226.4853303	362376528.	134.2076956	0.00008388	0.00006138	0.3473830	2.4292520
0.00000125	452.9791372	362383310.	76.1233527	0.00009515	0.00005015	0.3924801	2.7529465
0.00000188	679.4617879	362379620.	56.7705644	0.0001064	0.00003894	0.4373620	3.0771119
0.00000250	905.9277095	362371084.	47.1006652	0.0001178	0.00002775	0.4820276	3.4017482
0.00000313	1132.	362358825.	41.3039222	0.0001291	0.00001657	0.5264757	3.7268555
0.00000375	1359.	362343219.	37.4437576	0.0001404	0.00000541	0.5707049	4.0524336
0.00000438	1585.	362323613.	34.6901993	0.0001518	-0.00000573	0.6147139	4.3784815
0.00000500	1811.	362278687.	32.6279736	0.0001631	-0.00001686	0.6584957	4.7049562
0.00000563	2037.	362177889.	31.0260746	0.0001745	-0.00002798	0.7020371	5.0317659
0.00000625	2263.	362011865.	29.7459812	0.0001859	-0.00003909	0.7453271	5.3588341
0.00000688	2487.	361782635.	28.6996428	0.0001973	-0.00005019	0.7883574	5.6861038
0.00000750	2711.	361496682.	27.8284343	0.0002087	-0.00006129	0.8311223	6.0135345
0.00000813	2934.	361161651.	27.0918225	0.0002201	-0.00007238	0.8736179	6.3410982
0.00000875	3157.	360784542.	26.4608816	0.0002315	-0.00008347	0.9158409	6.6687737
0.00000938	3378.	360371427.	25.9144174	0.0002429	-0.00009455	0.9577890	6.9965448
0.00001000	3599.	359927480.	25.4365475	0.0002544	-0.0001056	0.9994604	7.3243988
0.00001063	3599.	338755275.	23.4743739	0.0002494	-0.0001331	0.9808346	7.1775790 C
0.00001125	3599.	319935538.	22.9361397	0.0002580	-0.0001470	1.0120872	7.4241906 C

```
0.00001188         3599.    303096825.    22.4428797     0.0002665    -0.0001610
1.0426714     7.6667792 C
0.00001250         3599.    287941984.    21.9882943     0.0002749    -0.0001751
1.0726152     7.9055067 C
0.00001313         3599.    274230461.    21.5684013     0.0002831    -0.0001894
1.1019991     8.1409603 C
0.00001375         3599.    261765440.    21.1788737     0.0002912    -0.0002038
1.1308492     8.3733009 C
0.00001438         3599.    250384334.    20.8161820     0.0002992    -0.0002183
1.1591935     8.6027084 C
0.00001500         3599.    239951653.    20.4774310     0.0003072    -0.0002328
1.1870618     8.8293825 C
0.00001563         3599.    230353587.    20.1602368     0.0003150    -0.0002475
1.2144863     9.0535448 C
0.00001625         3599.    221493834.    19.8626316     0.0003228    -0.0002622
1.2415011     9.2754402 C
0.00001688         3657.    216701188.    19.5829908     0.0003305    -0.0002770
1.2681430     9.4953387 C
0.00001750         3718.    212467266.    19.3186433     0.0003381    -0.0002919
1.2943698     9.7128615 C
0.00001813         3778.    208448001.    19.0685658     0.0003456    -0.0003069
1.3202209     9.9283024 C
0.00001875         3837.    204646717.    18.8326618     0.0003531    -0.0003219
1.3457861    10.1423849 C
0.00001938         3895.    201027182.    18.6085683     0.0003605    -0.0003370
1.3710016    10.3545519 C
0.00002000         3952.    197580096.    18.3954645     0.0003679    -0.0003521
1.3958904    10.5649694 C
0.00002063         4008.    194316128.    18.1940249     0.0003753    -0.0003672
1.4205729    10.7746387 C
0.00002125         4063.    191182610.    18.0006604     0.0003825    -0.0003825
1.4448661    10.9819820 C
0.00002188         4117.    188220848.    17.8182202     0.0003898    -0.0003977
1.4690350   -11.4198790 C
0.00002250         4171.    185365945.    17.6421396     0.0003969    -0.0004131
1.4928039   -11.8610539 C
0.00002313         4224.    182663267.    17.4757761     0.0004041    -0.0004284
1.5164760   -12.3020951 C
0.00002375         4276.    180054677.    17.3148366     0.0004112    -0.0004438
1.5397726   -12.7454313 C
0.00002438         4328.    177573066.    17.1619616     0.0004183    -0.0004592
1.5629442   -13.1889008 C
0.00002563         4430.    172896057.    16.8732749     0.0004324    -0.0004901
1.6085124   -14.0797852 C
0.00002688         4531.    168589003.    16.6071022     0.0004463    -0.0005212
1.6532716   -14.9740522 C
0.00002813         4630.    164615453.    16.3614030     0.0004602    -0.0005523
1.6973196   -15.8709181 C
0.00002938         4727.    160912499.    16.1314077     0.0004739    -0.0005836
1.7404628   -16.7722195 C
```

```
0.00003063        4823.    157478089.    15.9178803     0.0004875    -0.0006150
1.7829749   -17.6755700 C
0.00003188        4918.    154278737.    15.7186681     0.0005010    -0.0006465
1.8248408   -18.5811686 C
0.00003313        5011.    151282115.    15.5312883     0.0005145    -0.0006780
1.8659791   -19.4898437 C
0.00003438        5104.    148484103.    15.3563886     0.0005279    -0.0007096
1.9066036   -20.3996625 C
0.00003563        5196.    145850895.    15.1909899     0.0005412    -0.0007413
1.9465375   -21.3123460 C
0.00003688        5287.    143378574.    15.0356253     0.0005544    -0.0007731
1.9859560   -22.2262906 C
0.00003813        5378.    141052445.    14.8893120     0.0005677    -0.0008048
2.0248633   -23.1414918 C
0.00003938        5467.    138848594.    14.7498757     0.0005808    -0.0008367
2.0631108   -24.0594481 C
0.00004063        5557.    136776663.    14.6193862     0.0005939    -0.0008686
2.1010278   -24.9769730 C
0.00004188        5645.    134806067.    14.4943688     0.0006070    -0.0009005
2.1382891   -25.8973134 C
0.00004313        5733.    132937941.    14.3757441     0.0006200    -0.0009325
2.1750756   -26.8187225 C
0.00004438        5821.    131171762.    14.2641328     0.0006330    -0.0009645
2.2115367   -27.7397064 C
0.00004563        5908.    129486282.    14.1569271     0.0006459    -0.0009966
2.2474107   -28.6629533 C
0.00004688        5994.    127878865.    14.0543592     0.0006588    -0.0010287
2.2827807   -29.5876678 C
0.00004813        6081.    126351992.    13.9574208     0.0006717    -0.0010608
2.3178300   -30.5119620 C
0.00004938        6167.    124899530.    13.8656853     0.0006846    -0.0010929
2.3525575   -31.4358342 C
0.00005063        6252.    123500160.    13.7759670     0.0006974    -0.0011251
2.3865801   -32.3633959 C
0.00005188        6337.    122164510.    13.6906636     0.0007102    -0.0011573
2.4202603   -33.2908202 C
0.00005313        6422.    120889091.    13.6096465     0.0007230    -0.0011895
2.4536234   -34.2178258 C
0.00005438        6507.    119669738.    13.5326210     0.0007358    -0.0012217
2.4866682   -35.1444106 C
0.00005563        6591.    118495423.    13.4578659     0.0007486    -0.0012539
2.5191852   -36.0729174 C
0.00005688        6675.    117364786.    13.3855387     0.0007613    -0.0012862
2.5512244   -37.0028394 C
0.00005813        6759.    116280435.    13.3165713     0.0007740    -0.0013185
2.5829498   -37.9323419 C
0.00005938        6842.    115239432.    13.2507525     0.0007868    -0.0013507
2.6143602   -38.8614228 C
0.00006063        6926.    114239085.    13.1878888     0.0007995    -0.0013830
2.6454546   -39.7900803 C
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0.00006188        7009.    113274962.    13.1273494     0.0008123    -0.0014152
2.6761636   -40.7191247 C
0.00006313        7091.    112339511.    13.0677360     0.0008249    -0.0014476
2.7062964   -41.6508632 C
0.00006438        7174.    111438303.    13.0106651     0.0008376    -0.0014799
2.7361173   -42.5821770 C
0.00006563        7256.    110569369.    12.9559926     0.0008502    -0.0015123
2.7656251   -43.5130639 C
0.00006688        7338.    109730890.    12.9035851     0.0008629    -0.0015446
2.7948188   -44.4435220 C
0.00006813        7420.    108921177.    12.8533190     0.0008756    -0.0015769
2.8236973   -45.3735490 C
0.00006938        7502.    108138664.    12.8050796     0.0008884    -0.0016091
2.8522596   -46.3031427 C
0.00007063        7584.    107378895.    12.7579368     0.0009010    -0.0016415
2.8803740   -47.2339879 C
0.00007188        7665.    106640264.    12.7117065     0.0009137    -0.0016738
2.9080239   -48.1663491 C
0.00007313        7746.    105925052.    12.6672630     0.0009263    -0.0017062
2.9353611   -49.0982727 C
0.00007438        7827.    105232070.    12.6245174     0.0009389    -0.0017386
2.9623846   -50.0297563 C
0.00007938        8149.    102661231.    12.4689303     0.0009897    -0.0018678
3.0673188   -53.7512434 C
0.00008438        8468.    100358621.    12.3312461     0.0010404    -0.0019971
3.1665726   -57.4740451 C
0.00008938        8784.     98283903.    12.2100668     0.0010913    -0.0021262
3.2604234   -60.0000000 CY
0.00009438        9098.     96405316.    12.1045028     0.0011424    -0.0022551
3.3491178   -60.0000000 CY
0.00009938        9408.     94675931.    12.0097367     0.0011935    -0.0023840
3.4321766   -60.0000000 CY
 0.0001044        9664.     92585709.    11.9059879     0.0012427    -0.0025148
3.5067645   -60.0000000 CY
 0.0001094        9878.     90310260.    11.8000978     0.0012906    -0.0026469
3.5743450   -60.0000000 CY
 0.0001144       10090.     88218721.    11.7055703     0.0013388    -0.0027787
3.6372561   -60.0000000 CY
 0.0001194       10300.     86279145.    11.6172193     0.0013868    -0.0029107
3.6948954   -60.0000000 CY
 0.0001244       10483.     84289364.    11.5282055     0.0014338    -0.0030437
3.7465207   -60.0000000 CY
 0.0001294       10581.     81783656.    11.4142412     0.0014767    -0.0031808
3.7893757   -60.0000000 CY
 0.0001344       10650.     79257140.    11.2978380     0.0015181    -0.0033194
3.8269731   -60.0000000 CY
 0.0001394       10717.     76894883.    11.1873407     0.0015592    -0.0034583
3.8606073   -60.0000000 CY
 0.0001444       10783.     74690449.    11.0857887     0.0016005    -0.0035970
3.8907408   -60.0000000 CY
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 0.0001494        10849.     72627862.    10.9923044     0.0016420    -0.0037355
3.9173246   -60.0000000 CY
 0.0001544        10912.     70682755.    10.9017472     0.0016830    -0.0038745
3.9399578   -60.0000000 CY
 0.0001594        10973.     68852856.    10.8174022     0.0017240    -0.0040135
3.9590152   -60.0000000 CY
 0.0001644        11034.     67129113.    10.7393808     0.0017653    -0.0041522
3.9745115   -60.0000000 CY
 0.0001694        11094.     65502012.    10.6671453     0.0018067    -0.0042908
3.9863943   -60.0000000 CY
 0.0001744        11153.     63960729.    10.5989562     0.0018482    -0.0044293
3.9945751   -60.0000000 CY
 0.0001794        11210.     62495195.    10.5329000     0.0018893    -0.0045682
3.9990402   -60.0000000 CY
 0.0001844        11266.     61104193.    10.4716098     0.0019307    -0.0047068
3.9965831   -60.0000000 CY
 0.0001894        11321.     59781473.    10.4147710     0.0019723    -0.0048452
3.9997036   -60.0000000 CY
 0.0001944        11375.     58521553.    10.3620888     0.0020141    -0.0049834
3.9975084   -60.0000000 CY
 0.0001994        11428.     57320159.    10.3131826     0.0020562    -0.0051213
3.9998982   -60.0000000 CY
 0.0002044        11480.     56172354.    10.2679008     0.0020985    -0.0052590
3.9976949   -60.0000000 CY
 0.0002094        11531.     55072202.    10.2233471     0.0021405    -0.0053970
3.9998970    60.0000000 CY
 0.0002144        11580.     54018159.    10.1815241     0.0021827    -0.0055348
3.9970880    60.0000000 CY
 0.0002194        11629.     53008789.    10.1425674     0.0022250    -0.0056725
3.9996890    60.0000000 CY
 0.0002244        11677.     52040644.    10.1063964     0.0022676    -0.0058099
3.9955506    60.0000000 CY
 0.0002294        11724.     51111328.    10.0727723     0.0023104    -0.0059471
3.9989888    60.0000000 CY
 0.0002344        11770.     50219011.    10.0414000     0.0023535    -0.0060840
3.9990219    60.0000000 CY
 0.0002394        11816.     49360154.    10.0124222     0.0023967    -0.0062208
3.9972248    60.0000000 CY
 0.0002444        11858.     48523864.     9.9836955     0.0024398    -0.0063577
3.9996217    60.0000000 CY
 0.0002494        11897.     47705434.     9.9548943     0.0024825    -0.0064950
3.9960203    60.0000000 CY
 0.0002544        11927.     46887047.     9.9231277     0.0025242    -0.0066333
3.9973131    60.0000000 CY
 0.0002594        11952.     46080939.     9.8893832     0.0025651    -0.0067724
3.9994791    60.0000000 CY
 0.0002644        11967.     45266757.     9.8488605     0.0026038    -0.0069137
3.9988371    60.0000000 CY
 0.0002694        11979.     44470017.     9.8084272     0.0026421    -0.0070554
3.9947382    60.0000000 CY
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 0.0002744        11986.     43684250.     9.7663519     0.0026796    -0.0071979
3.9975988    60.0000000 CY
 0.0003044        12018.     39482986.     9.5467072     0.0029058    -0.0080517
3.9994825    60.0000000 CY
 0.0003344        12038.     36002228.     9.3596705     0.0031296    -0.0089079
3.9995244    60.0000000 CYT
 0.0003644        12051.     33073136.     9.2174469     0.0033586    -0.0097589
3.9985287    60.0000000 CYT
 0.0003944        12053.     30561841.     9.1036166     0.0035902    -0.0106073
3.9943775    60.0000000 CYT
 0.0004244        12053.     28401357.     9.0156958     0.0038260    -0.0114515
3.9905700    60.0000000 CYT


-------------------------------------------------------------------------------
   Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1
-------------------------------------------------------------------------------

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

 Load           Axial Thrust        Nominal Mom. Cap.      Max. Comp.
  No.              kips                 in-kip               Strain
 ----         ----------------     ------------------     ------------
   1               325.800             12026.309           0.00300000

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

In ACI 318, the value of the strength reduction factor depends on whether
the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.70).

The above values should be multiplied by the appropriate strength reduction
factor to compute ultimate moment capacity according to ACI 318, Section
9.3.2.2 or the value required by the design standard being followed.

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

Axial     Resist.       Nominal     Ult. (Fac)    Ult. (Fac)   Bend. Stiff.
Load      Factor      Moment Cap    Ax. Thrust    Moment Cap    at Ult Mom
 No.    for Moment      in-kips        kips         in-kips      kip-in^2
-----  ------------  ------------  ------------  ------------  ------------
   1       0.65            12026.    211.770000         7817.    105313775.

   1       0.70            12026.    228.060000         8418.    100714759.

   1       0.75            12026.    244.350000         9020.     96874891.
```

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.6000	0.00	N.A.	No	0.00	375.6026
2	1.2000	0.6000	No	Yes	N.A.	N.A.

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

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

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

Shear force at pile head = 71800.0 lbs
Applied moment at pile head = 4255200.0 in-lbs
Axial thrust load on pile head = 325800.0 lbs

Depth X	Deflect. y	Bending Moment	Shear Force	Slope S	Total Stress	Bending Stiffness	Soil Res. Es*h	Soil Spr. p Distrib. Lat. Load
feet	inches	in-lbs	lbs	radians	psi*	in-lb^2	lb/inch	lb/inch lb/inch
0.00	0.01362	4255200.	71800.	-9.14E-04	0.00	1.81E+11	0.00	0.00 0.00
0.07000	0.01287	4315759.	71800.	-8.94E-04	0.00	1.81E+11	0.00	0.00 0.00
0.1400	0.01212	4376313.	71800.	-8.73E-04	0.00	1.75E+11	0.00	0.00 0.00
0.2100	0.01140	4436861.	71800.	-8.52E-04	0.00	1.73E+11		

```
0.00       0.00       0.00
    0.2800    0.01069   4497404.     71800.  -8.30E-04       0.00   1.70E+11
0.00       0.00       0.00
    0.3500    0.01000   4557940.     71800.  -8.08E-04       0.00   1.68E+11
0.00       0.00       0.00
    0.4200    0.00933   4618470.     71800.  -7.84E-04       0.00   1.65E+11
0.00       0.00       0.00
    0.4900    0.00869   4678993.     71800.  -7.61E-04       0.00   1.63E+11
0.00       0.00       0.00
    0.5600    0.00806   4739510.     71800.  -7.36E-04       0.00   1.60E+11
0.00       0.00       0.00
    0.6300    0.00745   4800020.     71800.  -7.11E-04       0.00   1.58E+11
-0.1850    20.8656       0.00
    0.7000    0.00686   4860523.     71800.  -6.85E-04       0.00   1.56E+11
-0.5682    69.5520       0.00
    0.7700    0.00630   4921019.     71799.  -6.59E-04       0.00   1.54E+11
-0.8864   118.2384       0.00
    0.8400    0.00576   4981506.     71798.  -6.32E-04       0.00   1.52E+11
-1.1437   166.9248       0.00
    0.9100    0.00524   5041985.     71797.  -6.04E-04       0.00   1.50E+11
-1.3441   215.6112       0.00
    0.9800    0.00474   5102456.     71796.  -5.75E-04       0.00   1.49E+11
-1.4917   264.2976       0.00
    1.0500    0.00427   5162917.     71795.  -5.46E-04       0.00   1.47E+11
-1.5910   312.9840       0.00
    1.1200    0.00382   5223369.     71793.  -5.16E-04       0.00   1.45E+11
-1.6463   361.6704       0.00
    1.1900    0.00340   5283812.     71792.  -4.86E-04       0.00   1.43E+11
-1.6623   410.3568       0.00
    1.2600    0.00301   5344246.     57599.  -4.54E-04       0.00   1.42E+11
-33791.   9436959.       0.00
    1.3300    0.00264   5380827.     29234.  -4.22E-04       0.00   1.41E+11
-33746.   1.07E+07       0.00
    1.4000    0.00230   5393590.   947.5817  -3.90E-04       0.00   1.41E+11
-33602.   1.23E+07       0.00
    1.4700    0.00198   5382633.    -27176.  -3.58E-04       0.00   1.41E+11
-33358.   1.41E+07       0.00
    1.5400    0.00170   5348130.    -55051.  -3.26E-04       0.00   1.42E+11
-33011.   1.63E+07       0.00
    1.6100    0.00144   5290326.    -82589.  -2.95E-04       0.00   1.43E+11
-32556.   1.91E+07       0.00
    1.6800    0.00120   5209542.   -109698.  -2.64E-04       0.00   1.46E+11
-31989.   2.24E+07       0.00
    1.7500   9.91E-04   5106178.   -136282.  -2.35E-04       0.00   1.48E+11
-31307.   2.65E+07       0.00
    1.8200   8.06E-04   4980716.   -162243.  -2.07E-04       0.00   1.52E+11
-30504.   3.18E+07       0.00
    1.8900   6.44E-04   4833723.   -187474.  -1.80E-04       0.00   1.57E+11
-29569.   3.86E+07       0.00
    1.9600   5.03E-04   4665859.   -211771.  -1.55E-04       0.00   1.63E+11
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-28282. 4.72E+07   0.00
    2.0300 3.83E-04 4478033. -232900. -1.32E-04   0.00 1.71E+11
-22024. 4.83E+07   0.00
    2.1000 2.81E-04 4274660. -249096. -1.11E-04   0.00 1.80E+11
-16538. 4.94E+07   0.00
    2.1700 1.96E-04 4059613. -260994. -9.24E-05   0.00 1.92E+11
-11791. 5.05E+07   0.00
    2.2400 1.26E-04 3836241. -269197. -7.57E-05   0.00 2.07E+11
-7740. 5.16E+07   0.00
    2.3100 6.89E-05 3607403. -274264. -6.37E-05   0.00 3.56E+11
-4323. 5.27E+07   0.00
    2.3800 1.90E-05 3375513. -276590. -5.55E-05   0.00 3.60E+11
-1216. 5.38E+07   0.00
    2.4500 -2.43E-05 3142763. -276433. -4.79E-05   0.00 3.61E+11
1590. 5.49E+07   0.00
    2.5200 -6.15E-05 2911132. -274043. -4.09E-05   0.00 3.61E+11
4100. 5.60E+07   0.00
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6321. 5.71E+07   0.00
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8261. 5.82E+07   0.00
    2.7300 -1.41E-04 2239659. -255900. -2.30E-05   0.00 3.62E+11
9932. 5.93E+07   0.00
    2.8000 -1.58E-04 2028213. -246963. -1.80E-05   0.00 3.62E+11
11345. 6.04E+07   0.00
    2.8700 -1.71E-04 1824771. -236942. -1.35E-05   0.00 3.62E+11
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    2.9400 -1.81E-04 1630158. -226036. -9.54E-06   0.00 3.62E+11
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    3.0800 -1.91E-04 1269915. -202305. -2.83E-06   0.00 3.62E+11
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    3.1500 -1.92E-04 1105165. -189816. -7.42E-08   0.00 3.62E+11
15037. 6.59E+07   0.00
    3.2200 -1.91E-04   951024. -177114.   2.31E-06   0.00 3.62E+11
15207. 6.70E+07   0.00
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15224. 6.81E+07   0.00
    3.3600 -1.83E-04   674943. -151595.   6.07E-06   0.00 3.62E+11
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14075. 7.24E+07   0.00
    3.6400 -1.55E-04   248766. -103057.   1.02E-05   0.00 3.62E+11
13557. 7.35E+07   0.00
    3.7100 -1.46E-04   166978.   -91913.   1.07E-05   0.00 3.62E+11

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12975.   7.46E+07       0.00
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12340.   7.57E+07       0.00
    3.8500  -1.28E-04     30420.    -71199.   1.12E-05       0.00   3.62E+11
11664.   7.68E+07       0.00
    3.9200  -1.18E-04    -25275.    -61698.   1.12E-05       0.00   3.62E+11
10958.   7.79E+07       0.00
    3.9900  -1.09E-04    -73239.    -52798.   1.11E-05       0.00   3.62E+11
10233.   7.90E+07       0.00
    4.0600  -9.96E-05   -113982.    -44512.   1.08E-05       0.00   3.62E+11
9496.   8.01E+07       0.00
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8757.   8.12E+07       0.00
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7299.   8.34E+07       0.00
    4.3400  -6.55E-05   -215144.    -17528.   9.24E-06       0.00   3.62E+11
6593.   8.45E+07       0.00
    4.4100  -5.80E-05   -227544.    -12277.   8.73E-06       0.00   3.62E+11
5909.   8.56E+07       0.00
    4.4800  -5.09E-05   -235774.     -7590.   8.19E-06       0.00   3.62E+11
5251.   8.67E+07       0.00
    4.5500  -4.42E-05   -240300.     -3444.   7.64E-06       0.00   3.62E+11
4622.   8.78E+07       0.00
    4.6200  -3.80E-05   -241564.   188.1515   7.08E-06       0.00   3.62E+11
4025.   8.89E+07       0.00
    4.6900  -3.23E-05   -239988.      3333.   6.52E-06       0.00   3.62E+11
3463.   9.00E+07       0.00
    4.7600  -2.71E-05   -235968.      6020.   5.97E-06       0.00   3.62E+11
2936.   9.11E+07       0.00
    4.8300  -2.23E-05   -229877.      8281.   5.43E-06       0.00   3.62E+11
2446.   9.22E+07       0.00
    4.9000  -1.79E-05   -222059.     10145.   4.91E-06       0.00   3.62E+11
1993.   9.33E+07       0.00
    4.9700  -1.40E-05   -212835.     11645.   4.40E-06       0.00   3.62E+11
1577.   9.44E+07       0.00
    5.0400  -1.05E-05   -202498.     12811.   3.92E-06       0.00   3.62E+11
1199.   9.55E+07       0.00
    5.1100  -7.45E-06   -191315.     13674.   3.47E-06       0.00   3.62E+11
856.3596   9.66E+07       0.00
    5.1800  -4.72E-06   -179528.     14264.   3.04E-06       0.00   3.62E+11
549.1244   9.77E+07       0.00
    5.2500  -2.35E-06   -167353.     14611.   2.63E-06       0.00   3.62E+11
275.8753   9.88E+07       0.00
    5.3200  -2.96E-07   -154983.     14741.   2.26E-06       0.00   3.62E+11
35.1639   9.99E+07       0.00
    5.3900   1.45E-06   -142588.     14683.   1.92E-06       0.00   3.62E+11
-174.6278   1.01E+08       0.00
    5.4600   2.92E-06   -130317.     14460.   1.60E-06       0.00   3.62E+11
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-355.2497   1.02E+08       0.00
    5.5300   4.14E-06   -118296.     14098.   1.31E-06       0.00   3.62E+11
-508.5484   1.03E+08       0.00
    5.6000   5.13E-06   -106634.     13617.   1.05E-06       0.00   3.62E+11
-636.4347   1.04E+08       0.00
    5.6700   5.91E-06    -95421.     13038.   8.17E-07       0.00   3.62E+11
-740.8541   1.05E+08       0.00
    5.7400   6.50E-06    -84730.     12381.   6.08E-07       0.00   3.62E+11
-823.7600   1.06E+08       0.00
    5.8100   6.93E-06    -74621.     11662.   4.23E-07       0.00   3.62E+11
-887.0898   1.08E+08       0.00
    5.8800   7.21E-06    -65137.     10898.   2.61E-07       0.00   3.62E+11
-932.7430   1.09E+08       0.00
    5.9500   7.37E-06    -56312.     10102.   1.21E-07       0.00   3.62E+11
-962.5629   1.10E+08       0.00
    6.0200   7.41E-06    -48166.      9287.  -5.14E-10       0.00   3.62E+11
-978.3202   1.11E+08       0.00
    6.0900   7.37E-06    -40710.      8464.  -1.04E-07       0.00   3.62E+11
-981.6991   1.12E+08       0.00
    6.1600   7.24E-06    -33947.      7642.  -1.90E-07       0.00   3.62E+11
-974.2858   1.13E+08       0.00
    6.2300   7.05E-06    -27871.      6831.  -2.62E-07       0.00   3.62E+11
-957.5594   1.14E+08       0.00
    6.3000   6.80E-06    -22471.      6037.  -3.20E-07       0.00   3.62E+11
-932.8837   1.15E+08       0.00
    6.3700   6.51E-06    -17729.      5266.  -3.67E-07       0.00   3.62E+11
-901.5024   1.16E+08       0.00
    6.4400   6.18E-06    -13623.      4525.  -4.03E-07       0.00   3.62E+11
-864.5349   1.17E+08       0.00
    6.5100   5.83E-06    -10127.      3816.  -4.31E-07       0.00   3.62E+11
-822.9742   1.19E+08       0.00
    6.5800   5.46E-06     -7212.      3144.  -4.51E-07       0.00   3.62E+11
-777.6857   1.20E+08       0.00
    6.6500   5.07E-06     -4845.      2511.  -4.65E-07       0.00   3.62E+11
-729.4080   1.21E+08       0.00
    6.7200   4.68E-06     -2994.      1919.  -4.74E-07       0.00   3.62E+11
-678.7545   1.22E+08       0.00
    6.7900   4.28E-06     -1621.      1371.  -4.79E-07       0.00   3.62E+11
-626.2156   1.23E+08       0.00
    6.8600   3.88E-06  -689.8446   867.8525  -4.82E-07       0.00   3.62E+11
-572.1635   1.24E+08       0.00
    6.9300   3.47E-06  -162.5757   410.4645  -4.83E-07       0.00   3.62E+11
-516.8555   1.25E+08       0.00
    7.0000   3.06E-06       0.00       0.00  -4.83E-07       0.00   3.62E+11
-460.4409   6.31E+07       0.00

* This analysis computed pile response using nonlinear moment-curvature rela-
  tionships. Values of total stress due to combined axial and bending stresses
  are computed only for elastic sections only and do not equal the actual
  stresses in concrete and steel. Stresses in concrete and steel may be inter-
```

polated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     0.01362458 inches
Computed slope at pile head      =    -0.00091373 radians
Maximum bending moment           =       5393590. inch-lbs
Maximum shear force              =       -276590. lbs
Depth of maximum bending moment  =     1.40000000 feet below pile head
Depth of maximum shear force     =     2.38000000 feet below pile head
Number of iterations             =             14
Number of zero deflection points =              2
```

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

Boundary Condition Type 1, Shear and Moment

```
Shear      =          71800. lbs
Moment     =        4255200. in-lbs
Axial Load =         325800. lbs
```

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
7.00000	0.01362458	5393590.	-276590.
6.65000	0.01372203	5397357.	-277181.
6.30000	0.01370663	5394947.	-277365.
5.95000	0.01358993	5386290.	-276802.
5.60000	0.01337395	5374314.	-275624.
5.25000	0.01307021	5355863.	-273677.
4.90000	0.01332050	5371523.	-273815.
4.55000	0.01339021	5374909.	-273555.
4.20000	0.01328975	5368099.	-276173.
3.85000	0.01362771	5380728.	-292985.
3.50000	0.01415834	5373809.	-336487.
3.15000	0.02124121	5368405.	-441188.
2.80000	0.06945588	5340322.	-535819.
2.45000	-23.50135157	4255199.	588683.
2.10000	-18.62614737	4255176.	402127.
1.75000	-15.84828887	4255133.	244894.
1.40000	-14.87981221	4255220.	104726.

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

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

Load Case No.	Load Type	Pile-head 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	71800.	M, in-lb	4255200.	325800.	0.01362	-9.14E-04	-276590.	5393590.

Maximum pile-head deflection = 0.0136245791 inches
Maximum pile-head rotation = -0.0009137266 radians = -0.052353 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.